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Estimation of Precautionary Demand caused by Financial Anxieties

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Abstract

Pioneering work of modelling financial anxieties was given by Kimura et al. (1999) as psychological change of people due to financial shocks. Since they regressed financial position (easy or tight) by nonstationary interest rate, their results exhibit high peaks not only in financial crisis period of 1997 and 1998, but also in the bubble economy period of 1987 to 1989, which seems to be a spurious regression. Furthermore, defining financial anxieties as the conditional variance in TARCH model, one of estimated coefficients does not satisfy sign condition. We got rid of these difficulties by introducing a growth rate model, where a change of financial position (toward 'tight') under a change of interest rate (toward 'fall') is regarded as financial anxieties. Such anxieties are quantified by conditional variance of EGARCH model and shown to be stationary. Precautionary demand caused by financial anxieties is estimated in VEC model and it is shown that money adjusted by precautionary demand satisfies a long-run equilibrium relationship in the system (adjusted money, real GDP, interest rate) even in the interval 1980q1 to 2003q2.

Keywords: financial anxieties, precautionary demand, cointegration, EGARCH

1 Introduction

The relationship between the money supply and economic activity had been relatively stable in the 1970s and 1980s. This relationship had been observed, even during the period of the emergence and busting of the bubble economy, though both were related with a long lag. So, money supply had been one of the important targets in conducting monetary policy in Japan. However, the relationship between money supply and economic activity had become harder to discern since the end of 1990s. The Bank of Japan (2003) [1] and S. Miyagawa et al. (2004)[2] explicitly reported that the long-run equilibrium relationship between money stock and real economic activity could no longer

*a visiting scholar in Kyoto Gakuen University since Oct. 2004 be detected, though such relationship could be found before 1998. It was the year of 1997 when serious financial problems had come out in the Japanese economy. Several big banks and security companies had failed, including Hokkaido Takushoku Bank and Yamaichi Securities. The Hokkaido Takushoku Bank, well known as TAKUGIN, was the largest regional bank in Hokkaido and Yamaichi Securities Company was fourth largest bank of the Big Four securities firms in Japan. Though several financial institutions had been failing after the burst of the bubble economy in 1990, they were the small sized institutes and tactically dealt by insurance deposit. However, the failure of two big financial institutions was quite different from the former bank failures when the significance of their role in the Japanese economy was put into consideration. Further their failure triggered the rapid decline in the share prices of many financial institutions. Japan premium was also imposed in the international market at the same time. People's anxieties over the financial system rapidly increased. As a result both firms and household seem to try to increase the money demand by their precautionary motivation. Therefore, the rise of this motivation seems to break down the cointegration between real money, real GDP and share price, which existed in the pre-1998. These economic developments may be largely influenced by the disturbance in the financial system that occurred reflecting the failures of large financial institutions after 1997.

Kimura and Fujita (1999)[3] proposed a new variable to capture these financial shocks as psychological change of people due to financial anxieties. They used two kinds of diffusion indeces issued quarterly by Bank of Japan known as TANKAN : the Corporate Financial Position and a change of bank lending rate. They made a new interest rate by accumulating a change of bank lending rate and regressed Financial Position by a new interest rate with lags 0 and 1 over the period 1976q2 to 1999q3. The conditional variance of this regression was determined by TARCH(Threshold Autoregressive Conditional Heteroscedasticity) model and was ragarded as financial anxieties. However, due to nonstationarity of a new interest rate, their result may produce a spurious regression and exhibit high peaks in the bubble economy as well as in 1997 and 1998 of financial crisis. Furthermore, their estimation of TARCH model contains negative sign of a parameter, which is not adequate for the positivity of conditional variance.

We [4] have succeeded in improving Kimura's result using the same variables in a growth rate system with TARCH modelling, where a change of Financial Position is regressed by a change of bank lending rate with lags 0 and 1 and where a sign condition of estimated parameters is satisfied. Further studies of financial anxieties with classification of large, medium and small enterprises are given in our recent work [5]. Although a growth rate system is also used, TARCH model is insufficient to assure the positivity of conditional variance and we intorduced EGARCH (Exponential Generalized Autoregressive Conditional Heteroscedasticity) model. In this article, after surveying both Kimura and our results, a precautionary demand caused by financial anxieties of EGARCH model is estimated in macro economic system. Money adjusted by precautionary demand is newly defined and is shown to keep long-run equilibrium relationship among real GDP and opportunity cost (spread of interest rates).

2 Time Series Properties

2.1 Data Description.

Let $rm(t), y(t)$ and $r(t)$ be real money supply M2+CD deflated by GDP deflator, , real gdp and spread of interest rate at time $t = 1, 2, \cdots$ in the period 1980q1 to 2004q4 and these data are from OECD. Furthermore, the corporate financial position ('easy' minus 'tight') and a change of bank lending rate ('rise' minus 'fall') are respectively given by $DI(t)$ and $\triangle rate(t)$, where the former is a rate of financial position such that 'easy' ('tight') means the percentage with which company feels financial position as 'easy' ('tight') respectively, and where the latter is a change of bank lending interest rate such that 'rise' ('fall') is the percentage with which companies feel change of interest rate as rise (fall) respectively. The sample period of TANKAN is from 1976q3 to 2004q4. The symbolic notations are described by

$$
\begin{aligned}
rm(t) &= log((m2+cd)/GDP\ deflator) \\
y(t) &= log(real\ GDP) \\
r(t) &= 10\ years\ bond - 3\ months\ cd\ rate \\
DI(t) &= < easy > - < tight > \\
\triangle rate(t) &= < rise > - < fall > \\
rate(t) &= \triangle rate(1) + \cdots + \triangle rate(t)
\end{aligned}
$$

2.2 Unit Root Test.

In order to check whether variables are stationary or nonstationary, we carry out two kinds of tests: the first is DF-GLS test which has a null hypothesis of unit root (nonstationarity) by Elliott et al. (1996)[6] , and the second is LM test (called KPSS test) with a null hypothesis of stationarity given by Kwiatkowski et al. (1992)[7] . A common strategy is to present results of both DF-GLS and KPSS tests, and show that results are consistent (e.g., that the former reject the null while the latter fails to do so, or vice-versa). The lag length is selected by Akaike Information Criteria. The results are shown in Table 1.

$\triangle rate(t)$ is appeared as stationary process while $rate(t)$ is nonstationary according to all the test procedures shown in Table 1. Also real money ($rm(t)$), real GDP ($y(t)$) and spread of interest rate ($r(t)$) are shown nonstationary as well. $\hat{h}^2(t)$-process in Table 1 is financial anxieties defined later by Eq.(4). First difference of all nonstationary variables here are shown to be stationary. We cannot decide $DI(t)$ to be stationary or nonstationary, because unit root (nonstationarity) is not rejected and because stationarity is also not rejected. However, it should be noted that our objective is to consider $DI(t)$ as TARCH or EGARCH model with asymmetric variance and availability of unit

Table 1: Unit Root Test [1980q1,2004q4]

var.	ERS	*lag*	KPSS
DI	-0.107	5	0.237
$rate$	0.124	9	$1.089***$
$\triangle rate$	$-2.807***$	1	0.162
rm	-1.638	2	$0.222***$
y	0.636	3	$1.207***$
r	-1.341	0	$-4.482***$
h^2	$-2.90***$	0	0.094

$***$, $**$ and $*$ denote significance levels 1%, 5% and 10% respectively.

root tests stated above is not proved for systems with asymmetric variance. Therefore, neglecting the unit root property of $DI(t)$, we proceed to the growth rate model of $\triangle DI(t)$ regressed by $\triangle rate(t)$ and $\triangle rate(t-1)$.

3 Financial Anxieties

Kimura and Fujita (1999) considered the following TARCH model for all enterprises over the period of 1976q2 - 1999q3:

$$DI(t) = -4.580 + 0.073 rate(t) - 0.077 rate(t-1) + \varepsilon(t), \tag{1}$$
$$\text{(-6.058)} \quad \text{(9.749)} \quad \text{(-10.563)}$$

where $\varepsilon(t)$ is an error term with $\varepsilon(t)|I(t-1) \sim N(0,h^2)$, $I(t-1)$ is an information set available at the period of $(t-1)$, and where values in the parentheses are t-values. The financial anxieties can be captured as the conditional variance of this error terms. Then the conditional variance is described by

$$h^2(t) = 48.99 + 0.84\varepsilon^2(t-1) + 0.73\varepsilon^2(t-1)\, d(t-1) - 0.68h^2(t-1), \tag{2}$$
$$\text{(7.185)} \quad \text{(4.021)} \quad \text{(2.745)} \quad \text{(-6.049)}$$

where $d(t) = 1$ for $\varepsilon(t) < 0$, while $d(t) = 0$ otherwise.

Their basic idea is to regard the conditional variance as financial anxieties, that is, if there is a bad news or negative shock (< 0) inputted to financial position at time $(t-1)$, then $h^2(t)$ becomes larger at time t than in the case of good news or positive shock (> 0). This asymmetric property seems to produce larger uncertainties when a big and negative shock as financial anxieties is added to the economic system, and in such a case, an increase of precautionary demand will be expected so that many companies will keep cash with themselves against a credit crunch in a near future, while precautionary demand is not increased for a good news.

Figure 1(upper one) shows the behavior of $h^2(t)$ in Eqs.(1) and (2) .

Kimura's result seems to be strange from economic points of view. We can see a moderate peak in (1987,1989) as well as the highest peak in 1998. The latter is the real

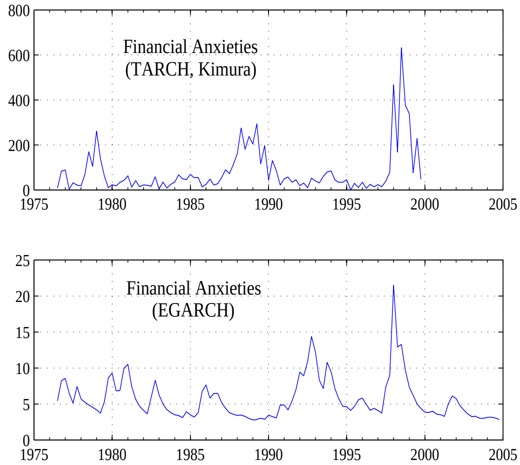

Figure 1: Financial Anxieties: Kimura's result (upper) and our result (lower)

financial anxieties after the bust of the bubble with a tight financial position and low interest rate, while the former is in the bubble economy with an easy financial position and high interest rate, which is not consistent over that period. Furthermore, one coefficient in Eq.(2) contains negative sign, which should be positive from a positivity of variance. Strange behavior of financial anxieties in bubbl economy may be due to a spurious regression with $DI(t)$ regressed by nonstationary $rate(t)$ and $rate(t-1)$. Therefore we introduce a growth rate model in which $\triangle DI(t)$ is regressed by stationary $\triangle rate(t)$ and $\triangle rate(t-1)$. In order to assure the positivity of variance, we use EGARCH model instead of TARCH model.

$$\triangle DI(t) = \underset{(0.18)}{0.0446} - \underset{(-0.37)}{0.0037}\triangle rate(t) - \underset{(-2.26)}{0.0236}\triangle rate(t-1) + \varepsilon(t), \quad (3)$$

$$log(h^2(t)) = \underset{(1.21)}{0.3565} + \underset{(4.26)}{0.7746}\, log(h^2(t-1)) + \underset{(1.08)}{0.2249}\frac{|\varepsilon(t-1)| + \underset{(-1.59)}{\gamma}\, \varepsilon(t-1)}{h(t-1)}, \quad (4)$$

where the conditional variance of $\varepsilon(t)$ is given by $Var_{t-1}(\varepsilon(t)) = h^2(t)$ and where estimated value of γ was -0.168 in the above equation. It can be seen that the leverage effect is exponential, and that forecasts of the conditional variance are guaranteed to be nonnegative. The presence of leverage effects can be tested by the hypothesis that $\gamma < 0$. The impact is asymmetric if $\gamma \neq 0$. The estimation result by EGARCH is given in Fig.1(lower one).

[Remark] Mathematically speaking in Equations (1) to (4) , the shock $\varepsilon(t-1)$ at (t-1)-period affects the increase of $h^2(t)$ in the next step at t-period. However, in the real economy, companies react to a big shock within the same period (t-1). Therefore, hereafter in our analysis $h^2(t)$ is shifted by one-step, that is, $h^2(t+1)$ is regarded as $h^2(t)$.

Inference of financial anxieties in Fig.(1) was given in our earlier papers [4] and [5].

4 Modelling of Precautionary Demand and Adjusted Money

4.1 Nonstationary financial anxieties (Kimura et al)

Kimura and Fujita modelled the precautionary demand $DV(t)$ as

$$DV(t) \equiv h^2(t+1). \tag{5}$$

They regard $DV(t)$ as a nonstationary variable and find out a cointegration relationship:

$$rm(t) + \beta_y y(t) + \beta_s rs(t) + \beta_D DV(t) = 0, \tag{6}$$

where $rs(t)$t is a share price in a stock market of Japan, deflated by GDP deflator. They insisted that, with a precautionary demand $DV(t)$, money and GDP has a stable long-run relationship in cointegration analysis even in the period containing 1998.

4.2 Stationary financial anxieties (our case)

Financial anxieties $h^2(t)$ derived in our growth rate model of Eqs. (3) and (4) are shown to be stationary by unit root tests (Table 1). When we refer to Kimura's work, then $h^2(t)$ implies that of Eq. (2), while without specification $h^2(t)$ usually means that of Eq. (4). Letting $DV1(t) \equiv h^2(t+1)$, we shall define (1) a precautionary demand caused by financial anxieties and (2) adjusted money by precautionary demand:

[Definition]

$$precautionary\ \ demand(t) \equiv k * DV1(t), \tag{7}$$

$$adjusted\ \ money\ \ rm_{adj}(t) \equiv rm(t) - k * DV1(t). \tag{8}$$

Our objective is to identify the precautionary demand by estimating the unknown parameter k in Eq.(7). We shall consider the VEC model described by a set of variables $(rm_{adj}(t), y(t), r(t))$:

$$\begin{aligned}
\triangle rm_{adj}(t) &= d_{m0} + \alpha_m ect(t-1) + \sum_{i=1}^{p} a_m^i \triangle rm_{adj}(t-i) \\
&\quad + \sum_{i=1}^{p} b_m^i \triangle y(t-i) + \sum_{i=1}^{p} c_m^i \triangle r(t-i) + \varepsilon_m(t), \qquad (9) \\
\triangle y(t) &= d_{y0} + \alpha_y ect(t-1) + \sum_{i=1}^{p} a_y^i \triangle rm_{adj}(t-i)
\end{aligned}$$

$$+\sum_{i=1}^{p} b_y^i \triangle y(t-i) + \sum_{i=1}^{p} c_y^i \triangle r(t-i) + \varepsilon_y(t), \quad (10)$$

$$\triangle r(t) = d_{r0} + \alpha_r ect(t-1) + \sum_{i=1}^{p} a_r^i \triangle rm_{adj}(t-i)$$
$$+\sum_{i=1}^{p} b_r^i \triangle y(t-i) + \sum_{i=1}^{p} c_r^i \triangle r(t-i) + \varepsilon_r(t), \quad (11)$$

where $ect(t-1)$ on each RHS of above equations is an error correction term defined by

$$ect(t) = rm_{adj}(t) + \beta_y y(t) + \beta_r r(t) + c. \quad (12)$$

Using the relation $\triangle rm_{adj}(t) = \triangle rm(t) - k * \triangle DV1(t)$, the above system equations can be rewritten: For simplicity, only Eq.(9) is rewritten as follows.

$$\triangle rm(t) = k * \triangle DV1(t) + d_{m0} + \alpha_m ect(t-1) + \sum_{i=1}^{p} a_m^i \triangle (rm(t-i)$$
$$-k * DV1(t-i)) + \sum_{i=1}^{p} b_m^i \triangle y(t-i) + \sum_{i=1}^{p} c_m^i \triangle r(t-i) + \varepsilon_m(t), \quad (13)$$

All parameters including k in Eqs.(9) to (11) should be decided in the criterion of minimizing $\sum_{i=1}^{N} \varepsilon_m^2 + \varepsilon_y^2 + \varepsilon_r^2$. It can be seen that there is a nonlinear relation of parameters $a_m^i * k$ in Eq.(13) . Therefore, initial conditions for parameter estimation are essentially important for the convergence of estimation.

[Estimation Procedures]

- step-1: Estimate an initial condition of k.
- step-2: Using the value of initial k, calculate $rm_{adj} = rm - k * DV1$.
- step-3: Estimate VEC model of (rm_{adj}, y, r) . Estimated parameters together with the initial k are regarded as initial conditions of nonlinear minimization procedures. Carry out the minimization procedures. If the obtained k is sufficiently near the initial k, then stop the procedures. If not, go to the step-4.
- step-4: With k revised, coefficients of the correction term $ect(t) = rm_{adj}(t) + \beta_y y(t) + \beta_r r(t) + c$ should be revised. Initial conditions of the other parameters are the same as the preceding results of step-3. Go to step-2.

It should be noted that the step-1 in the above procedures is most difficult to realize. Our estimation is in the following: VEC model with restriction is, first, estimated for variables of $(rm, y, r, DV1)$. Since DV1 is stationary, we restrict two error correction terms $ect1(t) = rm + c_1 y + c_2 r + c_3 DV1 + c_4$ and $ect2(t) = c_5 DV1(t) + c_6$. The initial value of k in the step-1 is given by $k = -c_3$.

4.3 Estimation result of precautionary demand

Cointegration without precautionary demand $k*DV1(t)$ holds till the interval (1980q1, 1998q4), and breaks hereafter the interval (1980q1,1999q2). However, when we introduce $k*DV1$, we can see that cointegration property holds and satisfies sign conditions in the interval after 1999q2. The cointegration result in (1980q1,2003q2) is exemplarily exhibited in Table 2.

Table 2: Cointegration Test of (rm_{adj}, y, r) in (1980q1,2003q2)

Test for the number of cointegrating vectors			
	rm_{adj}	y	r
Eigenvalues	0.224	0.076	0.016
Hypotheses	$r=0$	$r \leq 1$	$r \leq 2$
λ_{max}	22.86$*$	7.07	1.49
λ_{trace}	31.43$*$	8.57	1.49
Adjustment Coefficients α			
$\triangle rm_{adj}$	-0.0062		
$\triangle y$	0.0045		
$\triangle r$	-1.46		
Normalized cointegrating coefficients $\beta\prime$			
	1.00	-1.695	0.114

$**$ ($*$) denotes rejection of hypothesis at 1 % (5 %) significance level and lagged difference is decided to be $n=3$.

Table 3: Estimation of Precautionary Demand

interval	k
(1980q1,1999q2)	0.0143
(1980q1,2000q2)	0.0144
(1980q1,2001q2)	0.0161
(1980q1,2002q2)	0.0143
(1980q1,2003q2)	0.0141

Coupled with the calculation of cointegration, the precautionary demand parameter k related to the adjusted money $rm_{adj}(t) = rm(t) - k*DV1(t)$ was estimated in Table 3 in the interval (1980q1,1999q2) to (1980q1,2003q2) . Real money ($rm(t)$) and adjusted money ($rm_{adj}(t)$) in (1980q1,2003q2) are shown in Fig. 2.

5 Conclusion

Firstly, we have improved the financial anxieties over the Japanese economy initiated by Kimura and Fujita (1999) to quantify the psychological change of people due to financial shocks. They used two nonstationary TANKAN time series in TARCH model

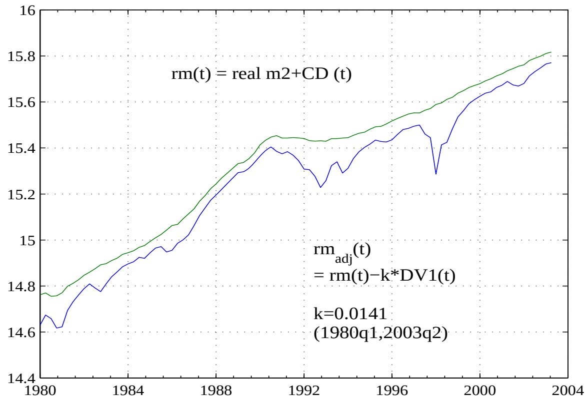

Figure 2: real money and adjusted real money

and treated the conditional variances as financial anxieties. Due to rough treatment of nonstationary variables their model is affected by unexpected parameter values and sign problems and hence cannot explain the asymmetric property properly. As a result, their model shows financial anxieties in the bubble as well as after the bust of the bubble economy, which does not bear economic meaning. To get rid of these problems we used growth rate system in EGARCH model for the same variables over the period (1976, 2005). The magnitude and non-negativity conditions of parameters in estimating our EGARCH model is valid in statistical sense and our estimation can exhibit the financial anxieties explicitly only after the bust of the bubble, which is consistent with economic views.

Secondly, precautionary demand for money is estimated as a function of financial anxieties in VEC model. During the anxiety period, households and firms try to increase the money demand by their precautionary motivation. Therefore, the rise of this precautionary demand seems to breakdown the cointegration among real money, GDP and interest rate. Finally, therefore, we adjusted the real money by precautionary demand and it can be found that cointegration relationship among adjusted real money, GDP and interest rate holds in (1980, 2003), while this relationship without precautionary demand exists only within (1980, 1998). This implies a good estimation of our precautionary demand as a function of financial anxieties.

Although we define $precautionary\ demand = k * DV1$, we can define a wider one as $precautionary\ demand = k_0 + k_1 * DV1$. However, since we use VEC model in a growth rate system for parameter estimation, $\triangle k_0 = 0$ and $\triangle k_1 * DV1 \neq 0$ make it possible to estimate only k_1 and not k_0. Estimation of constant parameter k_0 is a future problem.

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