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An Empirical Testing of Life-Cycle Hypothesis Using Bootstrapping

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ABSTRACT

Life-Cycle Hypothesis theory of saving is one of the prominent contributions to consumption theories. Since Life-cycle hypothesis theory describes the long run behaviour of consumers, many statistical studies based on short run data have failed to support the model effects. This study considers the regression modelling to examine the effect of the Life-Cycle Hypothesis theory on savings using disposable income, percentage growth rate of disposable income and percentage population in two different age groups. After the construction of the model, validity of the assumptions of regression modelling to the data was examined. This study observed few violations of assumptions of the regression assumptions to this data like the presence of outliers and influential observations. Then the model parameters and their standard errors were re-estimated using bootstrap technique to eliminate the influence of outliers and influential observations and the evidences that support the Life-Cycle Hypothesis theory were examined.

KEY WORDS: Life-Cycle Hypothesis, Aggregate personal savings, Per-capita disposable income, Ordinary least squares, outliers, influential observations and bootstrapping

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INTRODUCTION

Consumption expenditure and savings are the two key sectors of a country's economy and theories explaining them are a major part of the macroeconomics. Activities in these sectors are determined by a number of factors such as wealth, age group of the consumers, geographical regions etc., consumer expectations, consumer income and consumer preferences etc. There are many prominent theories explaining consumer expenditures and savings and Life-Cycle Hypothesis theory is one among them. This study re-examine the evidence of the theory in the already analyzed data using a simulation based bootstrapping technique.

CONSUMPTION THEORIES

Prominent earlier contributors of consumption theory were Keynes[8] and Friedman[6]. In the study of consumption function, Keynes focused on propensity to consume and put forward the popular Absolute Income Hypothesis which assumes that current aggregate consumption expenditure depends upon current level of income alone. According to Keynes, as income increases, consumption also increases but not to the same extent as the increase in income. This means that increase in income leads to decrease in marginal and average propensity to consume. But, a close examination of the consumption pattern among consumers reveals that the consumption does not depend upon income alone as pointed out by Keynes's Psychological law of Consumption Function.

Another, noticeable contribution to consumption theory was Permanent Income Hypothesis by Friedman[6] which assumes that households spend a fixed fraction of their permanent income on consumption. The permanent income hypothesis assumes that the current consumption depends on current income and anticipated future income. A noticeable drawback of this theory is that, since permanent income depends on future income, it cannot be measured directly. Friedman estimated permanent income as a weighted average of current and past incomes, with the current year weighted more heavily. Many economists questions permanent income hypothesis for the assumption of constant average propensity to consume and the assumption of zero marginal propensity to consume from transitory income.

THE LIFE-CYCLE HYPOTHESIS THEORY

Propounded by Franco Modigliani in 1950's, the Life-Cycle Hypothesis (LCH) theory of saving was yet another prominent contribution to consumption theories. It pertains to the behaviour of savings and spending of individuals over their lifetimes. LCH has some similarity with permanent income hypothesis and according to LCH, consumption is related not to the current income of a consumer, but to the income over whole life of the consumer. The LCH assumes that an individual maximizes his utility from life-time consumption, and savings are residuals of individual income and consumption. Following Modigliani[9], one can notice that, an individual beginning with null or negative savings at a young age (through education loans etc.), accumulating savings during working age, and finally returning to negative savings as he retires. This means that, during the middle years of age the consumer accumulate enough earnings and during the years of retirement he maintain the same consumption standard as of previous period. Consumer maintains a more or less constant or slightly increasing level of consumption over his life cycle. That is, we must expect a positive relation between consumption and age. The implication of the above model is a consumption function that depends on the resources available to the consumer over his entire life span, the rate of return on capital and the age of the consumer.

Criticisms against LCH also cannot be overlooked. It includes the un-addressed cyclical characteristics of consumer behaviour, effects of livelihood patterns and government social security programmes. Another strong reservation against LCH, probably more relevant for countries like Japan, India etc. is that, people do not run down wealth in old ages but prefer to pass on inherited wealth to children. Campbell and Mankiw[3], Palley[10], Setterfield[11] and Cynamon and Fazzari[4] discusses flaws of LCH and addresses issues with alternative models. Few empirical studies using advanced econometric tools failed to support the Life-cycle hypothesis theory (Hall[7]). The life cycle hypothesis has evolved in the decades since Modigliani and Brumberg first developed it, but despite many challenges discusses above, it remains a remarkable work of modern economic theory.

STATISTICAL MODEL

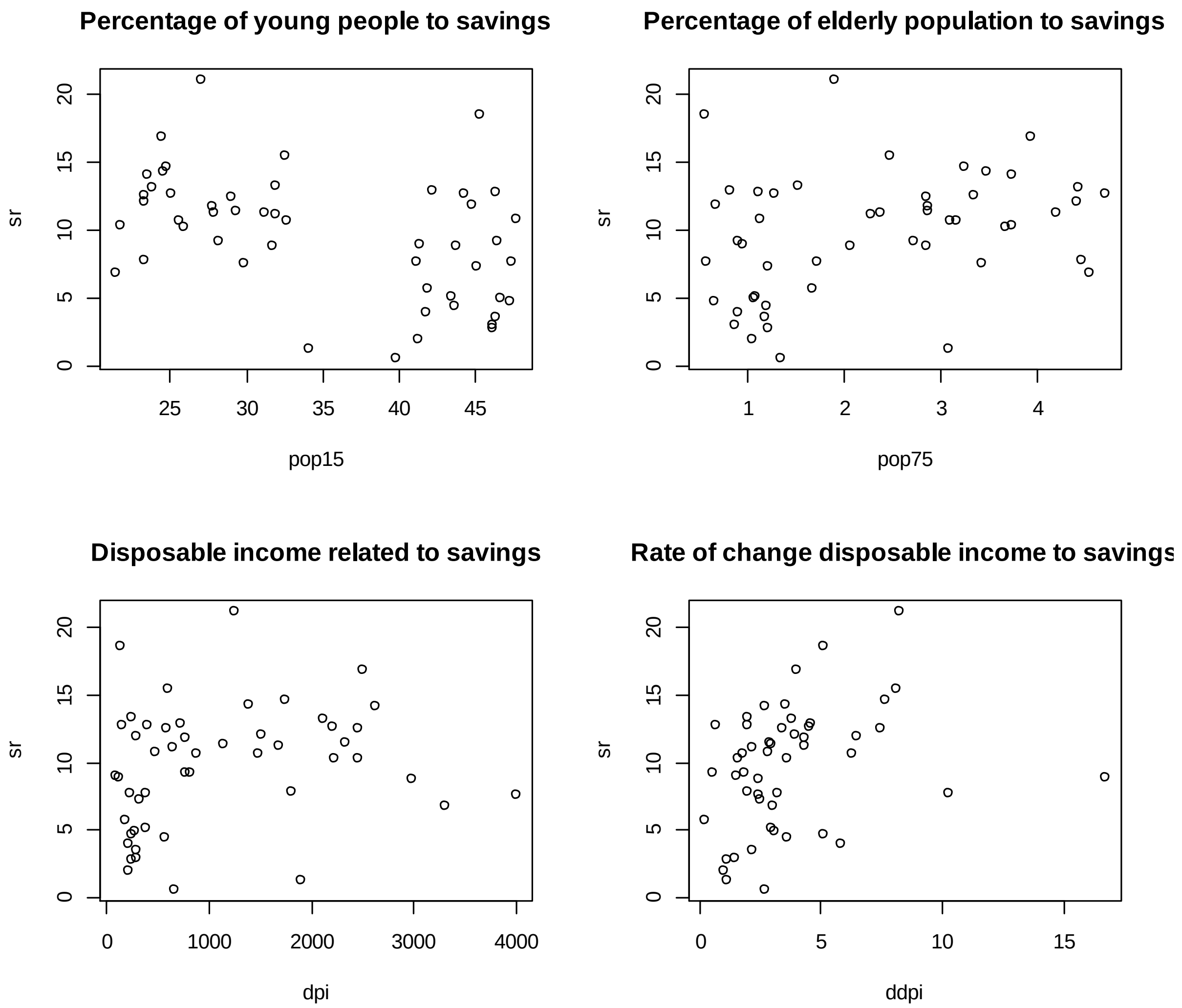
In this study, I revisit the life cycle hypothesis theory of saving by Franco Modigliani to examine the statistical validity of it using the data given by Belsley, Kuh and Welsch[2] collected from Sterling[12]. The data consists of 50 observations on each of the 5 variables. The variables in the data set are, aggregate personal savings (sr)**,** the percentage of population under 15 (pop15), the percentage of population over 75 (pop75), the real per-capita disposable income (dpi) and the percentage growth rate of dpi **(**ddpi). The observations are averaged over the decade to remove the business cycle or other short-term fluctuations. In the first part of the model building, the parameters of the model were estimated using Ordinary Least Squares (OLS). Based on this data, a likely life-cycle savings hypothesis model that can be used to explain the savings ratio is, per-capita disposable income, the percentage rate of change in per-capita disposable income, the percentage of population less than 15 years old and the percentage of the population over 75 years. The model suggested under the above theory can be mathematically expressed as

$$sr = \beta_0 + \beta_1 \, pop15 + \beta_2 \, pop75 + \beta_3 \, dpi + \beta_4 \, ddpi + \varepsilon$$

Since according to LCH, people maintain higher level of saving over the early years of his life cycle, we must expect a negative relation between savings and age. Therefore, when the percentage of population less than 15 years age (*pop15*) increases, the aggregate personal savings (*sr*) must increase and hence the expected sign of β_1 is positive under LCH. Using the same argument given above, when the percentage of population over 75 (*pop75*) increases, the aggregate personal savings (*sr*) must decrease and hence the expected sign of β_2 is negative. Further, the expected positive association between income and savings, the expected signs of the coefficients β_3 and β_4 are positive. The following figure shows the pair-wise scatter plot of the data taking variable aggregate savings (sr) along the Y axis and other predictors along the X axis.

DATA ANALYSIS

Figure-1: Pairwise scatter plot of the four predictors



The estimated model is

$$\hat{sr} = 28.5661 - 0.4612*pop15 - 1.6915*pop75 - 0.0003*dpi + 0.4097*ddpi \qquad (*)$$

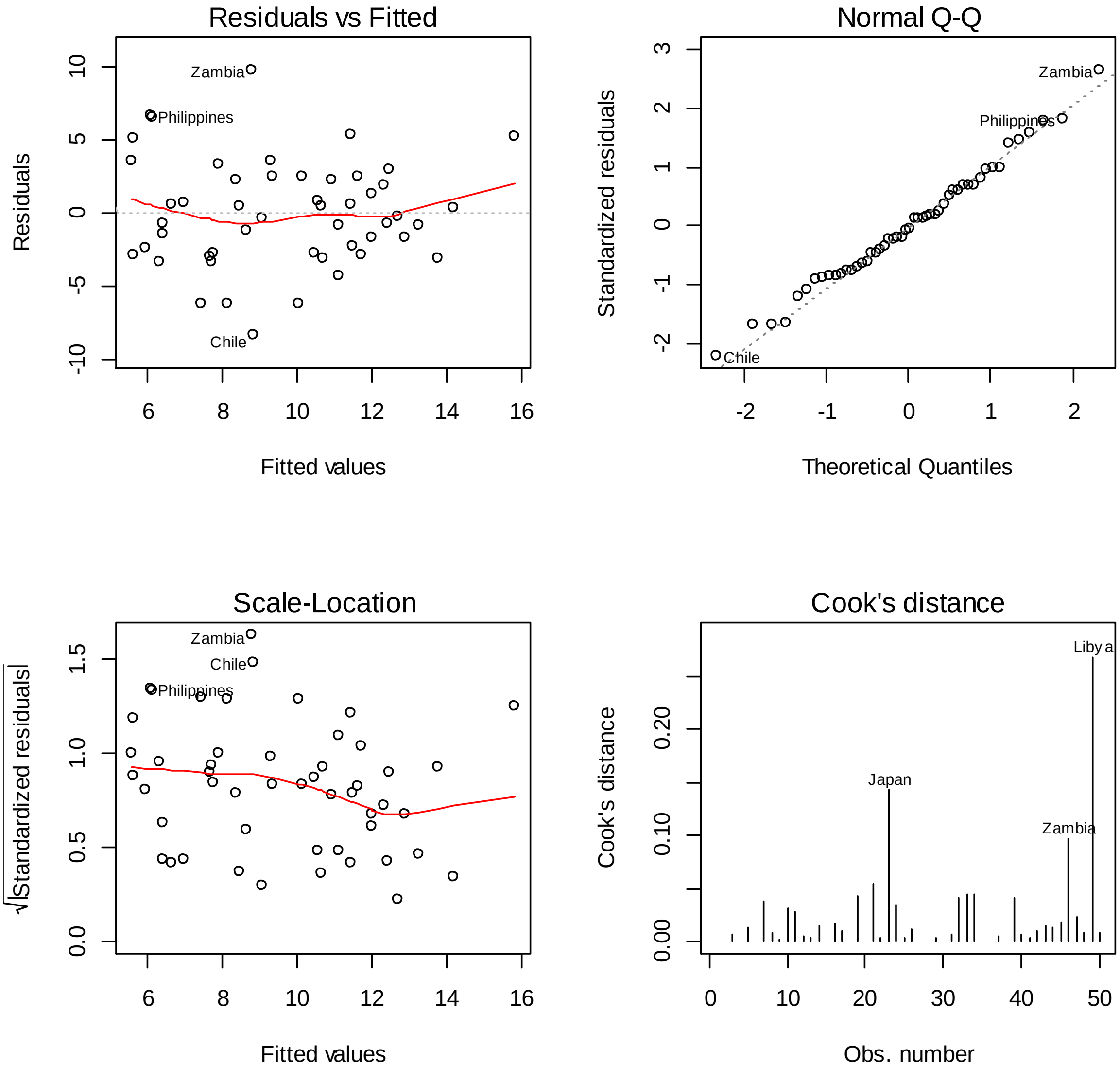
(7.3545) (0.1446) (1.0836) (0.0009) (0.1962)

(0.000) (0.003) (0.126) (0.719) (0.042)

The standard errors of the estimates and the significance values are reported in brackets below the fitted model. The model in (*) shows that the sign of the estimated β_1 is negative and this coefficient is statistically significant (t =-3.189, df =45, p= 0.003) which is not according to the assumptions of LCH. The observed sign of the estimated β_2 is negative which is in line with the theory but unfortunately, the coefficient is not statistically significant (t = -1.561, df =45, p= 0.125) at 5% level of significance. Further, contrary to our expectation, the sign of the estimated coefficient β_3 is negative and the coefficient is highly statistically insignificant (t = -0.362, df =45, p= 0.719). The estimated coefficient β_4 is positive which is in line with our expectations and this coefficient is statistically significant (t = 2.088, df =45, p= 0.042). Approximately, 33.85% of variations in savings are explained by disposable income, the percentage growth rate of disposable income and the two demographic variables together.

Now the relevant question here is, what might be reasons for the contradictory results obtained for the coefficients of estimated β_1 and β_3?. Is it due to the failure of the model or due to other reasons like wrong model specification or wrong estimation procedure?. Hall's[7] analysis, leads to the rejection of the pure life cycle hypothesis by the data but the lack of support by data need not be always due to the failure of the theory. If we rule out the failure of the theory, one possible reason could be, the OLS estimates are sustainable only when used in the analysis of the short-term models. Since life-cycle hypothesis describes the long run behaviour of consumers, such short run testing of the model effects could be insufficient and inaccurate. Another culprit for the not observing in line with expected signs of the estimates, could be OLS estimation procedure. It has observed that many models built based on OLS estimates to macroeconomic data lead to spurious results. The reason for the failure of the estimates comes from the violation of the assumptions underlying the OLS estimation procedure. OLS model requires certain assumptions to be satisfied and any serious violation of these assumptions may lead to in appropriate and meaningless results. Now, the following diagnostic plots of the OLS residuals can be used to check the validity of the assumptions for the OLS used for the initial model building.

Figure-2: Regression diagnostic plots of the residuals



First plot of Figure-2 is the plot of the residuals against the fitted values. When the assumptions are satisfied, we expect a random distribution of the points on the either sides of the horizontal line at y=0. We can see some minor deviations and slightly reducing fluctuations for the large values of the fitted response variable. This is an indication of minor non linearity and hetroscedastic variance of the residuals. Second plot is a normal probability plot and the linear pattern along the reference line supports the assumption of the normality of the errors. Third plot is the plot of the standardized residual against the fitted values. Plot suggests that three countries (Zambia, Chile and Philippines) behave like outliers. Fourth plot is the Cooks distance and it indicates the existence of three influential observations (Libya, Japan and Zambia) which might shift in the regression line inappropriately. Colinearity issues of this model were examined using VIF vlues, a leading indicator multicollinearity, but could not detect any unusually large VIF values suggesting that multicollinearity is not a issue for this data. Test for normality of errors using

Shapiro-Wilk normality test (W = 0.9876, p-value = 0.8765) also did not reject the normality assumption. A detailed discussion of the regression diagnostics problems encounter in this data set can be been seen in Belsley *at.al*[2]. pages 45-62.

Since the diagnostics checks suggests the existence of outliers and influential observations in the data, some robust procedures are required to compute the standard errors and significance values of the parameter estimates. One such procedure is the bootstrap (Efron B & Tibshirani[5]) estimation procedure. Hence, the parameter estimates and their errors were re-computed using bootstrap estimation method. In the first stage, the model was fitted using OLS method and estimated the unknown parameters β_j's (j=1,2,3,4) a large number of times using the concept of resampling. Then the bootstrap method was uses to estimate its standard errors, average of the estimates and significance values. Before run the model the insignificant variable per-capita disposable income was dropped from the model. The bootstrapped parameter estimates, standard errors and the significance values of the parameters were computed was reported below. The bootstrapped estimated model is

$$\widehat{sr} = 26.5326 - 0.4233 * pop15 - 1.6601 * pop75 + 0.4805 * ddpi$$

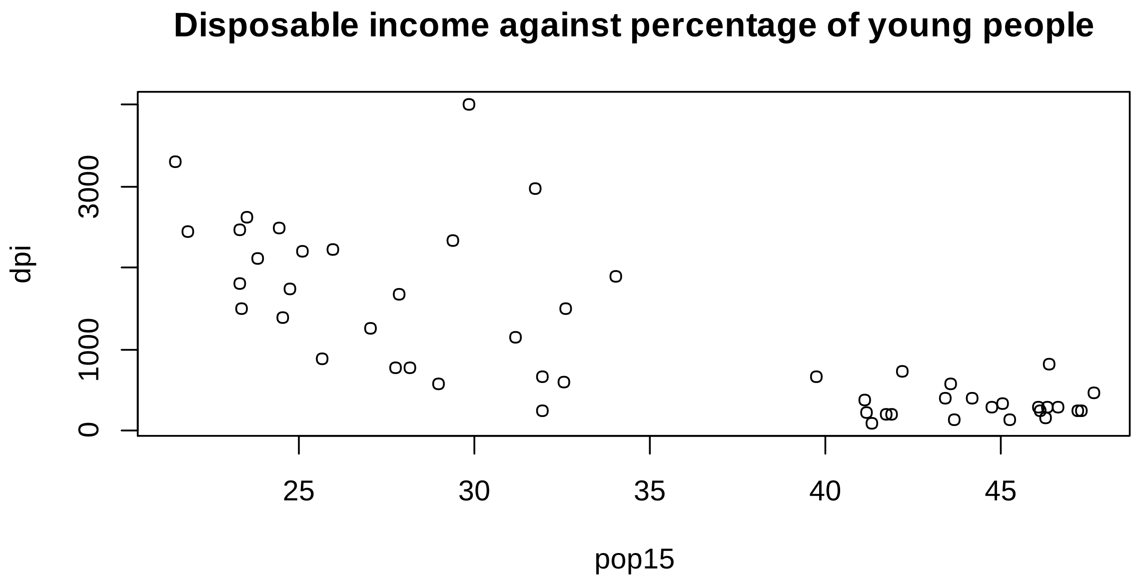
(7.2874) (0.1410) (1.0482) (0.2350) (0.0001)

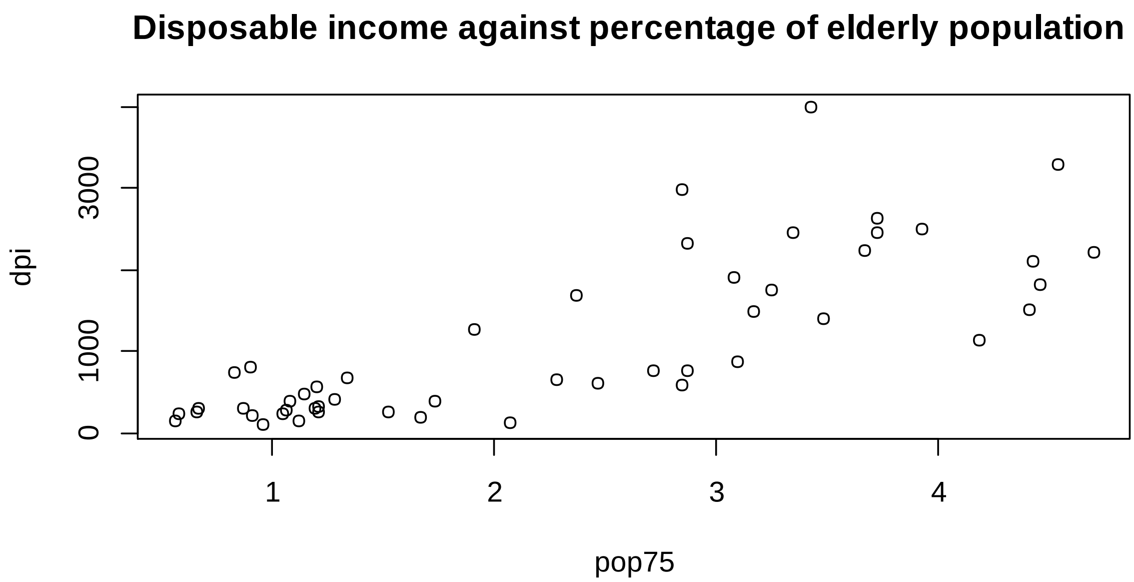
(0.0013) (0.0566) (0.0204)

DISCUSSION

Now, all the coefficients are significant at 10% level and the model explains approximately, 33.0% of variations in savings by the predictors, percentage growth rate of disposable income and the two demographic variables together. Contrary to the expectation, still the sign of coefficient of the variable percentage of population less than 15 years age is negative. But the observed signs of the variable percentage of population greater than 75 years age and the expected sign of the percentage growth rate of disposable income are in line with LCH. Now, it is worth interesting to investigate the relation between age groups and disposable income. The following plots give shows the relation between two age groups and disposable income.

Figure-3:*Relations showing the disposable income against percentage age group*





First plot of figure-3, shows the relation between percentage population under 15 and the disposable income. It shows a clear negative correlation between percentage younger population and disposable income. This means that, as expected, percentage younger population and per capita disposable income are negatively related. Second plot shows the relation between percentage population over 75 and the disposable income. Plot shows a strong positive correlation between percentage of aged population and the per capita disposable income. On the light of the above information, we can conclude that the reason for the unexpected sign of the coefficient of percentage of population less than 15 years need not be due to the failure of the theory. The percentage of population less than 15 years is not the representative of the earning group of people in a country.

The higher percentage of population less than 15 years need not imply that the country had higher younger earning group than the middle aged or elderly earning group. But unfortunately we don't have the data on percentage youth or middle-aged population during the relevant period to test this. Another explanation for the unexpected sign of the coefficient of percentage of population less than 15 years could be the wages for fresher's and workers during their initial years need not be sufficient enough for a large scale saving

CONCLUSION

The study showed that an increase in the percentage of elderly people has negative impact on the aggregate personal savings as predicted by Modigliani and probably they were spending relatively more than saving. On the other hand higher young population strongly correlate to having less disposable income, but this in fact did not reflect in the saving side in our study. Probably this might be due to the fact that the higher percentage of population less than 15 years need not imply higher percentage younger working class population or the higher percentage population with sufficient earning to raise the aggregate savings due to low salary structure in the initial years of entry into service. Apart this, the study provided strong empirical evidence supporting the life cycle hypothesis.

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