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Modelling the Dependency between Economic Growth and Health among Asia Countries Using Mixed-Effects Models

Madona Yunita Wijaya*

Department of Science and Technology, University of Syarif Hidayatullah, Jakarta, Indonesia

Abstract

Panel data require an elaborate modeling of the random variability due to their complex structure. For continuous panel data, linear mixed model, which is flexible enough in modeling, has been developed. In this study, the impact of health factors including life expectancy, mortality, and fertility on economic growth among Asian countries is examined using panel data from period 1990-2018. The results show that economic growth depends on health factors and the impact on economic growth is different between developed and developing countries. Economic growth of developed countries would be negatively affected by health factors while the developing countries are positively affected with higher fertility and mortality rate.

Keywords: Economic growth • Fertility • Life expectancy • Mortality • Mixed-models

Introduction

Health is a broad aspect which includes physical, mental and social wellbeing of an individual. Asia has mostly developing economies and the contribution of labour in the production is sizeable. The developed countries are in the race of replacing the human labour with robots and automating the systems but in the developing Asian countries, the labour have deeper involvement in the production cycle [1-3]. Performance of an individual at work is critically impacted by their health. The positivity at work, focus on the productivity and ability to train and skill improvement are some of the areas where health and economic growth have a strong direct relationship. This paper therefore analyses the impact of health parameters like Mortality, Fertility and Life expectancy on economic growth among the Asian Countries [4,5].

It is observed that when life expectancy is higher, then the employees look to save for their retirement and also work on their skills to enhance them for better suitability at work. Performance of the workers and their higher skills contribute to the economic growth and higher production [6]. The higher life expectancy ensures that the individuals take a long-term view and invest in their health, education, professional life and much more which indirectly makes them more employable and productive. But, at the same time, the employment opportunities for senior citizens remain very less in Asian countries and this leads to turning them dependent on their young family members [7]. The exorbitant medical expenses of this group of people drags the economy back especially in the Asian countries where a large section of population is not covered with government health insurance schemes.

Mortality and Fertility have many interlinked factors and their impact on the economic growth is multi-dimensional. Higher fertility rate ensures that there are enough new born for labour market to take up the jobs and drive the economic growth [8-10]. But, when there are more births then it leads to gender inequality as the females get involved in bearing and raising the children. For the economic growth, the participation of both Males and Females in the economy is much needed. Especially in the developed countries where both partners earn and have a professional career, the choice of kids comes as an additional burden not just financially but emotionally and socially as well.

The higher fertility rate also means that more labor force will be available in the market but with the finite resource of the developing countries, they do not get the quality education and are consumed in the industries as cheap labor. But, in the developed world where the automated machines take care of the jobs and have very less labor-intensive job opportunities, the fertility rate leads to unemployment. Even the couples in the developed countries are less inclined to have kids due to extra financial burden and female partners working in their full-time professions.

The Mortality stats show that the healthcare facilities are not up to the mark and it is especially so in the Asian countries. This is mainly because of the poor health infrastructure and the lack of cleanliness and awareness for personal and public hygiene in the Asian countries. The high mortality in the region leads to poor focus at work

***Address to Correspondence:** Dr. Madona Yunita Wijaya, Department of Science and Technology, University of Syarif Hidayatullah, Jakarta, Indonesia; E-mail:madona@uinjkt.ac.id*

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and the personal problems related to health often take a good amount of one's attention. Therefore, it results in poor productivity and skills of the workers in Asian countries. Whereas the low mortality rate in the western world leads to higher focus at work and higher level of skills of the workers in the industry. This report therefore tries to investigate the impact that the Fertility, Mortality and Life Expectancy have on the economic growth of the Asian countries [11].

Methodology

Data

This study utilizes annual data from 1990 to 2018 for Asian countries. A total of 48 countries are included in the analysis. Other countries such as Laos, State of Palestine, Taiwan, and North Korea are excluded due to the unavailability of the data at the World Development Indicator (WDI) of the World Bank database. Health factors such as fertility rate, mortality rate, and life expectancy are used as predictors in the model to investigate the impact on economic growth in terms of GDP per capita in USD. The response variable is transformed with natural logarithms to address skew data and also for ease of interpretation. The countries considered in this study are classified as developed and developing countries according to Human Development Index (HDI). Countries with high HDI are considered as developed countries. They are Brunei Darussalam, Japan, Israel, Qatar, Russia, Saudi Arab, Singapore, Korea, and Hong Kong. The remaining 39 countries are considered as developing countries.

Statistical model

In practice we are often confronted with observations taken repeatedly through time on a sample of experimental units (such as individuals, cities, countries, etc.) These types of data are often called longitudinal or panel data. Mixed effects models are one of well-suited approaches to the analysis of panel data and have been widely used in many statistical applications including in the field of study in economics. The general theory of panel data is mature and able to model complicated economic problems.

To select a random-effects model, preliminary mean structures, random-effects, and residual covariance have to be appropriately chosen. In order to test for the need of the random effects, Restricted Maximum Likelihood (REML) test is carried out as this will be based on the same mean structure. The classical Maximum Likelihood (ML) approach is used in the reduction of mean structure because the REML method breaks down. REML will give incomparable results due to the fact that we compare different mean structures in the mixed models [12].

In this study, implementation of linear mixed effects model is carried out in R using name and lme4 packages.

Results

Exploratory data analysis

The response variable of economic growth is transformed using logarithm function. These transformed individual profiles are shown in Figure 1. Economic growth profiles for each country begin at different level of GDP and there exists much between countries variability. There is also within country variability but this does not seem to exceed the between countries variability. This may suggest the need of random intercept and random slope in linear mixed effects model. In addition, it can also be observed that most developing countries experience economic growth at lower level than developed countries. This trend can be seen more obvious as depicted in Figure 1.

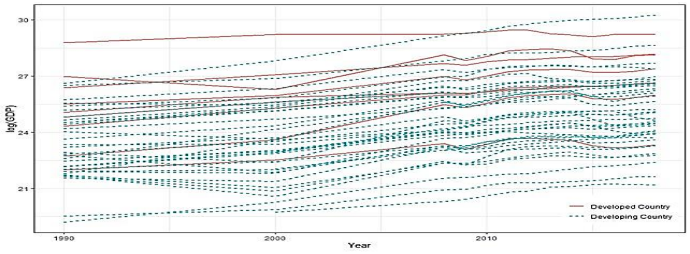

Figure 1. GDP profiles in logarithm scale among developed and developing countries.

Economic growth keep increasing since 1990 but developed countries show higher means than developing countries over time. These mean structures suggest that linear or quadratic time effect can be considered to capture the average evolution over time. The plot of variance structure shows the overall as well as by covariates evolution of the variance as a function of time. Overall, the variance seems to be fluctuating with time, it increased in year 2000 and started to decreased thereafter. However, the trend for developed countries declined over time. Generally, the variance is not constant thus a random intercept model may not be a good starting point. Furthermore, it may be plausible to start model fitting with unstructured covariance structure shows in Figure 2.

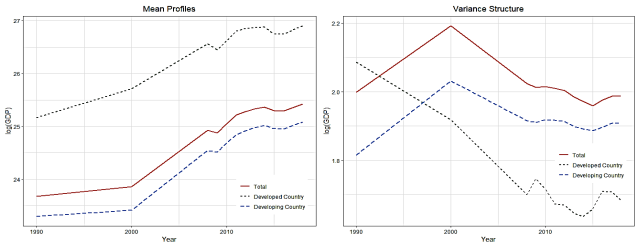

Figure 2. Mean and variance structures among developed and developing countries.

The pairwise correlation structure for the transformed GDP values at the different time points. For any pair of measurements at different time points, the correlation is fairly high with a minimum of 0.417 and a maximum of 0.999. In general, the pairwise correlation appears to decrease over time, i.e., the correlation become weaker between observations that far apart in time.

Linear mixed model

Based on average trends or individual profiles in exploratory data analysis, the evolution of economic growth is assumed to have a quadratic time effect as the preliminary mean structure. In conjunction with the most general covariance structure (unstructured), Likelihood Ratio Test (LRT) for the reduction of mean structures.

Since the effect of health factors may vary depending on whether they are developed or developing countries, interaction terms between developed variable and other predictors are considered in the linear mixed model. The model is further simplified by dropping a quadratic time effect (Model 2) but the LRT shows that Model 1 performs better since the p-value is less than 0.05. Each interaction term is also dropped from the model one at a time but the results show that it is not possible to simplify the mean structure and thus Model 1 is still preferable as compared to Model 3-Model 6 since it gives the same evidence of significant p-value of 0.029, 0.023, <. 0001, and <.0001, respectively. Model 1 also gives the smallest AIC value of 300.2 as compared to other models. Thus, the final model is quadratic time evolution including interaction terms between health factors and developed variables.

To investigate the need of random effects, LRT is performed by deleting random effects. It was observed that model including random intercept as well as time effects yields the best fitted model ($p<0.001$). Therefore, no further simplification of covariance structure is needed.

The estimated parameters from mixed effects model. The results show that all estimated parameters are significant at 5% level. This indicates that health factors have significant effect on economic growth in countries in Asia. In addition, the impact of health factors depends on whether the countries are developed or developing countries, or that the impact of fertility, mortality, and life expectancy on economic growth are not the same between developed and developing countries. Negative coefficients for interaction terms suggest that the impact of this health factor on economic growth are higher among developing countries than developed countries. To be more precise, the effect of these health factors is in the opposite direction. The impact of life expectancy on GDP is positive among developing countries and negative among developed countries when other variables are held constant in the model. These results are in line with the findings from a study of Fioroni showing that an increase in life expectancy can improve economic growth in poor countries while have a null or negative effect in rich countries. The impact of fertility on GDP are also positive among developing countries and negative among developed countries. When other variables are held constant in the model. Similarly, the impact of mortality on GDP is also positive among developing countries and negative among developed countries when other variables are held constant in the model. These means that higher fertility rate and mortality rate would raise economic growth in developing countries but would decrease economic growth in developed countries

Plot on the left panel of Figure 3 displays the marginal mean response evolution of economic growth by developed and developing countries. As can be expected, the evolution for developed countries tends to be higher than that for developing countries. The predicted subject specific effects for some selected countries are also displayed on the right panel of Figure 3. This shows that the random effect models have the flexibility to allow each country to experience different economic growth evolution by estimating different intercept and slope in Figure 3.

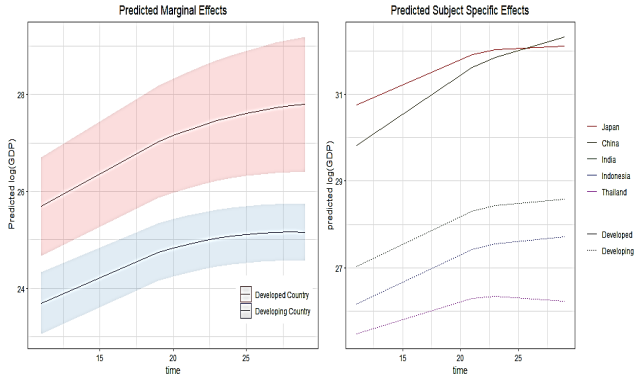

Figure 3. Predicted marginal effects.

Discussion and Conclusion

Many literatures have investigated how economic growth is affected by health factors. This study attempts to contribute to the literature from different point of view by using different approaches and only focusing among Asian countries. As this is a panel (longitudinal) study, appropriate analysis had to be done since classical statistical techniques fail in this context as observations within subjects (countries) are correlated. Thus, mixed-effects models were applied in the data. Mixed-effects models have the flexibility to estimate marginal effects as well as subject specific effects. The results reveal that the evolution of economic growth depends on health factors. Furthermore, it was observed that this evolution is different for developed and developing countries. The impact is much stronger in developing countries than in developed countries. It is also notable that the higher fertility and mortality would have a negative impact on growth of the developed countries. It is mostly because there is equal contribution of the females in the economy so higher fertility would distract the female workforce to the childcare work and this would result into unequal participation of the two genders. Another major aspect associated with higher fertility is that it needs more jobs to absorb the skilled workforce but in the developed nations, the workers are quickly being replaced by the robots and automated machines. This is a major reason why the growth developed countries would be negatively affected while the developing countries are positively affected with higher fertility and mortality rate.

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