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Comparing Gender Diversity in the Process of Higher Education Expansion among Japan, Korea, Taiwan, and the UK for SDG4-Education 2030

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Abstract: Ensuring equal access to affordable higher education for women and men has become a crucial target of UNESCO's SDG4-Education 2030. Currently, about one third of the world's college-age population participates in higher education, while the gender disparity persists in various systems. This study employed GDP per capita, gross entrance ratio (GER) and the gender parity index (GPI) to demonstrate how the education systems have expanded resulting in the transformation of gender parity. We select Japan, Korea, Taiwan, and UK as research targets using cross correlation function and trend analysis to detect concurrent relationships and future trends with GDP per capita, GER, and GPI. The findings suggest Japan, Korea, and the UK continue to show gender disparity and need to respond to this issue in their policy intervention for SDG4-Education 2030. The results reveal a potential problem in the UK when GPI growth might become unlimited with females dominated. This study suggests the higher education expansion phenomenon and gender diversity in mass and universal systems can be detected by the trend analysis with GDP per capita, GER, and GPI in different settings. The design of study provides an example to explore the gender diversity patterns in higher education systems for sustainable development.

Keywords: GDP per capita; Gender parity index (GPI); gross entrance ratio (GER); higher education expansion; trend analysis

1. Introduction

Higher education expansion has become a significant global phenomenon. Worldwide, the gross enrolment ratio (GER) in tertiary education increased from 10% in 1972 to 32% in 2012 and in 54 national systems, the GER reached 50%, compared to five systems twenty years before. There were 14 countries with a GER of 75% or more in the world [1]. The expanding higher education system has become one of the norms of modernization and is "pre-eminent as a social differentiator and allocator" [2,3]. Currently, about a third of the world's college-age population participates in higher education [3] but issues around gender parity persist. Higher education systems may follow rational processes to extend their numbers, with varying outcomes. For example, the GER in Japan is 63.58% and it is 59.41% in the UK, whereas it is 93.78% in Korea [4]. Following the example of the countries with high participation, the government of Taiwan has implemented an expansion policy. In Taiwan, the GER had increased to 85.31% in 2007. In view of the expansion phenomenon, a question we need to ask is whether expansion is likely to continue in the future and be unlimited. What are likely to be the consequences for the system in the case of ongoing higher education expansion?

UNESCO's World Atlas of Gender Equality in Education, published in 2012, is the clearest example of an international commitment to gender equality across and including all levels of education. The Atlas provides a vast amount of statistical information about

women and men students across the globe, relating the information to international criteria [5]. As indicated in the UNESCO Atlas, whilst there has been enormous growth in student numbers, up to a 500% increase across the globe, over the last 40 years, women have been less involved than men in higher education [6]. The gender disparity has become a persistent issue in various expanding higher education systems. As gender equality is a key feature of SDG4-Education 2030, particular attention needs to be paid to gender-based discrimination as well as to vulnerable groups to ensure that no one is excluded [7]. We are interested in the topic of gender parity as it has been determined that by 2030, men and women must have equal access to affordable and excellent technical, vocational and tertiary education, including university. This study focuses on the equal access issues in higher education settings. The question is how to evaluate the progress of the taskforce for a specific education system following the target of UNESCO's SDG4 2030. Therefore, searching for better ways to realize the gender diversity issue has become a pressing challenge.

When we reviewed gender related studies in higher education, we found previous studies have investigated this topic from widely different perspectives, generally using qualitative methods to do so. For example, Crabb and Ekberg explored the role of gender in the future career plans of postgraduate research students [8] while various studies focus on the barriers of participation [9,10]. Even though previous studies provide useful essential knowledge to realize gender issues, there are very few studies that explore gender diversity in expanding systems using fitted quantitative methods. While this may be due to a supposition that increased participation in higher education systems will eliminate gender disparity, we are still not sure of the relationship between higher education expansion and gender parity. Further, the trend analyses from cross-country comparisons have been discussed still very limited. Previous descriptive studies have provided persuasive information on the growth of GER and gender parity index (GPI), while the design of this study can offer wide pictures and future trends to interpret the phenomena. In this sense, we employed the indices data to explore gender diversity patterns in higher education expansion process. Why selected Japan, Korea, Taiwan, and the UK as high participation higher education systems to investigate their changing patterns of gender diversity? Japan, Korea, and Taiwan belong to oriental culture, while the UK has become a core country of world academic system, it can be used to represent western culture. Both Japan and the UK are mature economies, while Korea and Taiwan are neo-economies. The GER in Korea and Taiwan has reached 85% with fast speed, while the GER in Japan and the UK remains in the level of 60% [11,12]. We also consider Japan, Korea, Taiwan, and the UK belong to democratic countries, more important is the related data for gender diversity among these four countries are available. It is a little different from that of the USA and Australia. For these reasons, we selected these four countries as our research targets. This study employs an index format to highlight how gender diversity is transforming within a high expansion system. With these purposes, this study will answer the following research questions:

RQ1. To what extent is higher education expanding in the four counties?

RQ2. Has higher education expansion significantly transformed the patterns of gender diversity?

RQ3. What patterns in gender diversity trends in Japan, Korea, Taiwan, and the UK are expected?

This paper first addresses the context of higher education expansion and gender parity issues. It then provides a brief description of the research design, data transformation, and trend analysis before presenting the results of GDP per capita, GER, and GPI, respectively. After a discussion of the findings, conclusions are drawn and implications for the study are offered.

2. Literature Review

The transformation of higher education might due to economic or higher education system itself which might shape the pattern of gender diversity. Previous research on higher education expansion has moved into the direction: a focus on gender parity has become more acceptable in both the "expand out" and "expand up" system [13]. "Expand out" reflects the capacity of higher education has broadened, whereas "expand up" implies the graduate education has increased. Within the expanded higher education systems, there are various theories addressing these phenomena. This section focused on the related theories on higher education expansion and gender diversity.

2.1 Related Theories on Higher Education Expansion

Previous studies on participation in higher education have varied widely in terms of diversity and practices as shown in Trow's three-stage theory [14] and Marginson's study of high participation higher education [1,3]. World Academic System (WAS) perspectives contend that there is "a deeply entrenched stratification" in global higher education [15]. Relations between higher education institutions were argued to be marked by structural inequalities between a core (USA, UK, France), a semi-periphery (Australia, Germany, Japan), and a periphery across the rest of the world [16]. The related studies show that the expansion phenomenon has extended to most middle-income countries as well as to a significant number of low-income countries [17-20]. While the global expansion of higher education participation cannot be fully explained through the lens of a WAS characterized by unequal relations among core, semi-periphery, and periphery countries [21]. The rise of higher education outside of the traditional core of the WAS has enabled increasing higher education participation in the novel technological contexts, such as Korea and Taiwan.

The neo-institutionalism, known as sociological institutionalist approach or the world society theory, provides a conceptual framework to situate organizational change in the global cultural context [22,23]. Meyer and Bromley argued that expansion is supported by widespread cultural rationalization in a stateless and liberal global society, characterized by scientism, rights and empowerment discourses, and an explosion of education [24]. According to neo-institutionalism, the higher education expansion is deemed to reflect a global diffusion of first-order assumptions about how higher education is aligned with societal ideals about democratization and human rights, scientific and scholarly knowledge, and development planning for economic growth.

The technical-functionalism literature views the expansion of graduates as an effective policy response to the demands of modern employment by enhancing the overall skill levels of the labor force [21]. Higher education is argued to have a central role in training the next generation of young people to meet the demand for more high-skilled labors [25,26]. Hence, economic development has become an indicator that suggests the perceived need for highly educated graduates. Numerous studies offer theoretical discussions about the issue: for example, Barakat and Shields argued that "neither the human capital theory nor functionalism adequately supports the expansion policy" [27] while "the idea of credential inflation supporting the phenomenon has extended rapidly" [28]. For some young people, higher education participation may be viewed as a lifestyle choice associated with personal growth and life experiences [29]. Traditionally, the male and female are not equal pay in the labor market, this could very well have an impact on the wish/need for females to enrollment higher education. Their selection may impact the relationship between fields of study and labor market outcomes [30]. Therefore, societal expectations are accompanied by economic development which may impact the participation of different genders.

From the perspective of "survivalism", the emerging process can be viewed as a response by individuals and families to mitigate the instability inherent in work and employment as outlined in Beck's descriptions of the "risk society" [31,32]. The concept of the "risk society" makes an important contribution to explaining the decision of more young people to enter higher education, for example, increased necessity of the skills and

credentials of a degree as a means to "survive" in uncertain labor markets. Higher education is, therefore, increasingly a "defensive necessity" [28,33]. Moreover, uncertainty and fast technological changes will also affect unemployment directly, for example the 4th industrial revolution and AI replacing changing jobs [34]. The development of the high-tech economy has also been affected by educational credential inflation [35], which contributed to the participation in higher education.

2.2 Related Theories on Gender Participating in Higher Education

When gender parity has been considered in higher education expansion, the critical mass [36-38] and socio-cultural barriers theories [39-41] can be used to address this issue. As the critical mass theory, its central concept is the production function. The production function is defined as: Given the relationship between outputs of the collective good (y) and inputs of participation or contribution (x), a mathematical expression can be expressed as y = f(x). According to the model, once the number of women reaches a critical mass they will no longer be strangers [38]. Moreover, Ukpong provides supportive interpretations for this phenomenon [42]. For example, males have become a critical mass in STEM programs, while females participate in such programs could be an issue or a barrier. In practice, the related widening participation policy, which might impact the participation of disadvantaged and under-represented groups [43]. According to the theory of socio-cultural barriers, it is argued that women are confronted by these barriers when participating in STEMM (science, technology, engineering, mathematics, and medicine) programs in higher education. Basically, although science is inherently gender-blind, structural barriers have emerged that prevent gender equality and permit women to be treated as "strangers" in STEM programs [38]. The "social" and "cultural" are linked to each other in the process of higher education participation.

2.3 Contexts of Higher Education in the Target Countries

2.3.1 Higher education participation in Japan

In 2015, there were 779 universities and 346 junior colleges in Japan, comprising 86 national universities, 89 local public universities and 604 private universities. In addition, there were 328 private and 18 local public junior colleges [44]. In 2018 there were approximately 2.91 million students enrolled at Japanese universities, an increase from about 2.89 million students the previous year [45]. Before 1976, Japan's GER was stage one (below 25%); it moved to stage two (25%-50%) between 1976 and 2002, and stage three (over 50%) developed after 2002. The subsequent Act on Subsides for Private Schools in 1976 facilitated further rapid expansion of Japanese higher education [46]. Although Japan's population is stable, the percentage of college-age children is declining, with the number of high school students declining from more than five million in 1985 to under four million in 2002 [47].

In Japan, especially in the early stages of the development of a modern education system, females were at a considerable disadvantage in terms of educational opportunities available. This was despite the constitution of Japan, enacted after World War II, clearly stipulating respect for the individual and equality under the law. Since the constitution was written, Japan has pressed forward with laws in an effort to ensure gender equality and has radically improved the legal status of women [48,49]. The Basic Law for a Gender-Equal Society which came into effect in June 1999 was to promote measures at the level of the state and local governments as well as among the citizens to develop a gender-equal society [50,51]. It is an influential Act that might impact the gender participation in higher education.

2.3.2 Higher education participation in Korea

Higher education in Korea has experienced explosive expansion in the last decades. Currently, there are 189 higher education institutes at which 2,084,807 students are enrolled [52]. It took 10 years moving from elite stage to mass stage (1971 to 1981) in Korea.

A stage two GER (15%-50%) was reached between 1982 and 1996, and stage three (over 50%) in 1996. This rapid growth continued and the GER reached 85% in 2003, showing an increase of 35% within eight years. In 2008, the GER exceeded 100% [11].

With the start of the expansion of higher education in 1975, women's rights began to be questioned and the humanitarian attitude that physiological differences between males and females are no reason for social discrimination took root. During the 1970s, there was a shift in public perception of women and society began to accept that women could be competent and could pursue careers [53,54]. At the end of the 1980s, the drafting of the education policy included female education [55]. Korea have a long time of striving for gender parity in higher education. It is a little late in Korea that gender parity become the key components of equal opportunities to access higher education.

2.3.3 Higher education participation in Taiwan

Higher education in Taiwan has also expanded dramatically during the last three decades. The popularization of education has led to a rapid increase in student enrolment with the number of students increasing from 299,486 (1976) to 576,623 (1999) and the GER rising from 15% to 50% within 23 years [56]. However, the number of enrolments has levelled off in the last decade and higher education in Taiwan has gone from experiencing rapid expansion to facing serious oversupply issues [57]. To be noted, the number of births in the country has decreased from 328,461 in 1974 to 196,973 in 2016 – a decrease of 40%, according to data from Ministry of Interior's annual statistics report [58]. Given this decline, the Ministry of Education has warned that in the next few years, the declining birth rate will result in serious challenges to undergraduate enrolment in higher education [59].

Previous studies have revealed significant changes in participation according to gender during higher education expansion in Taiwan. For example, during the later GER stages, 15%–50% or over 50%, gradually more female than male students have enrolled [60], indicating that student numbers increase in higher education, the system will favor female students. The Gender Parity Act has been implemented at all levels of education in Taiwan and creating gender friendly campuses has become a critical indicator to evaluate the effectiveness of institutional leadership to implement this policy.

2.3.4 Higher education participation in the UK

According to the Implementation Report, students in the five countries with the highest number of tertiary education students (Russia, Turkey, Germany, France, and the UK) amount to 56.3% of the global total [61]. Among these countries, the UK is a unique in terms of its approach to higher education and it developed the 2003 Higher Education White Paper. The enrolment in higher education for those aged 18-30 has increased from 30% to 50% in 2013 [62]. In the UK, there are 164 higher education institutions in the system of which 136 are universities [63]. Statistics show that between 2012 and 2018, the total number of students enrolled in all types of higher education fluctuated between 2.26 million and 2.34 million. In 2017/18, there were about 2.34 million students [64]. Even though the UK remains dedicated to encouraging the aspirations of its youth, promoting equality, and implementing substantive development in education [65,66], the country may experience a shift from expansion to a decrease in tertiary enrolment.

In the process of her higher education expansion, the UK showed gender disparities in a horizontal mismatch in professional degrees [67]. In recent years, the UK-based Athena Swan and Gender Equality Charter Mark agendas have prompted universities to address gendered disparities. It is shown that although the gender gap is closing within higher education geography in the UK, there are significant ongoing gender disparities [68]. GER development in the UK may provide a unique experience in global higher education settings, both her expanding and gender parity patterns may offer good examples for developing countries to realize their higher education systems what should be and what will be.

2.4 Related Indices for Detecting Gender Issues

Gender parity reflects formal equality in terms of access to or participation in education at various levels. Various indices have been presented in current literature. First, Gender Gap Index (GGI) is one of them introduced by the World Economic Forum in 2006. It is a framework for capturing the magnitude and scope of gender-based disparities. Second, the Gender Inequality Index (GII) which examines gender inequality in three broad areas: reproductive health, empowerment, and economic activity. Specific categories are: (a) maternal mortality ratio, (b) adolescent fertility rate, (c) seats in the national parliament, (d) population with at least secondary education (female and male), (e) labor force participation rate (female and male) [51]. Third, Becker's D index can be used to evaluate gender parity. Becker defined the economics of discrimination and proposed the concept of a coefficient of discrimination [69]. It can extend the notion to detect gender diversity issue. Fourth, the Gender Equality Index (GEI_EU) is a composite indicator that is used in EU member states and measures the complex concept of gender equality over time. It measures gender gaps within a range of areas relevant to EU policy framework (work, money, knowledge, time, power, health, violence, and intersecting inequalities) and is guided by a conceptual framework [70]. Finally, the gender parity index (GPI) evaluates gender equality in higher education for a long time [71]. To standardize the effects of the population structure of the appropriate age groups, the GPI of the GER for each level of education is used.

3. Method

In this section, the research framework is first presented after which how the data have been transferred is explained. Considering the series data sets, the GDP per capita, GER, and GPI are transformed to identify their cross relationships. Using the Minitab package, a trend analysis is undertaken to project the GPI's future development in the four selected countries.

3.1 Research Framework

Based on previous expansion theories, we shaped the framework of research (Figure 1). Higher education expansion can be addressed as technical-functional, neo-institutional, a world academic system, or credential phenomena to explain. Both theory of critical mass and theory of barrier of female participating may impact the patterns of gender diversity. In addition, in the process of expansion, the growth of GDP per capita might exert significant influences. Considering the influential factors, this study developed the following assumptions:

A1: The growth of GDP per capita will impact the higher education expansion of the four countries.

A2: Both GER and GPI have high cross relationships among these target countries.

A3: The GPI will be changed in the different stages of higher education expansion of the target countries.

A4: The development of GPI will reflect the trend in 2030 regardless the culture of the countries.

With these assumptions in mind, we consider that the framework will lead the following research process: First, this study investigates the GDP per capita, GER, and GPI in the selected countries. Second, higher education in Japan, Korea, Taiwan, and the UK is reviewed according to their GER and GPI, respectively. Third, we conduct a trend analysis transforming the data and projecting future trends. Finally, the synthesis is done and related interpretations drawn. Comparisons are made of the mass, universal stages and of future stages until 2030.
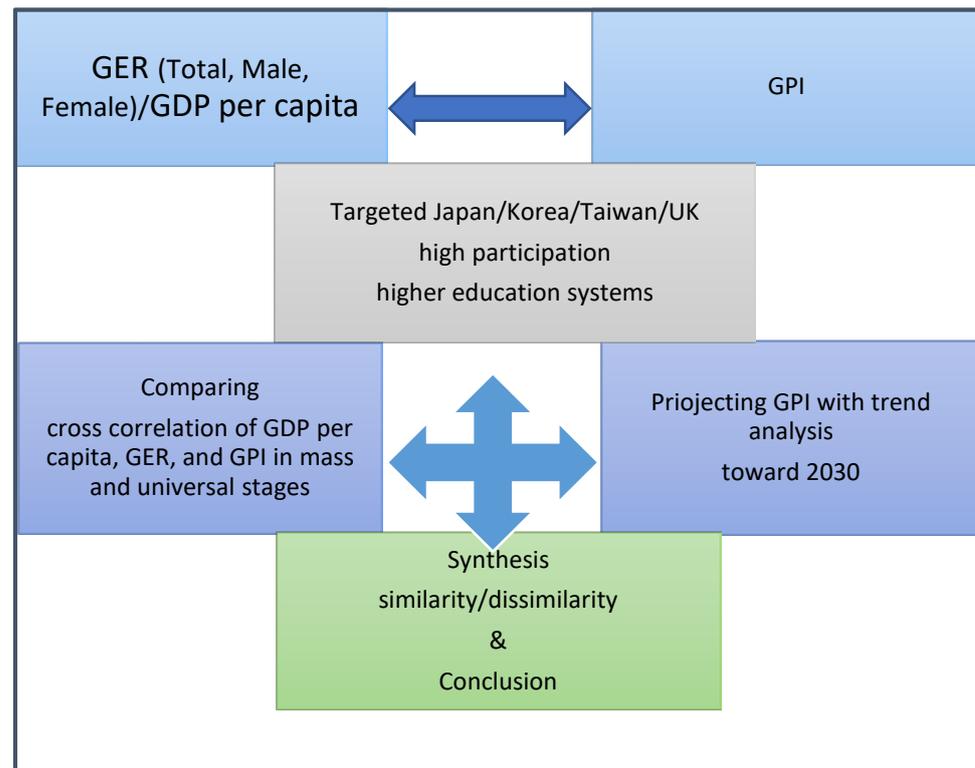
Figure 1. The research framework.

3.2 Data Transformation

We collected GER and GPI data from UNESCO (2018) and the Ministry of Education in Taiwan (2019) for our research. The GER and GPI in the UK, Japan, and Korea covers 46 periods from 1971 to 2016, while the data of Ministry of Education in Taiwan only provides 41 periods – from 1976 to 2016. The GDP per capita data were cited from World Bank and Taiwan government's data sets to fit the comparison purpose [72]. The definition of GER is as follows [73]:

GER = 100 x [Tertiary enrolment / five-year age cohort following theoretical age of secondary education completion]

According to the definition, it implies tertiary enrolment may include foreign mobile students. In the research targets, the UK has a very high proportion of foreign mobile students, while Korea has highest GER. The GPI is a socioeconomic or equal index usually designed to measure the relative access of males and females to a specific education level. According to UNESCO, the definition for GPI is [74]:

100 x [GER in higher education for females] / [GER in higher education for males]

A GPI equal to 1 indicates parity between females and males; a value less than 1 indicates disparity in favour of males; and a value greater than 1 indicates disparity in favour of females.

3.3 Checking the Cross Correlation Function

We conducted a cross correlation function (CCF) to verify the relationships of the series with their cross correlation coefficients (rxy). The calculation of CCF has been defined as follows [75,76]:

$$r_{XY}(k) = \frac{C_{XY}(k)}{\sqrt{C_{XX}(0)C_{YY}(0)}},$$

Where

$$C_{XY}(k) = \begin{cases} \frac{1}{n}\sum_{t=1}^{n-k}(x_t - \overline{x})(y_{t+k} - \overline{y}), & k = 0, 1, \ldots, n-1, \\ \\ \frac{1}{n}\sum_{t=1-k}^{n}(x_t - \overline{x})(y_{t+k} - \overline{y}), k = -1, -2, \ldots, -(n-1), \end{cases}$$

$C_{XX}(0)$ and $C_{YY}(0)$ are the sample variances of $\{X_t\}$ and $\{Y_t\}$. The CCF calculates the linear correlation between the series, ranging from -1 to 1. In this study, the CCF is conducted using the Statistical Package for the Social Sciences (SPSS). Based on the attribution of series data sets, we employ natural log transformation and difference. The significant cross-correlation coefficients were judged by a 0.05 significant level. The following rules can be used to judge the relationship of targeted series x_t and y_t:

When r_{xy} is positive and significant, x_t is possibly the independent variable, while y_t is the dependent variable in the model;

When r_{xy} is significant in lag 0 only, the impacts of x_t and y_t are concurrent. This means that x_t has an impact on y_t, while y_t also has an impact on x_t;

When r_{xy} is significant with positive and negative values in certain lags, we may assume that x_t impacts on y_t, where the impact of y_t will feedback to x_t.

This study performed a normalized cross correlation with time shift to detect if GDP, GER, and GPI lags or leads another. SPSS will provide visualized results for justifying.

3.4 Trend Analyses

This study conducted trend analyses to identify the GPI patterns in specific higher education systems toward 2030. We selected a model to fit a general trend for time series indices and provided forecasts. In the Minitab time series section, linear, quadratic, exponential growth, and S-curve (Pearl-Reed logistic) models are available [77]. The form of the fitted trend equation depends on the type of model that we selected. The type of trend model and its equation are displayed as follows [77]:

Linear model: $Y_t = b_0 + (b_1 * t)$;

Quadratic model: $Y_t = b_0 + b_1 * t + (b_2 * t^2)$;

Exponential growth model: $Y_t = b_0 + (b_1^t)$;

S-curve (Pearl-Reed logistic) model: $Y_t = (10_a) / (b_0 + b_1 * b_2^t)$.

y_t is the variable, b_0 is the constant, b_1 and b_2 are the coefficients, t is the value of the time unit, a can be 1 or 2, etc. The fitted trend models depended on their mean absolute percentage error (MAPE). We selected the relatively smallest MAPE as possible. For example, an MAPE equals to 5 means the average predicted accuracy has only 5% of errors.

4. Results

Based on the research questions, we addressed the following topics in this section. First, we demonstrated the GDP per capita, GER, and GPI in Japan, Korea, Taiwan, and the UK. Second, we displayed the concurrent relationships among GDP per capita, GER, and GPI in the target countries. Third, we compared the gender diversity in these four countries. Final, we presented the results of forecasting their GPI in 2030 based on the trend analyses.

4.1 The patterns of GDP per capita, GER, and GPI

4.1.1 The growth of GDP per capita

Figure 2 shows the growth patterns of GDP per capita of the four countries are dissimilar. Both Japan and the UK can be classified into one similar group, while Korea and Taiwan are located in the other similar group. Basically, the GDP per capita of Japan and the UK are higher than that of Korea and Taiwan. Whether the series data of GDP per capita exert influential effects on GER and CPI or not? It needs to further detecting with CCF among the selected time series data sets.
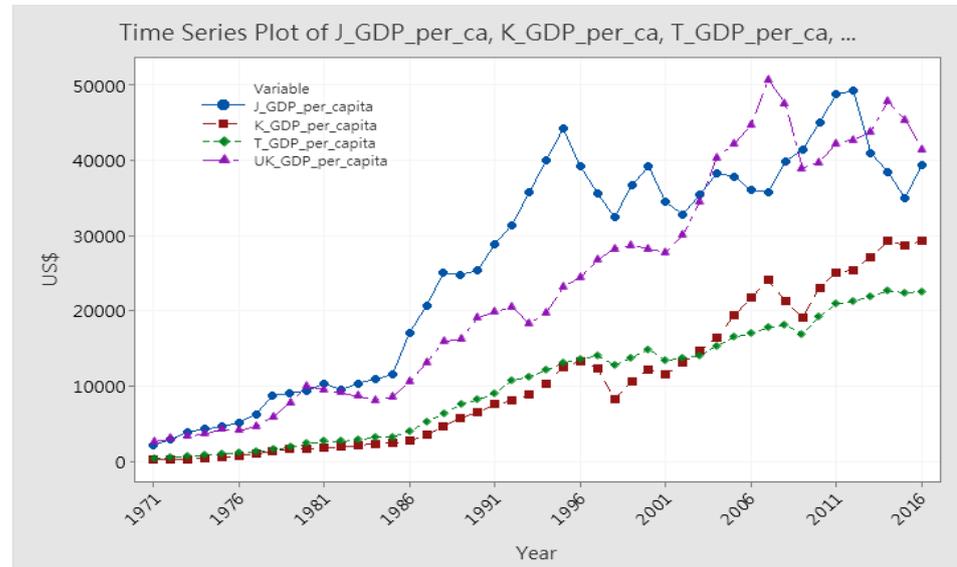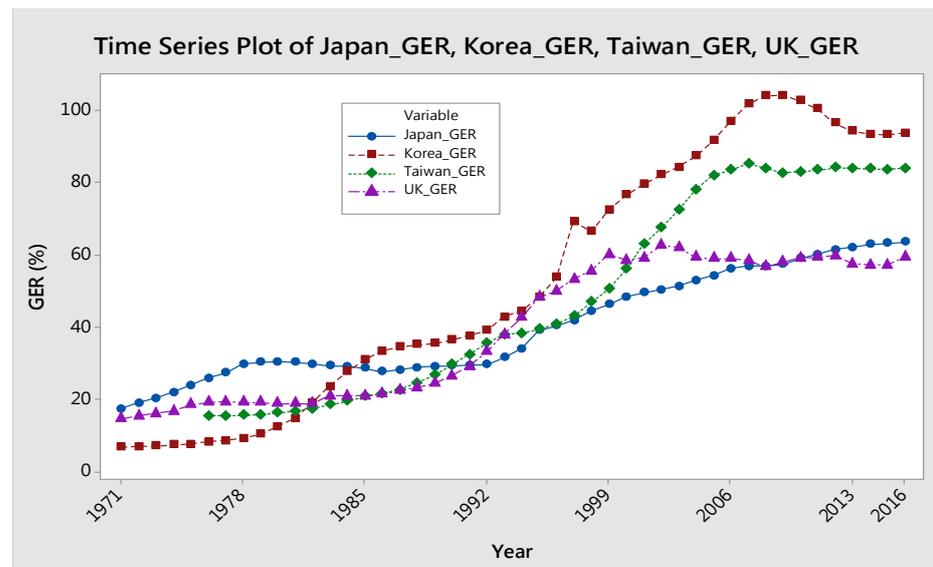

Figure 2. Comparison of GDP per capita in Japan, Korea, Taiwan, and the UK.

4.1.2 The growth of GER

GER is classified into three stages: elite (stage one), mass (stage two), and universal (stage three) as per Trow's definition. In the UK and Korea, the GER moved from the elite state to the universal stage (GER over 50%) 1996. In Taiwan, this was in 1999 while Japan was later than the other countries and moved to the universal stage in 2002. Figure 3 shows that Korea and Taiwan experienced explosive expansion after their higher education moved to the universal stage. The result may reflect the demand of human capital driven the expansion in both new economies. Taking into account specific social and economic factors, Korea has reached the uppermost GER in its higher education system. Figure 3 reveals that Korea's GER has dropped significant in the earlier year of 21th century. Both Taiwan and Korea have also shown a little drop in their GER in last decade. This patterns provides meaningful information for interpreting the phenomenon within over-expanded higher education system. Among the four countries, Japan is the only country that the GER is increasing steadily.

4.1.3 Changing the patterns of GPI

According to the interpretation of GPI, a GPI of 1 indicates that males and females have equal access to education. Within the four higher education systems, we found the GPI varies during the expansion process, as shown in Figure 4. The GPI in the UK suggests that females benefitted from the education expansion. Japan and Korea's higher education systems are still male dominated, but gender parity issue has diminished in both expanding systems. The result indicates that the patterns of gender parity with GPI in higher education in Taiwan are more acceptable than in the other three countries.

Figure 3. Comparison of GER among Japan, Korea, Taiwan, and the UK.
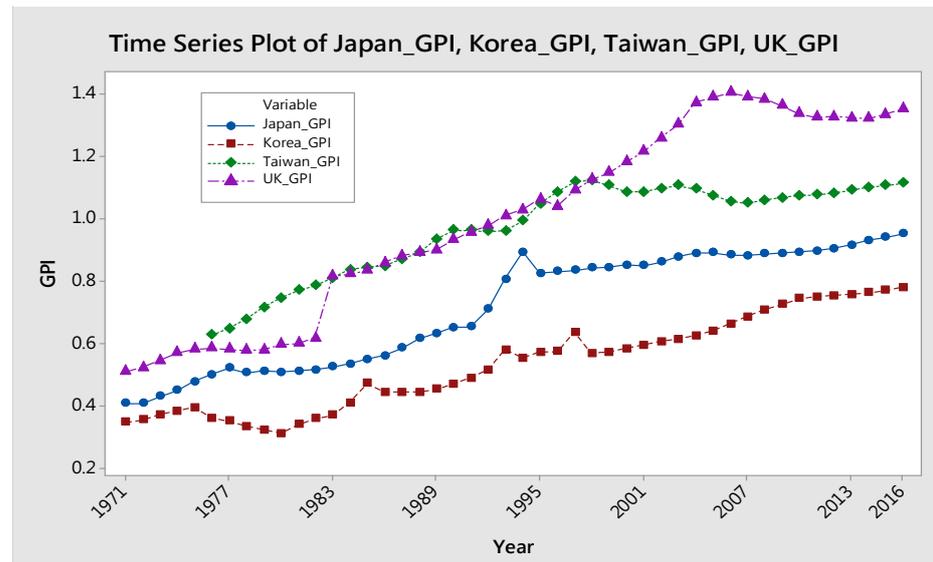
Figure 4. The transformation of GPI in higher education expansion process.

*4.2 Detecting the concurrent relationships among GDP per capita, GER, and GPI*

4.2.1 The relationships between GDP per capita and GER

We assume the growth of GDP per capita may impact GER, while the result of cross correlation function revealed the significant influence only shown in Korea and Taiwan. Since the patterns of GDP per capita are similar in Japan and the UK, the result may reflect that the GDP per capita did not impact the expanded patterns of higher education in both mature economies. The results may suggest that the fast higher education expansion of Korea and Taiwan have led by their growth of GDP per capita. The effects of growth of GDP per capita on GER are different from mature and new economies. The details of cross correlation with GDP per capita and GER are displayed in Figure 5.
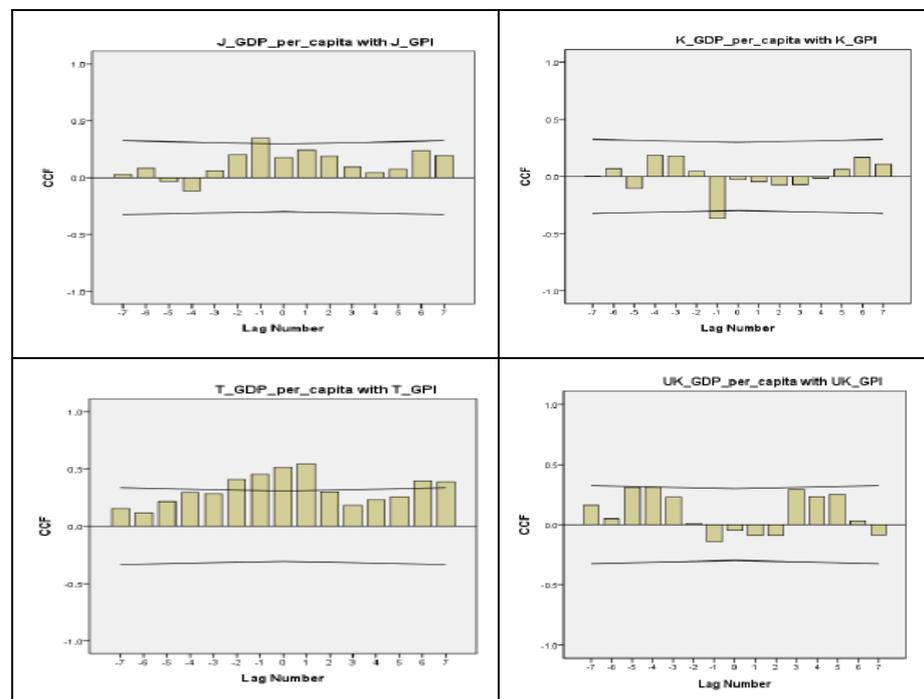
4.2.2 The relationships between GDP per capita and GPI

GDP per capita is one of indicators can be used to identify the change patter of GPI. Figure 6 shows the concurrent relationships between GDP per capita and GPI in Japan, Korea, Taiwan, and the UK. The result reveals the series of GDP per capita will lead GPI with one lag in Japan. Comparing to the result of Japan, we found Korea's concurrent relationship between GDP per capita and GPI has changed with backward. In Taiwan, the

impact of GDP per capita may lead or lag GPI couple years. While there is no concurrent relationship found between GDP per capita and GPI in the UK.
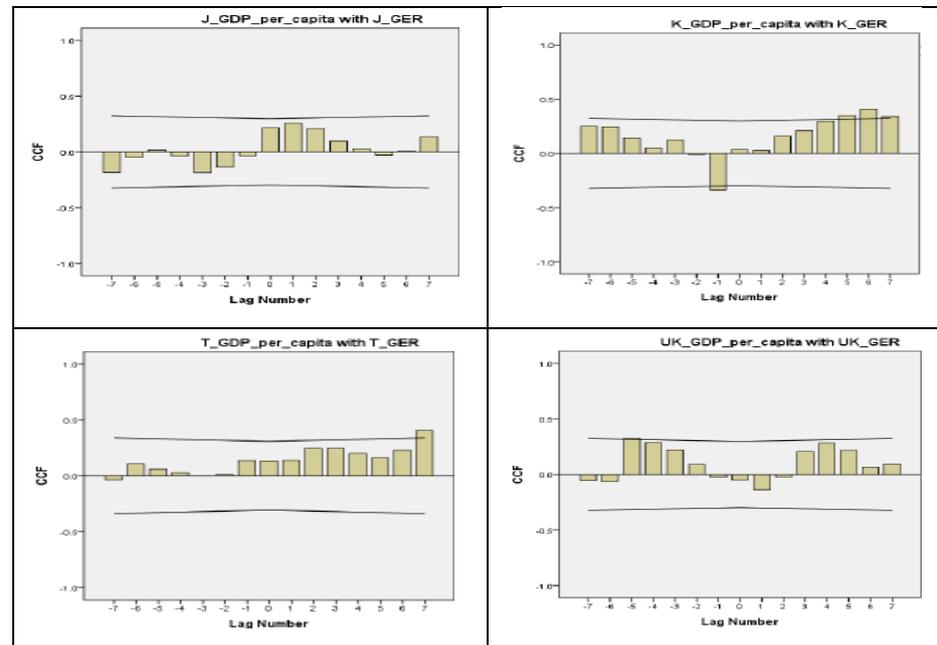
Figure 5. The cross correlation function with GDP per capita and GER among Japan, Korea, Taiwan, and the UK.

**Figure 6.** The cross correlation function with GDP per capita and GPI among Japan, Korea, Taiwan, and the UK.

4.2.3 The relationship between GER and GPI

The result demonstrates the cross correlations of GER and GPI among the four countries, as shown in Table 1. The trend of Japan's GER and GPI shows no significant relationship: there was a lag of one or two in both series. Korea's system shows a significant lag of 0, implying that the GER and GPI have concurrent relationships. Taiwan's GER and

GPI is significant in the 0-2 lags with negative cross correlation, implying that the GER will lag GPI two years. The UK's system displays no concurrent relationship between GER and GPI. The details are presented in Figure 7. This study suggests the gender diversity of higher education in Korea, Japan, and Taiwan can be interpreted by the dependency of system expansion directly. In Korea and Taiwan, the function of higher education expansion may significantly shift the pattern of GPI. While the Japan's situation has shown more complicated with the transformation of gender diversity pattern.

Table 1. Cross correlation coefficients with GER and GPI.

| Lag	Japan	Korea	Taiwan	UK
-7	.240	-.137	.329	-.076
-6	.239	-.144	.285	.025
-5	.172	-.186	.215	.008
-4	.107	.167	.213	-.053
-3	.151	-.159	.166	.022
-2	.411	.069	-.014	.008
-1	.444	-.109	-.222	-.003
0	-.167	.499	-.394	-.152
1	-.183	-.140	-.445	.032
2	-.352	.058	-.377	.008
3	-.207	.030	-.300	.025
4	-.188	.063	-.223	.010
5	-.152	-.018	-.193	.007
6	-.256	-.010	-.210	.013
7	-.323	.044	-.235	-.038
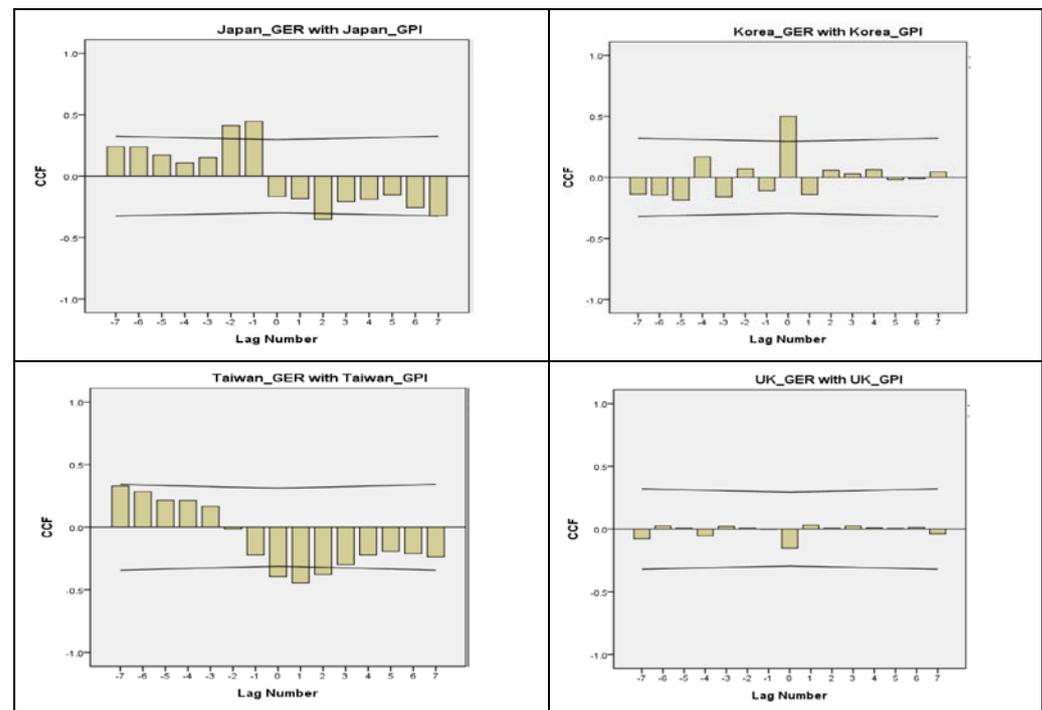
Figure 7. Cross correlation with GER and GPI for each country.

4.3 Comparison of male's and female's GER

The results of the GER plots reveal that females in Japan and Korea are underrepresented in their higher education systems, whereas females in Taiwan and the UK were favored in the process of expansion, as shown in Figure 8. The result reflects that female participation in higher education in Taiwan and the UK has experienced a structure change in both expanding systems. Female students in Taiwan and the UK have become critical mass in the higher education expansion process. While the gender gap in Japan

and Korea still existed regardless the higher education expansion. The findings suggest the gap of gender diversity is diminishing in Japan, while the UK provides a total different pattern.
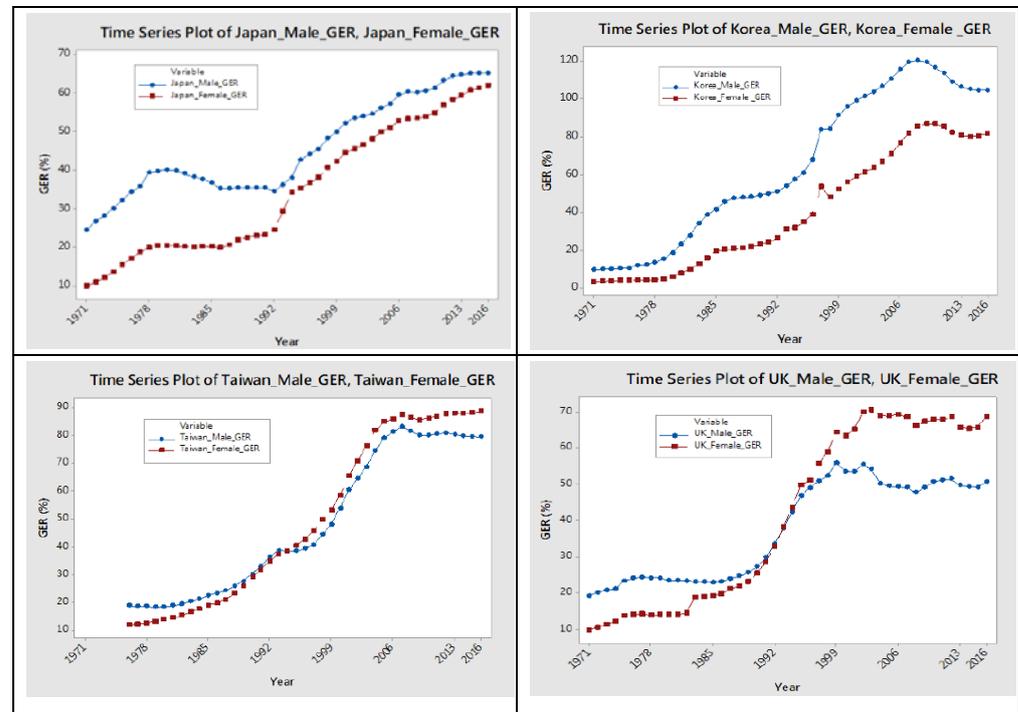
Figure 8. Comparing the GER of male and female in the four systems.

4.4 Forecasting GPI toward 2030

UNESCO has stated that gender parity is an integral part of its 2030 sustainable development goals (SDG4) and has targeted this at all levels of higher education. The fitted trends were determined by their smaller MPAE (mean absolute percentage error) in different models. Table 2 displays the results of predicted GPI with fitted trend analysis for the four education systems under discussion. In the prediction of Japan's GPI, we found both the quadratic trend and S-curve trend models are fits, although the S-curve model shows with a smaller MAPE (5.377). With Korea's GPI, we found the MAPE in the linear trend model is 6.498, while the MAPE in the S-curve trend model is only 5.952. In the prediction of Taiwan's GPI, we found the S-curve trend is the model with the best fit (MAPE = 4.317). For the prediction of the UK's GPI, it was found that the S-curve trend is the model with the best fit (MAPE = 5.034). When we reviewed the four higher education systems, we found that the GPI in Japan and Korea indicated a trend towards greater parity, while females in Taiwan will continue to be favored. In the UK, females will be dominant in the system for the near future.

The trend analysis for Japan's GPI shows the fittest model is $Y_t = (10^1) / (9.96739 + 18.6023 * (0.929853^t))$. The trend forecast is that its GPI will remain even until 2030. The GPI in Korea will show a significant increase in the future, as shown by its fittest model of $Y_t = (10^1) / (8.55100 + 26.2260 * (0.961366^t))$. In Taiwan, there is gender parity with both males and females participating in higher education. The GPI trend is stationary. The fittest model for Taiwan is $Y_t = (10^1) / (9.22501 + 129712 * (0.829257^t))$. In the UK, our trend analysis of GPI shows a steady increase. The fittest model for the UK is $Y_t = (10^1) / (5.92346 + 16.9724 * (0.938881^t))$. The results of forecasts for the higher education systems are shown in Figure 9.

Table 2. The forecasts of GPI from trend analysis until 2030.

Year	Japan (S-curve)	Korea(S-curve)	Taiwan (S-curve)	UK (S-curve)
2017	0.945	0.789	1.0834	1.4707
2018	0.950	0.799	1.0835	1.4824
2019	0.953	0.809	1.0836	1.4935
2020	0.956	0.819	1.0837	1.5041
2021	0.959	0.829	1.0837	1.5142
2022	0.962	0.838	1.0838	1.5238
2023	0.965	0.847	1.0838	1.5329
2024	0.968	0.856	1.0839	1.5416
2025	0.970	0.865	1.0839	1.5498
2026	0.972	0.874	1.0839	1.5576
2027	0.974	0.883	1.0839	1.5650
2028	0.976	0.891	1.0839	1.5721
2029	0.978	0.899	1.0840	1.5787
2030	0.980	0.908	1.0840	1.5850
MAPE	5.377	5.952	4.317	5.030
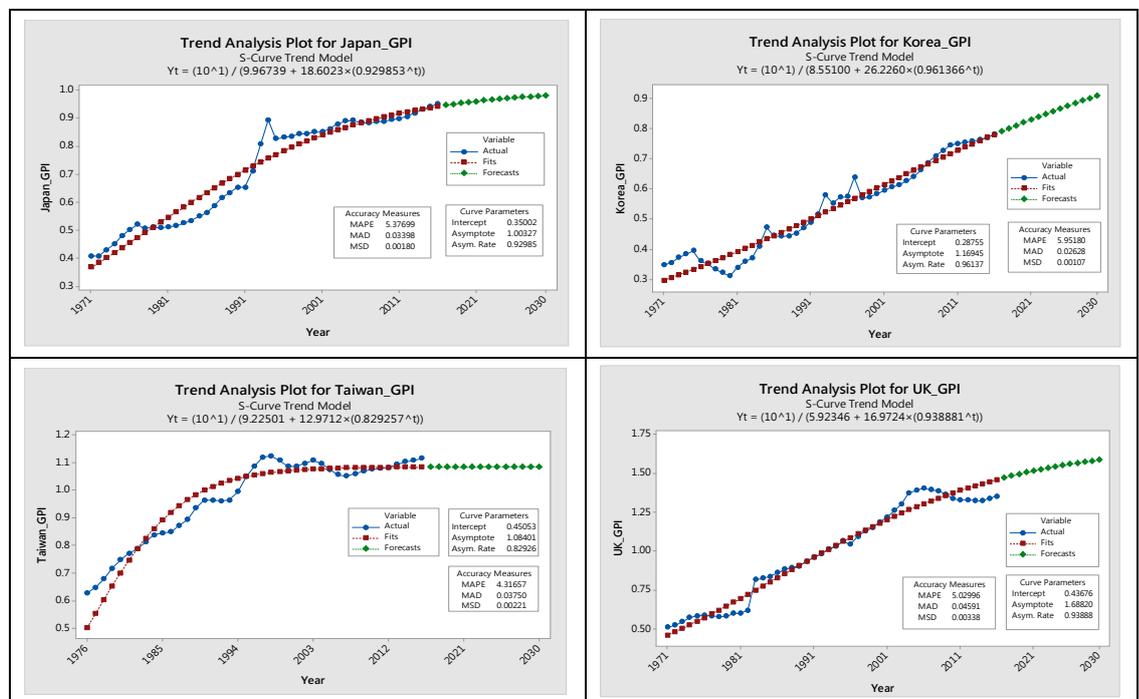
Figure 9. Model of trend analyses of GPI in higher education systems.

5. Discussion

This study provides an example of using an index to investigate higher education system expansion. From the perspective of GER, Japan and the UK became developed countries sooner than Korea and Taiwan and there are differences in the higher education expansion patterns. This study found two significant GER growth patterns among the four higher education systems: the GER in Korea and Taiwan is over 80%, while in Japan and the UK, it is only 60%. It is apparent that Korea and Taiwan have experienced explosive expansion, whereas Japan and the UK showed steady expansion when the systems moved to the mass and universal stage according to Trow's classification [14]. The causes of the expansion phenomena were discussed in the earlier section of this paper. Given the declining birth rate, the question needs to be asked about what will happen to the increased number of higher education systems that can accommodate a GER of over 75%. We suggest the new stage may provide a window to review the issues of high participation in expanded higher education systems, for example, unemployment, over supply,

and the devaluation of the qualification. The phenomena demonstrated in the expanded higher education reveal that when the system moves to a post-universal stage (GER over 85%), expansion will diminish steadily. In this study, both Korea and Taiwan have provided examples of this.

We found the expansion was shaped by government and/or market forces in response to the economic need for educated human resources at the start of changes in higher education. The related higher education policies may make significant progress in the GER of the four countries. We agree Marginson's argument that ongoing growth and the movement from elite to mass higher education itself creates a set of social and psychological forces that tend to sustain it [1]. Previous studies have reviewed the phenomenon of expansion in higher education and have provided various perspectives on its causes. For example, perspectives of neo-institutionalism [22,23], world academic system [15-17], and credentialism [29]. From economic purposes, expansion of graduates as an effective policy response to the demands of modern employment [26]. Therefore, from government's or individual perspective, higher education is increasingly a "defensive necessity" [28,33]. In addition, Barakat and Shields argued that neither human capital theory nor functionalism adequately support the expansion policy, while both Hirsch and Marginson addressed the credential inflation phenomenon which has received wide interest [3, 27,28]. Various perspectives can offer interpretations of the expansion phenomena at the macro level and supply relevant evidences. For example, both Korea and Taiwan have experienced fast speed expansion with these phenomena in their higher education systems.

Considering the economic factor impacting the higher education expansion phenomena, we found the series of GDP per capita will impact GER in emerging economies, for example in Korea and Taiwan. While this impact is unclear in Japan and the UK. The GDP per capita will impact GPI, the result reveals this phenomenon is significantly in Japan, Korea, and Taiwan. We may assume the social and cultural context with the individual economic consideration will determine the young generation participating in higher education actively. Both growth of GDP per capita and extension of GER have changed the patterns of GPI. The gap of gender diversity has shown diminishing in Japan, Korea, and Taiwan. While the UK could be a unique case that females has become a critical mass in higher education regardless the growth of GDP per capita and extension of GER.

When considering gender parity within expanding systems, certain patterns can be observed in the universal stage of the higher education systems. First, the GPI in both Japan and Korea is less 1, in the UK, it is over 1, and Taiwan's is near 1. This indicates that there is still gender disparity in Japan, Korea, and the UK; Both Japan and Korea are male dominated while the UK has become a female dominated system. The expansion of higher education in Taiwan has resulted in equal access to education for males and females. Second, it is of concern that even after higher education expansion, females are less able to participate in higher education in Japan and Korea. This phenomenon in Japan and Korea may be interpreted by the social-culture barriers. In the UK, access to higher education is less accessible for males than previously, it is a unique case. Third, higher education expansion will transform gender diversity patterns. The expanded higher education systems in Taiwan and the UK provide two different gender diversity patterns. Taiwan's expanded higher education has become equally accessible to both males and females. However, the UK's system shows different effects. When considering future development, the findings suggest that the UK might potentially experience problems when the growth of its GPI becomes unlimited. It is not certain how large GPI growth is acceptable in the UK. Fourth, even though GPI shows that there is less gender disparity in Japan and Korea, the trend analysis shows that achieving gender parity toward 2030 in these countries will be difficult. Considering the cultural context, it may play a crucial role in the process of higher education expansion. Japan and Korea are significant examples in the process of transforming gender diversity.

Due to the limitation of data, this study did not conduct the gender diversity in the specific programs. We suggest gender parity issues can be extended to review the specific programs and deal with the issues of higher education expansion process. For policy development reasons, it is necessary to create more accurate system-wide indices for detecting future trends with the gender diversity issue.

6. Conclusions

Higher education expansion has become a global phenomenon, but the issue of gender parity persists in various countries. This study found the culture factor has become crucial component of the society to shape the pattern of gender diversity, Japan and Korea have provided the example. In this study, we demonstrated that the issue of gender when explained by fitted indices can provide clearer pictures for related stakeholders. The findings suggest GPI per capita, GER, and GPI with concurrent relationships can be detected if higher education with a friendly gender setting in the process of expansion. For projecting future development, this study gives the trend analysis for four different models, transforming the data quickly and projecting future trends with different indices. The traditional autoregressive integrated moving average model (ARIMA) has also been used to deal with the time series data, while trend analysis provides more flexible ways to tackle index data regardless the periods of the data. It has been noted that higher education expansion has extended to most middle-income countries and to a significant number of low-income countries. Comparison studies can be extended to investigate universal provision of female access to education and to specific systems in the Middle East and the Southeast Asia. This study suggests the higher education expansion phenomenon and gender disparity in mass and universal systems can be detected by trend analysis of GDP per capita, GER, and GPI in different settings.

This study demonstrated how to explore the gender diversity phenomena that may become an emerging issue in the mass and universal stages with fitted indices. The data sets are available and transformed by the various indices in higher education settings, for example the GER and GPI are easy to access from the data set of UNESCO. With UNESCO's "Targets for Education 2030", we can carry the indices and monitor progress being made globally in higher education with the suggested methods. For further studies, GPI is a good index to interpret the gender diversity. Comparing the gender diversity with various programs, we suggest consider the Blau index to identify the diversity issues in programs. Blau index can be used to deal with multiple categories data, which might fit further analyses for different program participations.

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