Is the UK Housing Business Cycle an outlier in the G7 countries ?

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Abstract

Seeking to identify the contribution of the UK housing business cycle to the common G7 housing business cycle between housing price and GDP, we adopted the FIML Markov-switching model of Yoon (2006). We found that UK GDP is a significant variable contributing to the G7 GDP growth, and that the UK housing price is a significant variable to the G7 housing prices. However, we concluded that the UK is not a significant variable for determining the common international housing business cycle between housing price and the real growth of output in the G7 countries.

Keywords: housing business cycle, housing price, GDP, FIML Markov-switching model, UK, G7

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1. Introduction

Yoon and Lee (2014a) using FIML Markov-switching model of Yoon (2006, 2014b, 2017, 2018) found that the G7 housing price showed a procyclical movement with GDP during the oil shock periods of the 1970s, 80s, 90s, and the bursting of the housing bubble in 2008.

In this paper, we examined whether UK is really a significant variable contributing to the G7 housing business cycle.

To establish the relationship between UK and the G7 housing business cycle, we again adopted FIML Markov-switching model of Yoon.

Using this model, we test whether the UK GDP is a significant variable contributing to the G7 GDP and also whether the UK housing price is a significant variable contributing to the G7 housing prices. Lastly, we investigate whether UK is a significant variable for determining the common international housing business cycle between housing price and the real growth of output in the G7 countries.

The paper is divided into three further sections. Section 2 presents the FIML Markov-switching model. Section 3 presents the G7 housing business cycle 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 FIML Markov-switching model:

$$YB_{S_t} + Z\Gamma_{S_t} = U_{St} \ , \quad U_{S_t} \sim i.i.d.N(0, \Sigma_{S_t} \otimes I_T) \tag{1}$$

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):

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

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:

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

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

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

which can be maximized with respect to the model parameters.

3. Evaluating the G7 housing business cycle using FIML Markov-switching model

Let us consider the quarterly real GDP[3], Housing Price Index[4], and Consumer Price Index[4] in the G7 countries.

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

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

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

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

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

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

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

where ΔY is the log differenced real GDP, ΔH is the log differenced housing price, and ΔP is the log differenced consumer price.

$$\alpha_{St} = \alpha_0(1-S_t) + \alpha_1 S_t,\ \beta_{St} = \beta_0(1-S_t) + \beta_1 S_t,\ \sigma^2{}_{St} = \sigma^2{}_0(1-S_t) + \sigma^2{}_1 S_t,\ S_t = 0, 1$$

Table 1. MLE of the FIML Markov-switching model (1970.II to 2018.I)

Parameters	G7	G6 (except UK)
$\beta_{0\ us}$	0.054 (0.032)	0.053 (0.031)
$\beta_{1\ us}$	0.272 (0.067)	0.267 (0.066)

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

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

$\beta_{0\ \mathrm{fr}}$	0.050 (0.020)	0.032 (0.014)
$\beta_{1\ \mathrm{fr}}$	0.103 (0.041)	0.192 (0.041)
$\beta_{0\ \mathrm{de}}$	0.119 (0.094)	0.050 (0.019)
$\beta_{1\ \mathrm{de}}$	0.331 (0.116)	0.102 (0.043)
$\beta_{0\ \mathrm{it}}$	0.061 (0.039)	0.155 (0.076)
$\beta_{1\ \mathrm{it}}$	0.105 (0.050)	0.323 (0.117)
$\beta_{0\ \mathrm{ca}}$	0.006 (0.018)	0.064 (0.036)
$\beta_{1\ \mathrm{ca}}$	0.109 (0.043)	0.104 (0.054)
$\beta_{0\ \mathrm{jp}}$	0.186 (0.081)	0.012 (0.016)
$\beta_{1\ \mathrm{jp}}$	0.260 (0.064)	0.114 (0.040)
$\beta_{0\ \mathrm{uk}}$	0.034 (0.019)	
$\beta_{1\ \mathrm{uk}}$	0.183 (0.041)	
$\alpha_{0\ \mathrm{us}}$	0.718 (0.081)	0.710 (0.081)
$\alpha_{1\ \mathrm{us}}$	0.382 (0.191)	0.375 (0.182)
$\alpha_{0\ \mathrm{fr}}$	0.438 (0.050)	0.638 (0.050)
$\alpha_{1\ \mathrm{fr}}$	0.487 (0.159)	0.371 (0.200)
$\alpha_{0\ \mathrm{de}}$	0.533 (0.085)	0.440 (0.047)
$\alpha_{1\ \mathrm{de}}$	0.537 (0.205)	0.456 (0.140)
$\alpha_{0\ \mathrm{it}}$	0.235 (0.076)	0.523 (0.082)
$\alpha_{1\ \mathrm{it}}$	0.252 (0.303)	0.520 (0.199)
$\alpha_{0\ \mathrm{ca}}$	0.702 (0.063)	0.233 (0.103)
$\alpha_{1\ \mathrm{ca}}$	0.713 (0.193)	0.250 (0.392)
$\alpha_{0\ \mathrm{jp}}$	0.448 (0.087)	0.687 (0.061)
$\alpha_{1\ \mathrm{jp}}$	0.867 (0.191)	0.726 (0.186)
$\alpha_{0\ \mathrm{uk}}$	0.642 (0.050)	
$\alpha_{1\ \mathrm{uk}}$	0.448 (0.200)	
$\sigma^2{}_{0\ \mathrm{us}}$	0.198 (0.028)	0.195 (0.027)
$\sigma^2{}_{1\ \mathrm{us}}$	1.018 (0.175)	1.049 (0.171)
$\sigma^2{}_{0\ \mathrm{fr}}$	0.137 (0.022)	0.130 (0.019)
$\sigma^2{}_{1\ \mathrm{fr}}$	0.459 (0.077)	1.368 (0.222)
$\sigma^2{}_{0\ \mathrm{de}}$	0.372 (0.054)	0.137 (0.018)
$\sigma^2{}_{1\ \mathrm{de}}$	1.520 (0.261)	0.470 (0.076)
$\sigma^2{}_{0\ \mathrm{it}}$	0.276 (0.039)	0.383 (0.051)
$\sigma^2{}_{1\ \mathrm{it}}$	1.175 (0.206)	1.549 (0.250)
$\sigma^2{}_{0\ \mathrm{ca}}$	0.214 (0.034)	0.271 (0.037)
$\sigma^2{}_{1\ \mathrm{ca}}$	1.114 (0.181)	1.210 (0.198)
$\sigma^2{}_{0\ \mathrm{jp}}$	0.571 (0.103)	0.222 (0.030)
$\sigma^2{}_{1\ \mathrm{jp}}$	1.399 (0.226)	1.124 (0.181)
$\sigma^2{}_{0\ \mathrm{uk}}$	0.133 (0.021)	
$\sigma^2{}_{1\ \mathrm{uk}}$	1.339 (0.227)	
$\pi_{\ \mathrm{us}}$	-0.120 (0.094)	-0.108 (0.088)

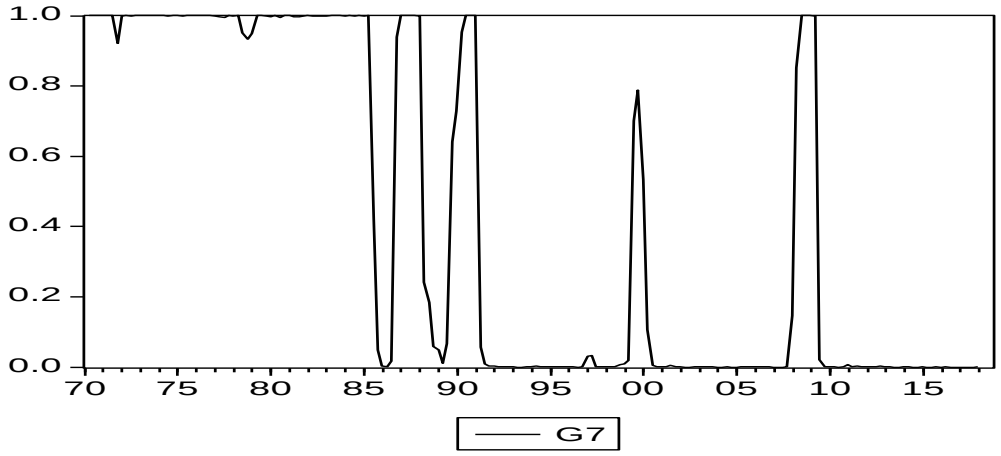
π_{fr}	-0.043 (0.073)	-0.164 (0.044)
π_{de}	-0.288 (0.114)	-0.028 (0.065)
π_{it}	0.001 (0.122)	-0.269 (0.112)
π_{ca}	-0.132 (0.073)	0.004 (0.162)
π_{jp}	-0.293 (0.075)	-0.141 (0.072)
π_{uk}	-0.181 (0.047)	
q	0.958 (0.021)	0.957 (0.020)
p	0.943 (0.027)	0.939 (0.028)
Log Likelihood	-1402.02	-1143.88

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 2018:I. 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 $\beta_1 > \beta_0$ including for Japan. Japan has been a Zombie economy more than 25 years, since housing bubble collapse in 1989. The variance σ^2_0 is significant and the variance σ^2_1 is also significant. The variance showed high volatility during regime 1 periods because $\sigma^2_1 > \sigma^2_0$.

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

Figure 1. G7 Common probabilities[5] $\Pr(S_t = 1 | Y_T)$ (1970:II to 2018:I).



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, have caused procyclical housing price movement with GDP, including the bursting of the housing bubble in 2008.

To examine the effect of the UK in the G7 housing business cycle, we adopted the likelihood ratio test (LR test) which compared the goodness of fit of two models in Table 1. The LR was compared to a critical value to decide whether to reject the null model in favor of the alternative model in Table 1.

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

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

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

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

variable	
UK	516.28**

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

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

From the results of the LR test in Table 2, we can found that the UK GDP is a significant variable contributing to the G7 GDP growth. We also found that UK housing price is a significant variable contributing to the G7 housing prices.

Figure 2. G6 Common probabilities $\Pr(S_t = 1 | Y_T)$ excluding UK

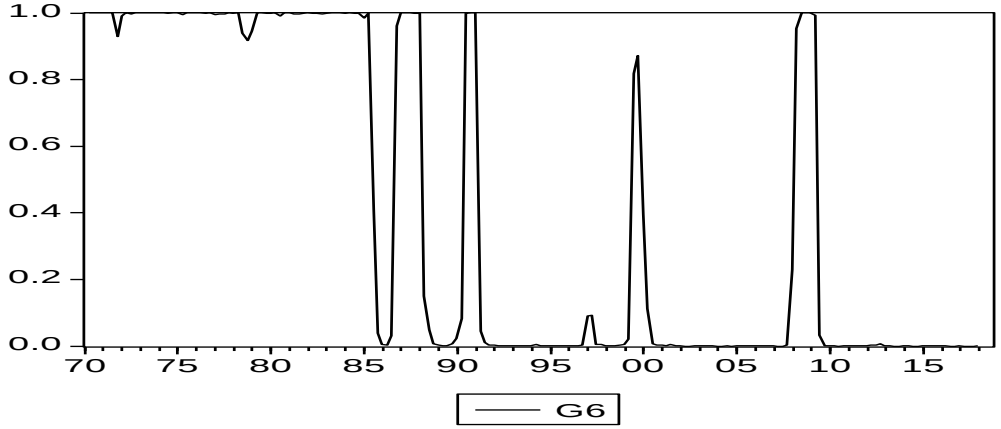
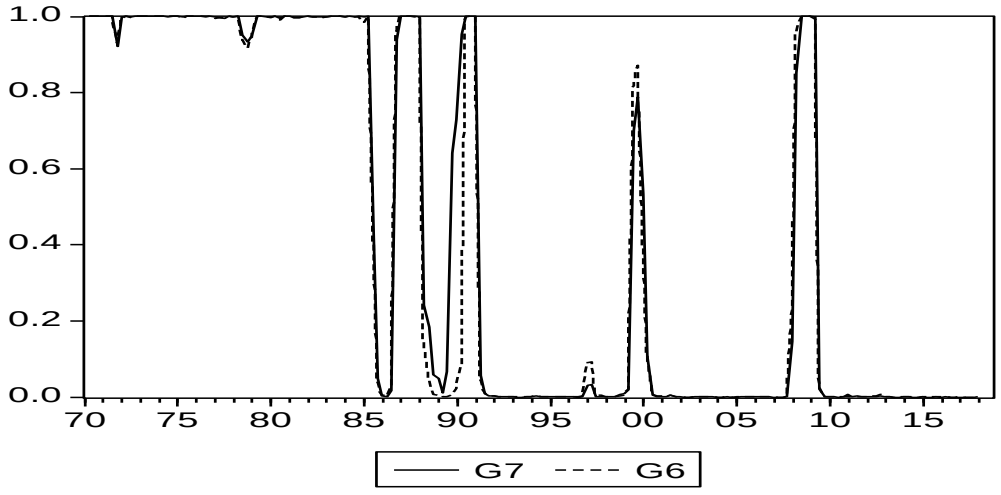


Figure 3. Comparison between G7 and G6 Common probabilities $\Pr(S_t = 1 | Y_T)$



However, we found that the G6 (excluding UK) common probabilities in Figure 2 are almost the same as the G7 common probabilities in Figure 1.

Figure 3 shows that UK is not a significant variable for determining the common international housing business cycle between housing price and the real growth of output in the G7 countries.

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.

We found that UK GDP is a significant variable contributing to the G7 GDP growth, and also found that UK housing price is a significant variable contributing to the G7 housing prices. However, we concluded that the UK is not a significant variable for determining the common international housing business cycle between housing price and the real growth of output in the G7 countries.

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