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Economic Linkages of the Age Structural Changes in Population of Sri Lanka

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ABSTRACT

During last few decades, the Sri Lankan population has undergone a structural change that can be characterized by declining child dependency and increasing elderly dependency. Though anecdotal evidences indicate that these have economic linkages, no proper study has been carried out in Sri Lanka. This study examines how the structural changes influenced the economic development such as agricultural sector production, industrial sector production, service sector production and per capita income. The secondary data obtained from Central Bank of Sri Lanka, Department of Census and Statistics and Reports of the United Nations, for the period 1950-2005 were used for the analysis. The analytical methods include estimating simultaneous equations and vector auto regression. The initial analysis revealed that the elderly population has increased, and longevity of female elderly population is higher than that of male elderly population. In the simultaneous equations modeling, it was found that the negative effect on the child dependency by all the four economic development indicators. The vector auto regressive analysis also gave consistent results. The developed models were capable of making reasonable predictions for 2006. However, the study could not establish the effect of elderly dependency on the economic development due to unavailability of a longer time series data set to capture the recent changes.

Key Words: **Age structural changes, Economic development indicators, Simultaneous equations, Vector-auto regressive models.**

INTRODUCTION

Structural changes of a population are of growing concern of the development planning in most developed and developing countries. It can be due to the effect of the changes in the population growth rate which is accompanied by changes in child and elderly populations, and changes of economically active population.

The growth rate of Sri Lankan population had increased rapidly in the second half of the 20th century. The highest population growth rate of 3.9% in Sri Lanka was recorded in 1956. The first official census, conducted by the British in 1871, recorded a total population of 2.4 million. Since then, about an eight-fold increment of the total population can be seen until 2006. Population growth until around 1900 was given impetus by considerable immigration from South India, as the British brought in thousands of Tamils to work in the plantation economy. Another significant factor in the growth of population after 1900 was declining mortality rates. The period of the fastest growth can be seen from 1948 to 1958 with the annual increment of 2.8%. In 1945, the death rate in Sri Lanka was fairly high (22/1000) mainly due to Malaria outbreaks. A large scale programme of mosquito control using DDT was started in 1946 and the incidence of Malaria dropped sharply. After 9 years, the crude death rate dropped to 10/1000 and presently it is 6 for 1000 persons (Central Bank of Sri Lanka, 2006). This shift of age structure from younger to older resulted in a transformation of the shape of the age pyramid of the country (Siddhisena, 2005).

Economically less developed countries generally have high fertility rates and high population growth rates (Nurvidya, 2006). In Sri Lanka, during the past few decades the population growth rate declined mainly due to downward trend in fertility linked with attitude changes, income effects and urbanization. Improved quality of living associated with increased access to immunization, better nutrition, better primary health care, improved sanitation, disease eradication programmes, improvement in agricultural production and subsidized distribution of food items and expansion of the free educational services had differential impact on population structure.

The slow reduction of the crude birth rate hinted a gradual aging of the population and change of the requirements of social services (De Silva, 1994; Abeykoon, 2000; Wickramasinghe, 2002). For time being, however, there was a considerable pressure for jobs, education and welfare facilities from the large number of people who were raising families or pursuing careers (Gaminirathna, 2004). In the remaining decades of the century and beyond there was likely to be greater pressure for housing and health care for an aged population. However various economic, social and environmental problems can be arisen with the structural changes of the population. These include influences on the national and regional economic development and influences to the labour forces (Rannan-Eliya, 1999). This is linked to the labour transformation from agricultural sector to the industrial sector mainly due to output expansion as explained by the Lewis theory of development. This structural transformation model says that the speed of the output expansion determined by the rate of capital accumulation in the industrial sector (Todaro and Smith, 2005).

It is a common fact that structural changes of the population influence the economic development. However, there is no systematic study available that model the economic consequences of those changes related to the increasing aged population and decreasing young population, and resulting changes in the economically active population. Against this background, this study is an attempt to address these issues with the objectives of investigating the impact of the structural changes as measured by child dependency and elderly dependency on the agricultural, industrial and service sector production and per capita income.

In this paper, first the conceptual framework and analytical models are presented using a path diagram. This is followed by a description of the data and methodology adopted. Then the empirical wok is described. This is followed by the results and discussion. Finally, the conclusions and implications are presented.

Conceptual framework

The figure 1 shows the relationship between the age structural changes and economic development which is consistent with the conventional theories of economic development (e.g., two-sector model). Following Fox (2002), figure 01 was used for formulating simultaneous equations model to identify the relationship between structural changes and economic development. Because they indicate the direction and nature of the casualty and it clarify the problem under the study. Among the variables, there is a two-way or simultaneous relationship between dependent and independent variables, that is, one economic variable affects another economic variable and in turn, affected by it.

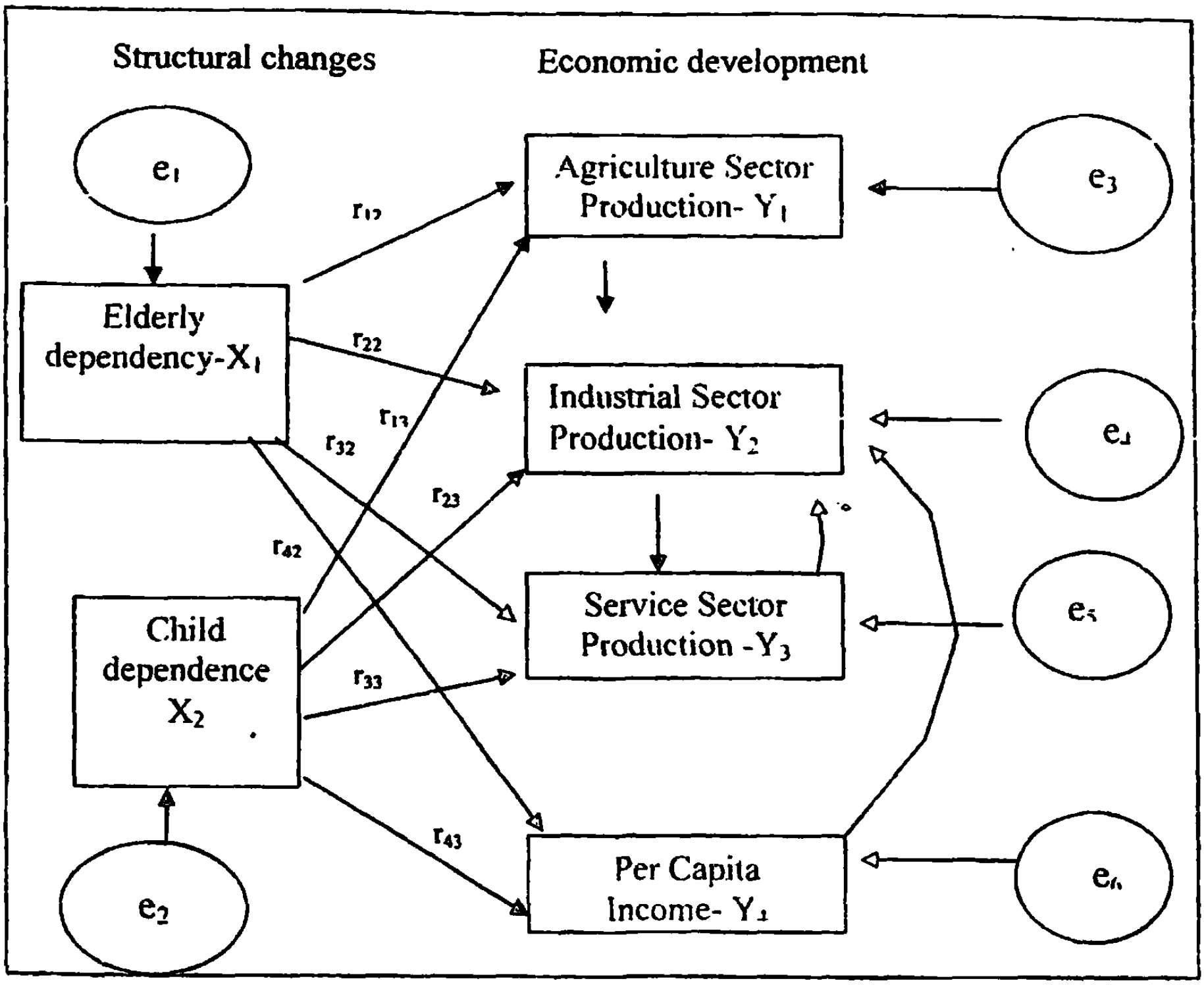

Figure 1: Relationship between age structural change and economic development

Simultaneous equations model:

$$Y_1 = \beta_{10} + \beta_{11} Y_2 + \gamma_{12} X_1 + \gamma_{13} X_2 + \gamma_{14} Y_{1t-1} + e_{11} \quad (1)$$

$$Y_2 = \beta_{20} + \beta_{21} Y_3 + \gamma_{22} X_1 + \gamma_{23} X_2 + \gamma_{24} Y_{2t-1} + e_{12} \quad (2)$$

$$Y_3 = \beta_{30} + \beta_{31} Y_2 + \gamma_{32} X_1 + \gamma_{33} X_2 + \gamma_{34} Y_{3t-1} + e_{13} \quad (3)$$

$$Y_4 = \beta_{40} + \beta_{41} Y_2 + \gamma_{42} X_1 + \gamma_{43} X_2 + \gamma_{44} Y_{4t-1} + e_{14} \quad (4)$$

where, Y_1 is agricultural sector production, Y_2 is industrial sector production, Y_3 is service sector production, Y_4 is per capita income, X_1 is elderly dependency, X_2 is child dependency, Y_{1t-1} is lag agricultural sector production, Y_{2t-1} is lag industrial sector production, Y_{3t-1} is lag service sector production, Y_{4t-1} is lag per capita income and e_{ij} is the random error term.

Vector Auto Regressive (VAR) Model

Further a Vector Auto Regressive (VAR) model (Gujarati, 1995) can be employed to identify the influences of structural changes on economic development.

$$Y_1 = \beta_{10} + \sum_{j=1}^{3} \beta_{11} y_{1t-j} + \sum_{j=1}^{3} \beta_{12} y_{2t-j} + \sum_{j=1}^{3} \beta_{13} y_{3t-j} + \sum_{j=1}^{3} \beta_{14} y_{4t-j} + \sum_{j=1}^{3} \beta_{15} y_{5t-j} + \sum_{j=1}^{3} \beta_{16} y_{6t-j} + U_{1t} \quad (5)$$

$$Y_2 = \beta_{20} + \sum_{j=1}^{3} \beta_{21} y_{1t-j} + \sum_{j=1}^{3} \beta_{22} y_{2t-j} + \sum_{j=1}^{3} \beta_{23} y_{3t-j} + \sum_{j=1}^{3} \beta_{24} y_{4t-j} + \sum_{j=1}^{3} \beta_{25} y_{5t-j} + \sum_{j=1}^{3} \beta_{26} y_{6t-j} + U_{2t} \quad (6)$$

$$Y_3 = \beta_{30} + \sum_{j=1}^{3} \beta_{31} y_{1t-j} + \sum_{j=1}^{3} \beta_{32} y_{2t-j} + \sum_{j=1}^{3} \beta_{33} y_{3t-j} + \sum_{j=1}^{3} \beta_{34} y_{4t-j} + \sum_{j=1}^{3} \beta_{35} y_{5t-j} + \sum_{j=1}^{3} \beta_{36} y_{6t-j} + U_{3t} \quad (7)$$

$$Y_4 = \beta_{40} + \sum_{j=1}^{3} \beta_{41} y_{1t-j} + \sum_{j=1}^{3} \beta_{42} y_{2t-j} + \sum_{j=1}^{3} \beta_{43} y_{3t-j} + \sum_{j=1}^{3} \beta_{44} y_{4t-j} + \sum_{j=1}^{3} \beta_{45} y_{5t-j} + \sum_{j=1}^{3} \beta_{46} y_{6t-j} + U_{4t} \quad (8)$$

$$Y_5 = \beta_{50} + \sum_{j=1}^{3} \beta_{51} y_{1t-j} + \sum_{j=1}^{3} \beta_{52} y_{2t-j} + \sum_{j=1}^{3} \beta_{53} y_{3t-j} + \sum_{j=1}^{3} \beta_{54} y_{4t-j} + \sum_{j=1}^{3} \beta_{55} y_{5t-j} + \sum_{j=1}^{3} \beta_{56} y_{6t-j} + U_{5t} \quad (9)$$

$$Y_6 = \beta_{60} + \sum_{j=1}^{3} \beta_{61} y_{1t-j} + \sum_{j=1}^{3} \beta_{62} y_{2t-j} + \sum_{j=1}^{3} \beta_{63} y_{3t-j} + \sum_{j=1}^{3} \beta_{64} y_{4t-j} + \sum_{j=1}^{3} \beta_{65} y_{5t-j} + \sum_{j=1}^{3} \beta_{66} y_{6t-j} + U_{6t} \quad (10)$$

Where Y_5 and Y_6 are redefined in the VAR, as child dependency and elderly dependency. The explanatory variables are lag effects (Gujarati, 1995). It is assumed that the disturbances, u_{1t}, u_{2t}, u_{3t}, u_{4t}, u_{5t} and u_{6t} are uncorrelated.

DATA AND METHODOLOGY

The secondary data for the period 1953-2005 were used for the analysis. The population data were obtained from the Central Bank Annual Report, Special Appendix (2006), Sri Lanka Socio-Economic data (Central Bank of Sri Lanka, 2007) and reports of the Department of Census and Statistics (1994).

The age composition data were categorized as age 0-19, 20-64 and >65 yrs and labeled as, child dependency, economically active group and elderly dependency, respectively. The necessary data for economic development variables such as agricultural sector production (Y_1), industrial sector production (Y_2), service sector production (Y_3) and per capita income (Y_4) were who obtainer from the secondary sources indicated above.

The over-identified equations may not be estimated by Ordinary Least Squares and Indirect Least Squares because they provide more than one estimate for each coefficient. As the matter of practice, one may apply OLS to over-identified equations; the estimates thus obtained will be inconsistent due to the correlation between the stochastic endogenous explanatory variables and disturbance terms (Fox, 2002). Therefore, Two-Stage Least Squares (2SLS) was applied in this study after examining the identification states. As the name indicates, the method involves two successive applications of OLS. The idea behind 2SLS is to "purify" the stochastic endogenous explanatory variable of the influence of the stochastic disturbances. The goal is achieved by performing the reduced-form regression of all endogenous variables taken from the pre determined variables in the system (stage 1). Obtained estimates from stage one are substituted to the original equation as endogenous explanatory variables. Then OLS can be applied to the equation thus transformed (stage 2) in order to achieve consistent estimates.

The true simultaneous system could be modeled as Vector Auto Regressive model which is a set of variables treated on an equal footing or there was no priory distinct between endogenous and exogenous variables. In the Vector Auto Regressive model, the suitable lag length had been decided by Akaike's Information Criterion (AIC), Schwarz's Baysian Information Criterion (SBIC) and Likelihood Ratio (LR) test.

RESULTS AND DISCUSSION

The graphical representations of variables in the model for the period 1954-2005 depicts that all the variables have an increasing trend (Figure 2). Augmented Dickey-Fuller test was used to test the stationary condition of the above variables, and found that the computed absolute τ values are smaller than the 1% (-4.148), 5 % (3.499) or 10% (-3.179) critical indicatory nonstationarity. Hence the first difference of time series integrated of order 1 (denoted by I(1), was obtainer and transformed the variables. These were labeled as, growth variables, i.e. growth of agricultural sector production, industrial sector production, etc. Figure 2 also shows endogenous

ıs and exogenous variables which were stationary, i.e. the computed absolute τ values
)t for all were greater than the 1% (4.148), 5% (3.499) or 10% (-3.179) critical values.

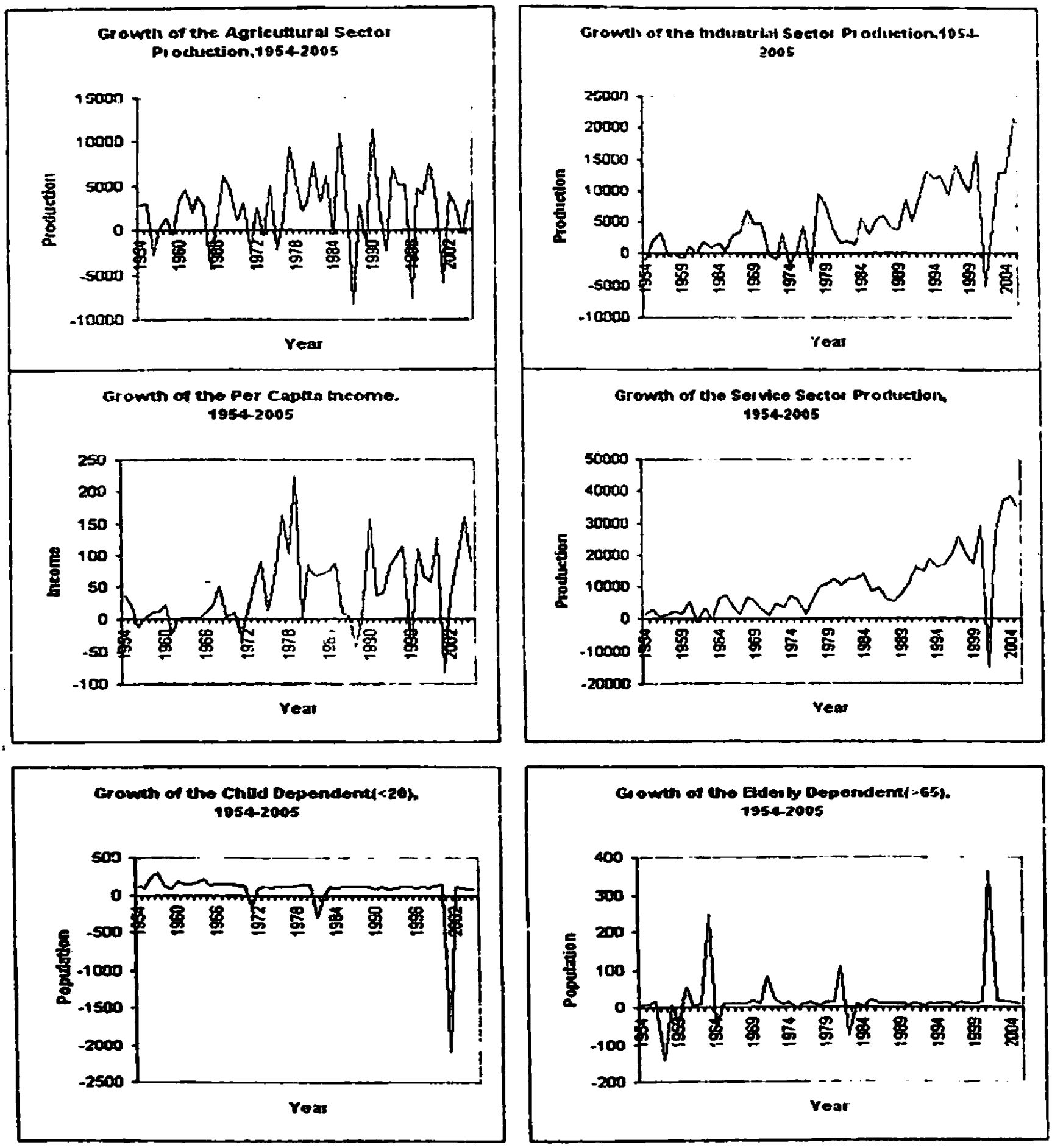

Figure 2: The graphical presentation of growth variables in the model

Then, rank and order condition of identification for above equations was employed. According to the order condition, all equations were over identified. Further

Hausman's specification test (Hausman, 1978) was used to test the simultaneity and it was found that, there was a simultaneity problem in the model.

The analysis was extended to examine how the structural changes influence the growth rates of agricultural sector production, industrial sector production, service sector production and per capita income, controlling the other variables. The economically active age group was not included into the model to avoid perfect multicolinearity. Simultaneous equations approach was used to reach the major objective of this study and the study applied the Two-Stage Least Squares (2SLS). The results indicated that elderly dependency was not related ($p>0.20$) to economic development. But child dependency was strongly related. The results given in table 1 shows that child dependency was a significant factor ($p<0.01$) in explaining economic development variables and negatively associated with them. This negative relationship of child dependency is consistent with the economic theory.

Table 1: Estimated Simultaneous equations

Endogenous / **Exogenous**	Y_1	Y_2	Y_3	Y_4
Constant	84,288.16 (6,033.47)	29,223.16 (6,120.613)	109,442.8 (29,548.41)	875.7522 (112.3571)
Y_2	7.264626 (0.829529)	-	48.53093 (10.90857)	0.1475308 (0.170836)
Y_3	-	6.694817 (0.4915897)	-	-
X_1	−70.27402 (18.22641)	−110.5932 (18.91158)	−478.5866 (137.141)	−1.480447 (0.352325)
X_2	−42.35756 (83.00209)	43.56326 (80.91399)	- 227.3624 (406.2741)	−1.264412 (1.544218)
Y_{1t-1}	−0.4429231 (0.9154135)	-	-	-
Y_{2t-1}	-	2.293212	-	-
Y_{3t-1}	-	-	−10.89618 (5.384628)	-
Y_{4t-1}	-	-	-	−0.9375564 (1.320756)
R^2	0.6208	0.8908	0.3150	0.6308

The elderly dependency in Sri Lanka has not made that much effect to the economic conditions since this was not prominent before 2000. This situation has changed 2001 onwards. However, the analysis could not identify a significant impact of the elderly dependency on economic development because the length of the data series was not adequate to indicate the demographic transition.

The endogenous explanatory variables were highly significant ($p<0.01$) and positively associated with each endogenous variable, such as industrial sector production with agricultural sector production, service sector production with industrial sector production, industrial sector production with service sector production, and industrial sector production with per capita income ($p<0.01$).

The service sector production and industrial sector production of the previous year were significant ($p<0.05$) with positive relationship in each equation. The coefficients in above equations can be interpreted as the direct effects on economic development with structural changes and lag variables. The reduced form equations for the system expressed each endogenous variable as a function of the predetermined variables.

The R-squared value of 0.6208 of the first equation showed that the Y_2 endogenous variable and X_1, X_2 and Y_{1t-1} explanatory variables explain about 62.08 % of the variation in agricultural sector production in Sri Lanka over the period 1954-2005. Industrial sector production had high R^2 value of 0.8908 and explained the 89.08 % variation out of the total variation. There was a small R^2 value 0.3150 for the service sector production. The R^2 value of 0.6308 of the model with per capita income showed that the endogenous and predetermined variables explain the 63.08 % of the variation. The estimated values and actual values of the simultaneous equations are given in table 2. As shown in table 2, there were no substantial differences between the estimated values and the actual values.

Table 2: ::The estimated values and actual values of endogenous variable in 2006

Variable	Estimated values	Actual values of	Difference
Y_1	224,854	187,729	37,125
Y_2	382,216	300,982	81,234
Y_3	670,923	627,504	43,419
Y_4	3,740	3,042.89	697.11

Vector Auto Regressive (VAR) model

In VAR modeling, the optimal lag lengths required to select the proper models were obtained using AIC, SBIC and LR test. According to the LR test, there was an evidence to reject a restricted model at $p<0.01$ with the 36 degrees of freedom in Chi squared distribution. In the other words, the lag lengths 1, 2, 3 and 4 intervals could be selected as lag lengths. The minimum LR value had found at the lag length 3 and it was reasonable to take lag length 3 according to the other selection criteria such as AIC and SBIC. Granger causality test confirmed that there was causality.

Agricultural sector production (Y_1) is given in table 3. Of the considered variables, Y_{3t-2} and the Y_{4t-3} showed positive signs and the Y_{1t-1}, Y_{1t-2}, Y_{1t-3}, Y_{2t-3}, Y_{3t-1}, and Y_{5t-2} showed negative signs. The R^2 value of 0.3971 indicated that the above nine explanatory variables explain about 40 percent of the variation in the agricultural sector production in Sri Lanka. Lagged 2 child dependency has strong negative relationship with the agricultural sector production.

As regard to the table 03, that is industrial sector production, Y_{1t-3}, Y_{3t-3} and Y_{5t-2} depicted a negative relationship with industrial sector production. After adjusting for all exogenous variables, it was found that except lagged 2 of child dependency that was negatively related with industrial sector production ($p<0.01$). There was a positive relationship between Y_{2t-2}, Y_{3t-2}, Y_{4t-3}, and Y_{5t-1} and industrial sector production, of the total variation about 54 percent explain the each lagged variables. Y_{5t-2} and Y_{5t-3} were negatively related and Y_{2t-2}, while Y_{3t-2}, and Y_{4t-3} were positively related with service sector production (Y_3). Y_{5t-2} had the greatest negative effect as the value of 22.47 on the service sector production.

Table 3 further indicates that child dependency and elderly dependency were not strongly related with per capita income except lagged 2 child dependency, but that was moderately significant variable. (P value = 0.088). Y_{1t-2}, Y_{1t-3}, Y_{2t-1}, Y_{2t-2}, Y_{3t-1}, Y_{3t-2}, Y_{4t-2}, and Y_{4t-3} were the other related variables with per capita income. The R-Squared value of 0.4994 of the equation showed that the each endogenous variable explains about 50 % of the variation in per capita income in Sri Lanka.

According to the table 3, Y_{3t-1}, Y_{3t-2} and Y_{5t-2} were strongly related with child dependency and, Y_{3t-3}, Y_{4t-3} and Y_{5t-1} were also significant factors. However explanatory lagged variables explain about 37 % of the variation in the number of child dependency in Sri Lanka.

Table 3: Vector Auto Regression results

Endo: **Exoge:**	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
Constant	4029.094 (1291.669)	2018.099 (1356.16)	7177.816 (2185.86)	53.01799 (17.2295)	0.0094323 (0.01466)	2.526114 (0.00297)
Y_{1t-1}	-0.351567 (0.183916)	0.1666164 (0.193099)	0.1673742 (0.311237)	-0.00183 (0.00245)	0.009432 (0.01466)	-0.00102 (0.00297)
Y_{1t-2}	-0.353268 (0.165205)	0.0238915 (0.173455)	-0.256094 (0.279574)	-0.00447 (0.00220)	-0.00497 (0.01316)	0.00243 (000267)
Y_{1t-3}	-0.491255 (0.16298)	-0.278849 (0.171128)	-0.308472 (0.275823)	-0.00943 (0.00217)	-0.01562 (0.01299)	0.0054231 (0.0026)
Y_{2t-1}	0.0953295 (0.22212)	0.0883212 (0.233221)	-0.027069 (0.375905)	0.003827 (0.00296)	-0.00531 (0.01770)	0.0051235 (0.00326)
Y_{2t-2}	-0.067051 (0.214972)	0.4608125 (0.225706)	0.6829939 (0.363793)	-0.00588 (0.00286)	0.0183871 (0.01713)	-0.002784 (0.00347)
Y_{2t-3}	-0.338244 (0.248118)	0.1746268 (0.260507)	0.4665255 (0.419885)	0.0022212 (0.00330)	-0.008203 (0.01977)	-0.002046 (0.00401)
Y_{3t-1}	-0.227006 (0.173950)	-0.136704 (0.182636)	-0.357505 (0.294372)	-0.003842 (0.00232)	-0.037858 (0.01386)	0.0062372 (0.002813)
Y_{3t-2}	0.5453908 (0.192912)	0.4107329 (0.202545)	0.5979413 (0.326462)	0.0042341 (0.00257)	0.0409829 (0.01537)	-0.010526 (0.003120)
Y_{3t-3}	-0.150486 (0.187219)	-0.267674 (0.196567)	-0.366492 (0.316827)	-0.001651 (0.00249)	-0.026376 (0.01492)	0.0071482 (0.00302)
Y_{4t-1}	10.59378 15.97791	-9.815203 (16.7757)	5.478984 (27.0391)	0.1849358 (0.21312)	-0.552008 (1.27362)	-0.128006 (0.258420)
Y_{4t-2}	4.176014 12.8728	-2.829933 (13.5155)	12.76235 (21.7843)	0.4298028 (0.17171)	-0.243625 (1.02610)	0.0573682 (0.20819)
Y_{4t-3}	23.01699 (13.06911)	20.94714 (13.7217)	32.12684 (22.1166)	0.4739559 (0.17432)	1.414109 (1.04175)	-0.437087 (0.21137)
Y_{5t-1}	4.653823 (3.864366)	6.873835 (4.05733)	2.250644 (6.53959)	0.0190725 (0.05154)	0.5888351 (0.30803)	-0.162755 (0.06250)
Y_{5t-2}	-10.24237 (4.420094)	-12.77969 (4.64080)	-22.47476 (7.48004)	-0.076421 (0.05895)	-1.030396 (0.35233)	0.1925693 (0.07148)
Y_{5t-3}	5.303485 (3.982199)	-0.133540 4.181048	-11.48128 (6.739)	-0.013778 (0.05311)	0.1451926 (0.31742)	-0.043046 (0.06440)
Y_{6t-1}	3.298785 (11.65728)	-4.294558 (12.2393)	-6.871469 (19.7273)	-0.051774 (0.15549)	-0.732799 (0.92921)	-0.089539 (0.18854)
Y_{6t-2}	-4.498327 11.59443	-5.228122 (12.1733)	12.38694 (19.6210)	0.0733444 (0.15465)	0.1047833 (0.92420)	-0.052108 (0.18752)
Y_{6t-3}	-9.388169 (11.33695)	1.260033 (11.9030)	5.970445 (19.1853)	0.1241364 (0.15122)	0.3669942 (0.90368)	-0.012535 (0.18335)
R^2	0.3971	0.5362	0.6914	0.4944	0.3715	0.3769

The elderly dependency (Y_6) in table 3, Y_{3t-2} , Y_{5t-1} and Y_{4t-3} showed negative signs and the Y_{1t-3}, Y_{3t-3}, Y_{5t-2} $Y_{3t-1}$and Y_{2t-1} showed positive signs. The R^2 value of 0.3769 showed that the above lagged explanatory variables explained about 38 % of the

variation in the elderly dependency in Sri Lanka. The table 4 depicts that the difference between actual values and estimated values by VAR model.

Table 4: Actual and estimated values of endogenous variables in 2006

Variable	Estimated value	Actual value	Difference
Y_1	11,922	8,451	3,471
Y_2	14,742	20,114	5,372
Y_3	39,548	46,940	7,392
Y_4	173.16	114.48	58.68
Y_5	280	450	170
Y_6	162	28	134

CONCLUSIONS

The hypothesized relationship between child dependency and all economic development indicators had been proved by this study under the two approaches adopted. Theoretically, economic variables are highly interrelated with each other. The significant relationships among these indictors were also found. The predicted agricultural sector production, industrial sector production, service sector production and per capita income achieved by set of simultaneous equations were very close to the actual. Vector Auto Regressive model also corroborated the same.

In observing the relationship between age structural transition and economic development, the study had found that the effect of ageing population does not effect in the same direction on all the economic development indicators. According to the estimated coefficients, it showed that there was a negative relationship between elderly dependency and agricultural sector production, service sector production and per capita income, and positive relationship between elderly dependency and industrial sector production. However, these were not statistically significant. This impact of the elderly dependency to economic development could not be statistically established because there was not much time duration to indicate this demographic transition correctly.

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