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I investigate the impact of demographic dynamics on the sectoral composition of final consumption expenditure

I employ non-homothetic preferences structure to include the income effect

I use a 12-sectors classification for a panel of 30 European countries

I assess model fit through econometric statistics and simulation-based indicators

Even if disregarded by most of the structural change literature, the age structure shows a significant and strong impact on the consumption sectoral composition

Population Age Structure and Consumption Expenditure Composition: Evidence from European Countries

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Abstract

This paper aims at evaluating the effect of population age structure on households' aggregate preferences and, through this channel, on the sectoral composition of the final consumption expenditure. The analysis of European COICOP 2-digit data shows that the contribution of demographic dynamics to model fit is highly relevant, only slightly lower than the contribution of the income effect.

JEL Classification: D12, E21, R20

KEYWORDS: Structural change, Multisector models, Non-homothetic preferences, Demographic dynamics, Consumption

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Abstract

This paper aims at evaluating the effect of population age structure on households' aggregate preferences and, through this channel, on the sectoral composition of the final consumption expenditure. The analysis of European COICOP 2-digit data shows that the contribution of demographic dynamics to model fit is highly relevant, only slightly lower than the contribution of the income effect.

1. Introduction

The historical decrease in the relative size of the agricultural sector and the increase in the relevance of the service sector has been the subject of several analyses in recent years (see Herrendorf *et al.*, 2014, for an extensive survey). A significant part of the literature has emphasized the importance of the preference structure (or demand side), particularly the income effect, as a determinant of the sectoral reallocation (e.g., Kongsamut *et al.*, 2001; Boppart, 2014; Comin *et al.*, 2017). Such literature, which originally focused on the evolution of the relative sizes of the agriculture, manufacturing, and service sectors, has developed theoretical and empirical frameworks that may be applied to investigate a more detailed sectoral composition of households' expenditure. Therefore, this paper uses a 12-sector classification to evaluate the relevance of other determinants, besides the growth process, in the determination of sectoral reallocations.

Specifically, this paper builds on the framework developed in Comin *et al.* (2017) since: *i*) it conduces to a system of equations that are log-linear; *ii*) it can be extended to include the role of other factors; and *iii*) the role of the different determinants can be clearly distinguished.¹ This contribution's novelty is in the introduction of the population age structure as a possible determinant of the relative preferences between different sectoral goods. This kind of analysis represents a first application that may open the way to further extensions aimed at characterizing the process underlying the aggregate preference structure in greater detail.

The significant changes observed in recent decades and confirmed by demographic projections drove the decision to focus on population age composition. Indeed, the role of demographic dynamics in the growth process has been widely investigated (see Cervellati *et al.*, 2017, about the secular stagnation debate), and microeconomic evidence shows that consumption choices (in terms of amount and composition) depend significantly on age (see Blundell *et al.*, 1994; Foster, 2015).

¹ For example, Buera and Kaboski (2009) and Addessi *et al.* (2017) discuss some problematic aspects related to the use of the generalized Stone-Geary preferences.

2. Data

The data analyzed in this paper concern the final consumption expenditure of households, classified according to the purpose (specifically, the COICOP 2-digit classification, $N = 12$ sectors), as issued by Eurostat for 30 (M) European countries from 1995 to 2016.²

Descriptive statistics from 28 countries observed in 1995 and in 2015 highlight the significant reduction in the average expenditure share in the food sector (from 19.7% to 15%) and the increase in the housing sector (from 19.7% to 22.7%), while the time comparison among standard deviations suggests international convergence in the sectoral shares (the sectoral standard deviations increase slightly and just in two out of the 12 cases). The same statistics referred to the population age structure (three-indicators structure, less than 20 years old, working age between 20 and 64, $a2064$, and aged 65 and over, $a65$), highlight that, on average, the share of persons aged less than 20 has decreased (from 26.5% to 21.4%), mostly in the favor of those aged 65 and more (from 14% to 17.8%).

Several mechanisms suggest that the population age structure may affect consumption expenditure composition and such links may or may not emerge from simple correlation analysis. For example, the expenditure share in housing, due to different types of constraints and since it includes almost non-rival forms of consumption, is expected to be negatively related to the share of persons less than 20 years old and, indeed, the correlation between the shares of this type of expenditure and this segment of the population is negative in 26 out of the 30 countries in the sample.³ On the contrary, the expenditure share in education, which represents an investment in human capital, should be associated to the presence of young people and working-age people willing to change or improve their career, but emerges to be positively correlated to the share of persons aged 65 and more in 26 countries.⁴

3. Methodology

The econometric analysis is based on the theoretical framework developed by Comin *et al.* (2017). Eq. (1) implicitly defines the consumption bundle C_t :

$$\sum_{i=1}^N \omega_{i,t}^{\frac{1}{\sigma}} C_{i,t}^{\frac{\varepsilon_i}{\sigma}} C_{i,t}^{\frac{\sigma-1}{\sigma}} = 1 \quad (1)$$

where t denotes the time period; $\omega_{i,t}$ and $C_{i,t}$ indicate, respectively, the preference for and the consumption of each sector I ; ε_i determines the sectoral income elasticity; and σ is the elasticity of substitution. As described in Eq. (2), sectoral preferences depend on a deterministic component, ω_i , a stochastic component, $e^{\mu_{i,t}}$, and,

² The source of the consumption expenditure data and demographic data are, respectively, EUROSTAT at http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10_co3_p3&lang=en, and OECD at http://stats.oecd.org/Index.aspx?DataSetCode=POP_PROJ#.

³ Children/teenagers are not sufficiently independent to and cannot afford to live on their own, and their impact on the value of the rent, on the maintenance of the dwelling, and on some types of bills can be relatively lower than the impact on other types of expenditures, such as clothing and education.

⁴ Detailed tables about descriptive statistics and correlations are available upon request.

differently from Comin *et al.* (2017), other factors synthesized by the product between a vector of sectoral coefficients, β_i , and a vector of aggregate variables, x_t .

$$\omega_{i,t} = \omega_i e^{\beta_i x_t + \mu_{i,t}}. \quad (2)$$

In a standard theoretical framework characterized by such a preference structure, manipulating the optimal condition conduces the following log-linear equation:

$$\log(s_{ij,t}) = \ln(\omega_{ij}) + (1 - \sigma)\log(p_{ij,t}) + \varepsilon_{ij} \log(C_t) + \beta_{1,ij} a_{2064_t} + \beta_{2,ij} a_{65_t} + \beta_{3,ij} t + \mu_{ij,t}, \quad (3)$$

which relates (the logarithm of) the relative expenditure share in sector i with respect to sector j , $s_{ij,t}$, to the sectoral relative prices, $p_{ij,t} = p_{i,t}/p_{j,t}$; the difference in the parameters controlling the income elasticities, $\varepsilon_{ij} = \varepsilon_i - \varepsilon_j$; and the differences in the sectoral impact of the selected aggregate variables. In this specific application, Eq. (3) includes three groups of age-structure variables, whose coefficients are $\beta_{1,ij}$ and $\beta_{2,ij}$,⁵ and a log-linear time trend, whose effect is assessed by $\beta_{3,ij}$,⁶ where $\beta_{k,ij} = \beta_{k,i} - \beta_{k,j}$ for $k = 1, 2, 3$. Finally, $\mu_{ij,t} = \mu_{i,t} - \mu_{j,t}$ represents the difference in the stochastic component of the sectoral preferences.

Once sector j is chosen, Eq. (3) can be estimated as a system of $N - 1$ (11) seemingly unrelated equations for each country, while cross-country restrictions are imposed. Specifically, coefficients do not vary across countries, apart from the deterministic component of the sectoral preferences.⁷

Different specifications of Eq. (3) are estimated. Model *Baseline* considers only the role of relative price dynamics, i.e., it imposes $\varepsilon_{ij} = \beta_{1,ij} = \beta_{2,ij} = \beta_{3,ij} = 0$. Model *Income* is interested in evaluating the contribution of the income effect on model performance; thus, compared to the model *Baseline*, ε_{ij} is not assumed null. Model *AS* focuses on the effect of the age structure by imposing $\varepsilon_{ij} = \beta_{3,ij} = 0$. Model *Complete* includes the income, age structure, and time effect.

4. Results

Table 1 reports the results obtained from the different models, and detailed tables are available upon request. First, it is worth noting that the elasticity of substitution estimates are not significantly affected by the set of variables included in the different models and are in line with the values expressed in the literature. The fit of each estimated model is evaluated through the AIC, BIC, and R^2 . The inclusion of the income effect and/or the population age structure significantly improves model performance, and the Model *Complete* provides the best fit.

⁵ At maximum, only two of the three age-structure coefficients can be estimated in the same regression.

⁶ Log-linear time trends in sectoral preferences have been included for completeness and to consider the results obtained in Addressi (2014), who showed that households' sectoral preferences may be characterized by time trends.

⁷ Similar specification characterizes Comin *et al.* (2017) and other papers that estimate the sectoral consumption expenditure in different countries.

On the basis of the estimated parameters, it is possible to simulate the sectoral expenditure shares and to compare the simulations to the observed shares. Since most of the estimated parameters represent the difference between sectoral coefficients, it is necessary to introduce criteria to set the level of such coefficients. The conditions imposed in each country are: *i*) the sum of the deterministic components of the sectoral preferences is equal to one; *ii*) the lowest sectoral income elasticity is set slightly above the elasticity of substitution;⁸ *iii*) the sum of the sectoral coefficients of each aggregate variable (age indicators, time) is equal to zero. To assess the fit of the simulations, two indicators are defined, focusing on the difference between the observed expenditure shares, $s_{r,i,t}$ (country r , sector i , time t) and the simulated shares, $\hat{s}_{r,i,t,x}$ (where x identifies the econometric model underlying the simulation).

Table 1. Estimation Results

	<i>Model</i>			
	<i>Baseline</i>	<i>Income</i>	<i>AS</i>	<i>Complete</i>
Σ	0.816	0.824	0.846	0.84
<i>AIC</i>	-9,284	-10,430	-10,319	-11,387
<i>BIC</i>	-7,802	-8,900	-8,739	-9,709
<i>mean R</i> ²	0.84	0.92	0.90	0.93
<i>min R</i> ²	0.51	0.75	0.74	0.77
<i>max R</i> ²	0.96	0.98	0.96	0.98
\underline{Q}	1.00	0.65	0.67	0.46
<i>mean D</i>	0.0060	0.0050	0.0051	0.0044
<i>st. dev. D</i>	0.0026	0.0018	0.0021	0.0017
<i>min D</i>	0.0027	0.0026	0.0023	0.0018
<i>max D</i>	0.0114	0.0087	0.0096	0.0088
<i>Included variables</i>				
<i>Overall Consumption</i>		X		X
<i>a2064</i>			X	X
<i>a65</i>			X	X
<i>Time</i>				X
<i>Num. of parameters</i>	331	342	353	375

Note: The definitions of the different models are reported in the main text. The table reports the average, minimum, and maximum R^2 associated with each of the 11 equations. Similar statistics are provided for D , as well as the standard deviation. In this case, the unit of reference is the country, and these statistics are calculated using the average D characterizing each country. The number of observations is 649 in all models.

As indicated in Eq. (4), the first indicator, Q_x , is based on the sum of the square of such differences and uses the performance of Model *Baseline* to normalize the results:

$$Q_x = \frac{\sum_{r=1}^M \sum_{i=1}^N \sum_{t=1}^T (s_{r,i,t} - \hat{s}_{r,i,t,x})^2}{\sum_{r=1}^M \sum_{i=1}^N \sum_{t=1}^T (s_{r,i,t} - \hat{s}_{r,i,t,Baseline})^2} \quad (4)$$

⁸ As explained in Comin *et al.* (2017), if the elasticity of substitution is lower than one, sectoral income elasticities higher than the elasticity of substitution ensure the strict concavity of the consumption aggregator. Practically, in each country, we set the lowest sectoral income elasticity equal to the estimated elasticity of substitution plus 0.1. The other sectoral income elasticities are consequently determined on the basis of the estimates.

The other indicator, D_x defined in Eq. (5), is given by the sum of the absolute values of such differences, divided by the number of observations (a sort of average error per observation):

$$D_x = \frac{\sum_{r=1}^M \sum_{l=1}^N \sum_{t=1}^T |s_{r,i,t} - \hat{s}_{r,i,t,x}|}{649} \quad (5)$$

The values of Q_x and D_x reported in Table 1 confirm what emerged from the previous statistical criteria. The best fit is achieved when the income effect, the population age structure, and the time trend are considered. Singularly taken, both the income effect and the population age structure improve model performance, where the former provides a slightly higher contribution.

Starting from such results, possible further developments concerning the characterization of the preference process are: *i*) the consideration of autocorrelation and/or spatial correlation in the stochastic component of the preferences; *ii*) the inclusion of other aggregate and/or sectoral variables as determinants; *iii*) a proper micro-foundation of the aggregate preferences.

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