US Monetary Policy and the G7 House Business Cycle:

FIML Markov Switching Approach

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Abstract

In order to determine the effect of US monetary policy to the common business cycle between housing price and GDP in the G7 countries (U.S., U.K., Canada, Germany, France, Italy, and Japan), this paper adopted FIML Markov-switching model of Yoon (2006).

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. US *m2* growth is not a significant variable to the common business cycle between housing price and GDP in the G7 countries.

Keywords: interest rate, *m2*, housing price, GDP, FIML Markov-switching model, business cycle, G7, U.S., U.K., Canada, Germany, France, Italy, Japan
JEL Classifications: C13; C32

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1. Introduction

Yoon and Lee (2014) showed that the G7 housing price has a procyclical movement with GDP during the oil shock periods of the 1970s, 80s, 90s, and the bursting of housing bubble in 2008 using FIML Markov-switching model of Yoon (2006). So the relationship between US monetary policy and house prices has been assumed to be positive during shock periods. 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. Ò scar Jordà, Moritz Schularick, Alan M. Taylor (2015) disagree over interest rates increase to curb asset price booms. Lucas, R. E., Jr. (1996) showed that monetary policy is neutral.

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

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).

This paper found that US interest rate is a significant variable to the G7 GDP and the G7 house business cycle. However, US $\Delta m2$ has no significant effect to the G7 business cycle between housing price and GDP in the G7 countries.

The paper has been divided in four sections. Section 2 presents the FIML Markov-switching model. Section 3 presents the effect of U.S monetary policy using FIML Markov-switching model. Section 4 concludes this paper.

2. FIML Markov-switching model

In order to estimate the parameters of the Markov-switching model in the simultaneous equations consistently, we consider the following FIML Markov-switching model:

$$YBs_t + Z\Gamma s_t = U_{St}\ ,\ U_{St} \sim i.i.d.N(0, \Sigma_{St} \otimes I_T) \qquad (1)$$

where **Y** is the T × M matrix of jointly dependent variables; $\boldsymbol{B_{St}}$ is an M × M matrix and is nonsingular; **Z** is the T × K matrix of predetermined variables; $\boldsymbol{\Gamma_{St}}$ is a K × M matrix and *rank*(Z) = K; and $\boldsymbol{Us_t}$ is the T × M matrix of the structural disturbances of the system. Consequently, the model has M equations and T observations.

$$E(U_{St}^{'}U_{St}) = \begin{pmatrix} \sigma_{S1t,S1t}I_T & \sigma_{S1t,S2t}I_T & \cdots & \sigma_{S1t,SMt}I_T \\ \sigma_{S2t,S1t}I_T & \sigma_{S2t,S2t}I_T & \cdots & \sigma_{S2t,SMt}I_T \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{SMt,S1t}I_T & \sigma_{SMt,S2t}I_T & \cdots & \sigma_{SMt,SMt}I_T \end{pmatrix} = \Sigma_{St} \otimes I_T$$

$$p_{ij} = \Pr(S_t = j \mid S_{t-1} = i) \text{ with } \sum_{j=1}^{N} p_{ij} = 1 \text{ for all } i.$$

To derive the FIML Markov-switching model in the simultaneous equations, we can obtain $\Pr(S_t = j \mid \psi_t)$ by applying a Hamilton filter (1989) as follows:

Step 1: At the beginning of the t^{th} 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 $\Pr(S_t = j \mid S_{t-1} = i)$, $i = 0,1,\cdots,N$, $j = 0,1,\cdots,N$ are the transition probabilities.

Step 2: Consider the joint conditional density of y_t and unobserved variable $S_t = j$, which is the product of the conditional and marginal densities:

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

from which the marginal density of y_t is obtained by:

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

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

where the conditional density $f(y_t \mid S_t = j, \psi_{t-1})$ is obtained from (2):

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

$$= (2\pi)^{-M/2} \det(\Sigma_{St})^{-1/2} \,|\det(Bs_t)|\cdot \exp(-\frac{1}{2}(y_t Bs_t + z_t \Gamma s_t)\Sigma_{St}^{-1}(y_t Bs_t + z_t \Gamma s_t)') \quad (2)$$

where $\Sigma_{St} = \frac{1}{T}(YBs_t + Z\Gamma s_t)'(YBs_t + Z\Gamma s_t)$, y_t is the t^{th} row of the **Y** matrix, z_t is the t^{th} row of the **Z** matrix, and $\boldsymbol{B}_{St}$ and $\boldsymbol{\Gamma}_{St}$ are obtained from (1).

Step 3: Once y_t is observed at the end of time t, we update the probability terms:

$$\Pr(S_t = j \,|\, \psi_t)$$

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

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

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

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

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

which can be maximized with respect to the model parameters.

3. US monetary policy using FIML Markov-switching model

Let us consider the quarterly real GDP[2] and Housing Price Index[3] in the G7 countries. We added US monetary policy variables [4] to the FIML Markov-switching model.

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

[2] We obtained the G7 quarterly real GDP from the OECD database (http://stats.oecd.org/)

[3] Source: National sources, BIS Residential Property Price database (http://www.bis.org/statistics/pp.htm)

[4] We obtained Federal Funds rate and *m2* from FRED database (http://fred.stlouisfed.org/)

$$\Delta Y_{uk} = \alpha_{S\,t} + \beta_{St}\Delta H_{uk} + \lambda M + e_{St,uk} \tag{4}$$

$$\Delta Y_{france} = \alpha_{S\,t} + \beta_{St}\Delta H_{france} + \lambda M + e_{St,france} \tag{5}$$

$$\Delta Y_{germany} = \alpha_{S\,t} + \beta_{St}\Delta H_{germany} + \lambda M + e_{St,germany} \tag{6}$$

$$\Delta Y_{italy} = \alpha_{S\,t} + \beta_{St}\Delta H_{italy} + \lambda M + e_{St,italy} \tag{7}$$

$$\Delta Y_{canada} = \alpha_{S\,t} + \beta_{St}\Delta H_{canada} + \lambda M + e_{St,canada} \tag{8}$$

$$\Delta Y_{japan} = \alpha_{S\,t} + \beta_{St}\Delta H_{japan} + \lambda M + e_{St,japan} \tag{9}$$

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*.

$$\alpha_{St} = \alpha_0(1-S_t) + \alpha_1 S_t\,,\;\; \beta_{St} = \beta_0(1-S_t) + \beta_1 S_t\,,\; S_t = \;0,\,1$$

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

Parameters			
β_0 us	0.059 (0.032)	0.078(0.029)	0.064(0.032)
β_1 us	0.245 (0.061)	0.211(0.082)	0.249(0.062)
β_0 uk	0.037 (0.015)	0.049(0.018)	0.036(0.015)
β_1 uk	0.182 (0.039)	0.185(0.050)	0.182(0.042)
β_0 fr	0.053 (0.019)	0.044(0.017)	0.054(0.019)
β_1 fr	0.098 (0.038)	0.092(0.044)	0.097(0.038)
β_0 de	0.111 (0.092)	0.108(0.081)	0.105(0.093)
β_1 de	0.269 (0.116)	0.470(0.144)	0.267(0.115)
β_0 it	0.080 (0.031)	0.070(0.036)	0.075(0.031)
β_1 it	0.105 (0.040)	0.084(0.046)	0.095(0.040)
β_0 ca	-0.004 (0.021)	-0.001(0.020)	-0.004(0.022)
β_1 ca	0.105 (0.039)	0.141(0.049)	0.103(0.039)
β_0 jp	0.258 (0.078)	0.284(0.068)	0.260(0.080)
β_1 jp	0.196 (0.064)	0.236(0.076)	0.195(0.064)
α_0 us	0.641 (0.059)	0.507(0.081)	0.735(0.092)
α_1 us	0.264 (0.157)	-0.309(0.225)	0.427(0.197)
α_0 uk	0.536 (0.044)	0.485(0.074)	0.558(0.072)

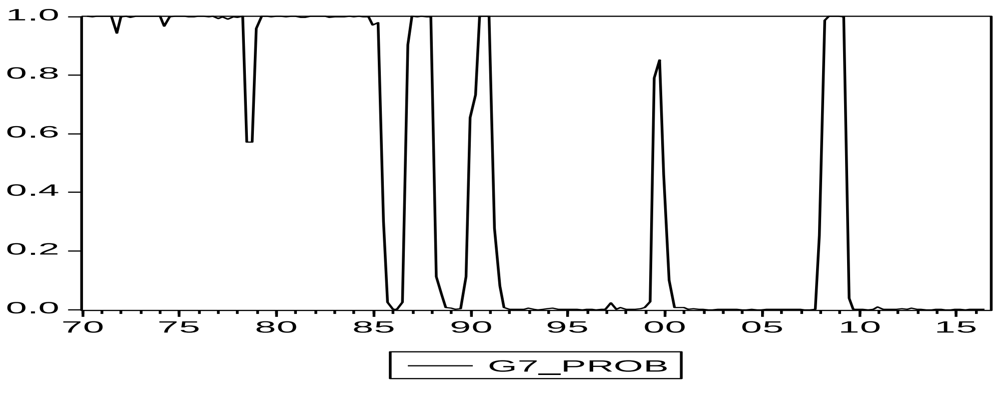
$\alpha_{1\ \mathrm{uk}}$	0.031 (0.136)	-0.509(0.261)	0.073(0.202)
$\alpha_{0\ \mathrm{fr}}$	0.407 (0.044)	0.282(0.056)	0.421(0.077)
$\alpha_{1\ \mathrm{fr}}$	0.410 (0.113)	-0.035(0.000)	0.445(0.157)
$\alpha_{0\ \mathrm{de}}$	0.417 (0.071)	0.255(0.104)	0.423(0.131)
$\alpha_{1\ \mathrm{de}}$	0.307 (0.185)	-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 1 gives the estimates from the FIML Markov-switching model using quarterly data for 1970:II to 2016:III. The coefficient β_1 is significant and positive correlated during regime 1 periods. The positive coefficient β_1 showed the co-movement between G7 housing price and G7 GDP during regime 1 periods. The coefficient β_1 showed an upward shift during regime 1 periods and the degree of the upward movement is obvious because $\beta_1 > \beta_0$ except Japan. Japan has been Zombie economy more than 25 years after housing bubble collapse in 1989. The yield of house price ΔH_t is more unstable than the growth rate of G7 GDP ΔY_t because absolute values of β_1 are smaller than 1. The variance σ_0 is significant and the variance σ_1 is also significant. The variance showed large volatility during regime 1 periods because $\sigma_1 > \sigma_0$. The coefficient interest rate (Federal Funds rate) is significant and positive. However, the coefficient $\Delta m2$ is not significant.

Figure 1 shows that the international common smoothed probabilities $\Pr(S_t = 1 | Y_T)$ match the oil price shock periods during 1970s, 80s and 90s well. In addition, there were common business cycles during the savings and loan (S&L) crisis (1986:IV to 1988:I) and the housing bubble burst (2008:II to 2009:II).

Figure 1. Common probabilities[5] of regime 1 $\Pr(S_t = 1 | Y_T)$ in the G7 countries: U.S., U.K., France, Germany, Italy, Canada, Japan (1970:II to 2016:III).



The results in Table 1 and Figure 1 give evidence of a common international business cycle between housing prices and GDP output with large shocks.

Especially, extremely large shocks such as oil shocks, cause procyclical housing price movement with GDP, including the bursting of housing bubble in 2008.

[5] For smoothed probabilities, we followed Kim's algorithm (1994).

To exam the effect of US monetary policy and the G7 house business cycle, we adopted the likelihood ratio test (LR test) which compared the goodness of fit of two models in Table 1. The LR compared to a critical value to decide whether to reject the null model in favor of the alternative model in Table 1.

$$LR = 2(\log L(\theta) - \log L(\hat{\theta})) \quad (10)$$

where $\log L(\theta)$ is a log likelihood of the null model

$\log L(\hat{\theta}))$ is a log likelihood of the alternative model,

The test statistic LR is will be asymptotically chi-squared distribution with degrees of freedom.

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

Monetary policy variables	
Federal funds rate	27.38**
Δ*m2*	6.34

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

From the results of LR test in Table 2, we can found that a positive relationship between US interest rate and G7 GDP growth. However there is no relationship between US Δ*m2* growth and the GDP growth rate of the G7 countries. We also have same results from the *t* values of US interest rate and Δ*m2* in Table 1.

Figure 2. Common probabilities of regime 1 $\Pr(S_t = 1 | Y_T)$ including interest rate

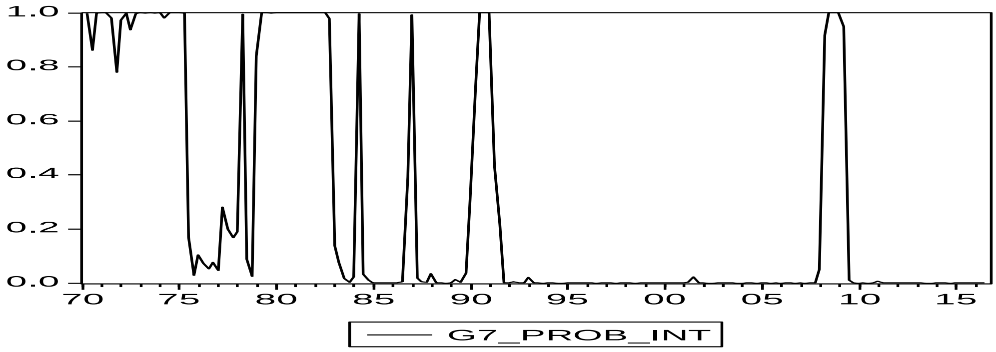
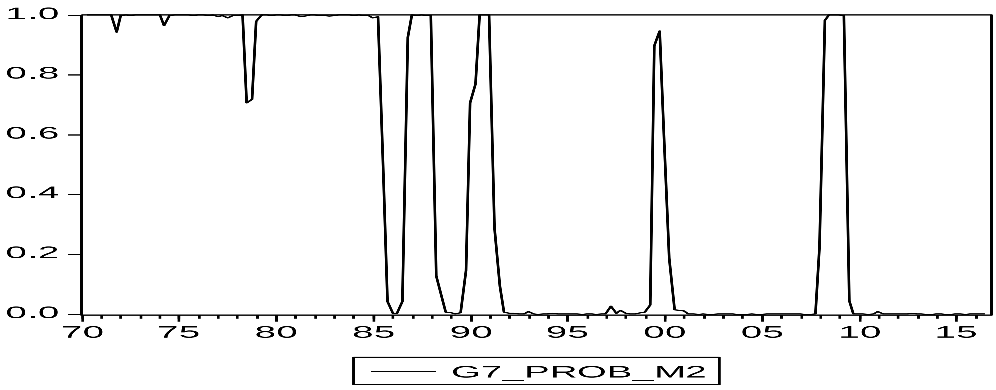


Figure 3. Common probabilities of regime 1 $\Pr(S_t = 1 | Y_T)$ including $\Delta m2$



We can found that $\Pr(S_t = 1 | Y_T)$ including US interest rate in Figure 2 is a little bit different from $\Pr(S_t = 1 | Y_T)$ in Figure 1. From Figure 2, we can found that US interest rate is a significant variable to the common business cycle between housing price and GDP in the G7 countries.

Especially interest rate showed a significant effect to the G7 house business cycle for small shock periods during the 1990s. However, interest rate policy showed no significant effect to the G7 house business cycle for extremely large shocks, such as oil shocks in 1970s and the bursting of housing bubble in 2008. This result is different form Deniz Igan and Prakash Loungani (2012), who insisted the effect of interest rates less strong.

$\Pr(S_t = 1 | Y_T)$ including $\Delta m2$ in Figure 3 is no different from $\Pr(S_t = 1 | Y_T)$ in Figure 1. From Figure 3, we can find that $\Delta m2$ is not a significant variable to the common house business cycle.

4. Conclusion

Applying a 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

This paper found that US interest rate is a very important tool to the relative small shocks. However, US interest rate is not working well for the extremely large shocks such as the bursting of housing bubble in 2008

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