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Liquidity Preference and Persistent Unemployment with Dynamic Optimizing Agents: An Empirical Evidence

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Abstract

Standard money-in-utility dynamic models assume satiable liquidity preference, and thereby prove the existence of a full employment steady state. In the same framework it is known that under insatiable liquidity or wealth preference there is a case where a full employment steady state does not exist and then unemployment persistently occurs. Using both parametric and nonparametric methods this paper empirically finds that insatiable liquidity/wealth preference is strongly supported. Thus, without assuming any permanent distortion, we can analyze an effective demand shortage in a dynamic optimization framework.

Keywords: Persistent Unemployment, Dynamic Optimization, Insatiable Liquidity Preference.

JEL Classifications: E12, E24, E41

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1. Introduction

Standard money-in-utility dynamic models assume that the marginal utility of liquidity becomes zero for a sufficiently large amount of liquidity. Since under this assumption a full employment steady state is proven to exist,[1] people do not bother to consider the possibility of permanent disequilibrium in this type of model. Moreover, they start the analysis by assuming that all markets are completely cleared at any point in time. When analyzing market disequilibrium on purpose (as in New Keynesian models), some economic distortions, such as monopoly power and imperfect information, are exogenously introduced.

In contrast, using the same model structure as standard money-in-utility dynamic models, Ono (1994, 1999) proves: when the marginal utility of liquidity has a strictly positive lower bound, there is a case where a full employment steady state does not exist, and then a steady state with persistent unemployment obtains. Thus, without considering any market distortion, we can analyze persistent unemployment caused by an effective demand shortage in a dynamic optimization setting.[2] In this steady state Keynesian implications hold, such that rapid wage/price adjustment deteriorates effective demand and that fiscal spending stimulates consumption.

One might then ask which hypothesis is more plausible, satiable or insatiable liquidity preference. In the literature, e.g. Feenstra (1986), it is insisted that the satiability of liquidity preference has a microeconomic foundation when liquidity is demanded only from the transaction motive. However, this is almost a tautology since they take into account only a motive that requires a finite amount of liquidity holding, although there are also other motives, such as wealth preference. Thus, to find which hypothesis is more plausible, empirical research on the (in)satiability of liquidity/wealth preference is required.

Using both parametric and nonparametric methods, we empirically investigate the

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[1] See Brock (1975), Obstfeld and Rogoff (1983, p.681), Blanchard and Fischer (1989, p.241), etc., for this proof.

[2] In Chapter 17 of *the General Theory* (1936, p.239) Keynes concludes that under insatiable liquidity preference persistent unemployment may occur. However, since he had not clearly provided a model with rational behavior, economists formulated an ad hoc Keynesian model. Because of its ad hoc structure, the effective demand theory itself is nowadays negatively considered.

(in)satiability of liquidity preference, and find that insatiable liquidity preference is strongly supported. Thus, a Keynesian effective demand shortage can be treated in a money-in-utility dynamic optimization model.

The plan of this paper is as follows. Sections 2 and 3 summarize Ono's model. Particularly, section 3 shows that in the presence of insatiable liquidity preference a steady state with unemployment obtains in a competitive economy with dynamic optimizing agents that have perfect foresight. By applying parametric and nonparametric methods respectively to two sets of data, section 4 empirically investigates if the marginal utility of liquidity has a strictly positive lower bound. Consequently, it is found that the hypothesis of insatiable liquidity preference is strongly supported. Finally, section 5 summarizes the implication of this paper.

2. The Model Structure

Let us first summarize the structure of Ono's model. For simplicity,[3] we assume that the firm sector produces output y by using only labor l with a constant-returns-to-scale technology:

$$y = \theta l, \tag{1}$$

where input-output ratio θ is constant. Therefore, given real wage w, the firm sector's demand for labor is represented by

$$\begin{aligned} l = 0 \quad &\text{if} \quad w > \theta, \\ 0 < l < \infty \quad &\text{if} \quad w = \theta, \\ l = \infty \quad &\text{if} \quad w < \theta. \end{aligned} \tag{2}$$

A representative household owns asset a which consists of liquidity m and interest-bearing asset b,[4]

$$a = m + b, \tag{3}$$

where a, m, and b are measured in real terms. It earns income from labor supply x and

[3] Even if the marginal productivity of labor decreases (Ono, 1996), or if firms use real capital as well as labor for production (Ono, 1994, Chap.12), the following argument is essentially the same.

[4] There are no equities since the firm sector's profits are zero under production function (1) and thus the firm value is zero. In the present setting there are only lending and borrowing between households.

interests from b. We assume the household's labor endowment to be 1, and therefore x represents the employment rate. Then, we have the flow budget equation of the household as follows:[5]

$$\dot{a} = ra + wx - c - Rm, \tag{4}$$

where c is consumption, r the real interest rate, π the inflation rate, and R the nominal interest rate:

$$R = r + \pi.$$

Subject to (3) and (4), the household maximizes

$$U = \int_0^\infty \left(u(c_t) + v(m_t)\right)\exp(-\rho t)dt,$$

where subjective discount rate ρ is assumed to be constant. The optimal conditions are

$$u'(c) = \lambda, \tag{5}$$

$$v'(m) = \lambda R, \tag{6}$$

$$\dot{\lambda} = (\rho - r)\lambda, \tag{7}$$

and the transversality condition is

$$\lim_{t\to\infty} \lambda_t a_t \exp(-\rho t) = 0. \tag{8}$$

From (5), (6), and (7) we derive

$$\rho + \eta(c)\left(\frac{\dot{c}}{c}\right) + \pi = R = \frac{v'(m)}{u'(c)}, \tag{9}$$

$$\text{where } \eta(c) = -u''(c)c/u'(c),$$

which implies equality between the three interest rates; that is, the time preference rate, the return rate of the interest-bearing asset, and the liquidity premium, all measured in monetary terms[6]. The household decides the time paths of c and m so that they satisfy (9) at any point in time and (8) in the infinite future.

The market of liquidity is assumed to adjust perfectly, and hence at any time[7]

$$M/P = m, \tag{10}$$

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[5] This equation is obtained from (3) and the following flow budget equation in nominal terms:

$$\dot{A} = Wx + RB - Pc.$$

[6] Note that liquidity premium $v'(m)/u'(c)$ does not depend on whether it is measured in monetary or real terms since it is the marginal rate of substitution between m and c at the same point in time.

[7] Because of Walras's law with respect to the asset markets, if the liquidity market is in equilibrium then the market of the interest-bearing asset also is.

where M is the nominal liquidity stock. The adjustment of the commodity market is also assumed to be perfect, and therefore it is always satisfied that

$$\theta x = c. \tag{11}$$

Finally, we assume that money wage W adjusts in a sluggish manner, dependent on the excess demand rate in the labor market, so that unemployment may occur.[8] Since labor demand is l and labor endowment is normalized to 1, the dynamics of W is given by

$$\frac{\dot{W}}{W} = \alpha(l - 1). \tag{12}$$

From (2), if $W/P > \theta$, labor demand l is zero and therefore commodity supply is zero, which immediately makes P jump upward so that $W/P = \theta$. If $W/P < \theta$, then from (2) l is ∞ and hence even under the sluggish money wage adjustment given by (12) W instantaneously rises to θP. Thus, it is always satisfied that

$$W/P = \theta, \tag{13}$$

from which

$$\frac{\dot{W}}{W} = \frac{\dot{P}}{P}. \tag{14}$$

Since (13) is valid, from (2) l can take any value. Since from (11) x equals c/θ,

$$l = c/\theta.$$

Therefore, from (12) and (14) we obtain the dynamics of P:

$$\frac{\dot{P}}{P} = \alpha(c/\theta - 1), \tag{15}$$

which implies that P and W move in parallel in accordance with the gap between production capacity θ and effective demand c.[9]

From (10) we derive

[8] Note that this assumption does not avoid the possibility of full employment to occur in the steady state. In fact, we shall show that under satiable liquidity preference the gradual adjustment of W defined by (12) eventually attains full employment. This assumption is imposed only for allowing the possibility of unemployment to exist. If perfect wage adjustment were assumed, the possibility of unemployment would tautologically be avoided from the beginning.

[9] Note that this equation is valid only when $c/\theta \leq 1$. If $c/\theta > 1$, demand exceeds supply in the commodity market since the maximum commodity supply is θ, and because of the instantaneous adjustment of the commodity market P immediately jumps upward so that $c/\theta = 1$. Thus, when considering the dynamics of this economy, we need to treat only the case where $c/\theta \leq 1$

$$\frac{\dot{m}}{m} = -\pi \; (= -\frac{\dot{P}}{P}).$$

By substituting (15) into this equation and into (9), we obtain the dynamic equations of *m* and *c* respectively.

$$\frac{\dot{m}}{m} = -\alpha(c/\theta - 1) \qquad (16)$$

$$\eta(c)\left(\frac{\dot{c}}{c}\right) = \frac{v'(m)}{u'(c)} - \rho - \alpha(c/\theta - 1) \qquad (17)$$

(16) and (17) formulate an autonomous dynamic system with respect to *m* and *c*.

3. Steady States

The Full Employment Steady State

As long as full employment obtains in the steady state of the dynamics represented by (16) and (17), the steady state is the same as that of the standard money-in-utility model.[10] In fact, in the steady state from (16) *c* is

$$c = \theta, \qquad (18)$$

and from (17) and (18) commodity price *P* satisfies

$$v'(M/P)/u'(\theta) = \rho. \qquad (19)$$

Does this state always exist? If $v'(M/P)$ has a strictly positive lower bound (β):

$$v'(m) \geq \beta > 0, \qquad (20)$$

there is a level of θ above which it is always satisfied that

$$\beta/u'(\theta) > \rho. \qquad (21)$$

If (21) is valid, *P* that satisfies (19) does not exist. This condition means that when consumption is determined to be large enough to attain full employment, liquidity premium $\beta/u'(\theta)$ exceeds time preference rate ρ. Obviously, the former implies the desire for saving whereas the latter the desire for consumption. Thus, consumption is set to be lower than the full employment level, causing a shortage in effective demand to occur. This tends to occur especially when per-capita production θ is large. If β is zero,

[10] The steady state given below is the same as that of the money-in-utility model without real capital or population

as is usually assumed in the literature, (21) is not satisfied for any θ, and hence the full employment steady state given by (19) always exists.

In the conventional model, only the cash-in-advance motive for liquidity holding is considered and hence liquidity preference is definitely satiable. However, if there is another motive, such as wealth-holding preference, (20) may be valid.[11] In section 4 we shall empirically investigate if the wealth-holding preference satisfies it.

The Unemployment Steady State

What steady state obtains if (21) holds and therefore a steady state with full employment does not exist?

If c is lower than θ, unemployment occurs and from (12) money wage W continues to decline. From (14), P follows W, causing m to increase and eventually $v'(m)$ to be β. Therefore, if c reaches the steady state level c_u that makes (17) zero, we have

$$\beta/u'(c_u) = \rho + \alpha(c_u/\theta - 1) \tag{22}$$

In figure 1 the ℓ and π curves respectively show the left- and right-hand side of (22).

$$\ell \text{ curve:} \qquad R = \beta/u'(c)$$

$$\pi \text{ curve:} \qquad R = \rho + \alpha(c/\theta - 1) \tag{23}$$

Consumption c_u that satisfies (22) is given by A, the intersection point of the two curves. Note that under (21) the ℓ curve is located above the π curve when $c = \theta$. Thus, for c_u to exist in the relevant range it must be satisfied that[12]

$$\rho > \alpha. \tag{24}$$

In this state P continues to decline and expands m to infinity. Nevertheless, transversality condition (8) is satisfied, as proven below. From (16) and (22) m satisfies

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growth. See Blanchard and Fischer (1989, pp.188-191) for it.

[11] Generally, each asset has both liquidity and profitability. In the present model m and b respectively summarize the liquidity and the profitability of all assets. In fact, we can obtain essentially the same result in a more general model where there are various assets a_i ($i = 0, 1, \ldots, n$) which constitute liquidity $a_0 + m(a_1, \ldots, a_n)$, generate the utility of liquidity $v(a_0 + m(a_1, \ldots, a_n))$, and also yield returns $(0, R_1, \ldots, R_n)$. Obviously, a_0 is cash in this model.

[12] Under (21) and (24) the dynamics given by (16) and (17) is proven to be saddle-path stable around the unemployment steady state defined by (22). See Ono (1994, 1999) for the proof of the stability.

$$\frac{\dot{m}}{m} = \rho - \beta/u'(c_u) < \rho. \tag{25}$$

From (25), transversality condition (8) is valid since the total stock of b is zero and thus $a = m$.

The steady state obtained above has Keynesian features. For example, an increase in fiscal spending raises consumption. Specifically, in the presence of fiscal spending g, the commodity market equilibrium condition (11) is replaced by

$$\theta x = c + g.$$

Thus, in (23) the π curve is rewritten as

$$\pi \text{ curve:} \qquad R = \rho + \alpha[(c + g)/\theta - 1],$$

while the ℓ curve remains unchanged. An increase in fiscal spending g shifts only the π curve upward. In figure 2 it is represented by a movement of the π curve to the π' curve. Consequently, A, the intersection point, moves to A′, causing consumption c_u to rise.

Also, a rise in α, the adjustment speed of money wage W, turns the π curve counterclockwise around B with the ℓ curve unaffected, as is clear from (23). Consequently, in figure 2, the π curve turns to the π'' curve, and hence A moves to A″, causing consumption c_u to decline. This result is opposite to the neoclassical or Keynesian view that the more rapidly prices and wages adjust, the sooner an effective demand shortage disappears. It is more in conformity with Keynes's own view (1936, Ch.19) that a rise in the wage adjustment speed tends to reduce effective demand.

Note that wage rigidity does not cause persistent unemployment in our model, while it does in Keynesian models. In fact, in the present steady state P and W continue to adjust and realize full-employment real wage θ, yet persistent unemployment occurs. Even if we assume the perfect adjustment of W, as in standard models, the full employment steady state does not exist, since condition (21) is unrelated to α.

4. Empirical Research on Insatiable Liquidity Preference

To summarize the previous section, if there is a strictly positive lower bound for

$v'(m)$, a shortage of effective demand is derived from a dynamic optimization framework. We can analyze economic fluctuations without using an ad hoc model, such as the IS-LM model. This section empirically investigates the validity of this hypothesis that $v'(m)$ has a strictly positive lower bound.

We use two different econometric methods. One is a parametric method that specifies utility functions and tests the hypothesis with the estimated parameters, while the other is a nonparametric method that does not specify any functional form. We apply these two methods to different data sets. A first is the cross-section data of all prefectures in Japan. Its sample size is only 47 per year, and hence it is too small to use a nonparametric method. The other is the survey data called NIKKEI RADAR, whose sample size is large enough to apply a nonparametric method. If the same result is obtained from both of them, it should be regarded as a reliable one.

The function to be estimated is given by the second equality of (9), which shows equality between the nominal interest rate and the liquidity premium:

$$R = v'(m)/u'(c). \tag{26}$$

Since a year is specified when using cross-section data, everybody faces the same interest rate R and therefore R is treated as a constant.

Parametric Analysis with Prefectural Data

In the parametric analysis we specify the utility function of consumption as the following constant-relative-risk-aversion type:

$$u(c) = c^{1-\delta}/(1-\delta), \tag{27}$$

where δ is the degree of relative risk aversion. Liquidity preference is specified in such a manner that we may incorporate the possibility that the marginal utility of liquidity has a positive lower bound (β).

$$v(m) = \beta m + \theta m^{1-\gamma}/(1-\gamma). \tag{28}$$

Substituting (27) and (28) into (26) and arranging the result yield the following equation to be estimated.[13]

[13] What we estimate here is an *intra*-temporal first-order condition between consumption and liquidity. The *inter*-temporal first-order condition of consumption (or the Euler equation) for Japanese households has empirically been tested by Hayashi (1985). He concludes that its validity is weakly supported.

$$(1/c)^{\delta} = \beta/R + (\theta/R)(1/m)^{\gamma}. \tag{29}$$

If and only if β is strictly positive, the intercept of (29) must be strictly positive. Note that R is taken to be constant since we use cross-section data.

We use the prefectural data in the fiscal years of 1980, 1985, and 1990, and estimate (29) for each year.[14] Final consumption expenditure of households are taken from *Annual Report on Prefectural Accounts, Economic Research Institute of Economic Planning Agency*, and liquidity from *National Survey of Family Income and Expenditure, Statistical Bureau of Management and Coordination Agency*. We construct two measures of liquidity. One is liquid financial assets defined by financial wealth minus life insurance. The other is the first liquidity measure minus stocks. All are measured on the per-household basis and divided by the deflator of final consumption.

Note that consumption and liquidity levels are simultaneously determined in (29). Therefore, we use the nonlinear three-stage least-square estimation. Since we are unable to estimate all the parameters of (29) stably, we use extraneous information only on the degree of relative risk aversion (δ). The value of δ is taken from two different studies. One is Ogawa (1993), where it is estimated to be 1.866, and the other is Ikeda and Tsutsui (1996), where the representative figure is 3.811. By choosing quite different values for δ we examine the robustness of our estimation results. The instrument variables are the active job opening ratio, population in the age bracket of 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50, 50-55, 55-60, and 60 over, the proportion of farm households, the proportion of house owners, and the average number of workers in a household.

The results are summarized in tables 1 and 2. In table 1 liquid financial assets are used to represent liquidity whereas in table 2 liquid financial assets excluding stocks are. They show that the intercept is significantly positive at the standard significance level, irrespective of the sample period, the liquidity measure, or the value of relative risk aversion. Thus, it is strongly supported that $v'(m)$ has a strictly positive lower bound.

In the previous section it is shown that in this case there is an upper bound of

[14] Asset data are available on the prefectural basis only for these three years.

consumption (c^*) for a given R. It satisfies

$$\beta/u'(c^*) = R.$$

Using the estimates obtained above we calculate it for each year. Table 3 summarizes estimates for c^*. Its level is found to be quite robust to the choice of liquid assets and relative risk aversion. Note that the actual average levels of consumption are 40.5286 (×100,000 yen) in 1980, 43.5695 in 1985, and 48.2405 in 1990. They are about 96%, 96%, and 97% of the estimated upper bound for each year.

Nonparametric Analysis with NIKKEI RADAR

In the nonparametric analysis we employ data from *NIKKEI RADAR* 1994, which surveys 5000 persons from 25-year-old to 69-year-old, living in Tokyo, Kanagawa, Chiba, or Saitama Prefecture. The liquidity measure we use is financial assets including securities and investment trusts, but excluding life insurance.[15] Consumption is calculated as the difference between annual income and saving. After excluding the households that do not report all of income, consumption, and assets, we eventually have 1539 samples.

We represent the implicit function of c and m given by (26) as[16]

$$1/c = \varphi(1/m). \tag{30}$$

Defining X_i and Y_i as the inverse of household i's observed per-capita liquidity and that of per-capita consumption respectively, and U_i as the random error, we have the following stochastic model:

$$Y_i = \varphi(X_i) + U_i, \quad i = 1,..., N. \tag{31}$$

The errors are assumed to be *i.i.d.*

We consider the following null and alternative hypotheses:

$$H_0 : \varphi(0) = 0,$$

$$H_1 : \varphi(0) > 0.$$

If the null is rejected, consumption c in (30) is bounded to be finite for any level of m. From (26) this implies that the lower bound of $v'(m)$ is strictly positive. We here employ

[15] We need not distinguish the real and nominal data of liquidity and consumption since we use just one-year data.

a nonparametric method, constructing the confidence interval of the nonparametric estimate of $\varphi(0)$, $\hat{\varphi}(0)$.[17] Since we do not specify $\varphi(\cdot)$, the result is robust to its functional form. Figure 3 plots the relationship between X and Y. Since the variance of Y conditional on X seems to be too large to conjecture a reasonable functional form between them, it is indeed better to use a nonparametric method than a parametric one.

When using a nonparametric method, we have to decide which kernel and what size of bandwidth h should be chosen. We employ 5 widely-used kernels, namely Gaussian, Epanechnikov, Quartic, Triangle and Uniform kernels. In deciding h we use the cross-validation criterion, which minimizes the prediction error of the model, since $\hat{\varphi}(0)$ is an out-of-sample prediction and this criterion is suitable for it.

Table 4 shows $\hat{\varphi}(0)$ and the critical values of one-sided 95% and 99% confidence intervals for various kernels and bandwidths. From the table it is immediately found that 0 is not included within neither the 99% nor the 95% confidence interval for any kernel or any bandwidth around the optimum one. Thus, null hypothesis H_0 is rejected.

Note that for all the kernels besides Gaussian data are truncated depending on the size of h. For them we start h from 0.3 since there are only a few data of Y_i below it and hence we doubt the efficiency of estimation. By contrast, the Gaussian kernel uses all data for estimation so that we can calculate the cross-validation for various sizes of h. Table 3 displays only the results for the value of h that minimizes the cross-validation and around.

5. Conclusion

If the marginal utility of liquidity reaches zero as the amount of liquidity infinitely increases, as assumed in standard money-in-utility dynamic models, a steady state with full employment necessarily exists. In this state neoclassical implications, such as the crowding-out effect of fiscal spending on private expenditure, would hold. If liquidity

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[16] Although $\varphi(\cdot)$ depends on R as well, we can neglect its influence since R is the same by all individuals in the same year, as mentioned at the outset of this section.

preference is insatiable, by contrast, and hence the marginal utility of liquidity has a positive lower bound, as assumed in Ono (1994, 1999), there is a case where a steady state with full employment does not exist and then persistent unemployment occurs. In this state various Keynesian implications hold, e.g., fiscal spending raises private consumption.

Using two data sets, prefectural and individual, and applying parametric and nonparametric methods to each of them respectively, we empirically investigate which hypothesis is more plausible. Consequently, the property that the marginal utility of liquidity has a strictly positive lower bound is strongly supported by both studies.

Thus, we conclude that the possibility of persistent unemployment, which have been excluded from the conventional dynamic optimization framework and treated only in either the ad hoc IS-LM analysis or static general equilibrium models with some permanent distortions, can be treated in the standard money-in-utility dynamic model.

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[17] For the detail of this method, see Hąrdle (1990) and Hąrdle and Linton (1994).

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Table 1: Empirical Result on Equation (29)
by Instrumental Variable Method
(The Case of All Liquid Assets)

	β/R	θ/R	γ
1980			
$\delta = 1.866$	0.00092	22.8188	3.4093
	(10.13)	(0.13)	(1.42)
$\delta = 3.811$	0.6291×10^{-6}	0.0652	3.5566
	(4.43)	(0.14)	(1.56)
1985			
$\delta = 1.866$	0.00081	17.1007	3.2878
	(14.45)	(0.19)	(2.00)
$\delta = 3.811$	0.4898×10^{-6}	0.0362	3.3882
	(6.19)	(0.20)	(2.12)
1990			
$\delta = 1.866$	0.00069	339.638	3.8979
	(17.73)	(0.11)	(1.61)
$\delta = 3.811$	0.3580×10^{-6}	1.0415	4.1514
	(8.43)	(0.12)	(1.74)

*) *t*-values in parentheses.

The instruments are active job opening ratio, population in the age bracket of 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50, 50-55, 55-60, and 60 over, proportion of farm household, proportion of house owner, and average number of workers in a household.

Table 2: Empirical Result on Equation (29)

by Instrumental Variable Method

(The Case of Liquid Assets without Stocks)

	β/R	θ/R	γ
1980			
$\delta = 1.866$	0.00092	295.605	4.3695
	(10.41)	(0.11)	(1.40)
$\delta = 3.811$	0.6446×10^{-6}	1.9935	4.8048
	(5.07)	(0.11)	(1.57)
1985			
$\delta = 1.866$	0.00081	101.129	3.9707
	(13.95)	(0.16)	(1.99)
$\delta = 3.811$	0.4878×10^{-6}	0.2538	4.1311
	(6.14)	(0.17)	(2.14)
1990			
$\delta = 1.866$	0.00067	67.0075	3.6287
	(6.14)	(0.11)	(1.29)
$\delta = 3.811$	0.3434×10^{-6}	0.3495	4.0565
	(5.47)	(0.11)	(1.47)

*) *t*-values in parentheses.

The instruments are active opening ratio, population in the age bracket of 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50, 50-55, 55-60, and 60 over, proportion of farm household, proportion of house owner, and average number of workers in a household.

Table 3

Upper Bound of Consumption that satisfies $\beta/u'(c^*) = R$

	The case of all liquid assets	The case of liquid assets without stocks
1980		
$\delta = 1.866$	42.376	42.376
$\delta = 3.811$	42.384	42.115
1985		
$\delta = 1.866$	45.369	45.3692
$\delta = 3.811$	45.262	45.310
1990		
$\delta = 1.866$	49.440	50.226
$\delta = 3.811$	49.142	49.682

Notes: The unit is one hundred thousand yen.

Table 4: Estimates of Various Kernels

				Gauss Kernel					
h =	0.10	0.12	0.14	0.16	0.18	0.20			
$\hat{\varphi}(0)$	0.4392	0.4473	0.4535	0.4584	0.4627(*)	0.4667			
95%CLO	0.4039	0.4169	0.4263	0.4335	0.4395	0.4447			
99%CLO	0.3893	0.4043	0.4151	0.4233	0.4299	0.4356			
				Epanechnikov Kernel					
h =	0.3	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46
$\hat{\varphi}(0)$	0.4172(*)	0.4282	0.4378	0.4447	0.4521	0.4570	0.4596	0.4616	0.4623
95%CLO	0.3652	0.3864	0.4011	0.4117	0.4219	0.4291	0.4337	0.4370	0.4389
99%CLO	0.3437	0.3691	0.3860	0.3980	0.4095	0.4176	0.4230	0.4269	0.4293
				Quartic Kernel					
$\hat{\varphi}(0)$	0.4147	0.4205(*)	0.4291	0.4359	0.4419	0.4473	0.4516	0.4547	0.4570
95%CLO	0.3524	0.3721	0.3873	0.3984	0.4077	0.4157	0.4220	0.4270	0.4307
99%CLO	0.3267	0.3522	0.3701	0.3830	0.3936	0.4026	0.4098	0.4155	0.4198
				Triangular Kernel					
$\hat{\varphi}(0)$	0.4171(*)	0.4277	0.4371	0.4438	0.4508	0.4556	0.4583	0.4603	0.4612
95%CLO	0.3649	0.3857	0.4001	0.4104	0.4203	0.4273	0.4320	0.4354	0.4374
99%CLO	0.3434	0.3684	0.3849	0.3967	0.4078	0.4157	0.4211	0.4251	0.4276
				Uniform Kernel					
$\hat{\varphi}(0)$	0.4216	0.4513	0.4480	0.4544	0.4655(*)	0.4676	0.4682	0.4649	0.4667
95%CLO	0.3768	0.4136	0.4163	0.4249	0.4389	0.4434	0.4454	0.4434	0.4457
99%CLO	0.3583	0.3980	0.4032	0.4127	0.4280	0.4335	0.4360	0.4345	0.4370

1) The cross-validation has the minimum value at the bandwidth with (*).

2) 95%CLO and 99%CLO respectively show the critical values of 95% and 99% confidence intervals.

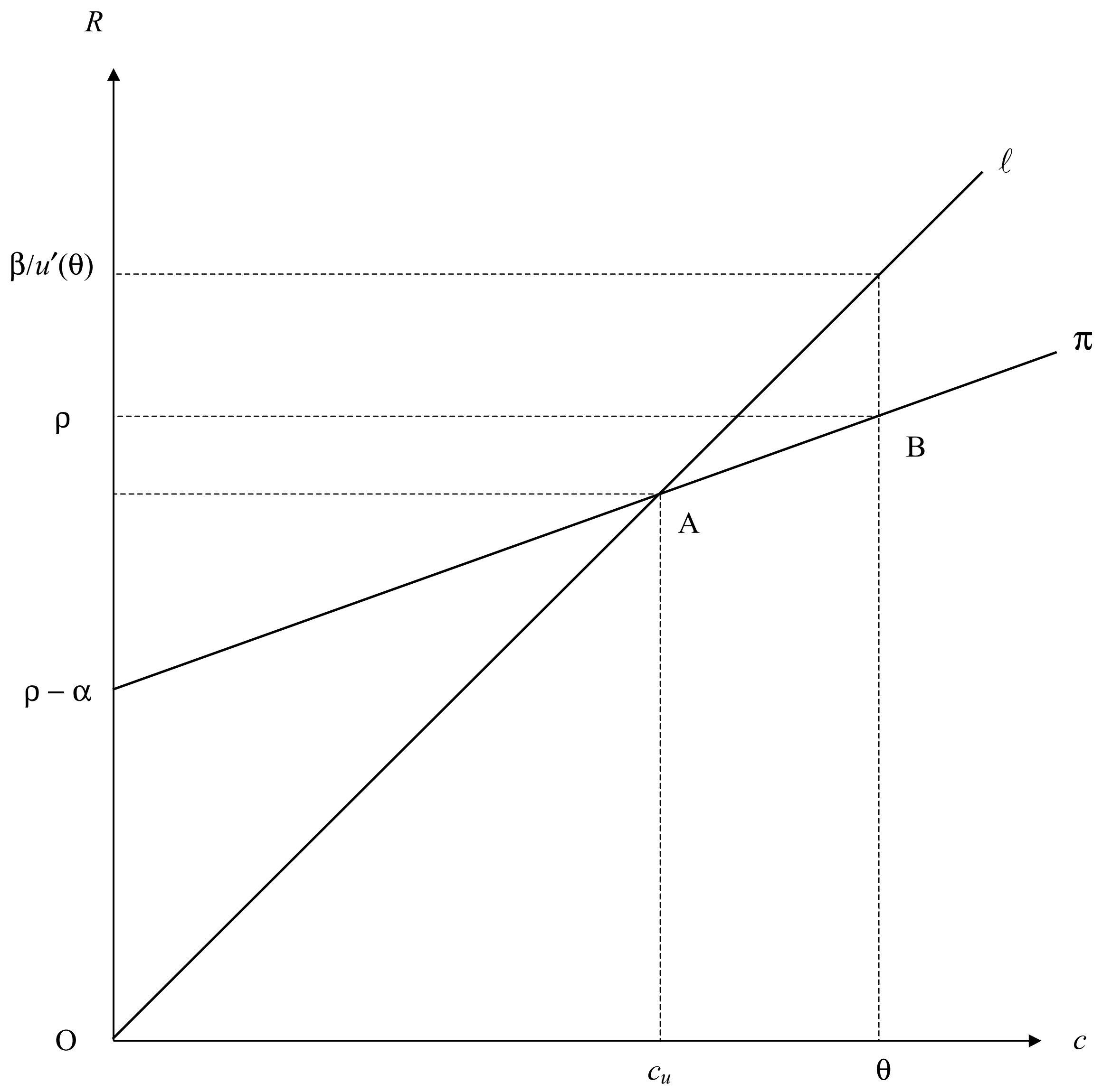


Figure 1

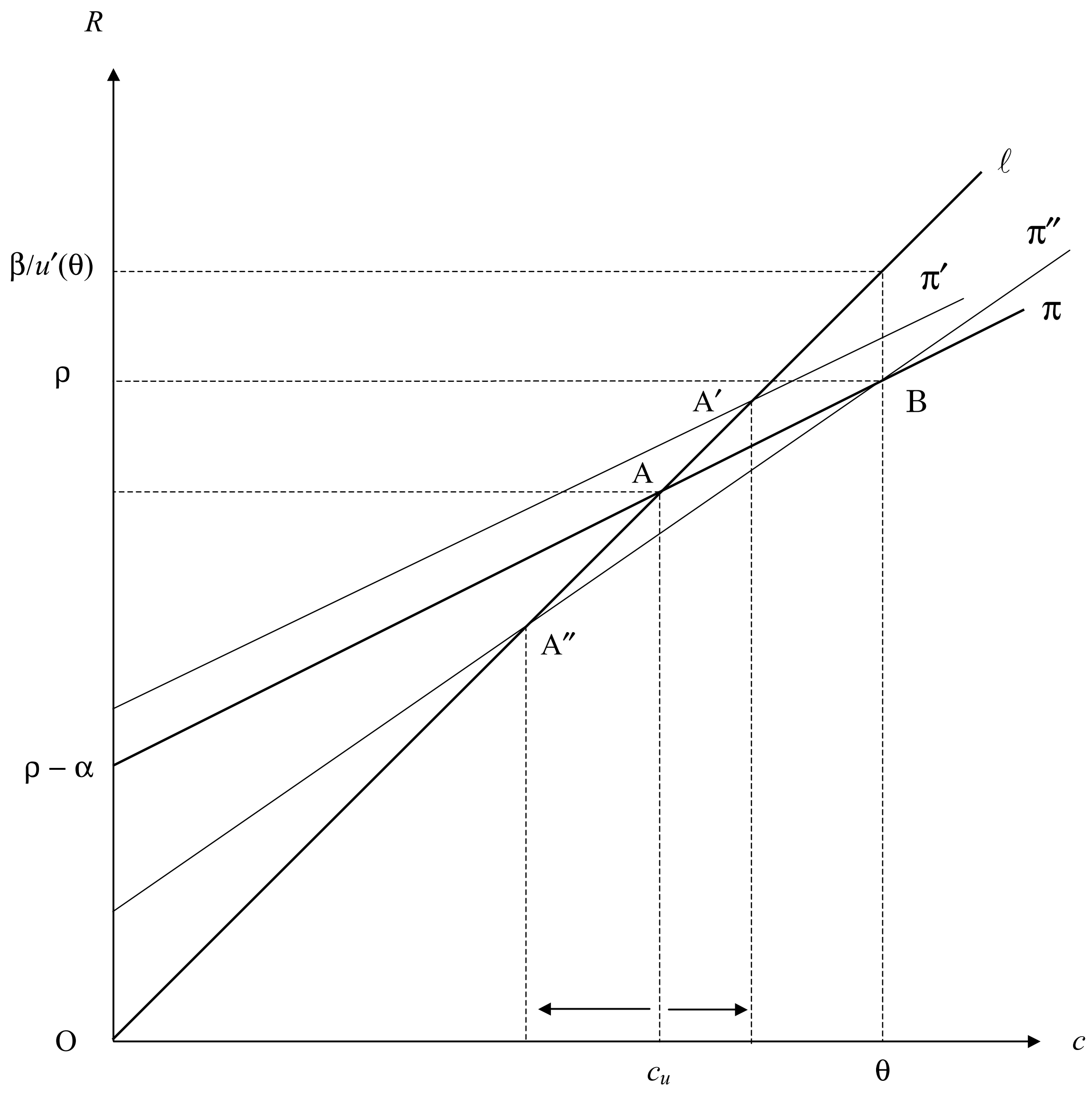
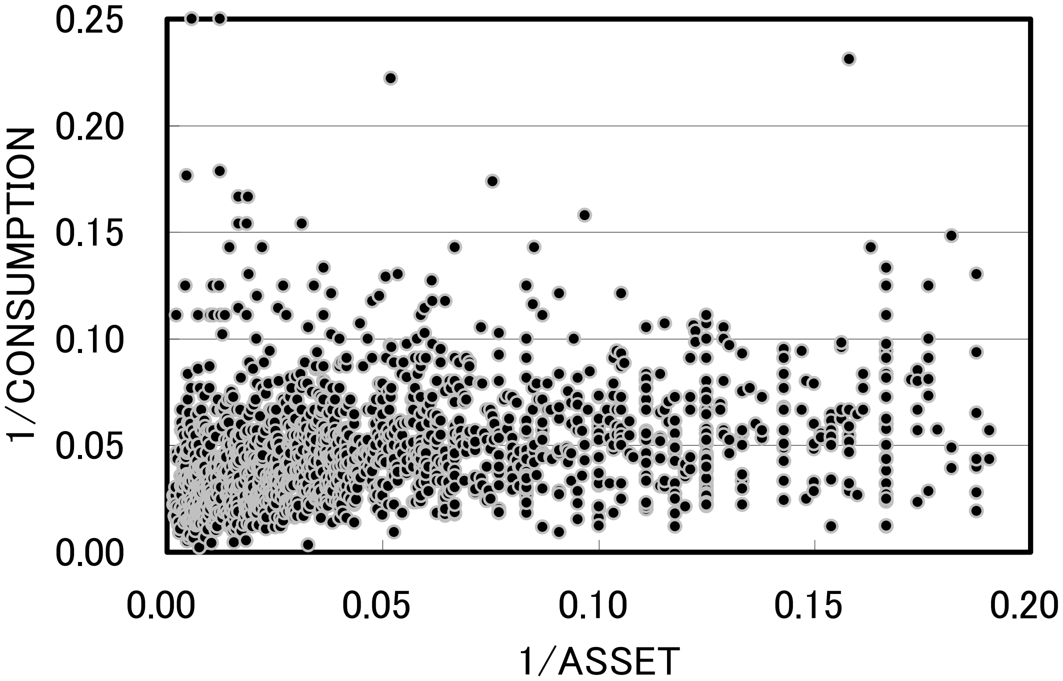


Figure 2

Figure 3



0.25
0.20
0.15
0.10
0.05
0.00
1/CONSUMPTION
0.00
0.05
0.10
0.15
0.20
1/ASSET