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IMPACT OF DEMOGRAPHIC INDICATORS ON HOUSEHOLD CONSUMPTION IN ALGERIA USING PCA

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ABSTRACT

This study examines the influence of demographic indicators on household consumption in Algeria from 1985 to 2022, utilizing Principal Component Analysis (PCA) as the primary methodological tool. Using annual data on population structure, life expectancy, urban and rural distribution, and household disposable income, the analysis identifies the demographic variables most strongly associated with consumption dynamics. The results reveal a robust positive relationship between household consumption and factors such as disposable income, total population, life expectancy, and age-specific cohorts (0–14, 15–64, and 65+), while the rural population exhibits a negative association. The PCA highlights four distinct phases in Algeria's demographic-consumption trajectory, reflecting shifts in rural development, economic recovery, improvements in health and income, and recent increases in household consumption linked to demographic transitions at both ends of the age spectrum. These findings underscore the importance of integrating demographic considerations into economic policy design. By recognizing the interplay between demographic change and consumption behavior, policymakers can better anticipate demand patterns, strengthen social infrastructure, and promote sustainable growth. The study also points to methodological and contextual limitations, suggesting future research directions such as nonlinear modeling, cross-country comparisons, and micro-level household analyses to deepen the understanding of demographic influences on consumption.

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1 INTRODUCTION

Since its inception, the Algerian economy has undergone economic, social, and demographic transformations that have influenced the concepts and strategies of household consumption. Household consumption is considered one of the most important macroeconomic variables and a key driver of economic growth, as it constitutes the largest share of GDP. It is affected by several demographic factors, such as population size and structure, as well as other variables, including consumption expectations and credit conditions. Therefore, it is essential to analyze these factors using econometric tools to understand consumption behavior, forecast its trends, and design more effective economic policies. Household consumption reflects the state of the economy, with higher levels indicating stronger consumer confidence and lower levels pointing to economic uncertainty. However, in developing economies such as Algeria, this indicator does not always reflect the true economic state due to various considerations, including the structure of output and weak economic growth rates.

Demographic indicators are among the most influential factors shaping household consumption patterns. Studying demographic transitions alongside consumption patterns and their forecasts is therefore vital. During the 1980s and 1990s, Algeria experienced sustained population growth accompanied by a gradual rise in consumption levels, which boosted domestic demand and supported economic activity. However, the acceleration of demographic transition and declining fertility rates since the 1990s generated new household consumption dynamics. A decline in births led to higher per capita income, which in turn increased demand for goods and services, raising aggregate consumption and positively impacting employment and growth rates.

Since the early 2000s, with improved security and political stability, Algeria has launched a series of development programs that helped restore demographic balance and stimulate the economy. The population grew from about 36 million in 2010 to over 45 million in 2021, alongside a rise in household consumption to nearly 9.8 trillion Algerian dinars in 2021. These dynamics highlight the uniqueness of the Algerian case, where household consumption serves as a key channel for stimulating domestic economic growth, making it necessary to conduct an in-depth analysis of the reciprocal relationship between demographic transformations and household consumption, as well as to identify mechanisms for directing it toward supporting sustainable development.

2 LITERATURE REVIEW

Demographic transitions remain crucial to understanding household consumption dynamics. In developing countries, increases in disposable income have improved consumption environments, particularly in rural areas Guo and Feng (2024). In China, demographic variables such as age structure and dependency ratios have been shown to influence household consumption and energy use Wang et al (2022). These studies highlight that smaller and aging households tend to consume differently, often prioritizing health-related and service expenditures.

Evidence from advanced economies mirrors these patterns. In the United States, household composition was found to significantly affect food expenditures Benus et al (1976), while lifestyle indicators were equally important as income in shaping household-level emissions Baiocchi et al (2022). In Canada, Ricciuto et al. (2006) demonstrated that family size, income, and education significantly determine food purchases.

2.1 Demographic indicators

Methodological advancements have allowed deeper insights into demographic influences on consumption. For example, Ali et al. (2022) proposed a validated model in Australia linking demographic factors such as household size and occupancy rates to energy use. Similarly, Hristov et al. (2022) applied a survey-based analysis across 13 European countries during COVID-19, highlighting the explanatory power of socio-demographic variables on shifts in food purchasing behavior.

In South Asia, Aslam et al (2018) identified education, employment status, and household size as significant predictors of household energy expenditures in Pakistan. Likewise, Mohanty et al. (2016) emphasized the role of age structure in driving health-related consumption in India, where

the elderly population increased healthcare spending disproportionately. Studies from Latin America also underlined the importance of household size, location, and appliance ownership in explaining more than half of household energy expenditures Jimenez Mori and Yépez-García (2017).

Closer to the Algerian context, research demonstrates the salience of demographic determinants. Adel et al. (2016) found that household size, income, and occupation significantly affect food consumption frequencies in Algeria. Akli et al. (2024) further revealed that demographic factors such as age, income level, and household structure influence preferences for agro-ecological foods. At the macroeconomic level, Traich and Amal (2023) showed that energy subsidies had a greater impact on household consumption in Algeria than demographic growth alone.

Comparable studies from the MENA region reinforce these findings. Souissi et al. (2022) identified household size and socio-economic status as critical determinants of water consumption footprints. Nyatefe and Okey (2020), using Togo's survey data, found that education and urban residence affect cultural spending positively, while large household size exerted a negative impact. In Ethiopia, Kalwij et al. (1998) reported that household size and spousal employment significantly alter household expenditure patterns.

Overall, the reviewed literature highlights the multidimensional nature of demographic determinants on household consumption. Household size, age composition, education, and income consistently emerge as key factors, though their effects vary across contexts. In North Africa, including Algeria, demographic shifts interact with structural policy factors such as subsidies and food security measures, shaping consumption behaviors in unique ways. Thus, a regionally grounded, methodologically rigorous analysis remains crucial for understanding Algeria's household consumption dynamics.

2.2 The Research Gap

Based on the discussion presented in this section, it is evident that the topic of household consumption has received considerable attention in economic literature, where it has been addressed through various methodological approaches. Our contribution in this study lies in the attempt to identify the demographic indicators that determine household consumption by employing the Principal Component Analysis (PCA) method. This is particularly relevant given that most previous studies on household consumption have been theoretical and analytical in nature, relying primarily on conventional econometric techniques.

3 DATA AND METHODOLOGY

We identify and highlight the most relevant demographic indicators related to household consumption using Principal Component Analysis (PCA) in R Studio. We present the demographic variables in a table consisting of five demographic indicators, along with one economic variable, household disposable income, which is considered a key determinant of household consumption.

***Table 1**. Data source*

Variables	Measurement	Descriptions	Sources
Total Population	In millions	Pop	https://www.ons.dz
Life Expectancy	In years Agrarian investment lands	Life expectancy (LE)	https://fr.statista.com
Population Aged 65 and over	In thousands	pop[65+]	https://data.worldbank.org
Population Aged 15–64	In millions	pop[15,65]	
Population Aged 0–14	In millions	pop[0,14]	
Urban Population	In millions	pop_urb	
Rural Population	In millions	pop_rur	
Household Disposable Income	In millions	Yd_M	https://www.ons.dz

Source: Author's calculations

Table 1 presents the demographic indicators under study. We aim to examine the impact of these variables on household consumption (denoted as Cons_M), based on data covering 38 observations representing the years from 1985 to 2022.

4 EMPIRICAL ANALYSIS

Means and standard deviations are fundamental tools for analyzing and understanding demographic indicators. Table 2 presents the means and standard deviations for the demographic indicators.

Table 2. Averages and Standard Deviations for Demographic Indicators

Variables	Means	Standard Deviation	Minimum value	Maximum value
Cons_M	33304	14897	13477	58947
Pop	32.57	6.65	21.86	45.38
pop [65+]	1468512	590973	667925	2731082
pop [15,65]	20290276	5206712	11508322	27878915
pop [0,14]	10853241	1059210	9572368	13567972
pop_urb	20678427	6501668	10616712	32807002
pop_rur	11933601	393318	11370967	12531184
Yd_M	44615	23420	15553	80455
Life expectancy (LE)	72.58	4.47	63.59	77.80

Note: Number of Observation=38

Source: Author's calculations using R Studio

Table 2 presents a detailed statistical summary of the variables included in the study. The variables pop (total population) and Life expectancy (LE) appear to play a significant role in the demographic concentration of the population, as indicated by their relatively low standard deviations (6.65 and 4.47, respectively), which suggest a high degree of stability and consistency in the data. Conversely, the variable p.rub (urban population) contributes to greater dispersion within the studied population due to its higher standard deviation. Given the heterogeneity in the means and standard deviations across the variables, we employ normalized Principal Component Analysis (PCA Normé). This method involves standardizing each variable by subtracting its mean and dividing by its standard deviation, allowing for the generation of homogeneous, dimensionless values suitable for multivariate analysis.

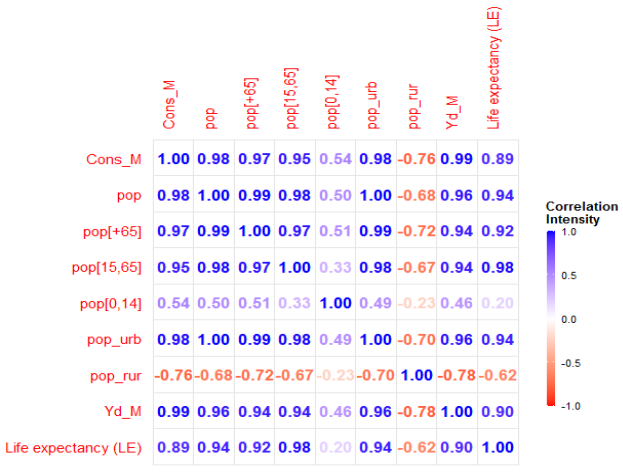
5 RESULTS

The results section first presents the presentation of the correlation matrix. The second section applies Bartlett's Sphericity Test to verify whether the matrix represents an identity matrix. Subsequently, the eigenvalues and the proportions of variance explained by the axes associated with the demographic variables are presented. The final section focuses on examining the axes and analyzing the correlations between the demographic variables and these axes.

5.1 Correlation Matrix

After calculating the mean and standard deviation for each variable, we proceed to compute the correlation matrix, as illustrated in Table 3.

Table 3. Correlation Matrix for Demographic Variables



Source: Author's calculations using R Studio.

The presented matrix illustrates the degree of correlation between the variables. In the first column, we observe the correlations of the household consumption variable (Cons_M) with the other variables. This variable shows a strong positive correlation of 98% with the total population, which clearly reflects a significant relationship between these two variables. In addition, Cons_M also exhibits strong positive correlations with urban population, population aged 65 and over, population aged 15–64, life expectancy, and population aged 0–14, respectively. The economic variable household disposable income shows an even stronger positive correlation of 99%, indicating its crucial role in determining household consumption. Conversely, a negative correlation is observed with rural population, suggesting an inverse relationship between rural residency and household consumption.

5.2 KMO and Bartlett's Sphericity Test

Table 4 presents the results of KMO. This test assesses the suitability of data for factor analysis or Principal Component Analysis (PCA). And Bartlett's Test of Sphericity, which is used to verify whether the correlation matrix is an identity matrix. Bartlett's Test of Sphericity allows us to test the null hypothesis that the correlation matrix is an identity matrix. If the p-value is less than 0.05, the null hypothesis is rejected, indicating that the correlation matrix is not an identity matrix.

***Table 4**. KMO and Bartlett's Sphericity Test*

Test	Value
Kaiser-Meyer-Olkin (KMO)	0.627
Bartlett's Sphericity	
Khi² (Critical value)	41.34
Khi² (Observed value)	1850.187
DDL	28
p-value (bilateral)	< 0.0001
Alpha	0.05

Source: Author's calculations using R Studio.

According to the test results, the null hypothesis is rejected since the calculated Chi-square value (1850) is greater than the critical value (41.34), and the p-value (0.0001) is significantly lower than the conventional significance threshold (0.05). Therefore, the correlation matrix is not an identity matrix. The Kaiser-Meyer-Olkin (KMO) value of 0.627 (Table 4) indicates a minimally acceptable level of data adequacy,suggesting that the correlations among the variables are statistically significant and strong enough to justify the use of standardized Principal Component Analysis (PCA Normé).

5.3 Calculating Eigenvalues

After computing the correlation matrix, the next step is to calculate the eigenvalues, which are derived from it.

***Table 5**. Eigenvalues and the Proportion of Variance Explained by the axes for the Demographic Variables*

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5	Dim.6	Dim.7	Dim.8	Dim.9
Eigenvalues	7.519	0.908	0.493	0.064	0.013	0.002	0.001	0.000	0.000
Percentage (Variance Explained %)	83.544	10.087	5.481	0.716	0.139	0.024	0.008	0.001	0.000
Cumulative %	83.544	93.631	99.112	99.828	99.968	99.991	99.999	100.0	100.00

Source: Author's calculations using R Studio

5.4 Axes Test

We may retain only those eigenvalues whose contribution to the total variance exceeds the average. In general, in Principal Component Analysis (PCA), we focus on the axes (components) that carry more information than 1/9, which in our case equals approximately 0.11 or 11.11%. Based on Table 5, we select the first principal component, and the second component may also be added as a supplementary axis to achieve greater precision. Together, these two components account for 93.63% of the total

information contained in the dataset. Therefore, we conclude that these two components provide the best representation in the first factorial plane. As a result, it is sufficient to represent the variables on a two-dimensional, orthogonal, and standardized coordinate system defined by axes F1 and F2.

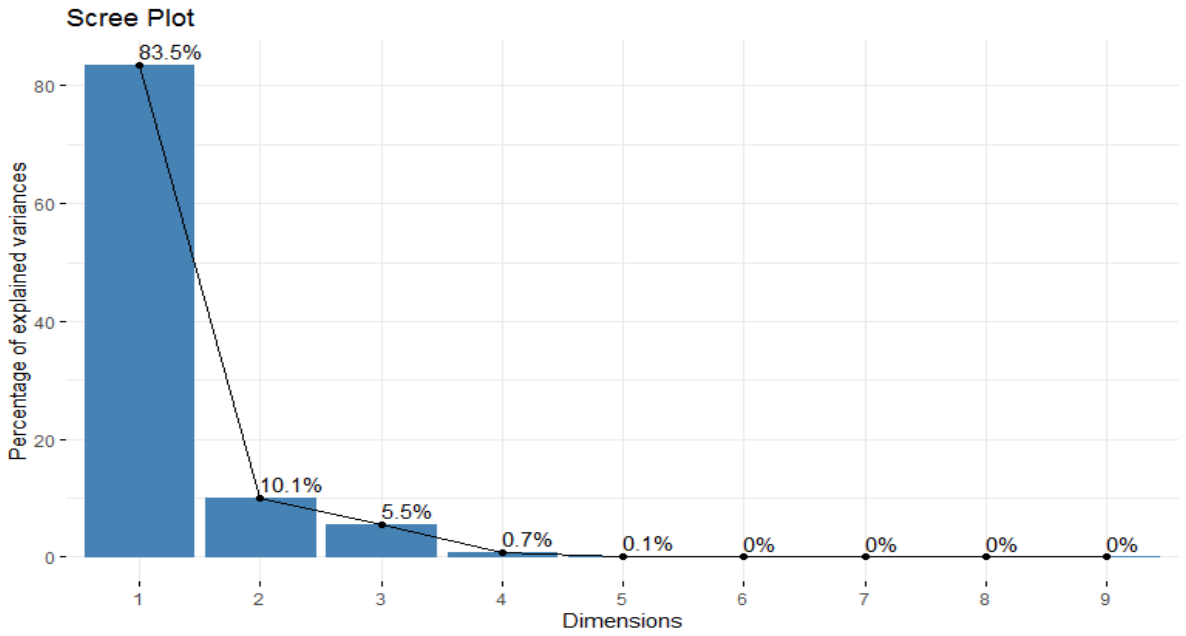


Figure1 *Graphical Representation of Eigenvalues*

Source: Author's calculations using R Studio.

5.5 Correlations Between Demographic Variables and Components

Table 6 and Figure 2 display the coordinates of the variables on the two principal components, F1 and F2.

Table 6. Coordinates of Demographic Variables

Variables	F1	F2
Cons_M	0.991	0.067
Pop	0.992	0.032
pop [+65]	0.989	0.031
pop [15-65]	0.975	-0.150
pop [0-14]	0.483	0.874
pop_urb	0.999	0.014
Pop rur	-0.757	0.188
Yd_M	0.981	-0.015
Life expectancy (LE)	0.929	-0.282

Source: Author's calculations using R Studio.

By using the variable coordinates presented in the table above on the factorial plane (F1; F2), we obtain the graphical representation known as the correlation circle. This circle allows us to interpret the various correlations that exist among the variables.

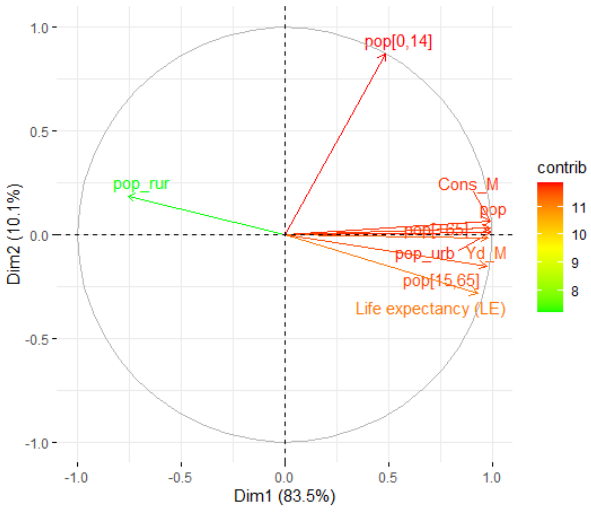


Figure 2 *Graphical Representation of Demographic Variables*

Source: Author's calculations using R Studio.

The endpoints of the vectors representing all the variables appear to lie very close to the circumference of the correlation circle. This indicates that the quality of representation for the

variables is satisfactory, meaning that the graphical output can be reliably used to interpret and analyze the relationships among the variables over the study period. This conclusion is supported both visually and by the high percentage of explained inertia, which reaches 93.63%. In other words, this value confirms that the first factorial representation provides a robust and meaningful analysis of the interrelationships between the variables, enhancing the validity of the conclusions drawn from this graphical representation. The first principal component (F1) explains 83.54% of the total variance. It is strongly and positively associated with the variables: household consumption, total population, life expectancy, population aged 65 and over, population aged 15–64, urban population, and the economic variable household disposable income, all plotted with positive coordinates. To a lesser extent, the variable population aged 0–14 also shows a positive association. In contrast, the variable rural population is strongly and negatively correlated with this axis the explanation of 83.54% of the variance indicates that there are strong linear relationships among the variables, meaning that most of them move in the same direction and follow a similar pattern. This phenomenon is known in statistical analysis as multicollinearity

Thus, the first axis effectively represents most of the variables, serving as the dominant dimension. This is clearly reflected in the variable factor map, where most variables cluster to the far right of the F1 axis, indicating a high level of contribution and similarity in their influence. Only one variable, rural population, shows a negative influence on this axis. The second principal component (F2) explains 10.09% of the total variance, which is notably less than the first component. The variable population aged 0–14 is strongly and positively associated with this axis. In contrast, variables such as total population, population aged 65 and over, urban population, and rural population show weak positive correlations with F2. Meanwhile, life expectancy, population aged 15–64, and household disposable income exhibit weak negative correlations with this component. As such, F2 can be considered a supplementary axis, offering a more nuanced classification of the variables. From the biplot (F1, F2), we can draw the following conclusion: There are two distinct groups of variables. The first group includes: household consumption, total population, life expectancy, population aged 65 and over, population aged 15–64, urban population, population aged 0–14, and household disposable income. These variables are strongly and positively correlated with each other and are well represented on the factorial plane, reflecting similarity in their characteristics and mutual influence. The second group consists solely of the variable rural population, which is negatively represented due to its negative coordinates, highlighting its opposing relationship to the first group..

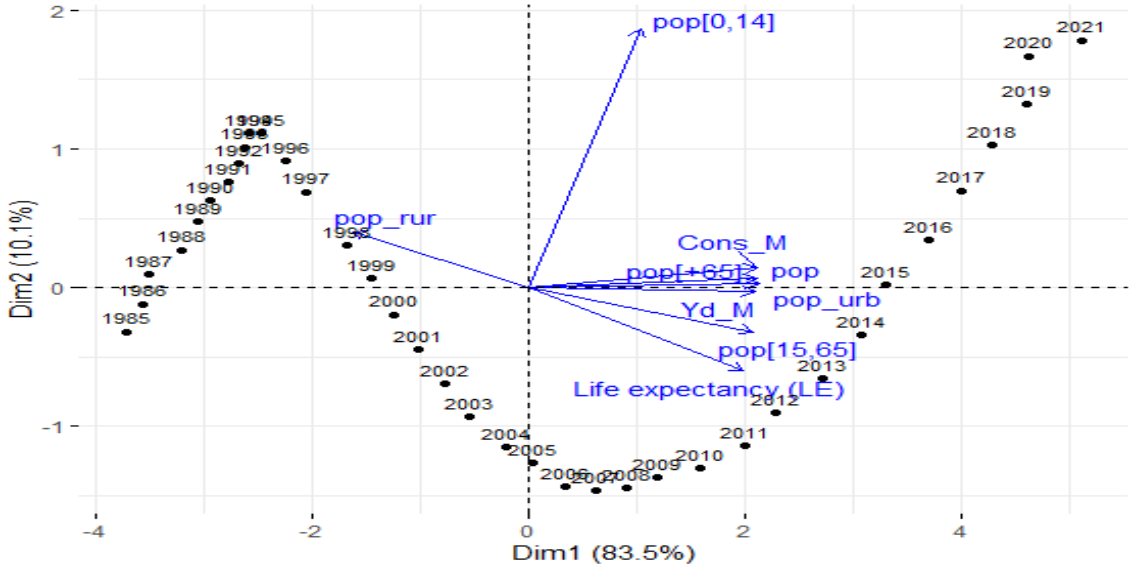


Figure 3 *Graphical Representation of Individuals and Demographic Variables*
Source: Author's calculations using R Studio

5.6 Demographic Visualization and Analysis

Based on the data and using R Studio, we obtained the following results.

The graph in Figure 3 illustrates the relationship between demographic variables and the years under study. From this representation, we can distinguish four groups reflecting the distribution of these variables:

- Group One (Rural Population), covering the period from 1985 to 1999.
- Group Two, covering the period from 2000 to 2004.
- Group Three (Life Expectancy, Population Aged 15–64, and Disposable Household Income), covering the period 2005–2014.

Group Four (Household Consumption, Population Aged 65 and Above, Population Aged 0–14), covering the period 2015–2021.

6 DISCUSSION

6.1 Group One: Rural (1985–1999)

During this period, many countries, including several in North Africa, focused on agriculture as a key sector of their economies. Algeria emphasized rural development and agricultural policies, which led to a higher proportion of the population living in rural areas. This phase was marked by the enactment of the Agricultural Investment Law in 1987, introduced as part of the reorganization of the agricultural sector following the abolition of agrarian socialism. This measure represented a significant milestone for Algerian agriculture: it defined the rights and obligations of producers and established conditions for land use. The new organizational framework promoted agricultural investments in the following forms:

- Model Farms: These include 188 agricultural farms specialized in plant production and farmer training.
- Collective Agricultural Holdings: These include 28,909 holdings, each consisting of 3 to 6 farmers and covering an area of about 80 hectares of land.
- Individual Agricultural Holdings: These include 16,436 individual farming units.

The 1987 reforms laid the groundwork for the transition to a market economy. The government reduced its intervention in the marketing of fruits and vegetables, enabled farmers to obtain loans from the Agricultural and Rural Development Bank, and allowed young people and graduates of agricultural schools to benefit from land designated for agricultural investment. These measures contributed to improving rural incomes and reducing rural-to-urban migrationThis period represented the beginning of a strategic shift in the structure of the Algerian economy, as the centralized approach was replaced by a move toward empowering local producers and promoting private investment in agriculture. Table 7 shows land use by sector during the period 1987–1990.

Table 7. Land Use by Legal Sector during the Period 1987–1990 Unit: (million/hectare)

	1987	1988	1989	1990
Arable agricultural land area	7.62	7.63	7.67	7.66
Agricultural land used for cultivation	3.970	3.976	3.972	3.959

Source: Ministry of Agriculture: S/D land organization: Report on operations related to agricultural land. (June 1994)

Table 8. Evolution of Production for the Periods (1985–1989, 1990, 1991) in millions

Sectors	1985–1989	1990	1991 Provisional
Agriculture	- - +8.9	-17	+35
Hydrocarbon	- - +3.6	+6.3	+1.6
Non-hydrocarbon Industry	- +0.4	+1.1	-2.9
Construction and Public Works	- -0.7	- 1	- 7
Services	- - -0.6	-3.7	+2.6
Gross Domestic Product (GDP)	+1	-2.5	+3.3

Source: Ministry of Agriculture: S/D Land Organization: Report on Operations Related to Agricultural Land (June 1994)

In addition to the points, industrial activity experienced a decline due to the scarcity of foreign currency resources. This led to an increase in the rural population, as job opportunities were limited in urban areas. Referring to Table 8, which shows the evolution of production for the periods 1985–1989, 1990, and 1991, fluctuations in industrial production performance can be observed These fluctuations reveal the fragility of the rent based economic structure, highlighting the need to diversify the economy and develop agro-industrial manufacturing during that period.

Another reason that contributed to migration to rural areas was the political instability (the “Black Decade”) that Algeria experienced in 1991, which lasted until 1999. This period led to harsher economic and social conditions and had a direct impact on industry and economic development. The effects of these disturbances intensified in the cities, forcing millions of families to leave urban areas for the countryside in search of safety and stability this demographic shift contributed to the redistribution of the workforce toward the agricultural sector however, it simultaneously weakened the productive structure in urban areas.

6.2 Group Two (2000–2004)

This group covers the period from 2000 to 2004, which is the contrasts with the fourth group, which includes indicators such as the number of people aged 0–14, the number of people aged 65 and above, and household consumption. This group experienced the lowest growth compared to 2015–2021, during which household consumption increased at a faster pace than population growth. This reflects both real and overall improvements in purchasing power. This stage corresponds to Algeria’s recovery period, during which the government launched a series of economic programs and reconstruction initiatives. The relative increase in household consumption compared to later periods can be seen as a phase in which the economy remained constrained, mainly due to its heavy dependence on hydrocarbons, limited diversification, and weak job creation outside the hydrocarbon sector Encouraging the development of the private sector and investment, expanding financing opportunities for small and medium-sized enterprises (economic diversification), and adopting inclusive employment policies are essential to ensure the sustainability of consumption growth in the long term.

6.3 Group Three: Life Expectancy, Working-Age Population, and Income (2005–2014)

This stage was characterized by a strong representation of life expectancy, the population aged 15–64, and disposable household income indicators. Algeria experienced positive economic growth during this period due to factors such as rising oil prices, and government policies played a crucial role in shaping the economic and social landscape.

Algeria implemented a series of development plans to meet citizens’ needs in employment, healthcare, housing, education, and social protection, which had a positive impact on disposable household income, as well as on birth and death rates, contributing to an increase in life expectancy and population growth. During these five years, the health sector benefited from 244 billion DZD in public investment, directed towards the construction of around 800 facilities, including (National Economic and Social Council, 2008, p. 77):

- 20 hospitals with 200 beds each
- 70 hospitals with fewer than 200 beds
- 260 specialized hospitals and centers
- 133 multi-service clinics

Since 2013, life expectancy has reached 77years, and in 2021, it stood at 77.7 years, reflecting stability in this regard ONS (Based on the household survey and not published online) (2019). In parallel, household consumption volume increased, which indicates a further improvement in the standard of living.

This can be interpreted as both the population aged 15–64 and household consumption being equally influenced by household income. According to Modigliani’s Life-Cycle Hypothesis of Consumption, individuals follow their lifetime income when making consumption decisions. Families make lifetime consumption decisions based on their income expectations and population size, which are particularly sensitive to income changes in developing countries. An increase in household income leads to lower

mortality rates, encourages childbirth, and consequently increases both population size and household consumption. Furthermore, political stability, a key driver of economic development, characterized Algeria during this period, attracting foreign investment, boosting economic activities, and contributing to an overall improvement in living standards.

6.4 Group Four: Household Consumption, Population Aged 0–14 and 65+ (2015–2021)

Economic progress and the expansion of infrastructure, including healthcare, social services, and education, compared to previous years, had a profound impact on household consumption and population growth. This, in turn, improved living standards, increased age-specific fertility rates ONS (2019), and reduced mortality rates. (These figures are considered close to reality, as they are based on the 2019 household survey and are not published online, however some differences exist when compared with World Bank data.) Consequently, the population increased in both the 0–14 age group and the 65+ age group.

These increases reflect the government's role in revitalizing economic activity by supporting both consumer and investment demand. This period was marked by two promising five-year programs aimed at giving a strong boost to the Algerian economy during that time This period can be considered a pivotal stage in Algeria's development trajectory, as it represented a gradual transition toward a more stable economy driven by domestic demand. However, it remained vulnerable to external shocks due to the continued dependence on the hydrocarbon sector.To ensure the sustainability of household consumption growth, it is essential to strengthen economic diversification by supporting non-oil productive sectors, particularly agriculture, manufacturing, and domestically oriented services.

7 CONCLUSIONS

This study identified key demographic indicators influencing household consumption in Algeria using PCA. Results show that household income, population size, and life expectancy are positively associated with consumption, while rural population exerts a negative effect. Four distinct phases of demographic-consumption dynamics were observed between 1985 and 2022. These findings highlight the importance of integrating demographic factors into economic policy design. Future strategies should focus on leveraging demographic transitions to support sustainable consumption growth, while addressing rural–urban disparities and enhancing social infrastructure.

8 STUDY LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study constitutes a contribution to the ongoing efforts aimed at deepening the understanding of household consumption dynamics. Nevertheless, certain methodological and practical limitations should be acknowledged, which may serve as avenues for future research. In this regard, several directions are suggested:

- While PCA methodology is useful in capturing linear relationships, dimensionality reduction, and correlations among variables, it does not account for nonlinear dynamics. Future studies could therefore employ more advanced nonlinear models to explore the complex relationships between variables.
- Broadening the scope of analysis by conducting comparative studies between Algeria and a sample of North African countries or other emerging economies that share similar demographic and household consumption patterns.
- Developing household consumption functions within the Algerian economy by incorporating qualitative variables in addition to quantitative ones.
- Extending the analysis to the microeconomic level by modeling household consumption at the household or individual unit level.
  - Enriching the analysis by integrating additional indicators such as consumer expectations, credit market conditions, and living standards to provide a more comprehensive and multidimensional assessment.

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