Unemployment Risk and Consumption: Can the Buffer Stock Saving Behavior Explain the Japanese Experience?∗

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Abstract

This paper shows that the drop of the aggregate propensity to consume (APC) in Japan during the lost decade is attributable to increase of income risks, mainly due to the rise in the unemployment rate. In order to assess impacts of income risks numerically, we use a buffer stock saving model that deals with transition dynamics of wealth distribution. Our simulation results well capture the evolution of the APC during the 1990s, which suggests not only the drop of the APC can be explained with the buffer stock saving behavior, but also it would be transit.

Keywords: Income Risk, Japanese Household Consumption, Precautionary Saving.

JEL classifications: E21, D91, E27

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1 Introduction

This paper shows, using a numerical method, that precautionary saving motives can explain the fall of aggregate propensity to consume (APC) in Japan during the lost decade; that is, the long-continued drop of the APC is attributable to the increase of income risks during the 1990s. Unlike previous studies, we focus on dynamics of wealth distribution which is driven by the optimal consumption-saving decision.

Japan has long been in slump since the early 1990s, which is referred to as the lost decade. The Japanese economy of this era has two particular features; serious drop of the APC and unprecedented rise of unemployment rate. To analyze the relationship between consumption and income risks, the precautionary saving theory has been applied in previous studies (see Ogawa, 1991; Nakagawa 1998; Murata, 2003; and Doi, 2004 for Japanese economy).

Among precautionary saving models, one of the most important models is the buffer stock saving model pioneered by Deaton (1991) and Carroll (1992). They show that if households face higher income risks, they would save more in order to prepare for unfortunate realization of their income states. Moreover, the buffer stock savers would have a target wealth such that, if wealth is below the target, households consume less and accumulate wealth, while if wealth is above the target, households dissave. Carroll (1992; 1994; 1997) emphasize that the target wealth increase when income risks become higher, which implies that households facing higher income risks have more saving stocks. Some empirical studies support this implication (for example, Carroll and Samwick, 1998; Carroll, Dynan and Krane, 1999; and for Japanese evidence, Bessho and Tobita, 2004).

It is, however, well known in the literature that once households achieve the target wealth, consumption out of flow income hardly depends on the degree of income risks. In other words, the APC is affected by income risks only immediately after the degree of risks changed, that is, while being on the transition towards some stable level of the APC. This suggests that we should consider the transition dynamics of wealth level in explaining the
long-continued drop of the APC as seen in Japan.\(^1\)

Our framework basically follows Carroll’s buffer stock saving model. Firstly, we set up a standard dynamic utility maximization problem in which households face income risks. Then, we calibrate the model with Japanese aggregate time series data for 1990-2002, and obtain the consumption function in terms of “cash on hand” for each year. With the consumption function and the dynamics of wealth distribution derived from the optimal behavior, we calculate the path of aggregate consumption.

Our calculation extracts two main conclusions. Firstly, it turns out that the consumption function shifts downwards during the 1990s, which implies that the consumption level decreases for any wealth level, and that the target wealth would become higher. In particular, the calculated target wealth increases distinguishably for 1997-1999 when the unemployment rate rose sharply. Such changes of the target wealth induce households to consume less and save more in order to achieve the new target, while if households reach at the new target, the APC would be almost same as the previous level. Secondly, the simulated path of the APC well captured the real data of Japan. This result suggests that the behavior of households on the transition towards the new target can explain the Japanese consumption behavior in the 1990s.

In addition to these results, there is an interesting yet unintuitive implication. By the assumption of our calculation, the fall of the APC during the lost decade would be *transitory*, and hence, consumption can be expected to recover without any improvements of economic situations. This implication seems to be consistent with the very recent recovery of household consumption, whereas the unemployment rate continues to stay relatively high level.

This paper constructed as follows. Section 2 set up the model and defines some important concepts. In particular, the definitions of the long-run and the short-run propensity to consume are significant in our analysis. Section 3 discusses the data construction. Section 4 presents the calculation results

\(^1\)Murata (2003) and Doi (2004) empirically investigate the effects of income risks on household saving rate, but theoretical backgrounds of their estimates are not clear.
and discusses some implications. Section 5 concludes.

2 The Model

The framework of analysis follows Carroll’s buffer stock saving model. Suppose that a household solves a dynamic utility maximization problem. There is no uncertainty with regard to the interest rate and no credit constraint. Households, however, earn wage income that varies stochastically.

The maximization problem at time $t$ is

\[
\max_{C_t} \left\{ u(C_t) + \sum_{j=t+1}^{\infty} \beta^{j-t} E_t u(C_j) \right\},
\]

subject to

\[
A_t = RA_{t-1} + W_t - C_t,
\]

where $u$, $\beta$, $A_t$, $C_t$, and $W_t$ is the instantaneous utility function, the discount rate, asset holding at the end of period $t$, consumption, and wage, respectively. $R$ is the constant gross interest rate that is one plus the real interest rate, $r$.

In our model, the wage income is subject to transit shocks while we omit the permanent shocks since there is only few evidence about distinction between permanent and transitory income shocks for the Japanese household income profile. By decomposing the realization of income into two factors, we obtain,

\[
W_t = Y_t \varepsilon_t = GY_{t-1} \varepsilon_t,
\]

where $Y_t$ is the permanent income that deterministically grows at constant rate, $G$ and $\varepsilon_t$ is the transitory income shock.

The transitory shock, $\varepsilon_t$, is denoted by households’ employment status. Suppose there are three states; employed as a higher wage worker, employed as a lower wage worker, and an unemployed. When a household is employed as a higher wage (lower wage) worker, the wage is the permanent income
multiplied with $w_H \ (w_L)$, while an unemployed household earns no income. In addition, we assume that $\varepsilon_t$ follows the i.i.d. process; then, the process is

$$\varepsilon_t = \begin{cases} 
0 & \text{with probability } \mu_t \\
 w_L & \text{with probability } (1-\mu_t)p_L \\
 w_H & \text{with probability } (1-\mu_t)(1-p_L) 
\end{cases} \tag{4}$$

These assumptions imply that the probability of job-loss, $\mu_t$, is equal to the unemployment rate and $p_L$ is the share of the lower wage workers among employees.

Following previous studies, we define the cash on hand, $X_t$, as the sum of the beginning-of-period wealth and the wage income (that is, $X_t \equiv RA_{t-1} + W_t$). In order to obtain numerical solutions, the instantaneous utility function is assumed to be of the CRRA and all variables are divided by the level of permanent income.\(^2\) Then, the problem can be rewritten in the recursive form as,

$$v(x_t) = \max_{c_t} \left\{ u(c_t) + \beta G^{1-\rho} E_t v(x_{t+1}) \right\}, \tag{5}$$

subject to

$$x_{t+1} = (R/G)(x_t - c_t) + \varepsilon_{t+1},$$

where the lower letters denote the ratio to the permanent income, $Y_t$.

Carroll and Kimball (1996) show that the optimal consumption at time $t$ depends only on the cash-on-hand at time $t$ in this framework with a given income process. Accordingly, we can obtain the following consumption function of households;

$$c_t = c(x_t). \tag{6}$$

In the literature, it is well established that if households follow the buffer stock saving behavior, they have the target wealth such that, if wealth is below the target, they consume less to accumulate wealth, while if wealth

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\(^2\)In our calibration, households are found to be impatient throughout the era of the simulation in the sense that they satisfy the condition of $(R\beta)^{1/\rho} < G$. This means the existence of buffer stock motivation. For the analytical proof of this argument, see Carroll (2002).
is above the target, they dissave. The target wealth in our model can be obtained as the fixed point of the budget constraint as

$$a^* = \frac{G}{G - R} \left\{ E_t(w_{t+1}) - c \left( \frac{R}{G} a^* + E_t(w_{t+1}) \right) \right\}, \quad (7)$$

where $a^*$ is the target wealth.

In principle, the wealth would stably converge toward the target wealth; however, since there is the income shock generated by $\varepsilon_t$, the wealth of each household fluctuate around the target level such that in the economy, the level of wealth has a non-degenerate distribution. Carroll (1992; 1994; 1997) find by simulation a property about the wealth distribution that there is the steady-state wealth distribution that emerges after sufficiently many periods and it depends only on the consumption function.\(^3\)

From the optimal consumption behavior for each household obtained above, we consider the aggregate consumption and propensity to consume. Suppose there is a distribution of wealth at time $t$, $F_t(a)$, then the distribution of the cash-on-hand can be easily obtained since the wage distribution is independent of $F_t(a)$. Thus, we can calculate aggregate consumption by evaluating the consumption function at each cash-on-hand level and summing up them with the weights from the distribution of $x$. Accordingly, the aggregate consumption, $AC_t$, is a functional of $c(x)$ and $F_t(a)$:

$$AC_t = AC(c(x), F_t(a)). \quad (8)$$

Using the budget constraint of each individual household, we can derive the distribution of wealth for the beginning of the next period, $F_{t+1}(a)$, which implies that the consumption function determines the evolution of the distribution of wealth.

In our framework, therefore, propensity to consume can be calculated as follows:

$$SPC_t = \frac{AC(c(x), F_t(a))}{(R/G - 1) \int a dF_t(a) + E(w_t)}, \quad (9)$$

where the numerator is the aggregate consumption defined above. The denominator is the aggregate income, that is, the sum of capital income from

\(^3\)For analytical proof of this argument, see Carroll (2002).
the wealth and the labor income, $w_t$. We refer to this propensity to consume as the short-run propensity to consume (SPC) since the distribution of wealth that we use for this calculation is not the steady state one.

In addition to the SPC, it will be useful to define the propensity to consume that emerges when the distribution of the wealth converges toward the steady-state one. We refer to this propensity to consume as the long-run propensity to consume (LPC). Since the steady-state distribution depends only on the consumption function, the LPC is also determined by the consumption function. The LPC is,

$$LPC_t = \frac{AC(c(x), F^*(a))}{(R/G - 1) \int adF^*(a) + E(w_t)}, \quad (10)$$

where $F^*(a)$ is the steady-state distribution of wealth. Since the difference between the SPC and the LPC comes from the distribution of wealth, the SPC will converge to the LPC if the consumption function is fixed.

### 3 Data

To calibrate the model to the Japanese economy during the lost decade, we construct the parameters that appear in the model: unemployment rate $\mu$; real interest rate, $r$; real income growth factor, $G$; lower wage, $w_L$; higher wage $w_H$; and probability to be lower wage employee, $p_L$, as well as the aggregate propensity to consume.

Since the seminal paper of Deaton and Paxson (1994), many studies attribute income variation to various heterogeneous factors across households such as age, age cohort, education, and types of jobs (See Storesletten, Telmer and Yaron, 2004a; 2004b; and Guvenen, 2004); and thus, income risks that individual households face should be described with micro data. However, we construct parameters from Japanese aggregate time series data because of limited availability of Japanese household survey data.\(^4\) Since we should use aggregate data, all households have been assumed to face the

\(^4\)Ohtake and Saito (1998) provides some evidence about income variation from micro data following Deaton and Paxson (1994), nevertheless information has still been limited.
same income risks in the model regardless of demographic and/or socioeconomic factors.\textsuperscript{5}

Firstly, we examine the APC in Japan. Figure 1 presents the APC for the Japanese households in the 1990s, which is defined as consumption expenditure divided by disposable income, and this is our goal that will be explained using the model. We use the data from the Japanese Family Income and Expenditure Survey (JFIES), while it is well known that the saving rates from the JFIES and the SNA have moved differently.\textsuperscript{6} Figure 1 shows that the APC decreases during the decade, while it started to increase after 1999, even though the Japanese economy as a whole might not escape the slump.

Among dependent variables, the most important variable is the unemployment rate since the buffer stock saving literature emphasizes that unemployment (zero income state) seriously affects household consumption.\textsuperscript{7} We can obtain the unemployment rate from the Labor Force Survey, and the data for the 1990s is presented in Figure 2. The unemployment rate sharply increases to over 5\% after 1993, while it stably ranges from 2\% to 3\% before the 1990s. In particular, the rise during 1997 to 1999 is distinguishable.

The factor of $R/G$ is another important dependent variable. The real interest rate, \( r \), is defined as the Government Bond rate minus the inflation rate of the Consumer Price Index (CPI), while the real income growth rate is defined as change rate of the disposable income deflated by the CPI. Since the interest rate and the inflation rate decrease in almost parallel, the real interest rate is relatively stable during the decade.\textsuperscript{8} On the other hand, the

\textsuperscript{5}In this sense, households are substantially homogenous even though the realizations of employment status are heterogeneous. Heterogeneity stems only from the level of wealth.

\textsuperscript{6}Throughout the 1990s, the saving rate obtained from the SNA data does not show such drops as in Figure 1, and the large part of this gap can be explained with the coverage of the two statistics. The JFIES data cover households whose household head is a wage earner that faces serious income risks. Therefore, we believe the JFIES would be more relevant for our purpose, even though the SNA data is a more relevant statistical indicator of macro consumption. For more discussion, see Ueda and Ohno (1993) and Iwamoto, Oazaki, Maekawa (1995).

\textsuperscript{7}See, for example, Carroll (1992).

\textsuperscript{8}We subtract 1.5\% from the inflation rate at 1997 in order to adjust the revise of
income growth rate is negative after 1998 when the financial crisis becomes serious. Accordingly, \( R/G \) has a slightly increasing trend during the decade. Since the higher \( R/G \) may shift downwards the consumption function, the consumption level could be decreased by this change in \( R/G \).

\( w_L, w_H \) and \( p_L \) are not available directly from the data. We construct these parameters using the average, the 20 percentile, and the 80 percentile of yearly income of households from the JFIES. We regard the ratio of the 20 percentile to the average as the lower wage and that of 80 percentile as the higher one. Then, the probability to become a lower wage employee is set such that the expected income conditional on being employed equals to unity. Finally, we multiply them with the real income, which is normalized to be unity at 1990. These three parameters represent wage inequality among employees that may generate wage risks in addition to the unemployment risk. The calculated data indicates the inequality in Japan becomes larger during the 1990s. This implies that households face higher income risks in the 1990s. However, it should be noted the heterogeneity of income risks among different types of households is not considered here. By this omission we may under- or over-estimate the income risks.

Finally, there are two parameters in the model, the discount factor, \( \beta \) and the elasticity of intertemporal substitution, \( \rho \). They are quite controversial parameters and difficult to give specific values. Here, we set them as \((\beta, \rho) = (.9, 5)\), which is very close to the calculation in Carroll (1992).

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9 Discussion of wealth inequality in Japan is highly controversial. See, for example, Ishikawa (1994) and Tachibanaki (1996).

10 Ohtake and Saito (1998) show that the log-income variance in Japan depends on age and age cohort, and is ranged from 0.15 to 0.5, while our value is about 0.3.

11 Carroll (2001) argues that the usual estimation of the elasticity of intertemporal substitution may be biased.

12 Carroll (1992) uses the parameter values of \((\beta, \rho) = (.9, 3)\) as the baseline and varies within some reasonable range.
4 Results

4.1 Consumption Function and the Target Wealth

Using the aggregate data described above, we derive the consumption function in terms of the cash-on-hand, (6), for each year. Figure 3 presents the consumption function for 1990, 1995 and 2000, which clearly shows the consumption schedule shifts downwards at any cash-on-hand level. Hence, the aggregate consumption decreases if the distribution of the cash-on-hand is fixed.

This downward shift implies that the target wealth become higher, thus we also calculate the target wealth for each year using the consumption functions obtained above. The higher line in Figure 4 presents the time path of the target wealth. The line shows that the target wealth became higher along with the unemployment rate. This change of target wealth level leads to the transit change of the APC.

As noted above, possibility of being zero income state has distinguished effects on household consumption. In order to clarify the impact of unemployment rate, we calculate the target wealth for an economy in which we keep the unemployment rate fixed at the level of 1990 and other parameters are drawn from the data. The result is presented with the lower line in Figure 4. Although the parameters are same in the two calculations except for unemployment rate, the two lines move quite differently. That is, if the unemployment rate was kept constant, the target wealth would not increase so sharply. This suggests that the large part of changes in the target wealth would be attributable to the increase of the unemployment rate.

In addition to this analysis, there is another way to clarify the importance of changes in the unemployment rate. When we investigate the consumption function, we know the fall of consumption between 1990 and 2000 is calculated as 8.25%, evaluating at the target wealth for 1990. However, if the unemployment rate does not change during the 1990s, the consumption would rather increase by 1.29%; that is, the increase in the unemployment rate causes the drop of consumption by 9.54%.

From these analyses we can conclude that increases of income risks dur-
ing the 1990s affect the individual consumption behavior seriously. Next, we have to aggregate these individual effects to evaluate the aggregate effects on the APC.

4.2 The LPC and the SPC

As discussed above, the distribution of the wealth is required to assess impacts of changes on the aggregate consumption. However, if we use some statistics about assets of households, we would have some difficulties such as domain of assets and/or valuation of real assets. Moreover, it is well known that the distribution of wealth is seriously affected by demographic structure due to the life cycle saving motive and the bequest motive, which is not explicitly analyzed in our model. Therefore, instead of using actual statistics about household assets, we assume that the wealth distribution at the initial year of 1990 is the steady state distribution. This assumption seems relevant since the economic situation was relatively stable for several years before 1990.13

Here, we obtain the SPC and the LPC as follows. Since the evolution of wealth distribution can be calculated with iterative uses of the consumption functions for each year, the SPC defined with (9) can also be calculated when the initial wealth distribution is given. On the other hand, it is possible to calculate the steady-state distribution of wealth for each year, using the corresponding consumption function. Accordingly, the LPC defined with (10) can also be obtained, and it is dependent on not the dynamics of wealth distribution but on the steady-state distribution for each year.

The broken line in Figure 5 shows the result for the LPC. As it can be seen from the figure, the LPC is almost constant. This outcome is consistent with theory that the APC is almost independent of income risks after the wealth distribution converges to steady state one; although the consumption function shifts downward as shown in Figure 3, the wealth distribution shift rightward, which cancel the drops of consumption for every level of cash-on-hand.

13We also calculate the steady state distributions for the year 1988, 1989 and 1991, and obtain similar results reported here.
Our long-run implication above is consistent with Bessho and Tobita (2004), who show using a cross sectional data that a household that faces higher income risks has more stocks of savings in Japan as well as in the US.\footnote{See, for US evidence, Carroll and Samwick (1997) and Carroll, Dynan, and Krane (1999).} However, although it is a plausible test of the buffer stock saving theory, it cannot explain a fall of the APC since the result of the LPC suggests that consumption behavior is not sensitive to the changes of income risks in the long-run.

In the short-run, on the other hand, changes of income risks do affect the consumption behavior. The solid line in Figure 5 presents the result of the SPC. The SPC traces the APC from the data which is presented with the dotted line. This implies that, during the 1990s, effects of the downward shift of consumption function dominates the effects of wealth accumulation. That is, the target wealth increases too fast for agents to fill up the gap between the previous target level of wealth and new one. It will be noteworthy that the SPC can be obtained only when we consider the dynamics of wealth distribution.

These results in the SPC and the LPC suggest not only that the fall of propensity to consume would be caused by the increase of income risks but also that it would be transitory. The latter implication, in particular, is interesting yet unintuitive. Since it is transitory, it would be expected that the propensity to consume could recover even without any improvements of economic situation. The discrepancy between the implication and the intuitive definition of transitory we are facing is that the APC has stayed at lower level more than ten years. Furthermore, Carroll (1992; 1994; 1997) point out that the convergence toward the steady state distribution is very fast.\footnote{He concludes that usually it is not necessary to consider the SPC due to this fast convergence.}

However, the relationship between the model assumption and the constructed data would explain the discrepancy. While households regard the parameters as constant over time in the model, the data for the parameters
are constructed for each year. Since the actual values are different for each year, our model implicitly assumes that expectation of households has been different from the realization throughout the 1990s. In other words, we implicitly assume that the expectation of households has been underestimating the worsening of economic situation during the lost decade.

It may seem an unusual assumption but there are some evidences indicating that households failed to predict the future situation in the 1990s. Doi (2004), who constructs a measure for income risks from the survey data, shows that households underestimated the seriousness of recession and recognized the increase of income risks only after the unemployment rate has risen significantly in late 1990s.\textsuperscript{16} That is, the changes of income risks were not predictable at the year of 1990. If household could predict the worse economic situation at 1990, the propensity to consume would be higher in the 2000, even though the fall of the APC might be larger than the actual in the early 1990s.

We will close this section by mentioning about the recovery of the APC. Although recent recover of APC in data seems to be implied by our simulation, it is future interesting to know when the APC will recover to the level of 1990. Hence, we simulate the APC in future with parameter values fixed at 2002 level and our simulation, which indicates that it take about ten years. This seems rather long as Carroll (1992) predicted that it might be shorter. However, if we simulate with parameters of 2003, we find that the path of recovery in the APC is more drastic and coincides with the prediction by Carroll.

\section{Conclusion}

Many researchers focused on the relationship between consumption and income risks with precautionary saving models, and empirical evidence has shown that the buffer stock saving model appears to be consistent with the Japanese household consumption behavior.

However, previous studies for the Japanese economy in the line of Deaton\textsuperscript{16} Nakagawa (1998) also provided similar results.
(1991) and Carroll (1992) care only about the long-run implications of theory, and so they are not suited for explaining the drop of the APC. On the other hand, our quantitative analysis clearly illustrates that the buffer stock saving behavior causes the fall of the APC. In particular, the evolution of the wealth distribution plays the central role in our analysis. As far as we know, this is the first application for Japanese economy with explicitly considering for the transition dynamics of wealth distribution.

One of the most interesting implications of our results is that the fall of propensity to consume is a transitory phenomenon even though it has continued more than ten years. This discrepancy between the implication and the intuitive definition of *transitory* would be explained by the fact that the households might underestimate the deterioration of economic situation at the starting point of the slump. The repeated revision of the expectation caused the prolonged transition toward the steady state.

For future research, it would be required to utilize micro data to allow the heterogeneity of income profiles across households. Furthermore, the model might be changed to finite horizon framework such that the model includes the life cycle implications.
References


Figure 1: Propensity to Consume in Japan
Figure 2: Unemployment In Japan

![Graph showing the increase in unemployment rate in Japan from 1990 to 2002.](image)

Unemployment Rate vs Year

- Unemployment Rate: 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07
Figure 3: Policy Function
Figure 4: Target Wealth

![Target Wealth Graph]

- Target Wealth (1990 = 1)
- Lines of curves: 
  - Solid line: Simulation with unemployment rate from data
  - Dashed line: Simulation with unemployment rate fixed at 90

Year:
- 1990
- 1992
- 1994
- 1996
- 2000
- 2002

Target Wealth ranges from 0.0 to 2.0.
Figure 5: Simulation Results and Data