On the modeling and estimation of health changes in the United States

Extended abstract

Ying Yang[1], Anja De Waegenaere[2], and Bertrand Melenberg[3]

[1]*Department of Econometrics and OR, CentER, and Netspar, Tilburg University, y.yang@uvt.nl*
[2]*Department of Econometrics and Operation Research, Department of Accounting, CentER, and Netspar, Tilburg University, a.m.b.dewaegenaere@uvt.nl*
[3]*Department of Econometrics and Operation Research, Department of Finance, CentER, and Netspar, Tilburg University, b.melenberg@uvt.nl*

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In this paper, we estimate and forecast self-assessed health, and quantify its uncertainty through a stochastic approach based on the framework by Lee and Carter (1992). Over the past century, the United States has enjoyed unprecedented improvements in health and longevity. A better understanding of changes in health is important to financial sectors like insurance company, pension funds, social security, and government institutes. For example, increased obesity reduces life expectancy, hence in principle, saves money for pension annuities; however, it also increases morbidity for a number of years before death, which increases medical expenditure in the future. On the other hand, reduced smoking lowers both mortality and morbidity, but increases people's remaining life time. Thus, the net effect in public liabilities remains unclear due to uncertain health changes. Understanding health changes is also crucial for labor decisions. For example, in many countries, an increase in the retirement age is currently implemented. However, such a decision should not only be based on an increase in life expectancy, but also on the remaining life years in good health, which is usually called *healthy life expectancy* (HLE).

There is an extensive literature on modeling past trends of health, but relatively little on investigating its future developments. Predicting future health changes is complex because health might be affected by many factors such as alcohol and tobacco consumption, or even the economic situation. Most of the literature focuses on the future health changes using deterministic projections, or models health changes as a function of demographic characteristics, lifestyle behaviors, and risk factors. However, in order to generate forecasts from these models, one needs to first develop forecasts of a large number of lifestyle behaviors and risk factors, which is a challenging task. Even then, the highly nonlinear structure of the models might lead to forecast instability.

This paper makes two main contributions to the current literature. First, it treats the health dynamics as a stochastic process, and adopts the Lee-Carter model for modeling health. We found that the Lee-Carter model fits the self-accessed health data quite well. Such a stochastic model for health also allows for uncertainty surrounding the changes of health and its forecasts. Second, we incorporate observed variables into the Lee-Carter model to better capture the behavior of health changes besides the latent health index. In this fashion, health dynamics can be forecasted not only based on historical patterns,

but also on the changes of its highly related factors, which are easier to predict. Our approach allows for different scenarios of the future observed variables when forecasting, and also allows for taking into account expert opinion.

We use health data from 1972 to 2010 from National Health Interview Survey (NHIS), which provides the self-assessed health status. Based on this, the *Health Status Index* (HSI), which represents the proportion of the population in "bad" health is constructed. Two macroeconomic variables, GDP and unemployment rate are obtained from the OECD Statistics Extracts. Two life-style factors, alcohol consumption and tobacco consumption from 1972-2008 are obtained from OECD Health Data (2010). For the age group from 0 to 85 years old, we apply the traditional Lee-Carter model to estimate health changes first. And then, the Lee-Carter model with single, two, three, and four observed variables are implemented. Such an analysis is also done for five sub-age groups. We also perform a forecasting analysis for health based on the original Lee-Carter model and based on the Lee-Carter model with observed variables. The analysis is done for males and females separately.

The latent Lee-Carter framework works quite well to estimate and model health changes. By including also observed variables, the model fit improves quite significantly, where a large part of the time trend in health can be attributed to the trends in the observed variables. These observed variables generally have significant effects on the health dynamics for separate age groups. The Lee-Carter models with two observed variables outperforms the other discussed models. The macroeconomic fluctuations, in particular, are able to capture the changes of health to a large extent. In addition, the Lee-Carter model with observed variables leads to a significant improvement in terms of forecasting. The Lee-Carter model with GDP and unemployment rate not only outperforms the Lee-Carter with a single or multiple observed variables, but also gives the smallest forecasting errors, suggested by the backtesting analysis. This indicates that the economic situation can largely explain health dynamics, which is very helpful to predict its future development. Finally, this article estimates and forecasts life expectancy and healthy life expectancy with uncertainties. In line with the method proposed by Sullivan (1971), both period life table and cohort life table are constructed for the purpose of the analysis. The study suggests that healthy life expectancy of both females and males has a larger relative increase than life expectancy compared with 1972. Males' life expectancy and healthy life expectancy are generally lower than the females', but converging to the females'.

Keywords: Health stochastic process, Lee-Carter model, Lee-Carter model with observed variables, Health forecast

References

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