DETECTING THE IMPACTS OF NEWBORN BABIES AND ITS EFFECT ON ELEMENTARY SCHOOL ENROLLMENT

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Abstract. *Factors such as war, epidemic, laws, and culture affect the worldwide birth rate whether in gender balance or birth rate itself. The Taiwanese birth rate is affected by traditional Chinese culture – the Chinese zodiac. The compulsory education in Taiwan begins from elementary school; thus, the declining birth rate has a direct impact on elementary school enrollment. This study intends to detect how cultural beliefs affect the number of infants and whether that affects elementary school enrollment. The target series data sets are infants and the first grade of enrollment in elementary schools. ARIMA (autoregressive integrated moving average) was used to build predicted models for the number of newborn babies. The results found that the year of dragon and tiger had effects on elementary school enrollment significantly. This study suggests the Taiwanese government should launch longitudinal planning to prepare the effect of the declining birth rate on school enrollment, budget, and teacher preparation programs.*
Keywords: ARIMA, Education management, Enrollment of elementary schools, Declining birth rate, Time series, Cultural beliefs, Chinese zodiac

1. **Introduction.** Many factors affect the worldwide birth rate, such as World War II contributing to the Baby Boom. COVID-19 is predicted to affect the worldwide birth rate, particularly in countries with lockdown or shelter-in-place orders [1]. Culture can also be an important factor in birth rate, such as the higher birth rate of male infants than that of the female infants in China. In Taiwan, the Chinese zodiac may affect the birth rate even though we live in the age of artificial intelligence (AI). The Chinese zodiac system includes 12 zodiac signs, in the following order: rat, ox, tiger, rabbit, dragon, snake, horse, goat, monkey, rooster, dog, and pig. The zodiac rotates in a cycle of 12 years and every year symbolizes one animal within the 12-year time frame. Each zodiac sign has its unique characteristics corresponding with the qualities of the animals the signs are named after. In Asian culture, some zodiac signs are seen as more favorable than others [2]. The birth rate is higher in some auspicious years, such as the year of the dragon, while some years such as the year of the tiger have a lower birth rate [3].

The birth rate in Taiwan decreased from a higher birth rate to below the replacement level back in the 1990s [4]. Since then, the birth rate in Taiwan has been decreasing every year. The birth rate is defined as the entry giving the average annual number of births during a year per 1,000 persons in the population at midyear, also known as crude birth rate. The birth rate is usually the dominant factor in determining the rate of population growth [5]. The birth rate in Taiwan decreased from 13.86 per thousand people in year

2000 to 7.98 in year 2020, almost a 50% decrease in 20 years [5]. The United States is around 12 per thousand people throughout the same 20-year timeframe [5]. Taiwan has the lowest birth rate in the world. The declining birth rate has brought up economic, educational, and social issues. In Taiwan, the birth rate is also affected by traditional Chinese culture [6], specifically, the Chinese zodiac [7].

The number of infants has been decreasing from 344,101 in 1985 to 166,473 infants in 2010; however, the number of infants is always higher during the year of the dragon [8]. For example, 166,473 infants were born during the year of the tiger in 2010 in contrast to the 234,599 infants born during the year of the dragon in 2012. There is a 1.5 times difference when comparing the number of infants born during the years of the dragon and the tiger. Chinese people traditionally believe children who are born in the year of the tiger might have a less auspicious life compared to others. As a result, the year of the tiger has a lower birth rate compared to other years. In contrast, the year of the dragon usually has a higher birth rate.

Previous studies on birth rates focus on zero-population growth, or the gender balance of infants born in that year [4,6]. Other studies also found that the number of infants born in the year of the dragon might encounter problems related to teachers' supply and demand [9] and resource shortage [10]. This study focuses on the fluctuating number of infants born in a specific year, for example, the number of infants born in each year and whether there is any particular year that had a higher or lower number of infants.

Traditional Chinese culture believes dragons are auspicious, and children who are born in that year are considered to be very fortunate. Compulsory education in Taiwan begins from elementary school; thus, the birth rate has a direct impact on elementary school enrollment, which subsequently affects the class size and the number of full-time teachers. This study intends to detect the impacts of Chinese cultural beliefs and their effects on elementary school enrollment. Given these purposes, this study addresses the following research questions:

1) What are the trends for infant birth rate and elementary school enrollment in Taiwan?

2) What are the patterns in birth rate and elementary school enrollment from the time-series data?

3) To what extent might the numbers of infants born impact elementary school enrollment?

This study explores the relationship between traditional cultural beliefs – Chinese zodiac – and the number of infants born. The findings of this study can confirm whether cultural beliefs affect the number of infants born and subsequently school enrollment in Taiwan. Meanwhile, it could also show to what extent the number of infants born is impacted by Chinese zodiacs. Does that impact every year or just a particular year? It could provide implications on teacher preparation, educational resources, and other factors related to different numbers of infants born and elementary school enrollment. The following sections of this paper include the method section which addresses the data and how it converts to the time series model and how it shapes the models; second, the study will display the findings and interpret their implications. Finally, the conclusion will be drawn and propose some suggestions for further studies.

2. **Method.** Methods such as fuzzy cognitive map (FCM), a regression can be used to analyze trend data [11]. The regression model typically fits randomized data, and it does not satisfactorily deal with time-series data sets [12]. Considering the characteristics of the data sets, ARIMA (autoregressive integrated moving average) was used to build predicted models. In this study, Minitab and SPSS software were used to verify the predicted models.

2.1. **Assumption of research.** We assume that the Chinese zodiac will affect the birth rate compared with the enrollment of elementary schools. Particularly, we want to explore the myth of cultural beliefs to see whether the year of the dragon had a higher birth rate compared to the year of the tiger with data ranging from 1976 to 2019. To what extent we could explore the differences between the year of the dragon and the year of the tiger. If those years indeed had a higher or lower birth rate then whether the impact will persist in elementary school enrollment. To detect such difference, time series will display data from 1976 to 2019 with the highlights of the year of the dragon and the year of the tiger. Examining such differences will show how birth rate and enrollment interact and how they might affect future educational planning.

2.2. **Target data and plot of series.** The number of infants refers to the data cited from the Macro statistical databank (National statistics, ROC) and the Ministry of Interior from 1952 to 2019 [13,14]. The data may include the number of national and non-national born in that year. Enrollment of elementary schools refers to the number of the 6-year old group who have entered elementary schools seven years later when they were born; the series data were collected from 1976 to 2019 based on the online databank in the Ministry of Education and Ministry of Interior [15,16]. Both series data will be plotted with time-series trends. We compare the time series plots to verify the impact on enrollment in elementary schools.

2.3. **ARIMA model building.** To detect the effect of newborn babies with the specific years on the enrollment, this study conducts ARIMA models to predict the newborn babies in the next decade. In this study, the ARIMA (p, d, q) refers to p as the order of the autoregressive part in terms of the number of autoregressive terms (AR) while d as the difference; finally, q as the order of the moving average, i.e., the number of lagged forecast errors in the prediction equation (MA) [17-20]. First, this study ascertains whether the number of infants and enrollment of elementary schools is a short-term or long-term effect. Second, the series for ARIMA was differed and displayed their visualizations of ACF (autocorrelation function) and PACF (partial autocorrelation function) [12,21-23]. The fittest model selection will depend on its parameters, BIC (Bayesian information criterion) and Q test. In this study, Box-Pierce Chi-square statistics (Ljung Box test) were used to determine whether the model met the assumptions that the residuals were independent [24,25]. Third, this study verifies the robustness of the series with the fitted ARIMA model for the next 10 years.

3. **Results.**

3.1. **Trends for the number of infants born and elementary school enrollment.** The result showed that the number of infants born is generally decreasing from year 1976 to 2019. The decreasing trend was obvious after year 1985 from 344,101 infants to 175,074 infants in year 2019. The number of infants born decreased by 50% in 34 years. Although there are 12 zodiac signs, the other zodiac signs do not differ too much in terms of the number of infants born. For example, the number of infants born in 2006, the year of the dog, was 204,459 while in year 2007, the year of the pig, the number of infants born was 204,414. The number of infants born decreased by 45, which accounts for less than 1% difference. In contrast, the year of the tiger and the year of the dragon had more significant differences. The differences ranged from 35,000 to 68,000 as shown in Figure 1. On average, the differences are around 47,000 when it comes to the year of the tiger and the year of the dragon.

More specifically, we found that the year of the dragon and the year of the tiger have different effects on the number of infants in that year and enrollment later, as shown in Figure 2. The increased ratios of specific dragon year are 8.92% in 1988, 7.62% in
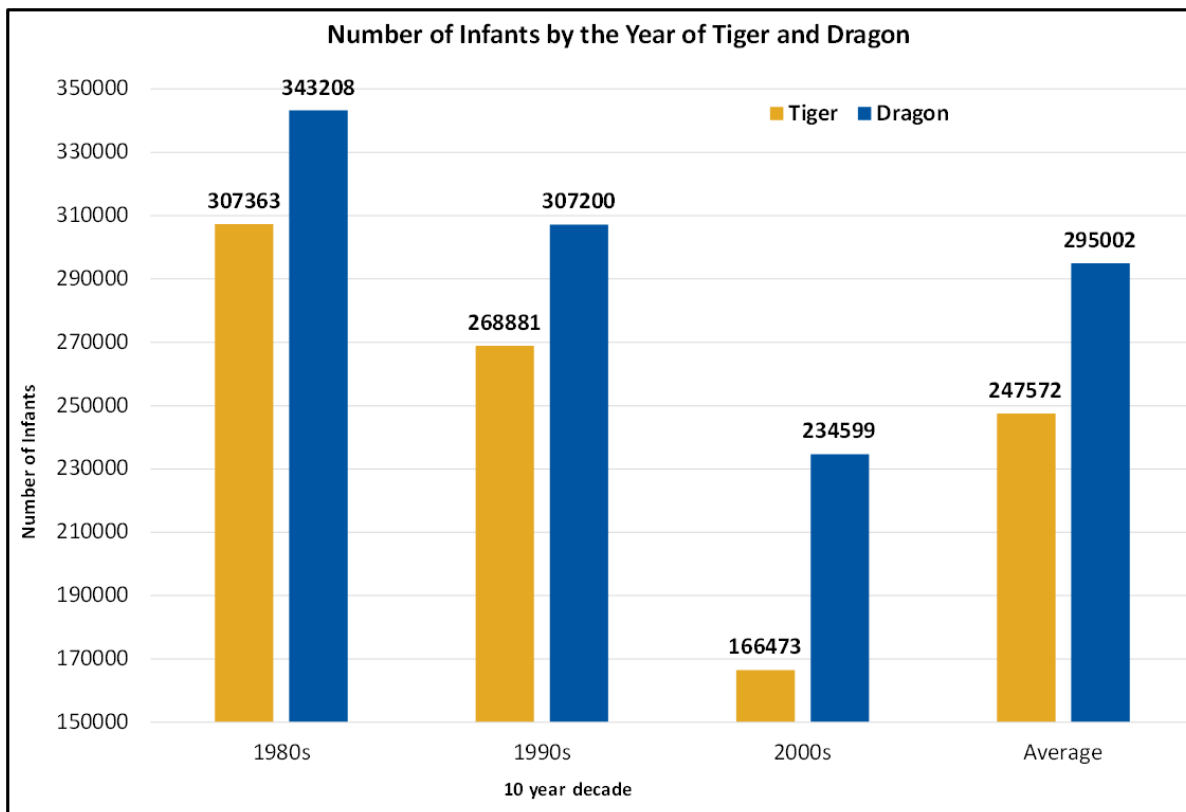
FIGURE 1. The difference in the number of infants by the years of tiger and dragon
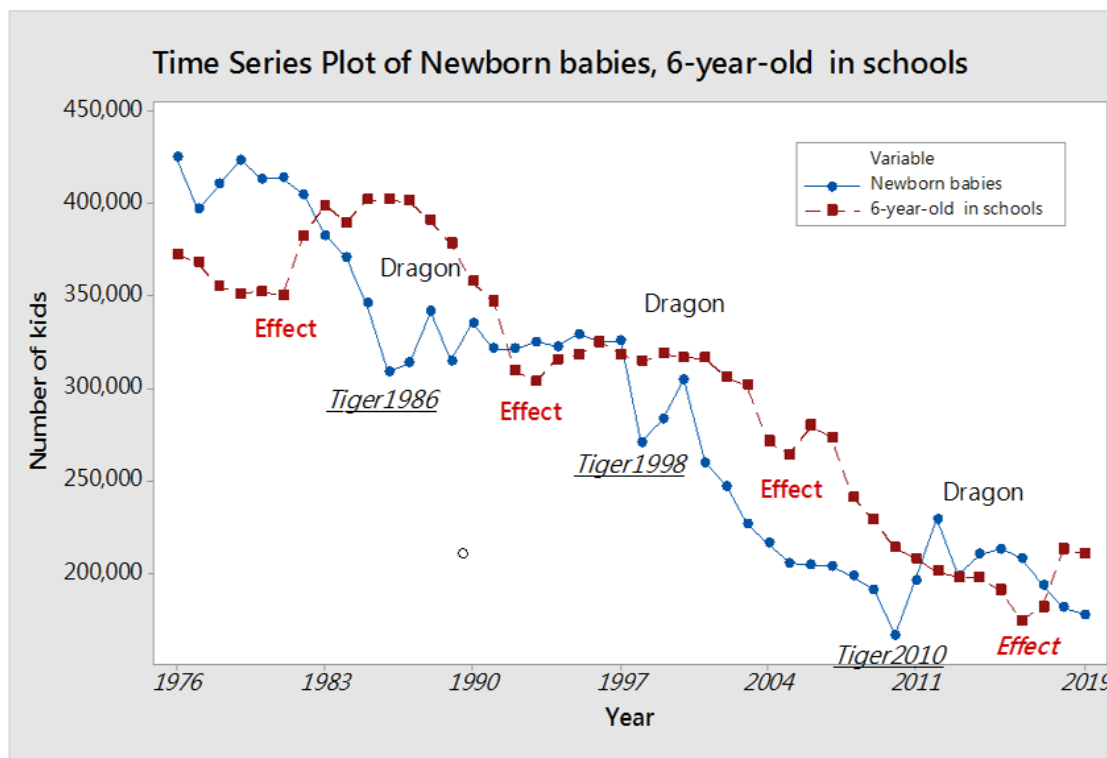

FIGURE 2. The number of infants and school enrollment from 1976 to 2019

2000, 16.71% in 2012, while the tiger effect has shown differently in 1986 (-10.68%), 1998 (-16.73%), and 2010 (-12.7%). We assume that the dragon and tiger effect might impact the enrollment of elementary schools 7 years later.

Reviewing the series plot of the 6-year-old group in elementary schools (enrollment of the first year), the result suggests the tiger effect has shown a significant impact on the enrollment in elementary schools. While the dragon effects may increase the enrollment in elementary schools but the patterns are different from that of the tiger effect. The details of the tiger and dragon effect on newborn babies and school enrollment are displayed in Figure 1. In this case, the tiger effect exerts more influence on enrollment which might cause a negative impact in elementary schools during the decline birth rate.

3.2. **Comparison of the predicted models.** To explore whether cultural beliefs – Chinese zodiac affect the number of infants and elementary school enrollment, this study conducted the time series model to predict the number of infants in the next 12 years. The data include the historical data from 1952 to 2019, which covered 68 years with one difference. The result shows that both ARIMA $(0, 1, 1)$ and ARIMA $(1, 1, 12)$ are the fitted models. The fitted models with their stationary R-squared, MAPE (mean absolute percent error), normalized BIC (Bayesian information criterion), and Ljung-Box Q (18) are presented in Table 1. The Ljung-Box Chi-square statistics are used to determine whether the models meet the assumption that the residuals are independent. The selected models show that the p-values are greater than .05. It implies the errors are randomized. The predicted values for the next 12 years are displayed in Table 2.

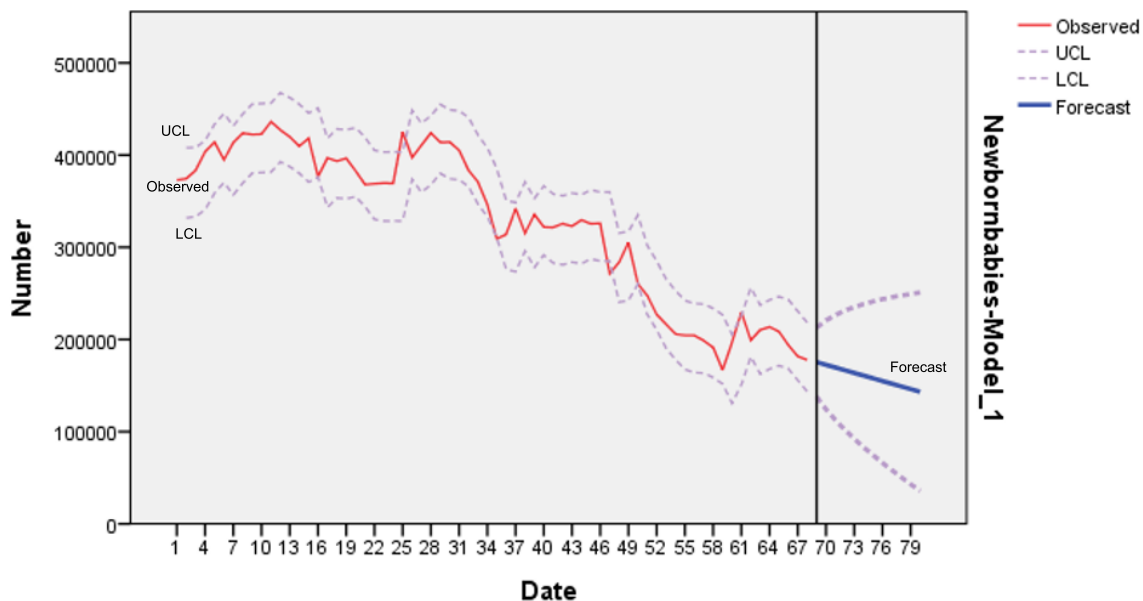TABLE 1. Comparison of ARIMA $(0, 1, 1)$ and ARIMA $(1, 1, 12)$ with 1952-2019 data

Fit model	Stationary R-squared	MAPE	Normalized BIC	Ljung-Box Q (18)
ARIMA $(0, 1, 1)$	.036	4.544	19.802	$p = .094$
ARIMA $(1, 1, 12)$	.297	3.837	20.444	$p = .266$

TABLE 2. Comparison of the predicted values in ARIMA $(0, 1, 1)$ and ARIMA $(1, 1, 12)$

Year	ARIMA $(0, 1, 1)$	Up_CL	Low_CL	ARIMA $(1, 1, 12)$	Up_CL	Low_CL
2020	175414	212841	137988	161283	195024	127542
2021	172489	220725	124254	143634	187691	99578
2022	169564	226596	112532	136689	188912	84467
2023	166639	231281	101997	143024	208658	77390
2024	163713	235159	92267	148545	223277	73812
2025	160788	238444	83132	138297	221112	55482
2026	157863	241268	74458	146079	236035	56124
2027	154938	243720	66155	145499	241476	49522
2028	152012	245865	58160	146767	247304	46229
2029	149087	247750	50425	136614	239054	34174
2030	146162	249410	42914	131579	235522	27635
2031	143237	250876	35598	127338	233035	21642

Figures 3(a) and 3(b) reveal the ARIMA $(0, 1, 1)$ has displayed the predicted values shaped a smooth project line in the next 12 years, while the ARIMA $(1, 1, 12)$ presents a fluctuated trend in the future. In this sense, the ARIMA $(1, 1, 12)$ has shown to be a better model to predict the number of infants in the future.

3.3. **Impact on enrollment of elementary schools.** Both predicted models suggest that the number of infants will decrease gradually in the future. Considering the previous trends of the declining birth rate and the number of infants, the finding shows that the declining number of infants will impact elementary school enrollment 7 years later. As per

(a)
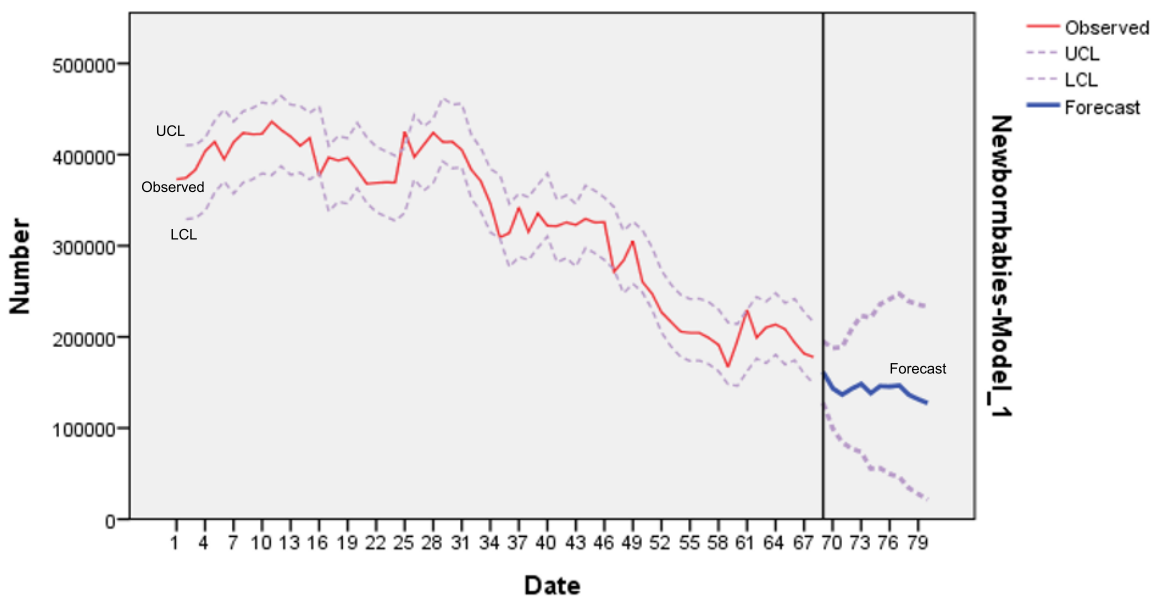
(b)

FIGURE 3. Comparison of ARIMA $(0, 1, 1)$ (a) and ARIMA $(1, 1, 12)$ (b)

our predicted values in ARIMA $(1, 1, 12)$, the tiger effect in 2022 will cause enrollment to decrease significantly in 7 years later, while the dragon effect in 2024 will contribute to an increased enrollment 7 years later. The result also shows that not the higher number of infants in the year of the dragon will affect elementary school enrollment. Although there are twelve animals in the Chinese zodiac, other animals did not have such a dramatic change in terms of the number of infants and the later enrollment. Such findings affirm how cultural beliefs affect the number of infants as well as elementary school enrollment.

4. **Conclusions.** This study applied trend analysis, time-series analysis, and ARIMA models to exploring the effect of the Chinese zodiac upon the number of infants born and elementary school enrollment. The findings suggest that the year of the tiger and the year of the dragon had a significant effect on the number of infants born and elementary school enrollment. This study validates how cultural beliefs can affect the number of

infants born and school enrollment. As similar trends also took place in China, Vietnam, Hong Kong, it might be worthwhile to study the similarities and differences.

The findings of this study also suggest the possible issues related to rapid changes in elementary school enrollment such as the teacher preparation programs, unequal educational resources per student, different class sizes, and potential budget planning in elementary school. The predicted ARIMA models provide implications for schools to prepare their student enrollment and budget planning. For system-wide concerns, the findings can offer useful information for policymakers or leaders at the elementary education level. This study suggests that assessing the annual trends might prepare better longitudinal educational planning. In the future, the Taiwanese government might consider implementing long-term planning to address the declining enrollment issues. It might be worthwhile to start a regional tracking system to identify the challenges and opportunities.

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