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DETECTING THE ISSUES OF POPULATION AGING BY USING ARIMA MODEL

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Abstract. *Population aging is poised to become one of the most significant social transformations of the twenty-first century. Perceiving the rapidly increasing population aging, this study selected Taiwan as a target to tackle the issue. Previous studies have warned the drawbacks of composite indicators dealing with aging issues; therefore, this study tries to find an alternative way to fit series data in an aging society. To achieve the specific purposes, the study aims to create appropriate indices to further interpret the issues of population aging. The time series analysis was carried out in this study by using the Minitab® statistical package. The result of the ARIMA model reveals the increasing of over 65 year-old adults in Taiwan will reach up to a new high in next decade. The potential support ratio will decline speedily. Realizing the gap, the suggestions are provided for the policy makers to deal with the issues more effectively.*
Keywords: Aging index, ARIMA, Population aging, Potential support ratio, Time series analysis

1. **Introduction.** The world's population is growing and aging. According to the results of the 2017 Revision, the world's population numbered nearly 7.6 billion as of mid-2017, implying that the world has added approximately one billion inhabitants over the last twelve years. Sixty percent of the world's people live in Asia (4.5 billion), 17 percent in Africa (1.3 billion), 10 percent in Europe (742 million), 9 percent in Latin America and the Caribbean (646 million), and the remaining 6 percent in Northern America (361 million) and Oceania (41 million). China (1.4 billion) and India (1.3 billion) remain the two most populous countries of the world, comprising 19 and 18 per cent of the global total, respectively [1]. Simultaneously, every country in the world is experiencing growth in the number and proportion of older persons in their population. Population aging is poised to become one of the most significant social transformations of the twenty-first century. Between now and 2030, every country will experience population aging, it will demonstrate a trend that is both pronounced and historically unprecedented. In the next four decades, the aging group is expected to rise to 22 percent of the total population in terms of a jump from 800 million to 2 billion people. Evidence suggests that cohorts entering older age now are healthier than previous ones [2]. The aging issues might impact nearly all sectors of society including labor and financial markets, the demand for goods and services, housing, transportation and social protection, as well as family structures

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and intergenerational ties [1,3]. Therefore, how to clarify the aging issues has become an emerging research topic.

To begin addressing these issues, the General Assembly convened the World Assembly on Aging in 1982, which produced the "Vienna International Plan of Action on Aging" [4]. It is the first international instrument on aging, and provides a basis for the formulation of policies and programs on aging. Following, specific actions on such issues as health and nutrition, protect elderly consumers, housing and environment, family, social welfare, income security and employment, education, and the collection and analysis of research data. The research societies are also busy dealing with the aging issues. For example, Nagarajan et al. employed bibliometric techniques and found that: (a) although aging has increasingly attracted more researchers within economics literature, the relative weight of aging and economic growth related papers does not evidence a clear positive trend; (b) recent studies reveal the willingness of researchers to evaluate less immediate mechanisms relating aging and economic growth; (c) the increase in the use of empirical methods reflects a trend to test economic phenomena with real-world data against the theory; (d) very few studies focus on developing and less developed countries [5]. Based on previous studies, this study assumed different countries might confront similar aging issues. Different methods using will deepen the realization of the issues.

Furthermore, previous studies indicated, the 'Active Aging Index' (AAI) is a composite indicator which aggregates information regarding several dimensions of active aging [6]. Several authors have warned regarding some of the drawbacks of composite indicators [7,8]. In this respect, according to Smith [8], a composite index may disguise poor performance in parts of the system because of the aggregation involved; it may be difficult to identify improvement actions based on the aggregated results provided by the index; and current methodologies to identify an appropriate set of weights are inadequate because they do not reflect alternative viewpoints regarding the preferences. The AAI was created precisely to help policy makers implement and monitor active aging both at European and national levels. This index is a project managed jointly by the European Commission's Directorate General for Employment, Social Affairs and Inclusion, and the Population Unit of the United Nations Economic Commission for Europe. Even though the AAI was created with policy purposes in both at European and national levels, this index has not fully achieved this purpose [8-10]. Did they have any simple and easy way to reflect the aging issue under the constraint of data collection? Therefore, this study seeks an alternative way to mining the aging population issues. The findings can be provided for the policy makers to deal with the issues more effectively.

This study selected Taiwan as a specific target to conduct related population aging concepts to tackle the issue. The purposes of this study are as follows: (a) to realize the effect of population aging in the system; (b) to project the development of population aging in the system. Given these purposes, the structure of this paper is as follows. Section 1 addresses the current issues of population aging and concepts of aging index. Section 2 provides a brief description of the ARIMA (autoregressive integrated moving average) model related to data transformation and forecasting. Section 3 examines the robustness of predictive method for aging index in this study. Conclusions are presented in Section 4.

2. **Method.** This study applied the concept of data mining to dealing with the population aging issue. This section addresses how the data have been collected and transformed. The population data selected from MOI cover 43 periods (from 1976 to 2016) [11]. Excel a useful tool, was used to transform the target data in the initial stage of the study. This study follows the format of aging index and potential support ratio to restructure the data set. The ARIMA model in Minitab was used to transform the population aging ratio and

potential support ratio as the target indices to interpret the issue of the population in the society.

2.1. **Definition of the index of population aging.** There are two aging indices implemented in this study. First, the aging index is calculated as the number of persons of 65 years old or over per hundred persons under age 15. Second, the percent of total adults over 65 years old is another aging index using to interpret the population aging. The calculation is added of the number of persons aged 65 or elders over the total population in the case country. Typically, the 65 years old population over 7% has been defined as an aging society, then over 14% as an aged society, and over 20% as an over-aged society. In 2018, this society has been announced as an aged society.

2.2. **Potential support ratio.** The potential support ratio is the number of persons aged 15 to 64 per every person aged 65 or older. Potential support ratio was used to display strength of the possible social, economic support come from 15-64 group of population in the society.

2.3. **Projecting the trend of aging index and potential support ratio.** This study follows the ARIMA model building process preparing data to obtain stationary series, identify potential models, check the partial autocorrelation function (ACF) and partial autocorrelation function (PACF) of residuals, and forecast [12-18]. A non-seasonal ARIMA model is classified as an "ARIMA(p, d, q)" model, where:

p is the number of autoregressive terms,

d is the number of non-seasonal differences needed for stationarity, and

q is the number of lagged forecast errors in the prediction equation.

The forecasting equation is constructed as follows. First, let y denote the dth difference of Y, which means:

If $d = 0$: $y_t = Y_t$

If $d = 1$: $y_t = Y_t - Y_{t-1}$

If $d = 2$: $y_t = (Y_t - Y_{t-1}) - (Y_{t-1} - Y_{t-2}) = Y_t - 2Y_{t-1} + Y_{t-2}$

The differencing was used to remove the linear trend for both series. The differenced series provides more stationary type for forecasting. This study plots the ACF and PACF of the differenced series to look for the data more consistent with a stationary process. This study also considered the Box-Pierce Chi square statistics to check the residual appears to be low and diminish as the number of lags increases [17,18]. In this study, the analyses are carried out using the Minitab® statistical package.

3. **Results.**

3.1. **The trend of aging index and percent over 65 years old adults.** The scatterplots of aging index and percent of over 65-year-old population (Over65% or Over65% adults) are displayed in Figure 1. Both of the series have similar growing trends. These trends implied the aging index and percent of over 65-year-old population are growing rapidly. In 2016, the aging index is almost up 100 in terms of the aging population vs. young population (0-14) is 1:1. The percent of over 65-year-old population is almost up to 14% in 2017.

3.2. **Trend of potential support ratio.** Figure 2 demonstrates the trend of potential support ratio is declining. It implies the society is aging while the support system will become weak steadily. Even though there is no significant information to determine which level of potential support index is acceptable, the declining trend presented a worry signal in the society.

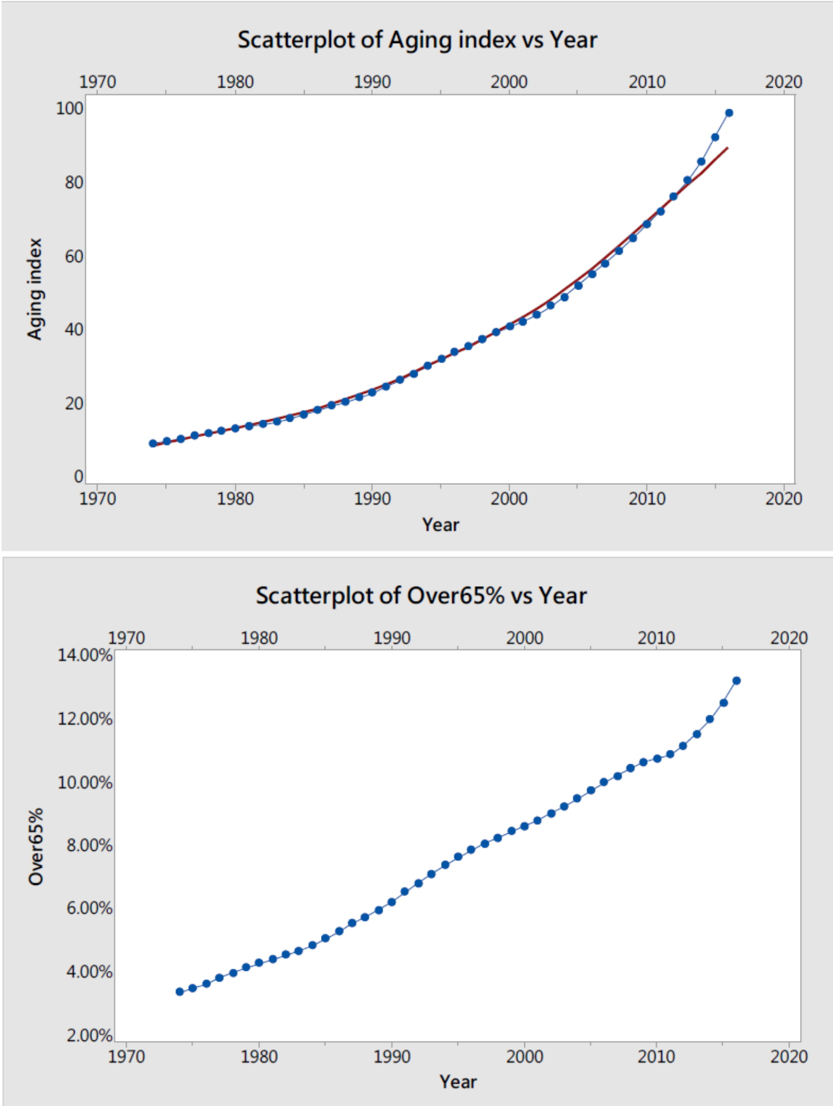

FIGURE 1. The trends of aging index and percent of over 65-year-old adults

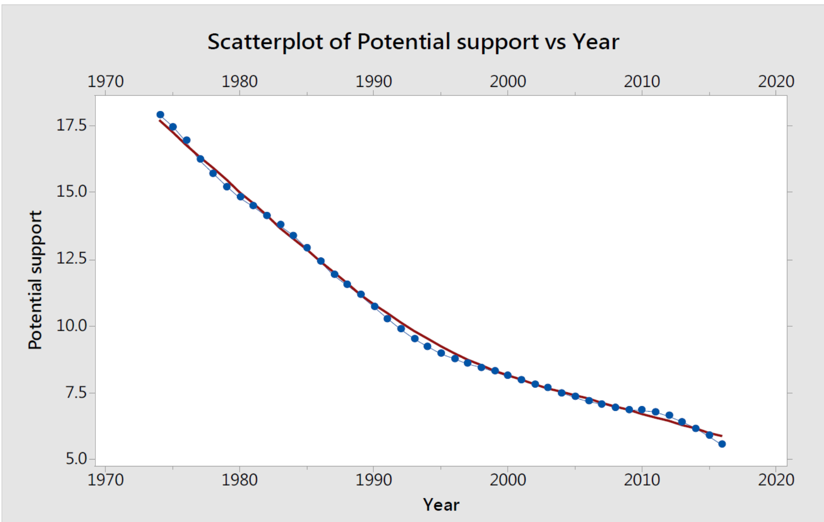

FIGURE 2. The trends of porential support index from 1976 to 2016

3.3. **Interpretation of the aging index and potential support ratio by ARIMA.** Initially, inspection of the ACF of the time series is necessary to determine if the series is stationary or will require differencing. Because the data are not stationary, both the series that present variance from one period to another need to one difference for station. Tests for ACF and PACF indicated that the model ARIMA$(1,1,1)$ could be used to predict the series of aging index. Evidence also exists to support that the residuals follow a white noise process and the ARIMA$(1,1,0)$ is a robust representation of the observed time series of potential support ratio. The final estimates of parameters for percent of over 65-year-old adults and potential support ratio are displayed in Table 1.

Table 1. Final estimates of percent of over 65-year-old adults and potential support ratio

Over65% adults ARIMA$(1,1,1)$	**Coef.**	**SE Coef.**	***t*-value**	***p*-value**
AR(1)	1.155	0.104	11.13	0.000
MA(1)	−0.316	0.168	−1.88	0.067
Constant	−0.000204	−0.000132	1.54	0.131
Potential support ratio ARIMA$(1,1,0)$	**Coef.**	**SE Coef.**	***t*-value**	***p*-value**
AR(1)	0.9188	0.0654	14.04	0.000
Constant	−0.0268	0.0105	−2.55	0.015

Note. Differencing: 1 regular difference; Original series 43, after differencing 41

The processes also check the robustness of predicting. Under the assumption of no correlation left in the residuals the Ljung-Box statistic is Chi-square distributed with K-n_C degrees of freedom, where n_C is the number of estimated parameters in model except for the constant δ [17,18]. In this study, Ljung-Box Chi-square statistics demonstrate the models meet the assumptions that the residuals are independent, see Table 2. Basically, a significant level of .05 (denoted as α) works well. In this study, the p-values for the Ljung-Box Chi-square statistics are all greater than .05.

Table 2. Modified Box-Pierce Chi-square statistics for ARIMA models

Over65% adults/Lag	12	24	36	48
Chi-square	4.37	15.60	27.32	*
DF	9	21	33	*
p-value	0.885	0.792	0.746	*

Potential support ratio/Lag	12	24	36	48
Chi-square	7.77	14.83	29.91	*
DF	10	22	34	*
p-value	0.651	0.869	0.669	*

The results of forecasting 10 years (2017-2026) in series of percent of over 65 years old and potential support ratio are displayed in Figure 3 and Table 3. The result of the ARIMA model reveals the increasing of over 65-year-old adults in Taiwan will reach up to a new high in next decade. The potential support ratio will decline speedily. The results reveal the increasing of over 65-year-old adults will impact the effect of potential support in the society. This study provides a clear picture that Taiwan has become an aged society. In the long run, the issues of lack of potential support in this society are emerging.

4. **Conclusions.** This study raised the issues of population aging. It is an emerging phenomenon in the world's population. Taiwan, as an aged society, has faced more serious issues than before. This study conducted aging index, percent of 65-year-old population, and potential support ratio to predict the future trends of the series. The results reveal

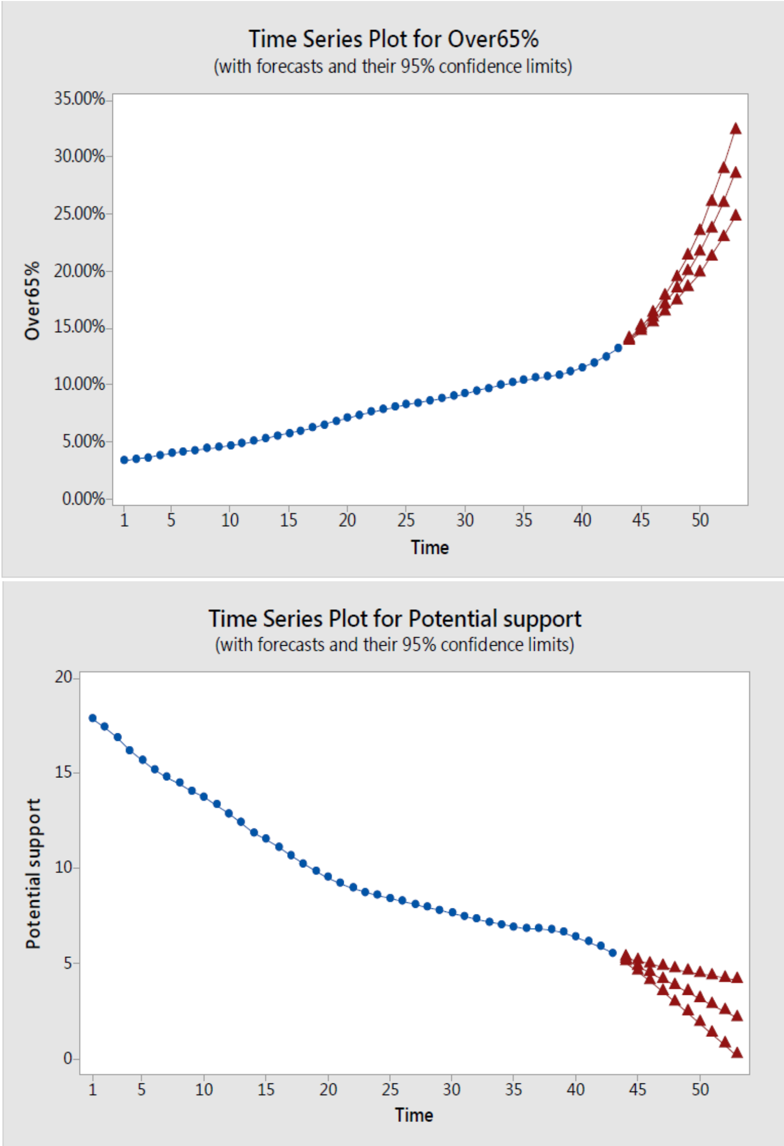

FIGURE 3. Time series plot for Over65% adults and potential support ratio from 1976 to 2026

TABLE 3. Forecasts from 2017-2026

Year	Over65% adults ARIMA(1, 1, 1)	95% limits		Potential support ratio ARIMA(1, 1, 0)	95% limits	
	Forecast	Lower	Upper	Forecast	Lower	Upper
2017	0.139994	0.139127	0.140861	5.22559	5.09505	5.35613
2018	0.149083	0.146773	0.151394	4.88511	4.60266	5.16755
2019	0.159382	0.155091	0.163673	4.54552	4.08742	5.00362
2020	0.171077	0.164244	0.177910	4.20676	3.55621	4.85731
2021	0.184386	0.174398	0.194374	3.86875	3.01366	4.72383
2022	0.199560	0.185736	0.213385	3.53143	2.46313	4.59973
2023	0.216889	0.198462	0.235316	3.19475	1.90707	4.48243
2024	0.236707	0.212809	0.260606	2.85866	1.34740	4.36992
2025	0.259402	0.229043	0.289761	2.52311	0.78559	4.26063
2026	0.285420	0.247468	0.323372	2.18805	0.22280	4.15329

both trends of aging index and percent of over 65-year-old population are growing rapidly. The increasing of over 65-year-old adults will impact the effect of potential support in the society. Simultaneously, the trend of potential support ratio is declining. This study suggests that the lack of potential support issue in the society is emerging. To reshape the structure of population, it needs effective strategies to get involved this issue. For example, encourage the young couples to raise one more kid, subsidy the aging people by creating a new saving system to reduce their dependency.

This study provides useful information for the related policy makers to ameliorate the worsen situation. Furthermore, the applications of related aging index and potential support ratio transformation may provide examples to tackle the similar issues in different settings.

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