

# THE DECLINE OF JAPAN'S SAVING RATE AND DEMOGRAPHIC EFFECTS\*

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This paper investigates the phenomenon in which Japan's household saving rate showed a sharp decline even during the long stagnation period called "the lost decade." Our empirical results show that the sharp decline in the saving rate in the 1990s can be explained by the significant impact of demographic factors. Furthermore, the estimated life cycle curve is hump shaped, meaning that the prediction of the life cycle model is confirmed with time series data on the Japanese saving rate.

JEL Classifications: E21, E27.

## 1. Introduction

The Japanese economy experienced a long stagnation called "the lost decade" and dampened consumption throughout the 1990s. However, the household saving rate also declined sharply during this period as shown in Figure 1. In this paper, we investigate the cause of this phenomenon by conducting an empirical analysis.

There have been many empirical analyses in previous studies of the Japanese saving rate, (see, for example, Ando *et al.* (1986); Hayashi (1986); Hayashi *et al.* (1988); Ishikawa (1988); Horioka (1990); and Yashiro and Maeda (1994)). Those studies explored the background of the high saving rate before the sharp decline of the 1990s; the recent sharp decline in the saving rate makes it necessary to clarify the reasons for the decline from a time series perspective. We need to reexamine the relationship between this phenomenon and the life cycle model because Japan has recently experienced a rapid ageing of its population.

The main features of this paper are as follows. First, we analyze demographic dynamics, considering not only the proportion of the elderly but also other age groups, rather than using a single variable represented by the dependency ratio as in past studies (for example, Horioka (1997)).

Second, we overcome the lack of reliable time-series data classified by age, which would have been used to analyze heterogeneity between age groups. In our analysis, this heterogeneity is taken into consideration when analyzing the determinants of the aggregate saving rate, and we clarify that the prediction of the life cycle model can be confirmed using time-series data on the Japanese saving rate.

In this paper, we find that demographic dynamics was a major cause of the decline in Japan's saving rate, especially in the 1990s. The relationship between the saving rate,

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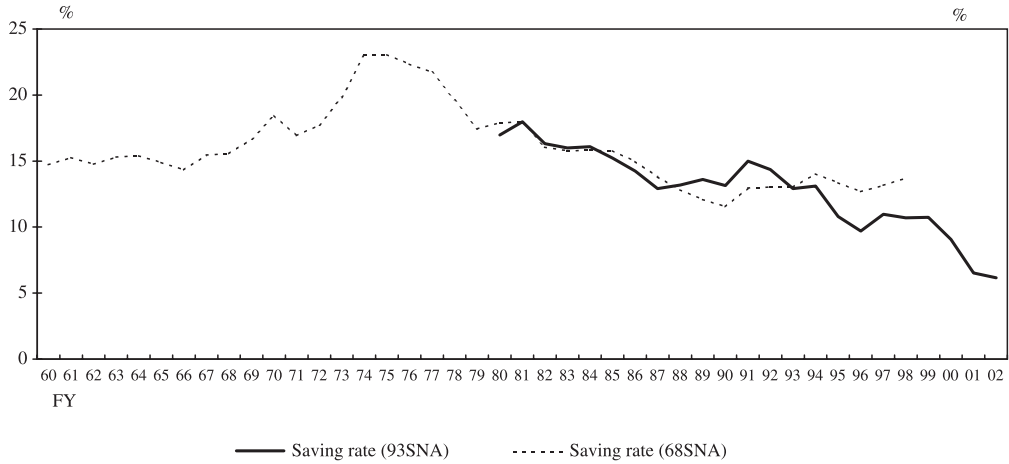


FIGURE 1. Saving rate

demographic factors, and the income factor can be described using a cointegration and error-correction representation. Our result shows that there exists a force that brings deviations back to the long-run equilibrium when these factors are cointegrated. Moreover, in equilibrium, the effect each age group has on the macroeconomy is described as a hump-shaped curve, which is consistent with what the life cycle model implies.

The paper is organized as follows. Section 2 introduces the empirical specification and Section 3 clarifies the data source and our calculations. Section 4 describes the empirical analysis. Section 5 concludes.

## 2. Empirical Specification

We describe the empirical specification where the saving rate explicitly depends on the demographic factor as well as the income factor within the usual permanent income model.

Here we assume that consumption and saving behaviour reflects the life cycle of consumers as Attanasio *et al.* (1995) among others showed, and we capture this effect at the household-level by dividing all households into  $K$  age groups based on the age of the household head. When we define  $SV_t$  as the saving rate minus one at time  $t$ , the specification we use is as follows (see Koga (2005) for more details).

$$SV_t = \lambda \frac{Y_t^p}{Y_t^d} + \sum_{k=1}^K \psi_k p_{k,t} \omega_{k,t}. \quad (1)$$

The first term in equation (1) is the income factor and  $Y_t^p = \sum_{k=1}^K p_{k,t} y_{k,t}^p$  denotes aggregate permanent income, while  $Y_t^d = \sum_{k=1}^K p_{k,t} y_{k,t}^d$  denotes aggregate disposable income, where  $y_{k,t}^p$ ,  $y_{k,t}^d$  and  $p_{k,t}$  are permanent income, disposable income, and the population of group  $k$ , respectively.  $\lambda$  is a parameter to be estimated.

The second term is the demographic factor at time  $t$ . It is represented as the sum of the product of the age-specific factor  $\psi_k$ , which can be regarded as the life cycle effect, population  $p_{k,t}$ , and income share  $\omega_{k,t}$  for each age group  $k$  at time  $t$ .

The life cycle effect  $\psi_k$  is assumed to be independent of time and estimated with an imposing restriction represented by a quadratic function of the index number  $k$ . This restriction captures the heterogeneity between age groups following the specification used in the work on consumption by Fair and Dominguez (1991) and Attfield and Cannon (2003).

$$\psi_k = \rho_0 + \rho_1 k + \rho_2 k^2. \quad (2)$$

When we estimate equation (1) with the above restriction (2), we also impose the restriction that the  $\psi_k$ 's among all  $k$ 's sum to zero.

In this specification, when the parameters  $\rho_1$  and  $\rho_2$  are positive and negative, respectively, the life cycle effect on the saving rate appears as hump shaped. We can confirm in the empirical analysis below whether the curve is hump shaped or not—that is, whether the prediction of the life cycle model can be confirmed by Japanese time-series data.

### 3. Data

#### 3.1 Saving rate

We define  $SV$ , the left-hand side variable in equation (1), as the saving rate  $SR$  minus one. The saving rate  $SR$  is the ratio of household saving to household disposable income. We also use an alternative variable and denote it as  $SVJ$ . It is based on the adjusted saving rate which is calculated with adjusted disposable income including net social transfers in kind (for example, benefits for medical care and education). When we refer to the relationship between the saving rate and its determinants, for ease of exposition, we refer to  $SV$  and  $SVJ$  as saving rate hereafter.

Both  $SV$  and  $SVJ$  are based on data from the National Accounts of Japan (SNA, Cabinet Office). The other commonly used time-series data for the saving rate are those from the Family Income and Expenditure Survey (FIES, Ministry of Internal Affairs and Communications), but they are known to have smaller coverage both for population and composition of consumption and income. For example, the FIES does not include the self-employed or imputed rent on owner-occupied housing.<sup>1</sup>

#### 3.2 Income factor

Income factor is defined as the difference between disposable income and permanent income and is denoted by  $DR$ . For data for this we use the same estimates as used above for calculating the saving rate or the adjusted saving rate. The name of the income factor using adjusted disposable income includes the letter  $J$ .

Past studies always faced a difficulty when permanent income is not observable and some assumptions are needed to measure it. To calculate permanent income in this paper, we define it as Flavin's (1981) permanent income, assuming each household calculates permanent income in a horizon long enough to be represented as infinity. It is the flow gained from the sum of human wealth (the discounted sum of future labour income) and non-human wealth that people have at the beginning of time  $t$ .

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<sup>1</sup> For the differences between data on the saving rate in the SNA and FIES, see Iwamoto *et al.* (1995, 1996).

Non-human wealth is calculated as the sum of tangible assets and net financial assets. The former is the sum of land, fixed assets, and inventories from SNA which is transformed to quarterly data using the technique of Lisman and Sandee (1963). The latter is obtained by subtracting liabilities from the sum of the currency, transfer deposits, time deposits and shares from Flow of Funds Accounts (Bank of Japan).

Human wealth, on the other hand, is calculated by assuming that the data generating process of future labour income is described by an ARIMA (1,1,0) model that the real rate of return  $r$ , is constant at 0.05. To capture future labour income, we use compensation of employees because other components of disposable income have a fluctuation which is too large for households to foresee. We also use total disposable income as an alternative variable. The difference ratios ( $DR$ ) calculated using each of them are named  $DR1$  and  $DR2$ , respectively.

### 3.3 Demographic factor

It is common in the earlier literature to use a single variable such as “dependency ratios,” the ratios of the population of dependent groups such as the elderly or children (aged 65 and older, or aged under 15) to the working age population (aged 15 to 64), when considering the influence of the demographic effect on the saving rate.

However, this paper is novel in that we use a measure of demographic changes that reflects both the different impact each age group has on the macroeconomy and the change in the overall age distribution. Specifically, as explained above, the demographic dynamics are expressed as the sum of the products of the life cycle effect  $\psi_k = [\psi_1, \dots, \psi_K]$ , age group distribution  $p_{k,t} = [p_{1,t}, \dots, p_{K,t}]$ , and income share  $\omega_{k,t} = [\omega_{1,t}, \dots, \omega_{K,t}]$ . We capture the effects of  $p_{k,t}$  and  $\omega_{k,t}$  with actual data and  $\psi_k$  with estimation.

As for  $k$ , we use 10 age groups, starting at age 24 and under, then categories grouped by five-year increments, from ages 25–29 up to ages 60–64, and finally age 65 and over. These age groups are numbered from 1 to 10 as index  $k$ .

The distribution of households  $p_{k,t}$  is calculated by multiplying the number of all households from Households Projections for Japan (National Institute of Population and Social Security Research) and the proportion of each age group from the FIES. The proportion in the FIES is the sample distribution adjusted to the population estimated by the Population Census (Ministry of Internal Affairs and Communications). The data are shown in Figure 2, and we can clearly observe two features. One is that baby-boomers, usually called the *dankai*-generation, has shifted to an older age group, which can be considered a transitory shock on the distribution. The other is a large increase in households aged 65 and over, which is the result of declining fertility and can be understood as a permanent shock.

The SNA-based distribution of income across age groups is calculated by Hamada (2002), and we use his results to capture the effect of income share  $\omega_{k,t}$ . Because the National Survey of Family Income and Expenditure (NSFIE) is conducted only every five years, this calculation is carried out for 1994 and 1999, both of which seem very similar. Thus, we use the latter calculation as a benchmark due to data limitations.

Regarding the life cycle effect, we estimate the parameters that indicate the shape of the curve, assuming it is described as a quadratic function of the group index  $k$ . This assumption is consistent with the evidence that the Japanese household saving rate across age groups is hump shaped, as Higo *et al.* (2001) found. Their calculation is based on the NSFIE whose coverage ratio of population is much larger than that of the FIES.

When conducting the estimation, the demographic factor, the product of three effects, is transformed to two variables  $Z_{1,t}$  and  $Z_{2,t}$  based on the restrictions on the coefficients

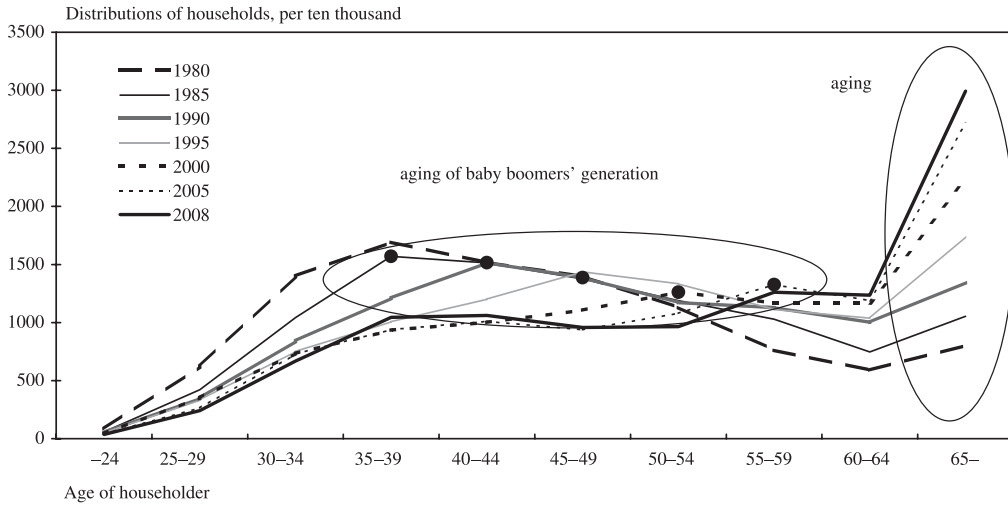


FIGURE 2. Distributions of households

Sources: Ministry of Internal Affairs and Communications, “Family Income and Expenditure Survey” National Institute of Population and Social Security Research, “Overview of Households Projections for Japan.”

discussed in the previous section. The derivations of these variables are described in the appendix in Koga (2005).  $Z_{1,t}$  and  $Z_{2,t}$  are first calculated on a yearly basis, then converted to a quarterly series using the Lisman and Sandee (1963) technique and finally multiplied by  $10^{-5}$  to adjust for scale.

## 4. Empirical analysis

### 4.1 Unit root properties of the data

We test the unit root property of the variables by employing Augmented Dickey-Fuller (ADF) statistics to test the null of a unit root and KPSS statistics to test the null of no unit roots (Kwiatkowski *et al.*, 1992). The results of the tests are presented in Table 1. The test statistics indicate that they have unit roots in their levels and are stationary in their first differences except for the case in which the ADF test is applied to the first difference of  $Z_1$  and  $Z_2$ , where the null of nonstationarity fails to be rejected by a slight margin. Therefore, we assume all variables are  $I(1)$ .

### 4.2 Tests of cointegration and estimates of the cointegrating vector

Given the time-series properties of the data, the empirical relationship between the variables is subject to cointegration analysis. We suppose that the dependent variable is  $SV$  and test for a cointegrating relationship using OLS-residual-based tests.

We first estimate the potential relationships between the saving rate and its determinants—the income factor  $DR_t$  and the demographic factor—in reduced form after relaxing the structural constraints described in the model. The demographic factor is reduced to two variables  $Z_{1,t}$  and  $Z_{2,t}$  by imposing the restrictions on the coefficients explained above. We then estimate the equation given below by static ordinary least squares during the period from 1981(I) to 2003(I), during which data for all variables are available.

TABLE 1  
Results of Unit Root Tests

Test			<i>SV</i>	<i>SVJ</i>	<i>DR1</i>	<i>DR1J</i>
ADF	Level	None	-1.90	-2.39†	0.32	0.17
		Constant	0.03	0.25	-2.10	-2.04
	Difference	None	-10.23††	-5.66††	-3.03††	-2.95††
		Constant	-10.58††	-6.32††	-3.07†	-2.96†
KPSS	Level	Constant	1.14††	1.16††	0.59†	0.50†
	Difference	Constant	0.05	0.07	0.44	0.45
Test			<i>DR2</i>	<i>DR2J</i>	$Z_1$	$Z_2$
ADF	Level	None	0.25	0.14	1.98	1.80
		Constant	-2.09	-2.02	1.63	1.80
	Difference	None	-2.96††	-2.91††	-0.38	-0.39
		Constant	-2.98†	-3.74††	-2.30	-2.14
KPSS	Level	Constant	0.54†	0.47†	1.21††	1.20
	Difference	Constant	0.42	0.45	0.11	0.17

Notes: *SV*: saving rate minus one. *DR1*: income factor using compensation for employees to calculate human wealth.

*DR2*: income factor using disposable income to calculate human wealth.  $Z_1$  and  $Z_2$ : demographic factor. The letter *J* denotes the variables derived with adjusted disposable income.

†† (†) denotes the rejection of the hypothesis at the 1% (5%) level.

Length of lags of ADF test is selected based on AIC.

For KPSS test, the method of estimating the frequency zero spectrum is Bertlet kernel.

$$SV_t = \gamma_1 DR_t + \gamma_2 Z_{1,t} + \gamma_3 Z_{2,t}$$

where  $\gamma_1$ ,  $\gamma_2$ , and  $\gamma_3$  are coefficients of the equation. We next use the common and straightforward OLS-residual-based tests of Phillips and Ouliaris (1990) for our cointegration test. Table 2 shows that the stationary property of the residuals is confirmed and that the equation can be regarded as a cointegrating relationship.<sup>2</sup>

Thus, we estimate the cointegrating vector by dynamic ordinary least squares (DOLS) following Stock and Watson (1993). The results are displayed in Table 3, which shows that the demographic and income factors are statistically significant.

The signs of the coefficients are as theoretically expected and are statistically significant. The coefficient of the income factor is negative ( $\gamma_1 < 0$ ), and the two coefficients of the demographic factor are positive ( $\gamma_2 > 0$ ) and negative ( $\gamma_3 < 0$ ), respectively.<sup>3</sup> Thus, we confirm that the effect each age group of households has on the aggregate saving rate is hump shaped as described in Figure 3 and this verifies that the prediction of the life cycle model can be confirmed with time-series data on the Japanese saving rate.

How much the demographic factor contributed to the saving rate during the estimation period is shown in Figure 4, which is calculated as the sum of the parameter  $\gamma_2$  times  $Z_2$  and  $\gamma_3$  times  $Z_3$ . Our results show that the demographic factor follows the declining trend of actual values in the cointegrating relationship.

<sup>2</sup> The significance of the  $Z_\alpha$  and  $Z_t$  statistics of Phillips and Ouliaris (1990) is evaluated based on the critical values (-34.0, -26.1, -22.7) and (-4.51, -3.85, -3.54) for significance at the (1%, 5%, 10%) levels, where the test is applied to the residuals of a cointegrating regression with 200 observations and without deterministic terms.

<sup>3</sup> The values of the parameters are not necessarily consistent with theoretical expectation. Misspecification of the equation and mismeasurement of the data can possibly affect these parameter estimates.

TABLE 2  
Results of the Residual-Based Tests for Cointegration

	$Z_\alpha$	$Z_t$	Variable Sets	
			SR	DR
Case 1	-34.62††	-4.65††	SR	DR1
Case 2	-33.92†	-4.61††	SR	DR2
Case 3	-34.59††	-4.63††	SRJ	DR1J
Case 4	-33.33†	-4.55††	SRJ	DR2J

Notes:  $Z_\alpha$  and  $Z_t$  are defined in Phillips and Ouliaris (1990).  
†† (†) denotes the significance at the 1% (5%) level.

TABLE 3  
Estimates of the Cointegrating Vectors by Dynamic OLS

	Variables			Adj-R2	S.E.
	DR	$Z_1$	$Z_2$		
Case 1	-1.986†† (0.80)	1.204†† (0.18)	-0.095†† (0.01)	0.841	1.213
Case 2	-1.908†† (0.83)	1.203†† (0.19)	-0.095†† (0.01)	0.835	1.234
Case 3	-1.603†† (0.81)	0.929†† (0.16)	-0.075†† (0.01)	0.859	1.051
Case 4	-1.505† (0.86)	0.930†† (0.18)	-0.075†† (0.01)	0.853	1.073

Notes: Regressions are run with the number of leads and lags of 1.

The error process is assumed to be AR(1).

The upper and lower figures indicate estimated coefficient and adjusted standard error, respectively.

†† (†) denotes the significance at the 1% (5%) level.

### 4.3 Estimates of the error-correction model

Given the result that the saving rate, the income factor, and the demographic factor are cointegrated, we estimate an error-correction model (ECM) to determine the short-run dynamics.

First, the long-run equilibrium model is rewritten as an error-correction model. Here, the demographic dynamics are assumed to satisfy its exogeneity in the short-term adjustment mechanism.<sup>4</sup>

We adopt the common method of Engle and Granger (1987) to estimate the following equation. We use the residuals calculated from the estimated value  $\widehat{SV}$  of static ordinary squares in the previous subsection.<sup>5</sup>

<sup>4</sup> Regarding the restrictions imposed on the four variables, we assume that the cointegrating rank is one and that the linear combination of the four variables shown above is the only stationary cointegrating relationship. We also suppose that the matrix of vector autoregressive parameters in the vector error correction model (VECM) representation is filled with zeros except for the parameters of the saving rate and income factor in the saving rate equation that are estimated in the ECM used here.

<sup>5</sup> While the generated least squares problem arises in usual two stage least squares, the standard error of the error correction term obtained from prior estimation is not biased when the variables are non-stationary and cointegrated, as McAleer *et al.* (1994) and McKenzie and McAleer (1997) showed in their studies.

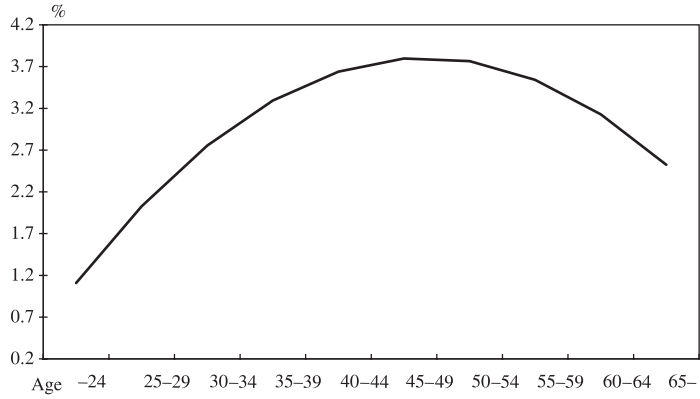


FIGURE 3. Estimated curve of age group effects on aggregate saving rate

Note: The calculation is based on the parameters estimated in case 1.

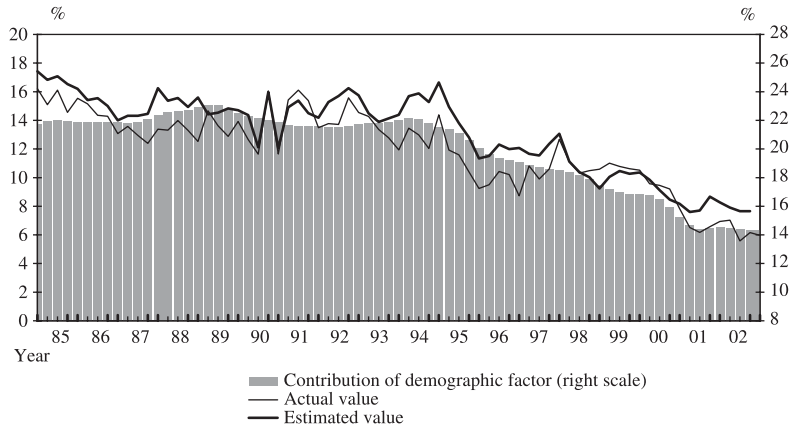


FIGURE 4. Cointegrating relationship of saving rate and demographic factor

Notes: The calculation is based on the parameters estimated in case 1. Estimated value depicts the value gained from the estimation plus one to describe the series comparable with actual saving rate.

$$\Delta SV_t = \sum_{n=1}^N \delta_{1,n} \Delta SV_{t-n} + \sum_{n=1}^N \delta_{2,n} \Delta DR_{t-n} + \delta_3 (SV_{t-1} - \widehat{SV}_{t-1}),$$

where  $\Delta$  indicates a difference operator and  $\delta_1$ ,  $\delta_2$ , and  $\delta_3$  are coefficients of each term. The number of lags in the ECM is set at no more than eight so that we accept the null of no serial correlation in the LM tests. The error-correction mechanism is found to exist when  $\delta_3 < 0$  is satisfied in the estimation results.

The estimation results and diagnostic tests for residuals are displayed in Table 4. The table shows that the coefficient of the error-correction term is negative and statistically significant in all cases, and this clarifies the mechanism moving the model back to equilibrium whenever any deviations from equilibrium occur.  $\delta_3$ , the adjustment speed parameter, ranges from  $-0.18$  to  $-0.21$ . This implies that a 1% deviation from the equilibrium can be corrected within no more than six quarters, whichever variable set is chosen.



TABLE 4  
 Estimation Results of the Error-Correction Model

	ECT	Length of Lags (N)	S.E.	Adj-R2	Diagnostic Checking			
					Breusch-Godfrey LM test	White test	Ramsey RESET	Jarque-Bera
Case 1	-0.180† (0.09)	1	1.148	0.221	1.724 (0.189)	15.250 (0.018)	0.000 (0.992)	13.114 (0.001)
Case 2	-0.180† (0.09)	1	1.147	0.223	1.794 (0.180)	15.392 (0.017)	0.000 (0.993)	12.550 (0.002)
Case 3	-0.207†† (0.09)	3	0.912	0.341	0.969 (0.325)	11.732 (0.628)	0.120 (0.730)	9.588 (0.008)
Case 4	-0.201†† (0.09)	3	0.911	0.342	1.015 (0.314)	11.752 (0.626)	0.092 (0.762)	9.117 (0.010)

Notes: ECM denotes the error-correction term, and the upper and lower figures indicate estimated coefficient and standard error, respectively.

For the diagnostic checking, the upper and lower figures indicate estimated statistics and p-value, respectively.

†† (†) denotes the significance at the 5% (10%) level.

## 5. Conclusion

The Japanese economy experienced a long stagnation called “the lost decade,” but the decline in the household saving rate also continued during this period. Our investigation provides an empirical analysis to explain this phenomenon.

In our study, the relationship among the saving rate, demographic factors, and the income factor can be described as a cointegration and error-correction mechanism. Our results show that there exists a force that brings deviations back to the long-run equilibrium where the above mentioned factors are cointegrated. Therefore, the demographic factor was a major cause of the sharp decline in the Japanese saving rate in the 1990s. Furthermore, in this equilibrium we estimate that the impact each age group has on the macroeconomy is described as a hump-shaped curve, which is consistent with what the life cycle model implies.

Further examinations are left for future study. Though our framework has assumed that the effect of the life cycle curve is constant, the shape might be determined simultaneously with consumers’ labour supply decisions. Due to the recent increase in the number of elderly, giving consideration to their labour supply decision is of growing importance in analyses of consumption and saving behaviour.

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