Comparing Concurrent Relationship Predictions between Higher Education Expansion and Economic Growth in China and India

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Abstract

Education has become an important component of driving the economic growth in a competitive world. Out of curiosity about the two largest developing countries, this study selects China and India as research targets to determine the concurrent relationships between their higher education expansion and economic growth. The series data in terms of gross enrollment ratio (GER) of higher education and gross domestic product (GDP per capital) in China and India from 1973 to 2018 are collected from the World Bank. This study demonstrates the ARIMAX to estimates the concurrent relationships between the GER and GDP per capital for both countries. According to the fittest model, the results show the GER of higher education in China and India is positively correlated with GDP per capital. The result reveals the expansion of higher education is closely related to the economic growth in the target countries. Our prediction trends suggest the GER of higher education in China will increase rapidly leading by economic growth, while India won't.

Keywords: ARIMAX, Expansion of Higher Education, Economic Growth, Gross Enrollment Ratio (GER), Gross domestic product (GDP per capital)

1. Introduction

Over the past 30 years, the global economy has undergone rapid changes. China and India are the two most populous countries in the world. According to a recent Goldman Sachs report, "in the next 50 years, Brazil, Russia, India and China – BRIC economies, could become a greater force in the world economy,' and India and China could become the world third largest and fourth largest economy in the next four decades. Rising from poverty, backwardness and failed policies to a powerful economically powerful nation (Kochhar, R. 2015). The main purpose of expanding higher education in China and India is to revitalize the economy and accumulate talents for future economy prosperity. The expansion of higher education means an increase in the total number of educational opportunities (L. Wu et al. 2010). The Chinese government has included the expansion of higher education as part of its economic revitalization plan in 1999. Most of China's higher education institutions are dominated by public institution (K. Roy et al. 2012).

In India, private higher education institutions play an important role in expanding higher education. The inequality of representation in higher education in India is mainly due to inequality at the lower level of the education ladder , followed by the inequality of access to higher education (S. K. Kotásková et al. 2018).

The purpose of this study is to explore the correlation between the expansion of higher education and economic growth in China and India from 1973 to 2026. The study selects China and India as examples to explore the simultaneous relationship between the expansion of higher education and economic growth. In this study, the expansion of higher education refers to the gross enrollment ratio (GER) and the economic growth refers to gross domestic product (GDP) per capital. Given this purpose, the study is going to explore the following research questions:

1. What were the trends of higher education expansion and economic growth in China and India in past decades?

2. What is the relationship between the expansion of higher education and economic growth in China and India?
3. What are the trends of China's and India's economic growth influence on expanding higher education in the next six years?

The study collected data of GER and GDP of China and India to explore the topic. The rest of the study is as follows: the section 2 will explain the research methods in this study; the section 3 is the research results which discussion the relationship between GER and GDP and their future trends of GER and GDP will be estimated; the section 4 will conclusion of the study.

2. Method.

According to the data of the World Bank from 1973 to 2018, this study selected gross enrollment rates (GER) in higher education and gross domestic product (GDP) per capital in the China and India to determine the synchronous relationship and future trends.

2.1 Logic of Cross Correlation Function.

This study clarifies the meaning of two series of data sets, which are used to build concurrent relationship in the predication model. Is X driven by Y or Y is driven by X? What do they reflect in the real situation? Then, using cross correlation function (CCF) to test the series. When CCF exists in two series, it can build prediction model through transfer function (H.-C. Chang Tzeng et al. 2019). The CCF is the degree of similarity between two times series in different times or space which the lag can be considered when time is under investigation. To simplify, when we conducted CCF, some basic properties should be considered. Usoro argued, for Xt and Yt, the properties hold in CCF may reflect ρxy(h) ≤ 1, ρxy(h) = ρx($-h$), or ρxy(0) ≠ 1. Furthermore, Mardia and Goodall defined separable CCF as Cij($X1$,$X2$) = ρ($X1$,$X2$)aij, where A = [aij] is a $p \times p$ positive definite matrix and ρ($X1$,$X2$) is a valid correlation function. Given two processes $X1tandX2t$, ($X1t$,$2t+k$) is the cross correlation between $X1tandX2tatlagk$, while, ρ($x2t$,$x1t+k$) is the cross correlation between $X2tandX1tatlagk$ (A. E. Usoro 2015).

2.2. Building Fitted ARIMAX Model.

The study assumes that there are two sequences expressed as Yt and Xt, both of which are stable. Then, the transfer function model can be written as follows:

•yt = C + ν(B)xt + Nt

where: yt is the output series (i.e. dependent variable), xt is the input series (i. e. independent variable), C is a constant term, Nt is the disturbance (i.e. the noise series of the system that is independent of the input series). ν(B)xt is the transfer function (or we called impulse response function), which allows x to influence y via a distributed lag. B is a backshift operator thus we can write as (G.E.P. Box et al. 2008 & D. Peter et al. 2012):

•ν(B)xt = (ν0 + ν1B + ν2B2 + ...) xt

This study was calculated using the Social Science Statistic Set (SPSS). The information in the recommendation model is display in the result section. In the comprehensive comparison of the different models, this study selected Stationary with a higher value and RMSE, MAPE, MAE, MaxAPE, MaxAE, Normalized BIG with smaller value are selected. Ljung-Box Q (18) is not significant. ARIMAX (1,1,2) is the best model of China and ARIMAX (3,1,1) is the best model of India.

3. Results.

3.1. The trends of GER and GDP in China and India from 1973 to 2018.

The Scholar M. Trow (1973) mentioned the expansion of higher education from the elite stage (stage 1) to the mass stage (stage 2), with a gross enrollment rate of at least 15% and then 50% in the universal stage (stage 3). Based on the scholar Trow's theory, this study divides the expansion of higher education into three stages in Figure 1. The following three stages to explain the expansion of higher education and the evolution of GDP from 1973 to 2018.

3.1.1. The trend of GER and GDP in China (1973-2018). Follow the adoption of the Private

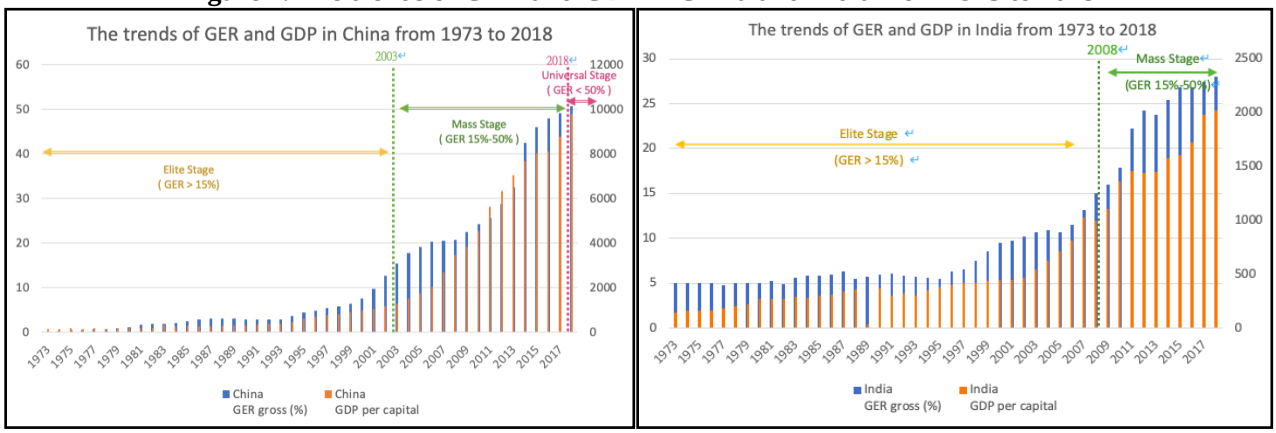
Education Promotion Act of 2003, the number of private higher education institutions offering formal courses rapidly to 278 in 2008. Higher education system entered the mass stage in 2003, entering universal stage in 2018. In 2018 (Universal stage), the gross enrollment ratio of higher education was 50.6, it has grown 35.1 percent since 2003 (mass stage). China's gross domestic product (GDP) increased by 102.9 percent from $US1657.23 billion in 2002 to $US 336.2 billion in 2008. China's GDP has grown rapidly since higher education system entered the mass stage.

3.1.2. The trend of GER and GDP in India (1973-2018). Figure 1 shows that the

gross enrollment ratio of higher education was 28.061 in 2018, only 21.5 percent grew from 1996 to 2018. India's GDP grew from $US573.79 billion in 2002 to $US107.26 billion in 2008, an increase of 87.7 percent.

Between 2000 and 2018, the average growth rates of China and India were 8.8 percent and 1.6 percent respectively. Although China's and India's GDP have been growing continuously, there is no evidence that much of this can be attributed to the expansion of higher education.

Figure 1. The trends of GER and GDP in China and India from 1973 to 2018



3.2. Forecasting the GER of higher education with GDP.

Table 1 shows the GER in higher education and GDP per capital of China and India respectively. The correlation coefficients from lag7 to lag -7 were significant different. Based on the significance of CCF of this series, this study will establish a fitting predication model for the transfer function of the data of the two series. Since the CCF of GER and GDP per capital are positive, the relationship between them can be GER driven by GDP or GDP driven by GER. The determination will be based on the result in Figure 2 and the parameters in ARIMAX model

TABLE 1. Coefficients of cross correlation for GER and GDP in China and India

Lag	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
Cross Correlation	.419	.491	.567	.642	.717	.790	.866	.950	.910	.866	.821	.771	.721	.668	.620
Std. Error[a]	.160	.158	.156	.154	.152	.151	.149	.147	.149	.151	.152	.154	.156	.158	.160
Lag	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
Cross Correlation	.537	.611	.668	.723	.769	.812	.861	.905	.842	.764	.701	.629	.557	.493	.431
Std. Errora	.160	.158	.156	.154	.152	.151	.149	.147	.149	.151	.152	.154	.156	.158	.160

Figure 2. Significances of CCF between GDP and GER in China and India

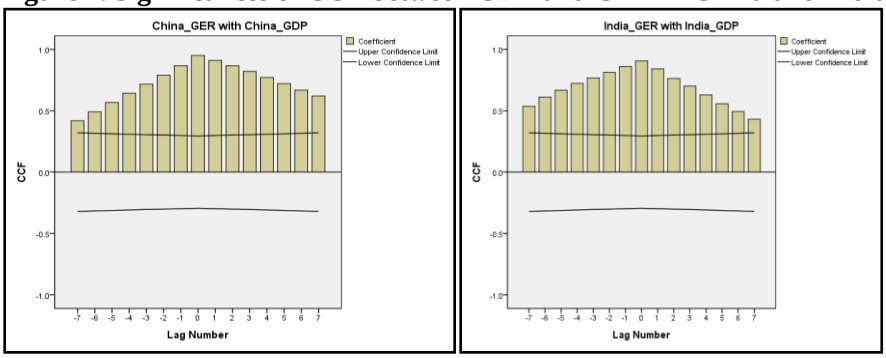


Table 2 shows the estimated errors in our proposed models. This study estimated the smooth R2, R2, RMSE, MaxAPE, MaxAE, nominalized BIC. According to the optimal model selection of SPSS, the study established ARIMAX (1,1,2) in China and ARIMAX (1,1,1) in India. Both of Ljung-Box Q (18) statistics show that the errors in predict model is not significant., which implies they are in while noise. The predicted models work well.

Table 2. Comparison of the errors in estimations

The statistical estimations for ARMAX (1,1,2) in China		The statistical estimations for ARMAX (1,1,1) in India	
Smooth R-squared	.281	Smooth R-squared	.103
R-squared	.993	R-squared	.990
RMSE	1.345	RMSE	.829
MAPE	6.638	MAPE	4.513
MAE	.722	MAE	.475
MaxAPE	25.199	MaxAPE	19.209
MaxAE	4.094	MaxAE	3.210
Normalized BIC	1.118	Normalized BIC	.141
Ljung-Box Q(18) Statistics with df 16	16.212 (p=.438)	Ljung-Box Q(18) Statistics with df 16	14.75 (p=.543)

The parameters of ARIMAX (1,1,2) show that GDP per capital can be used to as the denominator of GER. The estimated GER of AR (1) shows that the parameter -.399 works well (p=.031) in the predicted model, see Table 3. The result reveals the GDP in this model plays an import leading role. The result of time series plot of GER for China has displayed in Figure 3. As the prediction, the GER of China will increase steadily in the future.

Table 3. The parameters of ARIMAX (1,1,2) in China

ARIMAX (1,1,2) China					Estimate	SE	*t*	*p.*
GER	GER	log	Constant		.122	.025	4.839	.000
			AR	Lag 1	-.399	.178	-2.241	.031
			Difference		1			
			MA	Lag 1	-.912	.949	-.962	.343
				Lag 2	-.994	2.059	-.483	.632
	GDP	log	Numerator	Lag 0	-.178	.045	-3.909	.000
				Lag 1	.071	.050	1.427	.162
			Difference		1			
			Denominator	Lag 1	.156	.098	1.583	.122
				Lag 2	-.867	.102	-8.500	.000

The parameters of ARIMAX (3,1,1) show that GDP per capital can be used to as the denominator of GER. The estimated GER of AR (3) shows that the parameter .346 works well (p=.041) in the predicted model, see Table 4. The result of time series of India's GER are displayed in Figure 3. As the prediction, the GER of India will increase in the future, while the leading role of GDP is unclear in ARIMAX(3,1,1).

Table 4. The parameters of ARIMAX (3,1,1) of India

ARIMAX (3,1,1) India					Estimate	SE	t	p.
GER	GER	log	Constant		.039	.018	2.115	.041
			AR	Lag 3	.346	.163	2.124	.041
			Difference		1			
			MA	Lag 1	-.335	.163	-2.051	.048
	GDP	log	Numerator	Lag 0	-.012	.007	-1.675	.103
				Lag 3	.017	.007	2.322	.026
			Difference		1			
			Denominator	Lag 1	-.875	.094	-9.270	.000

4. Conclusions

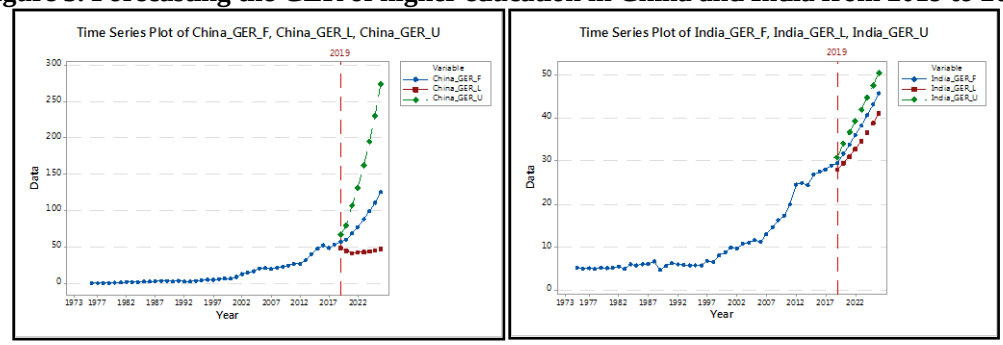
This study shows an example of ARIMAX construction to deal with time series data sets with concurrent relationships. Although the quantification method is usually limited by specific data sets, the trend provides a vertical perspective to examine the impact of GDP per capital on the expansion of higher education from the perspective of overall economic growth rate.

As the prediction, the GER of higher education in China will increase rapidly, especially, the GER will exceed 100 percent after 2023 in Table 5. In contrast, the GER of higher education in India is relatively slow. Table 5 shows that higher education in India is still in the mass stage (GER 15%-50%).

Table 5. Predicting the GER of higher education in China and India from 2019 to 2026

Year	Forecast GER for China	China_up	China_low	Forecast GER for India	India_up	India_low
2017	57.102	48.345	67.011	28.576	25.043	32.475
2018	60.269	44.457	80.011	29.605	23.635	36.656
2019	68.868	41.858	107.37	30.676	22.934	40.256
2020	77.395	42.139	131.418	31.791	21.894	44.762
2021	88.472	43.276	162.626	33.144	20.998	49.998
2022	99.283	44.311	194.755	34.588	20.380	55.281
2023	111.02	45.501	230.835	36.112	19.788	61.049
2024	125.382	47.474	274.684	37.777	19.268	67.389
2025	142.578	50.082	327.695	28.576	25.043	32.475
2026	160.759	52.619	386.001	29.605	23.635	36.656

Figure 3. Forecasting the GER of higher education in China and India from 2019 to 2026



As China and India will become the major economic centers in the world, higher education has also become an important part of national development. The result reveals the expansion of higher education is closely related to the economic growth of the target countries. Our prediction trends suggest the GER of higher education in China will increase rapidly with economic growth, while India will not. The findings will provide useful information for related policy makers. This study provides an example of processing time series data set with concurrent relationships. For further studies, this study suggests selecting fitted concurrent series data for ARIMAX which can be used to tackling the similar issues in other settings.

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