ICIC Express Letters
Part B: Applications
Volume **12**, Number **12**, December **2021**
 ISSN 2185-2766
pp. **1145–1153**

DETECTING THE ISSUES OF AGING SOCIETY BASED ON THE TREND OF DEPENDENCY AND SUPPORT POPULATION

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Received April 2021; accepted June 2021

Abstract. *Aging has become a prevailing phenomenon in the world. Various countries have shown moving into a super-aged society. When an aging society is confronted with a declining birth rate, what will happen in its structure of the population? We assumed both aging and declining of birth rate issues might change the structure of population fundamentally in a society. This study aims to explore the issue of the population structure change in an aging society. Both dependency and support populations have been addressed with a new definition to recalculate their proportion. Taking Taiwan as an example, this study utilized the data set from 1974 to 2020 in the Ministry of Interior and transferred the original series data. Becker's D index was used to interpret the transformation of the pattern in dependency and support population in the society. We employed ARIMA to build models for predicting a long-term trend with D. The findings suggest that the new calculation of the young dependency population with 0-20 years old is more reasonable. The new calculation D shows it can reflect sensitively the declining trend in the next decade. Even though the support population is still stable in this society, the balancing issue might become a new challenge in the future.*
Keywords: Aging society, ARIMA, Becker's D, Dependency population, Support population

1. **Introduction.** An aging society has come and goes fast toward the super-aged stage in many countries. The aging issues might impact nearly all sectors of society, especially labor and financial markets, the demand for goods and services, housing, transportation, and social protection, as well as family structures and intergenerational ties [1,2]. The growing aging population has become a new pressure in various societies. According to the World Health Organization, a society in which the proportion of people 65 years or older is 7% or higher is known as an "aging society", 14% or higher is regarded as an "aged society", and 20% or higher is called a "super-aged society". Various developed countries have become super-aged societies. Some countries taken a long period moved into the super-aged stage, for example, France spent 29 years and British spent 51 years in their transformation from an aged society to a super-aged society [3]. Some Asian countries have shown their abnormal transformation speed, for example, Japan spent 11 years and Korea may spend 8 years for such kind of transformation. Taiwan has become an aging society in 1993 and moved into an aged society in 2018. With the speed of social transformation, Taiwan could become a super-aged society soon. Population aging is poised to become one of the most significant social transformations of the twenty-first century [4]. The aging population has become an influential component of the dependency population. When an aging society is confronted with a declining birth rate, what will happen in the structure of the dependency population and potential support population?

DOI: 10.24507/icicelb.12.12.1145

For example, the birth rate in Taiwan decreased from 13.86 per thousand people in 2000 to 7.98 in 2020; it is almost a 50% decrease in the last 20 years [5]. The birth rate in Taiwan decreased from a higher birth rate to below the replacement level back in the 1990s [6]. Since then, the birth rate in Taiwan has been decreasing every year [7]. The declining birth rate has become a crucial component that might reshape the patterns of the dependency population. Regarding the calculation of the young dependency population issue, we found it is also questionable in the current statistical report. For example, the gross entrance ratio in higher education has reached 85% in Taiwan, which implied most of young people (1-22 years old) still study in higher education [8]. This part of young people cannot be calculated into the support population. Traditionally, the calculation of the young dependency population is from 0-15 years; it is obvious that a new calculation for the young dependency population needed to be reconsidered.

Previous studies provided some useful information to reconsider the issues. For example, Pekarek examined the problem of population aging on economic dependency ratio found using a broader definition of economic dependency allowing for variability in employment rates of age- and gender-specific groups. Studies found dependency ratios are predicted to increase from 110% in 2016 to 161% in 2060 and from 120% to 181% for the Czech and Slovak economy respectively. Decomposition of the indicator shows substantial old-age cohort contribution, which indicates increased pressure on fiscal stability due to population aging [9]. The total age-dependency ratio is a measure of the age structure of the population. It relates the number of individuals who are likely to be "dependent" on the support of others for their daily living. Related studies showed the total dependency ratio significantly declined from 102.5% in 1990 to 41.4% in 2012 [10,11]. Moreover, it has found the studies on the population dependency ratio issues with wide perspectives, for example, criticized traditional dependency ratios issues [12]; considered the economic support ratio by using the notion of National Transfer Accounts (NTA) [13,14]; prospected old-age dependency ratios [15,16]. Previous studies tried a reasonable way to calculate the dependency ratios and made an adequate interpretation. We found the dependency population and support population have fluctuated in various countries. To realize the variation, the percentage of both series is a distinctive format in current studies, while it seems not clear enough to interpret the phenomena in a long-term trend. The question is: Can we find a clear picture with an index format to realize the structure change of dependency and support population in a long term?

This study will focus on series data and employ a diversity index by using ARIMA (autoregressive integrated moving average) to build a long-term trajectory model. Because of the speed of an aging society and the declining birth rate, Taiwan could be a typical case, and it can be used to realize the issue of population pattern transformation. Taking Taiwan as an example, this study will explore the changing pattern of the dependency population and support population. The finding can provide a new model to interpret the diversity of the dependent and support population. Specifically, the purposes of the study are presented as follows:

a) What is the trend of dependency and support population in Taiwan?
b) Can the dependency and support population be transferred with an index format?
c) Will the revised calculation of the young dependency population make sense to interpret the series data?
d) What is the trend of the dependency and support population in the future?

This study explores the new transformation of the dependency population and support population in a rapidly changing society. The findings can confirm whether the new calculation of dependency population influences the proportion of support population significantly in Taiwan. Meanwhile, it could also show to what extent the index can be exerted by both series data in the future. The following sections of this paper include

the method section which addresses the data been converted to the time series model for projecting and how the fitted models been shaped; second, the study displays the findings and interprets their implications for an aging society. Finally, the conclusion is drawn and some suggestions for further studies are presented.

2. **Method.** The target data set is cited from the Ministry of Interior, Taiwan [17]. The series data cover 47 periods from 1974 to 2020. This study employed the notion of Becker's discriminant coefficient (D) to transform the original data of dependency and support population [18]. ARIMA model was used to project the future trend of the related data set.

2.1. **Definition of the terms.**

- Dependency population (DP) refers to young and old groups, traditionally, the young group refers to 0-14 years old, while the old one refers to over 65 years old. While the growth entrance ratio (GER) of higher education has reached 85 percent. It implies there are certain numbers of young people who still needed be supported by the adults. In this case, the traditional population statistics was used to deal with the dependency population which counted 0-14 years old young population as a target group. While such a calculation did not consider 15-20 years old students which might confront new challenges. In our new model, the calculation of the young dependency population refers to 0-20 years old. The main reason for this concern is young people of 20 years old with the right to vote in this country.
- Traditional support population (SP) refers to 15-65 years old group, this study will base on the new calculation of young dependency population (DP), the support population refers to 21-65 years old group.

2.2. **Data transformation.** D is an alternative index for evaluating the diversity of dependency and support population. Becker defined the economics of discrimination and proposed the concept of a coefficient of discrimination [18]. Although the definitions of discrimination vary depending on the field of study, the original definition might have equally concerned skilled people from specific demographic groups who were treated differently by a labor market. In the original concept, a method for equalizing skills is required to assess whether wage differences are inconsistent with observed productivity [19]. Becker provided an alternative index to estimate parity, which can be applied for testing the diversity between the specific groups. In this study, we extended the notion to calculate the diversity of dependency and support population. An alternative D for dependency and support population is defined as follows:

$$D_i = (\mathrm{SP}_i/\mathrm{DP}_i) - 1$$

where SP represents the support population, DP represents the dependency population in the country, and i represents the series data collection period from 1974 to 2020 in this study. The interpretation of D will follow the following rules.

- An increase in the calculated D implies a system with well support population.
- The calculated D being negative means that the system might suffer the pressure of the dependency population increasing.
- A calculated D of zero or near zero represents a quit balancing for both dependency and support population groups.

In this study, we define the $D(t)$ as the traditional transformation of DP and SP, while the D is represented of the calculation based on newly defined DP and SP. In this case, we assumed the D will demonstrate new meanings for this aging society.

2.3. **Forecasting the future trends of DP, SP, and *D*.** Time series analysis has been applied for wide settings, for example, predicting in the product of agriculture [20], business services [21], and AI technology [22]. In this study, we extended the notions to the issue of the social science domain. First, this study will check the attribution of the data whether the DP, SP, and D belong to seasonal or non-seasonal series. This study follows the ARIMA model building process, identify potential models, check the autocorrelation function (ACF) and partial autocorrelation function (PACF) of residuals, and forecast [23-27]. A non-seasonal ARIMA model is classified as an "ARIMA(p, d, q)" model, where:

p is the number of autoregressive terms (AR),
d is the number of non-seasonal differences needed for stationarity (I), and
q is the number of lagged forecast errors in the prediction equation (MA).

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 [28,29]. In this study, the analyses are carried out using the Minitab® 20 statistical package.

3. Results.

3.1. **Comparison of the DP and SP with traditional and new suggested calculations.** Figure 1 displays the traditional calculation of DP and SP with percentage format. The DP shows decreasing from 39.58% to 28.65%. It may reduce the DP in society. Meanwhile, SP shows decreasing from 65.78% to 40.16%. The SP has shown a larger percentage of decline than that of DP from 1974 to 2013. While the young dependency population declining rapidly in the last two decades, the DP and SP did not reflect the fact of declining and increasing properly. We argued the basis for calculation of young dependency population and SP may need to reconsider with more reasonable way.

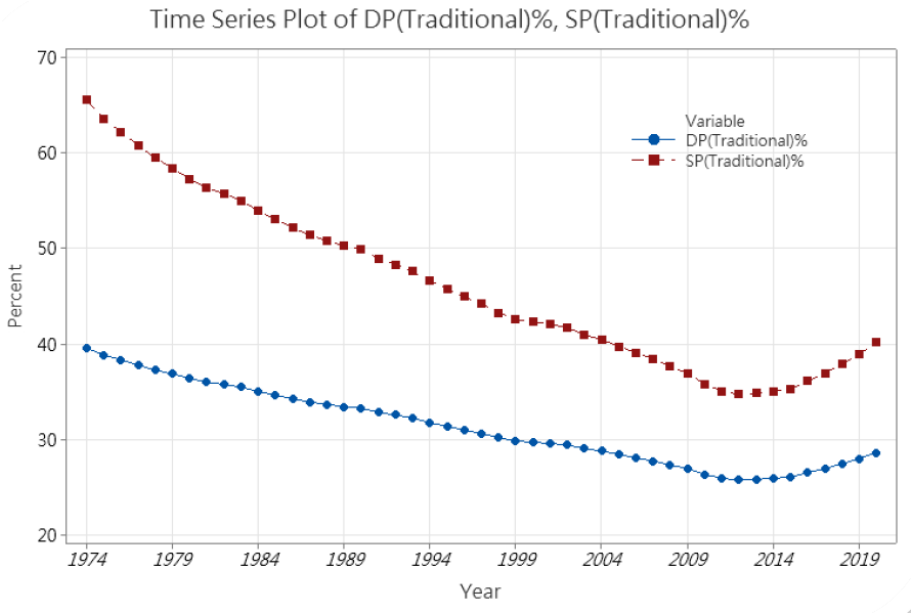

FIGURE 1. Time series plot for traditional DP and SP

The suggested calculation for DP for the young dependency population group should extend to 20 years old in terms of the young dependency population referring to the 0-20 years old group. Therefore, the new calculation support population will limit to the 21-65 years old group. Figure 2 shows the time series plot of the new DP and new SP with percentage format. Taiwan has moved into an aged society in 1998; the picture shows it still has a strong support population in the society. The DP has shown 51.55% dropped

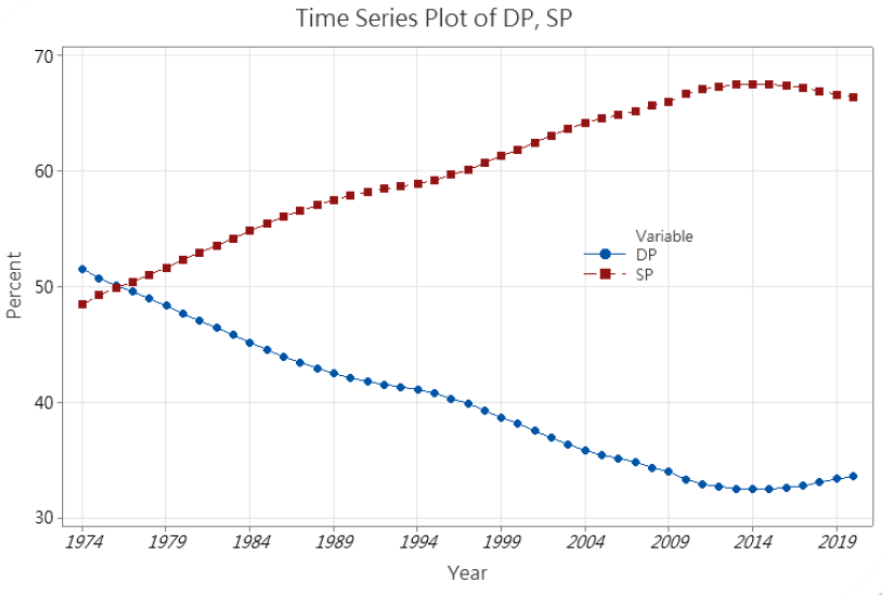

FIGURE 2. Time series plot for new DP and new SP

to 33.55%, while the SP shows from 48.45% to 66.45%. Figure 2 also reveals when the society moved into an aged stage in 2018, the dependency population has shown increasing and the support population has shown decreasing. While the gap between DP and SP is very large, the strong effect of support population still exists in the society.

3.2. **Becker's *D* transformation.** Comparing the traditional $D(t)$ and new D for detecting the diversity of dependency and support population, we found the ARIMA(1,1,0) fits Becker's $D(t)$ with the traditional calculation. While the ARIMA(1,2,1) fits the new D transformation. The estimated parameters for both models are displayed in Table 1. $D(t)$ with ARIMA(1,1,0) showed, AR(1) is 0.9289, $p < .000$ with one difference; D with ARIMA(1,2,1) indicated AR(1) is 0.9085, MA(1) is 1.0554, and both p are less than .000 with two differences. Ljung-Box Chi-square statistics displaying error terms are shown in Table 2. It implied the error terms are in an acceptable level. Based on ARIMA in Minitab, both models have fitted to the forecast of the series. The forecasts from period 47 (2020) for the next decade are demonstrated in Table 3. Based on the results, we found the traditional $D(t)$ will increase, while the new calculation D will decrease in the future. This is the basic difference in both transformed series to reflect the structure in the future. The result reveals when we consider the reasonable calculation of dependency population and support population the real meaning for the society might display. The time series of the plot for predicting $D(t)$ and D is shown in Figure 3 and Figure 4.

TABLE 1. Final estimates of parameters for $D(t)$ and D

***D*(*t*)** with ARIMA(1,1,0)				
Type	Coef	SE Coef	*t*-value	*p*-value
AR(1)	0.9289	0.0767	12.12	0.000
Constant	0.00119	0.00143	0.83	0.411

D with ARIMA(1,2,1)				
Type	Coef	SE Coef	*t*-value	*p*-value
AR(1)	0.9085	0.0734	12.38	0.000
MA(1)	1.0544	0.0146	72.13	0.000
Constant	0.000064	0.000023	2.78	0.008

3.3. **Comparing the trend of *D* for both series.** Figure 5 shows the $D(t)$ is a relative stationary series, while the D demonstrates its fluctuation. The result reveals both $D(t)$ and D have crossed in 1995. As we know, the society has moved into an aging stage in 1993. After that, the trends of $D(t)$ and that of D are different. It may imply that the

TABLE 2. Box-Pierce (Ljung-Box) Chi-square statistics for $D(t)$ and D

$\boldsymbol{D(t)}$ with ARIMA(1,1,0)				
Lag	12	24	36	48
Chi-square	21.69	33.09	37.82	*
DF	10	22	34	*
p-value	0.017	0.061	0.299	*

$\boldsymbol{D}$ with ARIMA(1,2,0)				
Lag	12	24	36	48
Chi-square	14.47	33.38	41.47	*
DF	9	21	33	*
p-value	0.106	0.042	0.148	*

TABLE 3. Forecasts for $D(t)$ and D from period 48 (2021) to 57 (2030)

$\boldsymbol{D(t)}$ with ARIMA(1,1,0)			
		95% limits	
Period	Forecast	Lower	Upper
48	0.413669	0.408751	0.418587
49	0.425599	0.415239	0.435959
50	0.437581	0.421217	0.453944
51	0.449673	0.427050	0.472297
52	0.461932	0.432996	0.490867
53	0.474404	0.439248	0.509561
54	0.487137	0.445952	0.528321
55	0.500169	0.453224	0.547115
56	0.513539	0.461153	0.565925
57	0.527279	0.469812	0.584747

$\boldsymbol{D}$ with ARIMA(1,2,0)			
		95% limits	
Period	Forecast	Lower	Upper
48	0.964951	0.947338	0.98256
49	0.951695	0.913427	0.98996
50	0.940568	0.878258	1.00288
51	0.931418	0.842600	1.02024
52	0.924104	0.806943	1.04127
53	0.918496	0.771610	1.06538
54	0.914472	0.736828	1.09212
55	0.911921	0.702754	1.12109
56	0.910737	0.669497	1.15198
57	0.910823	0.637135	1.18451

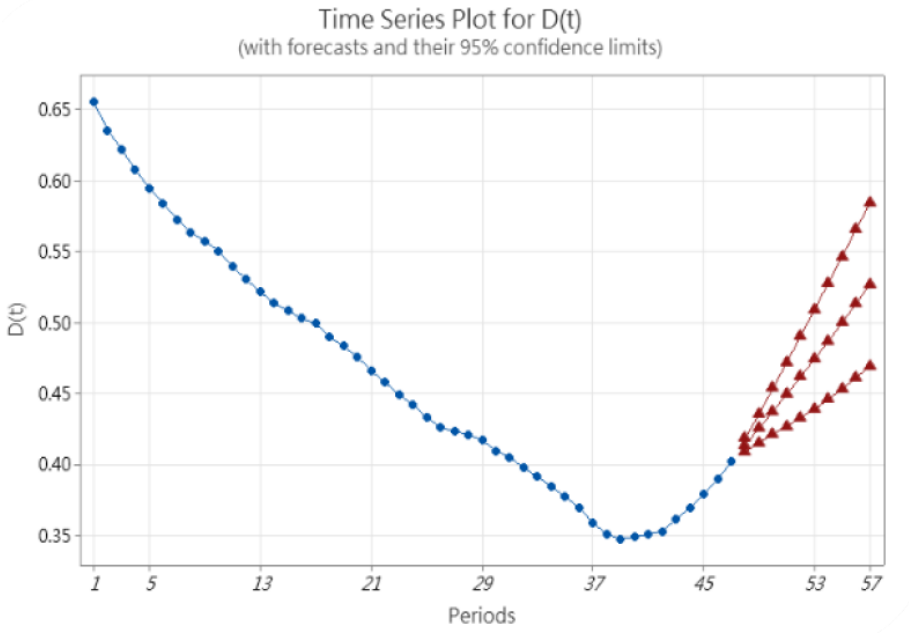

FIGURE 3. Predicting $D(t)$ from 2021 to 2030

new calculation D will reflect the fact that there is a strong support population in the society. When the society moved into an aged stage in 2018, the D shows the effect of support population will decline while the $D(t)$ reflects the effect of support population will increase. Even though the support population is still enough in the society, the balancing of both might confront a new challenge in the future. In this sense, the new calculation D can sensitively reflect the declining trend in the next decade.

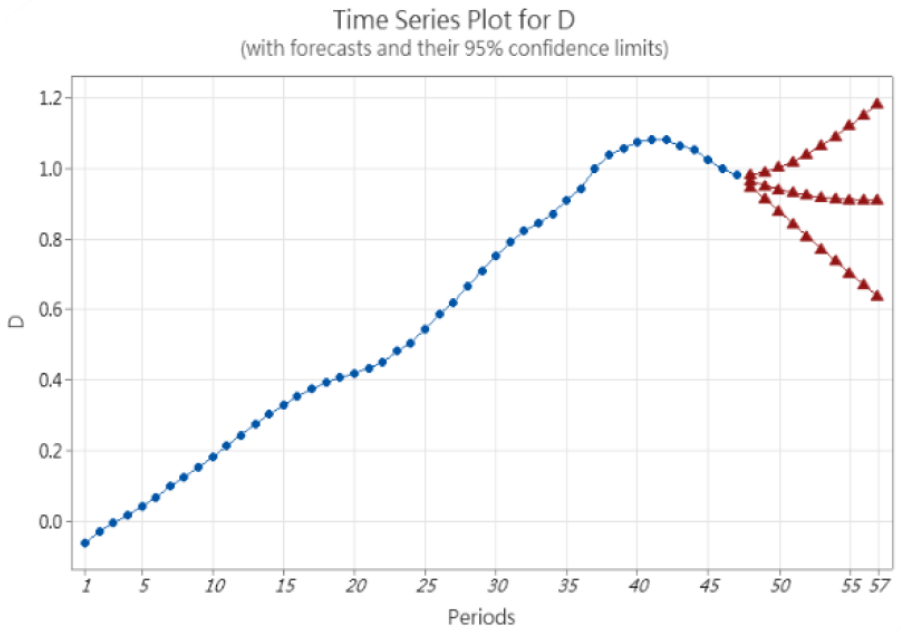

FIGURE 4. Predicting D from 2021 to 2030

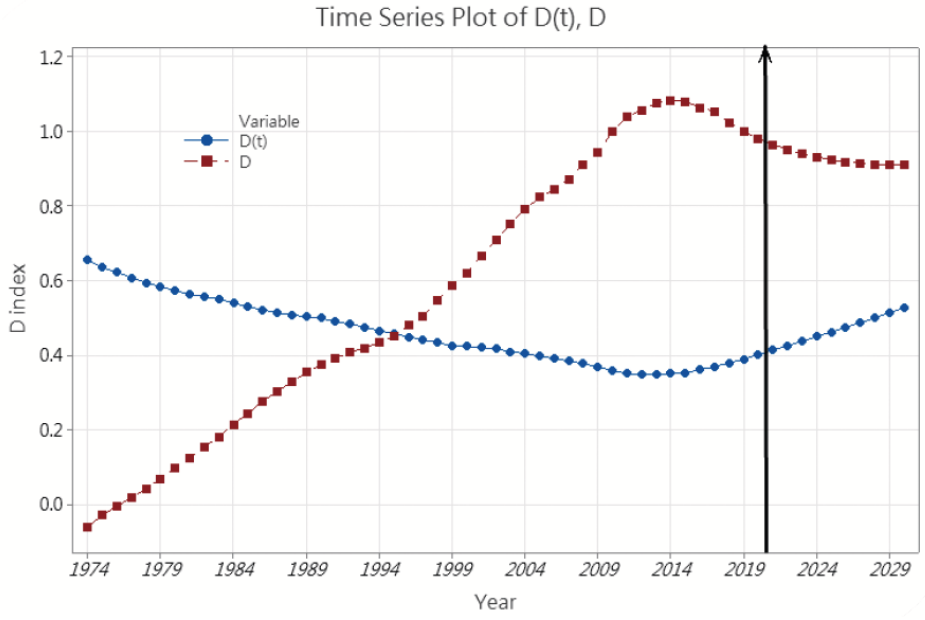

FIGURE 5. Time series plot for $D(t)$ and D from 1974 to 2030

4. **Conclusion.** This study indicates an issue: When an aging society confronted a declining birth rate, what will happen in its structure of the population? The aging and declining birth rate have become prevailing phenomena in the world. Both aging and declining birth rate issues might change the structure of the population fundamentally. This study merely demonstrates the new transformation of the dependency population and support population with age groups in a rapidly changing society. The findings suggest the new calculation of dependency population will influence the proportion of support population significantly in Taiwan. The D transformation with the ARIMA model shows that the index can display the impact exerted by both dependency and support populations in the future. Traditionally, the calculation of young dependency population is from 0-15 years old, a new calculation for young dependency population with 0-20 years old needed to be taken into account in the annual statistical report. Moreover, this study

demonstrates the alternative way to transform the application of Becker's D in the field of population structure issues. The design of the study can be extended to solve similar issues in other settings. The dependency and support population are complicated issues in society. It might contain a lot of factors in the country. For further studies, the issue tackling can extend to the economic factors and pension of an aging population.

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