

Estimation of Money Demand Function of South Korea Considering Regime Switching
(국면전환을 고려한 한국의 화폐수요함수 추정)

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Abstract: The stability of money demand function is an important issue in macroeconomic policy implementation. In the spirit of Beyer(1998), we estimate money demand of Korean economy.

Cointegration test with time dummy variables results show that there is not only long-run equilibrium relationship between money demand and macroeconomic variables, but also structural breaks in this equilibrium relationships. And, least squares, state-space and Markov switching methods shows that there also has been instability(or regime shifts) of parameters in money demand, especially over 1997 crisis and the early 2000s.

This fact implies that monetary policy for stabilization might encounter big problems due to change(instability) of money demand.

JEL Classification: E32, O30

Key Word: money demand function, cointegration, Markov switching

초록: 화폐수요함수의 안정성은 거시경제정책 수행에 있어 중요하다. 본 연구에서는 Beyer(1998)를 따라 한국경제의 거시적 화폐수요함수를 추정하였다.

시간 더미변수를 고려한 공적분분석 결과는 화폐수요와 거시경제 변수간 장기균형관계가 있을뿐 아니라 구조적 전환이 존재함을 보여준다. 또한, OLS, 상태공간 및 마코프 전환모형 모두 특히 1997년 금융위기 및 2000년 초반 수요함수 파라미터에 국면전환 (or regime shifts)이 있음을 보여준다.

이 같은 결과는 화폐금융정책을 통한 안정화 정책이 난관에 봉착할 수 있음을 보여준다.

JEL 분류기호: E32, O30

핵심어: 화폐수요함수, 공적분, Marcov 국면전환

I . Introduction

The stability of money demand is central issue of monetary policy. If it is unstable accompanying the variation of economic variables, like interest rate, the central bank has no certainty about the effects of monetary expansion on output, especially in recession. Nominal income(or interest rate) is determined by the supply and demand in money. So, deep understanding of money demand in macroeconomy is important to the implementation of monetary policy.

I. Fisher(1911) presented quantity theory of money showing that under some assumptions, inflation has one-to-one relationship with the quantity of money. He assumed that velocity is nearly constant.

Monetarists also assert that changing the amount of money can affect nominal output in short-run, due to the stability of velocity of money. This stability issue is also important to the inflation theory and policy. If it is stable, then there is close relationship between the money supply(or money growth) and inflation in the long-run. However, if demand responds sensitively to fluctuations of macroeconomic variables, the effect of money is dissipated into both inflation and output.

Monetarism or new quantity theory of money may be seen the determination theory of nominal income. It is incomplete in the sense that examination of aggregate supply side is need to decide how much share is imputed to real income from the change in aggregate demand.

The first systematically performed econometric study for money demand is Goldfeld(1973).

Beyer(1994, 1998) examined the structural change in money demand in Germany due to the 1990 reunification. He concluded that despite of dramatic change of 1990 in German economy, money demand seemed not to have structural change. He compares his previous results with new results with the addition of sample period including 1990 reunification of Germany. He considers (weak, strong and super-) exogeneity, parameter stability, nonstationarity, cointegration, dummy variables, error correction, stepwise simplified and reparameterized LS, steady state growth path of real money stock, seasonality of data, encompassing tests and the applicability of P-star for M3 in German money demand side. He concluded that from parameter stability tests and long-run steady state derived from ECM, German money demand is stable, in spite of 1990 reunification of Germany.

Lutkepohl et al.(1999), however, found the fact that extending sample period including monetary unification of 1990 revealed substantial instability of German money demand. They estimated nonlinear error correction with STR(smooth transition regression). They concluded that the creation of German Monetary Union did not cause break in money demand.

Sarno(1999) consider Italian money demand and added the concept of adjustment cost and nonlinear (cointegration) dynamics. He considers adjustment of short run money demand in the nonlinear error correction form. As a specialist for nonlinear long-run dynamics of economic variables like cointegration, he applied this framework to the case of money and other economic variables like interest rates and production. He estimated ECM with TAR error terms.

TAR(threshold autoregressive) model is used for testing regime changing.

Fleissig(1998) used the dynamic Laurent form for money demand. He derived asset demand by using direct utility function(DUF) and Mirishima elasticity of substitution, and compared the prediction errors between static and dynamic models.

For the case of South Korea, several authors have contributed to this area in empirical analyses.

Michell(2009) analyzed the tight monetary policy in 1979 of South Korea. Kim(2006) shows that velocity of Korean money has decreased and been unstable. He compares the predictive power for inflation using P-star-model and augmented Phillips curve. We extend this analysis in this study considering Beyer(1994)'s EC method.

In principle, the instability of money demand means that the Marshall's k is responsive(variable) to (the function of) the interest rate, but we consider the parameter instability in the regression equation of money demand on the interest rate in the sense of the second kind of instability in this study.

This paper consists of the following sections. In section 2, we use ordinary LS for testing stability of money demand. In section 3, we consider the nonstationarity of variables and use cointegration method with structural dummy variables. In addition, we investigate Switching model for seeing structural breaks in money demand. In section 4, we give some summary and conclude.

II. Econometric Model: Linear Regression

2.1 Basic Model

Intertemporal utility maximizer uses two kinds of assets for saving superfluous income in the current period. Bonds have positive nominal rate of interest, but money has negative real rate of interest considering inflation for goods and services. The main reason that people choose money as their savings instrument is that it has acceptability. So, the demand for money is originally affected by the interest rate as well as the amount of transaction.

The (real) money demand(M/P) is expressed by the function of real income Y , real interest rate r , the inflation rate π and the price level. The main reason why we study money demand to see the relationship between money stock and nominal income is that we examine this issue in the framework of simultaneous equations. If money supply is exogeneous, our observations for money

and income is the intersections of supply and demand. So, we only need to know the structure of demand.

$$M/P = L(r+\pi, Y)$$

The platform of econometric model is:¹

$$\ln M_t - \ln P_t = \alpha + \beta_1 \ln Y_t + \beta_2 R_t + \varepsilon_t \quad (1)$$

We can impose a restriction on the coefficient of income.

$$\ln M_t - \ln P_t - \ln Y_t = \alpha + \beta_1 SR_t + \beta_2 LR_t + \varepsilon_t \quad (2)$$

We use the data of financial institution liquidity(Lf; M) as monetary aggregate. it includes M2 and long-term time deposit, reserve of nonbanking financial intermediaries(eg. insurance company), etc. Price level(P) is used by CPI. Also, daily call rate and the interest rate of corporate bond are used as short-run(SR) and long-run(LR) interest rates, respectively. Data come from BOK, and are monthly from 1965 to 2009 of Korea. We use industrial production index as an income variable(Y) instead of GDP.

We transform the level variable into log value denoting by lowercase letters:

$$m_t - p_t - y_t = \alpha + \beta_1 SR_t + \beta_2 LR_t + \varepsilon_t \quad (2)'$$

The RHS can be viewed as the inverse of velocity, and <Fig. 1> shows that it is unstable across sample periods. To confirm the logic of traditional Keynesian view that income velocity of money varies in response to the change of the interest rate, we performed causality(exogeneity) test. Unstability of velocity implies unstability of real money demand. Macroeconomists have different views on the stability of velocity. Our study may give a little insight on empirical evidence. Velocity is equal to the inverse of Marshall's k.

We can see the unstability of velocity across sample periods. Velocity had decreased until 1997 financial crisis, and after that showed slightly upward trend.

Instability in money demand may mean two different facts. First, velocity is the function of the interest rate. Second, the function may have structural change. We find that velocity has decreased

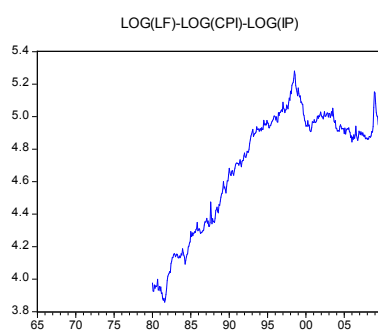
¹ We omit the inflation variable in this analysis as explanatory variables, focusing only on the production and the interest rates.

until recently, and the volatility of velocity itself is high. We investigate these two implications in this study, and derive appropriate policy implications.

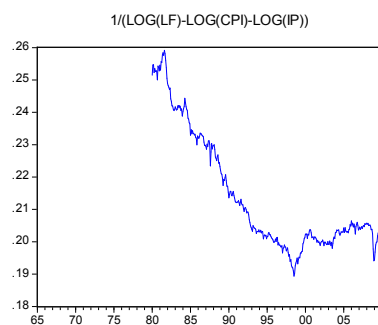
The volatility is measured by time-varying standard deviation(or variance) in ARCH equation for velocity.

<Fig. 1> Implied Income Velocity of Money, Conditional SD

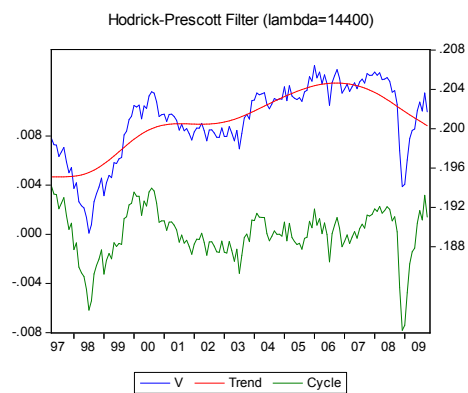
[inverse of velocity]



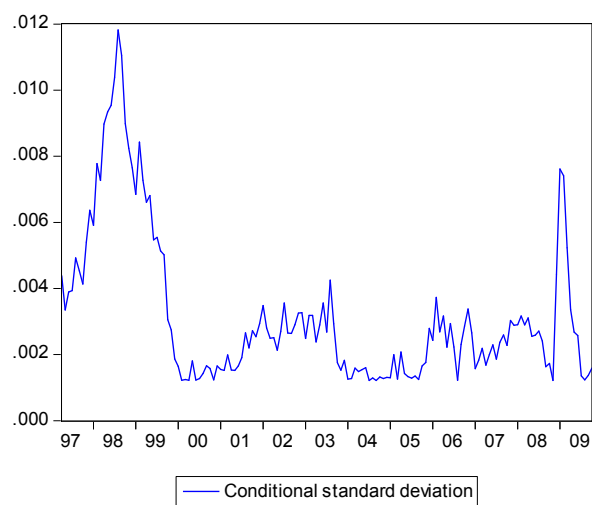
[velocity]



[velocity: 1997-2009]



[conditional SD in velocity equation of ARCH]



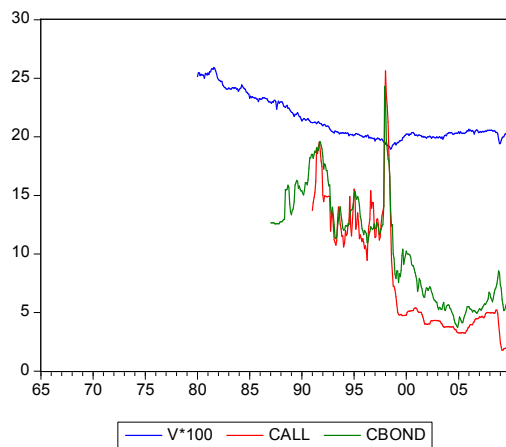
$$y_t = \beta_0 + e_t$$

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.202	0.000	1099.105	0.000

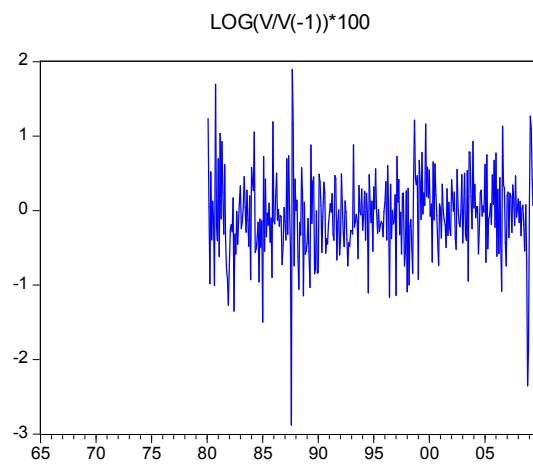
$$h_t = \alpha_0 + \alpha_1 e_{t-1}^2, \quad \alpha_0 > 0, \quad 0 \leq \alpha_1 < 1$$

C	0.000	0.000	6.642	0.000
RESID(-1)^2	0.803	0.303	2.653	0.008

[velocity and LR,SR interest rates]



[growth rate of velocity]



<Tab 1> Cointegration Test Results

Hypothesized	No. of CE(s)	$r \leq 1$
Eigenvalue		0.022
Trace	Statistic	6.027
0.05	Critical Value	3.841

Yielded cointegrating vector

$$V = -0.005CALL$$

(0.00134)

Cointegration test using trace test (trace test statistic is a function of canonical correlation in VAR)

variables or residuals) shows that there are two relationships, and normalized (for velocity) cointegration vector implies that velocity is well explained by the interest rate. But, in contrast to our intuition that velocity is increasing function of the interest rate, the sign of vector is minus. We discuss this issue in detail later.

2.2 Causality

Engle et al.(1993) consider the exogeneity of explanatory variable. Our interest is for the exogeneity of the interest rate. We performed pairwise Granger causality test. Generally, no existence of causality in reverse side and weak exogeneity lead to strong exogeneity. Test results show exogeneity of the short run (nominal) interest rate variable(CALL).

[Hereafter, we use the following abbreviation; money: LF, price level: CPI, short-run interest rate: CALL, long-run interest rate: CBOND, output: IP]

<Tab. 2> Causality Tests

Null Hypothesis:	Obs	F-Statistic Prob.
CALL → LOG(LF)-LOG(CPI)-LOG(IP)	224	3.92 0.0212**
LOG(LF)-LOG(CPI)-LOG(IP) → CBOND		2.60 0.0758*

We also test the exogeneity of each RHS variable in unrestricted model.

$$\ln M_t - \ln P_t = \alpha + \beta_1 SR_t + \beta_2 LR_t + \beta_3 \ln Y_t + \varepsilon_t \quad (3)$$

Test results show no exogeneity in the interest rate variables. But, we do not consider this problem in unrestricted model seriously in this section.

2.3 OLS and Parameter Stability

2.3.1 OLS

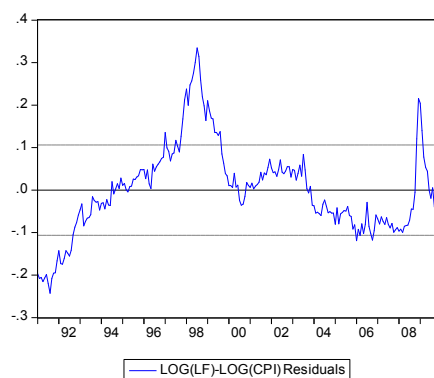
To test structural break, we firstly estimate the following equation by OLS:

$$\ln M_t - \ln P_t = \alpha + \beta_1 SR_t + \beta_2 LR_t + \beta_3 \ln Y_t + \varepsilon_t$$

The results are in <Table 3>. The coefficient for long-run interest rate is estimated negative significantly. Residual plot implies something missed in equation.

<Tab. 3> OLS for Money Demand(LOG(LF)-LOG(CPI))

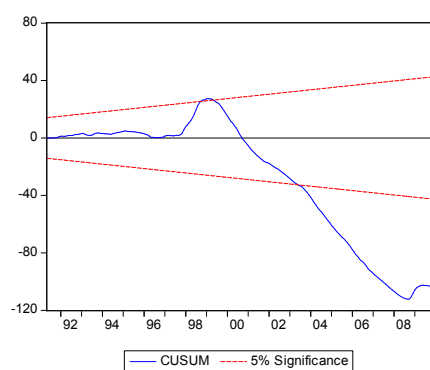
	Coefficient	Prob.
C	5.081	0.00
CALL	0.005	0.25
CBOND	-0.009	0.08*
LOG(IP)	0.981	0.00**



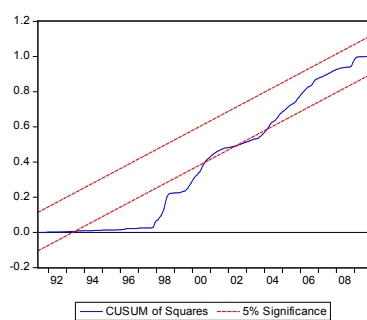
2.3.2 Parameter Stability: Recursive Residuals

We perform some stability tests for this OLS estimation model. These stability tests see whether some structural break in parameters occurred in the sample period. This investigates the second kind of instability, that is, V is not only the function of the interest rate but also its coefficient is not constant across periods.

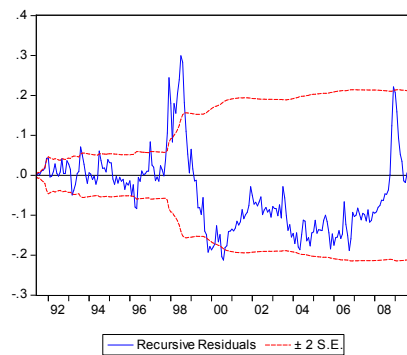
<Fig. 2> Recursive Residuals Test for Parameter Stability
[CUSUM Test]



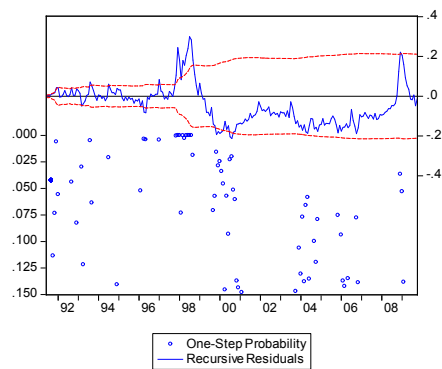
[CUSUM of Squares Test]



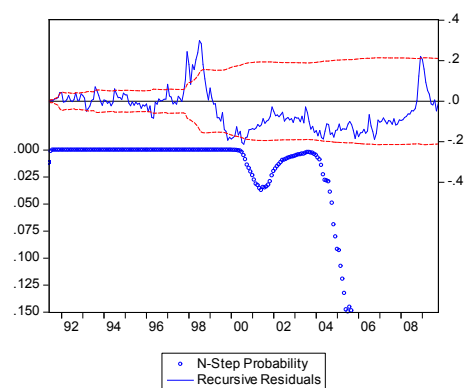
[Recursive Residuals]



[One-Step Forecast Test]



[N-Step Forecast Test]



Recursive residual is defined in EViews 6.0 as:

$$w_t = (\text{OLS residual}) / (\text{Forecast error Variance})^{(1/2)}$$

Parameter stability tests are based on these residuals. All parameter stability tests show that in two sub-period, 1997 crisis and the late 2000s, significant deviations (instability) of parameters from normal value. (except for CUSUM of squares, Fig.2)

We use other recursive LSs: CUSUM of squares, one-step forecast, n-step forecast tests. From <Fig 2>, we can also see instability over 1997 crisis and the late 2000s.

The CUSUM test is used for stability of regression function. It is based on the recursive residuals. If these recursive residuals deviate from the SE bands, we can infer that there is parameter instability. The CUSUM of squares test uses the square of recursive residuals. One-step forecast test shows a plot of recursive residuals, SE and points whose probability is at or below 15%. N-step forecast test carry out a sequence of Chow forecast test. (EViews 6)

We also use Chow's breakpoint, Quandt-Andrews breakpoint, and Chow's forecast tests. Test results show that there was significant breakpoint. Chow's forecast test compares the results for two different models. These facts well contrast with those of Bayer(1998) showing no significant instability in Germany.

<Tab. 4> Chow Test for Parameter Stability

Chow Breakpoint Test: 1997M04	
Prob. F(5,216)	0.0000**
Prob. Chi-Square(5)(LR)	0.0000**
Prob. Chi-Square(5)(Wald)	0.0000**

Chow Forecast Test: Forecast from 1997M04 to 2009M10	
Prob. F(151,70)	0.0000**
Prob. Chi-Square(151)	0.0000**

	1991M01 1997M03	1997M04 2009M10
C	3.862	5.992
CALL	0.003	-0.004
CBOND	-0.024	0.009
LOG(IP)	1.358	0.763

D(LOG(CPI))	-1.170	-2.209
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Chow Breakpoint Test: 2000M01	
Prob. F(4,218)	0.0000**
Prob. Chi-Square(4) LR	0.0000**
Prob. Chi-Square(4) Wald	0.0000**

Chow Forecast Test: Forecast from 2000M01 to 2009M10	
Prob. F(118,104)	0.0000**
Prob. Chi-Square(118)	0.0000**

Quandt-Andrews Break test performs the test of breakpoint between two data points by summing different k statistics at all observations. This examine whether there is break point between two points. Test results are in <Table 5>, and shows rejection of hypothesis of no structural break. In contrasts with ours, Bayer(1898) performs Mean Wald(Mean F), Exponential Wald, and Hansen's L_C tests.

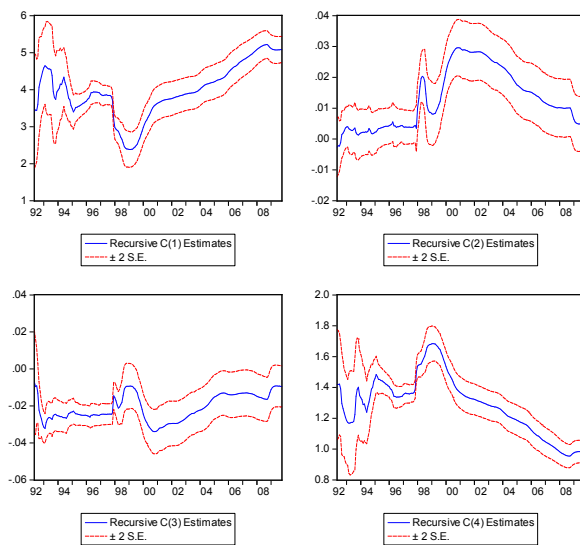
<Tab. 5> QA Test for Parameter Stability

Quandt-Andrews unknown breakpoint test	
Statistic	Prob.
Maximum LR F-statistic (1997M10)	0.0000**
Exp LR F-statistic	0.0000**
Ave LR F-statistic	0.0000**

2.3.3 Parameter Stability: Recursive Coefficients

We also estimate recursive coefficients adding new samples iteratively. Strong variation implies parameter instability and the existence of structural- break.<Fig 3> Recursive coefficients shows probable break in parameter value at 1997 and 2000.

<Fig. 3> Recursive Coefficient Estimates



	Coefficient
C	C(1)
CALL	C(2)
CBOND	C(3)
LOG(IP)	C(4)

2.3.4 State Space: Time-Varying Coefficient

Finally, we estimate state-space model which make possible to estimate time-varying coefficient using Kalman-filter. That is, we estimate simple state-space model for time-varying coefficient of short interest rate. To model the time-varying coefficient, we use state-space model adopting the famous Kalman filter. Kalman filter use two-step procedure: prediction and updating. Prediction for dependent variable is need for the updating of parameter estimate. For that, it is necessary to

calculate the estimate of parameter based on information up to the past period. Prediction stage gives information for prediction error. We can use this for updating the parameter estimate. In the first stage, we form an optimal forecast of dependent variable, conditioned on the all available information up to the past. For this, we need an optimal forecast of parameter, conditioned on the all available information up to the past.

$$\beta_{t|t-1} \rightarrow y_{t|t-1} \rightarrow \beta_{t|t}$$

This space model is useful for models with unobserved variables like: inflation expectation, natural rate of unemployment, permanent income and reservation wage.

The coefficient for the short interest rate reveals strong time-varying properties and substantial variation.<Tab 6>

Estimation results shows that in early 1990s, this coefficient(or marginal effect) has negative value, but has increased in its value into positive effect. This also seems to affect the stability of money demand. It is worth noting that this estimates are different from those of recursive residuals. In this model, the coefficient shows upward trending, but recursive case mixed. Notwithstanding, we can conclude that the response of money demand to the change in the interest rate is unstable. It's implication is important in that Bank of Korea performs monetary policy through affecting the (target) Call rate(eg. Target Federal Funds Rate in the US) in hope of transmitting the effects into the long-run (nominal) interest rate like Corporate bond rate. So, monetary policy focusing on the short rate may be misleading in South Korea, since the marginal effect(the value of coefficient) is unstable.

<Tab. 6> Random Coefficient Model: State-space Model

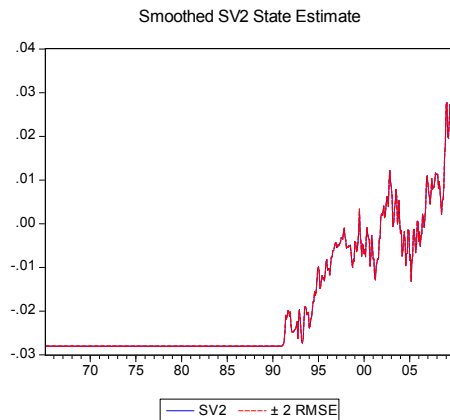
$$\log(lf) = c(1) + sv \cdot call + c(2) \cdot \log(cpi) + c(3) \cdot \log(ip) + c(4) \cdot cbond + e$$

$$\text{state } sv = sv(-1) + u$$

	Coefficient	Prob.
C(1)	2.879	0.0000**
C(2)	2.394	0.0000**
C(3)	0.049	0.0351**
C(4)	-0.001	0.5236
C(5)	-11.85	0.0000**

	Final State	Prob.
SV	0.033	0.0000**

[Estimated time-varying coefficient for short run interest rate]



III. Long-Run Relationship: Cointegration and Error Correction

As proceeds in this section, all variables in the money demand are nonstationary. This fact may invalidate the analysis of the previous section using OLS. But, if there are cointegration relationships between variables, it is known OLS estimators are superconsistent.(Daviddson and MacKinnon, 1993) Stock and Watson(1988) argue that cointegrated series have a common trend of some sort. We can interpret that linear combination of two cointegrated series is stationary, since this series do not have something that must ne present in original nonstationary series.

In this cointegration analysis, we add dummy variables denoting structural breaks in the long-run equilibrium relationship.

From these bases, we can compromise the conintegration analyses with those of LS methods of the previous section.

3.1 KPSS Test for Stationarity

As a first step, we perform unit-root test using Kwitkowski et al.(1992) (KPSS) method, which is recently widely used. This method reverses the strategy of ADF, that is, the null hypothesis is stationarity of variable. Test results show that all variables are nonstationary, I(1) variables.

<Tab. 6> KPSS Test

Null Hypothesis: LOG(LF/CPI) is stationary		LM-Stat
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.239
Asymptotic critical values*:	5% level	0.4630
Null Hypothesis: LOG(LF) is stationary		2.2750
Null Hypothesis: LOG(CPI) is stationary		2.748
Null Hypothesis: CALL is stationary		1.570
Null Hypothesis: CBOND is stationary		1.576
Null Hypothesis: LOG(IP) is stationary		2.298

3.2 Cointegration and Error Correction

The form of econometric model analyzing long-run relation is:

$$\ln M_t - \ln P_t = \alpha + \beta_1 \ln Y_t + \beta_2 R_t + \varepsilon_t$$

Estimated cointegrated vector(long-run relationship) is:

$$\ln M_t - \ln P_t = 0.87 \ln Y_t - 0.04 SR_t - 0.02 LR_t$$

Adding restriction to the coefficient of income reduces:

$$\ln M_t - \ln P_t - \ln Y_t = 0.32 SR_t - 0.11 LR_t \quad (2)$$

The estimates for cointegrating vector in equation (2) show that the income velocity of money(the inverse of LHS) is positively related with long-run interest rate. Our estimation for cointegration vector assures that a single-equation model for the long run money demand is appropriate and a valid way to proceed.(Greene, 2008)

BOK(2002) reports that the elasticity of money demand to income and interest rate as 1.16 and 1.5, respectively(2004).(compared to ours, 0.87 and 0.11)

<Tab. 7> Cointegration Vector Estimates

Specification 3

Restricted cointegrating coefficients (standard error in parentheses)				
LOG(LF)	LOG(CPI)	CALL	CBOND	LOG(IP)
1.0	-1.0	-0.087	0.049	-0.736
(0.00000)	(0.00000)	(0.01799)	(0.02218)	(0.14535)

We construct VEC(vector error correction) model considering short-run money demand change. VEC model has an advantage that it represent not only long-run response (cointegrating part), but also the speed at which it responds to change in equilibrium error.(EC part) Lag exclusion Wald test result shows that optimal lags in VEC are 4. VEC is a special case of VAR when the variables are nonstationary(I(1)) and cointegrated.

Estimation results show the coefficient of cointegrating error is significantly negative. This means that if demand is unusually high relative to cointegrated explanatory variables, demand change may decrease. Exogeneity test results show no significant casality.

<Tab. 8> Exogeneity Tests and Cointegration Vector, Error Correction Estimates

VEC Granger Causality/Block Exogeneity Wald Tests			
Dependent variable: D(LOG(LF)-LOG(CPI))			
Excluded	Chi-sq	df	Prob.
D(CALL)	1.160	4	0.88
D(CBOND)	7.288	4	0.12
D(LOG(IP))		4	0.93
All	16.87	12	0.15

Specification 1 (D denotes change)

Cointegrating Eq:	CointEq1
LOG(LF(-1))-LOG(CPI(-1))	1.000
CALL(-1)	-0.043
CBOND(-1)	0.017
LOG(IP(-1))	-0.868
C	-5.322
Error Correction:	D(LOG(LF)-LOG(CPI))
CointEq1	-0.0144**

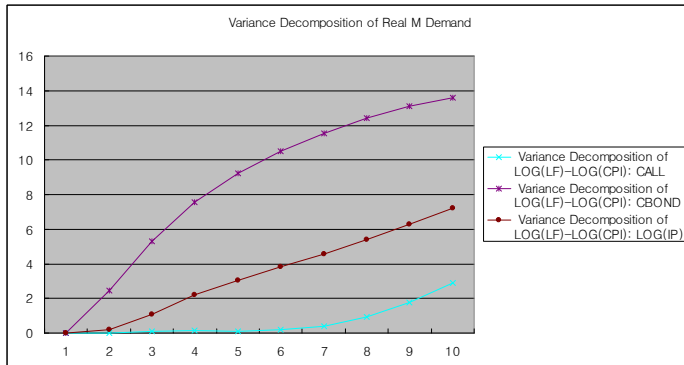
VAR(Vector Autoregression) model is useful in estimating impulse response function and deriving variance decomposition. The former is the function of the parameter coefficients in reduced form system and the latter the share of the error explained by the variance of specific explanatory variable.

Variance decomposition result shows the contribution of each type of shock to the variance of forecast error. Excluding its own contribution, the shock of long-run interest rate has the largest contribution. That is, its explanation power for money demand is highest. We can infer this share of contribution as “speculative money demand”, which decreases as the interest rate increase.

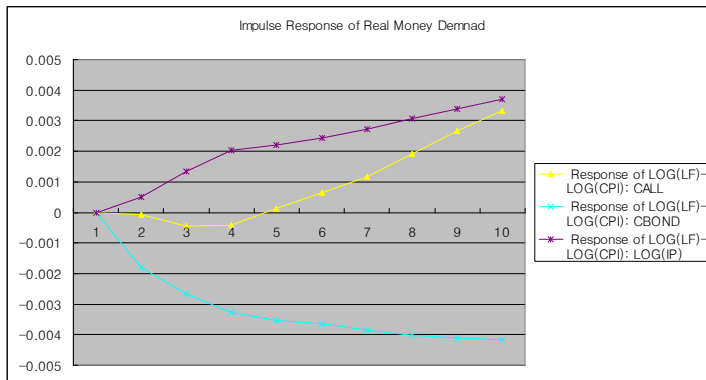
Our previous results of having significantly negative coefficient for the long-run interest rate and having large explanatory power in explaining the forecast error variance in money demand reveal that Korea’s money demand is unstable in the first sense of instability, which means velocity is the

function of long-run interest rate.

<Fig. 8> Variance Decomposition

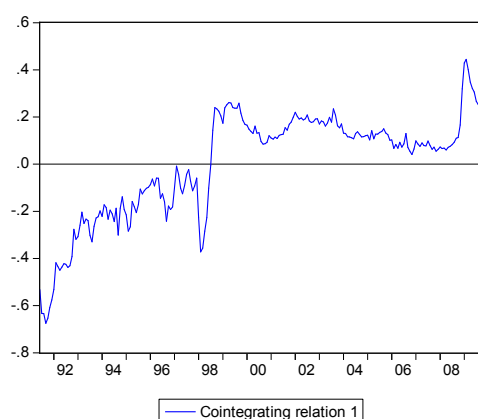


<Fig. 9> Impulse Response



Estimation for impulse response function shows that the shocks in production have the largest impact on real money demand. <Fig 10> shows the equilibrium error in cointegration equation. It shows that before 1997, the error has negative sign, and short-run money demand had increased in response to this deviation from long-run relationship, and vice versa, after that. This implies that there was structural break of money demand in 1997 in that before that actual money demand was lower than that of long-run equilibrium value suggested by cointegration vector estimate.

<Fig. 10> Equilibrium Error



Finally, we use dummy variables applied to suspected break points. We have to note that first dummy is different from that of the previous section.

Dummy1: 1 after 2003M01, 0 otherwise

Dummy2: 1 after 1997M01, 0 otherwise

These variables enter both into cointegration part and error correction part. Estimation results show that both dummies are significant and reduce both the level and change of money demand than otherwise. Two kinds of dummy are important, since the former implies the change(break) in the cointegration relationships, the latter the change in speed at which short run error correction occurs. Error correction model with two dummies shows that in the equations of real money demand and production(IP), the error correction coefficients are statistically significant. In contrast with Bayer(1994, 1998), we included dummy variables into the cointegration relation. All these dummies are significant in both short and long run relationships.

<Tab. 9> Cointegration Vector and Error Correction Estimates with Dummy Variables

Normalized **cointegrating coefficients** (standard error in parentheses)

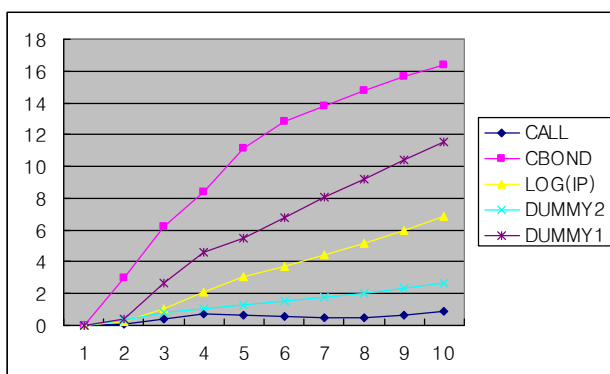
LOG(LF)- LOG(CPI)	LOG(IP)	CALL	CBOND	DUMMY2 (low money	DUMMY1 (lower money
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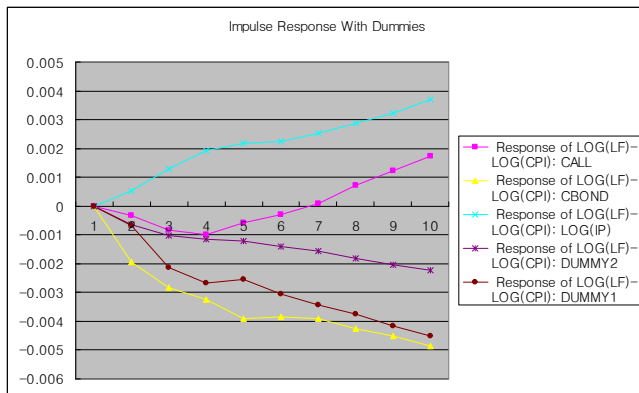
				demand)	demand change)
1.0	-1.85	-0.10	0.08	0.48	0.57
	(0.328)**	(0.029)**	(0.034)**	(0.158)**	(0.156)**

Error Correction:	D(LOG(LF)- LOG(CPI))	D(CALL)	D(CBOND)	D(LOG(IP))	D(DUMMY2) (low money demand)	D(DUMMY1) (lower money demand change)
CointEq1	-0.012**	0.1707	0.3420	0.018**	-0.040**	-0.000
t-ratio	[-5.146]	[0.607]	[1.292]	[2.606]	[-1.981]	[-0.039]

Variance decomposition and impulse response show that long run rate has the highest explanatory power, and production(IP) has the highest effects on money demand, which are similar to those without dummies.

[Variance Decomposition with Dummies]





3.3 Marcov Switching

Marcov switching model uses Kalman filter. It is extension of the simple F-test of model stability of Chow(1960). Goldfelt and Quandt(1973) introduce Marcov switching model where the time of switching is endogenous in the model. For simplicity, we introduce in this section the case of independent switching only considering constant terms. The probability to state 2(low money demand) is expressed as logistic distribution.

The simple econometric model is:

$$(\ln M_t - \ln P_t)_1 = \alpha_1 + \varepsilon_{1t}, \quad \varepsilon_{1t} \sim N(0, \sigma^2_1) : \text{high money demand}$$

$$(\ln M_t - \ln P_t)_2 = \alpha_2 + \varepsilon_{2t}, \quad \varepsilon_{2t} \sim N(0, \sigma^2_2) : \text{low money demand}$$

$$P(s=2)=p$$

$$P(s=1)=1-p$$

<Tab. 9> Estimation of Marcov (Independent) Switching Model

MAXIMIZE - Estimation by BFGS

Variable	Coeff	Std Error	T-Stat	Signif

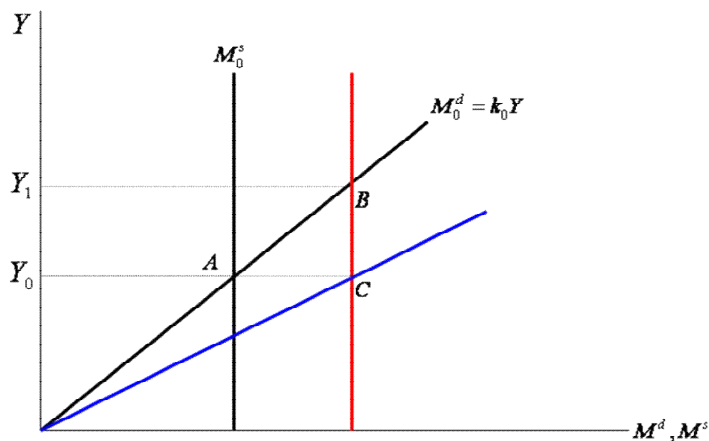
1. P	0.426	0.065	6.506	0.000**
2. A10	9.375	0.049	189.3	0.000**
3. A20	7.724	0.158	48.704	0.000**
4. SIGMA1	0.243	0.039	6.09	0.000**
5. SIGMA2	0.901	0.097	9.27	0.000**

There are high money demand regime and low demand regime. The probability to transition to low regime is 0.426. The implication of this outcome is that our demand equation with just constant reveals regime switching.

For simplicity, we only consider independent switching, and more rigorous analysis of (endogeneous) Marcov switching considering explanatory variables is needed in future research.

3.4 Monetary Policy Implications

<Fig. 11> The stability of Money Demand



The implication of the stability in money demand is understood well by using <Fig 11>. Government(BOK) wants to increase the nominal income by expanding money supply. It hopes to increase nominal income(to B), then, affect real income that is important to resource allocation only if inflation is stable. But, only if money demand(M^d) is stable, it can attain its initial goal. If money

demand also moves(to OC) responding accompanying corresponding change in the interest rate, it's policy cannot affect the real economy. Until now, almost all of empirical evidences reveal unstable money demand. So, they imply monetary policy focusing on changing monetary aggregate may fail due to undesirably unstable money demand.

If we express money demand as:

$$M^d = k(R) P y = 1/V(R) [P y]$$

In macroeconomics, the first kind of instability in money demand means that the Marshall's k is the function of (nominal) interest rate, not the fact that the relation between R and M is unstable. We need to recollect the Goodheart's law and Lucas critique. In addition, financial innovation(eg. innovation of new product of banks) made the money demand respond to the rates of return in diverse assets.

In the above figure, we denote nominal income in y-axis. For policy perspective, both inflation(or the level of price) and real income are important. So, we can use inflation for y-axis variable.

Baumol and Blinder(2006) summarize the determinants of income velocity as follows: First, the frequency with which paychecks are received. Second, the efficiency of payments mechanism like the use of credit cards, third, the rate of interest, fourth, the expected rate of inflation.

Cheong and Kim(2007) presents the factors that prevent economists from forecasting demand accurately. First, they point out aggregate supply shocks like the second oil shock in 1979. Second, many countries adopted monetary targeting, and set the amount of monetary aggregate as intermediate target. But, as soon as government controlled the money stock, the behavior of the index of money was changed.(Goodhart's law) Third, Financial deregulation, liberalization, globalization have made money demand unstable. Technical progress in financial management, spread of universal banking, financial innovation and deregulation in the determination of the rate of interest in deposit account.

Finally, introduction of inflation targeting increased the volatility of interest rate, and contributed to the instability of money demand.

From our empirical evidences, we can infer the following facts about the causes of unstable money demand;

- 1) Big depression due to financial crisis(currency + banking) caused large parameter instability in demand, in the view of instability means changing the relationship between V and LR .
- 2) Government transformed currency market into (managed) floating in Dec. 1997.
- 3) Overnight interbank loan market was liberalized and the call rate, the market outcome was deregulated.

- 4) In the mid- and late 1990s, overuse of credit card became social problem in South Korea, and this led to instability(increase) of velocity and liquidity constraints for borrowers with low credit.
- 5) In July, 1997, part of the rates of interest in deposit accounts were deregulated. These rates were the costs of banks in financing loan to private firms.
- 6) In 1998, BOK introduced inflation targeting policy. This focused on short run interest rate(call rate) as operational target of inflation targeting.

The following shows important change in payments mechanism, financial market and financial innovation, which seem to have affected the structure in money demand.

[Recession or Depression]

97-98

[Deregulation]

97. 12 floating

98. 5 stock market liberalize

99.5 call rate

02.4 foreign exchange market reform

04. 2 interest rate liberalization

[Monetary Policy]

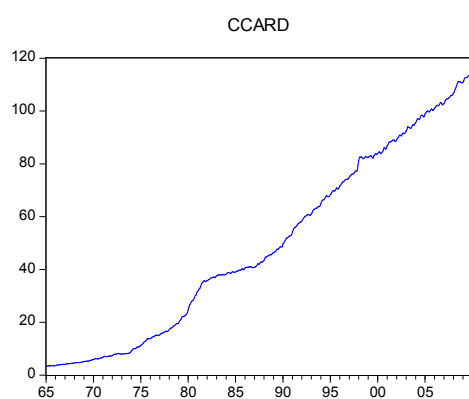
98.4 Inflation targeting

<Tab 7> Deregulation for Interest Rates (BOK)

	Lending	Deposit	Bond
Stage 1		Long run savings deposit	
(1991. 11)	Short run loan	&(CD, RP so on)	Corporate bond
Stage 3	Discount Rate	Demand deposit	—
(94. 7~95. 11)			

Stage 4		(7 days– 3 months) savings account	
(1997. 7)	–		–
Current	Subsidy	Demand deposit	

<Fig. 12> The amount of credit card used(BOK, mil. Won)



<Tab 8> Cointegration between V and the amount of credit card used(CCARD)

Normalized cointegrating coefficients (standard error in parentheses)			
LOG(V)	LOG(CCARD)	CBOND	CALL
1.00	0.36	0.00	0.03
	(-0.11)	(-0.01)	(-0.01)

Total amount of credit card has increased steadily until recently. Cointegration with V means our equation is sufficient for imputing money demand instability to innovation in payment system. It is worth noting that V is decreasing with the amount in contrast with the intuition that card use generally increase the income velocity.

IV. Summary and conclusion

Goldfield(1973) estimated the US money demand, and showed predictive power well. But, his estimate did not have goodness of fit over and after 1970s.

In this paper, we find 1) money demand function was instable over 1965-2009 period. And, 2) also structural breaks occurred about in 1997 and in 2000.

We can infer that the 1997 structural break in 1997 came due to Asian crisis, change in monetary policy regime and that of 2000 due to financial innovation. This paper's main contribution is that Korea's money demand not only is responsive to the interest rate but also shows regime switching or parameter change. So, using L_f (liquidity of financial intermediaries) may not be used any index or target for monetary policy.

So, insofar as the ratio of money holding k is concerned, Keynesian money theory may be correct in South Korea. Not only k is function of the rate of interest, but also the function itself changes.

But, more sophisticated analysis is needed for checking the implication for stabilization policy, and we postpone this for future research.

Recently, macroeconomists deviates from simple Keynesian money demand or quantity theory of money. They developed overlapping generations model(OLG; Samuelson, 1958), cash-in-advance model(Rotemberg, 1987) and money-in-the utility-model(Sidrauski, 1967). All these models are based maximization principles of agents and micro-foundation. They may solve the problem of instability of macroeconomic money demand.

Money(storable and divisible commodity) in OLG model play the role of reaching golden rule level of storage for the good.

Cash in advance model considers demand for cash goods in the next period as the determinant of money demand in the current period. Meanwhile, demand for credit goods need not retain money balance, since they can be settled other payment instrument like credit cards.

We need to develop these microeconomic money demand theory. It enables us to check the instability of demand at the micro-econometric level.

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<Appendix>

Instead of recursive coefficient or time-varying coefficient instate space model, we use

nonparametric estimation (Kernal fit) for coefficient for the rates of interest as well. Figures imply parameter instability(or structural break).

