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The Impact of Age Distribution on Household Consumption: Evidence from Saudi Arabia

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Abstract. This paper aims to analyze the impact of age distribution on household consumption at the aggregate level. For that, statistical and econometric techniques are used, such as Unit root test, Co-integration and Granger Engels causality through Vector Error Correction Model, for testing an eventual short and long run causal relationships. This study is important since it helps to develop efficient national strategies for the short and the long run according to the evolution of the demographic profile and structure. Empirical validation for the Saudi Arabian case shows that the causality's effect differs significantly according to consider the size versus the proportion of each age group. In addition, the analysis and discussions of results for each age categories gave specific conclusions for the overtime causality effect on Saudi Arabian household final consumption.
Keywords. Age distribution, Consumption, Causality, Cointegration; Statistical tests.
JEL. C22, D12, J11.
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1. Introduction

The demographic change in the world affected by the change in the age distribution of the population is predicted to be most significant in the 21st century. Indeed, the combined effects of control of family size and health care are predicted to result in an "ageing population". This raises interesting questions about the impact of such demographic changes on total household expenditure.

According to economic theory, the influence may be substantial. For example, Modigliani & Brumberg (1954) suggest a life cycle model where the age is the main determinant of individuals' consumption in addition to saving behaviour; an individual borrows generally as young then saves at middle aged and dissaves when he is old. Thus, at the aggregate level, changes in the age distribution over time may cause important variations in a nation's private saving rate.

Several studies based on aggregate macroeconomic data confirm this conclusion, these studies generally confirm the life cycle theory, showing that savings decrease and/or aggregate consumption rises, when the proportion of elderly persons increases (Masson et al., 1996; Horioka, 1997; Attfield & Cannon, 2003; Hong, 2005; Erlandsen & Nymoen, 2008; Estrada *et al.*, 2011).

Nevertheless, some other studies show no significant effect of age distribution on aggregate consumption. We cite for example Masson et al. (1996) and Fair & Dominguez (1991). Indeed, using microeconomic survey data on household, they find no, or only low effects of changes in the age distribution on savings at the national level. This leads to think that this impact may change from case to case and it is important to do a specific analysis for each case.

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In this context, this paper aims to enrich the debate on the impact of age distributions on household consumption. Our contribution will be by applying not used econometric and statistical method, such as Unit root test, Co-integration and Granger Engels causality through Vector Error Correction Model, for testing the existence of a short and/or long run equilibrium relationship over time.

This study is important since it allows the prediction of the consumer behavior and the over time needed consumer product. This will be necessary to develop efficient national strategies for the short and the long run according to the evolution of the demographic profile and structure.

The paper is organized as follow: Section 2 presents a theoretical description of the proposed statistical and econometrics methods for analyzing the impact of age distributions on household consumption. Then in Section 3, an empirical validation for the Saudi Arabian case between 1970 and 2010 is presented. Finally, concluding remarks are given in the end of this paper.

2. Methodology

In order to analyze the causal association between the age distributions and the household consumption at the aggregate level, we propose to use econometric and statistical techniques such as unit root test, cointegration and Granger Engels causality through Vector Error Correction Model (VECM).

According to Engle & Granger (1987), causal relationship between two variables may exist in at least one direction if they are individually integrated of order one and cointegrated. For that, first, a test of stationarity is needed for determining the order of integration of the time series.

In this paper, for testing the stationarity, we use the Dickey-Fuller Unit Root Test which is based on the estimation of an autoregressive model, AR(1) for y_t, as following:

$$y_t = \emptyset y_{t-1} + \varepsilon_t \quad \text{, where } \varepsilon_t \sim WN(0, \sigma^2) \tag{1}$$

The unit root null hypothesis against the stationary alternative corresponds to:

$$H_0: \ \emptyset = 1 \qquad (y_t \sim I(1))$$
$$H_1: \ |\emptyset| < 1 \qquad (y_t \sim I(0))$$

The Dickey-Fuller (DF) test is the t-test for H_0 as following:

$$t_{\emptyset=1} = \frac{\widehat{\emptyset}-1}{SE(\widehat{\emptyset})} \tag{2}$$

where $\widehat{\emptyset}$ is the least squares estimate and $SE(\widehat{\emptyset})$ is the usual standard error estimate. Note that if y_t is stationary (i.e.,$|\emptyset| < 1$) then following Hamilton (1994)

$$\widehat{\emptyset} \sim N\left(\emptyset, \frac{1}{T}(1-\emptyset^2)\right) \tag{3}$$

In a second step, a cointegration test is applied for testing the existence of a long run equilibrium relationship between the age distributions and the household consumption. For that, we propose to use the Johansen Maximum Likelihood (ML) approach (Johansen, 1988).

In addition, for analyzing the direction of the eventual causality between the age distributions and the household consumption, we propose to use the Granger

(1969) causality test and the Granger Engels causality through the Vector Error Correction Model.

The Granger causality test is based on testing the significance of past values (time lags) of two stochastic (stationary) time series: for a pair of linear covariance-stationary time series X and Y : Y is considered Granger-caused by X if X contributes significantly in the prediction of Y i.e. the coefficients on the lagged X's are statistically significant.

Formally, to test causality between the age distributions and the household consumption and its direction in Granger sense, the following equation is estimated:

$$Age_t^C = \alpha_1 + \sum_{i=1}^{n} \alpha_{i2} Age_{t-i}^C + \sum_{j=1}^{m} \alpha_{j3} C_{t-j} + \varepsilon_1 \tag{4}$$

$$C_t = \beta_1 + \sum_{i=1}^{n} \beta_{i2} C_{t-i} + \sum_{j=1}^{m} \beta_{j3} Age_{t-j}^C + \varepsilon_2 \tag{5}$$

Where C is the per capita consumption, Age^{C} is the Age category, α_{ki} and β_{kj} (k=1,2,3; i=1,…,n ; j=1,…,m) are the coefficients, ε_1 and ε_2 are the error terms, n and m indicate the maximum number of lags to be taken of running variable.

The causality test can be performed, based on the null hypothesis that there is no causal flow between age distributions and household consumption (in both directions), formally:

$$\mathrm{H}_0 : \sum_{j=1}^{m} \alpha_3 = 0 \quad \text{and} \quad \sum_{i=1}^{n} \beta_2 = 0 \tag{6}$$

Where the alternative hypotheses are:
There is unidirectional causality from Consumption to Age category:

$$\mathrm{H}_1 : \sum_{j=1}^{m} \alpha_3 \neq 0 \quad \text{and} \quad \sum_{i=1}^{n} \beta_2 = 0 \tag{7}$$

There is unidirectional causality from Age category to Consumption:

$$\mathrm{H}_1 : \sum_{j=1}^{m} \alpha_3 = 0 \quad \text{and} \quad \sum_{i=1}^{n} \beta_2 \neq 0 \tag{8}$$

There is mutual causality:

$$\mathrm{H}_1 : \sum_{j=1}^{m} \alpha_3 \neq 0 \quad \text{and} \quad \sum_{i=1}^{n} \beta_2 \neq 0 \tag{9}$$

Note that Granger procedure tests the long run relationship. For testing simultaneously the short and the long run relationship, Engle & Granger (1987) extend this procedure and propose a two-step procedure for cointegration: The first consists on applying the traditional Granger (1969) test while the second is the estimation of a Vector Error Correction Model as following:

$$\Delta Age_t^C = \alpha_1 + \sum_{i=1}^{n} \alpha_{2i} \Delta Age_{t-i}^C + \sum_{j=1}^{m} \alpha_{3j} \Delta C_{t-j} + EC_{t-1}^1 + \mu_1 \quad (10)$$

$$\Delta C_t = \beta_1 + \sum_{i=1}^{n} \beta_{2i} \Delta C_{t-i} + \sum_{j=1}^{m} \beta_{3j} \Delta Age_{i-j}^C + EC_{t-1}^2 + \mu_2 \quad (11)$$

where Δ is a first difference operator, α_1, α_{2i}, α_{3i}, β_1, β_{2j} and β_{3j} (i=1,…,n and j=1,…,m) are the unknown coefficients, EC^1 and EC^2 are the lagged error-correction term estimated from the long-run cointegrating relationship, i.e. models (5) and (6) respectively, μ_1 and μ_2 are the model errors .

Thus, the hypotheses of the test are the following:

Equation (10), H_0: $\alpha_{3j} = 0$ for j=1,.., m is tested against H_1: $\alpha_{3j} \neq 0$ for at least one j.

Equation (11), H_0: $\beta_{3j} = 0$ for j= 1,..., n is tested against H_1: $\beta_{3j} \neq 0$ for at least one j.

3. Empirical illustration for the Saudi Arabian case

3.1. Saudi Arabian demographic profile: a descriptive analysis

The Saudi Arabian population is increased from 5.8 million in 1970 to 28.8 million in 2013. According to the Union Nation (2012), It is expected that the population size trend will remain increasing to reach approximately 40 million in 2050. In the relative sense, fig. 1 presents the evolution of population growth (annual %) between 1960 an 2013.

Fig. 1 shows that the growth rate of the population in Saudi Arabia was relatively fluctuant. It was about 2.97 percent in 1960, increased continually to reach 6.35 in 1982. Then, it was dropped to 1.63 per cent between 1995 and 2000. Then it increased to reach 4.07 per cent between 2000 and 2005 and decrease again to 1.99 per cent by 2013. In addition, according to United Nations `s World Population Prospects, it is expected that the Saudi Arabian population growth rate will keep on decreasing to reach 0.50 per cent between 2045 and 2050.

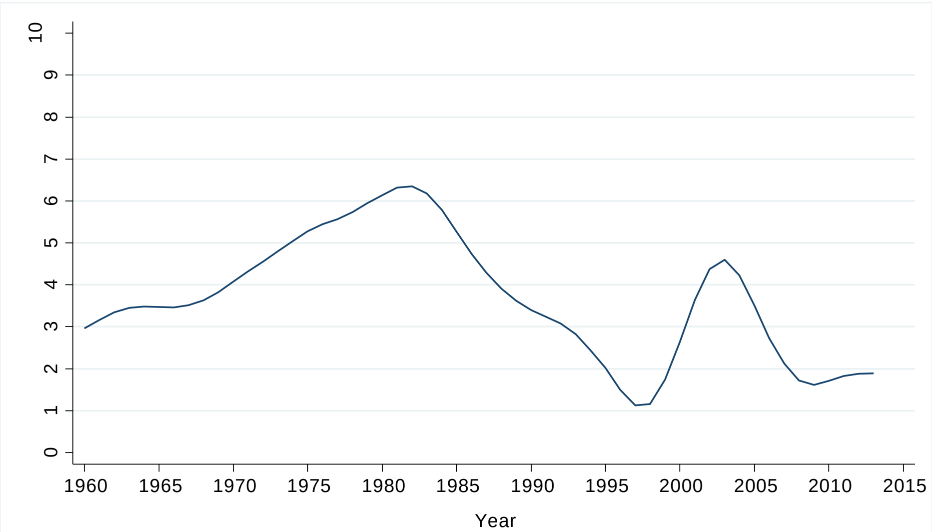

Figure 1. Saudi Arabia: population growth (annual %) from 1960 to 20113 (in years)

The fluctuant trend of the population growth may be affected by the evolution of demographic profile and structure. For that, Fig. 2 presents the evolution of the median age of the population in Saudi Arabia from 1950 to 2015. We deduce that the median age has had two different periods of evolutions. During the first period, from 1950 to 1975, the median age was slightly decreasing from 19 years to 18 years respectively. However, during the second period, started from 1980, the median age was continually and considerably increased to become 28.4 years (prediction) in 2015. This indicates that Saudi Arabia tend relatively to an ageing population.

On the other hand, the proportion of the population under 15 years of age in Saudi Arabia has been decreasing since 1980 and is projected to continue this downward trend till the year 2050. In parallel, the proportion of the working age group (15 - 64) has been increasing since 1980. Indeed, it increases from 52.6 per cent to reach about 68.08 per cent in 2013. It is expected to reach approximatively 74 per cent in 2035, then decrease to approximatively 66 per cent in 2050.

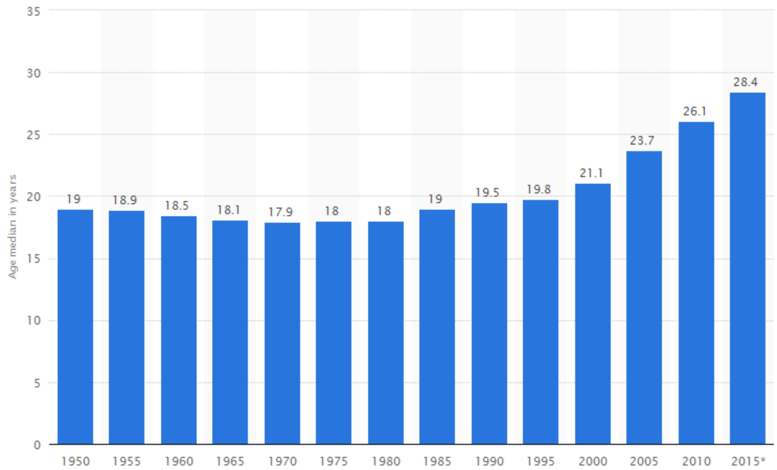

Figure 2. Saudi Arabia: Median age of the population from 1950 to 2015* (in years)
Note: * 2015 is a prediction. **Source:** Statista 2014, ESCWA.

The elderly (65+) population was in order of 3% of the population in 1980. It increased to reach 3.5 % in 2000 and then decreased to approximatively 3% in 2013. Prediction shows that it will start increasing afterwards to reach approximatively 19% in 2050. Fig.3 presents the trend of Saudi Arabian`s elderly population between 1950 and 2050 and confirms that the Saudi population is going to be elderly.

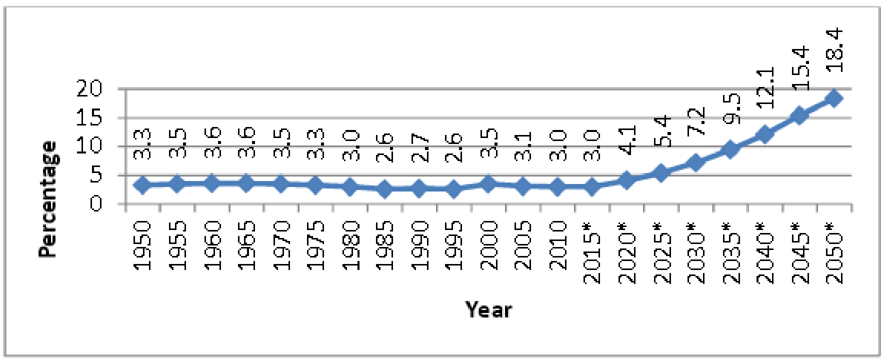

Figure 3. Saudi Arabia: proportion of elderly population between 1950 and 2050.
Source: United Nations, World Population Prospects: The 2012 Revision and ESCWA. * is a prediction.

3.2. Cointegration and Granger Engels causality analysis

Using data from the World Development Indicators (WDI) for Saudi Arabia between 1970 and 2013, which is a commonly used dataset for macro level data, three categories of age are defined according to the World Bank classification, as knowing, the population under 15 years of age (0-14 years), the working age group (15-64 years) and the elderly population (65+). We label these subpopulations as *Age1*, *Age2* and *Age3* respectively. On the other hand, the aggregated consumption indicator is considered as the household final consumption expenditure per capita (current LCU).

Fig. 4 presents a comparative illustration of the evolution over time of the household final consumption expenditure per capita (in thousands of Saudi Riyals (SAR)) against the defined categories of age.

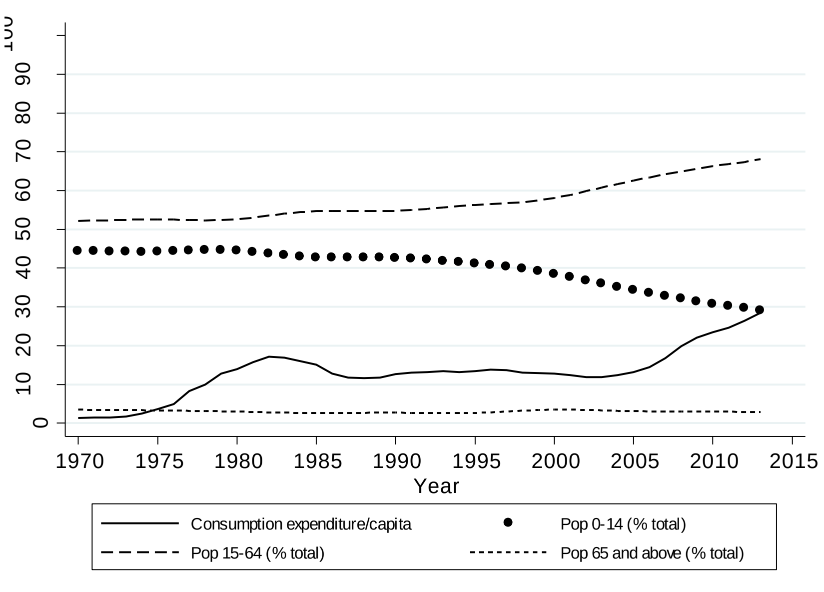

Figure 4. Saudi Arabia: household final consumption expenditure per capita (in thousands of Saudi Riyals (SR)) against subpopulations C1, C2 and C3 between 1970 and 2013.

We deduce that the evolution of consumption expenditure per capita seems to be relatively similar to the evolution of the population aged between 15 and 64 years. In addition, since 1990 the young population was decreased engendering an increase of the working age group (15-64 years) and evolutes in opposite direction compared to consumption expenditure per capita. The proportion of the elderly population (65+) seems to remain stable between 1970 and 2013. However, according to the prediction of the United Nations presented previously in Fig. 3, we expect that the trend of the elderly population will changes in the long term and will become increasing.

For analyzing the existence of an eventual causal relationships between the consumption expenditure per capita and the age distributions in the short and/or in the long run, we apply the methods decrypted in section 2, as knowing the cointegration and Granger Engels causality analysis.

Table 1 presents the results of the Augmented Dickey-Fuller Unit Root test applied on *Age* 1, *Age* 2, *Age* 3 and the household consumption expenditure per capita. In addition, we apply the test for each age group twice, i.e considering their size versus their proportion compared to the total population. Indeed, their effect may be significantly different. Results show that only the size of age1 group is stationary. All the other variables are non stationary series.

Table 1. *Augmented Dickey-Fuller Unit Root Tests*

Variables		Test statistics	1% Critical value	5% Critical value	10% Critical value	p-value
size	Age^1	-4.869	-3.628	-2.950	-2.608	0.0000
	Age^2	5.543	-3.628	-2.950	-2.608	1.0000
	Age^3	0.599	-3.628	-2.950	-2.608	0.9876
Proportion	Age^1	7.657	-3.628	-2.950	-2.608	1.0000
	Age^2	6.933	-3.628	-2.950	-2.608	1.0000
	Age^3	-1.542	-3.628	-2.950	-2.608	0.5124
HH Consumption expenditure per capita (C)		0.501	-3.628	-2.950	-2.608	0.9849

Therefore, the Johansen test for cointegration is applied between each age group with the household final consumption expenditure per capita. Results confirm that cointegration exist between all of them indicating the existence of a long run relationship.

Thus, for testing the direction of eventual long and/or short run association between the household final consumption expenditure and the age distribution, we report in Table 2 the estimation results of the Vector Error Correction Model (VECM) based on the model (10). Note that we only consider the direction of causality from age category to household final consumption expenditure and we negligee the opposite direction of causality (model (11)) which doesn't have important economic meaning.

We deduce that the causality effect of the age distribution on household final consumption expenditure differs significantly according to considering the size or the proportion of the subpopulation.

Note that the long run causality may be deduced according to the significance of the lagged error-correction terms *EC* in the VECM. Thus, we deduce that the size of younger population (0-14 years) doesn't have statistically long run significant association with the household final consumption expenditure. However, this effect becomes significant if we consider the proportion of the younger population instead of its size. We deduce that the relative weight of the young population (0-14 years) will have important effect in the long run on the household final consumption expenditure. For that, policy maker in Saudi Arabia have to give particular importance to the control of the proportion of this age category instead of its size.

Table 2. *Vector Error Correction Model estimation of Eq. 10 for each age categories*.

Age category		Explicative Variables	Coefficient	z	P>|z|
Age 1	Size	*EC*	0.0005942	0.06	0.956
		ΔC_{-1}	0.7363724	6.10	0.000
		ΔAge_{-1}	-1.12e-08	-0.66	0.507
		Constant	0.3499228	1.43	0.152
	Proportion	*EC*	-0.0746295	-3.94	0.000
		ΔC_{-1}	0.6567933	6.90	0.000
		ΔAge_{-1}	1.500183	3.02	0.03
		Constant	.0012888	0.01	0.994
Age 2	Size	*EC*	-0.0813686	-2.62	0.009

		ΔC_{-1}	0.7885722	7.89	0.000
		ΔAge_{-1}	-9.05e-10	-0.14	0.892
		Constant	3.928819	2.61	0.009
	Proportion	*EC*	-0.0839044	-3.56	0.000
		ΔC_{-1}	0.7173383	7.56	0.000
		ΔAge_{-1}	-0.9828395	-2.24	0.025
		Constant	0.0009282	0.01	0.996
Age 3	Size	*EC*	-0.0608272	-2.52	0.012
		ΔC_{-1}	0.7261081	6.82	0.000
		ΔAge_{-1}	-1.77e-07	-1.61	0.108
		Constant	0.7913734	2.89	0.004
	Proportion	*EC*	0.0078598	1.19	0.233
		ΔC_{-1}	0.7036198	6.09	0.000
		ΔAge_{-1}	-1.263843	-0.77	0.440
		Constant	0.0039446	0.02	0.985

The age group (15-64 years) seams to affect significantly in the long run the household final consumption expenditure wherever the method of its calculation is, i.e. size or proportion. However and contrarily to the younger population, only the size of elderly population (65+) causes significantly long run effect on final consumption expenditure. Indeed, the P -value of the *EC* term for the proportion of *Age 3* exceeds 5%.

On the other hand, the short run association is deduced according to the significance of the coefficient related to the differenced lagged ΔAge_{-1}. Thus, we deduce that the proportion of the younger population has statistically significant short run causality association with the final consumption expenditure (in addition to its long run effect). However, considering the size of this subpopulation, we don't find any significant effect.

Also, for the second age group (15-64 years), we find that only the proportion which generates short run causality effect on Household final consumption expenditure.

The elderly population (65+) appears without any significant short run causality effect on the final consumption expenditure in Saudi Arabia wherever the method of its calculation is, i.e. size or proportion.

4. Conclusion

This paper aimed to analyze the short and the long run causal relationships between the age distribution and the household final consumption expenditure at the aggregate level. For that, specific statistical and econometric methods non used in the literature are applied in this paper, such as Unit root test, Co-integration and Granger Engels causality through Vector Error Correction Model. This study is important for any country since it is useful to predict the consumer behavior and the over time needed consumer product for the different age categories.

Empirical validation for the Saudi Arabian case between 1970 and 2013 is given. First, a descriptive statistical analysis of the evolution of the demographic profile and structure is made. The main results showed that the growth rate of the population was significantly fluctuant and that Saudi Arabia tend relatively to an ageing population. In addition, the demographic changes are important and may have significant effect on the economic and social well being in the future.

Second, unit root test, Cointegration and Granger Engels causality through Vector Error Correction Model (VECM) are applied to test the short and the long run eventual causality relationship between the Saudi Arabian age distribution and the household final consumption expenditure.

Results showed that the causality effect of different age categories on household final consumption expenditure differs significantly according to considering the size versus the proportion of each age category. Discussion results are made for each age categories giving specific conclusions for the eventual overtime causality effect on Saudi Arabian household final consumption.

Finally, according to the importance of such study for any country and the proposed procedure and methods, we hope that its implementation may help policy maker to develop efficient strategies for the short and the long run according to the evolution of the country's demographic profile and structure.

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