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Economic Consequences of Population Aging in Sri Lanka

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ABSTRACT

The population aging is unprecedented in human history that brings numerous socio-economic consequences. In this context, this study was with the aim of understanding the impact of population aging on the economic growth of Sri Lanka and the role of the current pension system in Sri Lanka in determining the impact of population aging on economic growth. The study applies a growth accounting framework to evaluate the impacts of population aging on per capita output growth in Sri Lanka, from 1960 - 2019. The Structural Equation Model (SEM) and the dynamic regression with error ARIMA model were used to meet the study's objectives. The findings revealed that the aging population has a significant negative impact on Sri Lanka's economic growth, while total factor productivity growth and capital deepening have a favorable impact. Further, Sri Lanka's present pension system greatly tempered the direct association between population aging and total factor productivity increase. Overall, Sri Lanka's current pension system exacerbates the negative effects of population aging on economic growth. The findings of the study can be used to draw several policy implications for the planning of welfare and economic development programs in Sri Lanka. .

Keywords: Aging population, economic growth, pension system, growth accounting framework, structural equation model

1 Introduction

The rise in the aging population has become a universal phenomenon, which has attracted considerable attention from policy planners throughout the world. By 2050, the world's population aged 60 years and older is expected to total around 2 billion, up from 900 million in 2015 (Bloom et al., 2011, World Health Organization, 2021). The aging of the population means that the working-age population is dwindling in comparison to the elderly (Zuo and Yang, 2010;

Hsu, 2017). Recent declines in fertility rates and increases in life expectancy, when combined with the dynamic evolution of historical changes in birth and death rates, are generating a dramatic shift in the global age structure (Bloom et al., 2011; Mirkin and Weiberger 2001; Menike, 2014).

The economic characteristics of a country will most likely vary as to its population ages because different age groups have distinct needs and production capacities (Navaneetham 2002; Hsu, 2017). The institutional context mediates the relationship between population aging and the macroeconomic performance of a country. Retirement policy, pension and healthcare financing, labor and capital market efficiency and the structure of regional and global economic systems are all likely to change due to population aging (Hsu, 2017; Bloom et al., 2011). Sri Lanka has been mentioned as the fastest aging population in South Asia by United Nations, Asian Development Bank and various authors such as Mendis (2007) and Abeyratne et al, (2014).

Siddhisena (2004) argues that an unprecedented increase in the aging population of Sri Lanka affect various sectors of society and its institutions, either in positive or negative directions. Aging is often associated with retirement (World Health Organization, 2021) and eventually the pension system in the country and also increased longevity during the last few decades have meant an increase in the number of pensioners in Sri Lanka. Studying the aging process and its economic implications in Sri Lanka is important in order for academics, researchers, and policymakers to better understand the profound impacts of aging and formulate better policies for the country (Siddhisena, 2004). Therefore, this study is aim at determining the impact of population aging on the economic growth of Sri Lanka and assessing the role of the current pension system in Sri Lanka.

2 Theoretical framework

In most nations, population aging and decreased labor force participation rates do not always hinder economic growth (Futagami and Nakajima, 2001; Bloom et al., 2010). The logic is that the labor force-to-population ratio will actually rise as a result of decreasing adolescent reliance, which will be more than enough to offset the shifting share of the adult population toward older ages. Several researchers argued that, as a result, despite the phenomena of population aging, economic growth would continue (Bloom, Canning, and Fink, 2010). Vodopivec and Arunatilake (2008) argue that higher overall (multifactor) productivity, gains in worker quality, or increased labor force participation could counteract a drag on economic development caused by population aging. Furthermore, Bloom et al., (2010) stated that the effects of population aging on economic growth can be mitigated by behavioral responses of the economy to population aging, in the form of higher savings for retirement, greater labor force participation, and increased immigration from laborsurplus to labor-deficit countries.

Foot (2007) provides a framework linking the labor market consequence of population aging to output by identity. That is,

$$Q = (Q/H)(H/E)(E/L)(L/W)(W/P)P \tag{1}$$

Where Q = real output, H = average hours per employee, E = number of employees, L = labor force, W = working-age population, and P = population size. The identity illustrates that the annual output of any society can be decomposed into the product of various components. That is, the product of productivity performance (measured as output per hour worked, Q/H), the effort of employees (defined as average hours worked per year, H/E), the employment rate (E/L, which is 1 minus the unemployment rate), labor force participation (the share of the adult population looking for work, L/W), the share of the adult population in the total population (W/P), and the size of the population (P). It is clear from (1) countries with better productivity, more labor effort, lower unemployment, higher participation rates, lower child population proportions, and larger populations will produce more output. Output growth is the sum of the growth of each of these components. Although Identity (1) provides a valuable conceptual framework for relating population aging (L/W and W/P) and real production, it leaves out one key driver of real output: the level of capital stock.

Leibfritz and Roeger (2008) show a similar framework as Foot (2007) yet make extensive discussion of the role of capital stock in determining per capita real output growth. Leibfritz and Roeger (2008) present a strong theoretical interpretation of the relationship between population aging and economic growth; however, it does not perform an empirical investigation on this issue. In order to bridge this theoretical and empirical gap, Hsu (2017) tries to incorporate dynamic demographic transition using Solow (1956) growth accounting to investigate the prospect effect of population aging on economic growth. However, Hsu (2017) has not addressed the impact of time series data in his model. This paper attempts to develop a time series model that links population aging with economic growth by incorporating time series into Hsu's model.

2.1 The model

In the first stage, Total Factor Productivity (TFP) was computed using the primal growth accounting approach. Following Mankiw et al. (1992), this study considers a Cobb-Douglas type aggregate production function with constant returns to scale to describe real Gross Domestic Product (GDP, Y) as a function of physical capital (K), human capital (H), labor (L) and total factor productivity (A) as:

$$Y_t = A_t K_t^{\alpha} \; H_t^{\beta} \; L_t^{1-\alpha-\beta} \tag{2}$$

Where α and β are the shares of capital and human capital respectively. Shares of physical capital (α) and human capital (ß) are assumed to be 0.2 and 0.1 respectively as in the literature (see Bosworth et al., 2003 and Rodrik et al., 2004).

Hsu (2017) obtained the conceptual model that can be applied for an empirical investigation to evaluate the impact of population aging on economic growth as follows:

$$y_t - n_t = MFP_t + (1 - \alpha \,)(k_t - e_t) + (e_t - n_t) \tag{3}$$

$$e_t - n_t = (e_t - lf_t) + (lf_t - \gamma_t) + (\gamma_t - n_t) \tag{4}$$

$$y_t - n_t = MFP_t + (1 - \alpha \,)(k_t - e_t) + [(e_t - lf_t) + (lf_t - \gamma_t) + (\gamma_t - n_t)] \tag{5}$$

Where subscript ‘t’ denotes the time period; $y_t - n_t$ is output growth per capita, where y_t is output growth rate; n_t is the population growth. $MFP_t$is multi-factor productivity growth or total factor productivity growth (TFP_t); $(k_t - e_t)$ is capital deepening;$(e_t - n_t)$, is the sum of three labor market momentum that are influenced by the evolution of population aging. The three momentum are the growth of employment out of labor force $(e_t – lf_t)$, growth of labor force participation $(lf_t - \gamma_t)$, and growth of working-age population over total population $(\gamma_t - n_t)$.

This paper uses Hsu (2017) model as a baseline conceptual model to develop a time series model which investigates the effect of population aging on economic growth.

3 Methodology

3.1 Data

The study uses secondary data. A panel data from various sources from 1960 to 2019 was collected sources including the World Bank, Central Bank of Sri Lanka (CBSL), and Sri Lanka labor force survey. In computing TFP using the primal growth accounting approach was adopted as in TFP literature (Caselli, 2005; Conesa et. al., 2007; Duma, 2007; Nehru and Dhareshwar, 2011; Atiyas and Bakis, 2013). The total population, working-age population and the employed labor data were also collected from the CBSL annual reports. Since in Sri Lanka the pension scheme is supported by tax revenue it was assumed as total pension benefits equal to tax revenue (Rannan-Eliya,1998). The data on total tax revenue was obtained from the CBSL annual reports from 1960 to 2019.

3.2 Method of analysis

Statistical tests were conducted using statistical software packages such as SPSS AMOS 26, Excel, and Minitab 19.2. Minitab 19.2 version, a dynamic regression with error ARIMA model was used to model the impact of population aging on economic growth. In order to investigate the influence of Sri Lanka's current pension system on the impact of population aging on economic growth, structural equation modeling (SEM) was used. The moderating effect was explored using SPSS AMOS version 26. SEM is a multivariate statistical analysis technique and is preferred over regression as it allows to the assessment of the pathways through which the relationships among the dependent and independent variables are significant.

4 Results and Discussion

4.1 Impact of Population Aging on the Economic growth of Sri Lanka

The data used here was time series data so at first, the stepwise regression method was employed to fit the dynamic regression model. According to the results (table 1) first and second lag values of output per capita growth, capital deepening, growth of employed labor over total population (influenced by the evolution of population aging) and total factor productivity growth significantly influence the economic growth ($p<0.05$). Variance Inflation Factors (VIF) were used to check for multicollinearity among independent variables. All VIF values are below 10 implying that there are no multicollinearity issues. The model explains 98.35% of the variability $(F = 617.93, p = 0.000)$.

When employing time series variables in regressions, the residuals frequently exhibit a time series structure. This defies the commonly held premise in conventional least-squares regression that residuals are independent. If the time series structure of the errors is ignored, the estimations of coefficients and associated standard errors will be incorrect. The Durbin-Watson statistic was used to detect the autocorrelation. The Durbin-Watson statistic value was 0.98999 which is less than the lower bound value of 1.164 so there is evidence to say positive autocorrelation exists at a 1 percentage level of significance. (According to the Savin and White printed bounds are $dL = 1.164$ and $dU = 1.587$ at 1% significant level). Since there is autocorrelation in the model this model cannot be finalized.

Table 1: Regression analysis

Term	Coefficients	SE Coef	T-Value	VIF
Constant	-0.000411*	0.000029	-14.29	
$ln(y_{t-1})–ln(n_{t-1})$	0.0860*	0.0212	4.06	1.41
$ln(y_{t-2})–ln(n_{t-2})$	0.0484*	0.0194	2.49	1.25
□MFP_t	0.034397*	0.000693	49.63	5.07
$ln(k_t) - ln(e_t)$	0.18712*	0.00552	33.91	2.97
$ln(e_t)–ln(n_t)$	0.5927*	0.0131	45.40	8.10

*p<0.05

Therefore, in order to model the error term, the ARIMA model was utilized. Figure 1 shows the autocorrelation function plot (ACF) and Figure 2 shows the partial autocorrelation plot (PACF). Thus, ARIMA (1, 0, 0) or AR (1) model was identified as the best fitted ARIMA model for residual (Table 2). Modified Box-Pierce (Ljung-Box) Chi-Square Statistic also (Table 3) confirms the error term is having ARIMA (1, 0, 0). Therefore, in order to address the autocorrelation variable should be adjusted for the error term. Then, the variables were adjusted according to the AR (1) error ARIMA to use in the adjustment regression to fit the best fit model.

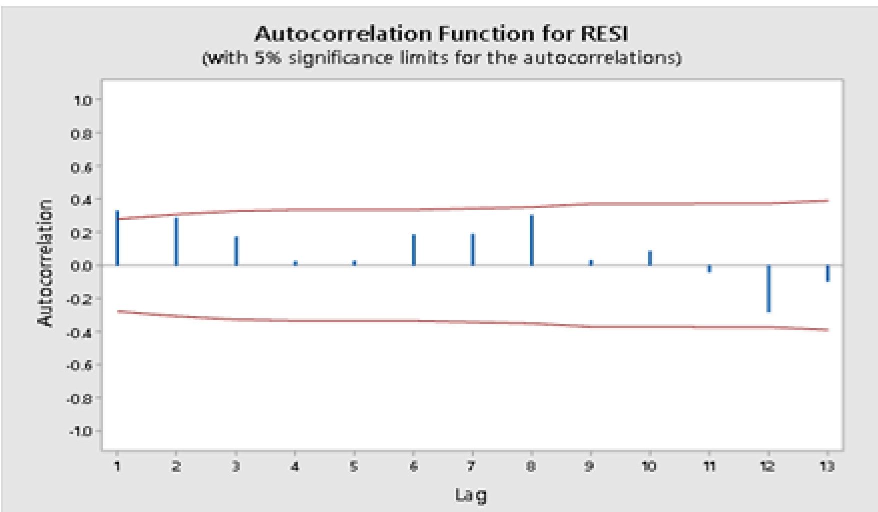

Fig. 1: ACF diagram for residual

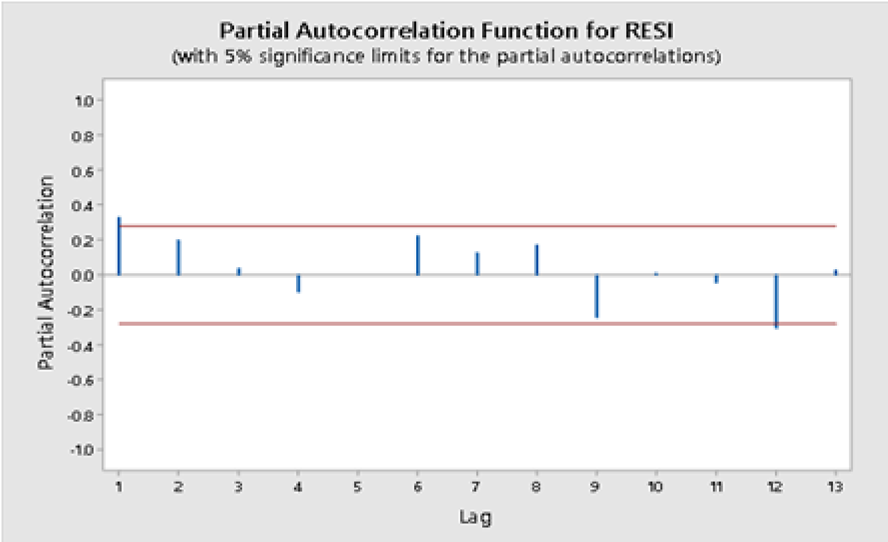

Fig. 2: PACF diagram for residual

Table 2: ARIMA model for residual

Type	Coef	SE Coef	T-Value
AR 1	0.427*	0.129	3.30
Constant	0.000509*	0.000100	5.11
Mean	0.000888	0.000174	

*p<0.05

Table 3: Modified Box-Pierce (Ljung-Box) chi-square statistic

Lag	12	24	36	48
Chi-Square	8.73	13.56	32.39	49.25
DF	10	22	34	46
P-Value	0.558	0.916	0.546	0.344

*p<0.05

Table 4 shows the result of regression analysis result after the adjustment of variables. The p-values indicate that all the coefficients estimated are significant at a 5% significance level. In this model regression, F is 546.90 and p = 0.0000 so this model is significant at a 95% confidence level. R-square of this model was 98.35% and the adjusted R-squared is 98.17%, the adjusted R-square accounts for the number true of predictors in the model, so 98.17% of the variability is explained by this model. The predicted R-square value is 96.40%, because the predicted R-square value is close to the R-square and adjusted R-square values, the model does not appear to over-fit and has adequate predictive ability.

All variables in the model are significant. When considering the VIF values all values are below the value of 10 indicating that there is no multicollinearity existing between independent variables. The Durbin-Watson statistic value was 2.24998 and the test statistic is (4-2.24998) 1.75002 which is larger than the lower bound value of 1.587 so there is evidence to say negative autocorrelation exists at a 1% level of significance. (According to the Savin and White printed bounds are dL = 1.164 and dU = 1.587 at 1% significant level).

As specified in the model population aging is having a negative impact on economic growth while lag values of output per capita growth, capital deepening and total factor productivity growth are having a positive impact on economic growth meaning that when lag values of output per capita growth, capital deepening and total factor productivity growth increase the economic growth also will increase and on the other hand when population aging increases economic growth will decrease.

Table 4: Regression analysis result after adjusting for time series structure

Term	Coef	SE Coef	T-Value	VIF
Constant	-0.000224*	0.000024	-9.26	
(lnYt-1 – ln Nt-1)	0.0720*	0.0200	3.61	1.09
(lnYt-2 – ln Nt-2)	0.0336*	0.0199	1.68	1.09
□TFPt	0.034413*	0.000676	50.91	6.46
(ln Kt - ln Et)	0.19132*	0.00495	38.61	2.86
(ln Et – ln Nt)	0.5953*	0.0126	47.24	9.26

*p<0.05

An important way of checking whether a regression, simple or multiple, has achieved its goal to explain as much variation as possible in a dependent variable while respecting the underlying assumption, is to check the residuals of a regression. So here several tests were done to test the residual in order to have a good model to explain the context of this study. Figure 3 shows the normality test for the standardized residual. According to the normality test p > 0.05 so is normally distributed.

In addition to normality test histogram and versus plot were also used to analyze the residual. Figure 4 shows the histogram for the residual. Here the histogram plot of the residuals exhibits a symmetric bell-shaped distribution, indicating that the normality assumption is likely to be true. Figure 5 shows the residual vs. fitted value plot according to the plot following decisions can be taken, the residuals ”bounce randomly” around the 0 line which suggests that the assumption that the relationship is linear is reasonable, and the residuals roughly form a ”horizontal band” around the 0 line which suggests that

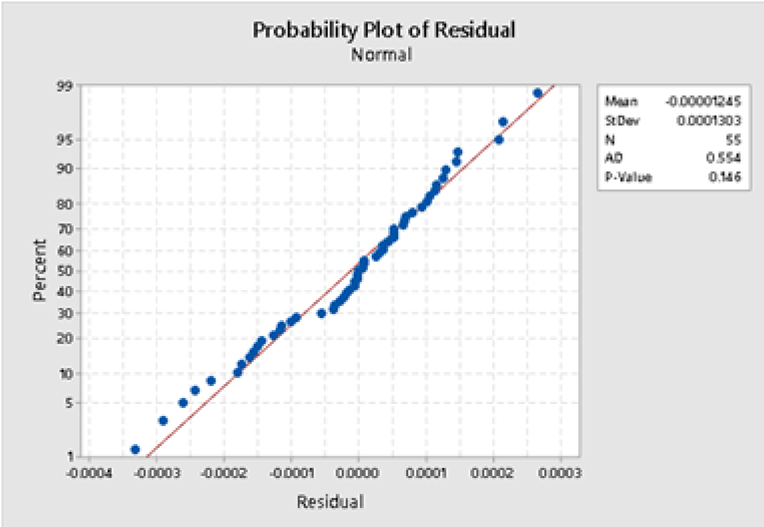

Fig. 3: Normality test graph of the residual

the variances of the error terms are equal. No one residual ”stands out” from the basic random pattern of residuals. This suggests that there are no outliers. So in accordance with residual analysis, the fitted model is adequate.

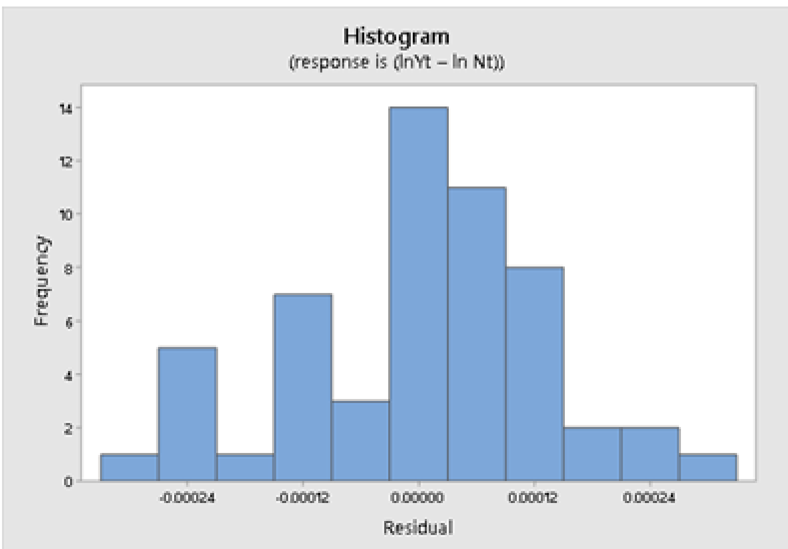

Fig. 4: Histogram for the residual

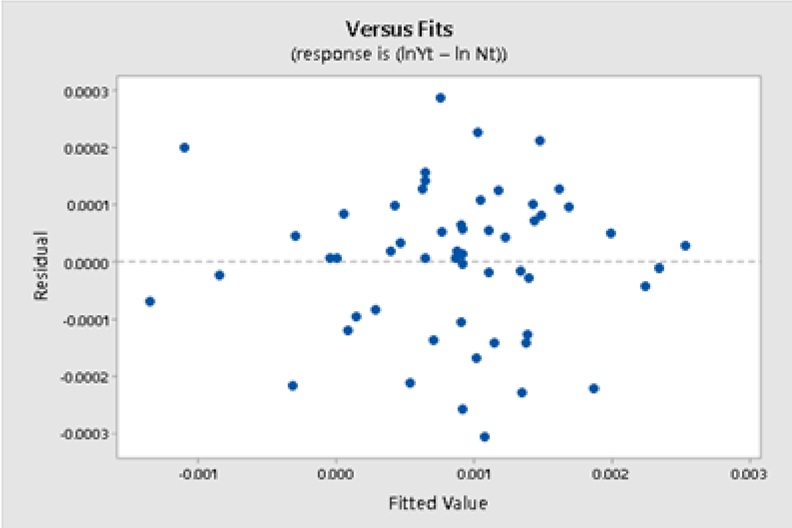

Fig. 5: Versus plot of the residual

4.2 Role of the current pension system in Sri Lanka in determining the impact of population aging on economic growth

The identified SEM model shows the pathways through which the pension system influences economic growth. Several models were tried out including all parameters before finalizing the suitable model. The path diagram of the identified structural model is depicted in Figure 6. The parameters were estimated using the Maximum Likelihood (ML) method. Table 5 depicts the path coefficient values on the arrows directed from independent variables to the dependent variables. The path coefficient values are usually considered as regression weights/coefficient values in multiple regression models.

The significant level obtained from the chi-square test (p-value) is higher than 0.05; the value of the statistic of Root Mean Square Error of Approximation (RMSEA) is less than 0.05; the value of comparative fitness index (CFI), general fitness index (GFI), adjusted general fitness index (AGFI), and non-norm fitness index (NNFI) or Tucker-Lewis Index (TLI) is higher than 0.9 (Joreskog and Sorbom, 1996; Shoghi and Safieepoor, 2013). Kim et al. (2016) suggested that RMSEA values less than 0.05 are good, values between 0.05 and 0.08 are acceptable, values between 0.08 and 0.1 are marginal, and value greater than 0.1 are poor. According to the coefficient estimates and the model fit indices (CMIN/DF = 1.245, GFI = 0.905, NFI = 0.937, IFI = 0.987, CFI = 0.987, TLI = 0.978, RMSEA = 0.069), it is evident that the hypothesized direction of effects between the constructs is supported by the data.

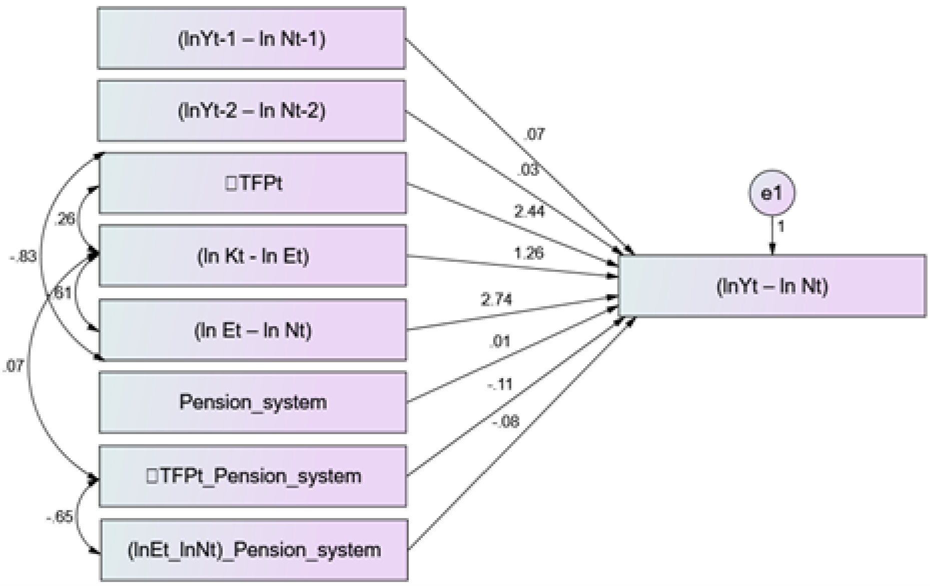

Fig. 6: Pathway diagram

Table 5: Path analysis result

			Estimate	S.E.
$ln(y_t)$–$ln(n_t)$	<—	$ln(y_{t-2})$–$ln(n_{t-2})$	.032*	.017
$ln(y_t)$–$ln(n_t)$	<—	MFP_t	2.442*	.041
$ln(y_t)$–$ln(n_t)$	<—	$ln(k_t)$–$ln(e_t)$	1.257*	.029
$ln(y_t)$–$ln(n_t)$	<—	MFP_t_Pension_system	-.115*	.051
$ln(y_t)$–$ln(n_t)$	<—	Pension_system	.011	.017
$ln(y_t)$–$ln(n_t)$	<—	$ln(e_t)$–$ln(n_t)$	2.737*	.051
$ln(y_t)$–$ln(n_t)$	<—	$(ln(y_{t-1})$–$ln(n_{t-1})$	.069*	.017
$ln(y_t)$–$ln(n_t)$	<—	$ln(e_t)$_$ln(n_t)$_Pension_system	-.082*	.038

*p<0.05

In accordance with the dynamic regression with error ARIMA model the estimated equation is given by,

$$ln(y_t) - ln(n_t) = -0.000224 + 0.072ln(y_{t-1}) - ln(n_{t-1}) + 0.0336ln(y_{t-2}) - ln(n_{t-2}) + 0.034413MFP_t + 0.19132ln(k_t) - ln(e_t) + 0.5953ln(e_t) - ln(n_t)$$

The left-hand side of equation (6), $ln(y_t) - ln(n_t)$, is output growth per capita, where y_t is real GDP; n_t is the number of population. $(ln(y_{t-1}) - ln(n_{t-1})$ is

LAG-1 output growth per capita and $(ln(y_{t-2}) - ln(n_{t-2})$ is LAG-2 output growth per capita. MFP_t is the growth of total factor productivity; k_t is capital stock, and e_t is the number of employed labor.

The estimated model implies that an increase in factor productivity growth (MFP_t) and increase in capital deepening $(k_t - e_t)$ contribute to increasing output growth. In addition, once employment growth outgrows that of the total population i.e. $(e_t - n_t) > 0$, there would also have a positive output growth effect otherwise population aging would have a negative impact on economic growth. In a simple demographic transition and economic growth model, one can use this simple two-equation model, equations (3) and (4), to explain the transmission and impact of demographic transition to economic growth. From the above model, it is clear that productivity growth and capital deepening will contribute to per capita GDP growth if capital deepening and productivity growth accelerate to compensate for the decline in labor input due to population aging.

When incorporating the moderator variable, the pension system into the model results indicate that the moderation was only significant with total factor productivity growth and evolution of population aging. When considering the estimated coefficients for an independent variable with and without moderating variable effect; for total factor productivity growth without moderation (0.034) and with moderation (-0.082) and for the evolution of population aging without moderation (0.595) and with moderation (-0.115). The pension system further increases the adverse impact of population aging on economic growth. Also moderating effect of the pension system suppresses the positive association between total factor productivity growth with economic growth.

5 Conclusion

The impact of population aging on Sri Lanka's economic growth is investigated in this study. This paper's analytical approach is built on the Cobb-Douglas production function, Solow's growth accounting, and Leibfritz and Roeger's (2008) concept of demographic effects on the labor market. The investigation used a simple two-equation model. The empirical model was estimated using data from Sri Lanka from 1960 to 2019. This study suggests that, like most affluent countries, Sri Lanka's population aging has a negative impact on economic growth.

The current research has a number of policy implications. The government should stimulate research and development to boost production efficiency and factor productivity in order to combat the future downward trend in output growth. Furthermore, older retirees are more likely to live off of savings acquired during their working years. Capital formation and capital deepening are slowed as more elders withdraw their savings. As a result, the government should continue to take steps to promote capital formation in the aging economy. Furthermore, long-term policies that boost workforce participation can help to offset the effects of population aging on output. Labor market measures aimed at boosting labor market efficiency and expanding employment options for the elderly should be promoted.

The study's significant policy implication is that, given the current aging transition trend, Sri Lanka must reform its pension system to mitigate the negative effects of an aging population on economic growth. In addition, policies that increase the size of the working-age population by encouraging continuous immigration or increasing total fertility can have the greatest impact on combating the negative effects of population aging on output growth.

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