An Analysis of the Factors Influencing Health Based on the Healt h Production Function

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Abstract: With the improvement of living standards, people are increasingly concerned about life expectancy at birth as an indicator of health status. In this article, we selected data from Japan, anchored the analysis of cases, and estimated the health production function, and then revealed the relationship between various factors and life expectancy at birth.

Key words: Health status; Health production function; Impulse response analysis; Autoregressive Distribution Lag (ARDL) model; Japan

Chapter 1 Important factors influencing people's health

As society's standard of living increases, there is a growing interest in life expectancy at birth as an indicator of health status. There are many factors that influence people's health, so examining the health production function will help to select the important ones and explore how they actually affect health.

In general, increased health expenditure and personal income can contribute to increased life expectancy. At the same time, improvements in environmental health and access to education can also improve people's health status. The published literature suggests that there are four categories of factors that can influence people's health in different ways, based on different country cases. In this paper, a health production function is estimated using four types of variables that influence people's health: economic, lifestyle, education and environment.

Japan has long been reputed as a nation with long life expectancy of people. The line plot in figure 1 compared the life expectancy at birth in Japan, Hong Kong SAR, China, high-income countries and the world between the year of 1985 and 2019. It shows that the life expectancy at birth of Japanese people occupied the first place in the world from 1985 to 2009, increasing from 77.65 to 82.93, which is much higher than those of high-income countries and the world average during the same periods, with 2006 as an exception second to Hong Kong. Life expectancy at birth is an important indicator of people's health and wellbeing. It has attracted numerous attentions from researchers in difference parts of the world. A vector autoregressive distributed lag (ARDL) model is also developed to explore the temporal relationship between the dependent variable (life expectancy) and the independent variables (GDP per capita, personal income, health expenditure, average concentration of sulphur dioxide, cigarette consumption per capita and college enrolment rate).

Chapter 2 Model Constructions and Variable Specifications

The theory of household production regards a household as a producer of products and services, and views the increase of health stock can only effect wage rate in the model (Becker, 1965). Based on Becker's model, Auster (1969) imported living habits and medical facilities as explanatory variables, and firstly considered the nation as the unit of observation.

Grossman (1972) proposed that the length of life is determined by a human's utility, and people's health level is endogenous and highly relevant to their production resources, represented by both investment and consumption functions. In a health production function, Grossman considered health as a basic commodity, medical care as its derived demand, and the money spent on health care as an investment in health.

Based on the theoretical health needs model, the following model is used to estimate the impact of various factors n health.

$$\ln H = \ln \Omega + \sum \alpha_i(\ln E_i) + \sum \beta_i(\ln F_i) + \sum \gamma_i(\ln G_i) + \sum \delta_i(\ln I_i)$$

Where the relevant influence factors ofeconomic (E_i), enironment (F_i), ifestyle (G_i), and ducation (I_i) areincluded. α_i denotes the elasticity coefficient of economic o health, β_i denotes the elasticity coefficient of environment o health, γ_i denotes the elasticity coefficient of lifestyle o health, β_i denotes the elasticity coefficient of education to ealth and δ_i denotes the elasticity coefficient of economic to health.

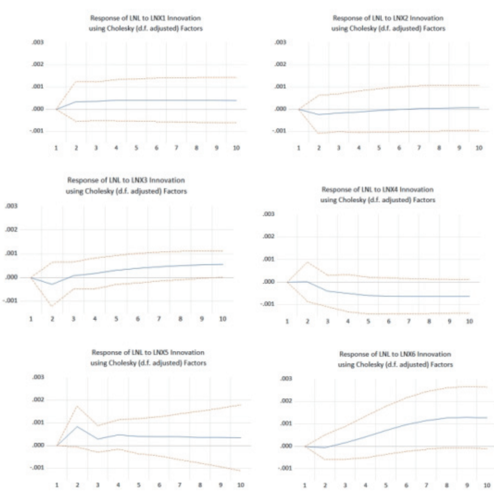
For the convenience in the regression, this paper uses the following indicator system: L denotes Life expectancy at birth, X1 denotes GDP per capita, X2 denotes personal income, X3 denotes personal health expenditure, X4 denotes the average concentration of Sulphur dioxide in the air, X5 denotes the consumption of cigarette per capita, and X6 denotes the college enrolment rate. The linear graphs in figure 2 show the trend of change of each variable by year.

This paper takes the logarithmic transformation to transfer these skewed variables into more normalized datasets. Correspondingly, the changes of log-linear regression models between the independent and dependent variables can be effectively be explained as a percent change of dependent variable with respect to each independent variable. The logarithm of all variables is denoted as LNL (logarithm of life expectancy at birth), LNX1 (logarithm of GDP per capita), LNX2 (logarithm of personal income), LNX3 (logarithm of personal health expenditure), LNX4 (logarithm of average concentration of Sulphur dioxide), LNX5 (logarithm of consumption of cigarette per capita) and LNX6 (logarithm of college enrolment rate). All the variables show a relatively consistent increase trend, while LNX3 (logarithm of personal health expenditure), LNX4 (logarithm of average concentration of Sulphur dioxide) and LNX5 (logarithm of consumption of cigarette per capita) show non-stationary characteristics.

Chapter 3 Single Factor Dynamic Analyses of the Health Production Function

In this section, the effects of imposing a standard deviation shock on the current and future values of the endogenous variables (all the independent variables employed in this study) are investigated using an impulse response function. The results are shown in the plots in Figure 1. Each plot shows the response of logarithm of life expectancy at birth to each variable after applying a standard deviation impulse.

Figure 1. Responses of dependent variable to independent variables' novation



Variable	Coefficient	Std. Error	T-Statistic	Prob.
D (LNL (-1))	-0.282185	0.192334	-1.467163	0.1644
D (LNL (-2))	0.246058**	0.110259	2.231633	0.0425
D (LNL (-3))	0.233384**	0.095801	2.436124	0.0288
D (LNX_1)	-0.088047**	0.039753	-2.214852	0.0439
D (LNX_1 (-1))	0.031650	0.021137	1.497403	0.1565
D (LNX_1 (-2))	0.024631	0.015733	1.565592	0.1398
D (LNX_2)	0.046454*	0.022224	2.090291	0.0553
D (LNX_3)	-0.044078*	0.022747	-1.937742	0.0731
D (LNX_3 (-1))	-0.075061**	0.029671	-2.529755	0.0240
D (LNX_3 (-2))	0.031537	0.028722	1.098012	0.2907
D (LNX_3 (-3))	0.095281**	0.037223	2.559764	0.0227
D (LNX_4)	0.006281	0.003655	1.718652	0.1077
D (LNX_5)	0.009530	0.011202	0.850769	0.4092
D (LNX_6 (-1))	0.025507	0.015079	1.691573	0.1129
D (LNX_6 (-2))	-0.031542**	0.010658	-2.959381	0.0104
D (LNX_6 (-3))	-0.037478**	0.015661	-2.392997	0.0313
D (LNX_6)	0.035331	0.021101	1.674421	0.1162
R-squared	0.593588			
Adjusted R-squared	0.129117			
Log likelihood	155.2544			
Durbin-Watson stat	2.308874			

Table 1. Estimation results of the ARDL model

Notes: dependent variable (logarithm of life expectancy at birth (LNL)) and independent variables (logarithm of GDP per capita (LNX1), logarithm of personal income (LNX2), logarithm of personal health expenditure (LNX3), logarithm of average concentration of Sulphur dioxide (LNX4), logarithm of consumption of cigarette per capita (LNX5), logarithm of college enrolment rate (LNX6))

Sources: Elaborated by author

The plot of response of LNL (logarithm of life expectancy at birth) to LNX1 demonstrates that the LNL (logarithm of life expectancy at birth) is positive in all the periods investigated. This indicates the increase of GDP per capita could improve life expectancy, while the rising trend of health status slows down after the fourth period. As previous literature showed, the increase of GDP per capita can provide people more opportunities of enjoying a wide range of entertainments, even, developing bad habits, such as smoking, alcohol abuse.

The plot of response of LNL (logarithm of life expectancy at birth) to LNX2 (logarithm of personal income) shows that LNL (logarithm of life expectancy at birth) is slight negative in the first six periods meaning a negative association between personal income and health status. As an economic factor similar to GDP per capita, the increase of personal income can lead to higher possibility of bad life habits including smoking and alcohol abuse for people. The response of LNL (logarithm of life expectancy at birth) to impulse of personal income declines and is negative in the first two periods, however it starts to rise in the second period, and changes into positive since period seven. This indicates that the positive influence of the personal income increase could have lagged for six-period.

The plot of response of LNL (logarithm of life expectancy at birth) to LNX3 (logarithm of personal health expenditure) shows that the LNL (logarithm of life expectancy at birth) is negative and declining during the period one and two, meaning that the increase in individual health expenditure could be a predictor of a decrease on life expectancy in the short run. However, it shows a positive relationship between health expenditure and life expectancy after period two. This indicate that the positive influence of individual health expenditure on health status might not be observed immediately, while the input on health expenditure could improve health status of a person in the long run.

The plot of response of LNL (logarithm of life expectancy at birth) to LNX4 (logarithm of average concentration of Sulphur dioxide) shows that the LNL (logarithm of life expectancy at birth) is negative after a one-period lag. This means that the average concentration of Sulphur dioxide in the air has a negative impact on life expectancy, which is consistent with the results of related previous studies showing that Sulphur dioxide can cause respiratory disease.

The plot of response of LNL (logarithm of life expectancy at birth) to LNX5 (logarithm of consumption of cigarette per capita) shows a positive but declining trend from the period two, indicating the consumption of cigarette per capita has positive influence on health status. This is contradictory with the results showed in previous studies.

The plot of response of LNL (logarithm of life expectancy at birth) to LNX6 (logarithm of college enrolment rate) shows that the LNL (logarithm of life expectancy at birth) is negative in the first two period, and changes into positive after period two. It indicates that the increase in college enrolment rate may have a negative influence on health status in the short run. As literature has shown that students might studying late at night hence affecting their health status negatively. However, after a two-period lag, the rising level of education contributes to individual health status, and extends life expectancy.

Chapter 4 Multifactorial Analyses of the Health Production Function

This paper uses a Vector Autoregressive Distribution Lag (ARDL) model to empirically analyse the relationship between each factor in the health production function and the improvement in the health status of the Japanese population, and the results are shown in Table 1.

Notes:

1. D denotes first-order difference
2. (-1) denotes one-period lag, (-2) denotes two-period lag, (-3) denotes three-period lag
3. ***Significant at 1% level, ** Significant at 5% level, * Significant at 10% level.

Sources: Elaborated by author

Firstly, it is shown that the change rate of life expectancy with two-period lag and three-period lag can have significant impact on the change rate of life expectancy at 5% level. The coefficients are 0.246058 and 0.233384 respectively. While the term with one period lag is insignificant. This indicate that the improvement of a person's health status can positively impact his/her health or be cumulated in the long run.

Secondly, it shows that the change rate of GDP per capita in current period has significant impact on the change rate of health status at 5% level. However, the coefficient is -0.88047, This is consistent with the results have shown in some previous studies. This is likely due to the change people's life style in terms of intaking more unhealthier diets, and the increased accident rates in construction and manufacturing as results of the economic growth. However, the impacts of change rate of with one-period lag and two-period lag are insignificant. In the year of 1985, the GDP per capita of Japanese was 2,664,256 Japanese Yen (equivalent to 11,175 USD). As a highly developed country in the world, Japan has high standard health care infrastructure for a long time, thus the marginal impact of the change of GDP per capita on health may be diminishing in the long term.

Thirdly, the change rate of current personal income is shown significantly influence on the change rate of health status at 10% level. The coefficient is relatively low (0.046454). It is likely due to the reason similar to the GDP per capita.

Fourthly, it is shown that the change rate of personal health expenditure in current period can influence the change rate of life expectancy significantly at 10% level. And the coefficient is negative with a small absolute value (-0.044078). The change rate of personal health expenditure with one-period lag to also has significant impact on the change rate of life expectancy at 5% level, and the coefficient is -0.75061. These indicate that the increase of personal health expenditure might have a negative relationship with life expectancy at birth. It is likely due to people who have health conditions tend to increase their health expenditure in the short term, thus an increase in personal health expenditure in the short term may predict an increase in the number of people who are suffering from illness. However, it shows a significant relationship at 5% level between the change rate of personal health expenditure with a three-period lag and the change rate of health status, and the coefficient is 0.095281. The direction of impact turns into positive after a three-period lag. It is likely due to the benefits of any increase in the health inputs taking effect be in a relatively longer time period, hence the total impact turn to positive for this variable with a three years lag.

Fifthly, it is shown that the change rate of the current consumption of cigarette per capita in current period and the term with one-period lag have no significant impact on the change rate of life expectancy. However, the change rate of the consumption of cigarette per capita with two-period lag and three-period lag are shown having significant influence on that change rate of life expectancy at 5% level, and the coefficients are -0.031542 and -0.037478 respectively. This result indicates that as a habit related to one's lifestyle, smoking's impact on people's health might not be observed in the short run, whereas its negative impact can be significant in the long run. This is also consistent with the results shown in previous research.

Finally, the change rate of current average concentration of Sulphur dioxide in the air and the college enrolment rate have been shown insignificant with the change rate of health status. The first result might be related to the fact that the Sulphur dioxide concentrations in the air in Japan has been reduced to a very low level by 1990s due to the spread of desulfurization technology in the 1980s. Therefore, the change of average concentration of Sulphur dioxide in the air cannot be observed to have significant impact on health status. With a similar reason to that of the economic factors, the average standard of education in Japan has been kept at a high level at the beginning of the observation period of this study, the marginal effect of development in education on health might have diminished to a level hard to be observed.

Chapter 5 Conclusions

The model constructed by this study uses the life expectancy at birth as a dependent variable representing health status, and includes three economic variables (GDP per capita, personal income and personal health expenditure), one environmental variable (average concentration of Sulphur dioxide in the air), one lifestyle variable (cigarette consumption per capita), and one education/social variable (college enrolment rate).

Based on Japanese data from 1985 to 2019, this paper constructs a health production function equation following the simplified health production function raised by Thornton (2002). The empirical analysis employs impulse response functions and an autoregressive distributed lag (ARDL) model, explores the factors affecting the health status of Japanese people.

The results of the single factor dynamic analyses show that the increase in GDP per capita, personal income, health expenditure per capita, consumption of cigarette per capita and college enrolment rate can impact the health status positively; while the increase in the average concentration of Sulphur dioxide in the air may impact the health status negatively.

The results of the multi-factor analysis (ARDL model) shows that the effect of GDP per capita on health improvement can be negative in the current period due to the change of life style and work stress induced by economic growth. As for the effect of personal income on health improvement, it can be positive in the current period; while the effect turns into negative with one-period lag and two-period lag. In terms of the increase of personal health expenditure per capita, it can have a positive impact on the health variable with a three-period lag. The effect of cigarette consumption per capita on the health status can be positive in the short run (in current period and with one-period lag), however, it turns into negative in the long run (with two-period and three-period lag), suggesting that smoking has a negative effect on health status in the long run. The impact of the average concentration of Sulphur dioxide in the air is insignificant probably due to the low level and small variations in the concentration of Sulphur dioxide in air in Japan; similarly, effect of university enrolment rate is also insignificant.

The result of this study indicates that the health care system can be one but not the only one key component of a larger health system effecting the level of the health status of a nation. In order to improve the health status of the whole population, governments and society should give more recognition to the role of personal expenditure on health and advocate the good lifestyles to prevent disease.

The ARDL model also shows the health status with two-period and three-period lag can associated with the health status in current period positively. This might indicate a cumulative effect in health in the long run due to good life habits and higher financial health investment. Correspondingly, imposing higher taxes over commodities including alcohol and tobacco, propagandising the harms of alcohol abuse and tobacco consumption can be choices of government policy to help people develop healthier habits and lifestyle.

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