ATLANTIS PRESS
Advances in Computer Science Research, volume 93
2nd International Conference on Mathematics, Modeling and Simulation Technologies and Applications (MMSTA 2019)

Predicting the Concurrent Relationships between GDP and GER Expansion in Japan and Korea by Using ARIMAX

Tien-Li Chen[1] and Dian-Fu Chang[2,*]
[1]Doctoral Program of Educational Leadership and Technology Management, No. 151, Yingzhuan Road, Tamsui District, New Taipei City 25137, Taiwan
[2]Graduate Institute of Educational Policy and Leadership, Tamkang University, No. 151, Yingzhuan Road, Tamsui District, New Taipei City 25137, Taiwan
[*]Corresponding author

***Abstract*—The return rates of investments in education have been estimated for a long time. The related advantaged linkage between extending higher education participation and economic growth has been spreading around the world. While the global expansion phenomena in higher education are not persistent to their economic growth as the policy makers expected. Curious the relationships between higher education expansion and economic growth, this study selected Japan and Korea as the research targets to determine their concurrent relationships. Based on the World Bank data set, the GER (gross entrance ratio) and GDP (gross domestic product) per capita in Japan and Korea were collected from 1971 to 2016. ARIMAX (multivariate autoregressive integrated moving average) was conducted to estimate the effect of concurrent relationships between GER and GDP per capital. Based on the fittest model, we predict the GER with GDP per capital for next decade. The result demonstrates that the GER and GDP per capital in Japan and Korea with positive correlation. Based on the trends, the predicted GER of higher education in Japan will increase, while Korea will decrease significantly in next decade.**

Keywords—ARIMAX; concurrent relationship; GDP; GER; higher education

I. INTRODUCTION

The benefits of higher education are not just for individuals, but society as well. According to the World Bank Group report, higher education graduates have become the highest in the entire education system. Typically, the students with higher education degree will increase 17 percent in earning as compared with primary and secondary graduates [1]. For example, a student with a higher education degree in Latin America and the Caribbean will earn more than twice as much as a student with just a high school diploma [2]. Not only individuals, but various countries believe that the higher education and economic growth with a close relationship. Expectation for expanding higher education to extend economic growth has become an optimal policy design in numerous countries. Japan and Korea with leading development in Asia could be interesting cases in this field. Both Japanese and Korean higher education have experienced their expansion in last decades. Even though the expansion led by private universities, the patterns of economic growth have shaped differently between the two countries. Whether these relationships are concurrently existed in their time series data or not? It needed to be estimated properly with fitted models. Moreover, facing uncertain future, can we still predict these concurrent relationships between higher education expansion and economic growth? Therefore, the study selected Japan and Korea as examples to tackle their concurrent relationships between higher education expansion and economic growth. Specifically, the higher education expansion refers to the gross entrance ratio (GER). The economic growth refers to the gross domestic product (GDP) per capital. Given this purpose, this study will explore the following research questions:

- What are the trends on higher education expansion and economic growth in Japan and Korea in last decades?
- What are the relationships between higher education expansion and economic growth in Japan and Korea?
- Which model can be used to estimate the trends of GER expansion in next decade?

In this study, we collected series data with GER and GDP per capital from Japan and Korea to explore the topic. The rest of the paper is organized as follows: First, the trends of GDP per capital and GER in Japan will be addressed. Next, the trends of GDP per capital and GER in Korea will be presented. Third, we will explain how the method be employed. Fourth, the result of concurrent relationships and their future trends will be estimated. Finally, the conclusion will be drawn.

II. THE TRENDS OF GDP PER CAPITAL AND GER IN JAPAN

Based on the data from 1971 to 2016 in Japan, the GER in higher education has experienced over 15% before 1971, implying the system entered the mass higher education stage [3]. For the past 30 years, the GER was over 50% in 2002, Japan's higher education system has moved to universal stage now. According to previous trends, the development of GDP per capital is not exactly accompanied with that of the GER, see Figure 1. The GDP per capital has experienced growth rapidly from 1986 to 1996 in Japan. While the Japanese had been a long economic depression after the collapse of bubble economy in 1980s. Most of the higher education expansion might contribute from private sector during these periods. The Japanese government began to launch new public management during the economic depression to reverse the economic downturn [4]. The relationships between GER and GDP per capital is unknown. Similarly, can GDP lead GER or GER lead GDP is unknown in this case.

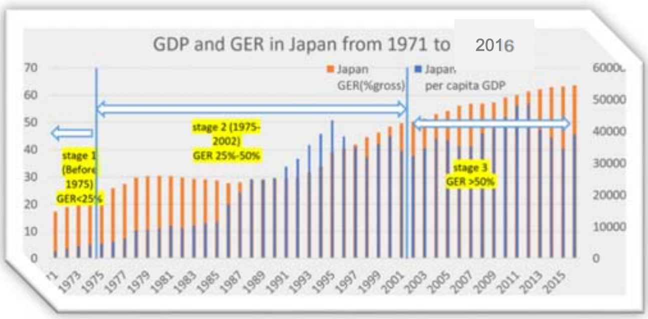


FIGURE I. THE TRENDS OF GER AND GDP PER CAPITAL IN JAPAN (1971 TO 2016)

III. THE TREND OF GDP PER CAPITAL AND GER IN KOREA

Higher education institutes in Korea has experienced an unprecedented expansion in last two decades. For expanding the opportunities of participation, private sector has shown played a heavily role in Korean higher education system [5]. Currently, there are 189 higher education institutes which provides 2,084,807 enrollments [6]. In Korea, the GER has reached to 15% in 1981 and moved over 50% in 1995. The expansion in higher education is amazed. The GER reached to 85% in 2003, is growing rapidly to increase another 35% in 8 years. In 2008, the GER even exceeded 100%. The economic growth has shown fluctuated in past decades, while the GDP per capital is steadily growth, see Figure 2. While which one can lead the other one? It needs more accurately method to estimate the relationship.

FIGURE II. THE TRENDS OF GER AND GDP PER CAPITAL IN KOREA (1971 TO 2016)

IV. METHODS

Based on the data of the World Bank from 1971 to 2016 [3], this study selected the GER and GDP per capital in Japan and Korea to determine their concurrent relationships and future trends. ARIMAX (multivariate autoregressive integrated moving average) was used to interpret the effect of GDP per capital on higher education expansion or higher education expansion on GDP per capital in these two countries.

A. *Logic of Cross Correlation Function*

First, we clarify the meaning of two series data sets for building concurrent relationships in predicted models. Whether X is driven by Y or Y is driven by X? What do they reflect in the real situation? Second, using cross correlation function (CCF) to test the series. When the CCF in both series existed, it can go through the transfer function to build predicting models [7]. 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 X_t and Y_t, the properties hold in CCF may reflect $\rho_{xy(\square)} \leq 1$, $\rho_{xy(\square)} = \rho_{x(-h)}$, or $\rho_{xy(0)} \neq 1$ [8]. Furthermore, Mardia and Goodall defined separable CCF as $C_{ij}(X_1,X_2) = \rho(X_1,X_2)a_{ij}$, where $A = [a_{ij}]$ is a $p \times p$ positive definite matrix and $\rho(X_1,X_2)$ is a valid correlation function [16]. Given two processes X_{1t} *and* X_{2t}, $(X_{1t,2t+k})$ is the cross correlation between X_{1t} *and* X_{2t} *at lag* k, while, $\rho(x_{2t,x1t+k})$ is the cross correlation between X_{2t} *and* X_{1t} *at lag* k [9].

B. *Building Fitted ARIMAX Model*

We assume two series denoted y_t and x_t, which are both stationary in this study. Then, the transfer function model can be written as follows:

$$y_t = C + \nu(B)x_t + N_t \tag{1}$$

where: y_t is the output series (i.e. dependent variable), x_t is the input series (i. e. independent variable), C is a constant term, N_t is the disturbance (i.e. the noise series of the system that is independent of the input series). $\nu(B)x_t$ 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 [10-13]

$$\nu(B)x_t = (\nu_0 + \nu_1 B + \nu_2 B^2 + \ldots)\, x_t \tag{2}$$

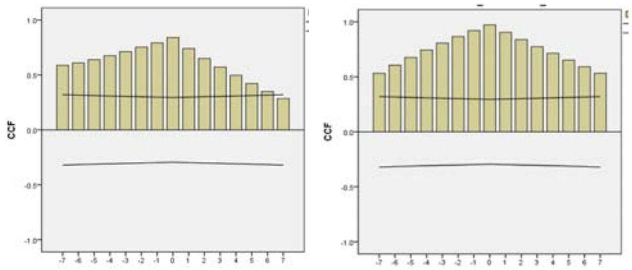
In this study, the calculation will be conducted by using statistical package for social science (SPSS). The related information in the proposed models will be display in result section.

V. RESULTS

Table 1 demonstrates the CCF with GER and GDP per capital in Japan and Korea respectively. The coefficients of cross correlation are significant differences from lag 7 to lag -7. Based on the CCF of the series are significant, this study will conduct the transfer function for both series data to building fitted predict models. Since the CCF of GDP and GER per capital are positive, the relations between them could be GDP per capital led GER or GER led GDP per capital. The judgment will base on the result in Figure 3 and the parameters in the ARIMAX models.

TABLE I. COEFFICIENTS OF CROSS CORRELATION FOR GDP AND GER IN JAPAN AND KOREA

Lag	-5	-4	-3	-2	-1	0	1	2	3	4	5
Cross Correlation	.639	.675	.712	.753	.792	.841	.740	.650	.572	.497	.422
Std. Error[a]	.156	.154	.152	.151	.149	.147	.149	.151	.152	.154	.156
Lag	-5	-4	-3	-2	-1	0	1	2	3	4	5
Cross Correlation	.676	.743	.806	.866	.920	.972	.905	.839	.774	.714	.652
Std. Errora	.156	.154	.152	.151	.149	.147	.149	.151	.152	.154	.156



Japan Korea

FIGURE III. SIGNIFICANCES OF CCF BETWEEN GDP AND GER IN JAPAN AND KOREA

The estimated errors displayed in Table 2. In this study, the smooth R^2, R^2, RMSE, MaxAPE, MaxAE, nominalized BIC have been estimated. According to the SPSS's model fittest selection, ARIMAX(2,1,1) for Japanese and Korean series data are fitted. Both Ljung-Box Q(18) statistics showed that the errors in predict models are not significant. It is implied they are while noise. The predicted models could work well.

TABLE II. COMPARISON OF THE ERRORS IN ESTIMATIONS

The statistical estimations for ARMAX(2,1,1) in Japan		The statistical estimations for ARMAX(2,1,1) in Korea	
Smooth R-squared	.473	Smooth R-squared	0.546
R-squared	.996	R-squared	0.994
RMSE	.969	RMSE	2.83
MAPE	1.721	MAPE	3.306
MAE	.640	MAE	1.531
MaxAPE	7.630	MaxAPE	15.469
MaxAE	2.984	MaxAE	10.443
Normalized BIC	.462	Normalized BIC	2.605
Ljung-Box Q(18) Statistics with df 16	16.860 (p=.395)	Ljung-Box Q(18) Statistics with df 16	15.259 (p=0.506)

The parameters of ARIMAX(2,1,1) with log in the series of Japan demonstrates that GDP per capital can be as the denominator for predicting GER. The estimated GER with AR(2) shows that the parameter .462 works well (p=.007) in the predicted model, see Table 3. The result of time series plot of GER for Japan has displayed in Figure 4. As the prediction, the GER in the future will increase steadily. The reasonable GER increasing in Japan is still acceptable under declining birthrate.

TABLE III. THE PARAMETERS OF ARIMAX(2,1,1) IN JAPAN

ARIMAX(2,1,1) in Japan					Estimated	SE	*t*	*p.*
GER	GER	log	Constant		.010	.017	.581	.565
			AR	Lag 2	.462	.163	2.833	.007
			Difference		1			
			MA	Lag 1	-.552	.155	-3.572	.001
	GDP	log	Numerator	Lag 0	.059	.038	1.551	.130
				Lag 2	-.004	.050	-.085	.933
			Difference		1			
			Denominator	Lag 1	.738	.305	2.421	.021

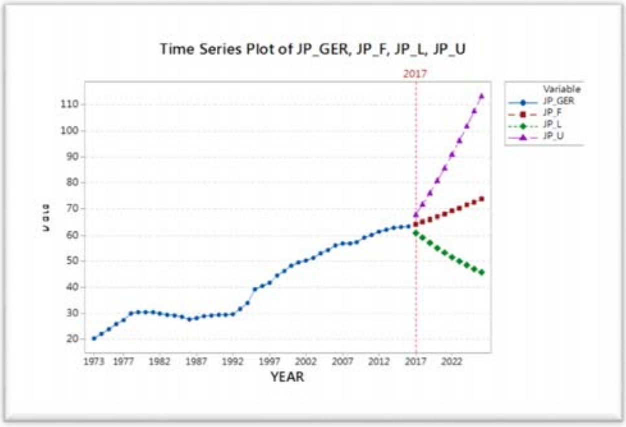


FIGURE IV. TIME SERIES PLOT OF GER FOR JAPAN

Table 4 reveals the parameters of ARIMAX(2,1,1) with log in the series of Korea. The result demonstrates that GDP per capital can be as the denominator for predicting GER, while the GDP per capital did not fit to the numerator. Both lag 0 and lag 2 are not significant for GDP on .05 level. The details of estimating the parameters show in Table 4. The result of time series plot of GER for Korea has displayed in Figure 5. In the future, the GER will drop significantly. Therefore, the system might suffer the oversupply.

TABLE IV. THE PARAMETERS OF ARIMAX(2,1,1) IN KOREA

ARIMAX(2,1,1) in Korea					Estimated	SE	*t*	*p.*
GER	GER	log	Constant		-.149	.152	-.977	.335
			AR	Lag 2	.452	.172	2.631	.012
			Difference		1			
			MA	Lag 1	-.422	.177	-2.387	.022
	GDP	log	Numerator	Lag 0	.102	.055	1.857	.071
				Lag 2	-.049	.053	-.924	.362
			Difference		1			
			Denominator	Lag 1	.923	.059	15.691	.000

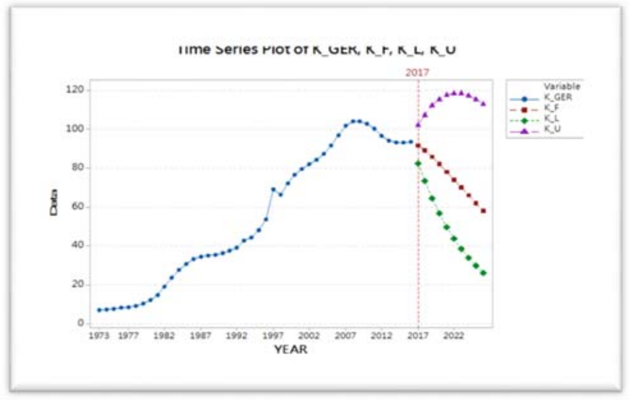


FIGURE V. TIME SERIES PLOT OF GER FOR KOREA

VI. CONCLUSIONS

This study demonstrates an example of ARIMAX building to tackle time series data sets with their concurrent relationships. Although the quantitative approach was usually limited by specific data sets, the trends provides a longitudinal perspective for reviewing the effect of GDP per capital on higher education expansion in GER term. Since the two higher education systems have faced the new crisis of declining birthrate, the cohort potential students might decrease steadily which may impact on the enrollment directly. The findings will provide useful information for related policy makers. This study provides an example to tackle 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.

REFERENCES

[1] The World Bank, Higher Education, 2017, https://www.worldbank.org/en/topic/tertiaryeducation

[2] The World Bank, Comparable Estimates of Returns to Schooling Around the World, 2014.

[3] The World Bank, School enrollment, tertiary(%gross), 2018, https://data.worldbank.org/indicator/SE.TER.ENRR?end=2016&locations=KR&start=1995

[4] H. Konyuba, 2018, Incorporation of national universities in Japan under new public management. In J. C. Shin (Ed.), Higher education governance in East Asia (pp. 21-36). Springer: Springer Nature Singapore.

[5] P. Yi, 2018. Half way toward incorporating national universities in Korea. In J. C. Shin (Ed.), Higher education governance in East Asia (pp. 37-54). Springer: Springer Nature Singapore.

[6] Korean Ministry of Education and Korean Education Development Institute (KMOE & KEDI), 2016, Statistical yearbook of education, Seool.

[7] H.-C. ChangTzeng, D.-F. Chang and Y.-H. Lo, Detecting Concurrent Relationships of Selected Time Series Data for ARIMAX Model, ICIC Express Letters Part B: Applications, vol.10, no.10, pp. 937-944, 2019.

[8] A. E. Usoro, Some basic properties of cross-correlation functions of n-dimensional vector time series, Journal of Statistical and Econometric Methods, vol.4, no.1, pp.63-71, 2015.

[9] G. E. P. Box, G. M. Jenkins and G. C. Reinsel, Time Series Analysis: Forecasting and Control, 3rd ed. Upper Saddle River, NJ: Prentice-Hall, 1994.

[10] E. Rublíková and L. Marek, Linear transfer function model for outflow rates, Ekonomické rozhľady. vol.30, no.4, pp.457-466, 2001.

[11] G. E. P. Box, G. M. Jenkins and G. C. Reinsel, Time Series Analysis: Forecasting and Control, New York, John Wiley & Sons, 2008.

[12] G. E. P. Box and G. C. Tiao, Intervention analysis with applications to economic and environmental problems, Journal of the American Statistical Association, vol.70, no.349, pp.70-79, 1975.

[13] Ď. Peter and P. Silvia, ARIMA vs. ARIMAX – which approach is better to analyze and forecast macroeconomic time series? Proceedings of 30th International Conference Mathematical Methods in Economics, pp.136-140, 2012.