



## MONEY DEMAND SENSITIVITY TO INTEREST RATES: THE CASE OF JAPAN'S ZERO-INTEREST RATE POLICY

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### ABSTRACT

*The goal of this paper is to provide new evidence on how the zero-interest rate policy implemented by the Bank of Japan has affected the sensitivity of money demand with respect to the opportunity cost of holding money. To the empirical ends of the analysis, the study makes use of the univariate conditional autoregressive value-at-risk (CAViaR) estimator to obtain robust quantile measures. The empirical findings document that the sensitivity of money demand with respect to the opportunity cost of holding money has significantly increased after the 1994 period. The results remain robust across quantile measures.*

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**JEL Classification:** E41, E50, C32.

### Contribution/ Originality

This paper contributes in existing literature by providing new evidence on how the zero-interest rate policy implemented by the Bank of Japan has affected the sensitivity of money demand with respect to the opportunity cost of holding money.

## 1. INTRODUCTION

Japan has been experiencing a serious liquidity trap since 1994, along with a deep recession caused by a dramatic fall in share prices and land prices, leading to the accumulation of huge non-performing loans in the financial market. The bank of Japan (BoJ) has been implementing a low interest rate policy to boost the economy.

The primary goal of this short paper is to explore how a radical change from a standard monetary policy to an ultra-low interest rate policy can affect the demand for real balances as well

as other activities in the real economy. In the literature, the general consensus is that money demand is highly interest-elastic when the nominal interest rate hits the zero bound (Lucas, 1988; Hendry and Ericsson, 1991). In the case of Japan, the number of studies quantifying money demand is rather limited with mixed results (Hondroyannis *et al.*, 2000; Fujiki and Watanabe, 2004; Miyao, 2004; Bae *et al.*, 2006; Nakashima and Saito, 2009). These studies, however, suffer from a number of methodological problems, such as spurious relationships due to non-linear money growth (i.e., a I(2) behavior), which renders the cointegration methodology invalid. This study contributes in the existing literature by offering a new methodological approach (described below) that overcomes those spurious deficiencies by adopting a quantiles type of approach that explicitly considers the potential time-varying characteristic of the Japanese monetary policy in relevance to the high interest elasticity of money demand.

In what follows, in Section 2, we present the econometric methodology of conditional quantile estimates. Section 3 provides an analytical description of the data uses, while Section 4, as a part of the empirical analysis, the results are reported and discussed. Finally, Section 5 concludes by summarizing the empirical findings.

## 2. ECONOMETRIC METHODOLOGY: ESTIMATING TAIL DEPENDENCE BASED ON CONDITIONAL QUANTILE MEASURES

Van Oordt and Zhou (2013) introduce a parametric approach to measure tail dependence between multiple time series. Their approach is based on a linear regression framework between unconditional quantile measures. In particular, let  $y_t$ ,  $x_{1t}$  and  $x_{2t}$  be three  $T \times 1$  vectors. They show that the OLS estimates of the slope coefficients  $b_j, j = 1, 2, 3$  in the regression:

$$I_{x_{3t}} = b_1 I_{x_{1t}} + b_2 I_{x_{2t}} + b_3 I_{x_{1t}} I_{x_{2t}} + \varepsilon_t \quad (1)$$

Quantify the degree of dependence among extreme events between  $x_{3t}$ , and  $x_{1t}$  as well as  $x_{3t}$  and  $x_{2t}$ , where:

$$I_{it} = 1\{x_{it} < q_i(k)\}, i = 1, 2, 3 \quad (2)$$

and  $1(\cdot)$  represents the indicator function, while  $q(k)$  denotes the quantile computed as the  $k$ -th lowest negative return. This particular methodology estimates tail co-behavior patterns based on an unconditional approach of measuring extreme downside risk. However, this approach fails to estimate accurately the tails below the risk quantile. Therefore, conditional quantile-based estimators have been used to quantify extreme downside risk. Our modelling scheme adopts (Engle and Manganelli, 2004) univariate CAViAR (conditional autoregressive value-at-risk) estimator to

obtain more robust quantile measures. Under the CAViaR specification, the tails are allowed to evolve as an autoregressive process:

$$q_{lt} = a + \sum_{i=1}^q \beta_i W(x_{lt-1}) + \gamma q_{lt-1} \quad (3)$$

where  $q_{lt}$  represents the quantile of series  $x_{lt}$  at time  $t = 1, 2, \dots, T$ ,  $a$  is the intercept,  $\gamma$  is the coefficient of the lagged term  $q_{lt-1}$ , while  $W(x_{lt-1})$  operates as a function which links the dynamic quantiles to observable variables that belong to the information set  $\{x_{lt-1}, l = 1, 2, 3\}$ . For instance, the CAViaR specification with asymmetric slope is defined as:

$$q_{lt} = a + \beta_1 x_{lt-1}^+ + \beta_2 x_{lt-1}^- + \gamma q_{lt-1}, l = 1, 2, 3, \quad (4)$$

where  $x_{lt}^+ = \max(x_{lt}, 0)$ , and  $x_{lt}^- = -\min(x_{lt}, 0)$ . The parameters  $a$ ,  $\beta_j$ ,  $j = 1, 2$ , and  $\gamma$  are estimated using Koenker and Bassett's (1978) regression quantile methodological approaches. After the proper transformation of  $q_l$ ,  $l = 1, 2, 3$ , for a given  $k\%$  to conditional estimates  $q_{lt}$ ,  $t = 1, 2, \dots, T$ , the risk indicator used in the estimation of the indicator regression (1) takes the form:

$$I_{lt} = 1\{x_{lt} < q_{lt}(k)\}, l = 1, 2, 3, \quad (5)$$

The indicator regression is applied to rolling window subsamples for  $t = \tau - w + 1, \tau - w, \dots, \tau$ ,  $\tau = w, w + 1, \dots, T$ , where  $w$  is the size of the rolling window.

### 3. DATA DESCRIPTION

Quarterly seasonally adjusted data on income, measured as real GDP at constant 1995 prices, commodity prices, proxied by the GDP deflator (1995=100), money balances, measured as M1 money, and the spread between the long-term interest rate, measured as the 10-year government bond yield, and the short-term interest rate, measured as the overnight call rate are retrieved from Datastream. This spread defines the opportunity cost of holding real money balances, given that the effect of a zero interest rate on all short-term interest rates is negligible, while we assume that they receive a return at the BoJ call money rate. In other words, the opportunity cost of M1 indicates that such wealth cannot accrue the interest paid on a less liquid long-term asset, such as the 10-year government bond. The sample period spans the period 1975 to (August) 2014. Money balances are deflated to real values by dividing them with the GDP deflator. All variables, excluding the yield spread, are transformed into logarithms.

#### 4. EMPIRICAL RESULTS

Figure 1 highlights the plots of the time varying nature of the Japanese money demand sensitivity to extreme events in the interest rates. In particular, the indicator function regression has the following specification:

$$I_{M1/P} = b_1 I_Y + b_2 I_{spread} + b_3 I_Y I_{spread} + \varepsilon_t \quad (6)$$

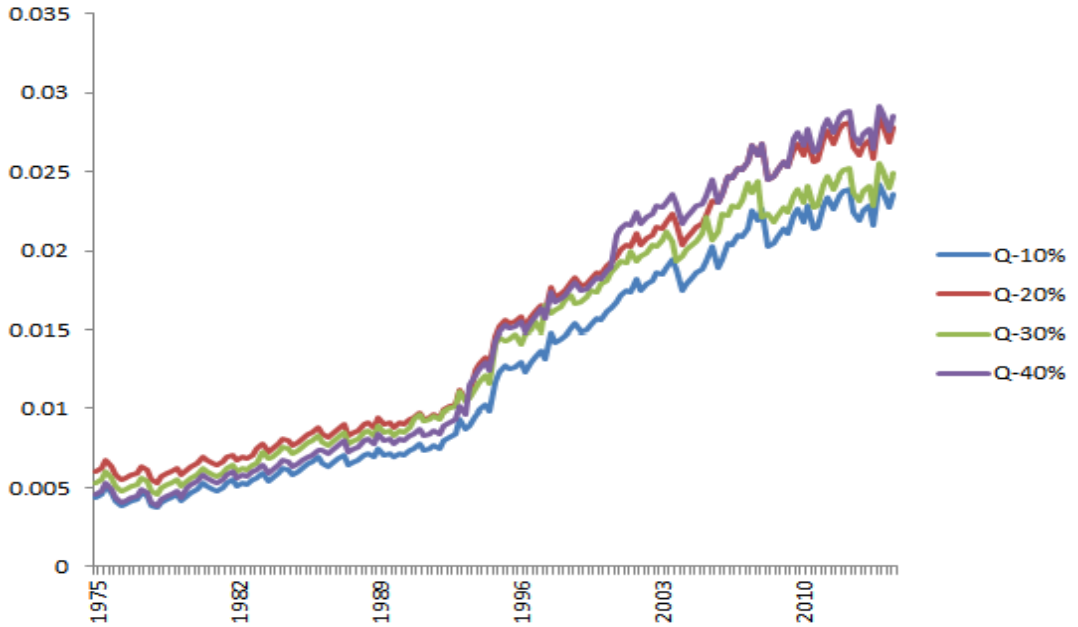
where  $I_{M1/P}$ ,  $I_Y$  and  $I_{spread}$  represent the indicator functions of real money supply growth, real income growth and the yield curve, respectively. The indicators are estimated based on equations (4)-(5). The plots display the coefficient  $b_2$  for the model estimated with fixed length rolling windows of data. The length of the data window is chosen to be 16 years, a total of 64 quarterly observations, starting with the sample period 1975:1-1990:4, and ending with the period 1993:4-2014:3. The rolling sensitivity coefficient is estimated for several quantiles  $k$ , such as 10%, 20%, 30% and 40%, in order to distinguish between extreme downside risk spillovers and interdependence patterns for the money demand-interest rate relationship.

It is interesting that for  $k = 10\%$  there is strong evidence of low risk dependence between money demand and the yield curve when the observation window moves towards the year 1994. By contrast, after 1994, the coefficient is shown to be very high. For  $k = 20\%$  the analysis provides robust findings across all subsamples.

Moreover, when larger quantiles, such as 30% and 40%, are used, we also find evidence of interdependence between money demand and the yield spread. Overall, the results indicate that over the zero lower bound period money demand has turned to be substantially sensitive to yield changes than it appeared to be over the normal period.

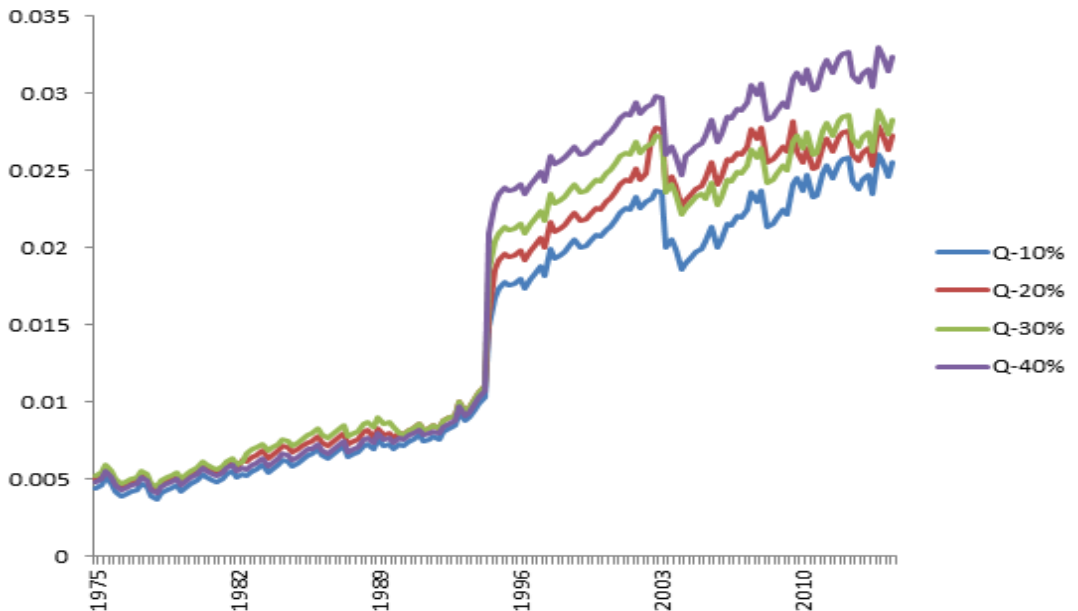
Given that the opportunity cost is defined with respect to the spread of interest rates and not with respect to the interest rate (i.e., while money is defined as M1 and not as cash), the empirical findings imply that liquid M1 and illiquid long-term assets remain as non-perfect substitutes, i.e. there is a disadvantage to holding a liquid as opposed to an illiquid asset.

Has the zero lower bound monetary policy drives the short-run interest rate to zero, the presence of the yield curve supports higher long-term yields, which makes long-term assets more attractive vis-à-vis cash. In order to further evaluate the dynamic evolution of the money demand sensitivity with respect to extreme changes of the interest rates, we estimate the indicator regression, presented in (5), for 16 year expanding length observation windows. Starting with the sample period 1975:1-1990:4, each estimation window expands each time by one observation, ending with the period 1975:1-2014:3. The results, displayed in Figure 2, provide similar and robust evidence across all  $k\%$  used as before..



**Fig-1.** Rolling estimates of money demand sensitivity to extreme changes of the yield curve in Japan: Fixed observation windows

All figures display estimates of the coefficient  $b_2$  from the indicator regression:  $I_{M1/P} = b_1 I_Y + b_2 I_{spread} + b_3 I_Y I_{spread} + \varepsilon_t$ , with fixed windows of data, starting with the sample period 1975:1-1990:4 and ending with the period 1993:4-2014:3. The terms  $I_{M1/P}$ ,  $I_Y$  and  $I_{spread}$  represent the indicator functions of real money supply growth, real income growth and the yield spread, respectively, calculated for quantiles  $k = 10\%$ ,  $20\%$ ,  $30\%$  and  $40\%$ , respectively. The indicator functions are estimated based on the CAViaR method.



**Fig-2.** Rolling estimates of money demand sensitivity to extreme events of interest rates in Japan: Expanding observation windows

All figures display estimates of the coefficient  $b_2$  from the indicator regression:  $I_{M1/P} = b_1 I_Y + b_2 I_{spread} + b_3 I_Y I_{spread} + \varepsilon_t$ , with increasing windows of data, starting with the sample period 1975:1-1990:4, and ending with the period 1975:1-2014:3. The terms  $I_{M1/P}$ ,  $I_Y$  and  $I_{spread}$  represent the indicator functions of real money supply growth, real income growth and the yield spread, respectively, calculated for quantiles  $k = 10\%$ ,  $20\%$ ,  $30\%$  and  $40\%$ , respectively. The indicator functions are estimated based on the CAViaR method.

## 5. CONCLUSIONS

This paper provided new evidence on the sensitivity of the demand for money in Japan to the opportunity cost of holding money prior and after the zero lower bound implemented monetary policy. The empirical results highlighted that the sensitivity of money demand turned to be substantially higher under the zero lower bound window, confirming the lower effectiveness of monetary policy.

These empirical findings are substantially interesting, given that at interest rate levels that give rise to the presence of a liquidity trap, the demand for money turns out to be highly unstable and indeterminate, which jeopardizes the stability of the monetary system with further (negative) repercussions in financial markets and in the real economy (through various monetary policy transmission mechanisms). In addition, such instability tends to deter the optimizing behavior of households and firms with further negative spillovers to the real economy.

Finally, the instability of money demand as well the higher interest rate sensitivity tend to substantially mitigate the capacity of monetary policy to affect real output and prices, regardless of the hard efforts made by the Abe administration to enhance the role of the Japanese monetary policy in the real economy. Money hoarding is still the primary issue that governs the efficiency of monetary policy and potentially non-conventional monetary policies should be adopted. However, the role of the latter policy is a potential venue for future research.

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