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EXPLORING THE ADEQUACY OF HUMAN RESOURCE INVESTMENT FOR QUALITY LOWER SECONDARY EDUCATION

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Abstract. *Human resource investment in lower secondary education has become a crucial issue due to the decline in enrollment and increase of small-sized schools. Taking the lower secondary education system in Taiwan as an example, this study aims to explore the core issue of human resource investment in terms of the structure of teachers, staff, and gender diversity that might impact the allocation. To explore this issue, this study collected a series of data from the Statistics Office of the Ministry of Education from 1968 to 2020. Gender diversity was transformed by Becker's discrimination coefficient (D) to detect the patterns of teachers and staff in lower secondary education. To predict the future trend, the ARIMA (autoregressive integrated moving average) was used to build forecasting models for the student teacher ratio (STR), student staff ratio (SSR), and teacher staff ratio (TSR). The findings suggest adjusting the related ratios following our predicted values can provide reasonable balancing of teacher and staff demand for quality lower secondary education. This study provides useful information for policy makers to intervene current lower secondary education system. The design of this study may provide an example to tackle the similar issue in other education systems.*
Keywords: ARIMA, D coefficient, Gender diversity, Human resource management, Lower secondary education

1. **Introduction.** Education resources usually refer to the input and process dimension of education. The significant resources for education can be counted as human resources, physical resources, and financial resources. The human resources mean the capacities of school, teacher, staff, ratio of teachers, and ratio of staff with students [1]. Human resource investment could be a crucial indicator for quality education. Quality education is a critical task of UNESCO's SDGs 4 [2]. By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes [3]. While human resources in school system have confronted serious challenges in the fluctuate era, for example, financial and budgeting issue due to indebted phenomena in the government system [4-6]; declining birthrate impacts the enrollment directly [7,8]. The declining birthrate has impacted the enrollment of education systems in China, Korea, and Taiwan, and above all their primary and secondary education systems have confronted the declining pressure. Moreover, within the worsening budget systems, the emerging issue has caused public concerns. Regarding the human resources that have spent 80% of the budgets at the school level, student teacher and student staff ratio could be an important part to reflect this issue directly. We have selected lower secondary education level as the research target, because it requires higher human investment than that of primary education. Moreover, a large part of lower secondary education belongs to the public funding system.

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Moreover, the number of teachers per class and the student teacher ratio (STR) are indicators of quality education in a country. The indicator may offer policy insights into opportunities for allocating teaching or non-teaching staff properly [9]. As OECD data showed, between 2013 and 2019 the average class size remained constant at the lower secondary school level. However, 8 out of the 31 countries show a decrease in the average class size by at least 5% in public lower secondary schools, and 6 out of the 29 countries had similar experiences in private lower secondary schools [10]. It means the number of junior high school (12-15 year-old teenagers) education systems in the world is declining year by year. Regarding the fitted STR, it is diverse in the global context. For example, on average across OECD countries, there are 13 students per teacher in lower secondary education. The average school class has 23 students in lower secondary education [10]. A student-teacher ratio can provide information on the level of teaching resources available in a country relative to its student population. It could be an important indicator of human resource investment in lower secondary education. STRs vary even more at the lower secondary education level, from fewer than 10 students per teacher in Austria, Belgium, Finland, Greece, Latvia, and Portugal to more than 25 students per teacher in Colombia and Mexico [10]. The other part of human resource in junior high schools is non-professional personnel who support teachers in providing instructions to students. Usually, we call them non-teaching staff or staff. The number of students with non-teaching staff can be transformed as student non-teaching staff ratio (SSR). It is lack of related information addressing SSR in OECD's report. We assumed the SSR could be an influential indicator to evaluate the human resource investment in lower secondary education.

This study took Taiwan's lower secondary education as an example to tackle the adequacy issue of human resource investment. Due to the decline in the birthrate seriously in Taiwan, not only the number of students in class is reduced, but also the number of classes. The subsequent problems are caused by the number of less students, and it also affects the needs of teachers and staff. Considering the declining enrollment, we worry the human resource structure of teachers and staff. Will the reduction in the human resource structure be appropriately adjusted under this situation? How to balance teacher and staff demand effectively has become an important issue that has to face in the current education system. Moreover, most of local government has suffered from heavy loan burden, for example, according to the financial alarm, local government's digital report [11]. Since the lower secondary education system is under the jurisdiction of the local and municipal government, with the current national budget deficit, the local and municipal government is also in debt. Human resource investment for quality education has become a new pressure for the government. Therefore, strategizing a reasonable teachers and staff ratio (TSR) has also become an important strategy to face the new financial crisis. Table 1 shows the actual debt of central, local and municipal governments in Taiwan [11].

TABLE 1. Public debt of local governments at all levels (unit: NT$100 million)

Government	**Debt for more than 1 year**	**Debt less than 1 year**	**Total debt**
Central	58,494	3,130	61,624
County	7,366	869	8,235
Municipal	6,129	478	6,607

Note. Debt under the Public Debt Law; counted by end of April, 2022

Under such circumstances, adequacy of educational human resource may become an important mechanism for balancing education quality and the worsening financial support. In this sense, we would like to know how the decline of enrollment might impact the pattern of STR and SSR, and how the future trend of STR and SSR can inform the related policy makers. In keeping the research purpose in mind, the research questions are listed as follows.

a) What are the trends of number of teachers and staff in lower secondary education?
b) What are the human resource structures in terms of STR and SSR exerted in the lower secondary education?
c) Can the trends of STR, SSR, and TSR be used to ameliorate the issues of the system in the future?

The rest parts of the paper are organized as follows. First of all, the method section will present research framework, data collection, data transformation, and predicted model building. Secondly, the result will address the trend of teachers and staff in lower secondary education, teachers' and staff's gender diversity, future trend of STR, SSR, and TSR. Finally, the conclusion will be drawn, and suggestions will be provided for related policy makers.

2. **Method.** This study employed the time series technique to transform STR, SSR, and TSR. Becker discriminant index (D) was used to represent the gender diversity in the specific data sets. The autoregressive integrated moving average (ARIMA) model was used to build projected models for realizing the future trend of STR, SSR, and TSR. Excel and Minitab were used to transform the data and model building.

2.1. **Research framework.** Figure 1 demonstrates the design of study. It is organized in three sections based on the framework. Firstly, the research framework displays the target data of teachers and staff in lower secondary education. The data were collected from the Ministry of Education (Taiwan) by an annual basis. Secondly, the D index refers to gender diversity of teachers and staff. Thirdly, this study transformed the major indicators below: STR, SSR, and TSR. The ARIMA was applied to building the fitted models projecting the three indicators to 2030.

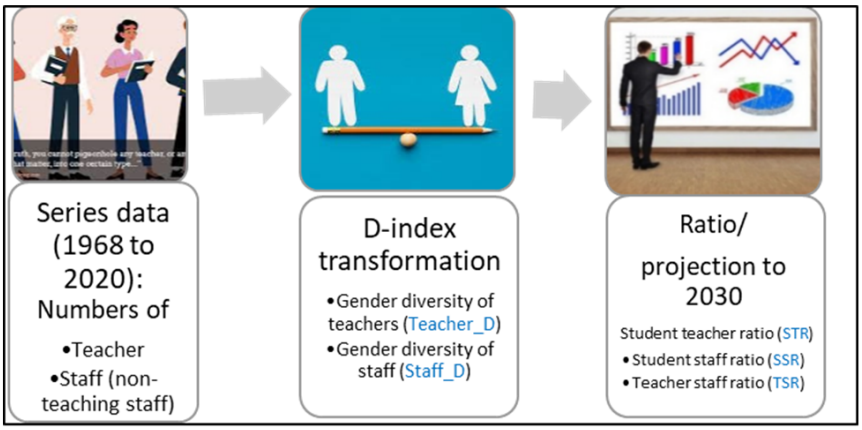


FIGURE 1. Research framework

2.2. **Data collection and transformation.** This study collected the number of teacher, staff and student data from gender statistical indicators and educational statistics year books before 2005 created by the Ministry of Education in Taiwan [12,13]. The target series data from 1968 to 2020 covering 53 periods are aggregated from both data sets. Based on the series data, we transform the following four indices: gender diversity index (D), STR, SSR, and TSR. The definitions of the four indices are listed as follows.

- D refers to the total number of male and female teachers or staff participating in lower secondary education on an annual basis. The time series of D, based on the Becker's discrimination coefficient index, was calculated as the following way [14-16]:

$$\text{For teacher's } D_i = (TM_i/TF_i) - 1$$
$$\text{For staff's } D_i = (SM_i/SF_i) - 1$$

TM_i is the number of male teachers on i year in lower secondary education; TF_i is the number of female teachers on i year in lower secondary education; SM_i is the number of male staff on i year in lower secondary education; SF_i is the number of female staff on i year in lower secondary education.

The positive D implies that the female teachers' or staff's participation is less than that of males, whereas, the negative D means that the proportion of females in lower secondary education is larger than that of males. If D becomes zero or nearly zero, it means the diversity of males and females is equal.

- STR refers to the number of students over the number of teachers on an annual basis in lower secondary education.
- SSR refers to the number of students over the number of staff on an annual basis in lower secondary education.
- TSR refers to the number of teachers over the number of staff on an annual basis in lower secondary education.

2.3. **Projecting the trend to 2030.** ARIMA models were used to build forecasting models for the STR, SSR, and TSR. The fittest models for predicting STR, SSR, and TSR in 2030 will be proposed. The processes of model building are portrayed as follows: a) detecting the series of STR, SSR, and TSR as a stationary or a nonstationary series; b) selecting ARIMA (p, d, q) model by using differences and the visual techniques, in the candidate model, the p as the order of the autoregressive part in terms of the number of autoregressive terms (AR), d as the difference, and the q as the order of the moving average (MA), i.e., the number of lagged forecast errors in the prediction equation [17-19]; c) using the Box-Pierce (Ljung-Box) Chi-square statistics to test the white noise to confirm whether the model met the assumptions that the residuals were independent [20,21]; d) verifying the robustness of series with the fitted ARIMA model for next ten years. In this study, Minitab and SPSS were used to select the prediction models. Both autocorrelation function (ACF) and partial autocorrelation function (PACF) were provided visualized diagnosis of the candidate models.

3. **Results.** Transforming the target series data, the results address the trend of teachers and staff from 1968 to 2020, teacher's and staff's gender diversity, and predicted future trend of STR, SSR, and TSR toward 2030 in the lower secondary education.

3.1. **Analysis of the trend of teachers and staff in lower secondary education.** The numbers of teachers and staff reflected the system expanding or declining. Figure 2 shows the number of staff from 1968 to 2020 in the lower secondary education system is steady, while the trend of teachers is varied. In the beginning, the system experiences increasing the number of teachers rapidly, and then the number of teachers has dropped steadily.

3.2. **Analysis of teachers' and staff's gender diversity.** In comparing the number of males and females participating in lower secondary education, both teachers' and staff's series present a similar pattern. The number of female teachers (Total.Tf) has crossed over the number of male teachers (Total.Tm) in 1978. Likewise, the number of female staff (Total.Sf) has also crossed over the number of male staff (Total.Sm) in 1979. Figure 3 demonstrates the female dominated phenomenon in lower secondary education system, which can be explained as the rapid economic development at that time. A large number of males have been attracted by the potential fields that results in the diversity of gender participating in lower secondary education.

When we check the gender diversity of teachers and staff with D index in lower secondary education, the result indicates the D is negative in both transformed series. The findings reveal that both teachers and staff in the education system are females dominated.

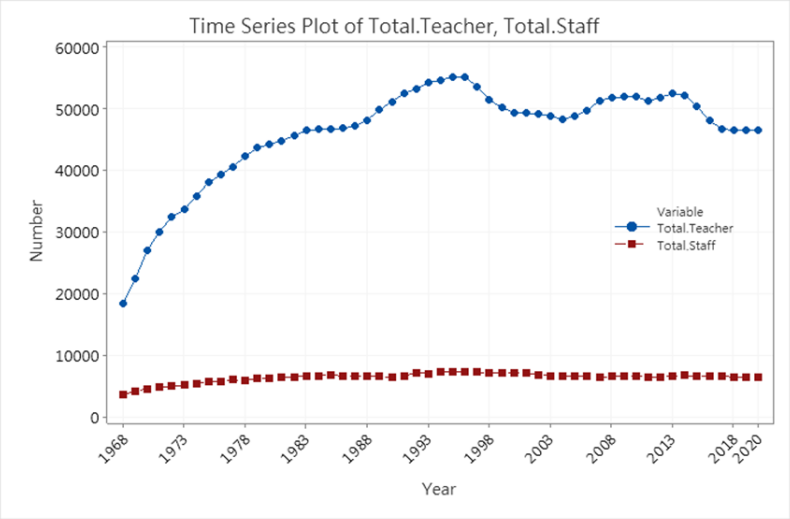
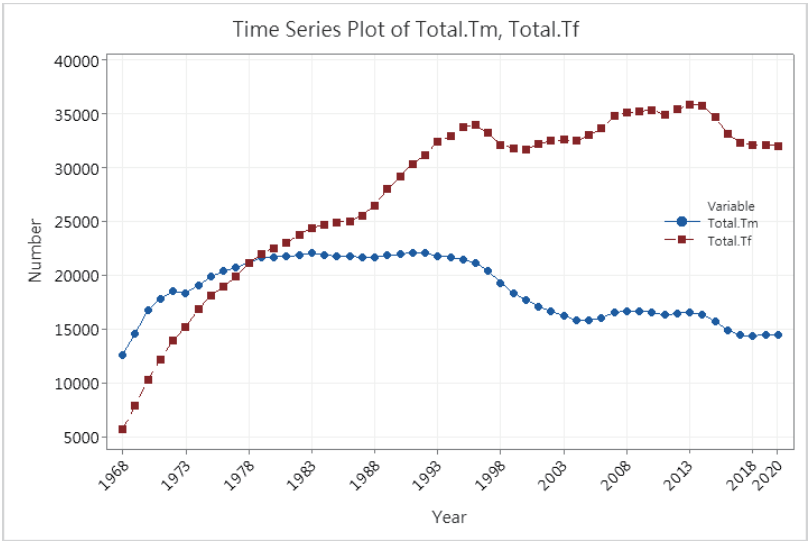


FIGURE 2. The series plot for teachers and staff from 1968 to 2020



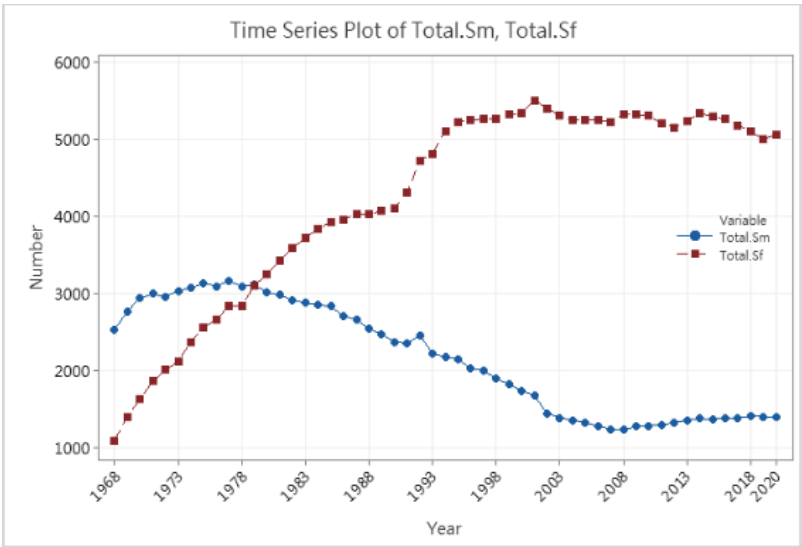


FIGURE 3. The trend of number of male and female teachers (upper) and staff (lower)

Based on the series of D index, the equivalent of gender parity for teachers and staff appeared in 1979. Since then, the females participating in this level of education are increasing. It is also a critical turning point for both series of D index. Before 1979 both groups demonstrated that the females become the critical mass who may dominate lower secondary education. The detailed D trends of teachers and staff are displayed in Figure 4.

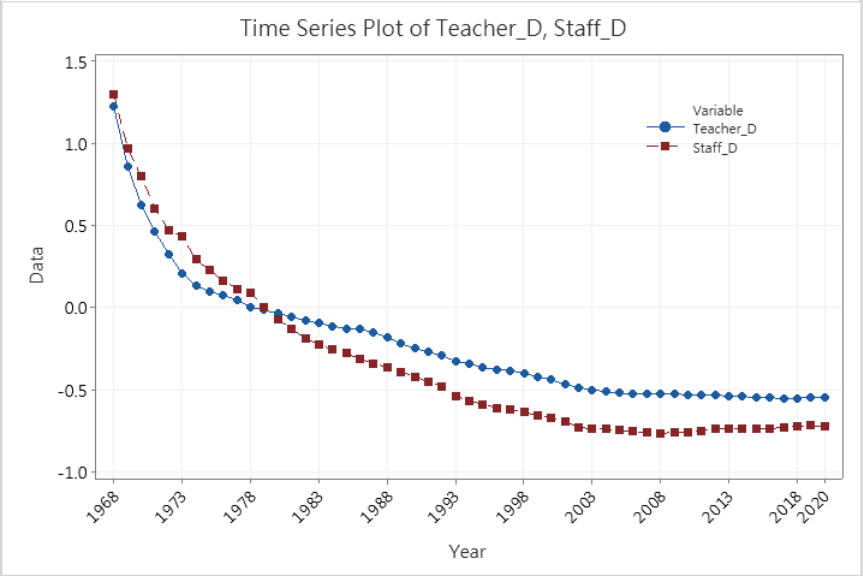


FIGURE 4. The D transformation of gender diversity for teachers and staff

3.3. **Projecting the future trend of STR, SSR, and TSR.** Based on one difference with the STR series, the result suggests the ARIMA $(1, 1, 1)$ is the fittest model. The ACF, PACF, and modified Box-Pierce (Ljung-Box) Chi-square statistics all work well in the proposed mode. The coefficients of AR(1) = 1.00 ($p = 0.00$) and MA(1) = 0.9817 ($p = 0.00$) are significant at 0.05 level (see Table 2). In the Box-Pierce (Ljung-Box) Chi-square statistics test, the predicted series values are found with the number of lags 12, 24, 36, and 48 and classified as white noise ($p > 0.05$) (see Table 2). The proposed ARIMA $(1, 1, 1)$ model is robust. Based on the predicted trend, the STR will decline steadily in the future. Table 3 reveals the forecasts of STR will decrease from 11.5688 in 2021 to 8.9495 in 2030. The time series plot of STR is displayed in Figure 5, and it implies the series will decrease in next ten periods. The declining enrollment has impacted the STR in the

TABLE 2. Estimation of parameters and Ljung-Box Chi-square statistics for STR

ARIMA (1,1,1) estimated parameters

Type	Coef	SE coef	T-value	P-value
AR(1)	1.00023	0.00694	144.03	0.000
MA(1)	0.9817	0.0569	17.26	0.000

ARIMA (1,1,1) Ljung-Box Chi-square statistics

Lag	12	24	36	48
Chi-square	17.79	30.58	37.42	42.05
DF	10	22	34	46
P-value	0.059	0.105	0.315	0.638

TABLE 3. Forecasts from period 54-63 for STR

Period	Forecast	95% limits	
		Lower	Upper
54 (2021)	11.5688	10.8834	12.2541
55	11.2781	10.2998	12.2563
56	10.9872	9.7780	12.1964
57	10.6963	9.2871	12.1054
58	10.4053	8.8154	11.9952
59	10.1143	8.3567	11.8718
60	9.8232	7.9077	11.7387
61	9.5320	7.4658	11.5982
62	9.2408	7.0297	11.4519
63 (2030)	8.9495	6.5981	11.3009

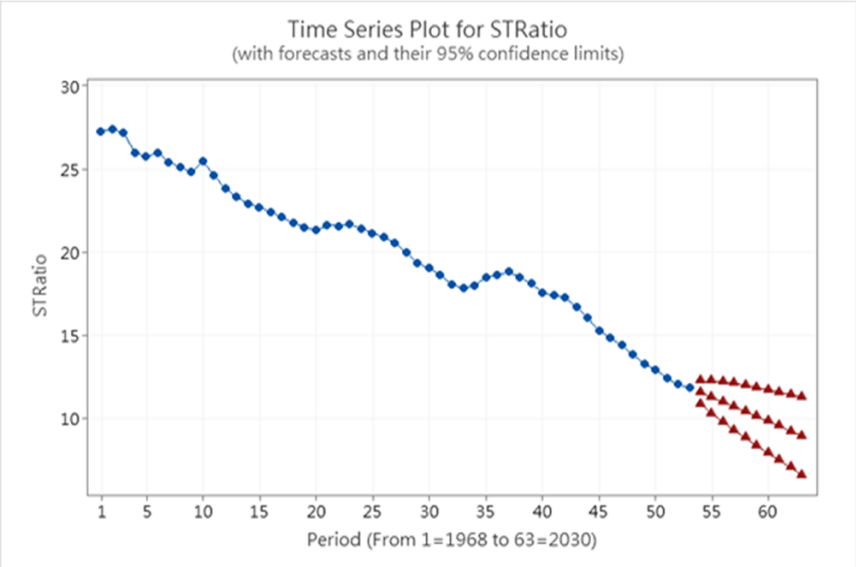


FIGURE 5. The time series plot for STR from 1968 (1) to 2030 (63)

education system. The projected STR may reflect the shrinking of student enrollment only. The issue includes how to merge many small-sized schools and adjust the STR. Both small scale schools and low STR will cost much money for human resource investment in that level of education.

Based on SPSS expert explorer's suggestion, the damped trend fits the SSR series data. A damped trend is a good approximation of a linear trend at short lead time [22-24]. In this case, we found the ACF, PACF, and Ljung-Box Chi-square statistics ($Q_{(18)} = 18.668$, df $= 15$, $p = 0.229$) all work well in the suggested model. The predicted trend of SSR will decline steadily in the future. Table 4 reveals that the forecasted values of SSR will decrease from 90.67 in 2021 to 87.64 in 2030. The forecasted trend of SSR has shown in Figure 6.

Based on one difference with the TSR series data, the result suggests the ARIMA $(1, 1, 0)$ is the fittest model to predict the teacher staff ratio in the lower secondary education. The ACF and PACF work well in the ARIMA $(1, 1, 0)$ model. The coefficient of AR(1) $= 0.318$ ($p = 0.020$) is significant at 0.05 level (see Table 5, upper). In the Box-Pierce (Ljung-Box) Chi-square statistics test, the predicted series values are found with the number of lags 12, 24, 36, and 48 which are classified as white noise ($p > 0.05$) (see Table 5, lower). The proposed ARIMA $(1, 1, 0)$ model is robust. Based on the predicted

TABLE 4. Forecasts from period 54-63 for SSR

Period	Forecast	95% limits	
		Lower	Upper
54 (2021)	90.67	81.51	99.83
55	89.78	74.06	105.5
56	89.14	66.25	112.04
57	88.68	58.64	118.73
58	88.35	51.41	125.28
59	88.10	44.62	131.59
60	87.93	38.25	137.6
61	87.80	32.29	143.31
62	87.71	26.68	148.73
63 (2030)	87.64	21.41	153.87

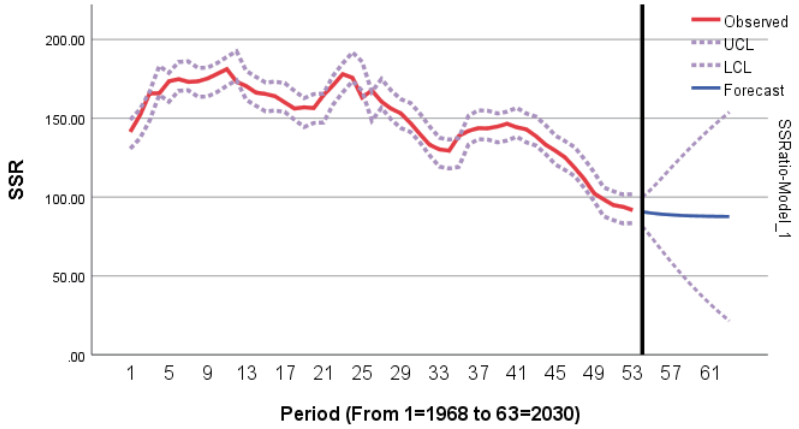


FIGURE 6. The time series plot for SSR from 1968 (1) to 2030 (63)

TABLE 5. Estimation of parameters and Ljung-Box Chi-square statistics for TSR

ARIMA (1,1,0) estimated parameters

Type	Coef	SE coef	T-value	P-value
AR(1)	0.318	0.133	2.40	0.020

ARIMA (1,1,0) Ljung-Box Chi-square statistics

Lag	12	24	36	48
Chi-square	5.70	18.81	26.81	42.77
DF	11	23	35	47
P-value	0.892	0.712	0.838	0.648

trend of TSR, it will drop slightly in the future. Table 6 reveals the forecast TSR will decrease steadily from 7.19014 in 2021 to 7.18116 in 2030. The time series plot of TSR is displayed in Figure 7.

4. **Conclusions.** The design of study with selecting methods has answered the research questions. The findings display the trends of number of teachers and staff are decreasing and the gender of teachers and staff is female-dominated since 1978 and 1979. The D index provides a useful indicator to reflect the long-term pattern of gender diversity.

TABLE 6. Forecasts from period 54-63 for TSR

Period	Forecast	95% limits	
		Lower	Upper
54 (2021)	7.19014	6.82047	7.55981
55	7.18402	6.57228	7.79576
56	7.18207	6.37600	7.98814
57	7.18145	6.21297	8.14992
58	7.18125	6.07208	8.29042
59	7.18119	5.94674	8.41563
60	7.18117	5.83287	8.52946
61	7.18116	5.72787	8.63445
62	7.18116	5.62995	8.73237
63 (2030)	7.18116	5.53784	8.82447

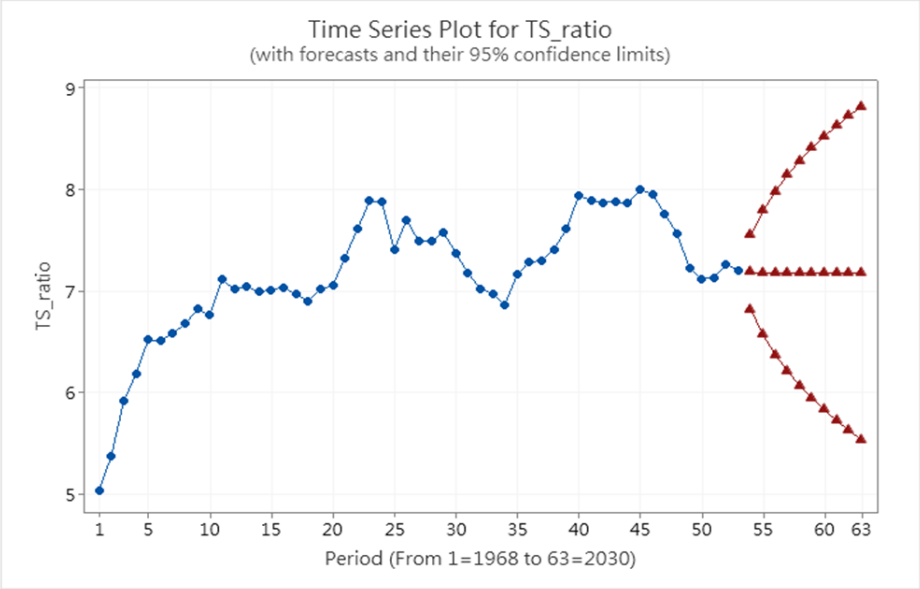


FIGURE 7. The time series plot for TSR from 1968 (1) to 2030 (63)

ARIMA models for building next ten-year values of STR, SSR and TSR have shown robustly. The low birthrate may affect the adequacy of teachers and staff ratio in lower secondary education. This study provides useful information to check the declining trend of students impacting the STR as well as the SSR. The findings can inform the related policy makers taking appropriate strategies to ameliorate the human resource investment in the education system. Based on the predicated values, this study suggests the trends of student teacher ratio can be adjusted following the OECD's average, and the range is from 10 to 25. It depends on the strong or weak policy of intervention. While providing a larger student teacher ratio in the future can reduce the burden of human resource investment in lower secondary education directly.

Regarding the budget constraint is a popular phenomenon in education systems, this study provides an example for tackling similar issues in other education systems. For further studies, we encourage to consider wide context factors, such as merging small-sized schools, considering the demand of area variances or selecting related valuable indicators to reallocate education human resources. It could be extended the practical knowledge of the field.

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