Correlation and Its Changing Characteristics in the Main Belt and Road Countries of Life Expectancy and GDP Per Capita from 1990 to 2020

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Abstract. Previous studies on the correlation between life expectancy and GDP per capita showed some variation. This study describes the trends of life expectancy and GDP per capita in 13 main countries along the Belt and Road from 1990 to 2020, and analyzes the relationship between male life expectancy, female life expectancy, or total life expectancy and GDP per capita in these countries using linear regression models. The results show that life expectancy and GDP per capita both increase gradually with increasing years. There is an immediate correlation between life expectancy and GDP per capita, and male life expectancy, female life expectancy, and total life expectancy are positively correlated with GDP per capita. This study confirms the positive correlation between life expectancy and GDP per capita, and these results will be the starting point for the public to pay attention to the health status of people in the Belt and Road countries.

Keywords: Life expectancy, GDP per capita, Belt and Road, gender difference.

1. Introduction

China introduced the "One Belt, One Road (OBOR)" concept for the first time in 2013, which aims to achieve common economic prosperity, complementary trade, and people-to-people ties by strengthening the connectivity of countries along the traditional Land and Maritime Silk Road. By the end of January 2021, China had signed 205 cooperation agreements with 171 nations or international organizations, covering issues such as policy coordination, financial integration, unrestricted commerce, infrastructure connectivity, people-to-people ties, etc. [1]. Health cooperation has always been an important part of China's participation in international affairs. President Xi of China signed a Memorandum of Understanding with the WHO in January 2017. This action demonstrates China supports international health regulation, actively participates in global health governance, shares global health knowledge and technology, and promotes health security along the Silk Road [2]. But in fact, due to the different levels of economic development of countries along the OBOR, there are obvious differences in the health status of the population.

Life expectancy (LE) is an important factor reflecting the level of population life expectancy, while Gross Domestic Product per capita (GDP for short) is a crucial indicator showing economic development. On the one hand, LE is considered to be a key that can affect many economic decisions of the individuals in accordance to the theory of life circle [3]. The extension of LE accelerated the change of population age structure, resulting in longer life span and more elderly people. Longer LE means higher return of human capital, which encourages more investment in education, and then stimulates economic growth [4, 5]. On the other hand, greater LE can lead to a greater population, diluting the income per capita [6]. Some studies showed that the impact of LE on income per capita is different before and after the demographic transition. Before the demographic transition, an increase in LE largely increases the population; however, following the demographic transition, it

slows population growth and encourages the building of human capital [7, 8]. Many studies across different countries have shown that there is a positive impact of LE, or a negative one on GDP, but the debate remains unsolved [9]. Thus, LE has both positive and negative impacts on GDP, making the association between the two indexes complex. Figuring out the relationship between LE and GDP can help the government formulate scientific and reasonable health care expenditure policies and implement health strategies and measures that are both economically and socially effective.

As mentioned above, the OBOR is a strategy for global development on infrastructure proposed by China. For the "Belt" and the "Road," it comprises the "Silk Road Economic Belt" and the "21st Century Maritime Silk Road." The "Belt" refers to the route from China heading west through Central Asia to the western region, while the "Road" travels through Southeast Asia to Africa, the Middle East and South Asia [10]. The signing nations are dispersed over all of the continents, with six countries in South East Asia, 35 in Europe and Central Asia, 25 in East Asia and the Pacific, 20 in Latin America and the Caribbean, and 43 in Sub-Saharan Africa. These countries vary greatly in income, thus to explore the relationship between the economic growth and health conditions among countries along the Belt and Road, we used correlation analysis and regression analysis to analyze the relationship between LE and GDP in major countries of the OBOR from 1990 to 2020. We hope to propose targeted policy recommendations for people's health and economic development in developing countries, and to provide theoretical basis and reference for government departments to weigh policy preferences and promote strategic measures.

2. Methods

2.1. Data Sources

For obtaining the accurate and reliable data, the LE data are from the World Bank data site and the GDP data are from the United Nations data site, ranging from year 1990 to 2020. In order to compact the data for further cross validation, we initially chose 13 countries among the 140+ countries, which are Bangladesh, China, Egypt, India, Indonesia, Iran, Myanmar, Pakistan, Philippines, Russia, Thailand, Turkey and Vietnam.

2.2. Variable Selection

The data used in this paper included 403 observations and 6 variables, i.e, Country, Year, Total life expectancy at birth (TLE), Male life expectancy at birth (MLE), Female life expectancy at birth (FLE), GDP per capita (GDP for short). The variable type of Country is character, and other variables are numeric.

2.3. Data Transformation

The data of TLE, MLE, FLE, GDP was transformed to log total life expectancy at birth (logTLE), log male life expectancy at birth (logMLE), log female life expectancy at birth (logFLE), log GDP per capita (logGDP). All the base of logarithmic functions is 10. The data used in this study are log-transformed.

2.4. Research Protocol

Firstly, this paper shows the changing trends of logTLE, logMLE, logFLE and logGDP in 13 OBOR countries by plotting a line chart. Next, the study compares logTLE, logMLE, logFLE and logGDP in the 13 OBOR countries in 1990 and 2020, showing the variability of them. Then, this study analyzes the immediate and lagged correlations of logTLE, logMLE, logFLE and logGDP. Finally, this paper uses the linear regression model, logGDP is the dependent variable (Y), and logTLE, logMLE, logFLE are the independent variables (X). R software is used for all plots and data analyses.

2.5. Model Principle

Linear regression model is one of the most widely used models in data analysis. This study uses a one-dimensional linear regression analysis method to analyze the effect of GDP on LE. The calculation formula is as follows:

$$Y = \beta_0 + \beta_k X_k \tag{1}$$

Y is logGDP, X_k is logMLE, logFLE, or logTLE. β_0 is the intercept and β_k is the slopes.

3. Results and Discussion

3.1. Trends in Life Expectancy and GDP

Figure 1 shows the trends of TLE in 13 OBOR countries. Overall, TLE in all 13 countries appears to be on the rise. India has the most dramatic increase in TLE, while Vietnam has maintained a high level of TLE, but it is increasing very slowly. TLE in Bangladesh has fluctuated but increases significantly. Myanmar's TLE decreased significantly in 2008 and then increased significantly, probably due to the severe tropical storms that hit the country in 2008 and caused heavy casualties.

Figure 1. Trends of TLE in 13 OBOR countries

Figure 2 shows the trends of MLE in 13 OBOR countries. It is very similar to the trends of TLE. However, China has the highest MLE of all countries. MLE in Myanmar is significantly lower than in other countries. Besides, Russia's MLE fluctuates considerably between 1990 and 2003 and then has risen markedly.

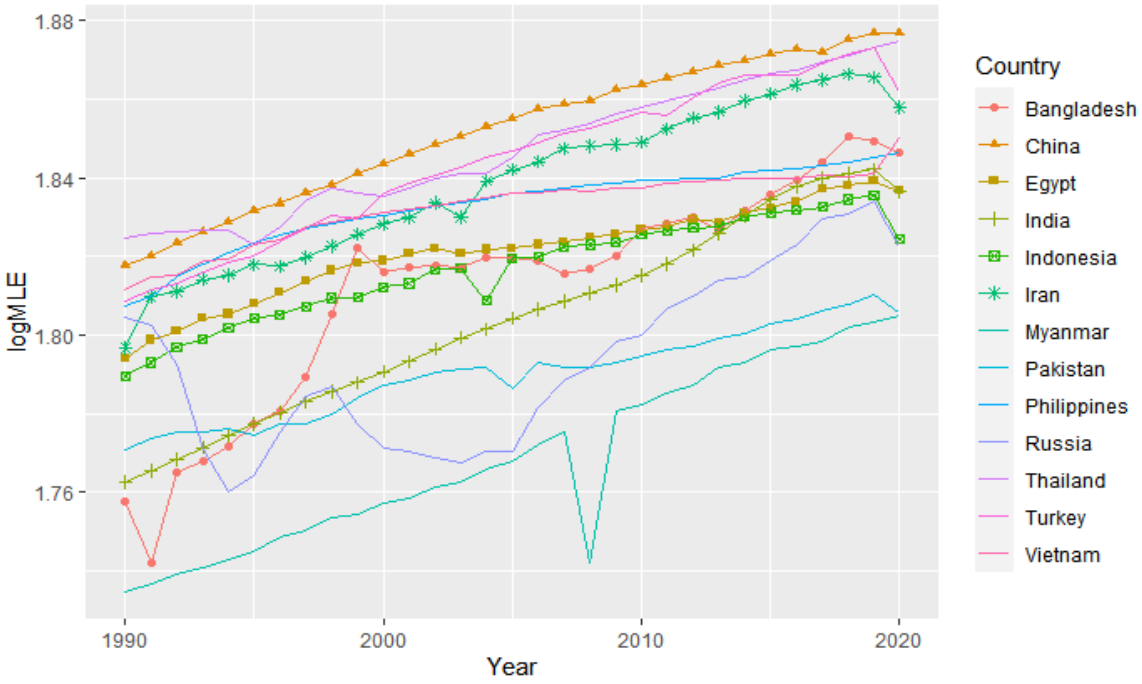

Figure 2. Trends of MLE in 13 OBOR countries

Figure 3 shows the trends of FLE in 13 OBOR countries. It is also similar to trends of TLE, but FLE is significantly higher than MLE in some countries. FLE in Russia is higher than in other countries and has been steadily increasing, and it increased very rapidly in Bangladesh between 1990 and 2020.

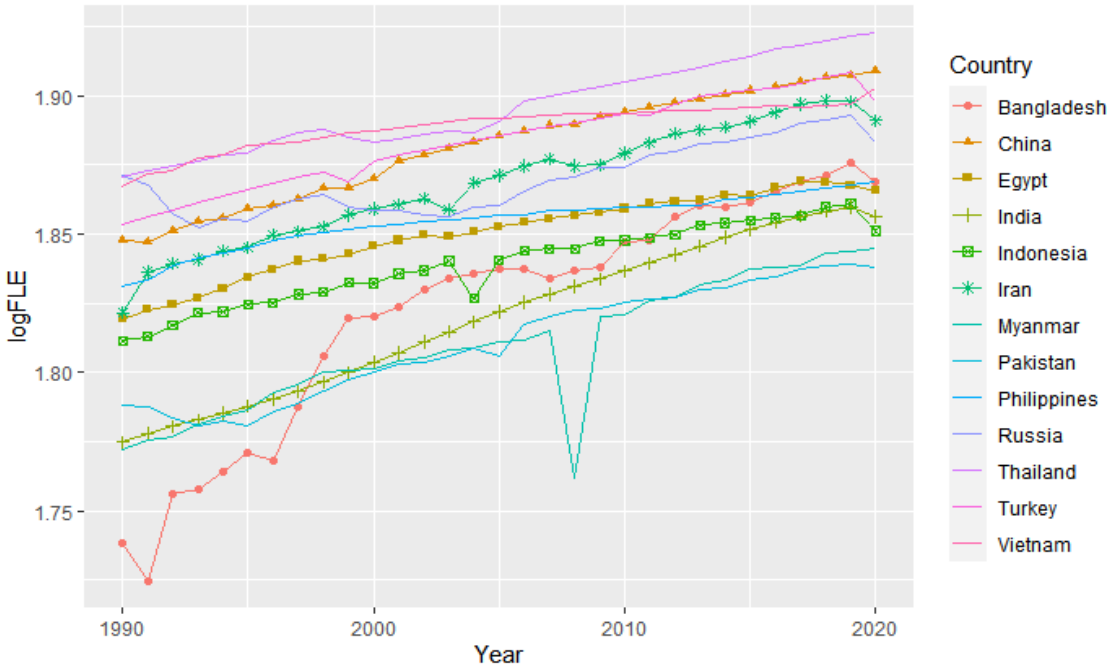

Figure 3. Trends of FLE in 13 OBOR countries

Figure 4 shows the trends of GDP in 13 OBOR countries. GDP is gradually increasing in all countries. In 1990, Vietnam had the lowest GDP of all countries, but it grew very rapidly over the next 30 years, surpassing almost half of the countries by 2020. Russia, Indonesia, and Myanmar experienced a significant decline around 1998, followed by a gradual increase. This is probably closely related to the economic crisis of that year.

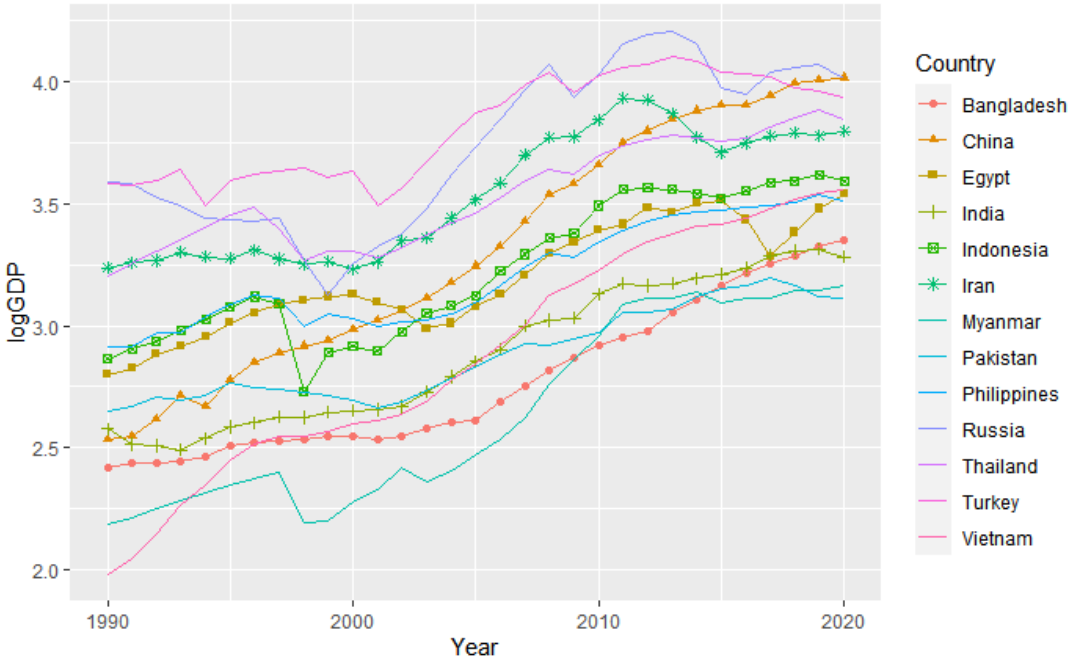

Figure 4. Trends of GDP in 13 OBOR countries

3.2. Variation of Life Expectancy and GDP between 1990 and 2020

As shown in Table 1, this study compares the changes in TLE, MLE, FLE and GDP between 1990 and 2020 in 13 OBOR countries.

Table 1. Comparison of LE and GDP in 13 OBOR countries

Country	Total (Male/Female) Life Expectancy			GDP Per Capita		
	1990	2020	Variation	1990	2020	Variation
Bangladesh	55.99 (57.21/54.76)	71.97 (70.19/73.96)	15.98 (12.98/19.20)	262.60	2231.27	1968.68
China	68.01 (65.71/70.42)	78.08 (75.31/81.06)	10.07 (9.59/10.63)	342.00	10307.70	9965.70
Egypt	64.15 (62.23/65.97)	70.99 (68.67/73.39)	6.84 (6.44/7.42)	629.12	3457.21	2828.09
India	58.65 (57.88/59.54)	70.15 (68.62/71.82)	11.50 (10.74/12.29)	378.13	1913.66	1535.53
Indonesia	63.18 (61.60/64.79)	68.81 (66.75/70.98)	5.63 (5.14/6.19)	731.79	3894.27	3162.48
Iran	64.37 (62.61/66.32)	74.83 (72.10/77.82)	10.47 (9.49/11.50)	1727.14	6228.13	4500.98
Myanmar	56.66 (54.29/59.18)	66.80 (63.79/69.96)	10.14 (9.50/10.78)	153.94	1465.99	1312.05
Pakistan	60.07 (58.98/61.41)	66.27 (63.95/68.83)	6.20 (4.96/7.42)	447.66	1292.94	845.28
Philippines	65.91 (64.15/67.76)	72.12 (70.24/74.00)	6.21 (6.10/6.24)	820.49	3224.42	2403.94
Russia	68.89 (63.73/74.30)	71.34 (66.49/76.43)	2.45 (2.76/2.13)	3878.65	10227.92	6349.27
Thailand	70.45 (66.76/74.20)	79.27 (74.95/83.70)	8.83 (8.19/9.49)	1601.72	6998.54	5396.82
Turkey	67.71 (64.36/71.41)	75.85 (72.77/79.06)	8.14 (8.42/7.65)	3820.96	8561.06	4740.10
Vietnam	69.21 (64.76/73.70)	75.38 (70.79/79.92)	6.17 (6.03/6.22)	96.72	3586.35	3489.63

Results show that Bangladesh is the country with the highest increase in MLE (12.98), FLE (19.20), and TLE (15.98), while Russia is the country with the lowest increase (2.76, 2.13, 2.45). China is the country with the highest change (9965.70) in GDP, while Pakistan is the country with the lowest change (845.28).

3.3. Correlation between Life Expectancy and GDP

In this study, the immediate and lagged correlation between LE and GDP in 13 OBOR countries was conducted every 10 years starting from 1990, and lagged correlation was also conducted for the 30 years from 1990 to 2020. The results of immediate correlation show that MLE is only correlated with GDP in 2020, while FLE and TLE are correlated with GDP in 2000, 2010, and 2020. The lagged correlation analysis only found that MLE is lag correlated with GDP in 2000-2010. Detailed results are presented in Table 2.

Table 2. Immediate and lagged correlation between LE and GDP in 13 OBOR countries

Year	logMLE and logGDP	logFLE and logGDP	logTLE and logGDP
1990	8.777	5.468	6.957
2000	6.926	7.945*	8.724*
2010	8.069	10.294***	10.170*
2020	9.031*	9.427***	9.806**
1990-2000	5.296	2.723	4.145
2000-2010	13.041*	-1.704	8.499
2010-2020	6.133	12.075	10.098
1990-2020	4.644	2.481	3.348

*: p-value < 0.05, **: p-value < 0.01, ***: p-value < 0.001

3.4. Regression Analysis of Life Expectancy and GDP

The regression results are as table 3 shows.

Table 3. Regression analysis between LE and GDP in 13 OBOR countries

Year	X	*B*	Std. Error	*t*	R^2	*F*
1990-2000	logMLE	7.361***	1.127	6.53	0.2269	42.67
	Intercept	-10.351***	2.030	-5.10		
	logFLE	6.309***	0.767	8.23	0.3197	67.74
	Intercept	-8.658***	1.405	-6.16		
	logTLE	7.471***	0.940	7.95	0.3047	63.24
	Intercept	-10.668***	1.707	-6.25		
2000-2010	logMLE	7.452***	1.133	6.58	0.2294	43.27
	Intercept	-10.406***	2.062	-5.05		
	logFLE	9.601***	0.866	11.09	0.4622	123.00
	Intercept	-14.651***	1.606	-9.12		
	logTLE	9.659***	1.018	9.49	0.3856	90.12
	Intercept	-14.591***	1.870	-7.80		
2010-2020	logMLE	9.041***	0.948	9.54	0.3880	91.03
	Intercept	-13.073***	1.742	-7.51		
	logFLE	10.214***	0.684	14.94	0.6100	223.10
	Intercept	-15.590***	1.281	-12.17		
	logTLE	10.431***	0.803	12.98	0.5413	168.60
	Intercept	-15.811***	1.491	-10.61		
1990-2020	logMLE	10.220***	0.593	17.23	0.4241	297.00
	Intercept	-15.392***	1.079	-14.27		
	logFLE	9.751***	0.447	21.84	0.5421	476.80
	Intercept	-14.871***	0.828	-17.96		
	logTLE	10.755***	0.511	21.05	0.5239	443.30
	Intercept	-16.549***	0.938	-17.64		

*: p-value < 0.05, **: p-value < 0.01, ***: p-value < 0.001

This study makes the regression analysis of MLE, FLE, TLE and GDP for every decade and the whole three decades from 1990 to 2020. It is manifest from Table 3 that all coefficient estimates are statistically significant ($p < 0.001$). In 2010-2020, about 61.00% of the variability in GDP can be explained by FLE.

4. Conclusion

This study explores the relationship between life expectancy and GDP per capita in main Belt and Road countries using a linear regression model. Due to the limited amount of data, this paper only studied 13 countries with populations above 50 million in 1990-2020 and did not include other OBOR countries. Therefore, the representativeness of the findings may be inadequate and needs to be treated with caution when making extrapolations. However, the present study is still of great value and innovation. First of all, to the best of our knowledge, this study is the first study on the correlation between LE and GDP in main OBOR countries, and the results of this study will be the starting point for public attention on the health status of people in OBOR countries, which will lay the foundation for more studies to follow. Secondly, this paper conducted both immediate and lagged correlations between MLE, FLE, TLE and GDP, and found that the lagged correlation effect was not significant, which may be due to the large heterogeneity among countries, suggesting that this paper should expand the sample size and include more data for the study. Finally, this paper confirmed that there is a positive correlation between MLE, FLE, TLE and GDP, which can be used as a theoretical basis and a realistic reference for other related studies. Life expectancy is closely related to the level of individual, family and society, and is influenced by various factors such as political, economic, cultural and medical, etc. Further study should systematically explore the effective influencing factors of life expectancy in Belt and Road countries based on mature theoretical models such as health ecology, and formulate targeted policy recommendations for improving people's health in developing countries.

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