Life Cycle Changes in Consumption Behavior: Age-Specific and Regional Variations

by

Masayo Wakabayashi and Geoffrey J.D. Hewings

REAL 02-T-13 October, 2002

Life Cycle Changes in Consumption Behavior: Age-Specific and Regional Variations[1]

Masayo Wakabayashi

Central Research Institute of Electric Power Industry, Ohtemachi, Tokyo, Japan

m-waka@criepi.denken.or.jp

Geoffrey J. D. Hewings

Regional Economics Applications Laboratory, University of Illinois, Urbana, Illinois, USA

hewings@uiuc.edu

Abstract: While research conducted over the last two decades has pointed to the important role played by household consumption in regional economic models, little attention has been directed to the consumption impacts associated not only with income changes but also life-cycle changes. Using Japanese data, this paper explores some of the implications of life cycle changes on consumption behavior using a modified AIDS estimation system. Testing is directed to differences in age-specific consumption behavior and the potential differences in consumption by age and province.

1 Introduction

Research over the last two decades has highlighted the important role that households play in the economic development of a regional economy. Early research revealed that the set of analytical important elements in extended input-output and social accounting models was dominated by consumption expenditure patterns (see Hewings, 1982, Hewings *et al*., 1989). More recently, data have been assembled to explore various facets of income distribution at the national and regional levels (Li *et al*., 1999, Rose and Li, 1999), to explore the nature and magnitude of transboundary income flows (Rose and Stevens, 1991; Kilkenny and Rose, 1995) and to

[1] This research has been carried out under a cooperative research program between CRIEPI and REAL that has been exploring the structure and evolution of regional economies in Japan and the US. The comments of Russel Cooper, Gerold Zakarias, Tatiane Menenzes and participants in the REAL seminar are appreciated.

development estimates of interrelation income multipliers (Rose and Beaumont, 1988, 1989; Rose and Li, 1999), using the formulations proposed by Miyazawa (1968, 1976). However, very little of this work has made its way into regional and interregional general equilibrium models. Further, the influence of demographic change, one of the most important factors that affect the consumption structure of the household sector, has rarely been considered even in the context of an ageing population. A recent projection of Japanese population reveals that although the total population has already started to decline, the elderly population is still increasing in both numbers and as a percentage of the total population (National Institute of Population and Social Security Research, 2002). This has caused a dramatic rising trend in the elderly population ratio, defined as the population over 65 years old divided by the total population. Figure 1 provides graphical evidence of the ageing process in Japan; it can be seen that the elderly population ratio is increasing such that it will reach more than 32 percent at the end of the first half of this century. This means almost one third of total population will be over 65 years old at that time.

<<insert figures 1 and 2 here>>

It is generally accepted that consumption behavior of a household changes according to stage in the life cycle. Figure 2 provides some empirical evidence again for Japan. Here the horizontal axis indicates life cycle stages of households; each line shows the average share of expenditures for a specific generation, with households grouped by the year of their household head's birth. The profile of each line indicates changes in consumption behavior across the life cycle while the shifts of lines provide an indication of the changes in consumption behavior by generation.

Looking at these figures, one can observe the greater generational changes in the transportation budget share especially in the earlier life stage. The data includes expenses for automobiles in transportation expenditure. For example, consider the households group *H*, whose household heads were born in the 1930's; a car was an extraordinarily luxury good when they were in the earlier life stage, and it was not common for the young households to possess a car. However, it is quite common now to own cars even though these households are relatively young. Factors such as these create the potential for large generational shifts in figure 2.

On the other hand, expenditure on education has a characteristic peak in the curve with the peak appearing later in the 40's of each generation. Note that the younger generation has the higher peak. This change across household's life cycle accords with school-aged children in a household. Generally, a household in the age of 40's and 50's has a child or children of school age in an institution of higher education. The new generations spend more than the elderly did in the past because the ratio of children who go on to the next stage of education has increased.

In contrast, medical care is greater at the beginning and the later of households' life cycle stages. In addition, it has a larger variation among generations in their young or elderly life stages.

The data in figure 2 reveal how the households' consumption behaviors change across their life cycle stages. With the demographic changes noted earlier, the consumption behavior of elderly becomes more and more important. Therefore, it is important to account for differences in consumption behavior in any long-term structural analysis of the economy.

In this paper, the main focus is a shift in a household's intra-temporal preference across its life cycle stage. Fixed effects as parameters' shifts of demand system are introduced to capture this effect. This paper is organized into six sections. After this section, we introduce the AIDS model to analyze households with age characteristics. The data used for the analysis is explained in section 3. In sections 4 and 5, the estimation results and implications using

Japanese households data are presented. In the final section, remaining problems in the analysis are reviewed and some guide is provided to the way these findings will be incorporated in multiregional models of the Japanese economy.

2 Model

The model used is based on AIDS (Almost Ideal Demand System), that was proposed by Deaton and Muellbauer (1980). This system is derived from the PIGLOG-class expenditure function defined as follows:

$$\ln c(u,p) = (1-u)\ln a(p) + u \ln b(p) \tag{1}$$

where

$$\ln a(p) = \alpha_0 + \sum_k \alpha_k \ln p_k + \frac{1}{2}\sum_k \sum_j \gamma^*_{kj} \ln p_k \ln p_j \tag{2}$$

$$\ln b(p) = \ln a(p) + \beta_0 \prod_k p_k^{\beta_k} \tag{3}$$

Applying Shepherd's lemma to this expenditure function results in the following demand system:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \cdot \ln\left(x/P \right) \tag{4}$$

Where w_i is the budget share of the i^{th} good for the household, p_i is the price of good *i*, and $\left(x/P \right)$ is the total expenditure on all *n* goods and services in real terms, with a price index P defined by:

$$\ln P = \alpha_0 + \sum_k \alpha_k \ln p_k + \frac{1}{2}\sum_j \sum_k \gamma_{kj} \ln p_k \ln p_j \tag{5}$$

where

$$\gamma_{ij} = \frac{1}{2}\left(\gamma_{ij}^{*} + \gamma_{ji}^{*}\right)$$

Since the price index P is defined as equation (5), the original AIDS model is a non-linear system. Deaton and Muellbauer (1980) suggested using the Stone price index $\hat{P}$ instead of the 'real' price index P to transform the system to a linear one.

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \cdot \ln\left(x / \hat{P} \right) \tag{6}$$

$$\ln \hat{P} = \sum_k w_k \ln p_k \tag{7}$$

The AIDS model using the Stone price index is called 'linear approximate almost ideal demand system' (LA/AIDS). This approximation makes the estimating process much easier, so that many application studies follow this procedure.

To be consistent with the consumption theory, demand functions are required to satisfy the following conditions:

a) Adding up:

$$\sum_i \alpha_i = 1, \quad \sum_i \gamma_{ij} = 0, \quad \sum_i \beta_i = 0 \tag{8}$$

b) Homogeneity:

$$\sum_j \gamma_{ij} = 0 \tag{9}$$

c) Symmetry:

$$\gamma_{ij} = \gamma_{ji} \tag{10}$$

Since the AIDS formulation has a flexible specification, the system is not guaranteed to assure the homogeneity and symmetry conditions by itself. These are testable properties of this model.

Testing regularity conditions of the demand system is not the primary focus of the present study here, so that these conditions were introduced as parameter restrictions in the estimation process. This means these properties are satisfied by parameter restrictions in our model.

It was assumed that the size of the family affects budget share and introduced n, the number of household members, as a shift parameter of α_i. Accordingly, the basic model with this correction is described as equation (11).

$$w_i^{kl} = \alpha_i + e_i \cdot n^{kl} + \sum_j \gamma_{ij} \ln p_j^{kl} + \beta_i \left(\ln x^{kl} - \ln \hat{P}^{kl} \right) + \varepsilon_i^{kl} \tag{11}$$

where ε_i^{kl} denotes error term of the model. The letters *k* and *l* refer to age group and region respectively, since the data are also available by region for Japan.

Given the data structure, the error term of the model can be decomposed into three components: (i) age-specific fraction (μ^k), (ii) region-specific fraction (ν^l), and (iii) the rest (ζ^{kl}). ζ^{kl} is assumed to be independent identically distributed.

$$\varepsilon_i^{kl} = \mu_i^k + \nu_i^l + \zeta_i^{kl} \tag{12}$$

<<insert table 1 here>>

Table 1 summarizes the error structure of the model (11), comparing the means of the error term (ε) by age groups. The reference group is G1, the average of all households. From G2 to G6 are age groups where households are categorized according to household head’s age into under 29 (U29), 30-39 (30’s), 40-49 (40’s), 50-59 (50’s), and over 60 (60+) respectively. A negative sign in shaded cells indicates that the average of ε in this age group is smaller than that of the reference group (G1), and a number in parentheses denotes the statistical significance level of the difference between these two groups. The last row (BP) denotes the results of the Breusch-Pagan test. This tests the heteroskedasticity of the error term under the null hypothesis, H0, that the variance of the error (σ^2) is constant over observations, against the alternative hypothesis, H1, that σ^2 is a function of the age dummy. The results show that the hull hypothesis is significantly rejected in every equation implying that there exists significant correlation in the error term in the same age group.

To deal with these age-specific fractions, fixed age effects were introduced into the model; the following equations denote the correction of the model regarding age effects:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \left(\ln x - \ln \hat{P} \right) + u_i \tag{13}$$

where

$$\alpha_i = \alpha_{i0} + e_i n + \sum_k \alpha_{ik} Dage_k$$
$$\beta_i = \beta_{i0} + \sum_k \beta_{ik} Dage_k$$

and where $Dage_k$ is a dummy variable for age group *k*.

The system described in (13) allows parameters α and β to shift as a household moves into a new life cycle stage.

3 Data

In this section, the data used in the following analyses are described briefly. The data source for consumption expenditure of households is the national survey of family income and expenditure in Japan, which is conducted every 5 years. These survey data were pooled for the four sets of observations made between 1984 and 1999. Consumption goods and services are aggregated into 11 categories; food (FD), clothing (TX), housing (HS), energy (EG), furniture (FN), medical care (MD), transportation (TS), communication (CM), leisure (LS), education (ED), and miscellaneous (OT). There are also divisions into 47 provinces and every province has the collection of each 5-years age group: under 24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, over 75, and the average for all ages.

<<insert table 2 here>>

Table 2 summarizes the budget share of each consumption good and service by age group. Households are classified into six age groups; under 29(U29), 30-39(30's), 40-49(40's), 50-59(50's), over 60(60+), and the average for all groups. On average, U29 spend more on transportation, communication, and medical care, and less on food and education. Similarly, those in their 30's spend more on leisure, and less on housing. While the households in their 40's spend more on education, and less on medical care and communication. The standard deviation is higher in U29 than in other age groups, reflecting the fact that the young households' consumption behavior varies among different regions as well as different years. Further, it may reflect the influence of the decade-long recession that has existed in Japan for much of the 1990s.

As for the price data, the regional consumer price indices were estimated the following formula:

$$R\_CPI_i^l = N\_CPI_i \bullet RD_i^l \tag{14}$$

where N_CPI_i is a national consumer price index of good *i* and RD_i^l is a regional differential index of good *i* in region *l*, scaled to the National average as 1.00.

<<insert table 3 here>>

Table 3 summarizes the statistical characteristics of the regional price indices. The overall deviation is larger in education (ED), housing (HS) and clothing (TX), and smaller in transportation (TS) and furniture (FN). The deviation among regions is larger in housing and education, and smaller in medical care (MD) and communication (CM) while the deviation among regions increases greatly in education and housing, and slightly less so in clothing, furniture and miscellaneous (OT) over time. From these results, it can be inferred that prices are different from region to region, even in the same year. However, the reasons for these deviations vary by category.

For example, the regional deviation in housing price indices is caused by great differentials in land values. On the other hand, the regional deviation in education price indices comes from differentials in enthusiasm for children's education, or the availability of public services. Roughly speaking, parents in urban areas have a higher propensity to provide their children with a higher education and are more eager to spend on additional education services, which are private and mostly expensive. In addition, urban areas have more school-aged children than the quota of public schools. For this reason, some of children receive education services from private schools, which are more expensive than public services in most cases. These attitudes lead to a higher education price index in urban area, and consequently generate price disparities among regions.

A significant shift of the mean over time is observed for education, medical care and clothing. For example, the mean of the price indices of education services increased by 4 percent per year from 1984 to 1994, and by 2 percent from 1994 to 99. On the other hand, the regional deviation in medical care is relatively small. Therefore, deviations across time is by far the more dominant factor in accounting for price differences. Prices of most goods and services increase over time but a price drop is observed in communication, furniture and transportation. The fall in communication prices is sizable, considering that most regional deviations in the same year are small.

4 Empirical results

Tables from 4 to 6 summarize the estimation results of AIDS model with life cycle effects. Here four versions were estimated of model (13)[2]: (i) Full life cycle model, (ii) Partial life cycle model, omitting life cycle effects on parameter α, (iii) Partial life cycle model, omitting life cycle effects on parameter β, and (iv) a model without life cycle, omitting life cycle effects on both parameters (same as model 11). SUR was used for estimation, since the dependent variables in the model are budget shares of households' consumption and they are simultaneously correlated with each other because of the budget constraint. In addition, it is possible to use a number of samples as a weight variable to adjust sample size biases caused by survey data in which sample sizes are different.

<<insert tables 4, 5, 6 here>>

Table 5 compares the estimated parameters, α and β, among these four models. The last row shows the *F* statistics to test the significance of the life cycle effects as a group. In this test, the restricted model is one of the models (ii), (iii), or (iv) and the non-restricted model is the full model (i). According to these results, the *F* test statistics support the statistical suitability of the full model compared with the other three.

Parameters in the full model and their statistical significance are summarized in table 6. A

[2] We have 2431 observations. However, there are outliers in terms of their negative price elasticity of expenditure function ($\partial C/\partial p_i$). Among them, we consider one which price elasticity of transportation is negative (Saga, 1994, U29) as an outlier and eliminate this sample from observations. We also have 161 samples which price elasticity of education is negative (84 samples in 1984, 45 samples in 1989, 28 samples in 1994 and 4 samples in 1999). 33 regions have at least one with negative price elasticity of education. The largest number is Yamaguchi (16 samples), the second largest is Okayama (14 samples), the third largest is Ehime (13 samples), and so on.
However, most of them are younger than 29 or older than 60, except for one (Kagoshima, 1989, 55-59). As we've seen before, budget share of education expenditure in these age groups is negligibly small because they do not have school-aged children. Although negative price elasticity is not theoretically acceptable, we regard the implications from this as negligible and include these observations in our estimation. As a consequence we use 2430 observations for our estimation.

coefficient of age dummy is used to assess the life cycle effect in each age group. For example, looking at β parameter in the leisure expenditure function, the coefficient of 40's age group is significantly negative (-0.077), implying that the β parameter in this age group is significantly lower than the average. Since β_0 is estimated as 0.028, the β parameter of leisure expenditure in 40's turns out to be negative (0.028 – 0.077 < 0).

β is a coefficient of real income term ($\ln\left(x/\hat{P}\right)$) in the model. A positive sign for this coefficient means that the good is a luxury good because its budget share goes up when income increases in real terms. In another words, the income elasticity is greater than one. A negative coefficient means the opposite and a good is recognized as a necessity if β is negative.

> β coefficients in leisure show that the income elasticity in leisure expenditure is higher than one over most of the life cycle, except in 40's. Pressure from education expenditures, described earlier, probably account for this exception, together with expenditures on housing. Similarly, there are several goods whose signs for the β coefficients change through the household's life cycle. Transportation, housing, and education belong to this type of goods and services.

5 Economic Implications

Figures 3 and 4 indicate shifts of parameters α and β across a household's life cycle. The larger and positive β is, the smaller α tends to be. Therefore, most of the combinations of α and β locate in either left-high or right-low quadrants. The goods that appear in the left-high are categorized as luxury goods, because as already noted, a positive value for β

indicates that the income elasticity of this good is greater than one. The goods that appear in right-low are necessities.

<<insert figures 3, 4 here>>

How do these categorizations vary across the life cycle? By examining figure 3, one can observe shifts in household preferences across the life cycle. For example, transportation (TS) locates in the upper box in the age group U29. Since transportation expenditure includes expenditures on cars, one could surmise that the younger household's income elasticity for cars is high, because in general they do not need to spend money on any other expensive goods and services when their budget allow them to spend more.

Figure 4 illustrates the same parameter shifts, but from another dimension. The scales of axes are different among each category. It is worth reminding that the scales of dependent variables are not the same in different goods and services, therefore they are not comparable by scale among different categories. Even relatively slight shift of parameters may mean significant differences in some goods, whose budget shares are relatively small.

Looking at transportation (TS), the parameter set of U29 is located in the upper left of the box; it moves downward considerably into the corner of lower right and β becomes negative when a household moves into its life stage of 30's. In other life periods, 40's, 50's, and 60+, β is positive and it means that the income elasticity is greater than one in these periods. However, it is not so high as in the age group of U29. However, it should be noted that these data refer to shares of income and, clearly, income could normally be expected to increase with age. Thus, the total volumes of expenditure on transportation may be higher in later years even though the share values may never reach the values observed for U29. It is also likely that the type of automobile purchased will also be different. These implications may turn out to be very important information for the supplying industry, especially in the light of the ageing of the Japanese population.

On the other hand, looking at expenditures on housing (HS) β is the highest in 30's and one can observe negative coefficients in U29, 50's and 60+. In Japan, it is common to buy a house after one enters the 30's since access to mortgage instruments increases according to the household heads' employment tenure. It is reasonable to assume that with larger budgets, these households can afford to pay more for housing. Therefore, income elasticity in housing expenditure is high in the age of 30's.

In general, leisure is considered as luxury, so that income elasticity of leisure would be expected to be above one. However, according to the estimation result, the β coefficient of 40's is negative and this means income elasticity is less than one. It happens as a counterpart effect of higher income elasticity in education and miscellaneous expenses in this life stage.

From the section, it was noted that younger households spend more on communication. However, their consumption behavior does not reflect higher income elasticities. In fact, their income elasticity is lower than others. Their expenditures on communication may be considered in large part as though it were a fixed cost in their budget so that the level of income does not affect their behavior.

The income elasticity of medical care expenditure is higher in U29 and over 50's. A change from 50's to 60+ is notable, with a shift into the upper right. This shift toward the upper right can be interpreted to mean that both the income elasticity and the basic expenditure on medical care increase when households move into their life stage of 60+. This finding is not unreasonable when the health demands of the elderly are considered.

The β coefficient of education is higher in 40's and 50's. In these life stages, most of households have children enrolled in higher education. As noted earlier, many parents opt to send their children to private schools – both high school and tertiary levels, creating significant demands on their income.

Energy consumption is a necessity so that the β coefficient never becomes positive. However, there is a slight shift across different life stages. Basically, the younger households have smaller income elasticities than older households. However, when a household moves into its life stage of over 60's, the elasticity decreases while α increases, the interpretation being that basic expenditure on energy is relatively much larger in this age group.

6 Conclusion

Several important implications can be drawn from this analysis. First, given the role of consumption expenditures in regional economies, it will become imperative to consider disaggregating household demands by age group. While the demographic components have been linked in many regional econometric input-output models (see Israilevich *et al*., 1997, Treyz, 1993), consumption is still often entered as an aggregation of household types. In many regional computable general equilibrium models, the demographic-related influences have not be accorded much prominence, with most attention directed to closure rules and functional forms. As these models become more dynamic in character, it will be difficult to justify the non-inclusion of greater specification of consumption behavior by cohort.

In the US, many regional economies are becoming increasingly dependent on non-wage and salary incomes, reflecting in-migration of retirees. Their expenditure patterns need to be considered much more carefully, since assigning them an "average" expenditure profile of all household types will generate incorrect demand signals for some sectors of the economy. At the same time, many regions are experiencing significant in-migration of younger, foreign-born households. Hence, a further dimension to the Japanese case study would need to be considered – age, location and perhaps ethnic background.

A second important implication from these findings is the potential for variation by cohort over time, reflecting differences in tastes, disposable income and location preferences. With increasing amounts of consumption now initiated electronically, matching regional income and consumption expenditures by location will become ever more difficult.

The final implication is the need to allocate more effort in model building to the income-consumption links. Li *et al.* (1999) and Rose and Li (1999) have demonstrated that it is possible to build data bases that go a long way to replicating the type of panel data used in this paper; however, to date, only a few studies have taken advantage of these sources of model enrichment. For short-term impact assessment, these omissions may not be serious, but for longer-term forecasting, the results may be severely compromised by neglect of household cohort consumption behavior.

7 References

Asche, F. and C.R. Wessells. 1997. "On price indices in the Almost Ideal Demand System." *American Journal of Agricultural Economics*, 79, 1182-1185.

Blundell, R., P. Pashardes, and G. Weber. 1993. "What do we learn about consumer demand patterns from micro data?" *American Economic Review*, 83, 570-597.

Buse, A. 1994. "Evaluating the Linearized Almost Ideal Demand System." *American Journal of Agricultural Economics*, 76, 781-793.

Chen, K. Z. 1998. "The symmetric problem in the linear almost ideal demand system." *Economic Letters*, 59, 309-315.

Chung, C-F. 2001. “Modeling demand systems with demographic effects based on the modifying function approach.” *Economic Letters*, 73, 269-274.

Clements, K. W., W. Yang, and D. Chen. 2001. “The matrix approach to evaluating demand equations.” *Applied Economics*, 33, 957-967.

Cooper, R. J. and K.R. McLaren. 1992. “An Empirically Oriented Demand System with Improved Regularity Properties.” *Canadian Journal of Economics*, 25, 652-668.

Deaton, A. and J. Muellbauer. 1980. “An Almost Ideal Demand System.” *American Economic Review*, 70, 312-326.

Diewert, W. E., and T.J. Wales. 1987. “Flexible Functional Forms and Global Curvature Conditions.” *Econometrica*, 55, 43-68.

Ghosh, A. and A. Sengupta. 1984. “Income distribution and the structure of production in an input-output framework.” In *Proceedings of the Seventh International Conference on Input-Output Techniques*. New York, United Nations.

Green, R. and J.M. Alston. 1990. “Elasticities in AIDS Models.” *American Journal of Agricultural Economics*, 72, 442-445.

Green, R. and J.M. Alston. 1991. “Elasticities in AIDS Models: A Clarification and Extension.” *American Journal of Agricultural Economics*, 73, 874-875.

Hewings, G.J.D. 1982. “Trade, Structure and Linkages in Developing and Regional Economies.” *Journal of Development Economics,* 11, 91-96.

Hewings, G.J.D., M. Fonseca, J. Guilhoto, and M. Sonis. 1989. “Key sectors and structural change in the Brazilian economy: a comparison of alternative approaches and their policy implications.” *Journal of Policy Modeling*, 11, 67-90.

Israilevich, P.R., G.J.D. Hewings, M. Sonis and G.R. Schindler. 1997. “Forecasting Structural Change with a Regional Econometric Input-Output Model.” *Journal of Regional Science* 37, 565-90.

Kilkenny, M. and A.Z. Rose. 1995. “A social accounting matrix framework for modeling transboundary flows of capital-related income.” In G.J.D. Hewings and M. Madden (eds.) *Social and Demographic Accounting*. Cambridge, University Press.

Li, P-C., A.Z. Rose and B. Eduardo. 1999. “Construction of an input-output income distribution matrix for the U.S.” In G.J.D. Hewings, M. Sonis, M. Madden and Y. Kimura (eds) *Understanding and Interpreting Economic Structure,* Advances in Spatial Sciences, Springer-Verlag, Heidelberg, Germany pp. 191-212.

Michelini, C. 1999. “The estimation of a rank 3 demand system with demographic demand shifters from quasi-unit record data of household consumption." *Economic Letters*, 65, 17-24.

Miyazawa, K. 1968. "Input-output analysis and interrelational income multipliers as a matrix." *Hitotsubashi Journal of Economics,* 18, 39-58.

Miyazawa, K. 1976. *Input-Output Analysis and the Structure of Income Distribution.* Heidelberg, Springer-Verlag.

Moschini, G. 1995. "Units of Measurement and the stone index in demand system estimation." *American Journal of Agricultural Economics*, 77, 63-68.

National Institute of Population and Social Security Research. 2002. "Population Projections for Japan: 2001-2050"

Pashardes, P. 1993. "Bias in Estimation the Almost Ideal Demand System with the Stone Index Approximation." *The Economic Journal*, 103, 908-915.

Rose, A. and P. Beaumont. 1988. "Interrelational income distribution multipliers for West Virginia." *Journal of Regional Science* 28, 461-75.

Rose, A. and P. Beaumont. 1989. "Interrelational income distribution multipliers for the U.S. economy." In R.E. Miller, K.R. Polenske, and A.Z. Rose (eds.) *Frontiers of Input-Output Analysis*. New York, Oxford University Press.

Rose, A. and P.-C. Li. 1999. "Interrelational income distribution multipliers: an application to welfare reform." In G.J.D. Hewings, M. Sonis, M. Madden and Y. Kimura (eds) *Understanding and Interpreting Economic Structure,* Advances in Spatial Sciences, Springer-Verlag, Heidelberg, Germany pp. 347-365

Rose, A.Z. and B.H. Stevens. 1991. "Transboundary income and expenditure flows in regional input-output models." *Journal of Regional Science* 31, 253-72.

Treyz, G.I. 1993. *Regional Economic Modeling*. Boston, Kluwer.

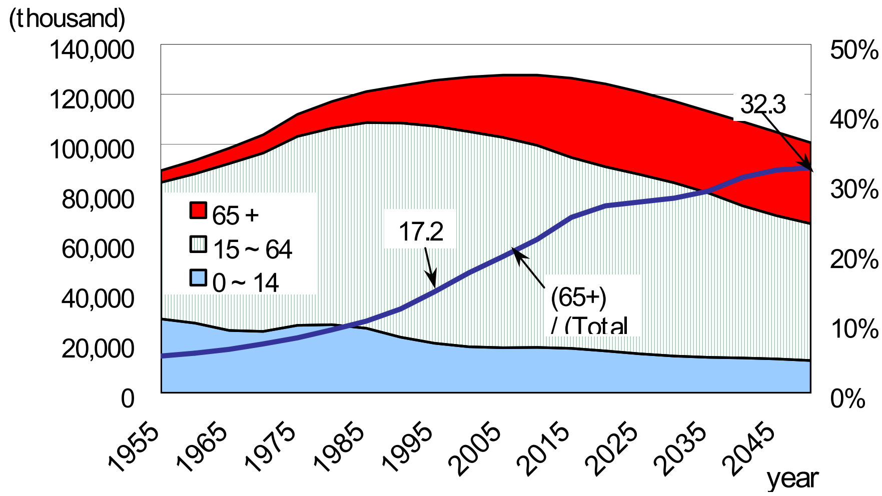

Figure 1 Demographic transition in Japan

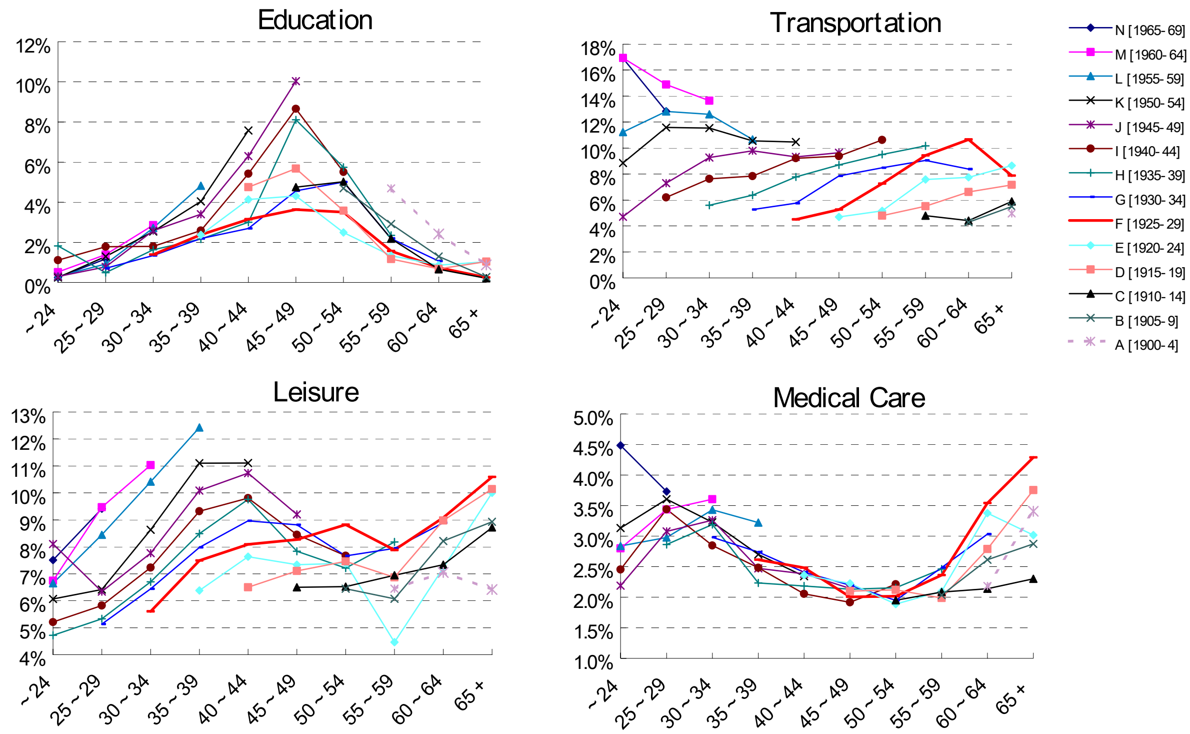

Figure 2 Life cycle changes in budget shares of households' consumption

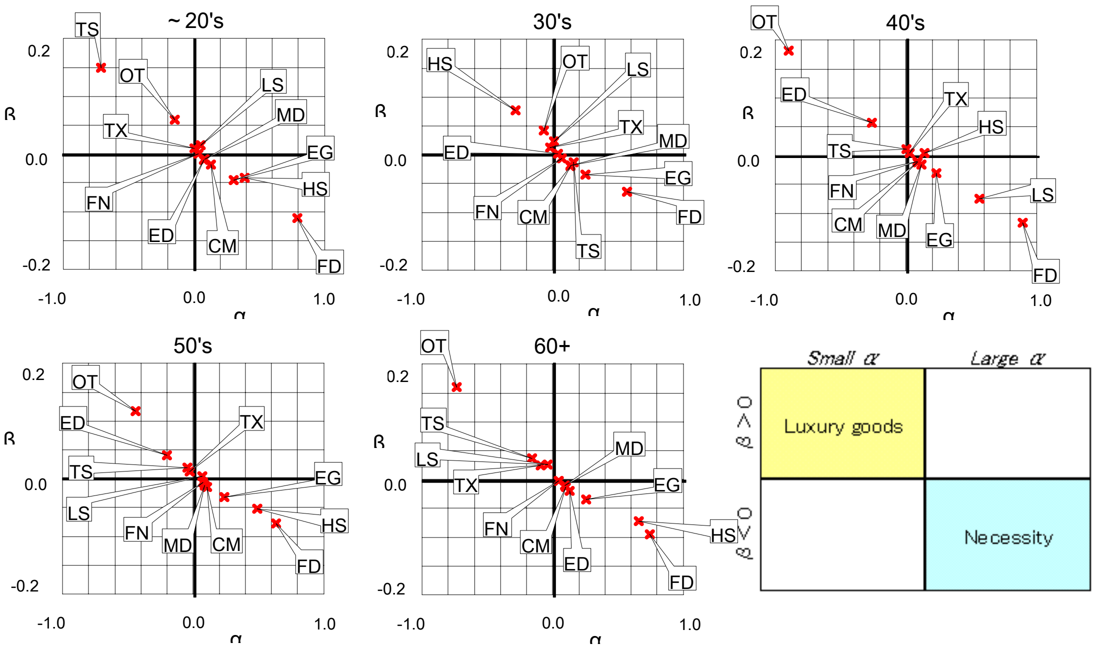

Figure 3 Life cycle shifts of Parameters (1)

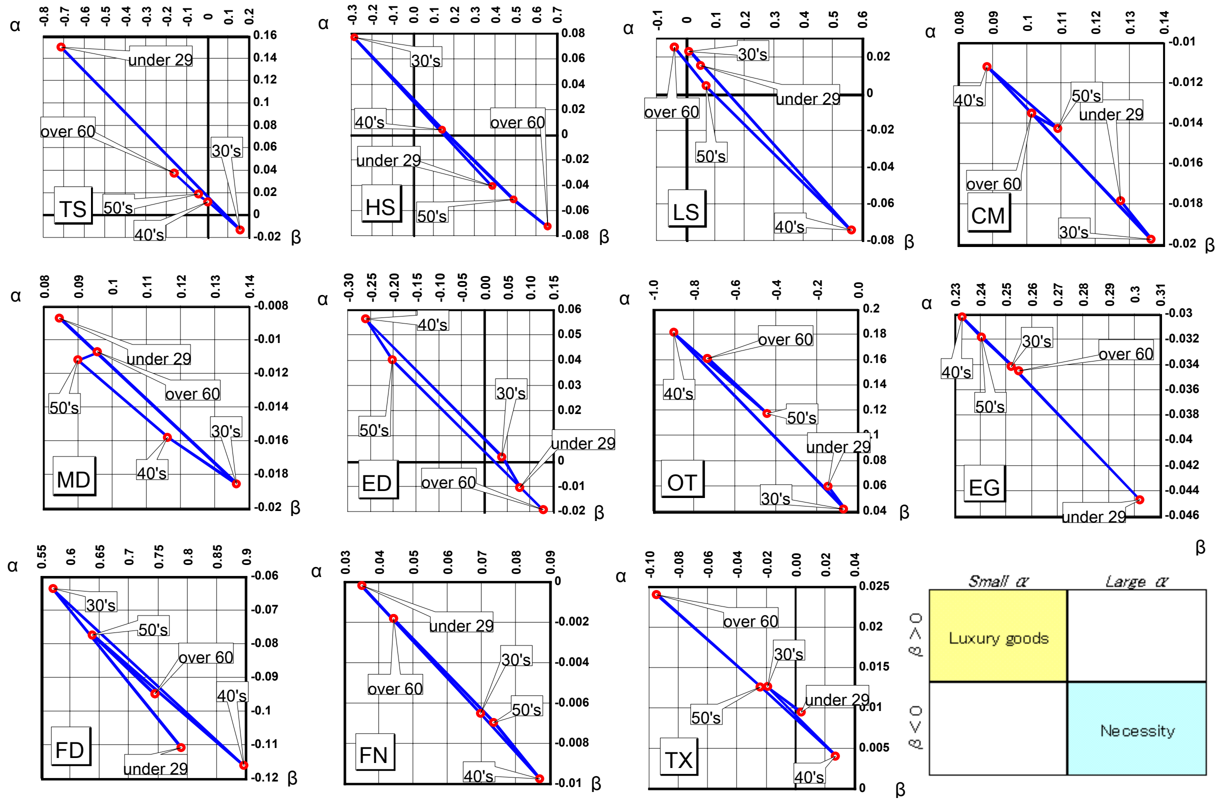

Figure 4 Life cycle shifts of Parameters (2)

Table 1 Age specific fraction in error term

	FD	LS	EG	EN	MD	TS	CM	ED	OT	HS	TX
G2	-0.25 (80.5%)	0.20 (84.2%)	-0.18 (85.5%)	0.02 (98.4%)	0.04 (96.7%)	0.39 (70.0%)	0.05 (96.4%)	0.00 (99.7%)	-0.07 (94.2%)	-0.16 (87.5%)	0.22 (82.7%)
G3	-0.05 (96.1%)	0.40 (68.7%)	-0.14 (88.5%)	0.10 (91.7%)	0.27 (78.7%)	0.17 (86.7%)	-0.11 (91.1%)	-0.23 (81.7%)	-0.15 (88.0%)	-0.08 (93.7%)	0.26 (79.1%)
G4	0.22 (82.3%)	0.06 (95.5%)	0.04 (97.0%)	-0.12 (90.5%)	-0.07 (94.6%)	-0.15 (88.1%)	0.04 (96.7%)	0.34 (73.5%)	-0.29 (77.2%)	0.06 (95.3%)	0.02 (98.7%)
G5	-0.11 (91.0%)	-0.13 (90.0%)	-0.04 (97.1%)	0.09 (92.9%)	-0.21 (83.6%)	0.09 (93.2%)	0.13 (89.4%)	-0.16 (87.6%)	0.24 (81.4%)	-0.10 (92.1%)	0.05 (96.0%)
G6	0.22 (82.2%)	0.11 (91.0%)	0.12 (90.3%)	0.08 (93.8%)	0.23 (81.5%)	-0.24 (80.7%)	-0.15 (88.2%)	-0.16 (87.0%)	-0.39 (70.0%)	0.34 (73.8%)	-0.38 (70.7%)
BP	Reject.	Reject.	Reject.	Reject.	Reject.	Reject.	Reject.	Reject.	Reject.	Reject.	Reject.

T test statistics, which examine differences in mean values of the error term between two groups (G2-G6 and G1, the average of all households).

$\left(\overline{\varepsilon}_i^k - \overline{\varepsilon}_i^{ave}\right) / \sqrt{\sigma_i^k / n - \sigma_i^{ave} / m}$ where n, m mean number of the sample in each group.

A number in parentheses denotes significance level.

Table 2 Summary of households' expenditure data

		Average	u29	30's	40's	50's	60+
Nmb	2420	188	357	376	376	375	748
Wfd	Mean	19.38	18.66	20.84	20.23	17.27	19.79
	Std. Dev.	(1.771)	(3.927)	(2.550)	(2.375)	(1.854)	(2.439)
Wls	Mean	10.84	12.81	13.55	11.13	8.90	10.18
	Std. Dev.	(0.948)	(3.865)	(1.473)	(1.862)	(1.283)	(2.120)
Weg	Mean	5.11	5.76	5.55	5.09	4.65	5.43
	Std. Dev.	(0.532)	(1.347)	(0.638)	(0.645)	(0.559)	(0.896)
Wfn	Mean	3.42	3.66	3.50	3.12	3.44	3.62
	Std. Dev.	(0.400)	(1.640)	(0.644)	(0.615)	(0.909)	(1.038)
Wmd	Mean	2.56	3.75	3.04	2.11	2.16	3.30
	Std. Dev.	(0.395)	(2.947)	(0.788)	(0.448)	(0.490)	(1.217)
Wts	Mean	7.34	10.74	8.78	7.21	7.14	5.51
	Std. Dev.	(0.910)	(5.738)	(2.719)	(1.660)	(1.792)	(2.386)
Wcm	Mean	2.19	2.95	2.27	2.09	2.19	2.31
	Std. Dev.	(0.405)	(1.487)	(0.712)	(0.523)	(0.396)	(0.414)
Wed	Mean	3.68	1.05	3.75	6.47	2.75	1.02
	Std. Dev.	(0.961)	(1.219)	(0.988)	(1.875)	(2.199)	(0.926)
Wot	Mean	23.67	19.79	18.77	21.76	29.47	21.79
	Std. Dev.	(2.302)	(5.360)	(2.178)	(4.341)	(4.006)	(4.604)
Whs	Mean	16.45	14.97	14.26	15.40	16.60	22.33
	Std. Dev.	(2.392)	(4.684)	(2.958)	(2.576)	(2.952)	(4.289)
Wtx	Mean	5.37	5.85	5.69	5.39	5.44	4.73
	Std. Dev.	(0.826)	(2.172)	(0.889)	(0.943)	(1.195)	(1.430)

Table 3 Summaries of Regional Consumption Price Indices

		Pfd	Pls	Peg	Pfn	Pmd	Pts	Pcm	Ped	Pot	Phs	Ptx
Average	Mean	0.946	0.915	1.050	1.021	0.985	0.974	1.007	0.821	0.957	0.807	0.930
	Std. Dev.	(0.070)	(0.079)	(0.080)	(0.044)	(0.099)	(0.037)	(0.063)	(0.171)	(0.072)	(0.145)	(0.111)
84	Mean	0.871	0.817	1.135	1.030	0.853	0.958	1.081	0.613	0.869	0.711	0.788
	Std. Dev.	(0.026)	(0.024)	(0.055)	(0.025)	(0.012)	(0.023)	(0.016)	(0.062)	(0.016)	(0.078)	(0.031)
89	Mean	0.894	0.881	0.980	1.029	0.959	0.965	1.053	0.748	0.926	0.772	0.889
	Std. Dev.	(0.028)	(0.033)	(0.058)	(0.024)	(0.015)	(0.023)	(0.013)	(0.074)	(0.020)	(0.103)	(0.045)
94	Mean	1.002	0.984	1.034	1.042	1.003	1.010	0.949	0.915	0.994	0.863	0.998
	Std. Dev.	(0.030)	(0.038)	(0.058)	(0.034)	(0.014)	(0.029)	(0.017)	(0.075)	(0.031)	(0.134)	(0.050)
99	Mean	1.016	0.980	1.052	0.982	1.126	0.963	0.947	1.007	1.038	0.883	1.044
	Std. Dev.	(0.030)	(0.045)	(0.061)	(0.057)	(0.019)	(0.045)	(0.023)	(0.100)	(0.048)	(0.177)	(0.068)
Shift in mean	84-89	0.53%	1.50%	-2.89%	-0.02%	2.37%	0.15%	-0.51%	4.08%	1.29%	1.64%	2.43%
	89-94	2.30%	2.25%	1.08%	0.25%	0.90%	0.92%	-2.06%	4.10%	1.43%	2.26%	2.34%
	94-99	0.27%	-0.09%	0.35%	-1.17%	2.35%	-0.95%	-0.05%	1.94%	0.86%	0.47%	0.91%

Table 4 Estimation Results of AIDS (1)

	DF Model	DF Error	Life cycle - Full Model Adj R-Sq	MSE	without Life cycle effect - α Adj R-Sq	MSE	- β Adj R-Sq	MSE	- α , β Adj R-Sq	MSE
FD	18.5	2412	0.6968	0.0289	0.6922	0.0293	0.6927	0.0293	0.6110	0.0371
LS	18.5	2412	0.5552	0.0244	0.5108	0.0269	0.5111	0.0269	0.3640	0.0349
EG	18.5	2412	0.7111	0.0019	0.7081	0.0019	0.7079	0.0019	0.6613	0.0022
FN	18.5	2412	0.2390	0.0050	0.2414	0.0050	0.2409	0.0050	0.2277	0.0051
MD	18.5	2412	0.5507	0.0036	0.5487	0.0036	0.5487	0.0036	0.4928	0.0041
TS	18.5	2412	0.2481	0.0440	0.2210	0.0456	0.2199	0.0457	0.0158	0.0576
CM	18.5	2412	0.5387	0.0018	0.5378	0.0018	0.5378	0.0018	0.5060	0.0019
ED	18.5	2412	0.7171	0.0222	0.6991	0.0236	0.6963	0.0238	0.5486	0.0354
OT	18.5	2412	0.6186	0.1052	0.6023	0.1097	0.6030	0.1095	0.4869	0.1416
HS	18.5	2412	0.4637	0.1098	0.4354	0.1156	0.4393	0.1148	0.2536	0.1528

Table 5 Estimation Results of AIDS (2)

	Full Model		Without α ik		Without β ik		Without α ik, β ik	
	estimate	T ratio	estimate	T ratio	estimate	T ratio	estimate	T ratio
α								
FD	0.64104	(27.88)	0.55763	(47.84)	0.66571	(44.25)	0.66596	(44.29)
LS	0.10549	(4.91)	0.41040	(35.98)	0.14626	(9.97)	0.14517	(9.91)
EG	0.20743	(33.56)	0.19088	(65.24)	0.22190	(54.53)	0.22255	(54.79)
FN	0.07179	(7.34)	0.06748	(15.4)	0.06606	(10.34)	0.06609	(10.36)
MD	0.09201	(10.79)	0.15800	(39.64)	0.10797	(19.14)	0.10885	(19.32)
TS	0.05305	(1.91)	0.15471	(10.81)	- 0.03112	(- 1.7)	- 0.03289	(- 1.8)
CM	0.11851	(20.05)	0.08765	(32.53)	0.11393	(29.36)	0.11390	(29.4)
ED	- 0.01205	(- 0.61)	- 0.17261	(- 15.45)	- 0.06423	(- 4.9)	- 0.06519	(- 5)
OT	- 0.31503	(- 7.33)	- 0.66345	(- 29.68)	- 0.41804	(- 14.85)	- 0.42054	(- 14.95)
HS	0.04697	(1.11)	0.18048	(7.99)	0.20642	(7.61)	0.21166	(7.79)
TX	- 0.00921		0.02883		- 0.01486		- 0.01556	
β								
FD	- 0.08715	(- 21.67)	- 0.07295	(- 35.54)	- 0.09231	(- 33.59)	- 0.09235	(- 33.58)
LS	0.00275	(0.73)	- 0.05893	(- 29.4)	- 0.00618	(- 2.31)	- 0.00616	(- 2.31)
EG	- 0.02951	(- 27.25)	- 0.02522	(- 49.06)	- 0.03190	(- 42.96)	- 0.03200	(- 43.12)
FN	- 0.00711	(- 4.15)	- 0.00514	(- 6.68)	- 0.00620	(- 5.31)	- 0.00620	(- 5.32)
MD	- 0.00942	(- 6.3)	- 0.01982	(- 28.34)	- 0.01214	(- 11.8)	- 0.01230	(- 11.96)
TS	0.00177	(0.36)	- 0.01919	(- 7.61)	0.01638	(4.89)	0.01656	(4.94)
CM	- 0.01513	(- 14.58)	- 0.01026	(- 21.65)	- 0.01424	(- 20.06)	- 0.01425	(- 20.08)
ED	0.00301	(0.87)	0.02027	(10.31)	0.01263	(5.26)	0.01279	(5.36)
OT	0.10765	(14.37)	0.17136	(43.67)	0.12683	(24.76)	0.12721	(24.82)
HS	0.02139	(2.95)	0.01713	(4.35)	- 0.00530	(- 1.1)	- 0.00581	(- 1.2)
TX	1.01176		1.00276		1.01244		1.01252	
F value			59.929	0.000	56.175	0.000	54.148	0.000

F test statistics is used to examine the validity of the restriction:

$$F=\left[\left(e_r^2-e_f^2\right)/J\right]/\left[e_f^2/\left(T-K\right)\right]=\left(\lambda^{-2/T}-1\right)\left(T-K\right)/J$$

where e_f and e_r are error term of the full and restricted models, T, J, K are number of data, restrictions, and parameters respectively.

Table 6 Estimation Results of AIDS (3)

(1)

α	estimate	T ratio	N estimate	T ratio
FD	0.64104	(27.88)	0.01713	(15.8)
LS	0.10549	(4.91)	- 0.00152	(- 1.51)
EG	0.20743	(33.56)	0.00505	(17.7)
FN	0.07179	(7.34)	0.00043	(0.93)
MD	0.09201	(10.79)	- 0.00280	(- 7.04)
TS	0.05305	(1.91)	0.00239	(1.8)
CM	0.11851	(20.05)	- 0.00178	(- 6.43)
ED	- 0.01205	(- 0.61)	0.01149	(12.24)
OT	- 0.31503	(- 7.33)	- 0.02901	(- 14.38)
HS	0.04697	(1.11)	0.00112	(0.61)
TX	- 0.00921		- 0.00249	

α	under 29 estimate	T ratio	30's estimate	T ratio	40's estimate	T ratio	50's estimate	T ratio	over 60 estimate	T ratio
FD	0.09791	(1.27)	- 0.14046	(- 3.06)	0.18208	(4.48)	- 0.06265	(- 1.48)	0.05256	(1.43)
LS	- 0.05029	(- 0.71)	- 0.08850	(- 2.09)	0.46651	(12.48)	- 0.03087	(- 0.79)	- 0.13888	(- 4.11)
EG	0.07987	(4.02)	0.02385	(2.02)	0.00377	(0.36)	0.01530	(1.4)	0.03250	(3.43)
FN	- 0.03802	(- 1.18)	- 0.00367	(- 0.19)	0.01350	(0.8)	0.00035	(0.02)	- 0.02869	(- 1.87)
MD	0.00094	(0.03)	0.05576	(3.43)	0.03615	(2.51)	0.00778	(0.52)	0.01204	(0.92)
TS	- 0.77343	(- 8.12)	0.09773	(1.72)	- 0.06120	(- 1.22)	- 0.10512	(- 2.02)	- 0.22079	(- 4.89)
CM	0.01421	(0.74)	0.02517	(2.22)	- 0.02254	(- 2.24)	- 0.00329	(- 0.32)	- 0.01179	(- 1.3)
ED	0.05498	(0.81)	0.00300	(0.07)	- 0.29820	(- 8.39)	- 0.23012	(- 6.23)	0.10737	(3.35)
OT	0.25698	(1.75)	0.36297	(4.14)	- 0.45877	(- 5.93)	- 0.02549	(- 0.32)	- 0.33278	(- 4.77)
HS	0.33651	(2.24)	- 0.33616	(- 3.76)	0.09146	(1.16)	0.44025	(5.37)	0.60666	(8.53)
TX	0.02034		0.00033		0.04725		- 0.00613		- 0.07821	

(2)

β	estimate	T ratio	under 29 estimate	T ratio	30's estimate	T ratio	40's estimate	T ratio	50's estimate	T ratio	over 60 estimate	T ratio
FD	- 0.08715	(- 21.67)	- 0.02380	(- 1.71)	0.02344	(2.94)	- 0.02908	(- 4.29)	0.00974	(1.39)	- 0.00771	(- 1.24)
LS	0.00275	(0.73)	0.01256	(0.98)	0.02032	(2.77)	- 0.07709	(- 12.35)	0.00172	(0.27)	0.02255	(3.92)
EG	- 0.02951	(- 27.25)	- 0.01524	(- 4.25)	- 0.00466	(- 2.28)	- 0.00071	(- 0.4)	- 0.00233	(- 1.29)	- 0.00499	(- 3.09)
FN	- 0.00711	(- 4.15)	0.00693	(1.19)	0.00061	(0.18)	- 0.00266	(- 0.94)	0.00015	(0.05)	0.00529	(2.03)
MD	- 0.00942	(- 6.3)	0.00068	(0.14)	- 0.00917	(- 3.25)	- 0.00638	(- 2.65)	- 0.00179	(- 0.72)	- 0.00129	(- 0.58)
TS	0.00177	(0.36)	0.14762	(8.6)	- 0.01497	(- 1.52)	0.00962	(1.15)	0.01704	(1.97)	0.03543	(4.61)
CM	- 0.01513	(- 14.58)	- 0.00273	(- 0.79)	- 0.00463	(- 2.35)	0.00393	(2.34)	0.00087	(0.5)	0.00162	(1.04)
ED	0.00301	(0.87)	- 0.01348	(- 1.11)	- 0.00150	(- 0.22)	0.05332	(8.99)	0.03720	(6.08)	- 0.02237	(- 4.1)
OT	0.10765	(14.37)	- 0.04820	(- 1.82)	- 0.06622	(- 4.36)	0.07415	(5.74)	0.00950	(0.71)	0.05312	(4.47)
HS	0.02139	(2.95)	- 0.06207	(- 2.29)	0.05593	(3.61)	- 0.01733	(- 1.32)	- 0.07288	(- 5.37)	- 0.09392	(- 7.76)
TX	0.01176		- 0.00226		0.00085		- 0.00777		0.00079		0.01228	

(3)

	γ 1		γ 2		γ 3		γ 4		γ 5		γ 6	
	estimate	T ratio	estimate	T ratio	estimate	T ratio	estimate	T ratio	estimate	T ratio	estimate	T ratio
FD	0.00257	(0.31)	- 0.04674		0.02461		0.01960		0.00142		0.04150	
LS	- 0.04674	(- 7.72)	0.00734	(0.87)	0.00365		- 0.00747		0.00413		- 0.01434	
EG	0.02461	(12.31)	0.00365	(1.91)	0.02683	(30.17)	- 0.01289		- 0.00605		- 0.02404	
FN	0.01960	(6.44)	- 0.00747	(- 2.42)	- 0.01289	(- 12.68)	0.01539	(6.67)	- 0.00833		0.01813	
MD	0.00142	(0.47)	0.00413	(1.35)	- 0.00605	(- 5.79)	- 0.00833	(- 4.96)	0.02721	(11.17)	- 0.01696	
TS	0.04150	(8.67)	- 0.01434	(- 3.08)	- 0.02404	(- 16.91)	0.01813	(7.66)	- 0.01696	(- 7.9)	- 0.02261	(- 3.88)
CM	0.00898	(4.36)	- 0.01573	(- 7.56)	- 0.00483	(- 6.94)	- 0.01038	(- 8.7)	0.00817	(6.9)	- 0.02264	(- 15.44)
ED	0.01456	(5.17)	- 0.00366	(- 1.32)	0.01119	(13.53)	- 0.01697	(- 13.1)	0.00185	(1.53)	- 0.02460	(- 8.9)
OT	- 0.04205	(- 4.99)	0.05521	(6.2)	- 0.01312	(- 5.34)	0.00054	(0.14)	- 0.00250	(- 0.62)	0.03596	(5.04)
HS	0.00028	(0.13)	0.03318	(15.27)	- 0.00390	(- 6.32)	- 0.00494	(- 5)	- 0.00139	(- 1.53)	- 0.00878	(- 3.47)
TX	- 0.02472		- 0.01558		- 0.00145		0.00733		- 0.00756		0.03838	

	γ 7		γ 8		γ 9		γ 10		γ A	
	estimate	T ratio	estimate	T ratio	estimate	T ratio	estimate	T ratio	estimate	T ratio
FD	0.00898		0.01456		- 0.04205		0.00028		- 0.02472	
LS	- 0.01573		- 0.00366		0.05521		0.03318		- 0.01558	
EG	- 0.00483		0.01119		- 0.01312		- 0.00390		- 0.00145	
FN	- 0.01038		- 0.01697		0.00054		- 0.00494		0.00733	
MD	0.00817		0.00185		- 0.00250		- 0.00139		- 0.00756	
TS	- 0.02264		- 0.02460		0.03596		- 0.00878		0.03838	
CM	0.01353	(12.1)	0.00429		0.01059		- 0.00311		0.01114	
ED	0.00429	(5.17)	0.03666	(15.4)	- 0.03533		0.02355		- 0.01154	
OT	0.01059	(4.26)	- 0.03533	(- 7.78)	0.09255	(5.5)	- 0.09886		- 0.00299	
HS	- 0.00311	(- 5.04)	0.02355	(13.15)	- 0.09886	(- 24.87)	0.05895	(15.17)	0.00501	
TX	0.01114		- 0.01154		- 0.00299		0.00501		0.00198	