An Empirical Study of the Impact of Consumption on Economic Growth under Negative Population Growth --Based on Panel Data of Countries with Negative Population Growth

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Abstract: This paper uses the United Nations World Population Prospects 2022 data to screen out countries with endogenous negative population growth, i.e., aging population and fewer children, and then selects Italy, Japan, and Hungary as typical countries with negative population growth for analysis, combined with the availability of household consumption propensity data. Based on gray correlation analysis, this paper analyzes the relationship between consumption structure and economic growth in typical countries with negative population growth after entering the negative population growth time domain. The analysis results show that food consumption and health care have a greater pull on economic growth, and the correlation between housing consumption and economic growth, although weaker than the first two, still cannot be ignored. Combined with international experience, it can shed light on China, which is about to enter into negative population growth.

1 Introduction

Negative population growth refers to the decrease in total population within a certain time and space. Negative population growth is mainly divided into exogenous negative population growth and endogenous negative population growth. In recent years, people discuss the phenomenon of negative population growth mainly referring to the endogenous negative population growth phenomenon which is not caused by exogenous events such as war and famine. Since the turn of the millennium, some developed countries in the world have entered into a negative population growth norm due to population aging and childlessness, which has caused widespread concern among all sectors of society. The reason is that this negative population growth is different from the exogenous negative population growth which is sudden and cumulative. After entering this state, it cannot be reversed and turned positive in a relatively short period of time, as in the case of Japan - since entering a negative population growth state in 2009, the whole economy has fallen into an unbalanced mechanism of lasting decline.

The switch from positive to negative population growth in a country simply means that the demographic dividend will gradually disappear. At the same time, the age structure of the country will change, and the impact on the macroeconomic growth of the whole country cannot be ignored. Unlike the factors such as technology and labor supply, which have already been discussed in the previous paper, the impact on macroeconomic growth is under negative population growth. This paper examines what kind of consumption can be promoted to revitalize the economy from the negative impact of population decline on economic growth in an era of negative population growth from the perspective of consumption structure. Analyzing countries that have already experienced negative population growth, it provides some insights and important practical implications for future policy making in China after entering negative population growth.

2 Literature Review

Negative population growth is gradually turning into a globalized phenomenon, and median projections from the United Nations suggest that the world population is still increasing but at the lowest rate ever since 1950 due to declining fertility. Delventhal, Fernandez Villaverde [1], and Guner (2019), by compiling a dataset of birth and mortality rates for 186 countries spanning more than 250 years, suggest that every country in the world has undergone or is undergoing a transition from a high-fertility/high-mortality regime to a low-fertility/low-mortality regime. jones and Tertilt [2] (2008) use census data to detail the decline in fertility in the United States. These studies have shown that the phenomenon of negative population growth has become a problem that cannot be ignored, and the question of how to develop various economic indicators in the face of negative population growth has prompted scholars to think about it.

During the Great Depression in the United States, Keynes already put forward the "economic stagnation theory", pointing out that a long-term population decline would lead to a contraction in aggregate savings and a reduction in capital accumulation, eventually leading to

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economic stagnation. From the perspective of technological progress, Jones (1995) [3] (1995), a semi-endogenous R&D growth model, investigates the rate of technological progress, the growth rate of total output, and the growth rate of output per capita when the population growth is negative. On the other hand, Christiaans (2011) [4] by a simple growth model, there is a non-monotonic relationship between population growth rate and long-run per capita income growth rate. The importance of negative population growth is illustrated. In recent years, Sasaki[5] and Hoshida (2016) applied a semi-endogenous growth model and concluded that the growth rate of output per capita remains positive when the long-term population growth is negative. Also in (2019)[6] The model that considers nonrenewable resources makes the zero depreciation rate more natural and obtains that the long-run growth rate is determined only by the rate of technological progress and is not affected by the rise in the capital-labor ratio due to negative population growth. However, some scholars also have a different view on the face of non-renewable resources, and Jones (2020) [7] writes that omitting capital and non-renewable resources from the model does not have much impact on economic growth.

Liu, Wei, and Fan, Xin [8] (2019) proposed an endogenous growth model in the long run that states the theoretical assumption that "population growth creates a scale effect that drives technological progress". That is, negative population growth will slow down technological progress and make income decline. Some scholars have also discussed the issue from a capital perspective, with Shuiying Zhong and Shiqi Wang suggesting that societies may face long-term stagnation when the effect of increasing dependency burden due to negative population growth exceeds the effect of human capital accumulation. [9] and Lucas [10] The human capital externality is also used to explain the long-run economic growth problem, and it is pointed out that human capital is the main factor of economic growth. Tao, T., Guo, Yalong, and Jin, G. [11] (2022) explored the macroeconomic impact of the degree of risk accumulation of negative population growth using an origin comparison model. It is shown that the effect of negative population growth on macroeconomic indicators is affected by multiple effects and is full of complexity.

In general, most of the studies are based on semi-endogenous growth models that discuss the relationship between negative population growth and macroeconomic variables from the perspectives of technological slowdown, capital, etc. that affect economic growth. However, none of the studies have considered the consumption perspective to identify how consumption affects economic growth in the context of negative population growth, and how governments can have a significant impact on economic growth in the era of negative global population growth in a consumer market with great potential.

Many scholars have studied the impact of consumption on economic growth, broadly focusing on it from a macro-state perspective, such as Jin, Xiaotong, and Yan, Chao [12] (2010) studied the mutual influence relationship between economic growth rate and the growth rate of population consumption. Liu, Dong-Huang, and Meng, Fan-Kun [13] (2012)'s empirical study shows that residential consumption has a significant pulling effect on economic growth, etc.

3 Data, methods, and ideas

Based on the United Nations Population Prospects 2022 (WPP2022) data, countries with negative population growth due to population aging and childbearing are screened based on their natural population growth rate and net migration rate. The population growth of different countries is examined. First, a negative population growth country is defined as a country with a negative total population growth rate in the most severe negative growth area; with a negative mean natural growth rate; with a negative natural growth rate mainly due to low fertility and aging; and with a population of 90,000 or more. [14] The population is above 90,000. This excludes countries with a small population base that are susceptible to exogenous time effects that cause large fluctuations in the natural population growth rate. Second, countries with positive natural population growth rates but negative mechanical natural growth rates are excluded. Finally, countries affected by exogenous events such as wars are excluded. Finally, Hungary, Japan, and Italy are selected as typical countries with a negative population growth rate for analysis.

This paper establishes a system of consumption and economic growth by combining household expenditure data and economic growth data of selected typical countries with negative population growth and divides the consumption structure of each country into eight categories: consumption of food, tobacco and alcohol (FA), consumption of clothing(CC), consumption of housing (CH), consumption of transportation and communication (TC), consumption of education (CE), culture and entertainment(E), consumption of health care (HC), and consumption of other goods and services(CO). The eight types of indicators are [15] In terms of economic growth, GDP per capita is chosen as the economic growth indicator.

3.1 Correlation coefficient

Due to the different legal currencies in each country, the data on the household consumption structure differs from the data on GDP per capita, which does not facilitate comparison. Therefore, this paper uses the mean value method to process the raw indicators to reflect the differences in indicators among different countries and the differences in the degree of mutual influence between indicators, and the following formula is used to calculate the correlation in this paper.

$$\gamma\left(x_0(\kappa),x_i(\kappa)\right)=\frac{\min\limits_i\min\limits_k|x_0(k)-x_i(k)|+\xi\max\limits_i\max\limits_k|x_0(k)-x_i(k)|}{|x_0(k)-x_i(k)|+\xi\max\limits_i\max\limits_k|x_0(k)-x_i(k)|}$$

K denotes different years, $x_i(k)$ denotes the mean-treated consumption indicator for that year, and $x_0(k)$ denotes the average value of economic growth indicators for that year. The coefficient of discrimination is $0.5.\zeta$ The analysis of consumption structure and economic growth data for each of the three countries is carried out.

The analysis is carried out in the series of years when the population entered the negative growth phase, and the correlation coefficients for the three countries are tabulated (see Tables 1, 2, and 3). The three countries were analyzed separately because of the differences in the data obtained for the structure of household consumption in each.

For Italy, the transformation of the correlation coefficient table into a correlation coefficient chart (see Figure 1) shows that for Italy the correlation coefficient for health care has been at a high level since the period of negative population growth. Except for the year 2020, which is affected by the new epidemic, the correlation coefficients of transportation and communication consumption, education consumption, culture, and entertainment consumption to GDP show an overall decreasing trend from year to year. In the year 2020, when the epidemic and controls are affected, food consumption, housing-related consumption, and education consumption all show a significant increase in their correlation coefficients to GDP.

For Hungary (see Figure 2), which has been in negative population growth for a long time, the correlation coefficients of food consumption, alcohol and tobacco consumption, clothing consumption, health care consumption, and transportation consumption to GDP show an overall significant increase until 2020, while the correlation coefficients of other goods and services to GDP show a decreasing trend year by year. Housing-related consumption shows a "V" shape. In Hungary, the correlation coefficient of cultural consumption is unstable.

In Japan (see Figure 3), the correlations of housing fuel-related costs, food consumption, and health insurance have remained high; the correlations of apparel consumption, other consumption, and services have been decreasing year by year; the correlation of education consumption has shown a decreasing trend year by year except for a sudden increase in 2021; and transportation consumption is less stable, with high and low levels. Entertainment consumption starts to decline year by year after reaching a peak in the 5th year of negative growth

3.2 Gray correlation degree

$$\gamma(x_0, x_i) = \frac{1}{n}\sum_{k-1}^{n} \gamma(x_0(\kappa), x_i(\kappa))$$

In this paper, the gray correlation is calculated using the formula above. The correlations of household food consumption, household alcohol consumption (non-food), household clothing consumption, household housing-related consumption, household health care, household transportation, household education, and household other services with GDP indicators for the three countries and their rankings are as follows (Tables 4, 5, and 6), and we can get the mean values of the correlations of consumption indicators with economic growth indicators as 0.687, 0.7651, and 0.7578, respectively. It can be shown that the correlation between consumption and economic growth is strong and the coupling is significant.

Table 1 Table of the number of contacts in Italy

year	Negative Growth Year	FA	CC	CH	HC	TC	E	CE	CO
12/2014	1	0.747	0.649	0.639	0.979	0.85	0.75	0.868	0.437
12/2015	2	0.817	0.665	0.769	0.953	0.839	0.637	0.911	0.756
12/2016	3	0.915	0.674	0.929	0.947	0.902	0.615	0.912	0.986
12/2017	4	0.984	0.743	0.865	0.704	0.676	0.728	0.697	0.735
12/2018	5	0.928	0.875	0.786	0.915	0.757	0.951	0.799	0.733
12/2019	6	0.801	0.771	0.571	0.841	1	0.92	0.984	0.839
12/2020	7	0.731	0.359	0.823	0.784	0.419	0.341	0.635	0.62

Table 2 Table of the number of contacts in Hungary

year	Negative Growth Year	FA	CC	CH	HC	TC	E	CE	CO
2000	1	0.585	0.426	0.735	0.559	0.777	0.974	0.352	0.905
2001	2	0.489	0.372	0.668	0.598	0.812	0.779	0.701	0.918
2002	3	0.534	0.378	0.59	0.567	0.719	0.863	0.427	0.788
2003	4	0.679	0.382	0.639	0.627	0.887	0.527	0.986	0.972
2004	5	0.908	0.404	0.736	0.588	0.852	0.515	0.831	0.88
2005	6	0.769	0.489	0.708	0.588	0.449	0.497	0.969	0.93
2006	7	0.673	0.607	0.673	0.466	0.558	0.602	0.757	0.836
2007	8	0.732	0.812	0.846	0.594	0.827	0.793	0.744	0.953
2008	9	0.72	0.548	0.806	0.633	0.976	0.958	0.617	0.936
2009	10	0.744	0.588	0.545	0.947	0.984	0.718	0.968	0.777
2010	11	0.675	0.592	0.42	0.804	0.665	0.688	0.704	0.489
2011	12	0.674	0.588	0.385	0.936	0.951	0.916	0.614	0.469
2012	13	0.764	0.53	0.347	0.735	0.953	0.949	0.538	0.482
2013	14	0.773	0.511	0.416	0.774	0.721	0.938	0.92	0.573
2014	15	0.611	0.431	0.622	0.822	0.723	0.676	0.906	0.478
2015	16	0.935	0.706	0.909	0.636	0.635	0.498	0.588	0.597
2016	17	0.889	0.83	0.976	0.617	0.799	0.563	0.467	0.544
2017	18	0.934	0.785	0.663	0.647	0.858	0.531	0.501	0.54
2018	19	0.946	0.752	0.505	0.519	0.943	0.638	0.461	0.491
2019	20	0.975	0.712	0.386	0.54	1	0.928	0.523	0.529
2020	21	0.496	0.404	0.414	0.336	0.484	0.419	0.778	0.402

Table 3 Table of Japan Customs Contacts

year	Negative Growth Year	FA	CH	HC	CC	TC	CE	E	CO
12/2010	1	0.941	0.957	0.942	0.669	0.834	0.564	0.439	0.596
12/2011	2	0.979	0.698	0.898	0.561	0.968	0.483	0.659	0.562
12/2012	3	0.966	0.807	0.974	0.654	0.969	0.334	0.753	0.619
12/2013	4	0.958	0.571	0.975	0.414	0.684	0.779	0.699	0.61
12/2014	5	0.948	0.781	0.793	0.426	0.825	0.937	0.807	0.715
12/2015	6	0.995	0.971	0.963	0.97	0.879	0.632	0.959	0.872
12/2016	7	0.951	0.678	0.643	0.694	0.96	0.434	0.939	0.974
12/2017	8	0.908	0.658	0.839	0.733	0.832	0.555	0.745	0.615
12/2018	9	0.929	1	0.884	0.635	0.888	0.716	0.699	0.806
12/2019	10	0.998	0.673	0.899	0.494	0.709	0.449	0.836	0.706
12/2020	11	0.953	0.973	0.798	0.466	0.929	0.626	0.54	0.553
12/2021	12	0.872	0.784	0.902	0.488	0.725	0.536	0.537	0.543

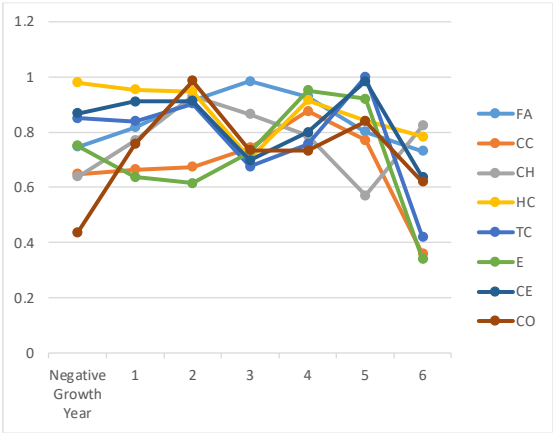

Fig. 1 Map of the number of Italian connections

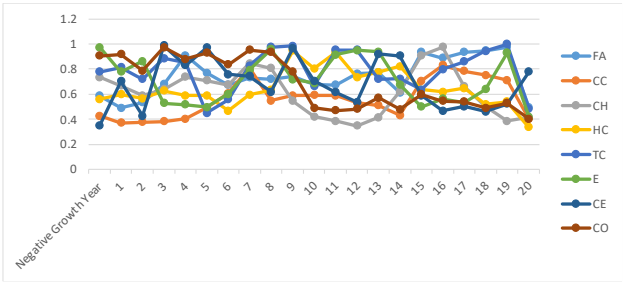

Fig. 2 Map of the number of contacts in Hungary

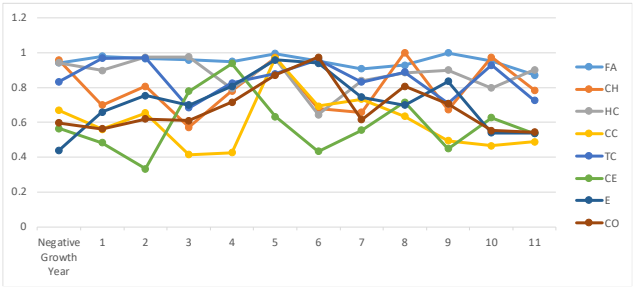

Fig. 3 Japan's customs linkage chart

Table 4 Italy Consumption and economic growth system correlation

Relevance results		
Evaluation item	Correlation	ranking
HC	0.875	1
FA	0.846	2
CE	0.829	3
TC	0.777	4
CH	0.769	5
CO	0.729	6
E	0.706	7
CC	0.676	8

Table 5 Systematic correlation between consumption and economic growth in Hungary

Relevance results		
Evaluation item	Correlation	ranking
TC	0.789	1
FA	0.738	2
E	0.713	3
CO	0.69	4
CE	0.683	5
HC	0.644	6
CH	0.618	7
CC	0.564	8

Table 6 Japan Consumption and Economic Growth System Correlation

Relevance results		
Evaluation item	Correlation	ranking
FA	0.95	1
HC	0.876	2
TC	0.85	3
CH	0.796	4
E	0.718	5
CO	0.681	6
CC	0.6	7
CE	0.587	8

3.3 Analysis

The following information can be derived from the analysis by combining the correlations of consumption to GDP for the three countries with negative population growth. First, food consumption has been at a high level with 0.846, 0.738, and 0.95, respectively. second, the correlation of health care consumption to GDP is 0.875, 0.644, and 0.876, which is a strong correlation. Although health care consumption in the three countries fluctuated while entering negative population growth, it remained high. Third, the correlations of housing-related consumption to GDP are 0.769,0.618, and 0.796, respectively. Thanks to the policies related to home purchase in the countries concerned, residents' housing-related consumption is higher. Fourth, the correlations of clothing expenditure are 0.676,0.564, and 0.6 respectively, with average correlations. Fifth, the correlation between education and GDP is 0.829, 0.683, and 0.587, with a strong correlation. Sixth, for leisure and entertainment, the correlations are0.706, 0.713, and 0.718, respectively, except in Italy, where entertainment consumption maintains a strong association with economic growth. Seventh, the correlations between transportation and communication and economic growth are 0.777, 0.789, and0.85, with strong correlations. Eighth, the correlations of other services consumption to GDP are 0.729, 0.69, and 0.681, which are stronger but weaker than other indicators overall.

4 Conclusion

It can be concluded that after entering the time domain of negative population growth, the pulling effect of health care consumption on economic growth is gradually obvious, survival-oriented consumption is still at a high level, and the higher correlation of housing and housing consumption is reflected in the society is that households will be more inclined to choose a risk-resistant asset for investment to provide some protection for their old age in an aging society.

5 Discussion

Long-term negative population size growth is already common in developed countries, although some countries have reversed this trend in a short time after entering negative population growth through migration and other means. However, there are still most countries that have difficulty reversing it in the short term due to, among other things, chronic low fertility. The new demographic status and patterns have prompted thoughts on whether they have an impact on economic growth.

This paper uses population data from WPP2022 to screen out typical countries with long-term negative population growth and uses gray correlation analysis theory to investigate the coupling relationship between household consumption and economic growth based on data on household expenditure propensity in the relevant countries during this period. In turn, we refine which consumption indicators contribute more to economic growth in the context of negative population growth. Due to the different starting time and duration of negative population growth in each country, and the availability of consumption data in some countries, it is not possible to conduct a more effective regression analysis. Therefore, a gray correlation analysis was conducted for typical countries with obvious data availability to examine the relationship between consumption indicators and economic growth indicators under negative population growth over time, to examine how the consumption propensity of households affects economic growth in the face of negative population growth, and to make relevant insights into the work of the government. It is found that the impact of health care consumption on GDP is consistently high under negative population growth, housing-related consumption is also highly correlated, and food consumption is less correlated than health care and housing, except for Japan.

The experience of different countries shows that the role of consumption on economic growth under negative population growth cannot be ignored. According to the relationship between household consumption and economic growth, it is better for the government to use the pulling effect of consumption to alleviate the problem of a declining working population and slowing economic development when the population grows negatively. By increasing policy support in related areas, the role of consumption in economic growth can be brought into play to promote economic development.

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