Welfare Cost of Inflation in an Incomplete Market Model with Idiosyncratic and Aggregate Risks: Application to the Japanese Economy *

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Abstract

We consider the sluggish Japanese economy in the 1990s as facing an idiosyncratic income risk that motivates precautionary saving, and investigate the welfare cost of inflation in an economy with such risk and aggregate income or unemployment rate fluctuation. Money holding in our model is motivated by self-insurance, different from the transaction motives as in cash-in-advance constraint model.

Our simulation result indicates that the Japanese monetary policy in the 1990s generated the welfare cost that is equivalent to changing the real GDP by 0.334%, which is a little smaller than the calculated "shoe-leather cost" (the area of a triangle under the money demand function) equivalent to 0.41% of GDP. The presence of two "hand-to-mouth" agents out of three augments the welfare cost equivalent to 1.141% of GDP. Unemployment spell shortened by two months reduces the welfare cost equivalent to 0.486% of GDP, even without any change in unemployment rate. Aggregate risk in social endowment with almost doubled unemployment rate and duration when recession increases the welfare cost equivalent to at most 0.522% of GDP .

Key Words: Aggregate Risk, Idiosyncratic Risk, Precautionary Saving, Self-Insurance, Welfare Cost of Inflation.

JEL Classification Codes: D31, D52, E21, E41, and E52.

1 Introduction

The Japanese economy has suffered from the chronic stagnation from the 1990s. The annual average growth rate of real GDP dropped from 1.7% in the 1980s to 0.6% in the 1990s, and the renowned low unemployment rate in Japan that had never exceeded 3% from 1953 to the early 1990, started to rise and exceeded 5% in 2001. Furthermore, deflation from the late 1990s becomes another concern, as discussed by Krugman (1999) that supports financial policies to raise inflation rate in order to avoid the "liquidity trap" in Japan. This critical slump of the Japanese economy has attracted global concerns, analyzed from various viewpoints such as lowered productivity growth (Hayashi and Prescott 2000), sources of the "lost-decade" (Bayoumi 1999; Sato 2001), macroeconomic and financial policies (Jinushi, Kuroki, and Miyao 2000; Krugman 1999; Motonishi, and Yoshikawa 1999; Posen 1998), and precautionary saving and habit formation (Carroll 2000a).

During the stagnation in Japan, the rise in the unemployment rate has been also associated with prolonged unemployment duration. This increasing insecurity of employment status leads households to be more conscious of an increasing income risk, not only by an increasing probability to lose their jobs, but also by prolonged periods to find next jobs once after dismissed. This income risk may be insurable with complete markets. However, a presence of borrowing constraints on households motivates precautionary saving (Ogawa 1991; Carroll 2000a); that is, households save when employed, and dissave when unemployed in order for consumption smoothing against the income risk. In this situation, inflation by monetary expansion possibly depreciates the purchasing power of money that is precautionary saved by households, when the means of saving for households are mostly liquid assets (especially money) as observed in Japan.

The objective of this paper is to quantitatively investigate the welfare cost of inflation and income risks that motivates precautionary saving, in the setting of the sluggish Japanese economy from the 1990s. For this purpose, we focus on the self-insurance motive for money holding, instead of the transaction motives as in cash-in-advance constraint models (for example, Cooley and Hansen 1995).

This research distinguishes two different sources of income risks. At the different point of time, households unanimously face *aggregate* income risk that fluctuates GDP due to business cycle. On the contrary, at the same point of time, some households are unemployed while others are employed; in this sense, households face *idiosyncratic* income risk. This idiosyncratic risk leads each household has own employment history, and thus hold different amount of money as precautionary saving. Therefore, the analysis assumes the presence of heterogeneous agents in an economy.

Our study is in the line of literature such as Imrohoroglu (1992) and Krusell and Smith (1998) that calibrate an aggregate economy that consists of forward-looking agents who solve an intertemporal utility-maximization problem by facing idiosyncratic unemployment risk in an incomplete market. We consider the stagnant Japanese economy, while the previous literature considers the economy of the United States. We also consider inflation as in Imrohoroglu (1992), an aggregate risk due to business cycle as in Krusell and Smith (1998), and also a presence of "hand-to-mouth" agents in addition to rational agents. In solving an individual optimization problem, this research adopt numerical methods as in the previous literature.

Our simulation result indicates that the Japanese monetary policy in the 1990s generated the welfare cost that is equivalent to changing the real GDP by 0.334%, which is a little smaller than the "shoe-leather cost" (the area of a triangle under the money demand function, Bailey 1956) calculated as 0.41% of GDP. The presence of two "hand-to-mouth" agents out of three augments the welfare cost equivalent to 1.141% of GDP. As for unemployment risk, unemployment duration shortened by two months reduces the welfare cost equivalent to 0.486% of GDP, even without any change in unemployment rate. Aggregate risk in endowment with almost doubled unemployment rate and duration when recession increases the welfare cost equivalent to at most 0.522% of GDP .

The structure of this paper is the followings. Section 2 explains noted evidences for the Japanese stagnant economy from the 1990s. Paying attention to these features, Section 3 describes an incomplete market model incorporating both idiosyncratic and aggregate risks with inflation. Section 4 presents simulation results of numerical experiments. In Section 5, our simulation results are compared with literature on micro foundations of aggregate consumption and saving. Finally Section 6 gives a conclusion.

2 The Japanese Stagnant Economy in the 1990s

We first present a sketch of the sluggish economy during the 1990s in Japan for providing some background information, because the stagnation during the decade seems to be conspicuous both in the international comparison and from historical perspective, as is suggested by many studies on the Japanese economy (Bayoumi 1999; Hayashi and Prescott 2000; Motonishi and Yoshikawa 1999; Posen 1998; Sato 2001).

2.1 Overview of Macroeconomic Performance

We first summarize recent macroeconomic performance of Japan. The annual growth rate of real GDP declined during the early 1990s, and after a temporal recovery around mid-1990s, dropped again to the lowest among G-7 countries since 1998 as shown in Figure 1-1.

A noted feature in the business cycle is found in deflation from the late 1990s. The inflation rates measured with the Consumer Price Index have been persistently the lowest among developed countries, especially assuming an aspect of deflation since 1999 as presented in Figure 1-2. The consecutive deflation in Japan has caused a controversy on the monetary policy by the Bank of Japan including the inflation targeting regime proposed by Krugman (1999).

Another feature is found in the sluggish demand of private consumption. Figure 2 compares recovery processes of private consumption after economic recession in the 1980s and 1990s. Particularly in the last recovery process from the second quarter in 1999, the private consumption could not recover from the bottom level until seven quarters passed; such slow restoration of the consumption is obviously different from other recovery processes after troughs of each business cycle.

2.2 Precautionary Saving and Unemployment

For the reason of the consumption recession, a surge of precautionary saving motive by the Japanese households [1] has been considered (Carroll 2000a;

[1] The peak of the Japanese household saving rate was in 1976. The rate was going down till 1990, as indicated by the adjusted saving rate extended till 1994 according to Hayashi (1986). The decrease in the saving rate is easily explained by the life cycle motive, where the demographically increasing aged dissaves (Horioka 1989).

In spite of the demographic aging, the decrease in the saving rate stopped at the still high rate in 1990. The steady saving rate could be explained by other hypotheses than the precautionary saving motive. One is the austerity fiscal policy for the fiscal reconstruction in 1996 and the following expansionary policy in Japan. The expansion might cause a Ricardian response of the taxpayers, who prepare at present more savings for their expected future tax burdens. However, the hypothesis is unrealistic, because the fiscal expansion has been done since 1997, while the decrease in the saving rate has suspended since 1990. Another hypothesis is the wealth effect on the private consumptions of the asset price crash, which transitory occurred from 1991 to 1992. It also contradicts with the timing between the transitory crash and the prolonged suspension. Consequently, we focus on the precautionary saving hypothesis.

Motonishi and Yoshikawa 1999; Ogawa 1991). The precautionary saving is motivated by an income risk due to an increasing insecurity of employment. In the 1990s, unemployment rates have more than doubled from 2.3% in 1990 to 4.9% in 2000 as presented by Figure 3. Among the unemployed, the long-term unemployment ratio (the ratio of workers unemployed for more than one year) has also risen from 19% to 25% [2].

During the same periods, the average duration of unemployment gradually rose regardless of gender as illustrated in Figure 4. The average durations in 1990 are 4.21 months for male, 2.28 months for female, and 3.14 months in total. The same figures in 1998 are 5.42, 3.09, and 4.20, respectively [3]. The rise in the unemployment rate leads households to become more aware of income risks due to unemployment. Measured income risks [4] sharply increase in the first half of the 1990s for the highest-income group and after 1998 for the lowest- and middle-income groups [5]. The surge in the income risk in the 1990s can explain the precautionary saving, which contribute to the Japanese high saving rate (Doi 2001).

[2] A natural question from a viewpoint of the labor economics would be, whether the Japanese "lifetime employment system" has gradually collapsed. As for the collapse of the Japanese practice, similarly to a few recent papers (Genda and Rebick 2000; Kato 2001), we only find weak evidences in the data. The job retention rate by occupation or education during 1994-1999 is higher than that during 1989-1994 for all the age profile. Similarly, the average tenure by gender or occupation is increasing year by year. However, data show a slight decrease in the average tenure by age. The average tenure of the aged 30-34 changed from 9.4 years in 1985 (the peak year) to 8.6 ones in 1999. The average tenure was also shortened from 13 years in 1987 to 12 ones in 1999 for the aged 35-39 and from 16.5 years in 1987 to 15.5 ones in 1999 for the aged 40-44, respectively. But for other age classes that include a large portion of workers, the average tenure is either unchanged or prolonged.

[3] However, the unemployment duration in Japan is never conspicuous especially in comparison with the European countries. The long-term unemployment ratios in 1998 are 21.5% in Japan, 32.7% in the United Kingdom, 52.6% in Germany, 41.6% in France, 59.6% in Italy and so forth.

[4] The income risks or employment risks can be indexed by the variance of expected growth rate of real disposal income (*the Family Income and Expenditure Survey*), estimated with the Carlson=Parkin method.

[5] The former increase was probably triggered by the collapse of land and equity prices in Japan beginning in 1991, while the latter may be due to an increase in the perceived employment risks (Nakagawa 1999).

Therefore, it is well grounded to consider that there was a surge in the precautionary saving, motivated by an increase in income risks due to the insecurity of employment during the 1990s in Japan with the prolonged slump in consumption.

2.3 Money Demand and Supply

Among the savings held by the Japanese households in 1999, bank deposits and postal savings accounted for 56.9% and insurance equities accounted for 28.9%, while securities such as stocks and bonds accounted only for 11.7% [6]. The security motive for saving prevailed in the "liquidity trap" situation, where the call loan rate in Japan since the second half of 1995 has been under 1% and the zero bound of nominal interest rate is binding on the central bank (Figure 5).

During the 1990s, the savings by the Japanese households came to more money [7]. The estimates of the interest rate elasticity of money demand are nearly 0.10 in Japan for the whole post-war period (Shiratsuka 2000). The figure is much lower than 0.5, the interest rate elasticity in the United States (Lucas 1994). However, the estimates during the 1990s in Japan jump up to 0.41 for M1, 0.16 for M2+CD and 0.35 for currency (Nakajima and Saito 2000).

The money supply in the Japanese 1980s and 1990s strikingly contrasts with each other (Figure 6). Since 1991, the money supply growth has been persistently even lower than before [8]. In the 1980s, the annual growth rate

[6] *The Family Saving Survey* (Statistics Bureau, Government of Japan)

[7] During the asset bubble era in the late 1980s, households seem to have diversified the financial portfolio from money to more profitable assets (Sato 2001); securities such as stocks and bonds shared 28.6% in 1989. After the collapse of the bubble, shares of money and insurance equities have increased, while share of stocks and bonds has decreased.

[8] The Bank of Japan publicly reconsiders the monetary policy during the asset bubble in the late 1980s (Okina, Shirakawa, and Shiratsuka 2001). The Bank of Japan's excessive reflection has been often criticized for the actual deflationary monetary policy in the 1990s.

of nominal M2+CD is on average 10.9% during a period of contraction, and 9.0% during expansion. In the 1990s, the average money growth rate is 9.5% during contraction while 2.6% during expansion [9].

3 An Incomplete Market Model with Idiosyncratic Risk

3.1 Environment and Equilibrium

We consider an economy that consists of many infinitely-lived agents who are different at a point in time in their real cash balances and employment opportunities. An agent maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{1}$$

where E_0 denotes an operator of expectation at the initial period, β is the discount rate ($0 < \beta < 1$), c_t is consumption in period t, and the utility function $u(.)$ has the following CRRA (constant relative risk aversion) form:

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1 - \sigma}$$

with $\sigma > 0$. An agent is endowed with one indivisible unit of time in each period and faces an employment opportunity which is independent across agents. The employment state, w_t, is assumed to follow a first-order Markov process with two possible states, $w = e$ for employed, and $w = u$ for unemployed, respectively. If employed, an agent receives y units of the consumption goods ($y_t = y$) using the time allocation. If unemployed, an agent

[9] The deflationary monetary policy in the 1990s can be also found in the call loan interest rate. In comparison with the benchmark rate following the Taylor rule, the actual call rate turns out to be consistently higher in the 1990s except the temporary boom in 1996 (Jinushi, Kuroki and Miyao 2000; Okina and Shiratsuka 2001). Moreover according to Jinushi, Kuroki, and Miyao (2000), the coefficient on inflation in the Taylor rule is significantly larger when the post-bubble period is included than otherwise. The empirical results suggest that the Bank of Japan became more active in a reaction to inflation.

receives θy $(0 < \theta < 1)$ units of consumption goods $(y_t = \theta y)$ through unemployment insurance.

Agents enter into each period with individual nominal money balances m_t and a lump-sum transfer from the government equal to $g_t M_t$ where M_t is an average nominal money from time t-1 to t, and g_t is a stochastic growth rate of money supply. The money supply follows the law of motion

$$M_{t+1} = (1 + g_t)M_t$$

Thus, the budget constraint of an agent becomes, in a nominal term,

$$p_t c_t + m_{t+1} \leq p_t y_t + m_t + g_t M_t \tag{2}$$

where p_t is the price of the consumption goods at time t. Here, borrowing is not allowed; m_t is required to be nonnegative. Since state-contingent insurance is not permitted, an agent has to insure only through holdings of money. An agent accumulates cash balances in order for unemployment risk during employed periods, and dissaves during unemployed periods in order for consumption smoothing.

An inflation rate π_t from time $t-1$ to t equals $\frac{p_t}{p_{t-1}} - 1$. An individual real asset saved at time t for the next period is defined by

$$a_{t+1} \equiv \frac{m_{t+1}}{p_t}$$

and an average real asset is

$$A_{t+1} \equiv \frac{M_{t+1}}{p_t}$$

Therefore, the budget constraint of an agent is, in the real term,

$$c_t + a_{t+1} \leq y_t + \frac{1}{1+\pi_t} a_t + \frac{g_t}{1+\pi_t} A_t \tag{3}$$

We introduce probabilistic processes both for an individual employment state and an aggregate state. First, transitional probabilities for the employment process are given by

$$\chi_w = \Pr(w_{t+1} = w' | w_t = w)$$

for $w, w' \in W = \{e, u\}$. That is, the transitional probability matrix is denoted by

$$\chi_w = \begin{bmatrix} \Pr(w' = e | w = e) & \Pr(w' = u | w = e) \\ \Pr(w' = e | w = u) & \Pr(w' = u | w = u) \end{bmatrix}$$

In this process, unemployment state is rather persistent rather than independent at each period. We follow Imrohoroglu (1992) in the calculation of this probability matrix. That is, $\chi_w(e, e)$ can be calculated from a constant unemployment rate of the economy using $\chi_w(u, u) = 1 - \frac{1}{D_u}$ where an average duration of unemployment D_u.

Second, we also assume a first-order Markov process with two possible aggregate states, $z = h$ for a good time, and $z = l$ for a bad time. Transitional probabilities are given by

$$\chi_z = \Pr(z_{t+1} = z' | z_t = z)$$

In the matrix form,

$$\chi_z = \begin{bmatrix} \Pr(z' = h | z = h) & \Pr(z' = l | z = h) \\ \Pr(z' = h | z = l) & \Pr(z' = l | z = l) \end{bmatrix} = \begin{bmatrix} \rho_1 & 1 - \rho_1 \\ 1 - \rho_2 & \rho_2 \end{bmatrix}$$

In this paper, we consider a symmetric process, i.e., $\rho_1 = \rho_2 = \rho$ for simplicity. The parameter ρ can be interpreted as a measure of persistence of business cycle or monetary policy.

In the equilibrium, the goods market clears such that

$$\sum_{i=1}^{N} c_t(i) = \sum_{i=1}^{N} y_t(i)$$

and also the money market clears such that

$$\frac{1}{N}\sum_{i=1}^{N} a_{t+1}(i) = A_{t+1}$$

where N denotes the number of agent in the economy. Therefore, the inflation rate: $\pi_t = (1+g_t)A_t/A_{t+1} - 1$ from $A_{t+1} = A_t(1+g_t)/(1+\pi_t)$ by aggregating the individual budget constraint (3) over N agents. Thus, the inflation rate depends on the current and previous aggregate states: z_t and z_{t-1}. Without the change of z_t, the inflation rate equals the growth rate of money, i.e., $g_t = \pi_t$.

Now, the optimality equation for this dynamic programming problem is expressed as the Bellman's equation:

$$V(a, w, z, z_{-1}) = \max\{u(c) + \beta \cdot E[V(a', w', z', z)|(a, w, z)]\}$$

with the budget constraint of (3), where z_{-1} indicates z of one period before, maximization is over a', and $a' \geq 0$.

3.2 Computational Strategy

Given a set of parameters that characterizes the economy, individual policy a' to solve the problem (1) subject to (3) is obtained by using numerical methods. However, the average asset of A' determined by aggregating individual behavior, also affects individual strategy through the inflation rate. Therefore, the algorithm must solve the individual policy and the average assets at once. Here, we apply the computational steps as follows:

(Step 1) Pick up an initial guess of A_h and A_l. Obtain the value function numerically, as described later.

(Step 2) Using the value function obtained in Step 1, calculate average assets of N agents with an initial distribution of endowments, after continuing the same money growth rate at sufficiently long periods. Then, obtain new A_h and A_l.

(Step 3) Repeat Step 1 and Step 2 until a convergence with sufficiently small computational errors. Or, in practice, obtain optimal A_h and A_l that satisfies Step 2 using any methods to solve a set of nonlinear equations.

(Step 4) Using an obtained numerical solution of the value function and average assets, calculate the averages and standard deviations of asset, consumption and utility from the simulated time series of T for N agents.

In Step 1 in obtaining the value function numerically, we discretize states: $s = \{w, z, z_{-1}\}$ into 8 categories: (e,h,h), (e,h,l), (e,l,h), (e,l,l), (u,h,h), (u,h,l), (u,l,h), and (u,l,l). Then, we treat real asset (a) of a state variable, and also real asset for the next period ($a\prime$) of the choice variable as a continuous state, while Imrohoroglu (1992) discretize this state. Rewrite the value function as

$$V(a,s) \;=\; \max_{a'}\{u(a,s,a') + \beta \cdot E[V(a',s')|(a,s)]\}$$

The policy function:

$$a'(a,s) = \arg\max_{a'}\{u(a,s,a') + \beta \cdot E[V(a',s')|(a,s)]\}$$

may be calculated by any constrained optimization methods. The optimal value function is approximated as a smoothed function

$$V_\alpha(a,s) = \sum_{k=1}^{K} \alpha(s)_k \cdot \phi_k(a)$$

where $\{\phi_1(a), \phi_2(a), ..., \phi_K(a)\}$ denotes a vector of the Chebyshev polynomials, and $\{\alpha(s)_1, \alpha(s)_2, ..., \alpha(s)_K\}$ denotes a vector of coefficient specific to each discretized states. The coefficient vectors are sought by projection methods following the algorithm developed by Judd (1993)[10] that makes projected

[10]Detail algorithm and its explanations are also found in Judd (1998) and Rust (1996).

residual functions

$$\sum_{j=1}^{J}[V(a_j,s)-\Gamma(V(a_j,s))]\cdot\phi_k(a_j)$$

to be zero for $k = 1, ..., K$, where the Bellman operator Γ is defined by

$$\Gamma(V)(a,s)=\max_{a'}\{u(a,s,a')+\beta\cdot E[V(a',s')|(a,s)]\}$$

and $\{a_1, a_2, ..., a_J\}$ are collocation grids. In our simulation, the number of collocation grid J equals 20 and the degree of polynomial K equals 10. For 8 discrete states, 80 coefficients are calculated in total.

In Step 2, we use N equals 1,000 and T equals 100 considering improvements of accuracy and computational costs. In Step 4, the simulated length of time series is 1000 for fixed money growth rates; thus, the number of sample is one million [11].

4 Simulation Results

4.1 Parameters of Simulations

First of all, we describe parameters applied. These parameters are effective throughout the simulation otherwise notified. The selected time period is 1 month. The unemployment rate equals 4.9% in 2000, and the average duration of unemployment equals 5 months [12]. Then, the transitional probability matrix of employment becomes

$$\chi_w=\begin{bmatrix}0.989 & 0.011\\ 0.204 & 0.796\end{bmatrix}$$

The ratio of income when unemployed compared with employed income (θ) is assumed to be 0.36 . This ratio is calculated based on three months

[11] We try more number for these variables, although accuracy was not improved much.

[12] We use data from the *Wage Census* (Ministry of Labour, Government of Japan).

Table 1: The Benchmark Case of Japan

	Money Growth	Asset		Consumption		Utility*100	GDP%
(A)	0.0%	1.814	(0.497)	1.0	(0.095)	-1.184	(Base)
(B)	0.223%	1.228	(0.333)	1.0	(0.106)	-1.521	-0.334%

Standard deviations are in parentheses.

unemployment insurance of 60% of monthly employed income during five months [13].

As for money growth rate g_t, we adopt an average rate of 0.223% between 0.331% during a recession from 1997: 2Q to 1999: 1Q, and 0.114% a recovery from 1999: 2Q to 2000: 3Q. The discount factor β equals 0.995, and σ in the utility function equals 1.5 as in Imrohoroglu (1992). Aggregate risk is considered in the Section 4.5 and 4.6.

4.2 The Benchmark Case of Japan

Table 1 presents averages and standard deviations of asset and consumption. The employed income y is given so that an average GDP (social endowment including unemployed), or consumption becomes unity. The welfare costs is expressed as the average utility and also a transformed to a percentage of GDP calculated as $(x - x_B)/x_B$ where $\overline{u} = u(x)$, $\overline{u}$ implies the average utility, and subscript B indicates a benchmark case to be compared with. That is, the same gain and loss of the average utility is attained, if GDP in the benchmark case is changed with this percentage.

In Table 1, case (A) indicates the case without money growth, and case (B) applies the average rate of money growth. The measured welfare cost of

[13] As of 2001, the unemployment insurance system in Japan prescribes that the benefit paid for an unemployed person is equal to 60-80% of wages earned before his or her quitting, depending on the wage level. The duration is also 90-330 days depending on age, insurance period, reason for leaving jobs and so forth.

Table 2: Shorter Unemployment Duration

Money Growth	Asset		Consumption		Utility*100	GDP%	(ΔGDP%)
0%	1.652	(0.459)	1.0	(0.080)	-0.791	0.392%	
0.223%	1.233	(0.342)	1.0	(0.090)	-1.031	0.152%	(+0.486%)

GDP% is compared with Case (A) in Table 1.
Standard deviations are in parentheses.

inflation is equivalent to 0.334% of real GDP.

4.3 Duration of Unemployment

Associated with a fact that the unemployment rate rose from 2.3% in 1990 to 4.9% in 2000, the average duration of unemployment rose from three months to five months during the same period. It is trivial that a decrease in unemployment rate improves welfare even when total GDP remains the same; without unemployment risk, average utility level of -0.0321 can be calculated without numerical approximation, and the welfare gain is equivalent to 1.24% of GDP comparing to Case (A) in Table 1. However, it is not necessarily trivial to what extent a curtailment of unemployment duration affects welfare. Therefore, we repeat the same simulation but reducing the duration period to be three months which is equivalent to the duration of Japan in 1990 or in the United States as in Imrohoroglu (1992). In this case, the transitional probability matrix becomes

$$\chi_w = \begin{bmatrix} 0.983 & 0.017 \\ 0.327 & 0.673 \end{bmatrix}$$

Compared to the matrix with five months duration, the probability to stay unemployment state declines more than 10%, while the probability from employed to unemployed increases from 1.1% to 1.7%.

Table 2 presents the simulation results with and without money growth. ΔGDP% indicates a change from Table 1 with the money growth rate of

0.223%. In both cases, two months curtailment of unemployment duration reduces welfare cost equivalent to 0.486% (0.392%) with (without) the money growth, even leaving the unemployment rate unchanged.

4.4 Presence of "Hand-to-Mouth" Agents

Next, we consider the presence of heterogenous agents; one type is "rational" agents who prepare precautionary saving for income risk, and another type is called "hand-to-mouth" agents who do not save for the risk of unemployment. The population estimates of such agents range from 0.30 to 0.66 (Table 5, Campbell and Mankiw 1989).

In the settings of "bubble" periods in Japan with 2.3% of the unemployment rate, three months of unemployment duration with hypothetically 60% of unemployed income and 5% of annual money growth rates adjusted by GDP growth, rational agents have motivation to save only a small amounts of money for income risk. We assume that some ratio of agents do not save for the risk of unemployment with given rates of money growth even after the collapse of the bubble. Thus, the budget constraint for agents without precautionary savings is, instead of the constraint (3),

$$c_t \leq y_t + \frac{g_t}{1+\pi_t} A_t$$

With a positive money growth rate ($g_t > 0$), on average, hand-to-mouth agents receive more than per capita GDP of this economy thanks to the governmental allocation from money growth, while rational agents receive less. In other words, there is a negative externality in the presence of hand-to-mouth agents.

Table 3 presents the simulation result of heterogeneous agents with hand-to-mouth agents, comparable to Cases (A) in Table 1. The selected ratio of agents without precautionary savings ("hand-to-mouth" ratio) are one third

Table 3: Hand-to-Mouth Consumers

H-to-M Ratio	Money Growth	Rational asset (s.d.)	Rational cons. (s.d.)	Rational util. *100	H-to-M cons. (s.d.)	H-to-M util. *100	All cons. (s.d.)	All util. *100	GDP% (ΔGDP%)
33.3%	0%	1.21	1.0	-1.184	1.0	-3.269	1.0	-1.878	-0.687%
		(0.3318)	(0.0954)		(-)		(0.0636)		
	0.223%	0.8225	0.9991	-1.620	1.0018	-3.064	1.0	-2.101	-0.905%
		(0.5313)	(0.1061)		(0.1426)		(0.1195)		(-0.571%)
66.7%	0%	0.6041	1.0	-1.184	1.0	-3.269	1.0	-2.574	-1.368%
		(0.1656)	(0.0954)		(-)		(0.0318)		
	0.223%	0.4101	0.9982	-1.717	1.0009	-3.167	1.0	-2.684	-1.475%
		(0.8887)	(0.1060)		(0.1426)		(0.1316)		(-1.141%)

"H-to-M" implies "Hand-to-Mouth"
GDP% is compared with Case (A) in Table 1.
Standard deviations are in parentheses.

and two third, and welfare costs as GDP percentages are a comparison with cases without money growth given hand-to-mouth ratio.

In a comparison between rational agents and hand-to-mouth agents, rational agents consume less but enjoy higher welfare than hand-to-mouth agents on average; with a positive money growth rate, rational agents lose welfare but hand-to-mouth agents gain, although money growth reduces welfare in total. With a two thirds hand-to-mouth ratio, the average welfare falls because of a lack of consumption smoothing for hand-to-mouth-agents, and a reduction of average consumption for rational agents. The welfare cost of the positive money growth for total economy equivalent to 1.475% of GDP.

4.5 Aggregate Risk (1): Income Fluctuation

It is assumed that the aggregate states in our model are twofold, either in a good state ($z = h$) or a bad state ($z = l$). We introduce two types of aggregate risk in our model that real GDP fluctuates[14]. One type is

[14] We also considered the money growth rate fluctuation according to business cycle, but this effect was negligible. Therefore, we present the result using average money growth rate throughout the paper.

characterized that the income level proportionally fluctuates across agents depending on aggregate endowment. The other type of risk is characterized that the unemployment rate is lower and the average unemployment duration is shorter in good periods than in bad periods, but that income for employed and unemployed are fixed across periods. For the purpose of comparison, the average endowment is normalized to unity. The transitional probability ρ from one aggregate state to another is assumed to be 10%. Thus,

$$\chi_z = \begin{bmatrix} 0.9 & 0.1 \\ 0.1 & 0.9 \end{bmatrix}$$

Selection of this probability ρ (such as 50%, 5%, or 1%) affects little to average utility. We measure effects of the income fluctuation on the welfare cost. Our motivation in this type of aggregate risk is the so-called "work-sharing system", originally advocated by Weitzman (1984) and recently reevaluated as a policy choice against the increasing unemployment risk in Japan (Abe, Higuchi, Kuhn, Nakamura, and Sweetman 1999; Fujiki, Nakada, and Tachibanaki 2001). We consider an extreme case of the work-sharing system in which unemployment rate would be intact, while individual income level proportionally fluctuates as the aggregate endowment does. We assume that the aggregate endowment becomes 1.02 in a good state, and 0.98 in a bad state[15], and the individual income level for employed (unemployed) becomes $1.02y$ ($1.02\theta y$) in a good state and $0.98y$ ($0.98\theta y$) in a bad state. Table 4 shows how income risk affects the welfare cost. The effects are trivial, so that the work-sharing system may be an effective mean of reducing the welfare cost of aggregate risk.

[15]The 4% difference is based on the recent drop of income level from *the Family Income and Expenditure Surveys* (Statistics Bureau, Government of Japan).

Table 4: Aggregate Risk(1): Income Fluctuation

Money Growth	Asset		Consumption		Utility	GDP%	(ΔGDP%)
0.0%	1.816	(0.500)	1.0	(0.097)	-1.213	-0.029%	
0.223%	1.218	(0.331)	1.0	(0.108)	-1.560	-0.373%	(-0.039%)

GDP% is compared with Case (A) in Table 1.
Standard deviations are in parentheses.

4.6 Aggregate Risk (2): Unemployment-Rate Fluctuation

The other type of aggregate risk affects unemployment risk rather than income level. Two scenarios are considered; one is rather an optimistic case based on the current recession and the bubble era in Japan as a boom period; another is rather a pessimistic case that the unemployment risk becomes as high as European countries (for example, Blanchard and Summers 1987).

The first scenario assumes that the average unemployment rate is 2.3% with 3 months duration in the good state as in 1990, while the unemployment rate is 4.9% with 5 months duration in the bad state like in 2000. Since the average unemployment rate fluctuates across aggregate states in the model, we follow the transitional probability matrices of employment status χ_w^{ij} depending on transition of aggregate state from i to j one-period ahead, where i or j means a good state (h) or a bad state (l).

$$\chi_w \equiv \begin{pmatrix} \chi_w^{hh} & \chi_w^{hl} \\ \chi_w^{lh} & \chi_w^{ll} \end{pmatrix} = \begin{pmatrix} \begin{pmatrix} 0.989 & 0.011 \\ 0.204 & 0.796 \end{pmatrix} & \begin{pmatrix} 0.992 & 0.008 \\ 0.694 & 0.306 \end{pmatrix} \\ \begin{pmatrix} 0.968 & 0.032 \\ 0.217 & 0.783 \end{pmatrix} & \begin{pmatrix} 0.992 & 0.008 \\ 0.348 & 0.652 \end{pmatrix} \end{pmatrix}$$

In the second scenario, the unemployment rate is considered as being worse than 4.9% with 5 months duration. We adopt 10% with the duration 10 months, the figure of which is approximately equal to the averages in Germany, France and Italy in 2000, and almost doubled of the figure in 2000

Table 5: Aggregate Risk(2): Unemployment-Rate Fluctuation

Unemployment Rate (Duration)	Money Growth	Asset	Consumption	Utility	GDP% (ΔGDP%)
2.3% or 4.9%	0.0%	1.347 (0.335)	1.0 (0.081)	-0.855	0.328%
(3 or 5 Months)	0.223%	0.915 (0.222)	1.0 (0.090)	-1.105	0.079% (+0.255%)
4.9% or 10%	0.0%	2.628 (0.849)	1.0 (0.113)	-1.620	-0.432%
(5 or 10 Months)	0.223%	1.831 (0.589)	1.0 (0.125)	-2.051	-0.856% (-0.522%)

GDP% is compared with Case (A) in Table 1.
Standard deviations are in parentheses.

in Japan. The transitional probability matrices as follows:

$$\chi_w \equiv \begin{pmatrix} \chi_w^{hh} & \chi_w^{hl} \\ \chi_w^{lh} & \chi_w^{ll} \end{pmatrix} = \begin{pmatrix} \begin{pmatrix} 0.989 & 0.011 \\ 0.204 & 0.796 \end{pmatrix} & \begin{pmatrix} 0.941 & 0.059 \\ 0.102 & 0.898 \end{pmatrix} \\ \begin{pmatrix} 0.990 & 0.010 \\ 0.600 & 0.400 \end{pmatrix} & \begin{pmatrix} 0.989 & 0.011 \\ 0.100 & 0.900 \end{pmatrix} \end{pmatrix}$$

Table 5 presents the simulation result on two scenarios. The average income level equals unity, and GDP fluctuation is less than $\pm 2\%$ in both scenarios. The first optimistic view on unemployment rate shows the welfare gain equivalent to 0.255% of GDP, while the second pessimistic scenario provides the indispensable welfare cost equivalent to 0.522% of GDP.

5 Comparison with Literature on Aggregate Consumption and Saving

In this section, we inquire into the simulation results applied to the Japanese economy. Our standpoint is not only specific to the Japanese economy, but also *general*, in the sense that it is related to micro foundations for aggregate consumption and saving. Compared with the macroeconomics literature, our model has three features as follows: one is an insurance motive for money holding instead of transaction motives (Bailey 1956; Lucas 1994), another is the ex post heterogeneous agents, not representative one (Carroll 2000b), and the other is concerning idiosyncratic and/or aggregate risks (Krusell and

Table 6: Welfare Cost of Inflation

Ranking	Unemployment		H-to-M	Income	GDP%
	Rate	Duration	Ratio	Risk	
(1)	4.9%	5 Months	66.7%	-	-0.107%
(2)	4.9%	3 Months	-	-	-0.204%
(3)	4.9%	5 Months	33.3%	-	-0.218%
(4)	2.3-4.9%	3-5 Months	-	-	-0.249%
(5 Base)	4.9%	5 Months	-	-	-0.334%
(6)	4.9%	5 Months	-	0.98-1.02	-0.344%
(7)	4.9-10.0%	5-10 Months	-	-	-0.424%

GDP% is the difference in cases with and without money growth of 0.223%.

Smith 1998). In the light of these critical issues for aggregate consumption and saving, We discuss our numerical results.

5.1 Transaction or Insurance Motive for Money Holding

As is often the case with macroeconomic models, money yields utility directly (money-in-utility model) or through transaction technology (shopping time or cash-in-advance model). In these models where money holding is motivated by consumption or transaction of households, inflation generates a welfare cost of the dead weight loss (Bailey 1956; Lucas 1994). The welfare loss is obtained by estimating the area of a triangle under the money demand function. The money demand under a liquidity trap situation as in the present Japan, is located at the tail end of a downward sloping curve. Then the evaluated "shoe-leather cost" of inflation is likely to be negligible. In our calculation, the shoe-leather cost is estimated to be at most 0.41% of the real GDP in the Japanese 1990s [16].

[16] We assume that the M2+CD annual growth rate is 6%, a simple average of 9.5% (the average growth rate during the monetary contraction) and 2.6% (that during the expansion) and that the interest rate elasticity of M2+CD demand is 0.16 (Nakajima and Saito 2000).

On the contrary, our model is essentially based on Imrohoroglu (1992), which is quite different from those models in the way of introducing money. The motive for households' money holding is to insure themselves against income risk with the borrowing constraint. Money held from such an insurance motive gains utility through consumption smoothing, even if money is never actually transacted. Difficulty in consumption smoothing facing unemployment risk is the source of the welfare cost of inflation there, which well explains the precautionary saving behavior of Japanese households facing an increasing insecurity of employment in the 1990s. As summarized in Table 6, the magnitude of the welfare cost is a little smaller in our model than the estimate of the shoe-leather cost. The effect of money growth is relatively small with the presence of heterogeneous agents because hand-to-mouth agents are not affected by inflation, and becomes larger with higher unemployment risk because inflation reduces the value of precautionary saving that is demanded more with higher risk.

5.2 "Requiem for the Representative Consumer"?

Next, we discuss another standard micro foundation of representative agent models for aggregate consumption. An exact aggregation into a representative agent requires that consumers can completely insure their income against idiosyncratic risks. Carroll (2000b) discuses this limitation as "requiem for the representative consumer", because, with the uninsurable risks, the consumption-policy function becomes so concave that the level of aggregate consumption could be affected by the distribution of wealth, that is, wealth distribution matters to aggregate consumption and saving.

In our model, borrowing constraint makes agents unable to insure against their idiosyncratic risks. Agents are ex post heterogeneous in the sense that they experience different history of employment status. The heterogeneity leads to an ex post wealth distribution among agents, as indicated by average asset and the standard deviation in each Table presented.

Our computational algorithm generates wealth distributions contingent on aggregate states of the economy. Figure 7-1 and 7-2 show examples of money holdings during boom or recession in a case of money growth with 5 months unemployment duration and no aggregate risks (Case (B) in Table 1).

In addition to heterogeneous rational agents, the presence of irrational agents such as hand-to-mouth agents possibly alters implications from the model. The presence of one (two) hand-to-mouth agent out of three increases the welfare cost equivalent to 0.905% (1.141%) of GDP as in Table 3. It may be surprising that the presence of hand-to-mouth agents considerably increases the welfare cost. The costs are all the more associated with aggregate risks of either income or unemployment-rate fluctuations.

5.3 Idiosyncratic and Aggregate Risks

Finally, the contribution to the welfare cost of inflation is compared to idiosyncratic and aggregate risks. The distinction between idiosyncratic risk and aggregate risk is a focus of dynamic macroeconomic models (Krusell and Smith 1998). A theoretical interest in the literature lies in obtaining a solution in a model with aggregate productivity shock as well as idiosyncratic risk. Krusell and Smith (1998) proposes a way of approximating an equilibrium of their model in which an aggregate productivity shock disturbs a random function of the individual asset distribution that is subject to the idiosyncratic risk. In the stationary stochastic equilibrium, they find that behavior of the US macroeconomy can be almost perfectly described using only the mean of the wealth distribution. Their finding may be considered as an evidence that precautionary saving motive against idiosyncratic risk is

Table 7: Welfare Ranking of Idiosyncratic and Aggregate Risks

Ranking	Money Growth	Income Risk	Unemployment Rate	Unemployment Duration	H-to-M Ratio	GDP%
(1)	0%		4.9%	3 Months		0.392%
(2)	0%		2.3-4.9%	3-5 Months		0.328%
(3)	0.223%		4.9%	3 Months		0.152%
(4)	0.223%		2.3-4.9%	3-5 Months		0.079%
(5)	0%		4.9%	5 Months		[Base]
(6)	0%	0.98-1.02	4.9%	5 Months		-0.029%
(7)	0.223%		4.9%	5 Months		-0.334%
(8)	0.223%	0.98-1.02	4.9%	5 Months		-0.373%
(9)	0%		4.9-10%	5-10 Months		-0.432%
(10)	0%		4.9%	5 Months	33.3%	-0.687%
(11)	0.223%		4.9-10%	5-10 Months		-0.856%
(12)	0.223%		4.9%	5 Months	33.3%	-0.905%
(13)	0%		4.9%	5 Months	66.7%	-1.368%
(14)	0.223%		4.9%	5 Months	66.7%	-1.475%

GDP% is compared with Case (A) in Table 1.

of little importance in determining the aggregate saving.

Similarly to Krusell and Smith (1998), our interest in the numerical experiments lies in relative contribution of idiosyncratic and aggregate risks to the welfare cost of inflation. Table 7 rank-orders the welfare costs in 14 cases relative to the benchmark case of zero money growth.

The aggregate income fluctuation has negligible effect on the welfare costs. The magnitude is 0.039% of GDP, measured with a difference between rank (7) and (8). When the unemployment rate fluctuates, the effect becomes bigger in either scenario, where unemployment rate either goes down to the level during the bubble (2.3%) or up to the rate comparable to European levels (10%). The former scenario gives a result that the welfare cost would be lowered by 0.413% of GDP (a difference between rank (7) and (4) in Table 7), while the latter shows an increase in the cost by 0.522% of GDP (a difference between (7) and (11)).

One policy implication of the simulation is found in the effect of a change in unemployment risk. A two months curtailment of the unemployment duration from 5 to 3 months turns out to bring considerable welfare gain equivalent to 0.486% of GDP, a difference between the ranking (3) and (7) in Table 7. An increasing unemployment risk also increases the welfare cost of inflation, because inflation reduces the value of precautionary saving that is demanded more with higher unemployment risk as in Table 7.

6 Conclusion

We have considered the sluggish Japanese economy in the 1990s as facing an idiosyncratic risk that motivates precautionary saving, and investigated the welfare cost in an economy with idiosyncratic and aggregate risks with inflation. Money holding in our model is motivated by self-insurance, different from the transaction motives as in cash-in-advance constraint models. We have also considered the effect of a change in the duration of unemployment, the presence of hand-to-mouth consumers without preparing for unemployment risk, and also aggregate risks in a fluctuation of social endowment. We summarize the quantitative exploration into the Japanese economy in the 1990s as follows.

First, the measured welfare cost of inflation is equivalent to 0.334% of the real GDP, due to a lack of consumption smoothing in face of idiosyncratic income risk . The magnitude is a little smaller than the estimated shoe-leather cost, that is equivalent to 0.41% of GDP.

Secondly, the presence of hand-to-mouth agents augments the welfare cost, because of a lack of consumption smoothing for hand-to-mouth agents and a reduction of average consumption for rational consumers. The welfare cost of the presence of two hand-to-month agents out of three exceeds 1% of

GDP.

Thirdly, as for aggregate risk due to business cycle, the welfare cost of income fluctuation of "work-sharing" type is negligible, while the welfare cost of doubled unemployment risk is measured at most 0.522% of GDP.

Faunally, the welfare gains of two months curtailment of unemployment duration is nearly 0.486% of GDP. An increasing unemployment risk also increases the welfare cost of inflation.

Krusell and Smith (1998) conclude that precautionary saving motive against idiosyncratic risk is of little importance in determining aggregate saving. If their result is robust, the welfare cost in the presence of idiosyncratic risk may be disregarded as a trifle. Otherwise, on the contrary, the considerable cost of the idiosyncratic risk shadows forth the future distress to the Japanese, who possibly face the collapse of the so-called lifetime employment system.

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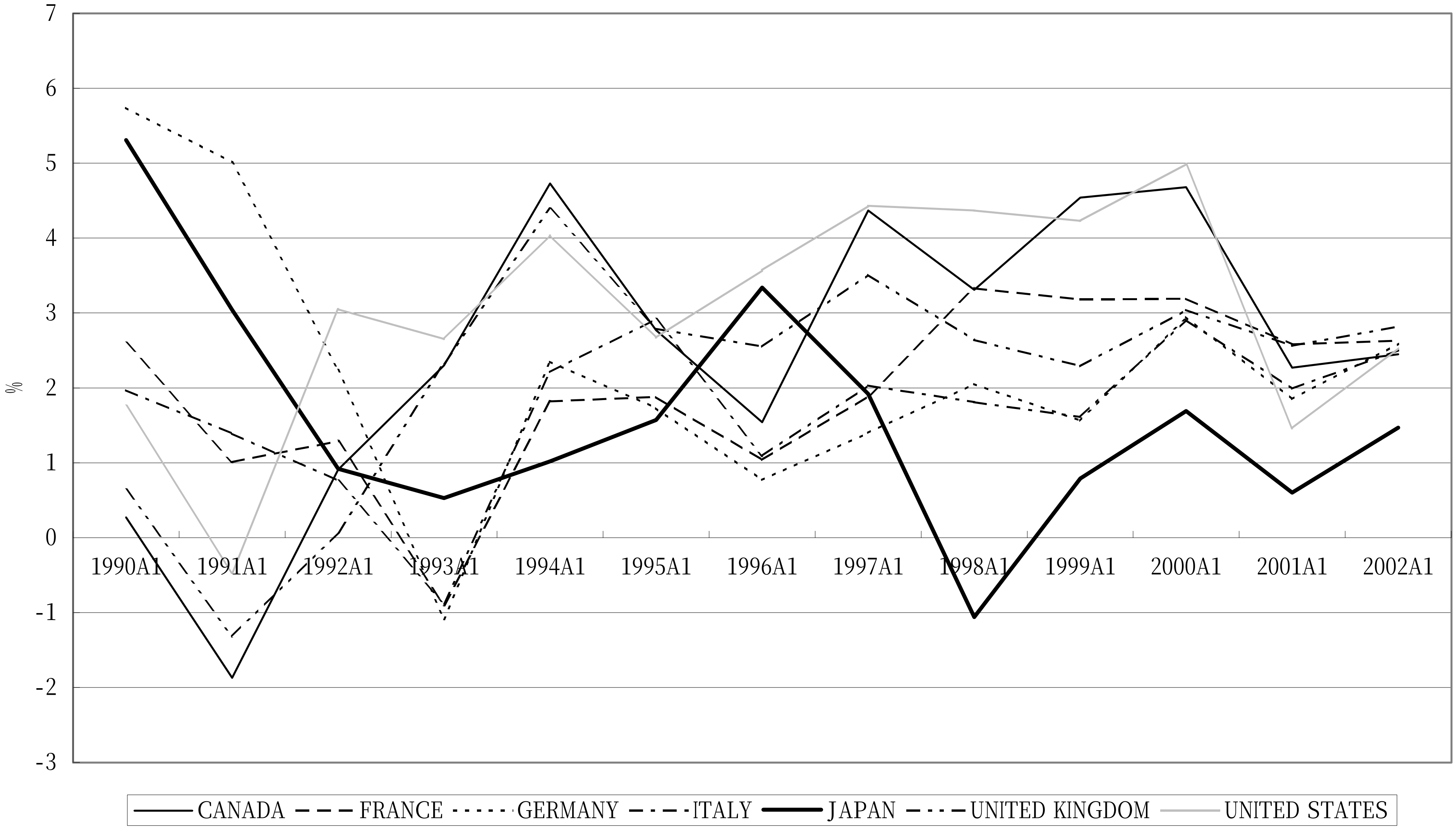
Figure 1. Real GDP, Annual Growth Rate.



Inflation, CPI.

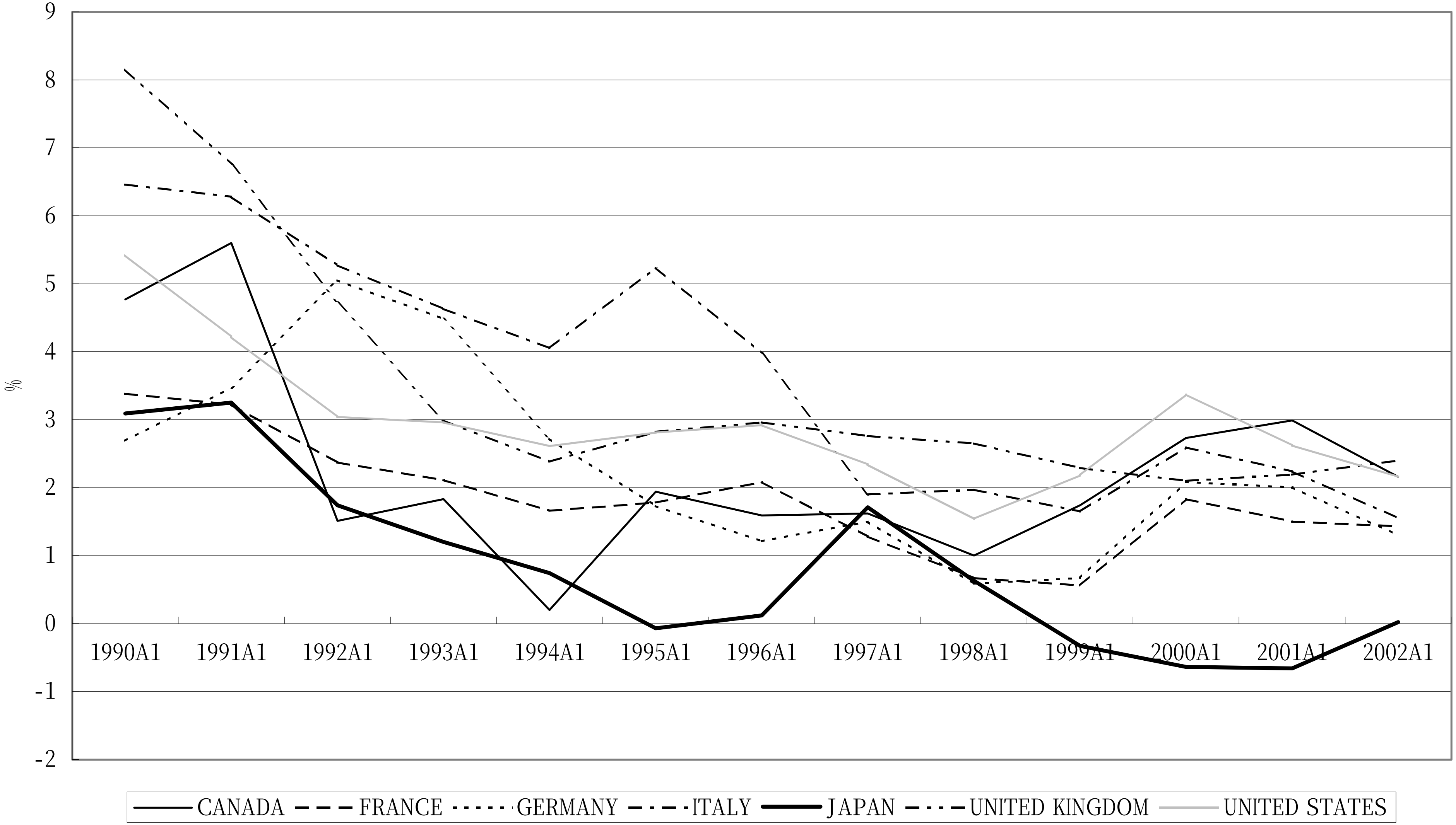


Figure 2. Recovery Processes from Trough in Private Consumption

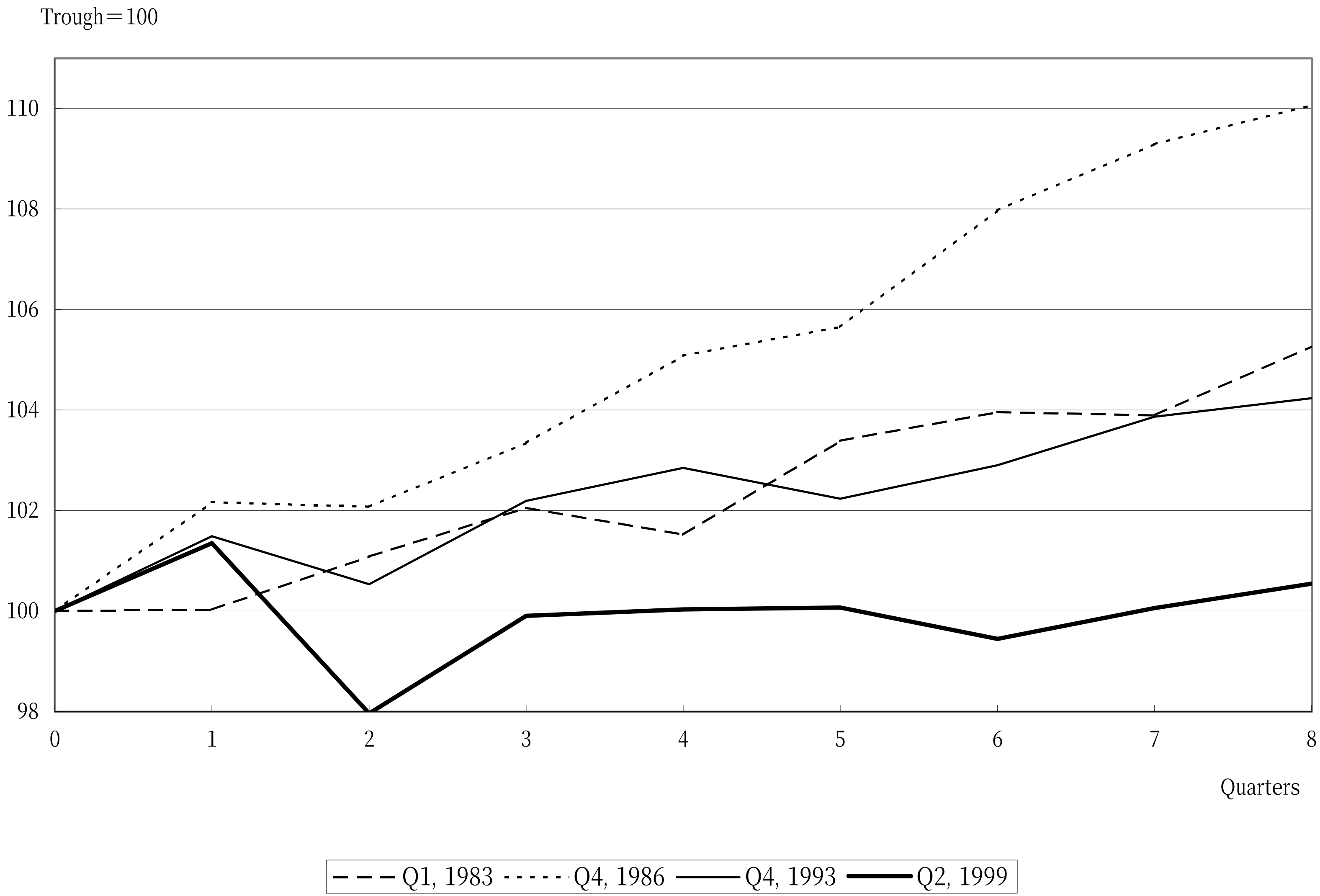
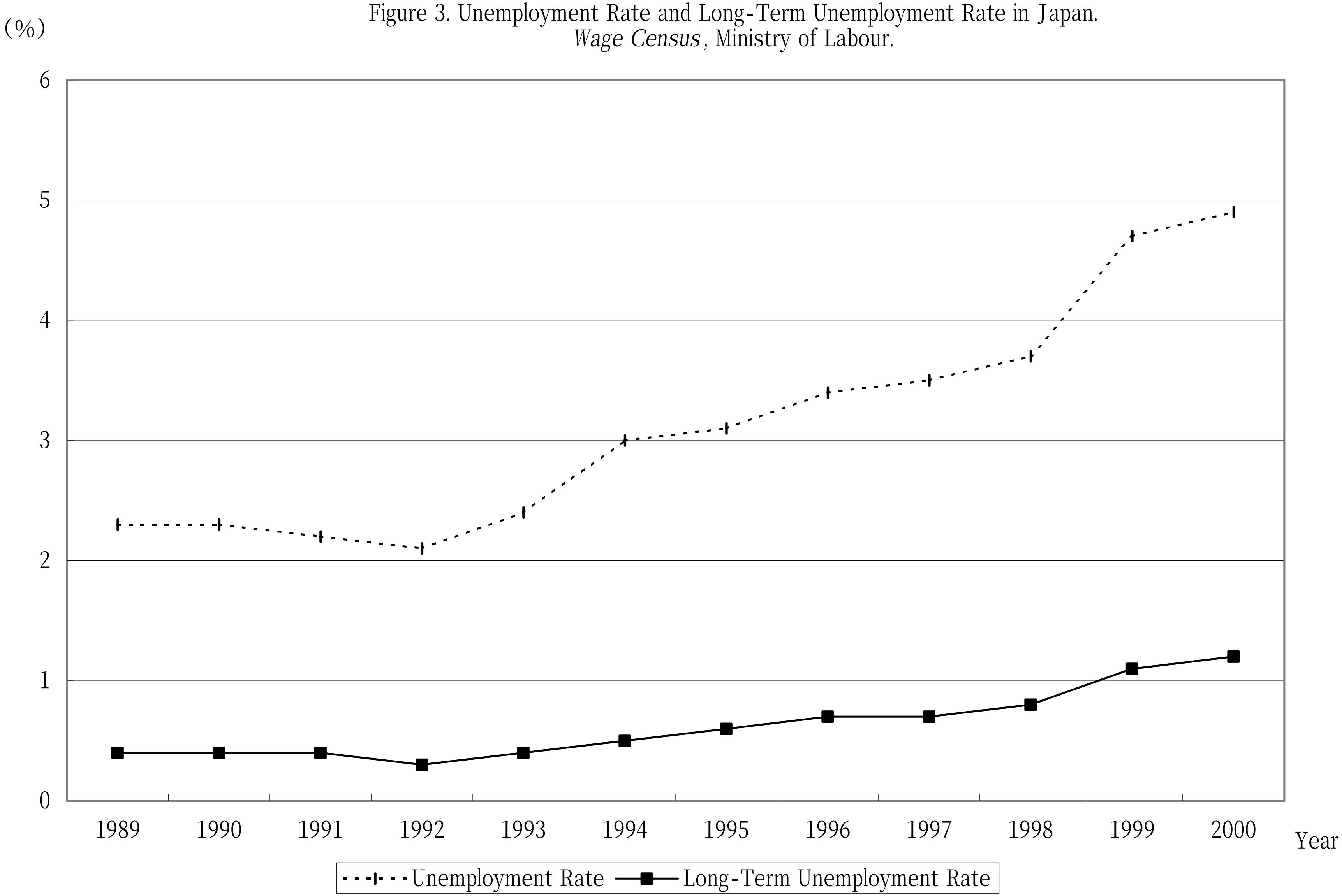


Figure 3. Unemployment Rate and Long-Term Unemployment Rate in Japan.
Wage Census, Ministry of Labour.



Ratio of Long-Term Unemployment in Japan.
Wage Census, Ministry of Labour.

Figure 4. Duration of Unemployment in Japan.
Wage Census, Ministry of Labour.

Figure 5. Share of Savings Held in Total Amount
The Family Saving Survey

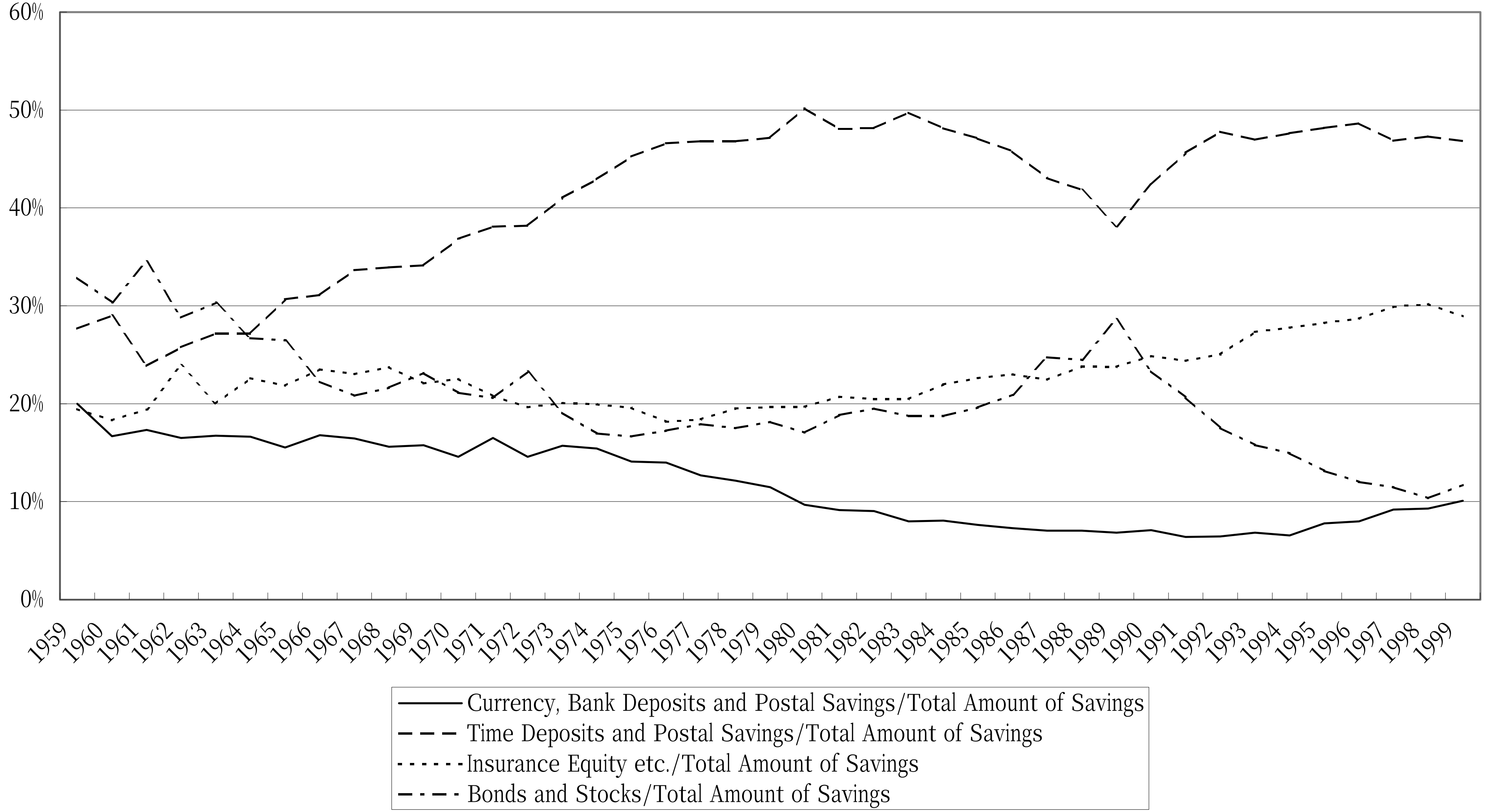


Figure 6. M2+CD Growth in Japan

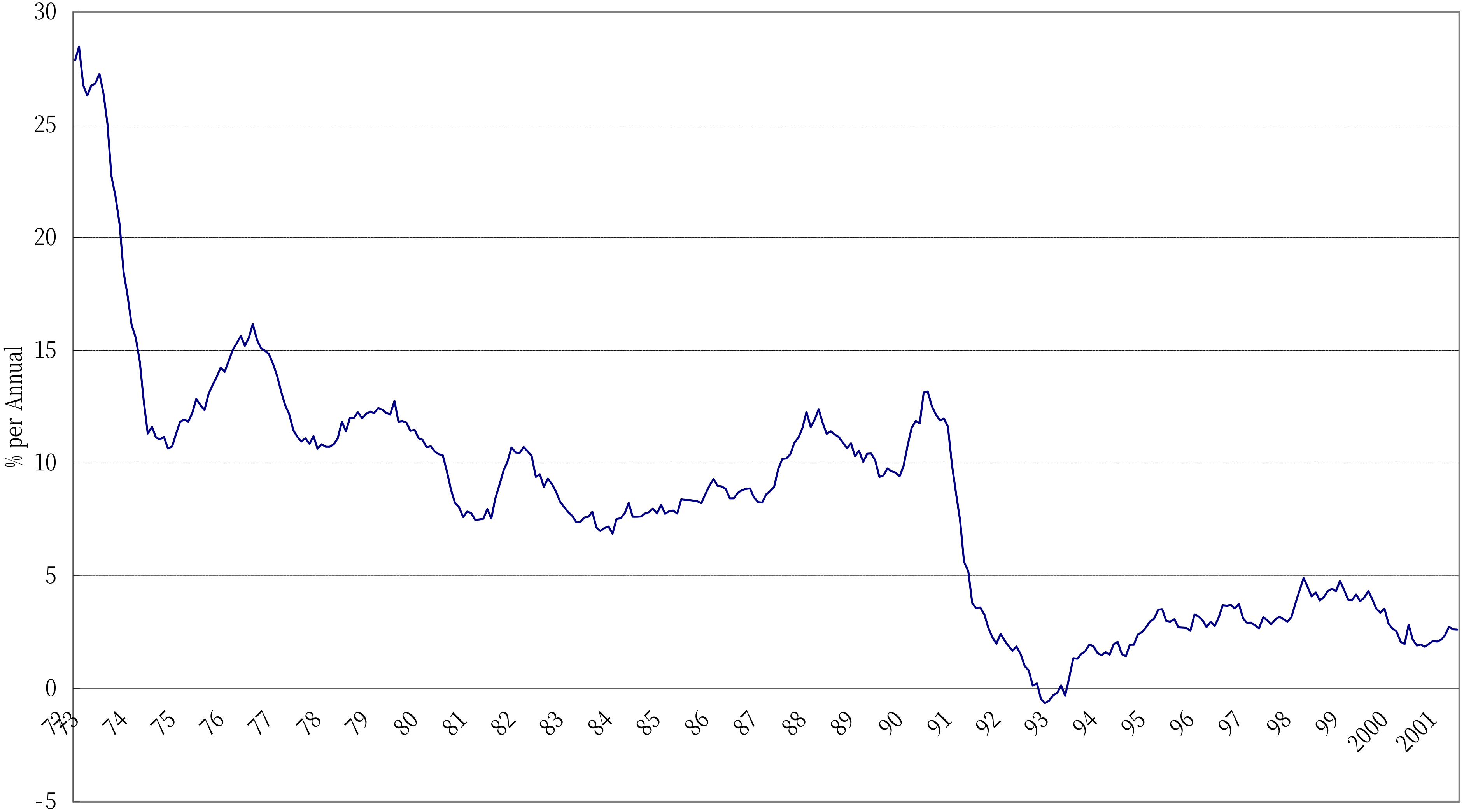


Figure 7-1. An Example of Wealth Distribution
in Boom

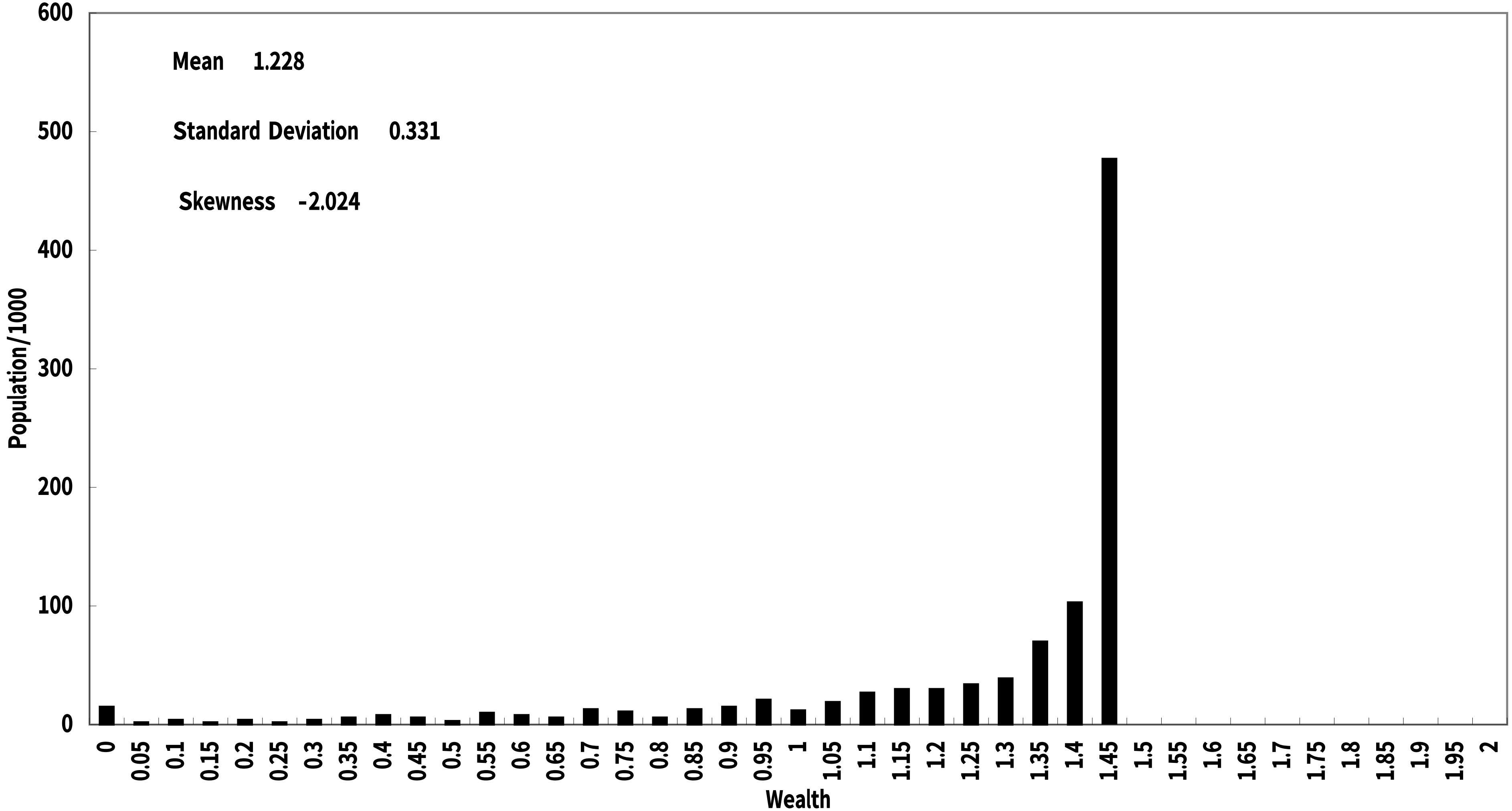


Figure 7-2. An Example of Wealth Distribution in Recession