Preliminary and Incomplete – please do not quote

The Seeds of the 2007-2009 Crisis: the Housing Market and the Business Cycle

Marcelle Chauvet[*] and Meichi Huang[**]
University of California Riverside Yuan Ze University

Abstract

The goal of this paper is to investigate the seeds of the recent housing and economic crisis by examining the interrelationship between the recent bust in the housing market, the economic recession, and related monetary policy actions undertaken by the Federal Reserve. We propose a nonlinear dynamic factor model to represent the housing market and the business cycle. We allow the factors to follow different two-state Markov-switching processes, in order to capture recessions and expansion phases of the business cycle as well as boom and busts in the housing market. The link between these two sectors is assumed to occur through changes in monetary policy as reflected in interest rates movements. We find a strong correlation between the business cycle and the housing market cycle, between the business cycle and interest rates, and between the housing market cycle and interest rates. However, these sectors' close relationship changed since the 2001 recession. The period after this recession was marked by great uncertainty, especially regarding its end, as the economy experience a sluggish recovery. As a result, interest rates remained low well into the expansion. We find that the housing market factor became more sensitive – to a higher extent than the historical record – to interest rates throughout the 2000s. On the other hand, the business cycle factor became less sensitive to interest rates. We find that the missed link between the 2001 recession and the housing market cycle, and between the subsequent expansion and interest rates, worked as a seed for the housing market bubble and bust, and the economic recession in 2007-2009.

***Keywords**:* Business cycles, Housing market, Dynamic Factor, Markov Switching, Monetary Policy, Interest Rates.

***JEL Classification**:* C32, E32, E44

---

[*] Marcelle Chauvet: Department of Economics, University of California Riverside, Riverside CA 92507, Phone: +1 951 827 1587, E-mail: chauvet@ucr.edu.

[**] Meichi Huang: Institute of Economic Research, Taiwan, E-mail: meichi.huang@email.ucr.edu.

1. Introduction

In the last decade, the movement of U.S. house prices departed dramatically from historical patterns. The developments in the housing market were the focus of increased attention because of their potential impact on the economy. The big gains in housing prices raised concerns about the impact on aggregate economic activity and credit markets if this trend was reversed. These concerns were materialized to an unexpected large scale. Housing prices began a downward fall movement in 2006. By 2007, the collapse in the values of subprime mortgages was accompanied by a substantial increase in foreclosures, and unusually large declines in house prices in some states. The housing crisis triggered a financial crisis and a recession – the longest since the Great Depression, and only paralleled in severity by the U.S. recessions that took place in the 1970s and 1980s.

This paper investigates the relationship between the U.S. housing cycle and the business cycle in the last decades. In particular, it examines whether the recent run up in housing prices and the subsequent decline is part of recurrent dynamics in the last few decades or whether this time was unique. The goal is to shed light on the possible origins of the recent boom and bust in the housing market, the linkages with the broad economy, and assessment on future prospects. We find that the crisis in the housing market sector is associated with the particular features of the 2001 recession. The question then is what has changed in the last decade to explain these dramatic shifts?

Figure 1 shows the U.S. Census regional and national real median price of houses sold. The shading in the graph indicates the NBER recession dates. The substantial increase in real home prices was observed across all regions of the U.S. The result of this rise in regional prices has been a massive increase in national home prices over a period of nearly a decade, which increased by almost 50% from 1996 to 2006.[1] The boom started with real home price increases in the West coast, but quickly spread to the Northeast, and to a lesser extent to the Midwest and South. Even during the 2001 recession, there were real price increases in the West and Northeast. Figures 2 to 4 show that the dramatic rise in house prices was accompanied by similar rises in ownership rate, house construction, and mortgage growth rate by households. The boom in the housing market ended with a sharp turnaround in real home prices as seen in Figures 1 and 2. From the peak that occurred in the first quarter of 2006 until the third quarter of 2009 the declines in real house prices were around 20%. The rapid growth in mortgage credit and house prices was substituted by record levels mortgage defaults, while the market value of mortgage securities fell sharply. By the end of 2007, the U.S. economy had entered a recession, which started as a mild downturn but turned into a deep contraction with the progression and ramifications of the housing crisis.

[1] The median house prices are obtained from the U.S. Census Bureau and are deflated by the U.S. core Consumer Price Index.

Historically, there is a strong link between the business cycle and the housing market cycle. Noticeably, house prices and construction are very closely linked to the U.S. economy until around 2000 (Figures 1-3), reaching peaks close to NBER recessions and troughs around their end. However, after 2000 prices and construction soared for six years in despite of the 2001 recession. Interestingly, the subsequent housing downturn took place almost two years before the 2007-2009 economic recession, the longest lead in the sample. Previously, housing only fell shortly before or with the aggregate economic activity.

In order to investigate the interrelationship among the recent bust in the housing market, economic recession, and related monetary policy actions undertaken by the Federal Reserve, this paper proposes a nonlinear two-factor model to represent the phases of the housing market cycle and the phases of the business cycle. The business cycle is represented by the same coincident economic variables considered by the NBER Business Cycle Committee, the official arbiter of business cycle chronology – personal income, employment, industrial production, and manufacturing trade. A latent factor is extracted from these variables, which summarizes their underlying common cyclical movements. A second latent factor is extracted from real housing prices across the four regions of the U.S. to represent the housing sector. The latent factors are assumed to follow distinct two-state Markov switching processes. The Markov process for the business cycle factor represents recession and expansions phases, whereas the Markov process for the housing factor corresponds to high or low phases in the housing market. These cyclical phases of the economy and the housing are linked trough the dependence structure of the factors in the transition equations and their covariance.

The Markov probabilities allow analysis of the interactions between the phases of the housing market and the phases of the business cycle. Since the lead-lag relationship between the phases can vary over time, rather than pre-imposing a structure to their linkages, the proposed flexible framework enables us to study their specific lead-lag relationship over each one of the expansions and recessions that occurred in the U.S. in the last 50 years. The advantages of the proposed model are that the common variation and asymmetries in the phases of housing market and the business cycle are modeled in a flexible setting. In addition, the relationship between the two cycles is analyzed simultaneously in a unified framework. The Markov switching dynamic bi-factor model is closely related to the framework used in Chauvet (1998/1999), Senyuz (2008), and Chauvet and Senyuz (2009), which apply this approach to study the relationship between the stock market, bonds market, and the economy.

The combined information from the business cycle, interest rates, and the housing market sheds light on the housing market bubble and bust. We find that there is a strong correlation between business cycles and the housing market cycles. Generally, low housing prices phases tend to slightly lead economic recessions. During expansions, the probabilities of low housing prices are close to zero, and a couple of months before the beginning of recessions the probabilities of low housing prices rise substantially. The end of low housing

price phases tends to coincide or slightly lag the end of economic recessions.

However, this relationship has changed over time. Noticeably, the housing market did not exhibit a regular cycle during the 2001 recession compared to the historical pattern. For the first time in the sample studied, variables measuring housing supply, demand, and prices did not fall during a recession. Another interesting aspect of the housing cycle in the last decade is that generally the downturn in housing takes place right before of at economic recessions. After 2007, the contraction in the housing market led the economic contraction by 2 years.

In summary, the relationship between the housing cycle and the business cycle changed remarkably in the last decade, with a missed link between these two cycles in the early 2000s. Interestingly, while the interrelationship between the housing cycle and the business cycle went missing during the 2001 recession, it became remarkably strong in the subsequent 2007-2009 recession.

In order to investigate the missed link between the housing cycle and the business cycle, we examine the role of interest rates. Interest rates generally rise during expansions, reaching a peak towards its end. Before the beginning of recessions interest rates start to fall and stay low until the early stages of the subsequent economic expansion. The results show that interest rates are an important factor in the relationship between the business cycle and the housing cycle. There is an inverse relationship between housing prices and the level of and changes in interest rates. In particular, interest rates movements lead housing market cycle: increases in interest rates are related to subsequent decreases in housing prices and housing starts, whereas increases in interest rates are related to subsequent decreases in economic activity.

Thus, it is worth exploring the causes of the changes in the housing cycle by examining the role of interest rates. Given the unique dynamics of the housing cycle since the mid 1990s, we extend the model to allow for changes in the relationship between the housing cycle, the business cycle, and interest rates. In order to capture these recent changes, we allow each of the coefficients of lagged interest rates in the transition equations to follow distinct Markov processes. The results from the model are somewhat striking. The linkage between business cycle factor and interest rate weaken during the 2002-2004 recovery. On effect, the Federal Reserve kept interest rates at low levels during this expansion period due to the uncertainty regarding the end of 2001 recession, and the slow recovery in 2002-2004. On the other hand, the association between lagged interest rates and the housing market factor became much stronger since the 2001 recession.

This suggests that the run up of housing prices, especially since 2001 is associated with the low level of interest rate, which on its turn is associated with the particular features of the 2001 recession and subsequent recovery. In particular, differently from other early stages of expansions, the jobless recovery led the Federal Reserve to keep interest rates at low levels

for quite some time. This monetary expansion catalyzed an abrupt increase in housing prices, housing starts, and ownership. The unique features of the cycle led investors to be uncertain regarding the possible end of the monetary expansion phase, and on the strength of its effect on the housing sector. When interest rates start rising in June 2004, it had a strong negative effect on the housing sector and was associated with a subsequent drastic fall in housing prices. This led many to own negative equity, which induced a wave of default and foreclosures. This was the beginning of the subprime crisis, which evolved into the longest recession since the Great Depression.

The paper is organized as follows. Section 2 introduces the nonlinear factor model of the housing market and the business cycle that allows examination of the interrelations between the phases of these sectors. Section 3 discusses the data and Section 4 the estimation results. Section 5 extends the model to include the link between business cycles and housing cycles – the interest rate. Section 6 presents the results when this third variable is considered. Section 7 concludes.

2. Literature

To be completed

3 The Basic Model

We propose a model that accounts for the dynamic links between the housing market cycle and the business cycle. The framework is used to investigate the historical relationship between the housing market and the business cycle, and the recent bubble-bust in the housing market. The model is composed of two unobserved factors, representing these two sectors: the latent housing market factor, F_t^H, is extracted from regional housing prices, while coincident indicators of the economy are used to construct the latent business cycle factor, F_t^{BC}. The dynamic factor model is cast in state-space, which allows simultaneous estimation of the two unobservable factors as well as their intertemporal relationship. The measurement equations are:

$$Y_{it} = \lambda_i^H F_t^H + \lambda_i^{BC} F_t^{BC} + v_{it} \qquad i = 1,2,...,8 \tag{1}$$

$$\psi_i(L) v_{it} = \varepsilon_{it} \qquad \varepsilon_{it} \sim i.i.d.\ N(0, \sigma_i^2) \tag{2}$$

where, Y_{it} is the 8x1 vector of observable variables in the housing sector and in the business cycle. In particular, it includes the growth rate of median housing prices in the Northeast, Midwest, South, and West, and the growth rate of industrial production, real personal income, employment, and manufacturing and trade sales. λ_i^H and λ_i^{BC} are, respectively, the factor loadings corresponding to the housing indicators and economic indicators. The idiosyncratic terms, v_{it}, are allowed to be serially correlated with autoregressive coefficients ψ_i, whereas

ε_{it} are the measurement errors. The factors are assumed to be uncorrelated with the idiosyncratic terms, v_{it}, at all leads and lags.

Each factor follows a latent vector autoregressive process with the drift term as a function of different Markov switching processes: S_t^H representing low and high price phases in the housing market, and S_t^{BC} representing economic recessions and expansions phases. The transition equations are:

$$F_t^{BC} = \mu_{S_t}^{BC} + \phi^{BC} F_{t-1}^{BC} + \beta^H F_{t-1}^H + \eta_t^{BC} \tag{3}$$

$$F_t^H = \mu_{S_t}^H + \phi^H F_{t-1}^H + \beta^{BC} F_{t-1}^{BC} + \eta_t^H \tag{4}$$

with

$$\mu_{S_t}^{BC} = \mu_1^{BC} S_t^{BC} + \mu_0^{BC}(1 - S_t^{BC}) \quad S_t^{BC} = 0,1 \text{ and}$$

$$\mu_{S_t}^H = \mu_1^H S_t^H + \mu_0^H (1 - S_t^H) \qquad S_t^H = 0,1$$

where $\mu_{S_t}^H$ is the mean growth rate of the housing factor in high ($S_t^H = 1$) and low states ($S_t^H = 0$), $\mu_{S_t}^{BC}$ is the mean growth rate of the coincident variables in expansions ($S_t^{BC} = 1$) and recessions ($S_t^{BC} = 1$). The model does not impose a priori restrictions on the relationship between S_t^{BC} and S_t^H. The consideration of two potentially independent Markov processes allows the factors representing the housing market markets and the real economy to switch between phases at different leads or lags. The transition probabilities are:

$$P[S_t^H = 0 \mid S_{t-1}^H = 0] = q^H,\ P[S_t^H = 1 \mid S_{t-1}^H = 1] = p^H$$
$$P[S_t^{BC} = 0 \mid S_{t-1}^{BC} = 0] = q^{BC},\ P[S_t^{BC} = 1 \mid S_{t-1}^{BC} = 1] = p^{BC}$$

with $\sum_{j=0}^{1} p_{ij}^{BC} = \sum_{j=0}^{1} p_{ij}^H = 1,\ i, j = 0,1.$

Thus, the linkages between the two factors are modeled by their covariance, by the Markov processes, and by specifying the factors as following a vector autoregressive system. The coefficients β^{BC} and β^H capture the lead-lag relationship between the housing factor and the business cycle factor, while we assume that the variance covariance matrix of the common shocks to each factor, $\mathbf{\Omega_t}$, is non-diagonal. The two factors and the Markov probabilities are simultaneously estimated from the observable variables and from their relationship with each other.

4 Data

The business cycle factor is extracted from the same series used by the NBER Business Cycle

Dating Committee to date business cycle turning points.[2] The four economic indicators that move simultaneously with the business cycle are the Industrial Production index, obtained from the Federal Reserve Board of Governors, Manufacturing and Trade Sales and Real Personal Income Less Transfer Payments, from the Bureau of Economic Analysis, and Employees on Nonagricultural Payroll, from the Bureau of Labor Statistics.

The housing market factor is obtained from quarterly median sales prices of houses sold considering the same regional division used by the US Census Bureau, which consists of four regions: West, Northeast, Midwest, and South. Since the median price of houses sold by region is available in quarterly frequency from 1963Q1, the sample considered is from 1963Q1 to 2007Q4.

Our goal is not to study local factors, but national comovements in housing prices that correlate with the business cycle and with monetary policy. Thus, it is crucial that the sample is long enough to include several housing market and business cycle phases, in order to allow for historical analysis of their interaction. We extract this national common cycle using the Census regional level data because these are the longest disaggregate series available. While city or Metropolitan Statistical Data (MSA) may provide a more refined picture of housing price movements, the multivariate framework considered does not allow starting aggregation from these data – it is not computationally feasible to consider all the U.S. MSA due to the size of the matrix of unobserved features involved. In addition, they are only available since 1975, which excludes two full business cycles.[3]

The housing series are deflated using the Consumer Price Index (CPI for All Urban Consumers: All Items Less Food & Energy), from the Bureau of Labor Statistics. All variables are considered in the log first difference form.

5 Empirical Results

Business Cycles

Table 1 reports the maximum likelihood estimates from the model. The Markov process captures the switches to business cycle phases underlying the four coincident variables. State 0 displays a negative mean ($\mu_0^{BC} = -0.5$) and a shorter average duration, which is associated

[2] See NBER site: https://nber15.nber.org/cycles/main.html?tools=printit

[3] Other alternative price indexes are also only available at smaller samples that do not consider several past recessions and expansions. For example, the Office of Federal Housing Enterprise Oversight (OFHEO) house price indexes and the S&P/Case-Shiller Home Price Indices at the quarterly frequency are only available starting from 1975 or 1976, respectively, missing the recessions in 1969-1970 and in 1974-1975 and the expansions in between (missing two business cycles).

with economic recessions. State 1 exhibits a positive mean (μ_1^{BC} =1.5) and longer average duration, depicting the features of expansions. In particular, the probability of staying in expansion, p_{11}^{BC} , is higher than the probability of staying in a contraction, p_{00}^{BC} . The expected duration for recession and expansion implied by the switching model is, respectively, 3.7 and 11.1 quarters, compared to 3.6 and 10.8 quarters implied by the NBER dating.[4]

Figure 5 shows the extracted business cycle factor and the associated smoothed probabilities of recessions, $P(S_t^{BC} = 0 \mid T)$. The shading in the graphs indicates the NBER recession dates. The Markov-switching model captures each of the NBER business cycle peaks and troughs in the sample, which the probabilities of recession closely match. During periods that the NBER classifies as expansions, the probabilities of recession are close to zero. At around the date where the NBER recessions begin, the probabilities of recession spike upward and remain high until around the time when the NBER dates the end of the recessions.

As extensively discussed in the media and in the business cycle literature, the 1990-1991 and the 2001 recessions were not followed by rapid revival periods as in the previous ones. This is particularly the case for the 2001 recession, which was followed by a jobless recovery (e.g. Chauvet and Hamilton 2006, Chauvet and Piger 2008, among several others, etc). The probabilities of recession reflect this sluggish recovery – they increase in early 2001 and remain high until mid 2003. Notably, there was a great deal of uncertainty in real time regarding the state of the economy between 2001 and 2003. On effect, the NBER Business Cycle Dating Committee only announced that the 2001 recession ended in November 2001 20 months later, in July 2003.[5] This was the longest delay in calling a business cycle turning point by the Committee since its inception in 1978.

Housing Cycles

The empirical results provide support to the Markov switching framework in the housing sector. The asymmetries in the phases of the housing cycle are also well characterized by the switching dynamic factor, which shares very similar patterns to the business cycle. As for the business cycle, the housing factor displays a significant positive mean (μ_1^H =3.5) in State 1

[4] For example, the expected duration of recession from the model is determined by the formula: $\sum_{k=1}^{\infty} k(p_{00}^{BC})^{k-1} = 1/(1 - p_{00}^{BC})$.

[5] An interesting observation is that the probabilities of recession do not remain high after the 2001 recession when the model is estimated using other measures of employment rather than payroll employment. The probabilities of recession in this case signal the end of the recession in November 2001, as does the NBER. This indicates that the "jobless recovery" is intrinsically associated with the formal labor market.

and a significant negative mean in State 0 (μ_0^H = *-2.5)*. State 1 exhibits a longer duration, corresponding to high housing price phases, whereas State 0 has a much shorter duration. The expected duration implied by the model for the low housing cycle phase is 8 quarters, and the expected duration of the high housing cycle phase is 34 quarters.

These features can be observed in Figure 6, which plots the extracted housing factor and the smoothed probabilities of low housing prices. The probabilities display a clear dichotomous pattern, remaining close to zero during high housing phases and spiking upward close to one during low housing market phases. There have been five low housing phases in the sample studied. The most recent low housing price phase started in early 2006 and had not ended until the last observation in the sample, in 2007Q4.

Figure 7 compares the housing factor extracted from the four regional housing prices with the aggregate U.S. house prices, also obtained from the Census. The factor is substantially smoother than the U.S. house prices. The model extracts only the common cyclical fluctuations underlying the four regions, as represented by the factor, while it separates out the idiosyncratic movements that are peculiar to each region. The resulting factor is a national index of housing prices.

Links between the Housing Cycle and the Business Cycle

The estimated contemporaneous covariance parameter between the housing cycle factor and the business cycle is 0.40. The non-contemporaneous linear relationship between the housing market factor and the economic factor is represented by the coefficients of the vector autoregression in the transition equations (3-4). The coefficient of the lagged business cycle factor in the housing market factor, β^H , and the coefficient of the lagged housing market factor in the business cycle factor, β^{BC} , are both positive. That is, on average, a positive economic growth is followed by a positive housing market growth and vice-versa.

Notice that the vector autoregressive coefficients in the transition equations reflect the average linear relationship between the two factors over the entire sample, without taking into account potential asymmetries before, during, and after recessions or low housing market phases. The lead-lag dynamics of the housing market and the real economy are better depicted by examining their relationship around the transitions between their cyclical phases. This can be directly examined within our proposed nonlinear framework, which allows for two distinct (but potentially dependent) Markov processes to represent the housing market and the business cycle. Figure 8 plots the smoothed probabilities of recessions and the smoothed probabilities of low housing prices. The graph indicates that the phases of the housing factor are fairly closely associated with the phases of the business cycle. Low housing prices phases tend to slightly lead economic recessions. During expansions, the probabilities of low housing prices are close to zero, and a couple of months before the beginning of recessions the probabilities of low housing prices rise substantially. The end of

low housing price phases tends to coincide or slightly lag the end of economic recessions.[6] On average, the housing cycle factor leads the business cycle factors by two quarters.

Housing Market Since 2000

An interesting feature of the smoothed probabilities of low housing market phase in Figure 8 is that they do not increase during the 2001 recession.[7] Noticeably, the housing market did not exhibit a regular cycle during this period compared to the historical pattern. For the first time in the sample studied, variables measuring housing supply, demand, and prices did not fall during a recession. Figures 1 to 3 show that housing prices and new house construction (housing start and housing permit) are very closely linked until around 2000. After that, construction continues to increase until 2006 in spite of the recession in 2001. The national and regional median prices of houses sold also did not display a typical behavior during this recession. Remarkably, the median prices in the West and Northeast regions presented a steep increase – rather than the expected fall – during the 2001 recession. In fact, there was a continuous increase in prices from 1995 to 2006, with the steepest rise taking place between 2002-2006, when US real housing prices increased by 31%.

Another factor that has changed in the last ten years is the soaring national rate of homeownership. Between 1965 and 1995 the homeownership rate fluctuated between 62 and 64 percent with little discernable trend. After 1995 it jumped 5 percentage points, and at the end of 2006 stood at 69% (Figure 3). Since then it has retreated down to 67% as of the second quarter of 2009. These movements were so pronounced that from 1998-2006 the total number of renters in the US actually declined for the first time since WWII. The rise in ownership meant that approximately 4-1/2 million more families that otherwise would have been renters owned their homes. Investors and second-home buyers also purchased a growing number of properties, accounting for more than one-sixth of all first-lien loans to purchase one-to-four-family site-built homes in 2005 and 2006. A movement in demand this large would certainly be expected to soften rents and put great pressure on prices. Since 2006, this trend reversed: the number of renters has grown sharply and the number of owners has actually declined.

Another interesting aspect of the housing cycle in the last decade is that generally the downturn in housing takes place right before of at economic recessions. After 2007, the contraction in the housing market led the economic contraction by 2 years.

In summary, the relationship between the housing market and the business cycle

---

[6] This indicates that around the end of recessions and beginning of expansions the non-contemporaneous relationship between the housing factor and the business cycle is negative.

[7] Notice that the smoothed probabilities also do not increase during the 1974-1975 recession. During this period, however, even though housing prices were relatively flat, other measures of the housing market such as housing start and housing permit displayed a strong cyclical fluctuation during this recession (Figures 1-3).

changed remarkably in the last decade. While the interrelationship between the housing cycle and the business cycle went missing during the 2001 recession, the link became remarkably strong in the subsequent 2007-2009 recession.

6 Housing Market and Interest Rates – Augmented Bifactor Nonlinear Model

In order to investigate the missed link between the housing cycle and the business cycle, we examine the role of interest rates. Figure 9 plots the growth rate of U.S. housing prices, the Federal Funds Rate, the 30-year Mortgage Rate, and NBER recessions.[8] Interest rates generally rise during expansions, reaching a peak towards its end. Before the beginning of recessions interest rates start to fall and stay low until the early stages of the subsequent economic expansion. As it can be observed in Figure 9, interest rates are an important factor in the relationship between the business cycle and the housing cycle. There is an inverse relationship between housing prices and the level of and changes in interest rates. In particular, interest rates movements lead housing market cycle: increases in interest rates are related to subsequent decreases in housing prices and housing starts, whereas increases in interest rates are related to subsequent decreases in economic activity.

Thus, it is worth exploring the causes of the changes in the housing cycle by examining the role of interest rates. As it can be observed, a striking feature of the period before, during, and right after the 2001 recession is the level of interest rates compared to historical records – mortgage rates and the Federal Funds Rate were at their lowest levels since the beginning of the sample (Figure 9).[9]

Augmented Model 1 – Introducing Interest Rates

In order to investigate the relationship between interest rates, the housing market, and the business cycle, the proposed model is extended to include interest rates. We consider the same measurement equations as in (1)-(2), but now the transition equations are:

$$F_t^{BC} = \mu_{S_t}^{BC} + \phi^{BC} F_{t-1}^{BC} + \beta^{H} F_{t-1}^{H} + \varphi^{BC} r_{t-1} + \eta_t^{BC} \tag{5}$$

$$F_t^{H} = \mu_{S_t}^{H} + \phi^{H} F_{t-1}^{H} + \beta^{BC} F_{t-1}^{BC} + \varphi^{H} r_{t-1} + \eta_t^{H} \tag{6}$$

where r_t is Federal Funds Rate. Now, the linkages between the housing factor and the business cycle also occur through their relationship with interest rates. Table 2 shows the estimated lagged interest rate coefficients in the transition equations of the housing factor and business cycle factor, which are negative and highly significant. This highlights the

[8] The Effective Federal Funds Rate and the 30-Year Conventional Mortgage Rate (available from 1971Q2) are obtained from the Federal Reserve Bank of Saint Louis.

[9] Notice that this is a common element in 1974-75 recession as well, during which house prices also did not fall.

importance of interest rate as a link between housing cycle and business cycle factor. Increases in interest rates are associated with subsequent decreases in the housing sector and in the economic activity.

Augmented Model 2 – Recent Changes in Interest Rates

Given the unique dynamics of the housing cycle since the mid 1990s, we extend the model to allow for changes in the relationship between the housing cycle, the business cycle, and interest rates. In order to capture the recent changes in their relationship, we allow each of the coefficients of lagged interest rates in the transition equations to follow distinct Markov processes:

$$F_t^{BC} = \mu_{S_t}^{BC} + \phi^{BC} F_{t-1}^{BC} + \beta^{H} F_{t-1}^{H} + \varphi_{S_t}^{BC} r_{t-1} + \eta_t^{BC} \qquad (5')$$

$$F_t^{H} = \mu_{S_t}^{H} + \phi^{H} F_{t-1}^{H} + \beta^{BC} F_{t-1}^{BC} + \varphi_{S_t}^{H} r_{t-1} + \eta_t^{H} \qquad (6')$$

with

$$\varphi_{S_t}^{BC} = \varphi_1^{BC^*} S_t^{BC^*} + \varphi_0^{BC^*} (1 - S_t^{BC^*}) \qquad S_t^{BC^*} = 0, 1$$

$$\varphi_{S_t}^{H} = \varphi_1^{H^*} S_t^{H^*} + \varphi_0^{H^*} (1 - S_t^{H^*}) \qquad S_t^{H^*} = 0, 1$$

and transition probabilities

$$P[S_t^{BC^*} = 0 \mid S_{t-1}^{BC^*} = 0] = q^{BC^*},\ P[S_t^{BC^*} = 1 \mid S_{t-1}^{BC} = 1] = p^{BC^*}$$

$$P[S_t^{H^*} = 0 \mid S_{t-1}^{H^*} = 0] = q^{H^*},\ P[S_t^{H^*} = 1 \mid S_{t-1}^{H^*} = 1] = p^{H^*}$$

where $\sum_{j=0}^{1} p_{ij}^{BC^*} = \sum_{j=0}^{1} p_{ij}^{H^*} = 1,\ i, j = 0,1.$

Housing Market, Interest Rates, and the 2001 Recession

The results from the model are somewhat striking. As shown in Table 3, there are two significant states for the interest rate coefficients in the business cycle equation as well as in the housing market equation. The estimates show substantially lower interest rate coefficient in the business cycle factor transition equation in State 0, and significantly higher in State 1 (in absolute value). This asymmetry is also observed in the relationship between interest rate and the housing market – the interest rate coefficient in the housing factor transition equation is significantly lower in State 0 and significantly higher in State 1 (in absolute value).

The smoothed probabilities reveal the intuition for these results. Figure 10 shows the smoothed probabilities of low interest rate coefficient in the business cycle equation,

$P(S_t^{BC*}=0|T)$. Over the entire sample until 2002, these probabilities are close to zero. After this year, the probabilities spike upward to values close to one, and stay high until around 2004. That is, the linkage between business cycle factor and interest rate weaken during the 2002-2004 recovery. On effect, the Federal Reserve kept interest rates at low levels during this expansion period due to the uncertainty regarding the end of 2001 recession, and the slow recovery in 2002-2004.

On the other hand, the smoothed probabilities of high interest rate coefficient in the housing cycle factor, $P(S_t^{H*}=1|T)$, are close to zero until mid 2001. After that date, the probabilities spike upward to values close to one, and stay high until the end of the sample. That is, the association between lagged interest rates and the housing market factor became much stronger since the 2001 recession.

7 Conclusion

This paper examines the historical linkage between business cycles and housing market cycles in order to understand whether the recent boom and bust in the housing sector in the last decade is unique or whether it had historical precedents.

We propose a nonlinear dynamic factor of the joint relationship between the housing market, the business cycle, and interest rates and we find a strong linkage among them. However, these relationships have changed during the 2001 recession and subsequent recovery. In particular, we find that the housing market became more sensitive – to a higher extent than the historical record – to interest rates throughout the 2000s.

This suggests that the run up of housing prices, especially since 2001 is associated with the low level of interest rate. The process started in early 2001 when interest rates decreased substantially to minimize the economic recession that had started in March of that year. Upon the end of this recession, the economy recovered at a very low pace. Differently from other early stages of expansions, this jobless recovery led the Federal Reserve to keep interest rates at low levels for quite some time. The 'missed' low housing market cycle during the 2001 recession, the continued growth in house demand and prices, and the record low interest rates led investors to believe that more likely returns would be realized in good states of the economy, when those returns are higher. The argument is that the monetary expansion during this first period led to both speculation and leveraging, especially regarding lending practices in the housing sector. In other words, this expansion made it possible for marginal borrowers to obtain loans with lower collateral values. These dynamics accentuated in 2003, when the economy was in a full recovery with still low level of interest rates – this catalyzed an abrupt increase in housing prices, housing starts, and ownership.

The unique features of the cycle led investors to be uncertain regarding the possible end of the monetary expansion phase, and on the strength of its effect on the housing sector. When interest rates start rising in June 2004, it had the reverse effect in the housing sector. As

the previous low interest rates stimulated the sector, the new upward trend in interest rates had a strong negative effect in the housing sector and was associated with a subsequent drastic fall in housing prices. This led many to own negative equity, and induced a wave of default and foreclosures.

The negative developments in the housing market impacted the aggregate economy through reduced investment in housing; a reduction in consumer spending because of decreases in household wealth; contagion in financial markets, which has negative effects on business investment and consumption of durable goods, in addition to consumers' and businesses' confidence about the future, which can constrain plans for future demand and supply. In the end of 2007 the economy entered a recession, which started as a mild contraction. With the ramifications of the subprime crisis and financial contagion in mid 2008, the recession became much more severe and lasted longer than any other recession since the Great Depression.

Reference

Case, Bradford and Susan Wachter, 2003, “Residential Real Estate Price Indices as Financial Soundness Indicators: Methodological Issues,” BIS Paper No. 21.

Ceron, J. and J. Suarez, 2006,” Hot and Cold Housing Market: International Evidence,” CEMFI Working Paper No. 0603.

Chauvet, Marcelle, 1998,”An Econometric Characterization of Business Cycle Dynamics with Factor Structure and Regime Switches,” International Economic Review, 39, 4, 969-96.

Chauvet, M. and J. Hamilton, 2006, “Dating Business Cycle Turning Points in Real Time,” with James D. Hamilton, “*Nonlinear Time Series Analysis of Business Cycles,*” ed. Van Dijk, Milas, and Rothman, Elsevier’s Contributions to Economic Analysis series, 1-54.

Chauvet, M. and J. Piger, 2008, “A Comparison of the Real-Time Performance of Business Cycle Dating Methods,” with Jeremy Piger, *Journal of Business Economics and Statistics*, 26, 1, 42-49.

Chauvet, M. and Z. Senyuz, 2009, A Joint Dynamic Bi-Factor Model of the Yield Curve and the Economy as a Predictor of Business Cycles,” Working Paper, University of California, Riverside.

Clayton, J.F., N.G. Miller, and L. Peng, 2008, “Price-Volume Correlation in the Housing Market: Causality and Co-Movements,” The Journal of Real Estate Finance and Economics, May.

Crawford, G.W., M.C. Fratantoni, 2003, “Assessing the forecasting performance of regime-switching ARIMA and GARCH models of house prices,” Real Estate Economics, 31, 2, 223-243.

Fadiga, M.L., Y. Wang, 2009,”A Multivariate Unobserved Component Analysis of U.S. Housing Market,” Journal of Economics and Finance, 33, 1, 13-26.

Goodman, A.C., and T.G. Thibodeau, 2008, “Where are the Speculative Bubbles in US Housing Market?,” Journal of Housing Economics, 17, 117-137.

Hamilton, J.D., 1989, “A New Approach to the Economic Analysis of Nonstationary Time

Series and the Business Cycle," Econometrica, 57, 2, 357-384.

Kholodilin, K.A. , V.W. Yao, 2005, " Measuring and Predicting Turning Points Using a Dynamic Bi-Factor Model ," International Journal of Forecasting, 21, 525-537.

Kim, S.W., and R. Bhattacharya, 2007, "Regional Housing Prices in the USA: An Empirical Investigation of Nonlinearity," The Journal of Real Estate Finance and Economics.

McMillen, D.P., 2007, "Changes in the Distribution of House Prices over Time: Structural Characteristics, Neighborhood, or Coefficients?"

Miles,W., 2007, "Boom-Bust Cycles and the Forecasting Performance of Linear and Non-Linear Models of House Prices," Journal of Real Estate Finance and Economics 36, 249-264.

Negro, M. and C. Otrok, 2007, "99 Luftballons: Monetary Policy and the House Price Boom across U.S. states," Journal of Monetary Economics 54, 1962-1985.

Holly, S., M.H. Pesaran and T. Yamagata, 2009, "A Spatio-Temporal Model of House Prices in the U.S.", forthcoming in *Journal of Econometrics.*

Senyuz, Z., 2008, "A Factor Analysis of Permanent and Transitory Dynamics of the U.S. Economy and the Stock Market," Working Paper, University of California, Riverside.

Vansteenkiste, I., 2007, "Regional Housing Market Spillover in the US: Lessons from Regional Divergences in a Common Monetary Policy Setting," ECB Working Paper No. 708.

Wheaton, W.C., and G. Nechayev, 2007, "The 1998-2005 Housing 'Bubble' and the current 'Correction': what's different this time," Journal of Real Estate Research.

Wheaton, W.C., and N.J. Lee, 2008, "Do Housing Sales Drive Housing Prices or the Converse," MIT Department of Economics Working Paper No. 08-01.

Table 1: Maximum Likelihood Estimates – Basic Model

Parameters	Business Cycle	Parameters	Housing Cycle
μ_1^{BC}	1.50 (0.20)	μ_1^{H}	3.52 (1.06)
μ_0^{BC}	-0.54 (0.16)	μ_0^{H}	-2.47 (0.79)
p_{11}^{BC}	0.93 (0.01)	p_{11}^{H}	0.97 (0.02)
p_{00}^{BC}	0.78 (0.03)	p_{00}^{H}	0.88 (0.06)
$\sigma^2_{\eta_{BC}}$	1.43 (0.21)	$\sigma^2_{\eta_H}$	1.19 (0.18)
ϕ^{BC}	0.46 (0.05)	ϕ^{H}	-0.28 (0.16)
$\lambda_{Production}$	1	$\lambda_{Northeast}$	1
λ_{Income}	0.56 (0.02)	λ_{West}	1.60 (0.50)
λ_{Sales}	0.78 (0.03)	$\lambda_{Midwest}$	1.41 (0.43)
$\lambda_{Employment}$	0.41 (0.02)	λ_{South}	1.26 (0.36)
$*\sigma^2_{v,Production}$	0.32 (0.02)	$\sigma^2_{v,Northeast}$	36.92 (3.93)
$\sigma^2_{v,Income}$	0.11 (0.01)	$\sigma^2_{v,West}$	8.85 (1.30)
$\sigma^2_{v,Sales}$	0.78 (0.05)	$\sigma^2_{v,Midwest}$	23.09 (2.60)
$\sigma^2_{v,Employment}$	0.13 (0.01)	$\sigma^2_{v,South}$	8.21 (1.05)
β^{BC}	0.16 (0.07)	β^{H}	0.17 (0.05)
$\psi_{Production}$	0.17 (0.05)	$\psi_{Northeast}$	-0.37 (0.07)
ψ_{Income}	0.16 (0.04)	ψ_{West}	-0.40 (0.08)
ψ_{Sales}	-0.24 (0.04)	$\psi_{Midwest}$	0.43 (0.07)
$\psi_{Employment}$	-0.49 (0.08)	ψ_{South}	-0.32 (0.08)
$\sigma_{BC,SM}$	0.40 (0.16)		
Log L	-3470.22		

Asymptotic standard errors in parentheses

Table 2: Maximum Likelihood Estimates – Augmented Model with Interest Rates

Parameters	Business Cycle	Parameters	Housing Cycle
μ_1^{BC}	1.48 (0.20)	μ_1^{H}	3.64 (1.04)
μ_0^{BC}	-0.53 (0.16)	μ_0^{H}	-2.45 (0.76)
p_{11}^{BC}	0.92 (0.01)	p_{11}^{H}	0.96 (0.02)
p_{00}^{BC}	0.78 (0.03)	p_{00}^{H}	0.89 (0.05)
$\sigma^2_{\eta_{BC}}$	1.41 (0.21)	$\sigma^2_{\eta_H}$	1.16 (0.16)
ϕ^{BC}	0.45 (0.05)	ϕ^{H}	-0.27 (0.15)
$\lambda_{Production}$	1	$\lambda_{Northeast}$	1
λ_{Income}	0.54 (0.02)	λ_{West}	1.61 (0.51)
λ_{Sales}	0.79 (0.03)	$\lambda_{Midwest}$	1.39 (0.41)
$\lambda_{Employment}$	0.42 (0.02)	λ_{South}	1.31 (0.34)
$\sigma^2_{v,Production}$	0.35 (0.02)	$\sigma^2_{v,Northeast}$	37.26 (3.91)
$\sigma^2_{v,Income}$	0.11 (0.01)	$\sigma^2_{v,West}$	8.17 (1.31)
$\sigma^2_{v,Sales}$	0.77 (0.05)	$\sigma^2_{v,Midwest}$	23.42 (2.58)
$\sigma^2_{v,Employment}$	0.12 (0.01)	$\sigma^2_{v,South}$	8.23 (1.10)
β^{BC}	0.15 (0.06)	β^{H}	0.14 (0.02)
$\psi_{Production}$	0.16 (0.05)	$\psi_{Northeast}$	-0.38 (0.06)
φ^{BC}	-0.08 (0.02)	φ^{H}	-0.09 (0.03)
ψ_{Income}	0.16 (0.04)	ψ_{West}	-0.41 (0.08)
ψ_{Sales}	-0.21 (0.04)	$\psi_{Midwest}$	0.43 (0.06)
$\psi_{Employment}$	-0.53 (0.08)	ψ_{South}	-0.31 (0.08)
$\sigma_{BC,SM}$	0.41 (0.16)		
Log L	-3412.98		

Asymptotic standard errors in parentheses

Table 3: Maximum Likelihood Estimates – Augmented Model with Markov Switching in the Interest Rates Coefficients

Parameters	Business Cycle	Parameters	Housing Cycle
μ_1^{BC}	1.46 (0.19)	μ_1^{H}	3.56 (1.01)
μ_0^{BC}	-0.52 (0.15)	μ_0^{H}	-2.42 (0.72)
p_{11}^{BC}	0.92 (0.01)	p_{11}^{H}	0.95 (0.02)
p_{00}^{BC}	0.79 (0.03)	p_{00}^{H}	0.88 (0.05)
$\sigma^2_{\eta_{BC}}$	1.42 (0.20)	$\sigma^2_{\eta_H}$	1.16 (0.14)
ϕ^{BC}	0.43 (0.04)	ϕ^{H}	-0.28 (0.14)
$\lambda_{Production}$	1	$\lambda_{Northeast}$	1
λ_{Income}	0.53 (0.02)	λ_{West}	1.63 (0.49)
λ_{Sales}	0.81 (0.03)	$\lambda_{Midwest}$	1.36 (0.41)
$\lambda_{Employment}$	0.45 (0.02)	λ_{South}	1.33 (0.33)
$\sigma^2_{v,Production}$	0.32 (0.02)	$\sigma^2_{v,Northeast}$	38.14 (3.92)
$\sigma^2_{v,Income}$	0.13 (0.01)	$\sigma^2_{v,West}$	8.12 (1.31)
$\sigma^2_{v,Sales}$	0.78 (0.04)	$\sigma^2_{v,Midwest}$	22.37 (2.56)
$\sigma^2_{v,Employment}$	0.11 (0.01)	$\sigma^2_{v,South}$	8.01 (1.12)
β^{BC}	0.14 (0.05)	β^{H}	0.12 (0.02)
$\psi_{Production}$	0.18 (0.05)	$\psi_{Northeast}$	-0.36 (0.05)
φ_1^{BC}	-0.08 (0.02)	φ_1^{H} *(2001 on)*	-0.18 (0.08)
φ_0^{BC} *(2002 on)*	-0.02 (0.01)	φ_0^{H}	-0.09 (0.03)
ψ_{Income}	0.15 (0.03)	ψ_{West}	-0.42 (0.08)
ψ_{Sales}	-0.24 (0.04)	$\psi_{Midwest}$	0.41 (0.05)
$\psi_{Employment}$	-0.51 (0.08)	ψ_{South}	-0.35 (0.08)
$\sigma_{BC,SM}$	0.43 (0.15)		
Log L	-3368.62		

Asymptotic standard errors in parentheses

Figure 1 – Real Median Prices of Houses Sold by Region in the U.S. and NBER Recessions (Shaded Area)

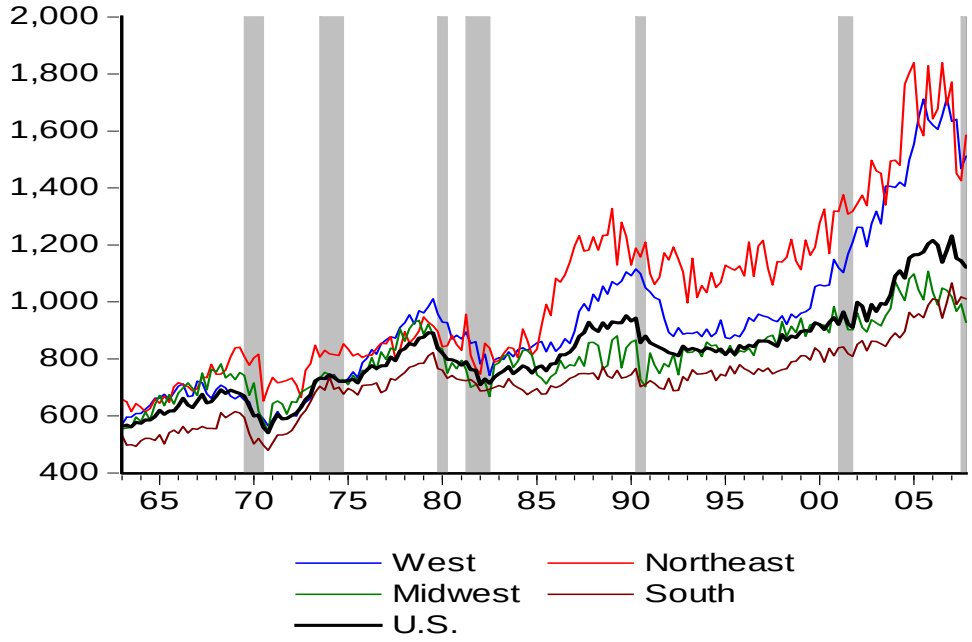

Figure 2 – U.S. Census Bureau Home Ownership Rate (---), U.S. Median House Prices (—), and NBER Recessions (Shaded Area)

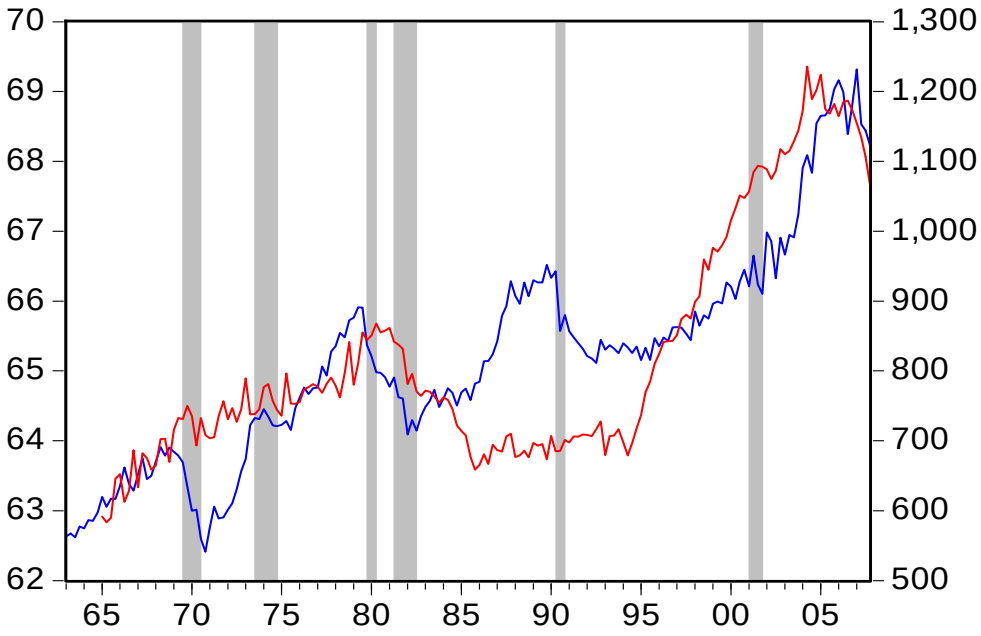

Figure 3 – U.S. Census Bureau New Privately Owned Housing Units Started (—), Housing Units Authorized by Building Permits (---), and NBER Recessions (Shaded Area)

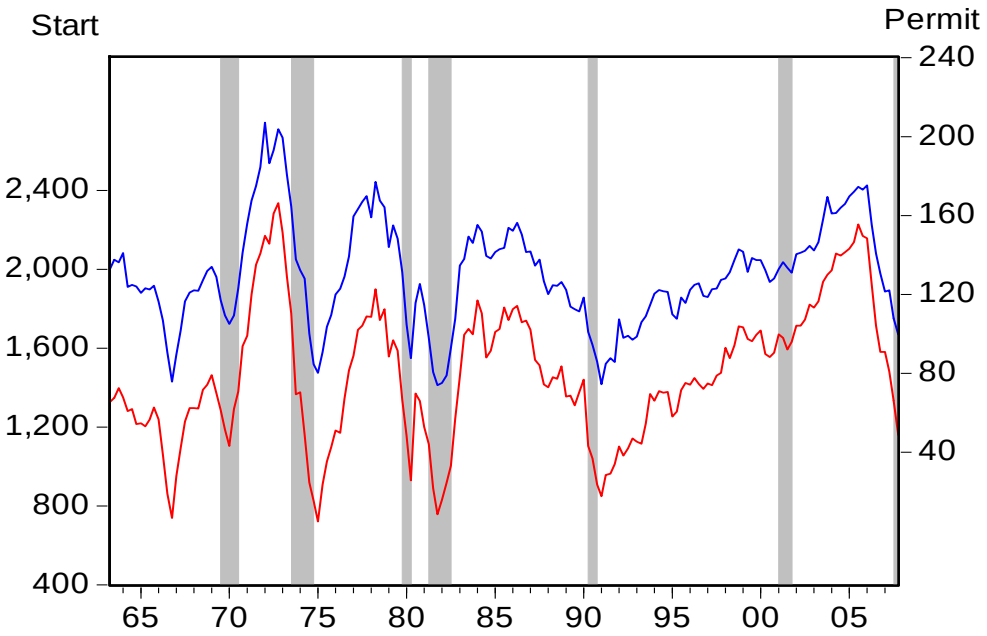

Figure 4 – 30-Year Fixed-Rate Mortgage (—), Home Mortgage Growth Rate by Household (---), and NBER Recessions (Shaded Area)

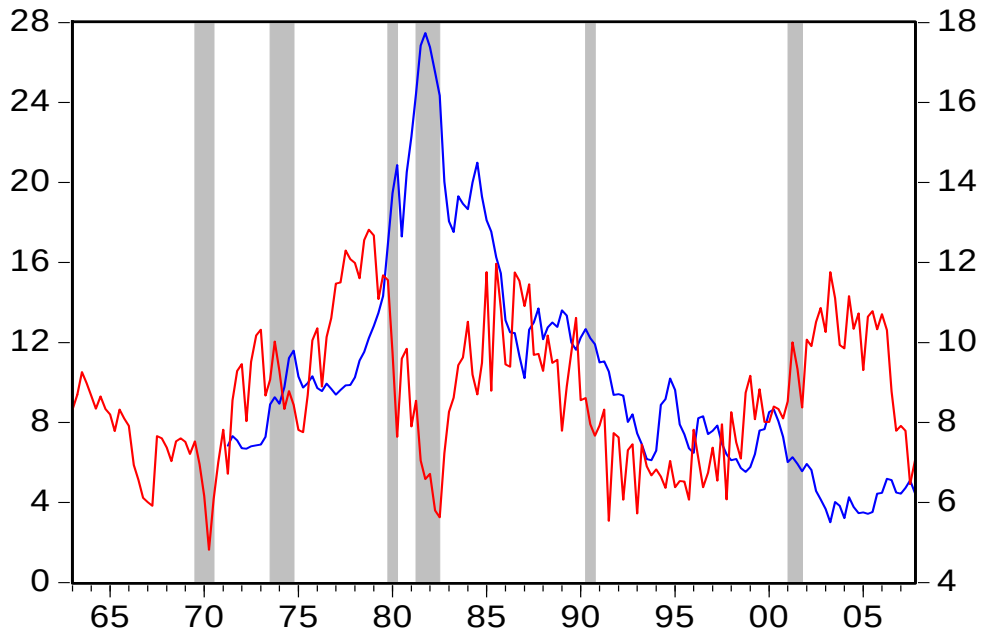

Figure 5 – Smoothed Probabilities of Recessions (—), Business Cycle Factor (---), and NBER Recessions (Shaded Area)

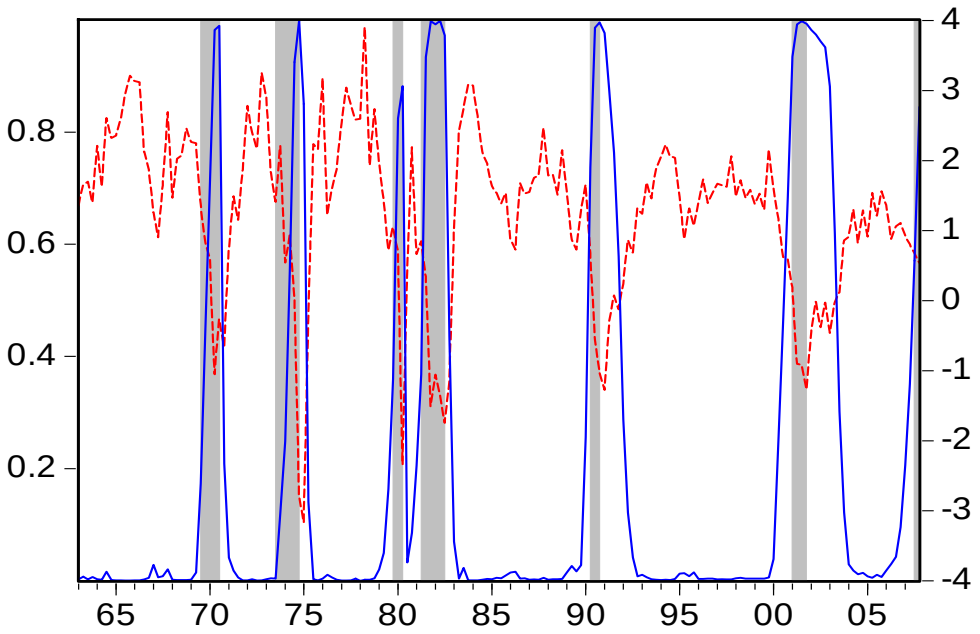

Figure 6 – Smoothed Probabilities of Recessions (—), Housing Factor (---), and NBER Recessions (Shaded Area)

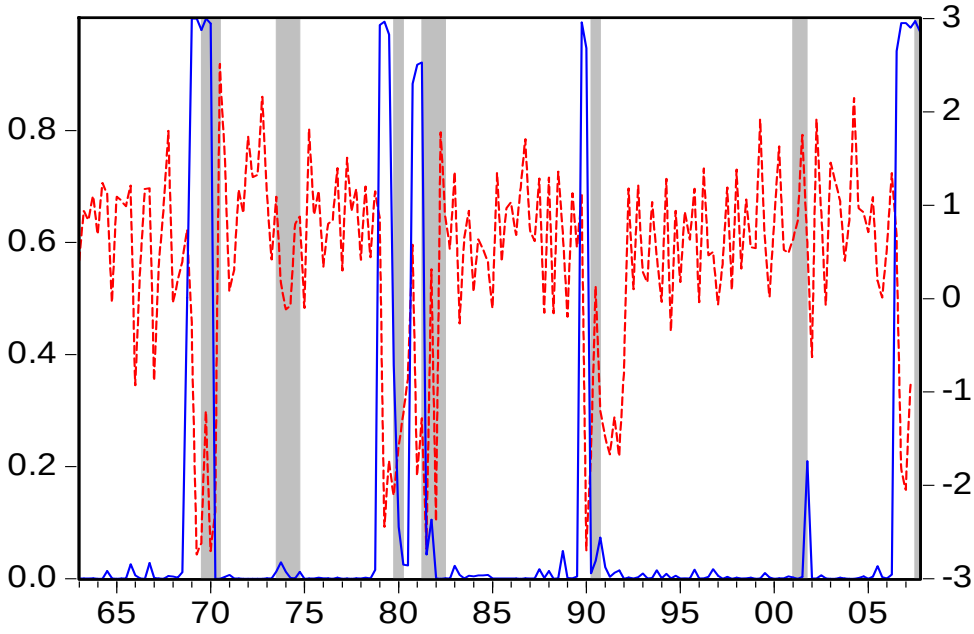

Figure 7 – Housing Factor (—), U.S. Median Price of Houses Sold (---), and NBER Recessions (Shaded Area)

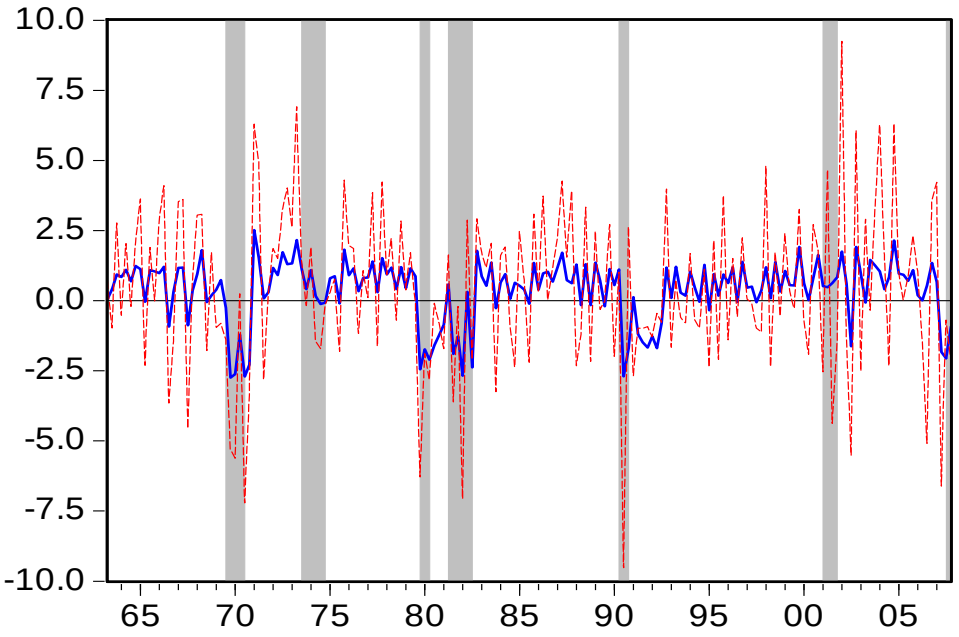

Figure 8 – Smoothed Probabilities of Low Housing Market (—), Smoothed Probabilities of Recessions (—), and NBER Recessions (Shaded Area)

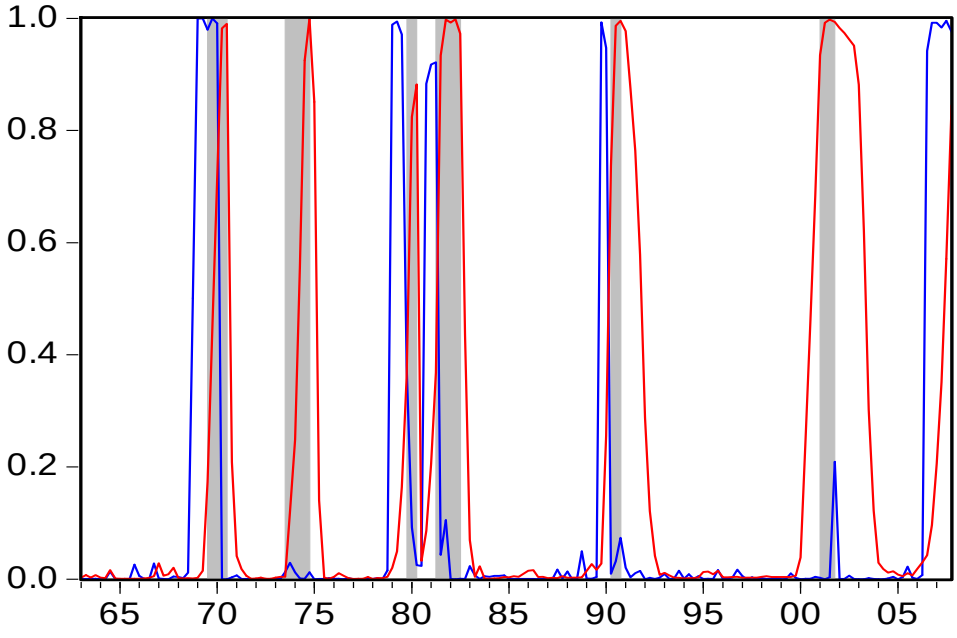

Figure 9 –30-Year Fixed-Rate Mortgage (—), Federal Funds Rate (—), US Real Median Housing Prices, Smoothed (—), 30-Year Mortgage in 1971: 7.4% (---),and NBER Recessions (Shaded Area)

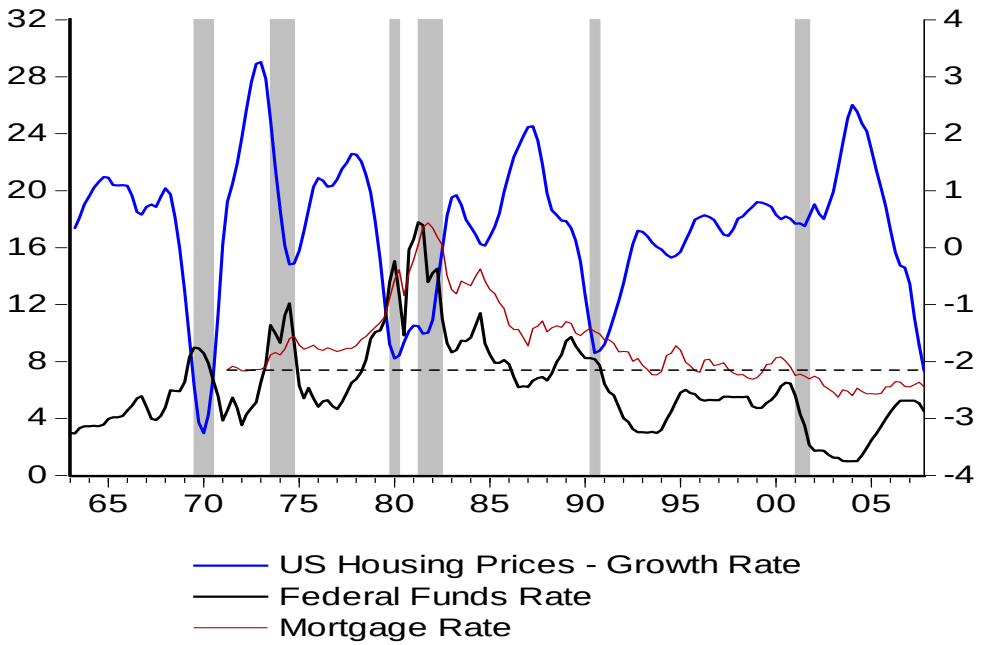

Figure 10 – Probabilities of Low Interest Coefficient in the Business Cycle Factor Equation, and NBER Recessions (Shaded Area)

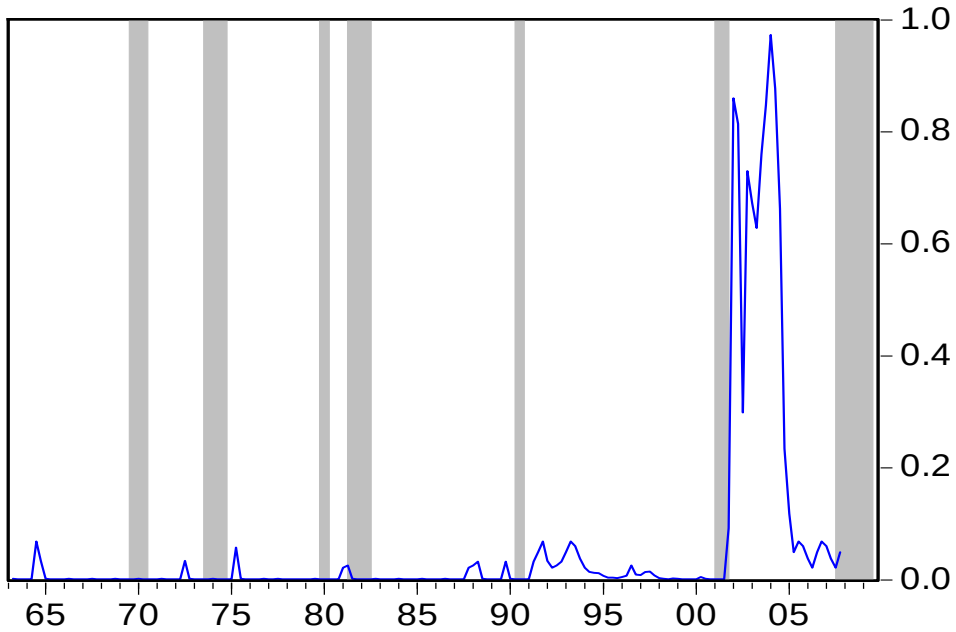

Figure 11 – Probabilities of High Interest Coefficient in the Housing Factor Equation, and NBER Recessions (Shaded Area)