What Moves the Price-Rent Ratio: A Latent Variable Approach

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Abstract

This paper proposes an unobserved component approach to decompose the price-rent ratio into time-varying expected rent growth, expected real interest rate and expected housing premia. Acknowledging that expected rental growth, expected real interest rates and expected housing risk premia are unobservable, the Kalman filter is used to extract them from the observed history of realized rent growth and realized real interest rates. Our results suggest that expected rent accounts for a very small share of variation in the price-rent ratio. On the other hand we find that the expected housing premia is much more volatile than the price-rent ratio, but a high negative correlation between the real rates and premia dampens the overall variation in price-rent ratio. Our empirical results also suggest that output growth, jobs growth, and junk spread contain extra information about the future variation in housing premia that is not already present in its lagged value. We also find that market's expected volatility measured by the VIX index affects premia positively and significantly.

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1 Introduction

The financial crisis of 2008-2009 had its roots in the boom and the bust of the housing market in the U.S. The collapse of the housing market led to the overall decline in macroeconomic stability, starting with a big fall in the stock market. It has been estimated that the net worth of the U.S. households has declined by $13 trillion dollars between 2007-2009[1]. The sustained increase in house prices prior to 2007 attracted widespread attention from empirical researchers. Most of these empirical studies used a present value model of house prices to investigate the existence of a housing bubble[2]. The present value model of house prices is based on Campbell and Shiller's (1988) model, which has been applied extensively in the finance literature. One interpretation of the present value model in the housing market is that the house prices and rents should move together in the long-run. This metric of valuation of the housing market suggests that the housing market was overvalued between 1997-2007 as shown in figure 1. Figure 1 shows that real house prices rose by only 3.7 percent between 1985 and 1995, but increased by 46 percent between 1995 and 2005. In sharp contrast, real rents remained virtually unchanged , as a result price-rent ratio peaked at approximately forty percent above its long-run level. The subsequent correction in the real house prices led to a decline of 34% from year-end 2006 through the first quarter of 2009.

Rather than focusing on the existence of bubbles, we examine factors that explain these large swings in price-rent ratio. To do so, we apply present value model to decompose the price-rent ratio into the present value of future expected returns and present value of expected rent growth. Expected returns on housing equals expected real interest rates and expected risk premia over risk free rate. A change in the price rent ratio can reflect either a change in the expected rent growth or change in expected real interest rates or a change in expected housing risk premia.

This paper uses a latent-variable approach within a present-value-model to decompose the price-rent ratio into expected rental growth, expected real interest rate and expected housing risk premia. Our framework explicitly takes into account that the price-rent ratio moves due to both expected

[1] Flow of funds data.

[2] Using the present value model, Gallin (2004) and Case and Shiller (2003) suggested that housing market in 2004 was over valued because it was significantly above its historical average. At the same time, Himmelberg, Mayer and Sinai (2005) suggested that there was no evidence of a bubble in 2004 in any of the regional markets. Most of these studies have compared the house price-rent ratio to its historical average, and found whether the current house price is above or below its historical average

return to housing and expected rent growth variation. We treat expected rent growth, expected real interest rates and expected housing premia as unobserved variables that follow an exogenously-specified time series model. This unobserved state space model is combined with present value model to decompose the movements in price-rent ratio. Few other papers have also used present value model to examine the determinants of price-rent ratio. Notably, Campbell et al. (2009) use a reduced form VAR approach to explain the movements in price-rent ratio. They measure expectations of the expected present value of risk-free interest rates, housing premia, and rent growth by specifying that households form expectations using a VAR with fixed coefficients. VAR is used to directly compute expected future real risk-free rates and expected housing risk premia and then, given the accounting identity identify expected future rents as a residual given data on rent–price ratios. The VAR approach postulates that the unobserved returns can be written as a linear combination of innovations to observable variables. The coefficient in these linear combinations are identified by using a time-series model to construct forecasts of the discounted value of future rents, real interest rates and risk premium, and so forth. Since by definition the future rent growth, risk free rate and housing risk premia are unobserved, an unobserved component model is more suitable to model the present-value-model for the housing market. Moreover, as pointed out by Cochrane (2008), structural state-space model is able to capture individually small but possibly important moving average error terms in the long run.

Acknowledging that expected rental growth, expected real interest rates and expected housing risk premia are unobservable, the Kalman filter technique is used to extract them from the observed history of realized rent growth and realized real interest rates. Since housing risk premia is the residual in accounting identity, we can trace the time variation in housing risk premia once we estimate the expected rent growth and expected real interest rate. To apply Kalman filter to the unobserved component model, the main assumption we make is to allow the three components of price-rent ratio to have an exogenously given time series process. In particular, we model these components based on a parsimonious autoregressive process. Similar models have been applied in finance literature to study the behavior of equity market. For example, Balke and Wohar (2002) apply state-space model to present value model of stock prices to estimate the low-frequency movements in stock prices. Binsbergen and Koijen (2008) follow a similar approach to estimate the expected stock returns, and apply it to predict stock returns.

Once we estimate the time-varying expected housing premia, the next step of the paper is to examine the role of different macroeconomic and financial market development indicators in explaining its movements. Julliard and Wong (2008) have performed a comparative study of the determinants of housing premia across OECD countries. They find that financial market development indicators and different regulation regimes play a significant role in determining the house premia across different countries. Campbell et al.(2009)'s findings however suggest that lagged value of premia encompasses all the information about the future movements of premia that is present in macroeconomic variables like GDP growth. Following this strand of literature, we also examine the role of macroeconomic and financial market development indicators in explaining the housing premia that we estimate using the latent variable model. We use three indicators of macroeconomic activity: real GDP growth, jobs growth, and stock market's expected volatility measured by the VIX index. We use loan-to-value ratio and junk spread as two measures of financial market development indicators.

Our findings suggest that expected rent growth, expected real interest rate, and expected housing premia are time-varying. We find that expected housing premia and expected real interest rates are more persistent than expected rent growth. The estimation results show that shocks to expected real interest rates and expected rent growth are positively correlated. Shocks to expected rent growth and expected housing premia are also positively correlated though insignificant. We find a very high degree of negative correlation between expected real interest rates and expected housing premia. One of the interpretations of negative correlation between expected rent growth and real rates may arise from the fact that house prices do not increase by "enough" when real rates decline. The decomposition of price-rent ratio based on the estimated return and rent growth suggest that expected rent accounts for only 7 percent of the variation in price-rent ratio. On the other hand we find that the expected housing premia accounts for more than 300 percent of the variation in price-rent ratio, and expected real interest rate accounting for more than 150 percent variation. The covariances between expected rent growth, expected real interest rate and expected premia contribute negatively to the overall variation and dampens the total variation in price-rent ratio. In fact, we observe that the covariance between expected housing premia and expected real interest rate reduces the variability of price-rent ratio by more than 350 percent. This implies that the negative covariance between premia and real rate cancel out the impact of the variability of housing premia on the overall variability of price-rent ratio.

The prediction equation of housing premia suggests that output growth and jobs growth contain extra information about the future variation in premia that is not already present in its lagged value. There is a positive correlation between these two macroeconomic variable and premia, implying that the price of holding risk falls in good economic times. On the other hand, market's expected volatility measured by the VIX index affects premia negatively and significantly. We also find that junk spread is a significant predictor of premia and is positively correlated. This positive relationship may arise from a fall in junk spread during the period of adequate availability of liquidity in the market. The increase in liquidity in turn may also affect the housing premia negatively.

The plan of this paper is as follows: section 2 proposes an unobserved component model to estimate present value model of house prices. Section 3 describes the data. Section 4 provides the empirical methodology of estimation of housing premia; section 5 examines the predictability of housing premia; and section 6 concludes.

2 Model Specification

2.1 An Unobserved Component Approach to Estimate Present Value Model of House Prices

In this section, we present a present-value model of price-rent ratio which is in the spirit of Campbell and Shiller (1988) and Binsbergen and Koijen (2008). In contrast to Campbell et al. (2006), we assume that expected house price returns and expected real rent growth are latent variables.

Consider the one-period total log return on housing:

$$h_{t+1} \equiv \log\left(\frac{P_{t+1} + R_{t+1}}{P_t}\right), \tag{1}$$

where P_{t+1} is house price at time t+1, and R_{t+1} is the rent. Let $\triangle r_{t+1}$ represent the aggregate rent growth rate:

$$\triangle r_{t+1} \equiv \log\left(\frac{R_{t+1}}{R_t}\right)$$

Defining $\mathrm{pr}_t = \log(PR_t)$, where PR is price-rent ratio, and $\overline{pr} = E[pr_t]$ is the average price-rent ratio. The log-linearized return can be written as

$$h_{t+1} = \kappa + \rho pr_{t+1} + \triangle r_{t+1} - pr_t \tag{2}$$

where $\kappa = \log(1 + \exp(\ \overline{pr})) - \rho\overline{pr}$, $\rho = \frac{\exp(\overline{pr})}{1+\exp(\overline{pr})}$

We can write equation (2) equivalently as

$$pr_t = \kappa + \rho pr_{t+1} + \triangle r_{t+1} - h_{t+1}$$

This can be iterated forward and written as

$$pr_t = \frac{\kappa}{1-\rho} + \sum_{j=1}^{\infty} \rho^{j-1}(\triangle r_{t+j} - h_{t+j})$$

Assuming that $\rho^{\infty} pr_{\infty} = \lim_{j\to\infty} \rho^j pr_{t+j} = 0$. Taking expectation at time t,

$$pr_t = \frac{\kappa}{1-\rho} + \sum_{j=1}^{\infty} \rho^{j-1} E_t(\triangle r_{t+j} - h_{t+j})$$

By defining the return to housing as the sum of an interest rate, i, and the per-period premium over that rate, $\pi_t = h_t - i_t$, we can express the log price-rent ratio as the sum of three pieces: future expected real rates, housing premia, and rent growth,

$$pr_t = \frac{\kappa}{1-\rho} + \sum_{j=1}^{\infty} \rho^{j-1} E_t(\triangle r_{t+j} - i_{t+j} - \pi_{t+j}) \tag{3}$$

We assume that expected rent growth, expected real interest rates, and housing premia are latent variables. We follow a parsimonious modeling strategy, and model expected rent growth, expected real interest rate and housing premia as AR(1) process.

$$\triangle r^e_{t+1} = \gamma_0 + \gamma_1(\triangle r^e_t - \gamma_0) + \varepsilon^{re}_{t+1} \tag{4}$$

$$i^e_{t+1} = \delta_0 + \delta_1(i^e_t - \delta_0) + \varepsilon^{ie}_{t+1} \tag{5}$$

$$\pi^e_{t+1} = \theta_0 + \theta_1(\pi^e_t - \theta_0) + \varepsilon^{\pi e}_{t+1} \tag{6}$$

where:

$$i^e_t = E_t[i_{t+1}]$$

$$\triangle r^e_t = E_t[\triangle r_{t+1}]$$

$$\pi^e_t = E_t[\pi_{t+1}]$$

The realized rent growth and realized real interest rate are equal to the expected rent growth and expected real interest rate plus an idiosyncratic shock:

$$\triangle r_{t+1} = \triangle r_t^e + \varepsilon_{t+1}^r \tag{7}$$

$$i_{t+1} = i_t^e + \varepsilon_{t+1}^i \tag{8}$$

Plugging equations (4-6) in equation (3) and solving, we get:

$$pr_t = \frac{\kappa}{1-\rho} + \frac{\gamma_0 - \delta_0 - \beta_0}{1-\rho} + \frac{\triangle r_t^e - \gamma_0}{1-\rho\gamma_1} - \frac{i_t^e - \delta_0}{1-\rho\delta_1} - \frac{\pi_t^e - \theta_0}{1-\rho\theta_1} \tag{9}$$

which can be written as

$$pr_t = A + B_1(\triangle r_t^e - \gamma_0) - B_2(i_t^e - \delta_0) - B_3(\pi_t^e - \theta_0) \tag{10}$$

where A=$\frac{\kappa}{1-\rho} + \frac{\gamma_0-\delta_0-\theta_0}{1-\rho}$, $B_1 = \frac{1}{1-\rho\gamma_1}$, $B_2 = \frac{1}{1-\rho\delta_1}$, $B_3 = \frac{1}{1-\rho\theta_1}$. The log price-rent ratio is linear in the expected rent growth $\triangle r_t^e$, expected real interest rate i_t^e and expected housing premia π_t^e. The loading of the price-rent ratio depends on the persistence of rent growth, interest rate and housing premia. There are five shocks in the model, shock to expected rent growth (ε_{t+1}^{re}), shocks to expected real interest rates (ε_{t+1}^{ie}), shocks to expected housing premia ($\varepsilon_{t+1}^{\pi e}$), shocks to realized rent growth (ε_{t+1}^r), and shocks to realized real interest rates (ε_{t+1}^i). These shocks have mean zero and have the following variance-covariance matrix

$$\sum = var\begin{bmatrix} \varepsilon_t^r \\ \varepsilon_t^i \\ \varepsilon_t^{re} \\ \varepsilon_t^{ie} \\ \varepsilon_t^{\pi e} \end{bmatrix} = \begin{bmatrix} \sigma_r^2 & \sigma_{ri} & \sigma_{rr^e} & \sigma_{ri^e} & \sigma_{r\pi^e} \\ \sigma_{ri} & \sigma_i^2 & \sigma_{ir^e} & \sigma_{ii^e} & \sigma_{i\pi^e} \\ \sigma_{rr^e} & \sigma_{ir^e} & \sigma_{r^e}^2 & \sigma_{r^ei^e} & \sigma_{r^e\pi^e} \\ \sigma_{ri^e} & \sigma_{ii^e} & \sigma_{r^ei^e} & \sigma_{i^e}^2 & \sigma_{i^e\pi^e} \\ \sigma_{r\pi^e} & \sigma_{i\pi^e} & \sigma_{r^e\pi^e} & \sigma_{i^e\pi^e} & \sigma_{\pi^e}^2 \end{bmatrix}$$

We follow Binsbergen and Koijen (2008) identification strategy and assume that covariance between shocks to realized rents and realized real interest rates are uncorrelated with shocks to unobserved state variables. This implies that $\sigma_{rre} = \sigma_{rie} = \sigma_{ire} = \sigma_{iie} = \sigma_{i\pi e} = \sigma_{r\pi e} = 0$. In addition, we also assume that shocks to realized rent growth and realized real interest rates are also uncorrelated, that is $\sigma_{ir} = 0$. As suggested by Cochrane (2008) and Morley et al. (2003), we sometimes need to impose restrictions on covariance structure in the state space model to achieve identification.

2.2 Variance Decomposition

We can decompose the variance of price-rent ratio using equation (10). The variance decomposition of the price-rent ratio is defined as

$$
\begin{aligned}
var(pr_t) &= B_1^2 var(\triangle r_t^e) + B_2^2 var(i_t^e) + B_3^2 var(\pi_t^e) + \\
&\quad 2B_1B_2 cov(\triangle r_t^e, i_t^e) + 2B_1B_3 cov(\triangle r_t^e, \pi_t^e) + 2B_2B_3 cov(i_t^e, \pi_t^e)
\end{aligned}
$$

$$
\begin{aligned}
var(pr_t) &= \frac{(B_1\sigma_{re})^2}{1-\gamma_1^2} + \frac{(B_2\sigma_{ie})^2}{1-\delta_1^2} + \frac{(B_3\sigma_{\pi e})^2}{1-\theta_1^2} - \\
&\quad \frac{2B_1B_2\sigma_{reie}}{1-\gamma_1\delta_1} - \frac{2B_1B_3\sigma_{re\pi e}}{1-\gamma_1\theta_1} + \frac{2B_2B_3\sigma_{ie\pi e}}{1-\delta_1\theta_1}
\end{aligned} \tag{11}
$$

The above formula implies that proportion of variation of price-rent ratio explained by expected rent growth=$\frac{(B_1\sigma_{re})^2}{1-\gamma_1^2}$, and percentage of variation explained by housing premia=$\frac{(B_3\sigma_{\pi e})^2}{1-\theta_1^2}$. It may also be possible that covariances explain a bigger percentage of variation in price-rent ratio.

3 Data Description

We use semi-annual data, and our sample runs from 1961 through 2009. We use price-rent ratio, house price growth, and rent growth data from Davis et al. (2008). Davis et al. combine different data sources and provide a measure of price-rent ratio for the U.S. economy that goes back to 1961. The measure of house price used in this paper is the Case-Shiller index for the U.S. economy. We convert the nominal rent growth and house price growth to real growth rates by deflating nominal rents and house prices by national CPI. The growth rate is calculated as half yearly changes and is annualized. We follow Campbell et al. (2009) and use an estimate of the ex-ante real expected yield on a 10-year US Treasury Bond. This measure has also been used by Cutts et al. (2005), Gallin (2008), Himmelberg et al. (2005) and Meese and Wallace (1994). The real rate is defined as nominal rate less the inflationary expectations. Inflationary expectations are calculated as 5-year moving average of past inflation. Other measures of inflationary expectations like the Survey of Professional Forecaster's 10-year inflationary expectations or Livingstone survey have also been used in the literature. However, SPF's measure of long-run inflationary expectations is not available before 1975.

The second part of this paper also examines the determinants of housing risk premia in the U.S. For that purpose, we use two broad determinants of housing risk premia: financial market development indicators, and overall macroeconomic indicator. We follow Julliard and Wong (2008) and use loan-to-value (LTV) ratio as one of the indicators of financial market development. Junk bond spread is the other measure of financial market development indicator we use in this paper. It is the difference between the yield on junk bond and yield on 1-year treasury bond. We use real GDP growth, and jobs growth as two broad measures of the macroeconomy. Jobs growth is non-farm payroll growth. In addition, we also look at the role macroeconomic uncertainty plays in the prediction of housing premia. We use the VIX index as a measure of the overall macroeconomic uncertainty. The VIX index shows the market's expectation of 30-day volatility. It is constructed by using the Black-Scholes option pricing model to calculate implied volatilities for a number of stock index options. These are combined to create an overall measure of the market's expectations for near term volatility. Bollerslev, Tauchen and Zhou (2009) have shown that this volatility index is a good predictor of excess stock returns.

We obtain real GDP, non-farm payroll jobs growth, junk bond spread and CPI data from the Federal Reserve Bank of St. Louis's Fred data set. Loan-to-value ratio has been obtained Federal Housing Finance Board. The VIX index data has been obtained from economagic.com[3].

4 Empirical Estimation of Housing Risk Premia

4.1 State Space Representation

The present value model of house price rent ratio has three latent variables: expected rent growth, μ_t, expected risk free rate, g_t, expected housing premia, π_t^e. We define the demeaned state variables as:

$$\triangle r_t^e = \gamma_0 + \widehat{\triangle r_t^e}$$

$$i_t^e = \delta_0 + \widehat{i_t^e}$$

$$\pi_t^e = \theta_0 + \widehat{\pi_t^e}$$

[3]Note that VIX index data is available from 1990:H1. Similarly, junk spread data is available from 1985:H1, and LTV ratio data goes back only till 1973:H1.

There are three transition equations associated with above demeaned latent variables:

$$\widehat{\triangle r^e_{t+1}} = \gamma_1 \widehat{\triangle r^e_t} + \varepsilon^{re}_{t+1}$$

$$\widehat{i^e_{t+1}} = \delta_1 \widehat{i^e_t} + \varepsilon^{ie}_{t+1}$$

$$\widehat{\pi^e_{t+1}} = \theta_1 \widehat{\pi^e_t} + \varepsilon^{\pi e}_{t+1}$$

and three measurement equations:

$$\triangle r_{t+1} = \gamma_0 + \widehat{\triangle r^e_t} + \varepsilon^r_{t+1}$$

$$i_{t+1} = \delta_0 + \widehat{i^e_t} + \varepsilon^i_{t+1}$$

$$pr_t = A + B_1(\triangle r^e_t - \gamma_0) + B_2(i^e_t - \delta_0) + B_3(\pi^e_t - \theta_0)$$

Since third measurement equation does not contain any error term, we can use the trick employed by Binsbergen and Koijen (2008) and substitute out the third latent variable, expected housing premia, π^e_t. This makes the state space system smaller by reducing the number of transition equations. The final state space system has two transition equations:

$$\widehat{\triangle r^e_{t+1}} = \gamma_1 \widehat{\triangle r^e_t} + \varepsilon^{re}_{t+1} \tag{12}$$

$$\widehat{i^e_{t+1}} = \delta_1 \widehat{i^e_t} + \varepsilon^{ie}_{t+1} \tag{13}$$

and three measurement equations:

$$\triangle r_{t+1} = \gamma_0 + \widehat{\triangle r^e_t} + \varepsilon^r_{t+1} \tag{14}$$

$$i_{t+1} = \delta_0 + \widehat{i^e_t} + \varepsilon^i_{t+1} \tag{15}$$

$$pr_{t+1} = (1-\theta_1)A + B_1(\gamma_1 - \theta_1)\triangle r^e_t - B_2(\delta_1 - \theta_1) i^e_t + \theta_1 pr_t + B_1 \varepsilon^{re}_{t+1} - B_2 \varepsilon^{ie}_{t+1} - B_3 \varepsilon^{\pi e}_{t+1} \tag{16}$$

We can estimate the above state space model using maximum likelihood via the Kalman filter.

4.2 Empirical Results

Equations (12-16) can be converted into a state space form and Kalman filter can be applied to estimate the hyperparameters of the model[4]. The estimated hyperparameters are shown in table 1. These estimated hyperparameters warrant careful analysis. The unconditional mean for unobserved state variables: expected rent growth, expected real interest rates, and expected housing premia are 1.63%, 2.97%, and 3.5%. It shows that expected return on housing or expected house price growth has been on average 3.5% higher than expected real interest in the U.S. between 1960-2009. Campbell et al. (2009) reports that the difference between the realized house price growth and the realized real interest rate is 3% in the U.S. for 1975-2007 time period. The estimated AR parameters for expected real interest rate and expected premia are highly persistent with 0.91 for expected real interest rate and 0.95 for premia. The high persistence of the state variables arises from the high persistence of price-rent ratio for the whole sample. The corresponding estimate of AR parameter for expected rent growth is 0.75. We also find that variance of shocks to realized real interest rates are much smaller as compared to the shocks to expected real interest rates. On the other hand, they are similar in magnitude for realized and expected rent growth. Table 2 shows the estimated value of implied present value parameters. Note that $\rho = \frac{\exp(\overline{pr})}{1+\exp(\overline{pr})}$.

The estimated correlation between different state variables provides us some interesting insights. We find that correlation between expected rent growth and real interest is positive. There is also a positive correlation between expected cash flow and expected housing premia. This positive correlation between the fundamental and the premia is consistent with what other researchers have found for the stock market. For example, Bernanke and Kuttner (2005), Campbell and Ammer (1993) found that shocks to expected dividend growth and equity premia are positively correlated. We find that expected real interest rates and expected housing premia are highly negatively correlated with a correlation coefficient of -0.85.

The positive correlation between expected future rent growth and premia that we document could simply indicate that house prices do not increase by "enough" during periods of rising rent growth, which mechanically implies a contemporaneous increase in housing premia. This interpretation may also be applied to our finding that premia and real rates are negatively correlated, in

[4] Measurement and transition equations for the state space model are derived in Appendix.

the sense that house prices do not increase by "enough" when real rates decline.

Table 3 presents the variance decomposition results for price-rent ratio from the estimated state space model. This decomposition exercise is based on equation (11). The results show that variation in expected cash flow, that is expected rent growth explains only 7 percent of the overall variations in price-rent ratio. Expected housing premia is three times more volatile than the price-rent ratio, whereas the variance of expected real interest rate is 1.5 times higher. If the variance of expected present value of real interest rates and expected housing premia are much higher than the variance of price-rent ratio, then what causes the relative smoothness of price-rent ratio? The answer lies in the covariance between expected real interest rates and housing premia. A very high degree of negative correlation between the housing premia and expected real interest rates magnifies the negative contribution of the covariance between expected real interest rates and housing premia to overall variability of price-rent ratio. Covariance between expected rent growth and real interest rates and covariance between expected rent growth and premia also contributes negatively to the overall variability of the price-rent ratio. Therefore variance decomposition of price-rent ratio indicates that high negative covariance between premia and expected real interest rate cancels out the high relative variance of premia and it leaves the overall variability of price-rent ratio relatively low. Campbell and Ammer (1993) found that about 70 percent of the variance of excess stock returns was attributable to the "news" about future risk premiums for holding stocks and about 15 percent of the stock return variance was attributable to "news" about future dividends; real interest rates were found to play a relatively minor role in the variation of stock returns.

Once the state space model is estimated using maximum likelihood, we can trace out the time-varying housing premia using equation (10). Figure 2 shows the estimated housing premia from our unobserved component model. Clearly we find that expected housing premia is time-varying. The evolution of the housing premia in the U.S. fits nicely with the overall developments in the housing market as well as the macroeconomic environment in the U.S. We find that expected housing premia was higher on average in the 1960s and the 1970s. There was a sharp decline in the early 1980s and it hovered around 2.5 percent between 1985-2000. There was a sharp decline in the housing premia between 2002-2007. It again rose sharply in 2008. This decline in the expected housing premia between 2002-2007 coincides with the big run-up in the house prices, and the resulting unprecedented increase in price-rent ratio between 2002-2007. Figure 3 plots the realized rent growth together with the expected rent growth. The expected rent growth is smoother than the realized growth, but follows the overall evolution of rent growth closely.

Since estimation of housing premia is one of the main contributions of this paper, it warrants further discussion. Our results show that the housing premia, which is the price of risk in housing market, has fallen over time, and reached its lowest level in 2007. There was a significant fall in the risk premia between 2002-2007. The decline in housing premia in between 1975-1985 coincides with a rise in price-rent ratio and a bear market in stock market. Housing market has witnessed significant changes in its regulatory regime over time. This change was especially pronounced in how housing finance system has evolved in the U.S. The housing finance system has moved away from Banks to the capital market. Bernanke (2007) and Weiss (1989) argue that the shift from reliance on specialized portfolio lenders financed by deposit lenders to a greater use of capital markets represented the second sea change in mortgage finance, equaled in importance only by the events of the New Deal. Government policy led to the split of Fannie Mae into two agencies: Ginnie Mae and rechartered Fannie Mae, which became a privately owned government sponsored enterprise (GSE), authorized to operate in the secondary market for conventional as well as guaranteed mortgage loans. In 1970, another GSE, Freddie Mac, was created to compete with Fannie Mae in secondary market. By the 1990s, increased reliance on securitization led to greater separation between mortgage lending and mortgage investing even as the mortgage and capital markets became more closely integrated. Almost 60 percent of the home mortgage market is now securitized compared with only 10 percent in 1980 and less than 1 percent. In addition to these revolutionary changes in housing finance system, some important regulatory changes also took place in the 1980s and the 90s. Regulation Q was phased out during the 1980s; state usury laws capping mortgage rates were abolished; restrictions on interstate banking were lifted by the mid-1990s; and lenders were permitted to offer adjustable rate mortgages.

All of the above changes in the housing market in combination with the behavior of equity market can explain the evolution of housing premia over time in the U.S. The increased access to credit has played a role in the decline of premia over time, and it was clearly evident between 2002-2007. The increase in premia between 1986-2000 coincided with slow and sometimes negative growth in house prices and a bull market in stock market. Both housing market and stock market has suffered in the current crisis, and we also see a big increase in housing premia between 2007-2008. We examine the determinants of housing premia in detail in the next section.

4.3 Comparison with Implied Equity Risk Premia

As compared to housing risk premia, equity risk premia has attracted widespread attention from researchers. Therefore it would be instructive to compare equity risk premia with the estimated housing premia from the above state-space model. Housing market differs fundamentally from the equity market because of frictions like transaction costs or liquidity. However, Bernanke (2007) points out that housing market has become more like the frictionless financial market of the textbook, with fewer institutional or regulatory barriers to efficient operation. Figure 4 plots implied equity risk premia which has been taken from Damodaran (2010) with housing premia. Damodaran (2010) uses consensus estimate of expected growth of earnings and expected dividend yield to estimate time-varying implied equity risk premia. We use this measure of equity risk premia since Damodaran's method of estimating the premia is also based on the present value model. The equity risk premia measure is estimated annually. To compare it with our semi-annual housing premia measure, we convert half-yearly data into annual frequency by taking the average of data within that year. The figure suggests that for most of the time period the price of equity risk has been higher than the price of holding housing risk. On average, equity risk premia is 0.5 percent higher than housing risk premia for the whole sample period. Roughly speaking, these two measures have tended to move together. However, there was significant divergence for some time periods. Both the premia started falling in late 1970s, with the fall in housing premia preceding the fall in equity premia. The big stock market rally coincided with a big fall in equity risk premia, but the housing premia increased slightly in the late 1990s. The last disconnect between these two premia occurred between 2001-2006, when there was a big drop in housing premia but equity risk premia witnessed a big increase. The housing market during this time period was booming, and households were willing to hold housing risk at a very low price, whereas the risk associated with equity market was relatively high. We observe a big increase in both the premia at the end of the sample in 2007-2008, when the financial crisis hit the U.S. economy. Therefore, the results indicate that whenever there was a disconnect in the housing market and equity market in the U.S., we also observe a disconnect between equity risk premia and housing premia. This suggests that these premia play a significant role in explaining the variation in housing market and equity market.

5 Determinants of Housing Risk Premia

We propose an unobserved component model to estimate housing risk premia in the previous sections. Though the latent variable estimation of housing premia is an important exercise in itself, we would also like to understand the determinants of the variations in housing risk premia over time. It is widely known that housing market has undergone significant structural changes over the last three decades, and in many cases these structural changes in the housing market has been affected by the macroeconomic developments in the U.S. economy. In a previous study, Julliard and Wong (2008) studies the determinants of housing premia in OECD countries. They find that financial market development, liquidity in the equity market and different types of zoning law are significant determinants of housing risk premia. Their estimate of housing premia for all OECD countries is also based on the conventional VAR measure.

In this paper we also look at role of financial market developments and the role of the macroeconomy in determining housing risk premia. To examine the impact of different variables on housing risk premia, we estimate the following simple regression:

$$\pi_t^e = c + \beta\pi_{t-1}^e + \lambda x_{t-1} + \varepsilon_t \tag{17}$$

where π_t^e is the housing premia estimated from the latent-variable model and x_t is a set of explanatory variables. If λ is significant in the above regression, then the lagged value of x_t contains useful information about the future movements of premia that is not already present in its lagged value. We focus on a set of variables that represent the level of financial development, the stance of monetary policy and different macroeconomic indicators. We follow Julliard and Wong (2008) and use loan-to-value (LTV) ratio as one of the indicators of financial market development. We also use junk spread which is the difference between the yield on junk bond and yield on 1-year treasury bond as another indicator of financial development. Julliard and Wong (2008) have argued that a higher degree of financial development should lower the expected housing premia. The literature suggests that higher degree of financial development should increase the loan-to-value ratio, and lower the junk spread. We also examine the role of macroeconomic factors in predicting housing premia. Macroeconomic factors include real GDP growth, and jobs growth. In addition, we also look at the role macroeconomic uncertainty plays in the prediction of housing premia. It has also been argued that the overall reduction in macroeconomic volatility in the U.S. economy has affected household's attitude towards risk, and the reduced macroeconomic volatility may have reduced the expected housing risk premia. The VIX index is used as a measure of macroeconomic uncertainty. It shows the market's expectation of 30-day volatility. VIX is constructed by using the Black-Scholes option pricing model to calculate implied volatilities for a number of stock index options. These are combined to create an overall measure of the market's expectations for near term volatility. Bollerslev, Tauchen and Zhou (2009) have shown that this volatility index is a good predictor of excess stock returns and outperforms other popular predictors.

We perform the analysis for the sample that runs from 1961:H1 through 2009:H2, as well as for 2001:H1-2009:H2 sub-sample. We have also performed the empirical analysis for the later sub-sample because there was a substantial increase in price-rent ratio till 2007 and then a big fall between 2008-2009. The estimated premia also witnessed a big decline in between 2002-2007 and a jump in 2008. Hence it would be interesting to examine the predictive ability of financial market development indicators and the macroeconomic indicators during this period of high volatility in the housing market.

Tables 4-5 show the predictive power of macroeconomic indicators and financial development indicators for housing premia. P-values are in parentheses, and Newey-West HAC standard errors are used for estimation. We estimate different versions of equation (17). First we estimate a simple AR version of expected housing premia. As the AR coefficient from state-space model indicated, housing premia is highly persistent. The lagged premia itself explains 85 percent of the variations in one period ahead premia for the full sample. Real GDP growth is significant if it is included as one of the regressors in addition to the lagged premia. This implies that real GDP growth contains extra information about future movements in housing premia that is not already contained in its lagged value. We find that non farm payroll jobs growth also has significant additional information about future movements in housing premia. In fact, when jobs growth is added as an extra variable in the regression equation, R-squared increases by 3 percent. The VIX index is used as a measure of macroeconomic uncertainty. Recent research has shown this measure to be a powerful predictor of excess stock returns and real economic activity (See Bollerslev, Tauchen and Zhou (2009), Zhou

(2009)). The estimation results for the full sample show the significant predictive ability of the VIX index in predicting expected one period ahead housing premia. Note that data for this index is only available from 1990.Lower R-squared for this model specification is caused by smaller sample size. We also estimate equation (17) for the later sub-sample 2001-2009, when housing market witnessed high volatility. Simple AR regression estimation shows that the persistence of premia declined during the last eight years, and R-squared increased. The results for the later sample is qualitatively similar to the full sample. Our findings suggest that measures of real economic activity: real GDP growth and jobs growth are significant predictors of housing premia, and they are negatively correlated. This is an intuitive result, which suggests that agents are willing to hold risky asset in the form of housing asset at a lower expected return. We find that the VIX index and expected housing premia are positively correlated. This implies that an increase market's expectation of volatility also affects the risk attitude of agents in the housing market in the same direction, leading to an increase in premia.

Table 5 shows estimation results for the predictive power of financial market development indicators for housing premia. We use two measures of indicators of financial market development: junk bond spread and loan-to-value (LTV) ratio. Junk bond spread is the difference between the yield on junk bond and yield on 1-year treasury bond. LTV ratio is total loans outstanding as a percentage of the total value of a new house. We follow Julliard and Wong (2009) in using LTV ratio as an indicator of financial market development indicator. Junk bond spread has been shown to have significant predictive ability for the real economic activity. This spread also reflects the availability of liquidity in the financial market, with tight liquidity conditions implying a high junk bond spread. We do not find any significant evidence of LTV ratio affecting housing premia for the whole sample. However, if lagged premia is not present in the regression specification, we find that LTV ratio is significant[5]. This suggests that lagged premia encompasses all the information that is present in the LTV ratio. Junk bond spread, on the other hand, is significant even in the presence of lagged premia for the full sample. Note that R-squared is lower for the regression with junk bond spread as an additional regressor because of smaller sample size as the data for junk spread is available only since 1985.The estimation results for the later sub-sample are qualitatively similar to the full sample.

[5] To save space, we do not report this result in table 5.

6 Concluding Remarks

In this paper we propose a latent variable approach to decompose price-rent ratio into expected real rent growth, expected real interest rate and expected housing premia. Acknowledging that expected rental growth, expected real interest rates and expected housing risk premia are unobservable, the Kalman filter technique is used to extract them from the observed history of realized rent growth and realized real interest rates. Since housing risk premia is the residual in accounting identity, we can trace the time variation in housing risk premia once we estimate the expected rent growth and expected real interest rate. To apply Kalman filter to the unobserved component model, the main assumption we make is to allow the three components of price-rent ratio to have a parsimonious autoregressive process.

The decomposition of price-rent ratio based on the estimated return and rent growth suggest that expected rent accounts for only 7 percent of the variation in price-rent ratio. On the other hand we find that the expected housing premia accounts for more than 300 percent of the variation in price-rent ratio, and expected real interest rate accounting for more than 150 percent variation. The covariances between expected rent growth, expected real interest rate and expected premia contribute negatively to the overall variation and dampens the total variation in price-rent ratio. In fact, we observe that the covariance between expected housing premia and expected real interest rate reduces the variability of price-rent ratio by more than 350 percent. This implies that the negative covariance between premia and real rate cancel out the impact of the variability of housing premia on the overall variability of price-rent ratio.

We also examine the determinants of housing premia estimated from the unobserved component model. It has been suggested in the literature that the state of the macroeconomy and the level of financial market development affect housing premia. Our empirical results suggest that output growth and jobs growth contain extra information about the future variation in premia that is not already present in its lagged value. There is a negative correlation between these two macroeconomic variables and the premia, implying that the price of holding risk in housing market falls in good economic times. On the other hand, market's expected volatility measured by the VIX index affects premia positively and significantly. We also find that junk spread is a significant predictor of premia and is positively correlated. This positive relationship may arise from a fall in junk spread during the period of adequate availability of liquidity in the market. The increase in liquidity in turn may also affect the housing premia negatively.

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Appendix

State Space Representation of the Present Value Model

Equations (12-16) can be represented in a state-space form. The measurement equation can be written as:

$$
\begin{bmatrix} \triangle r_t \\ i_t \\ pr_t \end{bmatrix} = \begin{bmatrix} \gamma_0 \\ \delta_0 \\ A(1-\theta_1) \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \theta_1 \end{bmatrix} \begin{bmatrix} \triangle r_{t-1} \\ i_{t-1} \\ pr_{t-1} \end{bmatrix} +
$$

$$
\begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ B_1(\gamma_1-\theta_1) & -B_2(\delta_1-\theta_1) & 0 & 0 & B_1 & -B_2 & -B_3 \end{bmatrix} \begin{bmatrix} \widehat{\triangle r^e_{t-1}} \\ \widehat{i^e_{t-1}} \\ \varepsilon^r_t \\ \varepsilon^i_t \\ \varepsilon^{re}_t \\ \varepsilon^{ie}_t \\ \varepsilon^{\pi e}_t \end{bmatrix}
$$

Transition equation is represented as:

$$
\begin{bmatrix} \widehat{\triangle r^e_{t-1}} \\ \widehat{i^e_{t-1}} \\ \varepsilon^r_t \\ \varepsilon^i_t \\ \varepsilon^{re}_t \\ \varepsilon^{ie}_t \\ \varepsilon^{\pi e}_t \end{bmatrix} = \begin{bmatrix} \gamma_1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & \delta_1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \widehat{\triangle r^e_{t-2}} \\ \widehat{i^e_{t-2}} \\ \varepsilon^r_{t-1} \\ \varepsilon^i_{t-1} \\ \varepsilon^{re}_{t-1} \\ \varepsilon^{ie}_{t-1} \\ \varepsilon^{\pi e}_{t-1} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \varepsilon^r_t \\ \varepsilon^i_t \\ \varepsilon^{re}_t \\ \varepsilon^{ie}_t \\ \varepsilon^{\pi e}_t \end{bmatrix}
$$

Variance-Covariance matrix of the transition equation errors are:

$$
\sum = var \begin{bmatrix} \varepsilon^r_t \\ \varepsilon^i_t \\ \varepsilon^{re}_t \\ \varepsilon^{ie}_t \\ \varepsilon^{\pi e}_t \end{bmatrix} = \begin{bmatrix} \sigma^2_r & \sigma_{ri} & \sigma_{rr^e} & \sigma_{ri^e} & \sigma_{r\pi^e} \\ \sigma_{ri} & \sigma^2_i & \sigma_{ir^e} & \sigma_{ii^e} & \sigma_{i\pi^e} \\ \sigma_{rr^e} & \sigma_{ir^e} & \sigma^2_{r^e} & \sigma_{r^e i^e} & \sigma_{r^e\pi^e} \\ \sigma_{ri^e} & \sigma_{ii^e} & \sigma_{r^e i^e} & \sigma^2_{i^e} & \sigma_{i^e\pi^e} \\ \sigma_{r\pi^e} & \sigma_{i\pi^e} & \sigma_{r^e\pi^e} & \sigma_{i^e\pi^e} & \sigma^2_{\pi^e} \end{bmatrix}
$$

Table 1: Maximum Likelihood Estimates of Hyperparameters

Parameter	Estimate	Standard Error
σ_r	0.0081	0.0013
σ_i	0.0001	0.0001
σ_{r^e}	0.0072	0.0012
σ_{i^e}	0.0079	0.0056
σ_{π^e}	0.0049	0.0012
γ_0	0.0163	0.0030
γ_1	0.7557	0.0690
δ_0	0.0297	0.0080
δ_1	0.9153	0.0310
θ_0	0.0351	0.0098
θ_1	0.9567	0.0164
$\rho_{r^e i^e}$	0.3400	0.1450
$\rho_{r^e \pi^e}$	0.1073	0.1955
$\rho_{i^e \pi^e}$	-0.8507	0.0858

Table 2: Implied Present Value Model Parameters

Parameter	Estimate
A	2.980
B_1	3.879
B_2	9.90
B_3	16.55
ρ	0.982

Table 3: Variance Decomposition of Price-Rent Ratio

	Estimate	Share
$var(pr_t)$	0.0211	1.000
$\frac{(B_1\sigma_{re})^2}{1-\gamma_1^2}$	0.0018	0.072
$\frac{(B_2\sigma_{ie})^2}{1-\delta_1^2}$	0.0380	1.522
$\frac{(B_3\sigma_{\pi e})^2}{1-\theta_1^2}$	0.0807	3.226
$\frac{2B_1B_2\sigma_{reie}}{1-\gamma_1\delta_1}$	-0.0048	-0.193
$\frac{2B_1B_3\sigma_{re\pi e}}{1-\gamma_1\theta_1}$	-0.0017	-0.071
$\frac{2B_2B_3\sigma_{ie\pi e}}{1-\delta_1\theta_1}$	-0.0889	-3.555

Table 4: Effect of Macroeconomy on Housing Premia*

Dependent Variable: Housing Premia (1961:H1-2009:H2)						
Model #	Constant	Lag	$DGDP$	$DEMP$	VIX	R^2
1	**0.010 (0.11)**	**0.93 (0.00)**				0.85
2	0.004(0.01)	**0.95(0.00)**	**-0.003(0.01)**			0.88
3	**0.003 (0.05)**	**0.96(0.00)**		**-0.001 (0.00)**		0.88
4	-0.001(0.80)	**0.80(0.00)**			**0.0003(0.06)**	0.75
Dependent Variable: Housing Premia (2001:H1-2009:H2)						
1	**0.003 (0.03)**	**0.85 (0.00)**				0.91
2	0.007(0.00)	**0.77(0.00)**	**-0.004(0.00)**			0.93
3	0.009(0.01)	**0.57(0.00)**		**-0.002(0.03)**		0.93
4	**-0.05 (0.35)**	**0.86(0.00)**			**0.0006 (0.00)**	0.94

[1] P-values are parentheses. Newey-West HAC errors are used for estimation. DGDP is output growth calculated as semi-annual changes and annualized, DEMP is non-farm payroll jobs growth calculated as semi-annual changes and annualized,VIX index shows the market's expectation of 30-day volatility. Non-availability of VIX index before 1990 makes R-squared smaller for the full sample regression.

Table 5: Effect of Financial Market Development on Housing Premia*

Dependent Variable: Housing Premia (1961:H1-2009:H2)					
Model #	Constant	Lag	*JunkSpread*	*LTVRATIO*	R^2
1	**0.010 (0.11)**	**0.93 (0.00)**			0.85
2	0.002(0.53)	**0.77(0.00)**	**0.001(0.01)**		0.71
3	**0.001 (0.095)**	**0.91(0.00)**		0.0001 (0.95)	0.82
Dependent Variable: Housing Premia (2001:H1-2009:H2)					
1	**0.003 (0.03)**	**0.85 (0.00)**			0.91
2	0.001(0.37)	**0.61(0.00)**	**0.001(0.00)**		0.92
3	**-0.05 (0.35)**	**0.86(0.00)**		0.0001 (0.29)	0.93

[1] P-values are parentheses. Newey-West HAC errors are used for estimation. Junk spread is is the difference between the yield on junk bond and yield on 1-year treasury bond. The data for junk spread is avaialble from 1985, and the data for LTV ratio is available from 1973.

Figure 1: Data

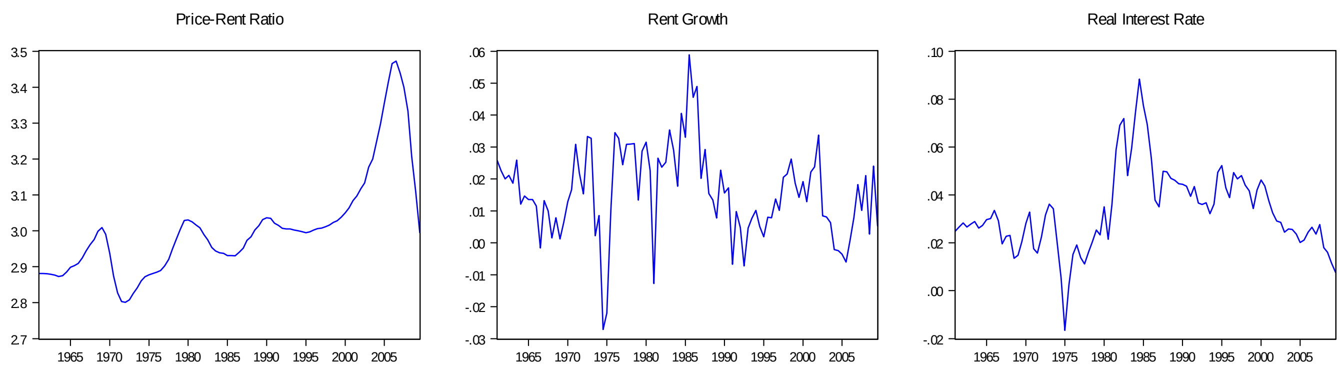

Figure 2: Housing Premia

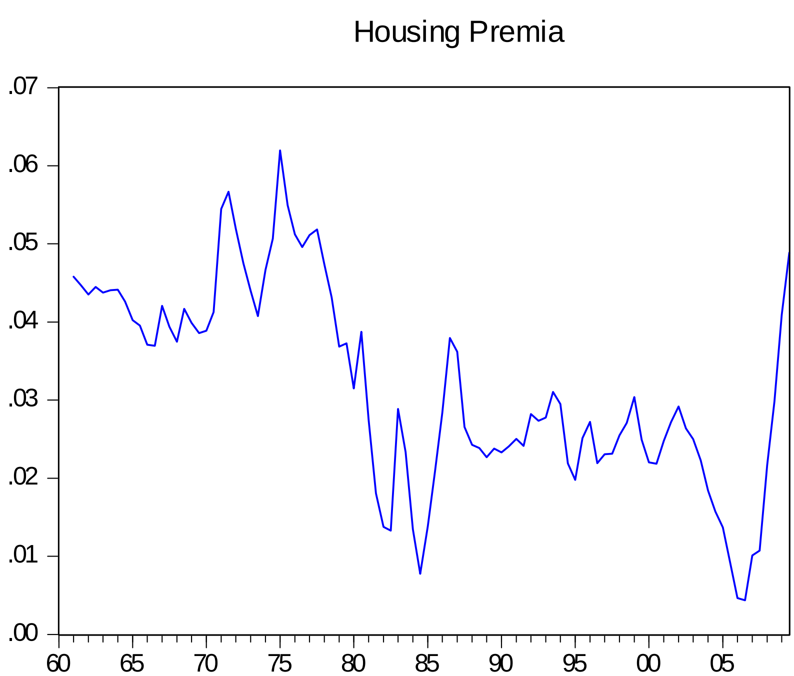

Figure 3: Expected Rent Growth

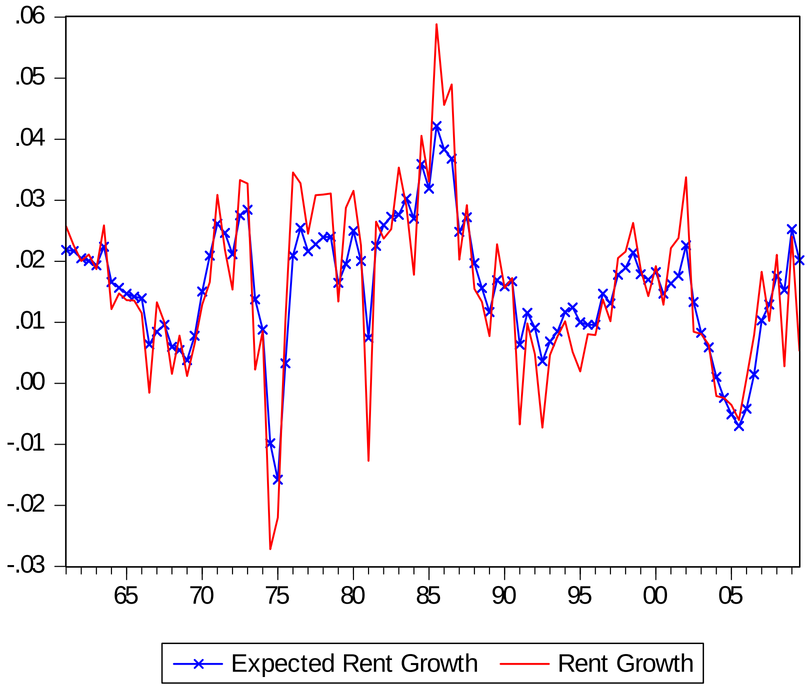

Figure 4: Equity Premia and Housing Premia