Life-Cycle Consumption of Food at Home in France: Empirical Evidence from Food Expenditures and Home Production

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Abstract:

The share of the elderly population in France increases steadily, raising concerns that the aging households cannot maintain the pre-retirement level of consumption. We use panel data on food purchases to investigate whether households use the variation in the life-cycle availability of the two inputs of home production – time and money, to sustain consumption. Our results indicate that food consumption peaks in early 40's, drop afterwards in the late 50's. However, it picks up at the early 60's dramatically by as much as 40% compared to the late 50's. This would indicate that food consumption remains uncompromised as households age.

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1. Introduction

Aging population is a major demographic change documented in Europe, North America and the rest of the developed and developing world. The United Nation projections indicate the number of individuals age 60 and over nearly doubles from 2005 to 2050 (Guerin *et al*., 2015). 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. The increasing proportion of the elderly population in France, compounded by substantially higher health care costs for the elderly (Tenand, 2014), makes it a major public health concern and one of the important foci of public, academic and industry interests in the country today. To this end, providing empirical life-cycle food consumption profiles in France cannot be underestimated. In this paper, we investigate the effect of aging on food consumption. In particular, we focus on food at home consumption over the course of life cycles of the French households.

There is sizable research done in the area of life-cycle consumption (see Fernandez-Villaverde and Krueger, 2007; Moreau and Stancanelli, 2013; Aguila, Attanasio and Meghir, 2011; Attanasio *et al.*, 1999; Gourinchas and Parker, 2002; 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). This documented decline in consumption could raise a legitimate concern whether the elderly population can maintain consumption, particularly post retirement.

Our research builds on the previous research and contributes in the following ways. First, we use purchase data from the Kantar Homescan panel from 1998-2014, as opposed to the repeated cross-sectional data from the consumer expenditure surveys previously used, to document the life-cycle food expenditure profiles. The expenditure surveys, a widely used source for information on the life-cycle consumption, are essentially cross-sectional in nature[1]. The common practice for using

[1] The consumer expenditure surveys track households for relatively short periods. For example, the consumer expenditure survey in the U.S. – CEX, tracks each household for at most five quarters (Consumer Expenditure Survey, Bureau of Labor Statistics, United States Department of Labor), while the consumer expenditure survey in France – Enquête « Budget de famille », tracks households' food purchases for 14 consecutive days, generalizing them to a year.

such cross-sectional data to explore the life-cycle consumption, which is dynamic in nature, is to create synthetic panels or “pseudopanels” (Deaton, 1985). The panel nature of our data allows us to track the life-cycle consumption of households for up to 13 years. Our results clearly show that the consumption peaks at mid 40’s, declining steadily until early 60’s and picks up afterwards up until the end of the age limit in our sample. Notably, the life-cycle consumption actually starts rising, while the income is still declining, reflecting, perhaps, the inter- and intra-period dynamics of the elasticity of substitution between time and money (Ghez and Becker, 1975). This means that *within* each period, for a given level of consumption, households would choose to engage in more home production, which would result in reduced food expenditures. However, conditional on the total cost of life-time consumption, households optimize by postponing consumption at home, hence increased food expenditures. The combined effect would have to reflect the relative magnitudes of the elasticity of substitution between time and money within and between periods.

The assumptions of declining life-cycle consumption based on the declining expenditures have been met with some scepticism, however, 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). In fact, even in the face of diminishing expenditures, the quantity of foods consumed may remain intact or even increase if the declines in price, achieved, for example, through strategic shopping and home production, could offset or more than offset the increase in quantity consumed. In their analysis of life-cycle home production, Aguiar and Hurst (2007) in fact use the price savings due to strategic shopping to measure the cost of time. They demonstrate that the home production of consumption, relative to expenditures, increases post 50’s, using a cross-section of purchase microdata for Denver, Colorado, USA. The second contribution of this paper is to revisit the home consumption production by using the price savings due to the strategic changes in the purchased food basket composition – purchase of less value-added, but lower priced, foods that are inputs to the home meal production, as the measure of the cost of time, in addition to the savings due to strategic shopping. Our imputed life-cycle home consumption production closely tracks the food expenditures, indicating an increase in the implied consumption post 60’s, albeit at a lower rate than that of the expenditures.

The life-cycle movements of food expenditures and home production in France received considerable attention. While some papers addressed 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), others documented the life-cycle evolution of food expenditures (Moreau and Stancanelli, 2013). Nonetheless, to our knowledge, no previous effort of empirical analysis of the life-cycle evolution of actual food production in France exists.

While it has been previously demonstrated that a use of a parsimonious set demographic variables and time effects, in addition to the lagged consumption, would improve the explanatory power the intertemporal consumption models, the past literature on consumer expenditure typically abstracts from time, region and cohort effects (Attanasio *et al.*, 1999; Fernandez-Villaverde and Krueger, 2007). Attanasio *et al.* (1999), for example, demonstrate that the inclusion of simple demographic information, such as the household size and the number of children, helps reconcile the theory (Hall, 1978) and the empirical evidence. Fernandez-Villaverde and Krueger (2007) argue that it is key to control for the cohort effects as well since, in the face of increasing real wages and life expectancy, a 35-year-old individual in 2014 would have higher discounted lifetime earnings and, therefore, face different consumption possibilities and make different consumption choices than a 35-year-old individual in 1960, all else equal. We contribute to the knowledgebase by exploiting the panel nature of our data to fully explore the time, region and cohort effects, in addition to the age effects, on both the life-cycle expenditures and implied consumption. Our results indicate that failing to account for the cohort effects would, first, underestimate the actual increase in home production and expenditures at every age, and, second, improve the fit reducing the dispersion around the mean.

The rest of paper is organized as follows. Section 2 sets up the life-cycle consumption model and discusses the general specification. Section 3 describes the data. Sections 4 and 5 discuss the conceptual setups, empirical specifications and results of the life-cycle consumption measured by food expenditures and implied consumption, respectively. In Section 6 we discuss the cohort effects on the consumption. Section 7 includes various sensitivity test results. The concluding remarks and recommendations appear in Section 8.

2. The Conceptual Setup

The life-cycle consumption model (Hall, 1978; Attanasio *et al.*, 1999) assumes a typical household optimizes the following problem:

$$\max E_t \sum_{\tau=0}^{T-t} (1+\delta)^{-\tau} U(C_{t+\tau})$$

subject to

$$\sum_{\tau=0}^{T-t}(1+r)^{-\tau}(A_{t+\tau}+I_{t+\tau}-C_{t+\tau})=A_t,$$

where C is the consumption, r is the real interest rate, δ is the rate of subjective time preference and A and I are the assets and income, respectively.

Assuming a constant elasticity of substitution within-period utility function:

$$U(C_t)=C_t^{\frac{\sigma_c-1}{\sigma_c}}$$

where σ_c is the elasticity of intertemporal substitution of consumption, the Euler optimality condition renders

$$C_t^{-\frac{1}{\sigma_c}}=\frac{1+\delta}{1+r_{t+1}}C_{t+1}^{-\frac{1}{\sigma_c}} \qquad (1)$$

In the empirical specification of (1), we take into account the cohort effects discussed and motivated above. While cohort effects describe the variation in consumption attributable to a specific generation, Fernandez-Villaverde and Krueger (2007) argue that accounting for time or macroeconomic effects is just as important. The inclusion of time, cohort and age effects in the model specification inevitably creates collinearity. We deal with this collinearity following the identification procedure developed by Deaton (2000).

Furthermore, considering the spatial differences in food, rent, leisure, etc. prices in France and urban/rural areas (in the Paris metropolitan area, in particular), we account for the region and area (urban/rural) variation as well (INSEE). The resulting log-linear specification of (1) is as follows:

$$\ln C_{j(r,a,c),t}=\alpha_0+\sum_{i=3}^{I}\beta_i t_{j,t}^{*}+\sum_{r=2}^{R}\gamma_r region_{j,t}+\sum_{k=2}^{K}\delta_k area_{j,t}+\sum_{c=2}^{C}\theta_c cohort_j$$
$$+\sum_{\alpha=2}^{A}\pi_a age_{j,t}+\varepsilon_{j,t} \qquad (2)$$

where $C_{j(r,a,c),t}$ is the log consumption for household j at time t. As noted above, one of our contributions is to use both expenditures and production to express consumption. We use dummy variables to account for 15 time periods $t_{j,t}^{*}$, orthogonal to a time trend and normalized to sum up to zero (Deaton, 2000); 94 regions or départements – the official geographical units in France; three levels for the urbanization level of the residential areas – Paris metropolitan area, urban areas with

200,000+ population, and urban areas less than 200,000 (the reference group is the rural areas); 10 five-year cohort dummies and 10 five-year age group dummy variables[2]. Despite earlier criticisms of estimating the life-cycle model with age expressed as a set of dummy variables, causing unduly non-smooth consumption paths (Fernandez-Villaverde and Krueger, 2007), we find it convenient to express the age with dummies thereby capturing the (logarithmic) change in consumption described in (1). To account for the time variation of the consumption within each household-unit, we use the fixed effects (FE) estimation method to estimate (2).

3. Data

In this research, we use the food at home purchase data from Kantar homescan panel. The Kantar panel is selected to be nationally representative. The panelists are supplied with hand-held scanner devices, which they use to scan the bar codes of all the grocery purchases made and transfer the data to Kantar regularly. The complete set of the product and producer information contained in the bar codes, as well as the information on the expenditures paid and the quantity purchased for each item, the shopping venue (the retailer name, typically) and shopping trip date is stored within Kantar. An annual survey collects an array of demographic information concerning the panelists (the age, year of birth and gender) and the participating households (the area of residence, household income, household size, number of children, etc.), made available with the purchase data as well. For this study, we use the Kantar panel data from 1998 to 2014.

We applied a two-tier censoring to the data. First, households with reported purchases for six or fewer calendar months were not included in the sample to eliminate the seasonality effects on the monthly averaged purchases. Second, we restricted our sample to only households with the head aged no younger than 25 or older than 75. The upper age limit is imposed to ensure that the preferences, rather than possible health issues, drive the food choices. The lower limit is imposed to retain only the households with more or less established consumption habits. The resulting sample is an unbalanced panel of 54,245 households with 196,673 household/year observations. In our sample, on average, 89% of the panelists are women, with approximately 80% in active work force. Couples (including married) constitute 72% of the sample, with 0.88 children and an average household size of 2.67 persons. The variable names, descriptions and summary statistics appear in Table A1 in the Appendix.

[2] The results are robust to the choice of the length of both the age and cohort periods.

4. Life-cycle consumption – food expenditures

The previous research in life-cycle consumption documents a peak of expenditures around 40's and a significant drop towards more advanced ages, all the while closely following the life-cycle income. Fernandez-Villaverde and Krueger (2007) demonstrate that correcting for household size using several adjustment scales, may reduce the hump by as much as 50%, but does not make it disappear altogether. To trace the life-cycle consumption measured by expenditures, we fit the life-cycle model described in (2). Since the age is expressed as a set of five-year age dummies, the parameter estimates express the log differences from the reference age group of the 25-29-year olds. The parameter estimates appear in Table 1 and are plotted against the age of the household head in Figure 1.

Table 1. Life-Cycle Food at Home Expenditures and Household Size: Log deviation from 25-29-year olds.

	Expenditures, per HHD	Expenditures, per HHD	Expenditures, per capita	HHD Size
Age Groups	POLS	FE	FE	FE
	I	II	III	IV
Age 30-34	0.1358	0.0400	-0.1208	0.1607
	(0.0078)	(0.0072)	(0.0069)	(0.0055)
Age 35-39	0.2162	0.0530	-0.2032	0.2563
	(0.0096)	(0.0091)	(0.0088)	(0.0069)
Age 40-44	0.2632	0.0599	-0.2312	0.2912
	(0.0110)	(0.0103)	(0.0102)	(0.0077)
Age 45-49	0.2468	0.0377	-0.2233	0.2610
	(0.0127)	(0.0114)	(0.0115)	(0.0085)
Age 50-54	0.1774	-0.0090	-0.1688	0.1598
	(0.0143)	(0.0126)	(0.0130)	(0.0095)
Age 55-59	0.1437	-0.0324	-0.0923	0.0599
	(0.0161)	(0.0138)	(0.0145)	(0.0104)
Age 60-64	0.1341	-0.0187	-0.0233	0.0045
	(0.0177)	(0.0150)	(0.0157)	(0.0112)
Age 65-69	0.1182	-0.0031	0.0259	-0.0290
	(0.0194)	(0.0161)	(0.0171)	(0.0121)
Age 70-75	0.0873	0.0001	0.0377	-0.0375
	(0.0212)	(0.0173)	(0.0183)	(0.0130)
Number of HHD/Years	196,673	196,673	196,673	196,673
Number of HHDs	54,245	54,245	54,245	54,245

In Figure 1, we demonstrate a similar hump in France. The plot clearly shows a hump in the early forties, at approximately 6% above the expenditure level of the reference group of 25-29-year-olds. After reaching the peak, the expenditures drop sharply and continue the decline steadily until late 50’s to nearly 3% below that of the 25-29-year-olds, take off again in the early 60’s and keep rising until the last age group in our sample, gaining 3.25%.

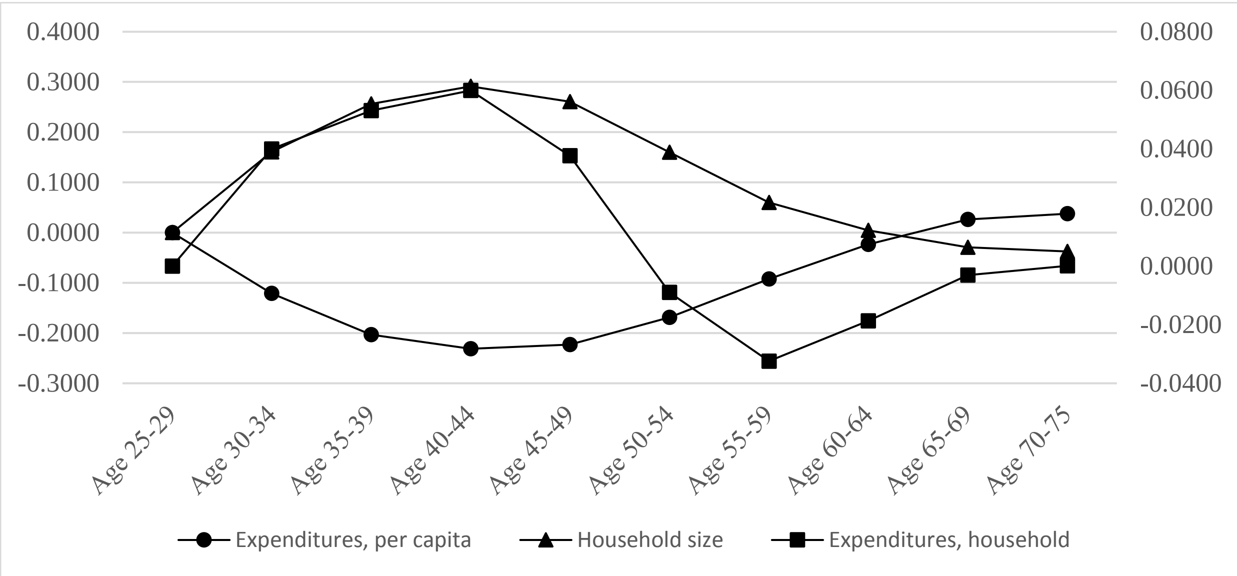

Figure 1. Food at home expenditures and household size over life-cycle: Log deviation from 25-29-year olds

Despite the similarities with the earlier evidence – the household expenditures do have a clear peak and they peak around the same age as in the previous literature – around 40’s, two differences are noteworthy. First, the peak in our data is relatively mild compared to near 40-60% increase reported previously (Gourinchas and Parker, 2002; Fernandez-Villaverde and Krueger, 2007; Aguiar and Hurst, 2007; for example). Second, unlike the monotonic decline in the expenditures after the 40’s in the previous evidence, our results clearly indicate a rise towards more advanced ages, starting in early 60’s and almost completely recovering the reference level of the 25-29-year-olds by the age of 75.

There could be a number of reasons giving rise to this departure from the previous evidence. First, an appealing explanation that suggests itself is the differences in the nature of our data (panel) and the data typically used previously (repeated cross-sections). To check this hypothesis, we ignore the panel dimension of our data and estimate (2) using the pooled ordinary least square

(POLS) instead of the FE estimation method (Figure 2). As before, the household expenditures estimated by POLS do peak around 40's, but at a 26% increase, as opposed to 6% from the FE estimation. Furthermore, unlike the FE estimates and in accordance with the precious evidence, the household expenditures in the POLS estimation do decline monotonically after the peak in the 40's.

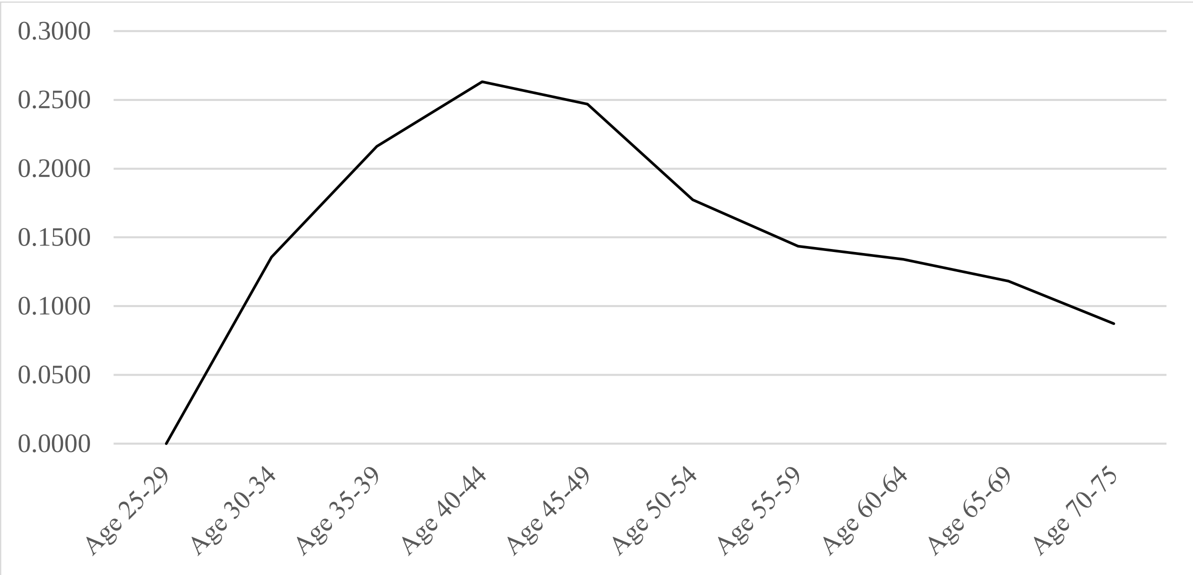

Figure 2. Life-cycle Expenditures estimated by POLS: Log differences from 25-29 year-olds.

Another reason for the increasing consumption after 50's in Figure 1 could be that in this analysis we are using only expenditures on grocery foods or food at home, while the expenditure surveys, used in the previous works, capture all food expenditures – both food at home and away from home. As such, the estimation based on the Kantar Homescan reflects the life-cycle nature of the substitution between the restaurant food and food at home production. In fact, the evidence from the French expenditure survey demonstrates a steady decline in the food budget proportion away from home through life cycles (Figure A1), possibly giving rise to the increase in the food at home expenditures after the 50's.

In a broader context, the observed pattern of the household expenditures in Figure 1 could be attributed to the households' life-cycle optimization (Ghez and Becker, 1975). Ghez and Becker (1975) maintain that households with higher elasticity of substitution between goods and time in home production (σ_F – we will defined and discuss it below) than the elasticity of substitution in consumption (σ_c) would allocate more consumption earlier in life, while households with the reverse preferences prefer to defer consumption later in life.

In line with the previous assertions that the demographic factors, such as the household size, drive the life-cycle consumption path in Figure 1 (Attanasio *et al.*, 1999; Fernandez-Villaverde and Krueger, 2007), we plotted the life cycle movements of the household size and the per capita food expenditures (Figure 1).

From the graph, it is clear that the household size, a mirror image of the per capita consumption, is the dominating factor in the household consumption up until the early 60's. The early growth of the household consumption until mid-40's, despite the steady decline in the per capita consumption by an impressive 20%, could clearly be attributed to the growth of the household size. It continues dominating the behavior of the household consumption following its peak in the early- to mid-40's to late 50's, despite the rising per capita consumption. After the early 60's the increase in the household consumption is attributable to the increase in per capita consumption, despite the continuous decrease in the household size.

In summary, in accordance with the previous evidence from other studies, our results replicate the familiar hump, albeit much smaller, around the 40's and decline thereafter. However, unlike the previous findings, our results indicate that the expenditures pick up at the early 60's and increase steadily afterwards. While taking into account the household size does explain the general shape of the household expenditures until the early 60's, it does not offer any insights afterwards. The panel nature of our data allows us to follow individual households and capture the intra- and inter-period substitution behavior, materialized in the reversal of the declining streak of the expenditures after the early 60's.

5. Life-cycle consumption – food production

As we mentioned before, concerns about the practice of measuring consumption with expenditures has met with considerable criticism in the literature. Indeed, considering a household's ability to substitute time, materialized in search and strategic shopping, and monetary expenditures in order to achieve lower total expenditures, indicates the possibility of facing different level of expenditures for the purchase of identical goods (Stigler, 1961; Aguiar and Hurst, 2007). Aging, with the decreased demand for time for work- and non-work-related time-intensive activities, e.g. caring of young children, and decreasing monetary income, provides a perfect natural setting to observe such behavior. For example, in their life-cycle consumption model 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 argument that the expenditures may not be an appropriate measure of consumption is also rooted in the home production theory (Becker, 1965; Ghez and Becker, 1975). According to the home production theory, households engage in home meal production using inputs of time and market goods to produce commodities. 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 with 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 meal production. Granted that the market prices for the lesser value-added foods or ingredients to ready-to-eat meals (henceforth, ingredients) are lower than those of the ready-to-eat foods (henceforth, RTE), aging consumers, with more time at hand and lower monetary income, would be expected to engage in home consumption production more intensively.

5.1 Conceptual Framework

We invoke the Beckerian production theory in an expenditure minimization setup. In each period $t, t = 1, \dots, T$, household $j, j = 1, \dots, J$, purchases q_{ijt} units of market good $i, i = 1, \dots, N$, paying the price p_{ijt}. The households have the ability to affect the expenditures through strategic shopping (s) and home production (h) to achieve lower prices. All else equal, we assume the price declines in time spent shopping and home production at a diminishing rate: ${\partial P}/{\partial s} < 0, {\partial P}/{\partial h} < 0, {\partial^2 P}/{\partial s^2} > 0, {\partial^2 P}/{\partial h^2} > 0$. To fully capture the variability in price, we allow the price to depend also on other factors that are the elements of the vector N, such as the quantities or the number of items purchased. For example, variation in price due to quantity discounts, or spending less ‘per unit’ or ‘per food’ time in search, holding the shopping time or the number of shopping trips constant.

Formally, in every period, in order to maintain consumption level c, a typical household makes consumption decision by minimizing the expenditures on meals by

$$\min_{Q,s,h} P(s, h, N)Q + \mu(s + h) \qquad (3)$$

subject to the home technology possibilities of converting market goods to meals, using time as an input:

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

where Q is the quantity of goods purchased; P is the price paid; s and h are the time spent shopping and production, respectively; N is a vector of factors affecting the price; μ represents the cost of time, and c is a parameter representing the consumption level[3]. Regular concavity conditions of the production function $f(h, Q)$ are implied.

The optimality conditions yield

$$\frac{\partial P}{\partial Q}Q + P = \frac{\partial f}{\partial Q}\lambda \qquad (4)$$

$$-\frac{\partial P}{\partial s}Q = \mu \qquad (5)$$

$$\frac{\partial f}{\partial h}\lambda = \mu + \frac{\partial P}{\partial h}Q \qquad (6)$$

where λ is the multiplier in the Lagrangian.

Combining the optimality conditions (4) and (6) yields the marginal rate of transformation between the market goods and time:

$$\frac{\frac{\partial f}{\partial h}}{\frac{\partial f}{\partial Q}} = \frac{\mu + \frac{\partial P}{\partial h}Q}{\frac{\partial P}{\partial Q}Q + P} \qquad (7)$$

The condition (7) states that, in equilibrium, the marginal rate of technical substitution is equal to the ratio of the factor costs.

Condition (5) is the optimality condition for the shopping time that equates the benefits of extra shopping to the cost of extra shopping. As mentioned above, all else equal, we would be expected that as time becomes a more abundant resource and the opportunity cost of time declines, the households can spend some of that time in search of lower price of market goods. The optimality condition for the shopping time (5) reflects that. For a fixed Q, as μ falls, ${\partial P}/{\partial s}$ would increase causing a movement on the price curve to the right, associated with higher s and lower P.

[3] While the dietary guidelines and recommendations indicate different consumption requirements by age, gender and activity level, it is challenging to adjust c to specific household profiles for at least three reasons. First, Kantar homescan consumption does not reflect foods consumed away from home, thereby making assigning caloric recommendations impractical. Second, the purchase decisions in the Kantar households are made by the household heads, but the consumption is at the household level. While Kantar provides the relevant demographic information (age and gender) concerning the household heads, such information is not available about the rest of the household members, again making household-specific consumption level hard to recommend. Finally, the voluntary (exercise) and involuntary (work) physical activity levels are not available at all.

5.2 Specification and Estimation

5.2.1 The Price Function

We fit a log-linear functional form to the price $P(s,h,N)$ function in (3). Formally, each household j, in each period t, pays prices

$$lnp_{jt} = \alpha_0 + \alpha_s lns_{jt} + \alpha_h lnh_{jt} + \sum_{k=1}^{K} \alpha_k N_{jtk} + \varepsilon_{jt} \qquad (8)$$

where p_{jt} is the price for household j, at time t; s_{jt} is the measure of the shopping time for household j, at time t; h_{jt} is the measure of the time in home production for household j, at time t; N_{jtk} is the shopping factor k for household j, at time t; and ε_{jt} is the error term.

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 and across time, we resort to constructing an index that would not only allow comparisons over time, but also cross-sectionally. Unfortunately, it is impractical to create commonly used price indices (e.g. Fisher index) that tracks individual products through time as the product identification codes in the Kantar data change at least twice in the time span of our sample, making the identification of unique products through time challenging.

Instead, 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 capture the cross-sectional variation in price, we normalize the price index of the rest of the sample to one, following Aguiar and Hurst (2007). To reflect 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

$$\overline{p}_{it} = \sum_{j \in J} p_{ijt} \frac{q_{ijt}}{\overline{q}_{it}} \quad, \forall t \in T \qquad (9)$$

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 (9) and the expenditure actually paid:

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

or

$$\tilde{p}_{jt} = \frac{X_j^t}{Q_j^t} \qquad (10)$$

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 composite quantity, by household j, in time t:

$$Q_j^t = \sum_{i\in I,t\in T} \overline{p}_{it}q_{ijt} \qquad (11)$$

Finally, to normalize prices, the price index is centered around one by dividing the annual price index for each household in (10) by the mean index across all other households:

$$p_{jt} = \frac{\tilde{p}_{jt}}{\frac{1}{J-1}\sum_j \tilde{p}_{-jt}} \qquad (12)$$

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

The obvious measure of the shopping time – s, in (3) would be the length of time devoted to shopping and search. Unfortunately, the duration of search and shopping is not available in Kantar. Instead, we consider the frequency of the shopping trips. As households shop frequently, they are more likely to find store and manufacturer promotional prices. The average number of trips per day – *Trips*, captures this strategy.

The time in home production (h) – washing, cleaning, cutting, cooking, etc. is not a part of our purchase data either. Instead, we use the proportion of ingredient foods in all foods purchased – *Ing*, which, as an input to the production function, indicates the intent and the extent of engaging in home production. The ingredient foods are identified by using recipes from the Individual and National Study on Food Consumption – 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" or components of the recipes in this database is identified as an ingredient for our purposes[4]. To allow comparison across household that

[4] Note that the status of "ingredient" has nothing to do with the state of being processed or fresh, it merely means the particular food was an ingredient to a dish.

purchase different amounts and quantities of market foods, we express *Ing* is defined as the quantity of ingredient foods divided by the quantity of all foods purchased[5], rather than levels.

The factors in N allowed to affect the price in (3) are the quantity index defined in (11), the number of unique products purchased per shopping trip – *UPC*, and the number of unique product groups purchased per shopping trip – *VFID*. The list of these variables, along with the description and summary statistics, appears in Table A1 as well.

5.2.2 The Production Function

In order to use the home production technologies in estimating the life-cycle consumption, certain restrictions need to be imposed. Pollak and Wachter (1975) discuss the limited applicability of the home production theory when the production technology does not have constant returns to scale or the time inputs of married householders are not perfect substitutes. To address these issues, we adopt a general functional form for the production function – constant elasticity of substitution, below:

$$c = f(h, Q) = \left(\varphi_h h^\rho + \varphi_Q Q^\rho\right)^{\frac{\gamma}{\rho}} \qquad (13)$$

with the elasticity of substitution between time and money as $\sigma_f = \frac{1}{1-\rho}$.

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

$$\frac{\frac{\partial f}{\partial h}}{\frac{\partial f}{\partial Q}} = \frac{\varphi_h}{\varphi_Q}\left(\frac{h}{Q}\right)^{\rho-1} \qquad (14)$$

Combining the optimality condition (5) and the optimality solution for (7) for the marginal rate of transformation in (14) yields

$$\frac{\frac{\partial p}{\partial h}Q - \frac{\partial p}{\partial s}Q}{\frac{\partial p}{\partial Q}Q + P} = \frac{\varphi_h}{\varphi_Q}\left(\frac{h}{Q}\right)^{\rho-1} \qquad (15)$$

Expressing in logarithms and rearranging yields

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[5] We also used the ratio of the numbers of ingredient foods and the number of all foods. Since typically many ingredients are required to cook a single meal, we suspected that this way of constructing *Ing* might overestimate the proportion of ingredient foods purchased, leading to the final choice of the ratio of quantities (kilograms) rather than numbers. Regardless of this choice, the results were robust to the choice of the calculation method for *Ing*.

$$\ln\left(\frac{h}{Q}\right) = -\frac{1}{\rho}ln(\alpha_Q + 1) - \frac{1}{\rho}\ln\left(\frac{\varphi_h}{\varphi_Q}\right) + \frac{1}{\rho}\ln\left(\alpha_h - \alpha_s\frac{h}{s}\right)$$

or

$$ln\left(\frac{h}{Q}\right) = \beta_0 + \frac{1}{\rho}ln\left(\frac{h^*}{s^*}\right) \qquad (16)$$

where $\beta_0 = -\frac{1}{\rho}ln\left(\left(1+\alpha_Q\right)\varphi_h\Big/\varphi_Q\right)$, $\frac{h^*}{s^*} = \alpha_h - \alpha_s\frac{h}{s}$, $\alpha_Q = \frac{\partial p}{\partial Q}\frac{Q}{P}$, $\alpha_h = \frac{\partial p}{\partial h}\frac{h}{P}\frac{Q}{h}$ and $\alpha_s = \frac{\partial p}{\partial s}\frac{s}{P}$. In this regression, in search of the model specification to improve the fit, we also use a set of demographic variables: the marital or couple status of the panelist (*couple*); the gender of the panelist (*female*); the log of the household income (ln*income*); and a dummy indicating whether the panellist is retired (*retired*).

We use the estimates from (16) to recover the necessary parameters to imply the consumption level c from (13). Without making extra assumptions φ_h, φ_Q and γ cannot be identified. We restrict φ_Q and γ to be equal to unity. Imposing γ to be equal to unity also ensures that the technology has constant returns to scale, mentioned above.

5.3 Price Estimation

As mentioned above, we measure the shopping time by the frequency of the shopping trips. We use the quantity of the purchased ingredient foods as the measure for the time for the home production. The estimates of the elasticities of price with respect to shopping frequency and home production are reported in Table 2.

The pooled OLS estimates for $lnIng$ and $lnTrips$ in (16) are -0.0060 and -0.0041, respectively, and both have the expected sign (column I of Table 2). This means, all else held equal, doubling the proportion of ingredients or the frequency of shopping would result in the price savings of 0.60 percent and 0.41 percent, respectively.

The frequency of the shopping trips as a measure for the shopping time faces several issues – it fails to account for shopping efficiency and lacks the ability to reflect the effects of the accumulated knowledge and periodical (weekly) nature of the store promotions. Just as with the measure of the shopping time, the measure of the home production time, too, is riddled with shortcomings. The most obvious shortcoming is the overlap between ingredients and the ready-to-eat foods. In other words, while some foods cannot be consumed in their current form (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)[6]. Another issue is the binary nature of the ingredient decision to describe a continuous state. For example, both fresh tomatoes and a can of diced tomatoes are an ingredient for a dish requiring diced tomatoes, but obviously have different levels of value-added and would consequently require different amount of time to prepare.

Table 2. The Elasticity of Price with Respect to Shopping and Home production Time

Elasticities	OLS	IV
	I	II
α_h	-0.0060 (0.0014)	-0.2717 (0.0398)
α_s	-0.0041 (0.0017)	-0.3447 (0.0619)
First stage regressions Ln*Ing*		
Child		0.0214 (0.0013)
Saturday		-0.0630 (0.0099)
F for excluded instruments (Prob >F)		145.70 (0.0000)
First stage regressions Ln*Trips*		
Child		0.0146 (0.0012)
Saturday		0.0269 (0.0068)
F for excluded instruments (Prob >F)		82.76 (0.0000)

Notes. Robust standard errors clustered at the household level are included in the parentheses.

[6] We check the robustness of our finding to this shortcoming in Section 7.

Considering the measurement concerns, 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 shopping 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 not to 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 positive significant factor in restaurant visits (Binkley, 2008; Nayga and Capps, 1992). Assuming food away from home is a substitute to food at home, it could be rationalizable that the day of the week is a good predictor for home production and shopping time. In this line of reasoning, one would expect it to be negatively associated with the time in home production. The effect on the shopping time would be ambiguous.

To capture the weekend effect, we use the ratio of the trips on Saturdays to all trips throughout the week. We chose to use only one of the weekend day – Saturday. In France, according to the current regulation, the grocery stores are required to be closed on Sundays, however, some stores could be exempted. For example, the small proprietorships are not subject to this legislation. Even the larger-sized stores could opt to open on Sundays for a fine or a fee (Code de Commerce). Because of 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 systematic differences in price, we felt it safer to consider the trips on Saturdays only. This instrument has the appealing quality that it is unlikely to be associated with the error term in (16) as there is no reason to believe that the prices are systematically different on Saturdays.

Another instrument we use in the IV estimation 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 foods and can take advantage of 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, making it hard to predict the sign of this association.

The estimates from the IV regression appear in column II of Table 2. The first stage regression estimates are generally of the predicted sign and are significant at 1 percent level or better, indicating relevance of the instruments. The first stage F-statistics testify to the strength of the excluded instruments. The IV parameter estimate for both *Ing* and *Trips* are consistent with the sign of the OLS estimates, but are much larger, indicating that doubling the ingredients (trips) would result in a whopping 27.17% (34.47%) drop in the price.

5.4 Home production

In order to impute the home production, we use the parameters estimated in (16): ρ and ${}^{\varphi_h}/_{\varphi_Q}$. For the imputation, we use the parameters from the estimation with the IV method (Table 2, Column II), although the choice of the estimation method is immaterial as far as the parameters ρ and, consequently, the elasticity of substitution between time and money – σ_f, are concerned, as under the either method they are not significantly different (p-value = 0.2026). Our estimate of $\sigma_f = -1.1704$ is in line with the previous findings in the literature (see Aguiar and Hurst, 2007, for a more detailed discussion). Finally, to be able to identify the rest of the parameters, additional assumption are required. Therefore, setting $\varphi_Q = 1$ and $\gamma = 1$, we are equipped to estimate the home production in (13):

$$\hat{c} = \left(\hat{\varphi} h^{\hat{\rho}} + Q^{\hat{\rho}}\right)^{\frac{1}{\hat{\rho}}} \qquad (17)$$

While the consumption level as defined in (17) generally measures the consumption generated in households, it is also useful to trace the path of the home production generated from each euro expended: $\frac{\hat{c}}{X} = \frac{\left(\hat{\varphi} h^{\hat{\rho}} + Q^{\hat{\rho}}\right)^{\frac{1}{\hat{\rho}}}}{\sum_{i \in I, t \in m} p_{ijt} q_{ijt}}$. The latter, as a metric normalized with regard to the expenditures, helps to abstract from the demographic and other, most notably the household size, effects that raised concerns in the literature (Attanasio *et al.* 1999; Fernandez-Villaverde and Krueger, 2007).

As in the case of the consumption measured by the expenditures, to trace the path of the life-cycle consumption measured by home production – $\hat{c}$, we fit the life cycle model in (2), with the implied consumption as the dependent variable. The parameter estimates appear in Table 3. In Figure 3, we plot the life-cycle path of the implied consumption and consumption-t-expenditures ratio. For the comparison purposes, in the same figure we also plot the expenditures, as they appear in Figure 1.

As it is clear from Figure 3, the life-cycle consumption, measured by the life-cycle home production, closely traces that of the expenditures: peaks at the early 40's and declines thereafter until the late 50's, only to take off again and keep climbing until the oldest age group in our sample.

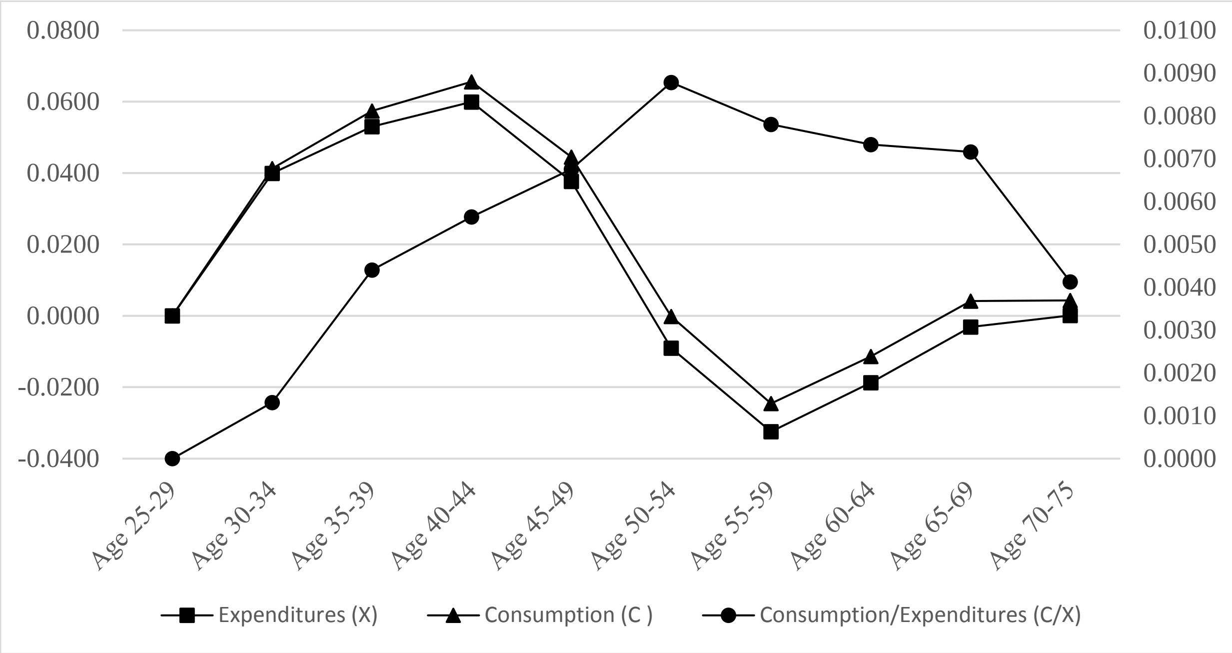

Figure 3. Food at home expenditures, implied consumption and implied consumption-to-expenditure ratio over life-cycle: Log deviation from 25-29-year olds

The increasing home production after the late 50's, in accordance with that of the expenditures, indicates that the consumption, at least the food at home consumption, increases after the households reach the retirement age, or at least remains uncompromised.

The consumption-to-expenditure ratio is positive and significant (Table 3, Column II) at every age. According to the results from the $\frac{\hat{c}}{X}$ estimates, for a given level of expenditures, the households generate increasingly more consumption at any age group until the early 50's. Despite the subsequent decline, it remains positive significant in the entire age range in our sample, indicating that the households do engage in home production at every age.

Table 3. Consumption and consumption-to-expenditure ratio over the life cycle: Log deviation from 25-29-year olds

Age Group	Consomption	Consumption to Expenditure Ratio	Income
	I	II	III
Age 30-34	0.0413	0.0013	0.0734
	(0.0071)	(0.006)	(0.0070)
Age 35-39	0.0574	0.0044	0.1170
	(0.0090)	(0.0008)	(0.0081)
Age 40-44	0.0656	0.0056	0.1461
	(0.0102)	(0.0010)	(0.0087)
Age 45-49	0.0445	0.0068	0.1661
	(0.0113)	(0.0012)	(0.0095)
Age 50-54	-0.0002	0.0088	0.1683
	(0.0125)	(0.0014)	(0.0103)
Age 55-59	-0.0246	0.0078	0.1330
	(0.0137)	(0.0016)	(0.0112)
Age 60-64	-0.0113	0.0073	0.0702
	(0.0148)	(0.0017)	(0.0121)
Age 65-69	0.0041	0.0072	0.0291
	(0.0160)	(0.0019)	(0.0131)
Age 70-75	0.0043	0.0041	-0.0029
	(0.0171)	(0.0021)	(0.0139)
Number of HHD/Years	196,673	196,673	196,673
Number of HHDs	54,245	54,245	54,245

However, despite our predictions that the changing life-cycle availability of time and money would give rise to more home production towards more advanced ages were not justified. In fact, holding expenditures constant, the generated consumption – $\frac{\hat{c}}{X}$, increases significantly until the early 40's, and remains relatively flat thereafter. In other words, there appears to be weak evidence that the households engage in home production more intensively to save in the expenditures as they age.

6. Cohort Effects

As discussed in the Introduction, the cohort effects are of key importance in explaining life-cycle consumption. To check if there is empirical merit to this assertion, we estimated (2) with consumption measured by both expenditures and home production, with and without cohort effect. The results of this exercise appear in Figures 4 and 5.

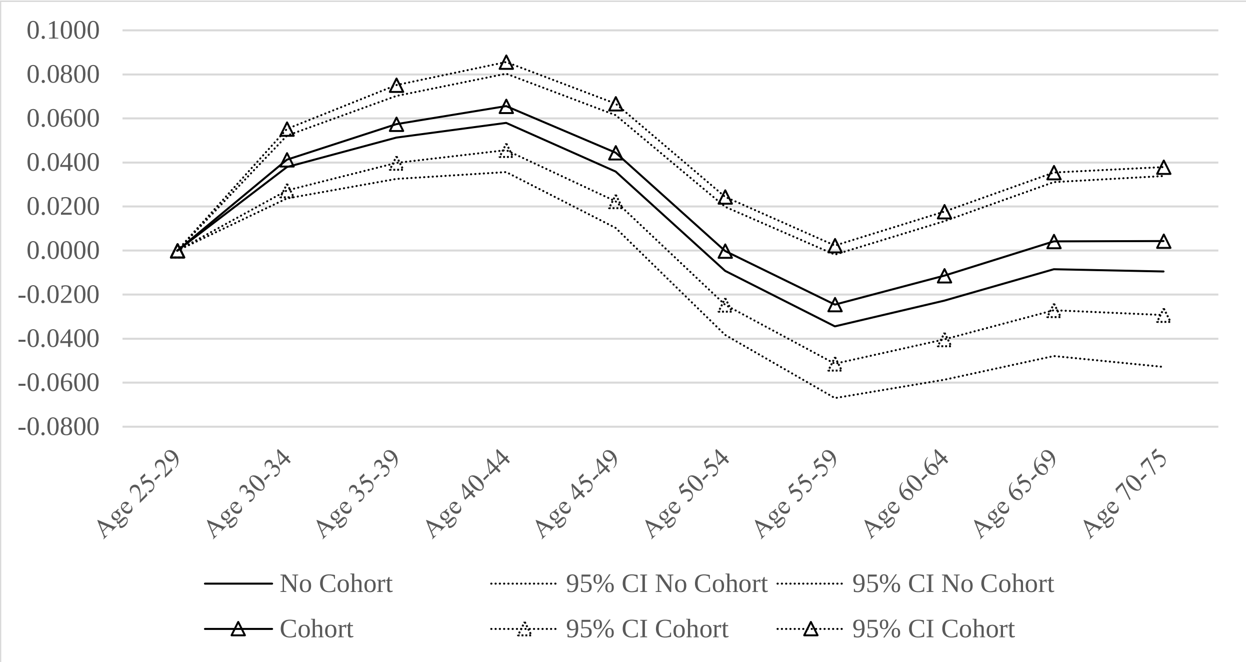

Figure 4. Implied consumption with and without cohort effects, and the confidence intervals over life-cycle: Log deviation from 25-29-year olds

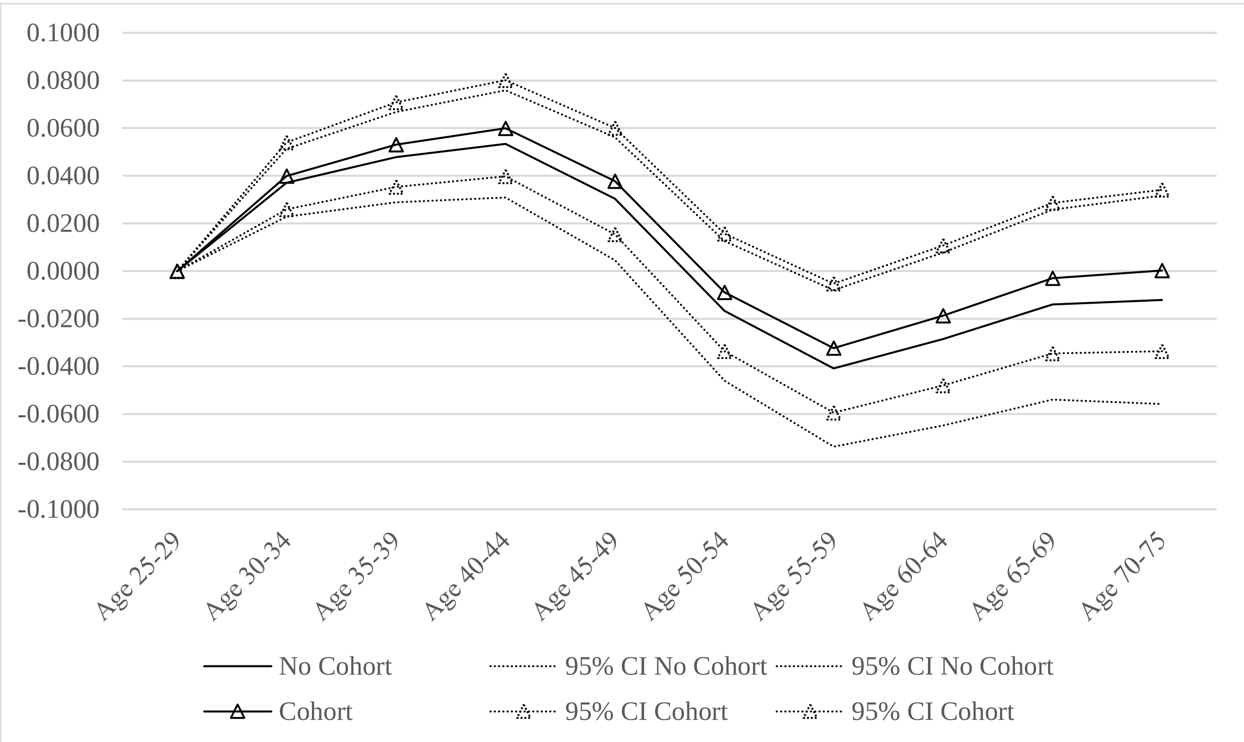

Figure 5. Expenditures with and without cohort effects, and the confidence intervals over life-cycle: Log deviation from 25-29-year olds

Our results, depicted in Figures 4 and 5, clearly indicate that failing to account for the cohort effects would underestimate the actual consumption measured by both expenditures and home production, at every age, by 8%-102% and 9%-149%, respectively.

This gap is particularly important for two reasons. First, the omission of the cohort effects will underestimate the life-cycle consumption more heavily towards more advanced ages. It will underestimate the consumption 3-5 times for the age 60 and above, compared to the gap in the immediately preceding age group of 55-59. Second, taking into account the cohort effect seems to improve the fit, making the confidence range around the mean tighter, notably the lower bound of the interval, reflecting the important role the cohort effects play in explaining away the variation in consumption for those below the mean consumption.

In summary, the cohort effects appear to improve the precision and the accuracy of the consumption estimates at every age and across the consumption measures. However, the shape of the life-cycle consumption – peaking at 40's and dipping before the monotonic rise in early 60's, remain intact regardless of inclusion of the cohort effects or not.

7. Robustness Checks

In this section, we ascertain the robustness of our results to the judgement choices made at roadblocks on the way. First, we would like to ascertain that our findings are robust to the way we measure the home production time – the proportion of the ingredient foods purchased. As mentioned above, there could be a significant overlap between what is labelled an ingredient and what is actually an ingredient. For example, most of the fruits are listed as ingredients in INCA2, but are more likely than not to be consumed as just snack, or not ingredients. To check whether our findings are robust to a dubious inclusion such as this, we constructed an alternative ingredient variable – one that does not consider the fruits as ingredients, but as ready-to-eat foods. The results of this estimation appear in Table A2, Column I.

It has been emphasized that one of the contributions of this study is the use of the panel data to address issues that have been previously studied using repeated cross-sectional data only. While the Kantar homescan is a panel data set, some households appear to be leaving the panel after one year, or were attrition in the course of the two-tier censoring discussed in the Data section. To check whether our results are sensitive to the inclusion of these households, which may unnecessarily overemphasize the cross-sectional effect relative to the time-series effect. The results with this revised sample appear in Column II, Table A2.

As is apparent from Table A2, our results are minimally, if at all, affected by these alternative treatments.

Throughout the literature on the life-cycle consumption, there is substantial evidence of it following the life-cycle income. This concept is suggestive that the life-cycle consumption paths might differ by income group and warrants investigation.

The household income in the Kantar panel is reported by a categorical variable (see Table A3 for the delineations and frequencies). To investigate whether the affluent and poor households have similar patterns of life-cycle consumption, we replicate our analyses for the top and bottom 15 percent subsamples. The results appear in Table A4. In Figure 6, we depict the consumption measured by the home production only.

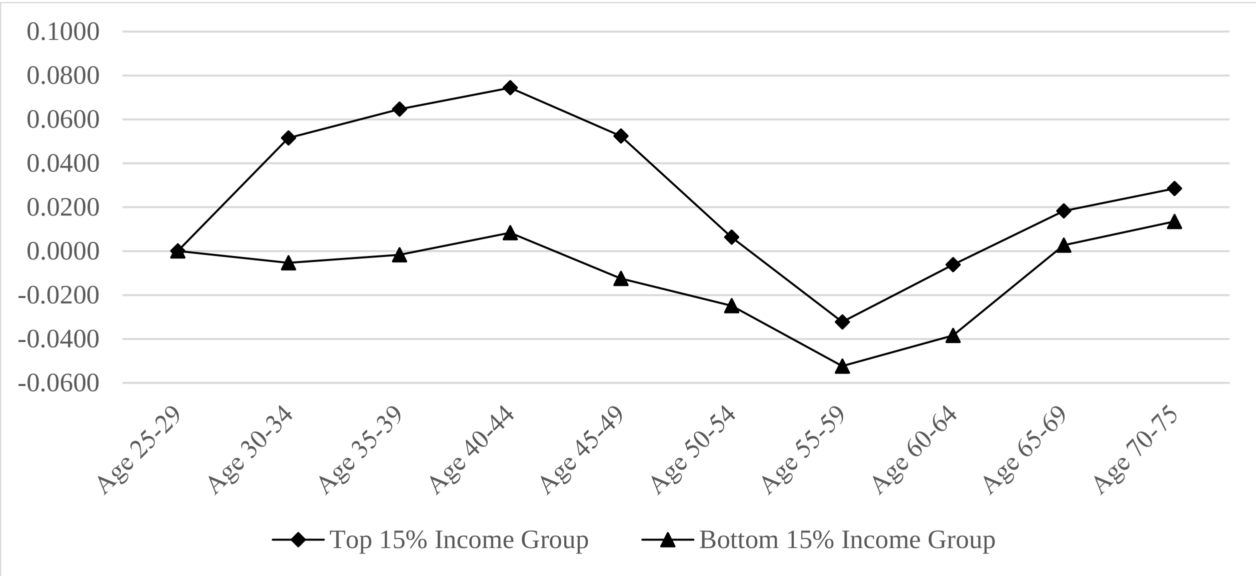

Figure 6. Home production by income level over life-cycle: Log deviation from 25-29-year olds

Our results strongly indicate that there are substantial differences in consumption paths of the top and bottom 15% income groups. At every age group the consumption of the bottom 15% income group remains lower than that of the top 15%. The former is also less peaked, at almost one tenth of the latter. Nonetheless, the general similarities prevail – both peak at the same age of 40-44, dip at the same age of 55-59, and take off afterwards.

8. 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 examine the life-cycle path of food consumption in France. We demonstrate that both food expenditures and home production peak at the age of 40-44 and drop to their minima at around 55-59, as previously demonstrated in the literature. However, unlike the previous findings, we find evidence that the consumption takes off at early 60's and continues to rise monotonically. We find mild evidence that this latter rise is due to the household efforts to reduce expenditures through strategic shopping and/or home production. It appears the increase in per capita expenditures is the cause of the increase in consumption after the 50's rather than the intra-period optimizing behaviour of the households. This finding perfectly chimes with the predictions of the life-cycle consumption concept advanced by Ghez and Becker (1975). A series of sensitivity checks reveal the robustness of our findings.

A cautionary note is in place though – our results pertain to home consumption only. Unfortunately, we do not have access to the data, most notably, to address this issue for the entire food consumption. Nevertheless, as is well documented previously (INSEE), 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.

There is room for future research on life-cycle consumption. For example, if available, the use of a more complete data set on all quantities or expenditures, more notably information on food away from home, would be enable a more holistic approach to the life-cycle food consumption. Another potential improvement would be disaggregating consumption by distinct, potentially more appealing and meaningful from the public perceptive, food groups. The latter would offer an intimate knowledge of the life-cycle evolution of the consumption of certain foods or food groups in which the private stakeholders have vested interest, and which would render the public intervention more viable and efficient.

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