# Liquidity Traps and the Stability of Money Demand: Is Japan Really Trapped at the Zero Bound?

Ryuzo Miyao*

Research Institute for Economics and Business Administration

Kobe University

Email: miyao@rieb.kobe-u.ac.jp

October 2002

--- preliminary draft ---

[Abstract]

Is the Japanese economy really trapped at the zero interest rate bound? The question seems particularly important because recent theoretical discussions on liquidity traps suggest that undesirable dynamics such as ``deflationary spiral'' are likely to occur when the economy reaches the lower zero bound. This paper attempts to answer the above question by analyzing the stability of an equilibrium money demand relationship in Japan. Specifically, it performs a formal analysis on the presence and stability of cointegration in M1 demand in Japan and argues that the answer seems negative. With the double-log specification, a cointegrating M1 relationship exists and is found to be stable (i.e. no break in the interest elasticity) even after 1995 when nominal rates were lowered to a decimal point level or virtually ``zero percent''.

* I am grateful to seminar participants at Kobe University and Kosuke Aoki for helpful comments and discussions given to an earlier version of this draft. Any errors are of my own.

## 1. Introduction

Is the Japanese economy really in a ``liquidity trap''? Liquidity traps may be broadly defined as a situation in which conventional monetary policies are ineffective to raise output or prices with near zero nominal interest rates. This broad definition seems to fit Japan well. In fact, the call rate, a primary indicator of monetary policy in Japan, was lowered to 1 basis point (0.01 percent) in 1999 by the zero interest rate policy and further down to 0.1 basis point by a sequence of aggressive monetary injections known as ``quantitative easing'' in 2001. Yet the economy exhibits no sign of strong recovery and prices are still gradually declining. All these observations seem consistent with the broad definition of liquidity traps.[1]

Perhaps more controversial is whether the Japanese economy has already reached the lower zero bound on nominal interest rates. Krugman (1999) refers to liquidity traps as a situation where money and bonds become perfect substitutes or indistinguishable when nominal rates vanish. If this is the case, money demand will be indeterminate. A further increase in money supply will be simply hoarded by the public or banks by an arbitrary amount in the form of extra cash or excess reserves. This implies that an equilibrium or ``long-run'' money demand relation will cease to exist as residuals of that relationship become no longer stationary. Alternatively, money demand becomes perfectly elastic at the zero interest rates, so that one should observe a break in the interest elasticity. In either case, reaching the zero floor may cause a fundamental shift in an equilibrium money demand relation.

Recent theoretical contributions on liquidity traps also suggest that the economy at the zero interest rate bound has important implications in terms of economic dynamics. For instance, Buiter and Panigirtozoglou (1999) develop a dynamic framework where monetary policy is assumed to follow an active interest rate feedback rule known as ``Taylor (1993) rule.'' Their phase diagram indicates that both a stable equilibrium in normal times and a lower, ``liquidity trap'' equilibrium emerge. The latter one may appear when deflationary pressures increase and the nominal rate actually reaches the zero floor. Reifschneider and Williams (2000) also employ a simple stylized model with a

---

[1] See e.g. Miyao (2000, 2002) for recent evidence on the effectiveness of monetary policy in Japan

Taylor rule and demonstrate that the economy exhibits a ``deflationary spiral,'' where a decrease in inflation raises the level of real interest rates at the zero nominal rate, lowers aggregate demand and inflation, and therefore raises the real interest rate even further. Such instable dynamics tend to emerge when the economy stays at the zero interest rate bound and experiences further deflationary pressures. [2]

Because these undesirable dynamics such as deflationary spiral are likely to occur after the economy reaches the zero interest rates, it is all the more important to examine empirically whether Japan is really trapped at the zero bound. To this end, we return to the implications of zero interest rates on an equilibrium money demand relation discussed above and examine the stability of money demand in Japan in some detail.

More specifically, we study the presence and stability of a cointegrating M1 demand relation in Japan using quarterly observations for the period of 1975-2001. Some previous studies addressed the issue of a liquidity trap in Japan and investigated it empirically in one way or another. But the existing evidence appears mixed. For example, Hondroyiannis, Swany, and Tavlas (2000) showed that the absolute value of the estimated interest elasticity declines at a lower level of interest rates, which is contrary to the presence of a liquidity trap. Nakashima and Saito (2002), on the other hand, used a semi-log specification and found that the interest semi-elasticity becomes larger in recent years of low interest rate policy in Japan. Fujiki,Hsiao and Shen (2002) performed a dynamic panel analysis using Japanese prefecture data for 1992-97 and argued that there is no evidence of a liquidity trap from perspectives of out-of-sample prediction. Finally, Fujiki (2002) reexamined the aggregate stability using his cross-sectional estimate of the income elasticity and documented a similar increase in the interest elasticity as Nakashima and Saito (2002).[3] With these mixed results, the question still needs to be resolved. In particular we address the issue concerning the interest elasticity

---

2 One may obtain different dynamics when the role of fiscal policy and/or the wealth effect of deflation are taken into account. See also Benhabib, Shmitt-Grohe and Uribe (2001, 2002) who demonstrate a different type of instability. In their framework, a lower liquidity-trap equilibrium emerges anywhere before the economy reaches the zero bound. Note further that the lower equilibrium is also shown as stable (i.e. no deflationary spiral).

3 Other related studies include Cargill, Hutchison and Ito (2000). They discussed rather informally whether the recent ineffectiveness of Japan's monetary policy can be attributed to a liquidity trap as claimed by Krugman (1999).

versus semi-elasticity (i.e., the use of interest rates in log versus in levels) with some care as the difference necessarily matters near zero interest rates.

Summarizing our main results here, we find that (i) the presence of cointegration in M1 is reasonably well supported by the data and (ii) with the double-log specification, the relationship is in fact found to be stable and no break in the interest elasticity is detected. Thus the evidence seems to suggest that Japan is not yet trapped at the zero bound even after 1995 when nominal rates were lowered to a decimal point level and more or less ``zero percent''.

## 2. Theoretical Background

This section briefly reviews recent development on theories of liquidity traps. While there seems little disagreement in terms of the broad definition of liquidity traps that monetary policies are impotent due to near or virtually zero interest rates, economic theories on liquidity traps have several related but nonetheless different characterizations.

Firstly, in a standard textbook-type presentation, liquidity traps are referred to as a horizontal LM curve when money demand is perfectly elastic with respect to interest rates. Thus there must be a break and a fairly large increase in the interest elasticity at some low level of interest rates. Note that in this characterization, the lower bound on nominal interest rates may not be necessarily zero and can be some positive value. From optimality conditions under a standard money-in-utility framework, this implies that marginal utility of holding additional real balances is bounded at some positive level, i.e. the desire of holding money is insatiable even when money holding becomes infinitely large. Ono (2001) demonstrates that such insatiable liquidity preference generates the liquidity trap and neutralizes the Pigou effect, which in turn makes economic stagnation persistent.

Secondly, Krugman (1999) defines liquidity traps as a situation where money and bonds become indistinguishable when nominal rates reach the lower zero bound. As we discussed in the introductory section above, this implies that money demand becomes indeterminate and an equilibrium or long-run money demand relation will cease to exist. Woodford (1999) also refers to liquidity traps as equilibria in which nominal rates are at the lower zero bound and real money balances are at or beyond a finite satiation level (i.e., the marginal utility of money is zero).

Thirdly, Buiter and Panigirtozoglou (1999) and Reifschneider and Williams (2000) characterize liquidity traps in a dynamic framework in which monetary policy is assumed to follow an active interest rate feedback rule known as ``Taylor (1993) rule.'' Buiter and Panigirtozoglou (1999) set up two differential equations (i.e. consumption growth and Phillips-curve type inflation growth equatoins). Their phase diagram indicates that there exists a saddle-path stable equilibrium in normal times when the zero bound constraint is not binding. But when the economy hits the zero bound due to an increase in deflationary pressures and the constraint is binding, a lower, ``liquidity trap'' equilibrium emerge. Reifschneider and Williams (2000) also employ a simple stylized model with aggregate demand growth, inflation growth and again a Taylor rule with the zero lower bound. They demonstrate that the economy exhibits both a stable equilibrium in normal times and ``deflationary spiral'' after the zero bound constraint is binding. The latter situation occurs because a decrease in inflation raises the level of real interest rates at the zero nominal rate, lowers aggregate demand and inflation, and therefore raises the real interest rate even further. Note that in these two studies, the liquidity trap regime and the deflationary spiral region are attributed to nominal rates at the zero lower bound.

Finally, Benhabib, Schmitt-Grohe and Uribe (2001, 2002) demonstrate a different type of liquidity traps. They use an optimizing money-in-utility framework together with an active Taylor rule and show that a stable, liquidity-trap equilibrium may emerge. What is different here is that liquidity traps may occur before the economy reaches the zero interest rate bound, i.e, before the marginal utility of money becomes zero. This clearly differs from the second and third characterizations above. This is also different from the first type because here no assumption of insatiable liquidity preference (which corresponds to a positive lower bound of the marginal utility of money) is imposed. Thus, unlike the above three cases, Benhabib and others' liquidity traps may emerge even when an equilibrium money demand relation is well defined.

The brief review of these theories of liquidity traps motivates our formal econometric analysis of Japanese money demand in the subsequent section. If we fail to support the presence of cointegration in money demand especially in recent years of near zero nominal rates, this suggests that Japan may experience Krugman's liquidity traps where the zero interest rate bound is reached and undesirable dynamics such as deflationary spiral may be likely to occur. Alternatively, when we support the presence of cointegration but detect a break in the interest elasticity and moreover the elasticity becomes fairly large, then we cannot rule out the possibility of the first, conventional type of liquidity traps. The stagnation story regarding insatiable liquidity preference may also apply. A formal cointegraiton analysis of long-run money demand helps us understand the presence and nature of a possible liquidity trap in Japan.[4]

## 3. Investigating the Stability of Money Demand in Japan

We analyze the following two forms of a conventional money demand relationship with assuming the unit income elasticity:

$$M - P - Y - b_r LRCALL = e \quad (1)$$

$$M - P - Y - \tilde{b}_r RCALL = e \quad (2)$$

where *M*, *P*, and *Y* denote nominal money supply (here M1), the price deflator (here the GDP deflator) , and real output (real GDP), all in logarithm, *LRCALL* and *RCALL* denote the overnight call rate in log and in levels, respectively, $b_r$ and $\tilde{b}_r$ are the interest elasticity and semi-elasticity, respectively, and $e$ is the money demand residual.[5] Thus equations (1) and (2) correspond to the ``double-log'' and ``semi-log'' forms of an equilibrium money demand relation. We use quarterly observations for the period of 1975:1-2001:4.[6]

---

[4] Not to mention, even when the evidence is in support of both the presence and stability of cointegration, we cannot rule out the possibility of Benhabib and others' liquidity traps.

[5] We assume the unit income elasticity mainly because the dimension of the estimation system is reduced and thereby more reliable empirical results can be obtained in the cointegration analysis below. Note that one can derive the unit income elasticity specification from a standard money-in-utility framework with log or CRRA type utility: see e.g. Walsh (1998). However, to check robustness, we later impose alternative values of the income elasticity taken from cross-sectional estimates by Fujiki (2002) and Fujiki, Hisao and Shen (2002).

[6] M1 is seasonally adjusted, monthly average series taken from the Nikkei Database (MT code 32917) and monthly observations are averaged within each quarter to obtain quarterly series. Real GDP and GDP deflator are seasonally adjusted and retrieved from 93SNA. Because 93SNA data are available since 1980, they are linked with corresponding 68SNA data at 1980:1. These SNA statistics can be taken from the Cabinet Office of Japan's web site at www.esri.cao.go.jp/en/sna/menu.html. The call rate series is constructed first by linking the uncollateralized overnight rate (monthly

As a preliminary to apply the concept of cointegration, we perform unit root tests for each of the variables: $M-P-Y$ (which is denoted as *M1VEL* hereafter) and the two call rate series *LRCALL* and *RCALL*. We run the augmented Dickey Fuller (1979) tests of a unit root against no unit root (ADF), and a modified Dickey-Fuller test based on GLS detrending series (DF-GLS), a powerful univariate test proposed by Elliot, Rothenberg and Stock (1996). A constant term is included in both tests. We further perform the sequential minimal Dickey-Fuller test proposed by Banerjee, Lumsdaine and Stock (1992) (denoted as BLS) that allows for a break in a deterministic trend in an unknown timing. In all these tests, the optimal lag length is chosen based on SBIC (up to six lags). As shown in Panel A of Table 1, no tests reject the null of a unit root against the alternative of stationarity even with the allowance of a possible break in a linear trend. Taking the first difference, both ADF and DF-GLS detect strong rejections for all the cases (Panel B). These results imply that each of the underlying variables can be treated as a single unit root process or integrated of order one (I(1)).

We now proceed to the cointegration analysis for equations (1) and (2). Here two conventional cointegration tests are performed: the augmented Dickey-Fuller test of no cointegration against cointegration (denoted ADF again) and Johansen's (1988) and Johansen and Juselius's (1990) maximal eigenvalue test of no cointegration against one cointegrating vector (JOH). Moreover, to allow for a possible break in cointegration, we employ a test procedure proposed by Gregory and Hansen (1996) and implement the augmented Dickey-Fuller test of no cointegration against cointegration with a structural shift in cointegration (i.e. a break in the cointegrating vector --- both intercept and slope coefficients) in an unknown timing (denoted as GH). The optimal lag length is chosen based on SBIC and is shown in parentheses except for JOH test with *RCALL*, where five lags are arbitrarily used.[7] Critical values for each of the tests are tabulated by

---

average) after July 1985 and the collateralized rate (monthly average) until June 1985 and then taking average of monthly observations in each quarter. In linking the two series, the mean difference between the two is added to the collateralized rate. These call rate data are taken from the statistics section of the Bank of Japan homepage at www.boj.or.jp. Note also that the starting date here is chosen to avoid possible structural breaks in the early 1970s including the first oil crisis and the exchange rate regime shift.

[7] Using SBIC, one lag is selected with *RCALL* for JOH, which appears too short. We perform a modified likelihood ratio test proposed by Sims (1980) and test (i) one lag versus five lags and (ii) five lags versus eight lags. Then the null of one lag is rejected in

MacKinnon (1991) for ADF, Osterwald-Lenum (1992) for JOH, and Gregory and Hansen (1996) for GH. As for JOH, following the procedure by Cheung and Lai (1993), Osterwald-Lenum's critical values are corrected to account for possible size distortions (over-rejections) in finite samples.

Table 2 reports the cointegration test results. Using conventional ADF tests, we cannot detect cointegration. On the other hand, JOH tests consistently support cointegration with finite-sample critical values. When we allow for the possibility of a structural shift in cointegrating vector, GH test detects cointegration with the logged call rate (*LRCALL*) but not with the call rate in levels. Because augmented Dickey-Fuller tests are known to have a low power in general, we interpret that the failure of ADF (or partially GH) detecting cointegration can be attributed to a low power of these tests. On the other hand, since the Johansen procedure here already takes into account the over-rejection problem in finite samples, these consistent rejections by Johansen tests of Table 2 are reasonably reliable. Thus the evidence seems generally in support of the presence of a cointegrating M1 demand relation in Japan. Because money demand residuals are characterized as stationary, we view that the Japanese economy has not yet experienced the zero interest rate bound.

Given that cointegration in M1 exists, we then investigate parameter stability, i.e., constancy in the cointegrating vector. We perform Hansen's (1992) two stability tests: SupF and MeanF. SupF tests the null of constancy against the alternative of a parameter shift in an unknown timing. MeanF tests the null of stability against the alternative of instability where the parameter follows a random walk process. The Bartlet kernel estimator (unprewhitened) is used with automatic bandwidth selection procedure proposed by Andrews (1991). We further employ Hansen and Johansen's (1993) stability test (denoted as HJ). In that procedure we use the benchmark parameter that is estimated with the subsample upto the second quarter of 1995. Note that the call rate was lowered to a decimal point level (i.e. below one percent) in July 1995. We test the null hypothesis that the benchmark estimate is equal to the parameter estimated with the full sample. HJ test statistics follow a chisquare distribution with degree of freedom

---

the former test and the null of five lags is not rejected in the latter, which seems to justify the present five lag specification.

2.

Table 3 summarizes the stability tests results. Using *LRCALL*, we are unable to reject the null of parameter constancy from all the three tests, providing support to the stability in M1 demand relation (i.e. no break in the interest elasticity). On the other hand, when *RCALL* is used, we find consistent rejections from each of the three stability tests. These results suggest that while the interest elasticity remains stable during the sample period, the interest *semi-elasticity* shifted during the sample period, particularly in 1995. The possible shift in the semi-elasticity is consistent with the finding by Nakashima and Saito (2002).

Finally we estimate the cointegrating vector by dynamic OLS procedure of Saikkonen (1991) and Stock and Watson (1993). Five leads and lags are used in these estimations together with the Newey-West standard error with five lags truncation. We estimate the cointegrating vector with and without allowing a possible break in 1995:2/1995:3. Here the sample period begins in 1985 (i.e. 1985:1-2001:4) in order to make a comparison with earlier studies such as Nakashima and Saito (2002) and Fujiki (2002).[8]

Table 4 presents the estimation results. The estimated interest elasticity $b_r$ with no break is -0.133 for *LRCALL*. When a possible break at 1995:2 is allowed in the double-log specification, estimated shifts in a constant and the elasticity coefficient turn out insignificant, as shown in Panel B (first row). This is in contrast with Fujiki's (2002) finding in which he reports a substantial increase in the interest elasticity in 1995. On the other hand, when *RCALL* is used, we find a significant break both in the constant term and the semi-elasticity $\tilde{b}_r$ . The point estimates indicate that the interest semi-elasticity becomes larger by 0.530 in absolute values (i.e. from -0.025 to -0.555). The estimated shift looks largely consistent with the evidence of Nakashima and Saito (2002).[9]

## 4. Discussions

The main findings in the previous section can be summarized as follows. First,

[8] We also obtain similar estimation results using the full sample period. Nonethelss the estimates appear more precise with smaller standard errors when the 1985 sample is used and therefore we choose to report the 1985 results in the text.

[9] Their point estimates range from-0.035 to -0.038 before 1995 and from -0.571 to -0.746 after 1995.

cointegration in M1 demand is largely supported by the data. Second, with the double-log specification, the interest elasticity is found to be stable, but using the semi-log form, the interest semi-elasticity increased in 1995.

Then how can we interpret these two seemingly conflicting results in terms of stability? The answer may be straightforward if we look at scatter plots of actual data. Figure 1 displays two scatter plots: (A) *LRCALL* versus *M1VEL* and (B) *RCALL* versus *M1VEL* for the period of 1985:1-2001:4. While the relationship looks fairly stable in graph A, one can observe an apparent break near zero percent in graph B. These are exactly what the formal analysis finds above. But it is also evident that graph B can approximate the very log function. If this is the case, then the two graphs would suggest the same result of stability in terms of the interest elasticity.

This interpretation can be supported using the point estimates of the two elasticities $b_r$ and $\tilde{b}_r$ as well. Recall that in Table 4 the estimated elasticity $b_r$ equals -0.133 and the semi-elasticity $\tilde{b}_r$ rises from -0.025 to -0.555 in 1995. By definition, $b_r / r = \tilde{b}_r$ (where $r$ is nominal interest rates) and using the average of the call rate before and after 1995 (4.573 percent for 1975:1-1995:2 and 0.287 percent for 1995:3-2001:4), we can compute the implied semi-elasticity for each period. These are -0.028 before 1995 and -0.463 after 1995 and therefore reasonably close to the actual point estimates of the semi-elasticity for each period. Again, we are able to demonstrate that the observed increase in the semi-elasticity is consistent with the stable elasticity.

From these considerations, I would like to interpret that the two conflicting results can be reconciled with each other and that the findings here consistently suggest that the interest elasticity in Japan remains stable even after 1995. Accordingly the previous evidence of instability by Nakashima and Saito (2002) may be reconciled with this interpretation.

Finally let me discuss the evidence of instability documented by Fujiki(2002). Fujiki imposed his cross-sectional estimate of the income elasticity (0.874) as opposed to the unit income elasticity and showed that there was a substantial increase in the interest elasticity rather than semi-elasticity in 1995. In Figure 1 (graph A), one may observe the slope somewhat steeper for several years in the middle of the sample (those observations are for 1995-1999). Fujiki's subsample estimation by OLS may pick up this shift. Note also that his sample ends in August 2000, while our sample here ends in 2001:4. The last three observations after 2001:2 correspond to the aggressive quantitative easing by the Bank of Japan and consequently the call rate was further lowered below 1 basis point level. Adding these observations would seem helpful to maintain the stable relationship in graph A.

To check robustness of our findings, we impose Fujiki's estimate of the income elasticity rather than the unit income elasticity and perform the same exercises as above. But our main fin dings are unaffected. We obtain similar cointegration and stability test results. The dynamic OLS estimate of the interest elasticity for the full sample is -0.140, while the semi-elasticity estimates before and after 1995 are -0.030 and -0.560, respectively, so that the above interpretation may be maintained.

## 5. Conclusion

We investigated whether in fact the Japanese economy is trapped at the zero interest rate bound. While several different characterizations on liquidity traps are possible, the question seems particularly important because undesirable dynamics such as ``deflationary spiral'' are likely to occur when the economy actually reaches the zero bound. And at zero interest rates, money demand becomes indeterminate and therefore is not well defined, or it becomes perfectly elastic with respect to the interest rates. We thus examined the presence and stability of an equilibrium money demand relation (cointegrating M1 relation) in Japan for 1975-2001.

Our evidence suggests that the answer would be negative. With the double-log specification, a cointegrating M1 relationship exists and is found to be stable (i.e. no break in the interest elasticity) even after 1995. The observed constancy in the interest elasticity can be reconciled with the previous evidence of instability in the interest semi-elasticity such as Nakashima and Saito (2002). We also checked robustness by imposing Fujiki's(2002) cross-sectional estimate of the income elasticity rather than the unit income elasticity.

It might be reassu ring that the Japanese economy has not yet been trapped at the zero bound. An equilibrium money demand relation is stable and still well defined. Therefore the Japanese economic conditions even in such difficult times can be viewed as fully consistent with standard economic thinking such as optimizing behavior of households with money-in-utility. Moreover, the undesirable deflationary trap case may not be an urgent concern.

Nevertheless we should note somewhat paradoxically that monetary policy remains ineffective to affect output or prices even with the stable money demand relation. As we observe in Figure 1 (graph A), the call rate in log now takes a negative value and has been lowered substantially by recent quantitative easing. With the stable interest elasticity, this also raised money demand of the public (i.e. Marshall's *k*) substantially, and therefore P and Y remain unaffected even when a huge amount of M was supplied Thus Japan's well-defined money demand relation has been, and perhaps will be for sometime to come, consistent with strong money hoarding by the public and ``a liquidity trap'' in general terms.

## References


Andrew, Donald W. K., 1991. ``Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimation,'' *Econometrica* 59, 817-858.

Banerjee, Anindya, Robin L. Lumsdaine and James H. Stock, 1992. ``Recursive and Sequential Tests of the Unit-Root and Trend-Break Hypotheses: Theory and International Evidence,'' *Journal of Business and Economics and Statistics* 10, 271-287.

Benhabib, Jess, Stephanie Shmitt-Grohe, and Martin Uribe, 2001. ``The Perils of Taylor Rules,'' *Journal of Economic Theory* 96, 40-69.

Benhabib, Jess, Stephanie Shmitt-Grohe, and Martin Uribe, 2002. ``Avoiding Liqudity Traps,'' *Journal of Political Economy* 110, 535-563.

Buiter, William H. and Nikolaos Panigirtzoglou, 1999. ``Liquidity Traps: How to Avoid Them and How to Escape Them,'' NBER Working Paper No.7245.

Cargill, Thomas F., Michael M. Hutchison, and Takatoshi Ito, 2000. ``Inflation Targeting, Liquidity Traps, and the New Bank of Japan," in T. F. Cargill, M. M. Hutchison and T. Ito eds., *Financial Policy and Central Banking in Japan* (Cambridge, Massachusetts: MIT Press).

Cheung,Yin-Wong and Kon S. Lai, 1993. ``Finite-Sample Sizes of Johansen's Likelihood Ratio Tests for Cointegration," *Oxford Bulletin of Economics and Statistics* 55, 313-328.

Dickey, D. A. and W. A. Fuller, 1979. ``Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of American Statistical Association* 74, 427-431.

Elliott, Graham, Thomas J. Rothenberg, and James H. Stock, 1996. ``Efficient Tests for an Autoregressive Unit Root," *Econometrica* 64, 813-836.

Fujiki, Hiroshi, 2002. ``Money Demand near Zero Interest Rate: Evidence from Regional Data," *Monetary and Economic Studies* 14, Bank of Japan, 25-41.

Fujiki, Hiroshi, Cheng Hsiao, and Yan Shen, 2002. ``Is There a Stable Money Demand Function under the Low Interest Rate Policy? A Panel Data Analysis," *Monetary and Economic Studies* 14, Bank of Japan, 1-23.

Fuller, W. A., 1976. *Introduction to Statistical Time Series*, New York: John Wiley and Sons.

Gregory Allan W. and Bruce E. Hansen, 1996. ``Residual-Based Tests for Cointegration in Models with Regime Shifts," *Journal of Econometrics* 70, 99-126.

Hansen, Bruce E., 1992. ``Tests for Parameter Instability in Regressions with I(1) Processes," *Journal of Business and Economic Statistics* 10, 321-335.

Hansen H. and S. Johansen, 1993. ``Recursive Estimation in Cointegrated VAR-Models." Institute of Mathematical Statistics, University of Copenhagen.

Hondroyiannis, George, P. A. V. B. Swany, and George S. Tavlas, 2000. ``Is the Japanese Economy in a Liquidity Trap?'' *Economics Letters* 66, 17-23.

Johansen, Soren, 1988. ``Statistical Analysis of Cointegrating Vectors," *Journal of Economic Dynamics and Control* 12, 213-54.

Johansen, Soren and Katarina Juselius, 1990. ``Maximum Likelihood Estimation and Inference on Cointegration - With Application to the Demand for Money," *Oxford Bulletin of Economics and Statistics* 52, 169-210.

Krugman, Paul. 1999. ``It's Baaack! Japan's Slump and the Return of the Liquidity Trap," *Brooking Papers on Economic Activity* 2, 137-205.

Krugman, Paul. 2000. ``Thinking about the Liquidity Trap," *Journal of the Japanese and International Economies* 14, 221-237.

Laidler, David E. W., 1985. *The Demand for Money: Theories, Evidence and Problem*s, Third Edition, (New York: Harper and Row).

Lucas, Robert E. Jr., 2000. ``Inflation and Welfare,'' *Econometrica* 68, 247-274.

MacKinnon, James G., 1991. ``Critical Values for Cointegration Tests,'' in R.F. Engle and C.W.J. Granger eds., *Long-Run Economic Relationships: Readings in Cointegration*, Oxford University Press.

Miyao, Ryuzo, 2000. ``The Role of Monetary Policy in Japan: A Break in the 1990s?" *Journal of the Japanese and International Economies*. 14, 366-384.

Miyao, Ryuzo, 2002.``The Effects of Monetary Policy in Japan,'' *Journal of Money, Credit, and Banking* 34, 376-392.

Nakashima, Kiyotaka and Makoto Saito, 2002. ``Strong Money Demand and Nominal Rigidity: Evidence from the Japanese Money Market with a Low Interest Rate Policy,'' Discussion Paper No.2001-11, Graduate School of Economics, Hitotsubashi University.

Ono, Yoshiyasu, 2001.``A Reinterpretation of Chapter 17 of Keynes's *General Theory*: Effective Demand Shortage under Dynamic Optimization,'' *International Economic Review* 42, 207-236.

Osterwald-Lenum, M., 1992.``A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics," *Oxford Bulletin of Economics and Statistics* 54, 461-472.

Reifschneider, David and John C. Williams, 2000. ``Three Lessons for Monetary Policy in a Low-Inflation Era,'' *Journal of Money, Credit, and Banking* 32, 936-966.

Saikkonen, Pentti, 1991.``Asymptotically Efficient Estimation of Cointegrating Regressions,'' *Econometric Theory* 7, 1-21.

Sims, Christopher A. 1980, ``Macroeconomics and Reality," *Econometrica* 48, 1-48.

Stock, James. H. and Mark. W. Watson, 1993.``A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," *Econometrica* 61, 783-820.

Taylor, John B., 1993. ``Discretion versus Policy Rules in Practice,'' *Carnegie-Rochester Conference Series on Public Policy* 39, 195-214.

Woodford, Michael, 1999. ``Price-Level Determination under Interest-Rate Rules,'' manuscript, Princeton Univeristy.

Walsh, Carl E., 1998. *Monetary Theory and Policy*, Cambridge: MIT Press.

Table 1. Unit Root Test Results

| Variable | ADF | DF-GLS | BLS |
|---|---|---|---|
| | *A. In levels* | | |
| *M1VEL* | 3.05(1) | 2.13(1) | -3.34(1) |
| *LRCALL* | 3.19(5) | 3.99(5) | -3.51(5) |
| *RCALL* | -2.09(1) | -0.08(3) | -4.04(1) |
| | *B. In first differences* | | |
| *ΔM1VEL* | -5.98(0)** | -5.61(0)** | --- |
| *ΔLRCALL* | -7.10(4)** | -2.65(5)* | --- |
| *ΔRCALL* | -5.72(2)** | -5.42(2)** | --- |

Notes: This table reports statistics testing for a unit root for a reciprocal of M1 velocity (*M1EL*), the logged call rate (*LRCALL*), and the call rate in levels (*RCALL*). ADF is the augmented Dickey-Fuller (1979) test of a unit root against no unit root, and DF-GLS is a Dickey-Fuller test based on GLS-detrended series, proposed by Elliott, Rothenberg and Stock (1996). A constant term is included in both tests. BLS is the sequential minimal Dickey-Fuller test proposed by Banerjee, Lumsdaine and Stock (1992) that allows for a break in a deterministic trend in an unknown timing. In all these tests, the optimal lag length is chosen based on SBIC and is shown in parentheses. The sample period is 1975:1-2001:4. Critical values, tabulated by Fuller (1976), Elliott, Rothenberg and Stock (1996), and Banerjee, Lumsdaine and Stock (1992) are:

| | 10%(†) | 5%(*) | 1%(**) |
|---|---|---|---|
| ADF | -2.58 | -2.89 | -3.51 |
| DF-GLS | -1.61 | -1.95 | -2.60 |
| BLS | -4.20 | -4.48 | --- |

Table 2. Cointegration Test Results

| Variable | ADF | JOH | GH |
|---|---|---|---|
| *LRCALL* | -2.20(5) | 19.15(5)* | -5.06(1)* |
| *RCALL* | 0.08(3) | 22.12(5)* | -3.13(1) |

Notes: This table reports statistics testing for cointegration between M1 velocity (*M!VEL*) and the logged call rate (*LRCALL*) or the call rate (*RCALL*). ADF is the augmented Dickey-Fuller (1979) test of no cointegration against cointegration. JOH is Johansen's maximal eigenvalue test of no cointegration against one cointegrating vector. GH is the augmented Dickey-Fuller test of the null of no cointegration against the alternative of cointegration with a possible structural break, proposed by Gregory and Hansen (1996). The optimal lag length is chosen based on SBIC and is shown in parentheses. The exception is for the case of JOH test with *RCALL,* in which five lags are arbitrarily used (see footnote 7 in the text). Critical values are tabulated by MacKinnon (1991) for ADF, Osterwald-Lenum (1992) for JOH, and Gregory and Hansen (1996) for GH. As for JOH, following the procedure by Cheung and Lai (1993), Osterwald-Lenum's critical values are corrected to account for possible size distortions in finite samples.

| | 10%(†) | 5%(*) | 1%(**) |
|---|---|---|---|
| ADF | -3.10 | -3.41 | -3.51 |
| JOH | 15.09 | 17.23 | 22.21 |
| GH | -4.68 | -4.95 | -5.47 |

Table 3. Stability Tests Results

| Variable | SupF | MeanF | HJ |
|---|---|---|---|
| *LRCALL* | 5.47 | 2.90 | 1.29 |
| *RCALL* | 207.79** | 62.50** | 7.57* |

Notes: This table reports statistics testing for stability of a cointegrating M1 demand relation in Japan. SupF is Hansen's (1992) procedure that tests the null of constancy against the alternative of a parameter shift in an unknown timing. MeanF is another Hansen's (1992) procedure that tests the null of stability against the alternative of instability where the parameter follows a random walk process. For both tests, the unprewhitened Bartlet kernel estimator is used with the corresponding automatic bandwidth selection proposed by Andrews (1991). HJ is Hansen and Johansen's (1993) procedure testing that the benchmark parameter estimated with the subsample of 1975:1-1995:2 is equal to the parameter estimated with the full sample. Five lags are assumed here. HJ statistics follows a chisquare distribution with degree of freedom 2. Critical values for SupF and MeanF tests are tabulated by Hansen (1992):

| | 10%(†) | 5%(*) | 1%(**) |
|---|---|---|---|
| SupF | 10.6 | 12.4 | 16.2 |
| MeanF | 3.73 | 4.57 | 6.78 |

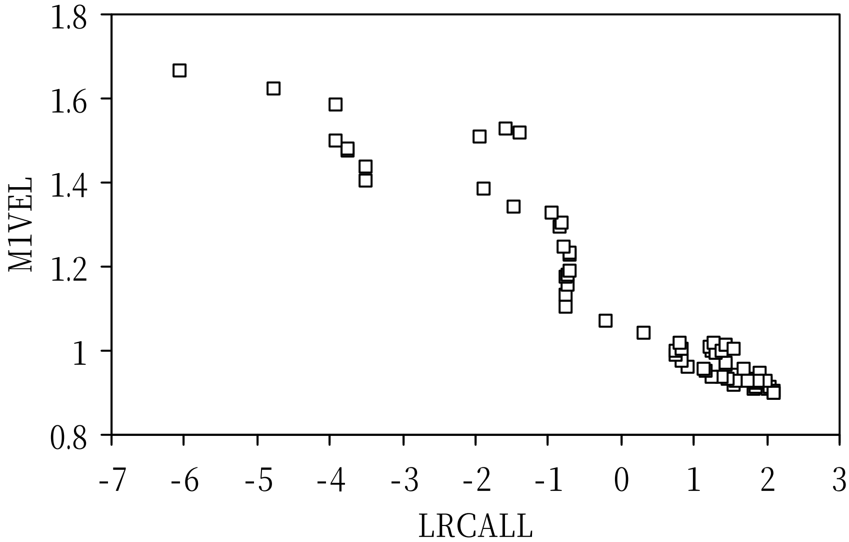
Table 4. Estimates of the Cointegrating Vector

| Variable | Constant | $b_r$ , $\tilde{b}_r$ | Shift in constant | Shift in $b_r$ , $\tilde{b}_r$ |
|---|---|---|---|---|
| | | *A. With no break* | | |
| *LRCALL* | 1.164 | -0.133 | | |
| | (0.011) | (0.006) | | |
| *RCALL* | 1.323 | -0.071 | | |
| | (0.055) | (0.011) | | |
| | | *B. With a Break at 1995:2/1995:3* | | |
| *LRCALL* | 1.131 | -0.112 | 0.010 | -0.031 |
| | (0.032) | (0.017) | (0.028) | (0.017) |
| *RCALL* | 1.087 | -0.025 | 0.400 | -0.530 |
| | (0.019) | (0.004) | (0.026) | (0.050) |

Notes: This table reports estimates of cointegrating vector (the interest elasticity and semi-elasticity) using the dynamic OLS method proposed by Saikkonen (1993) and Stock and Watson (1993). Five leads and lags are used in these estimations. Newey-West standard error is computed with five lag truncation and shown in parentheses. In Panel A, no break in the cointegrating vector is allowed, while in Panel B, a possible break at 1995:2/1995:3 is permitted. The sample period is 1985:1-2001:4 .

Figure 1. Scatter Plot

(A) LRCALL and M1VEL
- 1985:1-2001:4 -




(B) RCALL and M1VEL
- 1985:1-2001:4 -