US Monetary Policy and the G7 House Business cycle : FIML Markov Switching Approach

Yoon, Jae-Ho

2017. 6.20

http://sites.google.com/site/beowulfkorea/

1. Introduction

Motivation

- ❑ **Greenspan Doctrine vs. Bernanke Doctrine**
- ❑ **Taylor rule vs. ?**
- ❑ **House Business Cycle (Bubble and Bust)**

1. Introduction

The Purpose of this paper

- Plamen Iossifov, Martin Čihák, and Amar Shanghavi1 (2008) showed that the short-term interest rate has a sizable impact on residential housing prices. Lastrapes, W. D. (2002) showed that money supply shocks have real effects on the housing prices.
- However, Deniz Igan and Prakash Loungani (2012) found that long-run house price dynamics are mostly driven by local fundamentals such as income and the effect of more globally connected factors such as interest rates appears to be less strong.
- Òscar Jordà, Moritz Schularick, Alan M. Taylor (2015) disagree over interest rates increase to curb asset price booms.

⇒ Therefore, this paper examined whether there really is a positive relationship between US monetary policy and the G7 house business cycle

1. Introduction

Methods

- To establish a relationship between US monetary policy and the G7 house business cycle, we adopted the full information maximum likelihood (FIML) Markov-switching model of Yoon (2006).

The findings of this paper

- The paper showed a positive relationship between US interest rate and G7 GDP growth. US interest rate is a significant variable to the common business cycle between housing price and GDP in the G7 countries. However,US interest rate showed a significant effect to the G7 house business cycle for small shock periods, not extremely large shocks periods.
- This paper also found no relationship between US m2 growth and the GDP growth rate of the G7 countries.

2. FIML Markov-Switching Model (Yoon Model)

FIML Markov Switching Model

= Simultaneous Equation + Markov Switching

- **FIML : Full Information Maximum Likelihood**

3. Derivation of the FIML Markov Switching Model

$$YBs_t + Z\Gamma s_t = U_{St} \qquad U_{St} \sim i.i.d.N(0, \Sigma_{St} \otimes I_T)$$

Where,

$$Y = \begin{bmatrix} Y_{11} & Y_{12} & \cdots & Y_{1M} \\ Y_{21} & Y_{22} & \cdots & Y_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ Y_{T1} & Y_{T2} & \cdots & Y_{TM} \end{bmatrix} = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_T \end{pmatrix} \quad Bs_t = \begin{bmatrix} \beta_{11,S1t} & \beta_{12,S2t} & \cdots & \beta_{1M,SMt} \\ \beta_{21,S1t} & \beta_{22,S2t} & \cdots & \beta_{2M,SMt} \\ \vdots & \vdots & \ddots & \vdots \\ \beta_{M1,S1t} & \beta_{M2,S2t} & \cdots & \beta_{MM,SMt} \end{bmatrix} \quad Z = \begin{bmatrix} Z_{11} & Z_{12} & \cdots & Z_{1K} \\ Z_{21} & Z_{22} & \cdots & Z_{2K} \\ \vdots & \vdots & \ddots & \vdots \\ Z_{T1} & Z_{T2} & \cdots & Z_{TK} \end{bmatrix} = \begin{pmatrix} z_1 \\ z_2 \\ \vdots \\ z_T \end{pmatrix}$$

$$\Gamma s_t = \begin{bmatrix} \gamma_{11,S1t} & \gamma_{12,S2t} & \cdots & \gamma_{1M,SMt} \\ \gamma_{21,S1t} & \gamma_{22,S2t} & \cdots & \gamma_{2M,SMt} \\ \vdots & \vdots & \ddots & \vdots \\ \gamma_{K1,S1t} & \gamma_{K2,S2t} & \cdots & \gamma_{KM,SMt} \end{bmatrix} \quad U_{St} = \begin{bmatrix} u_{11,S1t} & u_{12,S2t} & \cdots & u_{1M,SMt} \\ u_{21,S1t} & u_{22,S2t} & \cdots & u_{2M,SMt} \\ \vdots & \vdots & \ddots & \vdots \\ u_{T1,S1t} & u_{T2,S2t} & \cdots & u_{TM,SMt} \end{bmatrix} = (u_{S1t} \quad u_{S2t} \quad \cdots \quad u_{SMt})$$

$$E(U'_{St}U_{St}) = E\left(\begin{pmatrix} u_{S1t} \\ u_{S2t} \\ \vdots \\ u_{SMt} \end{pmatrix} (u_{S1t} \quad u_{S2t} \quad \cdots \quad u_{SMt}) \right) = \begin{pmatrix} \sigma_{S1t,S1t} I_T & \sigma_{S1t,S2t} I_T & \cdots & \sigma_{S1t,SMt} I_T \\ \sigma_{S2t,S1t} I_T & \sigma_{S2t,S2t} I_T & \cdots & \sigma_{S2t,SMt} I_T \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{SMt,S1t} I_T & \sigma_{SMt,S2t} I_T & \cdots & \sigma_{SMt,SMt} I_T \end{pmatrix} = \Sigma_{St} \otimes I_T$$

3. Derivation of the FIML Markov Switching Model

Step 1 : At the beginning of the tth iteration $\Pr(S_{t-1} = i \mid \psi_{t-1})$ $i = 0,1,\cdots,N$ is given. And, we calculate

$$\Pr(S_t = j \mid \psi_{t-1}) = \sum_{i=1}^{N} \Pr(S_{t-1} = i, S_t = j \mid \psi_{t-1}) = \sum_{i=1}^{N} \Pr(S_t = j \mid S_{t-1} = i) \Pr(S_{t-1} = i \mid \psi_{t-1})$$

where $\Pr(S_t = j \mid S_{t-1} = i)$ are the transition probabilities.

Step 2 : Consider the joint conditional density of

$$f(y_t, S_t = j \mid \psi_{t-1}) = f(y_t \mid S_t = j, \psi_{t-1}) \Pr(S_t = j \mid \psi_{t-1})$$

from which the marginal density of

$$f(y_t \mid \psi_{t-1}) = \sum_{j=1}^{N} f(y_t, S_t = j \mid \psi_{t-1}) = \sum_{j=1}^{N} f(y_t \mid S_t = j, \psi_{t-1}) \Pr(S_t = j \mid \psi_{t-1})$$

where the conditional density

$$f(y_t \mid S_t = j, \psi_{t-1}) = (2\pi)^{-M/2} \det(\Sigma_{St})^{-1/2} \mid \det(Bs_t) \mid \cdot \exp(-\frac{1}{2}(y_t Bs_t + z_t \Gamma s_t) \Sigma_{St}^{-1} (y_t Bs_t + z_t \Gamma s_t)')$$

where

$\Sigma_{St} = \frac{1}{T}(YBs_t + Z\Gamma s_t)'(YBs_t + Z\Gamma s_t)$ y_t is the tth row of the Y matrix. z_t is the tth row of the Z matrix.

3. Derivation of the FIML Markov Switching Model

Step 3 :

y_t is observed at the end of time t, we update the probability terms:

$$\Pr(S_t = j \mid \psi_t) \quad = \Pr(S_t = j \mid \psi_{t-1}, y_t)$$

$$= \frac{f(S_t = j, y_t \mid \psi_{t-1})}{f(y_t \mid \psi_{t-1})}$$

$$= \frac{f(y_t \mid S_t = j, \psi_{t-1}) \Pr(S_t = j \mid \psi_{t-1})}{f(y_t \mid \psi_{t-1})}$$

As a byproduct of the above filter in Step 2, we obtain the log likelihood function:

$$\ln L = \sum_{t=1}^{T} \ln f(y_t \mid \psi_{t-1})$$

4. Data

Variables

- **t=1970:I to 2016:III from OECD database**
- **BIS database**
- **FRED**

- **Yt, is real GDP in the G7**
- **Ht is Housing Price Index in the G7**
- **M is federal fund rate or △m2**

Equation

$$\Delta Y_{G7} = \alpha_{S_t} + \beta_{St}\Delta H_{G7} + \lambda M + e_{St,G7}$$

Where:

$$\alpha_{St} = \alpha_1 S_t + \alpha_0 (1 - S_t) \qquad \beta_{St} = \beta_1 S_t + \beta_0 (1 - S_t)$$

$$\Pr(S_t = 0 \mid S_{t-1} = 0) = q \quad \Pr(S_t = 1 \mid S_{t-1} = 1) = p$$

4. Data

Equation

$$\Delta Y_{us} = \alpha_{S_t} + \beta_{St}\Delta H_{us} + \lambda M + e_{St,us} \quad (3)$$

$$\Delta Y_{uk} = \alpha_{S_t} + \beta_{St}\Delta H_{uk} + \lambda M + e_{St,uk} \quad (4)$$

$$\Delta Y_{france} = \alpha_{S_t} + \beta_{St}\Delta H_{france} + \lambda M + e_{St,france} \quad (5)$$

$$\Delta Y_{germany} = \alpha_{S_t} + \beta_{St}\Delta H_{germany} + \lambda M + e_{St,germany} \quad (6)$$

$$\Delta Y_{italy} = \alpha_{S_t} + \beta_{St}\Delta H_{italy} + \lambda M + e_{St,italy} \quad (7)$$

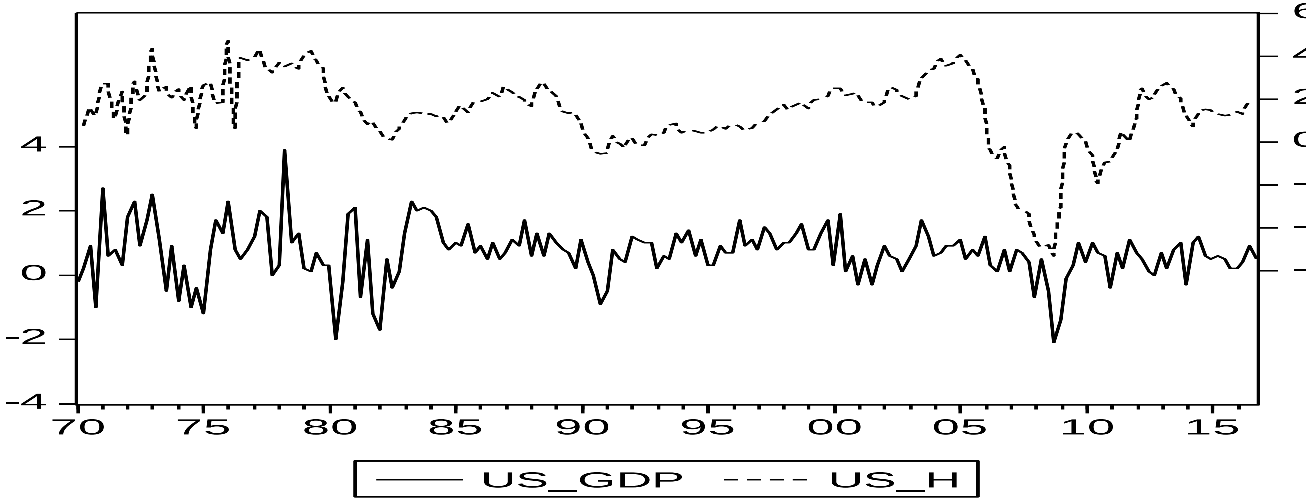
$$\Delta Y_{canada} = \alpha_{S_t} + \beta_{St}\Delta H_{canada} + \lambda M + e_{St,canada} \quad (8)$$

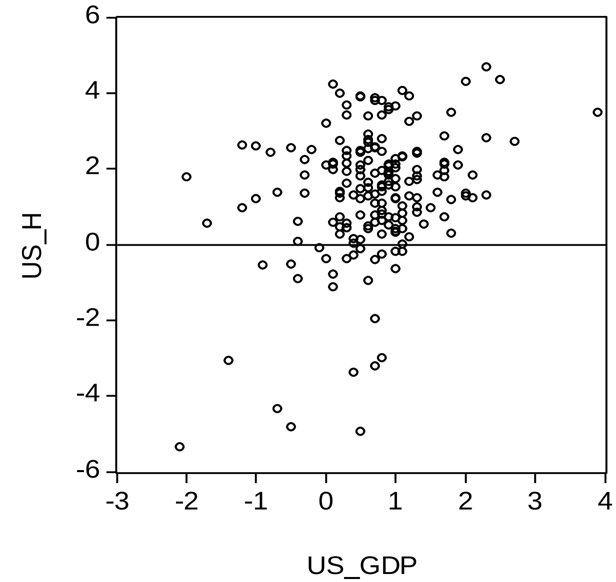
$$\Delta Y_{japan} = \alpha_{S_t} + \beta_{St}\Delta H_{japan} + \lambda M + e_{St,japan} \quad (9)$$

where $\Delta Y_{,}$ is the log differenced real GDP and ΔH is the log differenced housing price in the G7 countries. $M_{,}$ is federal funds rate or the log differenced $m2$.

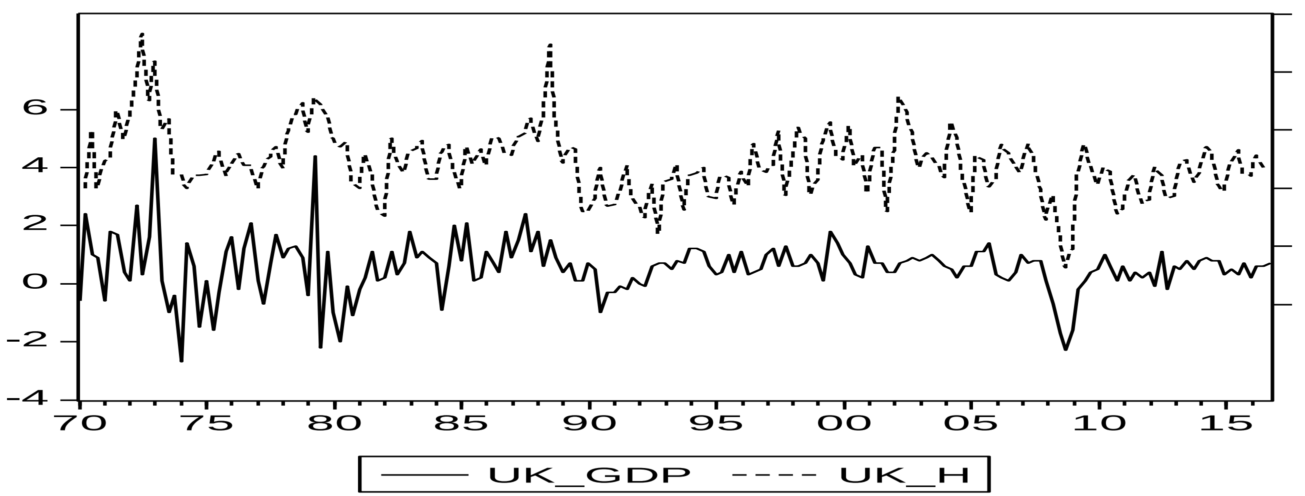
4. Data (GDP and House Price)

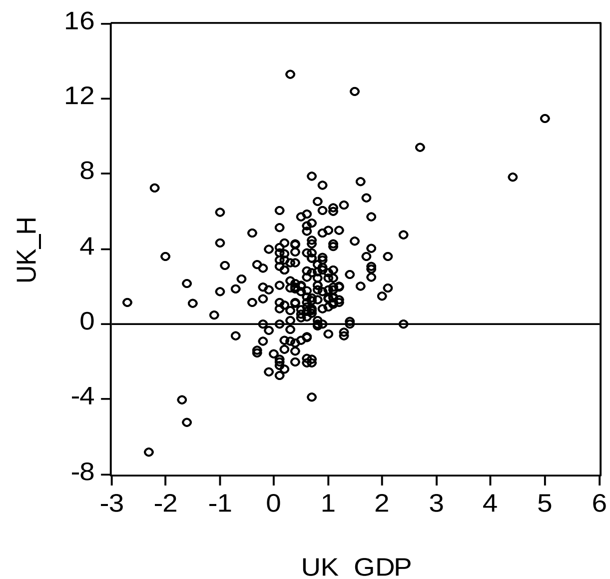
GDP △*Y* and House Price △*H* in the US





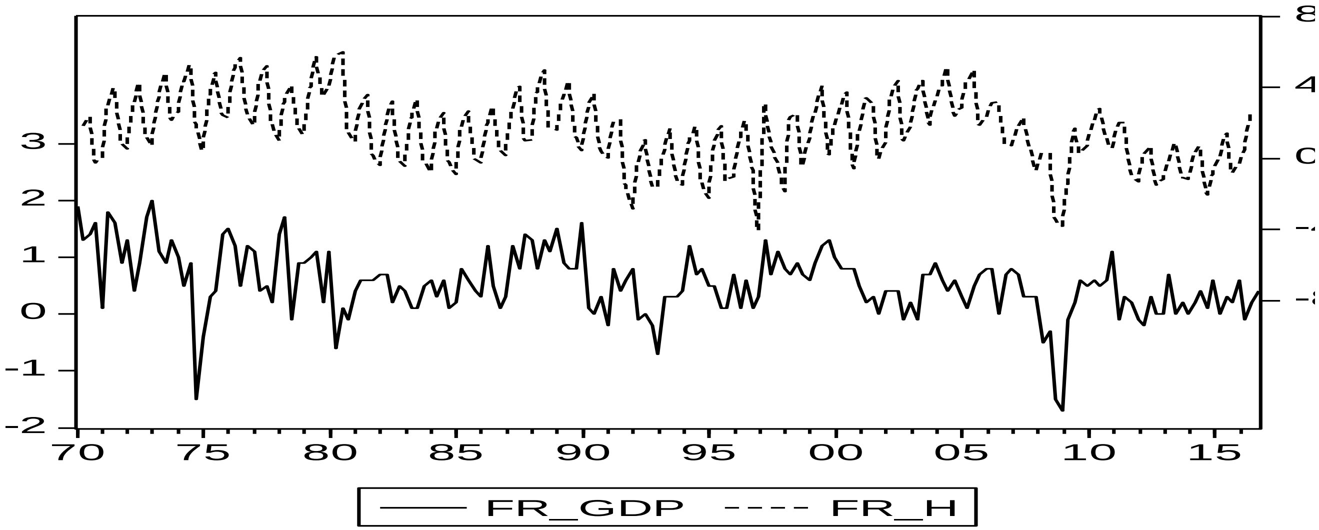
GDP △*Y* and House Price △*H* in the UK

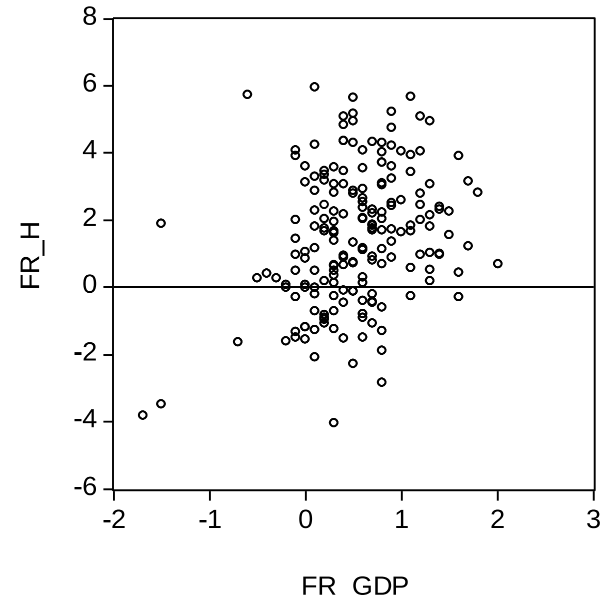




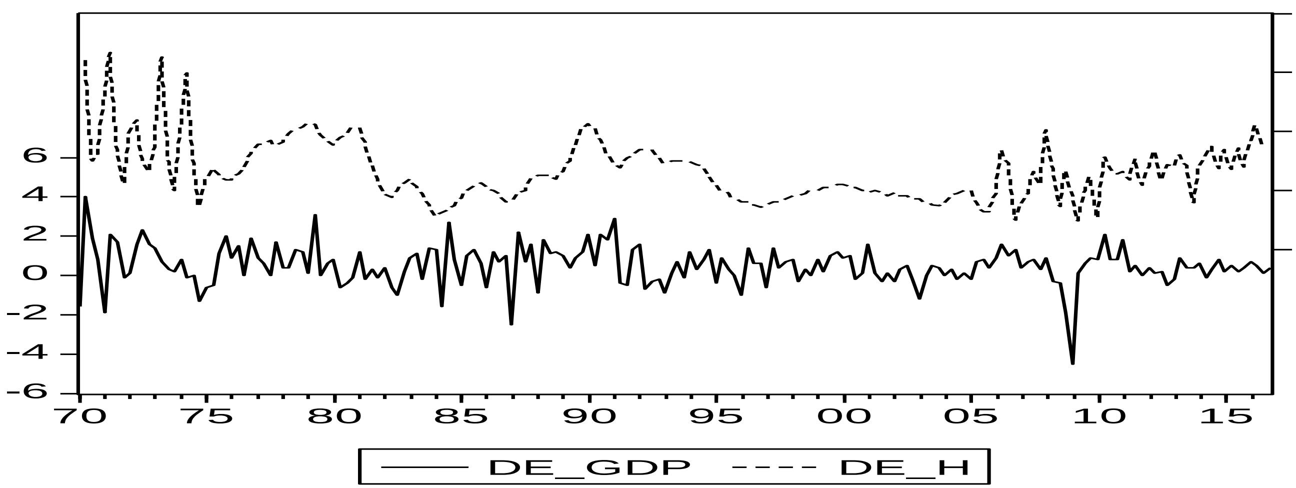
4. Data (GDP and House Price)

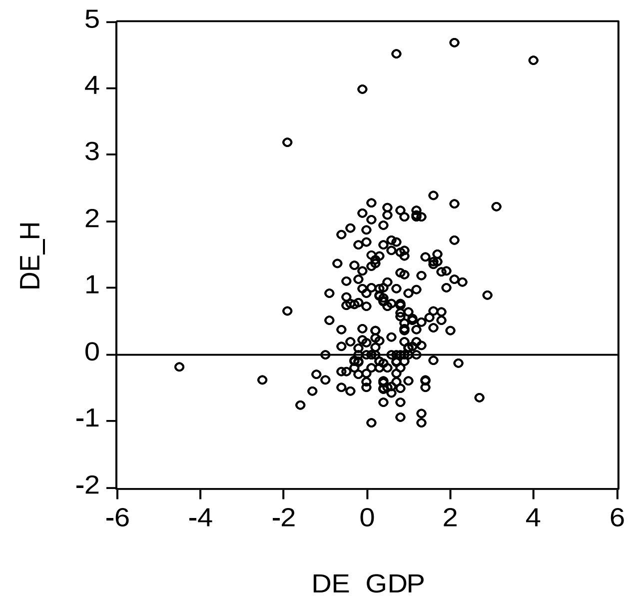
GDP $\triangle Y$ and House Price $\triangle H$ in the FR





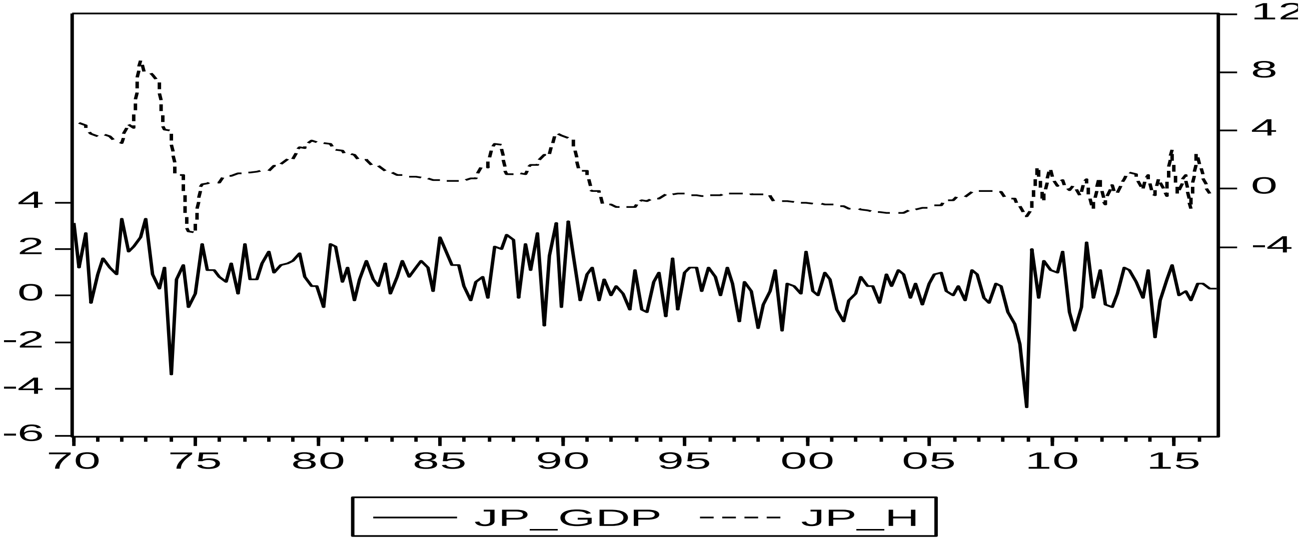
GDP $\triangle Y$ and House Price $\triangle H$ in the DE

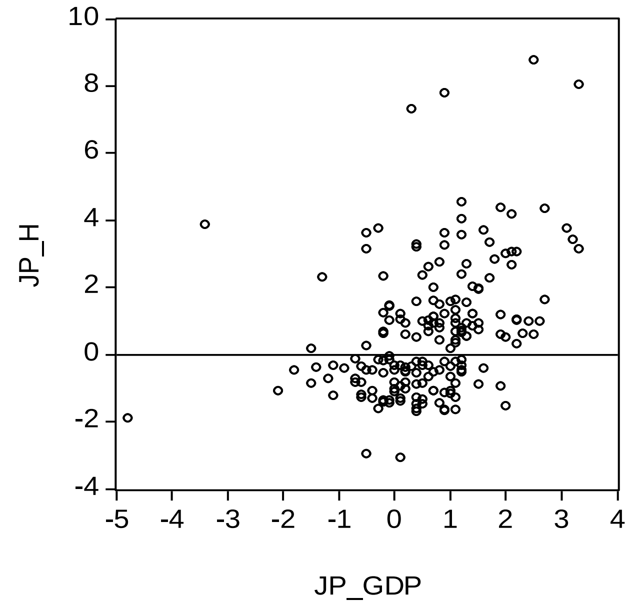




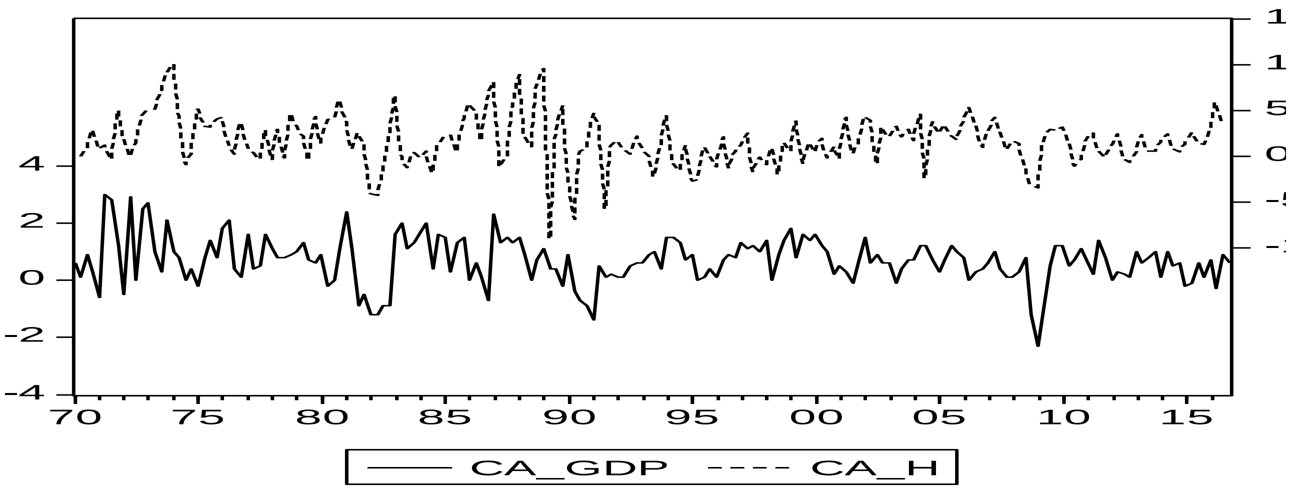
4. Data (GDP and House Price)

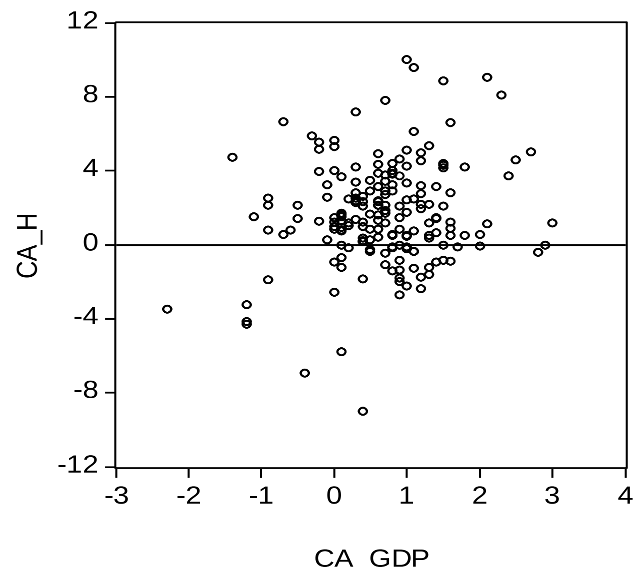
GDP △*Y* and House Price △*H* in the JP





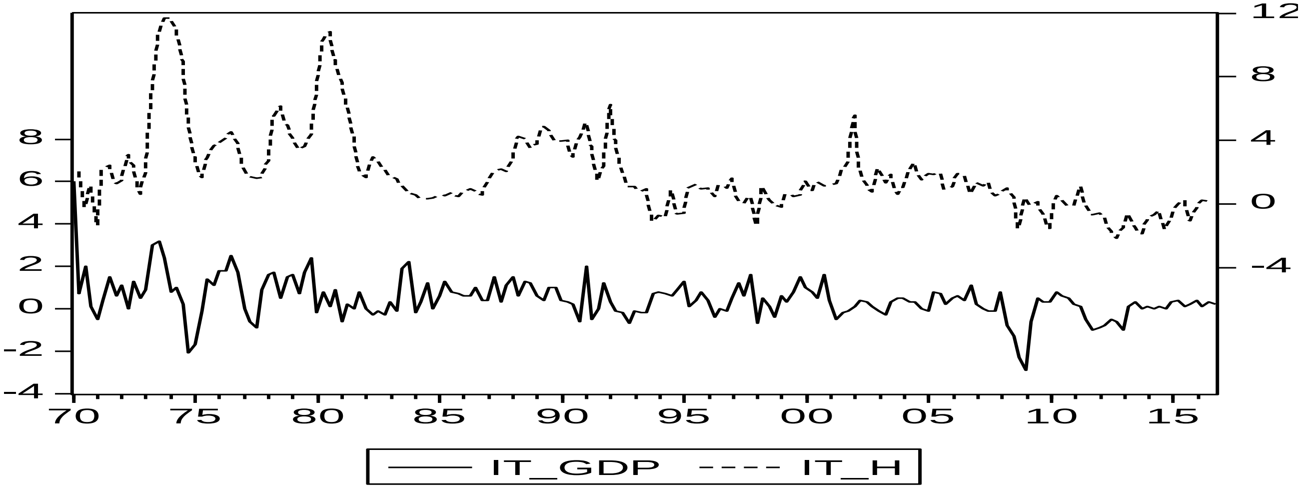
GDP △*Y* and House Price △*H* in the CA

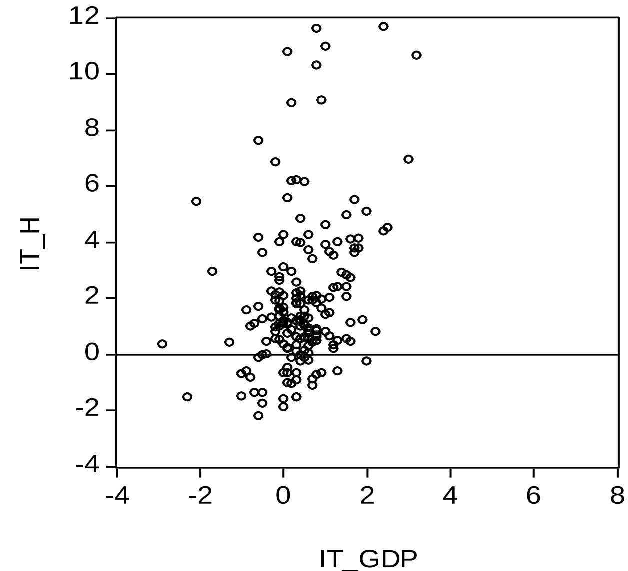




4. Data (GDP and House Price)

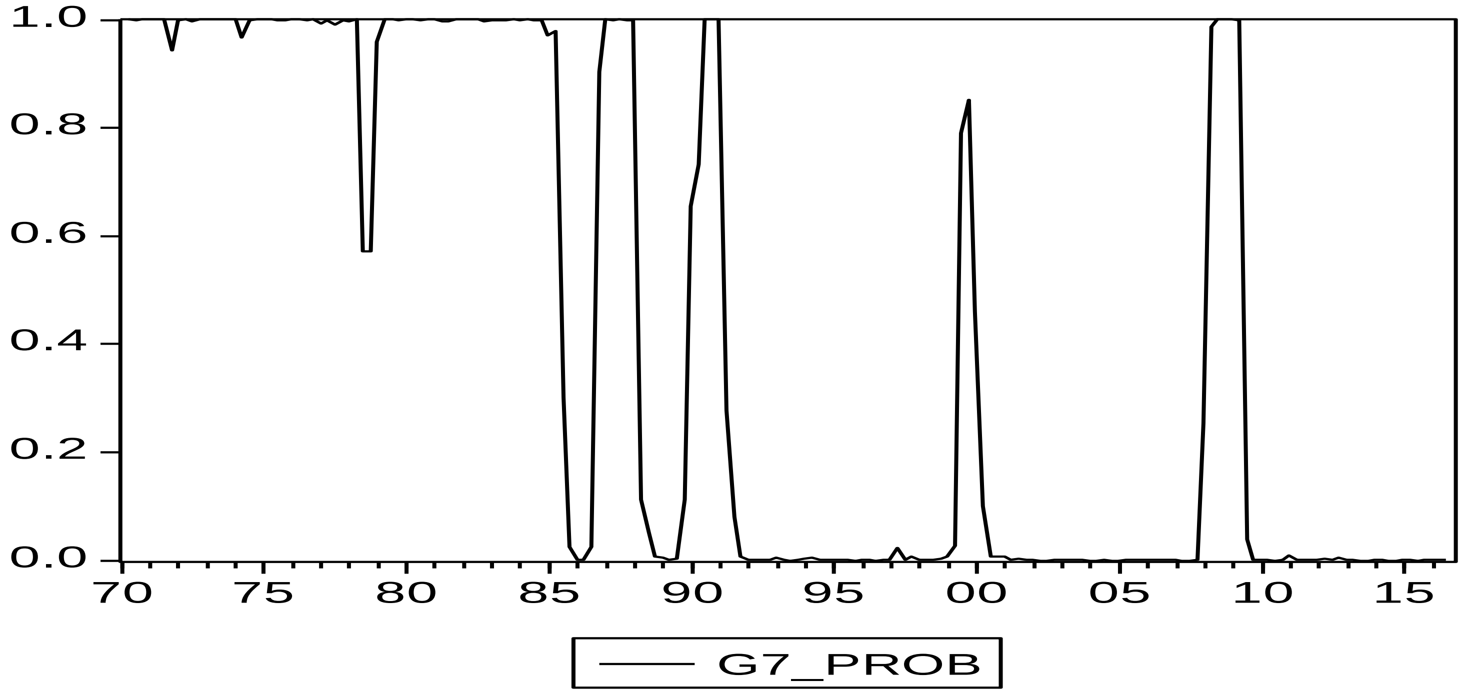
GDP △*Y* and House Price △*H* in the IT





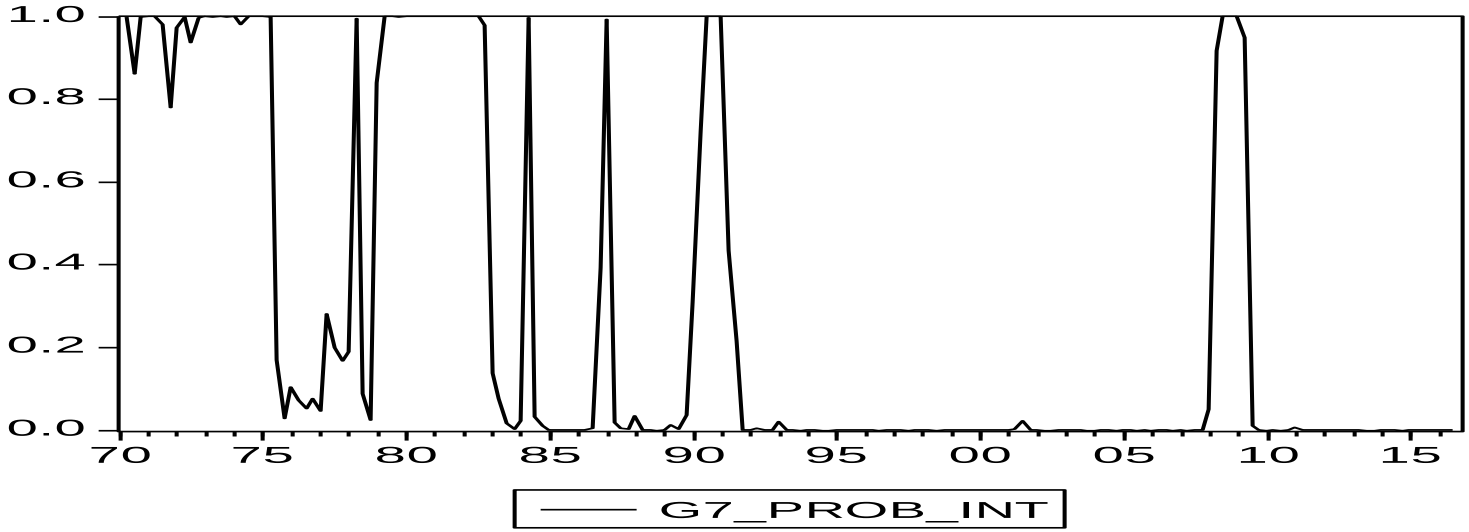
5. Empirical Results

Probabilities of regime 1 $\Pr(S_t = 1 \mid Y_T)$ **for 1970:II~2016:III**



5. Empirical Results

Probabilities with Interest



Probabilities with m2

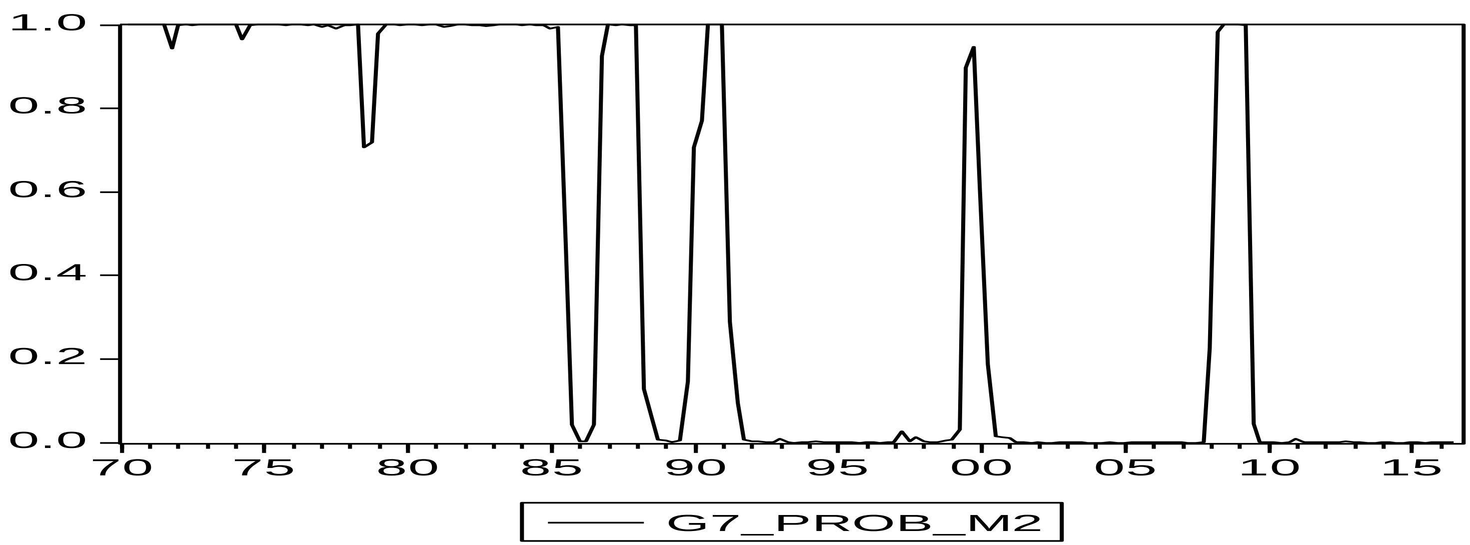


Table 1: MLE of the FIML Markov-switching model (1970.II to 2016.III)

Parameters			
$\beta_{0\ us}$	0.059 (0.032)	0.078(0.029)	0.064(0.032)
$\beta_{1\ us}$	0.245 (0.061)	0.211(0.082)	0.249(0.062)
$\beta_{0\ uk}$	0.037 (0.015)	0.049(0.018)	0.036(0.015)
$\beta_{1\ uk}$	0.182 (0.039)	0.185(0.050)	0.182(0.042)
$\beta_{0\ fr}$	0.053 (0.019)	0.044(0.017)	0.054(0.019)
$\beta_{1\ fr}$	0.098 (0.038)	0.092(0.044)	0.097(0.038)
$\beta_{0\ de}$	0.111 (0.092)	0.108(0.081)	0.105(0.093)
$\beta_{1\ de}$	0.269 (0.116)	0.470(0.144)	0.267(0.115)
$\beta_{0\ it}$	0.080 (0.031)	0.070(0.036)	0.075(0.031)
$\beta_{1\ it}$	0.105 (0.040)	0.084(0.046)	0.095(0.040)
$\beta_{0\ ca}$	-0.004 (0.021)	-0.001(0.020)	-0.004(0.022)
$\beta_{1\ ca}$	0.105 (0.039)	0.141(0.049)	0.103(0.039)
$\beta_{0\ jp}$	0.258 (0.078)	0.284(0.068)	0.260(0.080)
$\beta_{1\ jp}$	0.196 (0.064)	0.236(0.076)	0.195(0.064)
$\alpha_{0\ us}$	0.641 (0.059)	0.507(0.081)	0.735(0.092)
$\alpha_{1\ us}$	0.264 (0.157)	-0.309(0.225)	0.427(0.197)
$\alpha_{0\ uk}$	0.536 (0.044)	0.485(0.074)	0.558(0.072)
$\alpha_{1\ uk}$	0.031 (0.136)	-0.509(0.261)	0.073(0.202)
$\alpha_{0\ fr}$	0.407 (0.044)	0.282(0.056)	0.421(0.077)
$\alpha_{1\ fr}$	0.410 (0.113)	-0.035(0.000)	0.445(0.157)
$\alpha_{0\ de}$	0.417 (0.071)	0.255(0.104)	0.423(0.131)
$\alpha_{1\ de}$	0.307 (0.185)	-0.812(0.314)	0.333(0.252)

$\alpha_{0\ \mathrm{it}}$	0.218 (0.059)	0.027(0.065)	0.385(0.102)
$\alpha_{1\ \mathrm{it}}$	0.254 (0.182)	-0.586(0.273)	0.558(0.234)
$\alpha_{0\ \mathrm{ca}}$	0.650 (0.059)	0.606(0.083)	0.634(0.094)
$\alpha_{1\ \mathrm{ca}}$	0.519 (0.145)	-0.088(0.213)	0.511(0.186)
$\alpha_{0\ \mathrm{jp}}$	0.469 (0.085)	0.384(0.121)	0.539(0.152)
$\alpha_{1\ \mathrm{jp}}$	0.582 (0.185)	-0.139(0.325)	0.710(0.272)
$\sigma_{0\ \mathrm{us}}$	0.201 (0.028)	0.242(0.031)	0.193(0.028)
$\sigma_{1\ \mathrm{us}}$	1.085 (0.175)	1.402(0.286)	1.096(0.177)
$\sigma_{0\ \mathrm{uk}}$	0.131 (0.020)	0.234(0.032)	0.128(0.019)
$\sigma_{1\ \mathrm{uk}}$	1.506 (0.244)	1.797(0.360)	1.489(0.239)
$\sigma_{0\ \mathrm{fr}}$	0.142 (0.021)	0.149(0.019)	0.140(0.021)
$\sigma_{1\ \mathrm{fr}}$	0.484 (0.077)	0.609(0.123)	0.482(0.077)
$\sigma_{0\ \mathrm{de}}$	0.399 (0.055)	0.449(0.056)	0.398(0.055)
$\sigma_{1\ \mathrm{de}}$	1.590 (0.257)	1.735(0.352)	1.571(0.254)
$\sigma_{0\ \mathrm{it}}$	0.269 (0.037)	0.336(0.045)	0.256(0.036)
$\sigma_{1\ \mathrm{it}}$	1.194 (0.193)	1.326(0.270)	1.182(0.189)
$\sigma_{0\ \mathrm{ca}}$	0.225 (0.032)	0.284(0.037)	0.223(0.032)
$\sigma_{1\ \mathrm{ca}}$	1.145 (0.185)	1.347(0.273)	1.135(0.182)
$\sigma_{0\ \mathrm{jp}}$	0.699 (0.102)	0.689(0.088)	0.694(0.101)
$\sigma_{1\ \mathrm{jp}}$	1.496 (0.242)	1.801(0.365)	1.487(0.239)
q	0.952 (0.022)	0.943(0.021)	0.952(0.021)
p	0.936 (0.029)	0.859(0.053)	0.938(0.028)
		$i_{us\ \mathrm{us}}$ 0.046 (0.014)	$\Delta m2_{us\ \mathrm{us}}$ -0.078 (0.060)
		$i_{us\ \mathrm{uk}}$ 0.028 (0.014)	$\Delta m2_{us\ \mathrm{uk}}$ -0.018 (0.047)
		$i_{us\ \mathrm{fr}}$ 0.044 (0.010)	$\Delta m2_{us\ \mathrm{fr}}$ -0.013 (0.052)
		$i_{us\ \mathrm{de}}$ 0.065 (0.018)	$\Delta m2_{us\ \mathrm{de}}$ -0.007 (0.084)
		$i_{us\ \mathrm{it}}$ 0.076 (0.015)	$\Delta m2_{us\ \mathrm{it}}$ -0.127 (0.063)
		$i_{us\ \mathrm{ca}}$ 0.034 (0.014)	$\Delta m2_{us\ \mathrm{ca}}$ 0.008 (0.053)
		$i_{us\ \mathrm{jp}}$ 0.044 (0.023)	$\Delta m2_{us\ \mathrm{jp}}$ -0.056 (0.094)
Log Likelihood	-1398.52	-1384.83	-1395.35

Standard errors of the parameters estimates are reported in the parentheses

Table 2: The results of likelihood ratio test (LR test)

Monetary policy variables	
Federal funds rate	27.38**
$\Delta m2$	6.34

* 5% significance level, ** 1% significance level

6. Conclusion

- Applying FIML Markov-switching model to the G7 countries, we found that the housing price movement was procyclical with GDP during the oil shock periods of the 1970s, 80s, and 90s, and the bursting of housing bubble in 2008

- US interest rate is a significant variable to the common business cycle between housing price and GDP in the G7 countries.

- However, US interest rate showed a significant effect to the G7 house business cycle for small shock periods, not extremely large shocks periods.

- No relationship between US m2 growth and the GDP growth rate of the G7 countries.

7. Reference

Deniz Igan and Prakash Loungani (2012), “Global housing cycles”, IMF working paper 12/217

Hamilton, J.D. (1989), “A new approach to the economic analysis of nonstationary time series and the business cycle”, *Econometrica*, **57** (2), 357-384.

Hamilton, J.D. (1994), *Time Series Analysis*, Princeton University, Princeton, N.J.

Kim, C.J. (1994), “Dynamic factor models with Markov switching”, *Journal of Econometrics*, 60, 1-22.

Kim, C.J. and Nelson, C.R. (1999), *State-space models with regime switching*: *Classical and Gibbs sampling approaches with applications*, MIT Press, Cambridge

Lastrapes, W. D. (2002), “The real price of housing and money supply shocks: time series evidence and theoretical simulations”, *Journal of Housing Economics*, *11*(1), 40-74.

Lucas, R. E., Jr. (1996), “Nobel Lecture: Monetary Neutrality,” *Journal of Political Economy*, 104, 661-82.

Plamen Iossifov, Martin Čihák, and Amar Shanghavi1 (2008), “Interest Rate Elasticity of Residential Housing Prices”, IMF working paper 08/247

Ò scar Jordà, Moritz Schularick, Alan M. Taylor (2015), “Interest Rates and House Prices: Pill or Poison?”, *FRBSF Economic Letter* 25

Yoon, J.H. (2006) “The co-movement of inflation and the real growth of output”, *The Journal of the Korean Economy*, **7** (2), 213-229

Yoon, J.H. (2009)”Simultaneous equations in the Markov-switching model”, Far East and South Asia Meeting of the Econometric Society, Tokyo

Yoon, J. H. and Lee, J. H. (2014) "The Linked Movement of House Prices and GDP in the G7 Countries," *The Korea Spatial Planning Review*, Vol. 82, 49-60