Abstract

This paper estimates expected return on housing by exploiting information from the movements in consumption, income, and observable assets. To do so, we combine a present-value model of consumption with an unobserved component model. This strategy allows us to express the observed excess consumption (consumption in excess of labor income)-assets ratio as a linear function of unobserved expected return on housing assets, financial assets and expected consumption growth. We apply Kalman filter to extract expected return on housing assets from the observed history of realized returns and realized excess consumption growth. Our results suggest that the filtered housing returns obtained from the present-value model does a significantly better job in predicting realized housing returns than other popular predictors like mortgage rate, price-rent ratio, and GDP growth.

Keywords: Consumption, Housing Market, Unobserved Component Model, Present-Value Model.
1 Introduction

The recent financial crisis has shown the importance of housing market for the U.S. macroeconomy. Housing wealth accounts for almost half of the overall household net worth in the U.S.\(^1\) More importantly, around two-third of the U.S. households own a house, therefore, any changes in the housing market tend to have a widespread impact on the overall economy. One of the channels through which the housing market affects the overall macroeconomic activity is through its impact on the household balance sheet. There is a consensus in the economic literature and policymaking about housing wealth being one of the determinants of consumption expenditure\(^2\). The linkage between housing wealth and consumption suggests that changes in household consumption should contain information about expected changes in housing market wealth.

The traditional literature on the relationship between housing market wealth and consumption has mainly focused on estimating the consumption response to changes in the housing market wealth. Case, Quigley and Shiller (2005) find that a dollar increase in housing wealth leads to 6-10 cents increase in consumption. Researchers have postulated different reasons for this relationship. For example, La-Cour-Little et al. (2010) suggest that the run-up in the housing prices between 2000 and 2006 led to a big increase in home equity withdrawal, which in turn raised consumption spending. Kishor (2007) suggests that the greater response of consumption to housing wealth as compared to financial market wealth may be attributed to a bigger percentage of housing wealth movement being permanent. We take a different approach in this paper. Rather than estimating consumption response to changes in housing wealth, we utilize the information in consumption, income and observable assets to estimate expected housing returns. To do so, we combine a modified version of a present-value model proposed by Whelan (2008) with an unobserved component model. Whelan’s modified present-value model suggests that an upward surprise in excess consumption-assets ratio—a modified measure of consumption-wealth ratio—today must correspond to lower than average excess consumption growth or higher than average asset returns in future\(^3\). In simple words, if representative household’s consumption

\(^1\)U.S. Flow of Funds data.


\(^3\)Excess consumption is defined as consumption in excess of labor income.
increases relative to its housing wealth, it may be either due to higher than expected housing wealth growth or lower than average consumption growth. Therefore changes in expected housing return should be reflected in the current consumption decision of the households. The households can smooth their consumption by borrowing in anticipation of expected increase in housing wealth. For example, the households can use home equity withdrawal for consumption smoothing (La-Cour-Little et al. (2010)). The challenge is to estimate the expected return on housing assets using the present information set that contains information about current and past excess consumption, return on financial assets, and return on housing assets\(^4\). One simple method that can be applied to estimate expected housing returns is the standard VAR approach, where lags of consumption-wealth ratio and past asset returns can be used as predictors of housing return. In the housing market literature, Rapach and Strauss (2007) have also used auto regressive models to forecast house prices. However, the application of traditional VAR or univariate autoregression approach in the present context is fraught with limitations, as has been suggested by Binsbergen and Koijen (2010) and Rytchkov (2008) in the context of stock returns literature. In particular, the VAR approach only uses finite lags to predict the variable of interest, and may miss individually small but possibly important moving average terms in the long run as pointed out by Cochrane (2008).

In this paper, we use Kalman filter to extract expected housing asset returns from the present-value model. In doing so, we combine the consumption-wealth literature and the house price forecasting literature. This approach allows us to expand the information set by using the information from the whole history of observed housing asset returns, financial asset returns, and excess consumption growth rather than using just finite lags of excess consumption-assets ratio. The state space approach provides us an estimate of expected housing return that uses information from an expanded information set. Since the estimate of expected housing returns in our model uses more information than the conventional finite lag approach, it should yield a better forecast of realized housing returns. The results obtained in this paper broadly support this hypothesis. In particular, we find that the filtered returns explains 18% of the variation in one-period ahead housing asset returns. Our results show that filtered series of expected hous-\(^4\)Note that housing asset or housing wealth has been used interchangeably in this paper. Section 4 explains how housing asset or housing wealth is calculated.
ing return obtained from the present-value model is a superior in-sample and out-of-sample predictor of realized housing asset returns compared to other predictors like mortgage rate, price-rent ratio, yield spread, \( cay \), and real GDP growth. The superiority of the predictive power of the filtered return is also statistically significant.

The rest of the paper is organized as follows. The next section provides a brief literature review; section 3 proposes an unobserved component model to estimate the present value model of consumption. Section 4 describes the data. Section 5 provides the empirical methodology. Section 6 documents the main findings on the predictability of housing asset returns. Section 7 concludes.

2 Brief Literature Review

This paper combines the literature on the present-value models of consumption with the literature on the housing market predictability. Present-value models have been applied extensively in macroeconomics and finance literature. For example, Campbell and Mankiw (1989) show that consumption-wealth ratio reflects information about expected returns on wealth and expected consumption growth rate. Lettau and Ludvigson (2001) also use consumption-wealth ratio as a proxy for future asset returns and show that whenever consumption-wealth ratio moves above/below its long-run value, wealth adjusts to correct for the disequilibrium. The literature on the estimation of marginal propensity to consume out of wealth is also based on the present-value model of consumption that states that current consumption depends on the present discounted value of life-time income and current wealth. A number of empirical studies have used this model and analyzed the impact of changes in housing wealth on consumption. Poterba (2000) finds that the traditional wealth effect estimate implies that for every dollar increase in wealth, consumption should increase by 2-10 cents. Case, Quigley and Shiller (2005, 2011) find strong evidence that variations in housing market wealth have important effects upon consumption. According to them, housing wealth effect on consumption is especially important in recent decades as institutional innovations have made it simple to extract cash from housing equity. Benjamin, Chinloy and Jud (2004a,2004b) have shown that

\footnote{Lettau-Ludvigson (2001) use estimated residual from a cointegrating regression of consumption, labor income and wealth (\( cay \)) as a proxy for expected asset returns.}
an additional dollar of real estate wealth increases consumption by 8 cents. They point out that with the availability of home equity loans and low-cost tax deductible refinancing, homeowners can access their housing to finance consumption.

The literature on the forecastability of housing market is substantial, starting with Case and Shiller (1989), who show that unlike stock returns, there is a significant predictive component in house prices. Other papers like Crawford and Fratantoni (2003) utilize ARIMA, GARCH, and regime switching univariate time series model to estimate the behavior of home price growth rates in California, Florida, Massachusetts, Ohio, and Texas. They find that regime-switching models perform better in-sample, while ARIMA and GARCH perform better in out-of-sample forecasting. Rapach and Strauss (2007) analyze the forecasting ability of a large number of potential predictors of state real housing price growth using an autoregressive distributed lag model framework. Guirguis, Giannikos, and Anderson (2005) use estimation methodologies where the estimated parameters are allowed to vary overtime. They find that the forecasts generated by the Kalman Filter and rolling GARCH techniques outperform the forecasts of all the other specifications considered. Jud and Winkler (2002) find that real housing price appreciation is strongly influenced by the growth of population and real changes in income, construction costs and interest rates. Our approach contributes to the literature by deriving an estimate of future housing market returns from a version of widely used present-value model of consumption.

In this paper, we estimate the expected return on housing assets from a present-value model using an unobserved component approach. Using this filtered return, we examine the predictive power of our measure in forecasting realized housing asset returns and compare the forecasting performance with other popular predictors like mortgage rate, price-rent ratio, yield spread, and GDP growth, among others.

3 The Present-Value model and Expected Return on Housing

This section presents a modified present value model of consumption that is based on Whelan (2008) and Binsbergen and Koijen (2010). The present value of consumption links excess consumption-asset ratio to expected hous-
ing asset returns, expected financial asset return and expected excess consumption growth. We modify this present value model and apply Kalman filter to extract expected housing return. The household budget constraint can be described as follows:

\[ A_{t+1} = R^a_{t+1}(A_t + Y_t - C_t) \]  

(1)

where \( A_t \) is total household assets and equals sum of household assets and financial assets, \( R^a_{t+1} \) is the gross return on assets, \( Y_t \) is labor income, and \( C_t \) is consumption. Dividing across by \( A_t \) and taking logs we get:

\[ \Delta a_{t+1} = r^a_{t+1} + \log \left( \frac{1 - C_t - Y_t}{A_t} \right) \]  

(2)

Equation (2) can be rewritten as:

\[ \Delta a_{t+1} = r^a_{t+1} + \log(1 - \exp(x_t - a_t)) \]  

(3)

Define, excess consumption as \( X_t = C_t - Y_t^6 \).

Total wealth is sum of housing wealth \( H_t \) and stock market wealth \( S_t \) i.e. \( A_t = H_t + S_t \). The logarithm of total assets may be approximated as:

\[ a_t = \omega h_t + (1 - \omega) s_t \]  

(4)

where \( a_t \) is log of total asset, \( h_t \) is the log of housing wealth, and \( s_t \) is the log of stock of net financial assets, \( \omega \) is the steady state share of housing assets in total assets and \( (1 - \omega) \) is the steady state share of financial assets in total assets\(^7\).

The return on total assets can be decomposed into the return of its two components:

\[ r^a_t \approx \omega r^h_t + (1 - \omega) r^s_t \]  

(5)

\(^6\)For the US data series used in this study, which rely on a standard definition of labor income, consumption always exceed labor income. Therefore, \( X_t \) is always positive. One of the interpretation of this positive sign may arise from the fact that in addition to after tax labor income \( Y_t \), consumption is financed out of total wealth.

\(^7\)This logarithmic approximation is widely used in economics and finance. For example, see page 820 Lettau and Ludvigson (2001). As long as the share of a particular component doesn’t explode over time, \( \omega \) and \( (1 - \omega) \) refer to the long-run averages of the share of different types of wealth.

\(^8\)The sample average is used as the steady state share. In our case, the data suggests that \( \omega = 0.25 \) and \( (1 - \omega) = 0.75 \).
Substituting (4) and (5) into (3) gives
\[
\Delta(\omega_{t+1} + (1-\omega)s_{t+1}) = (\omega r^h_t + (1-\omega)r^s_t) + \log(1 - \exp(x_t - (\omega h_t + (1-\omega)s_t)))
\] (6)

In the above equation, \(\log(1 - \exp(x_t - (\omega h_t + (1-\omega)s_t)))\) is a non-linear function. Taking a first order Taylor expansion around the mean \((\bar{x} - (\omega \bar{h} + (1-\omega)\bar{s}))\) results in the following approximation:
\[
\log(1 - \exp(x_t - (\omega h_t + (1-\omega)s_t))) \approx \kappa + (1 - \rho^{-1})(x_t - (\omega h_t + (1-\omega)s_t))
\] (7)

where \(\rho \equiv 1 - \exp(\bar{x} - (\omega \bar{h} + (1-\omega)\bar{s}))\) and \(\kappa\) is a constant and equals \(\log(1 - \exp(\bar{x} - (\omega \bar{h} + (1-\omega)\bar{s}))) - (1 - \rho^{-1})(\bar{x} - (\omega \bar{h} + (1-\omega)\bar{s}))\).  

Substituting equation (7) into equation (6) and rearranging we obtain:
\[
x_t - a_t \approx \rho((\omega r^h_{t+1} + (1-\omega)r^s_{t+1}) + \kappa - \Delta x_{t+1}) + \rho(x_{t+1} - (\omega h_{t+1} + (1-\omega)s_{t+1}))
\] (8)

Solving forward via repeated substitution and imposing the condition that \(\lim_{j \to \infty} \rho^{-j}(x_{t+j} - (\omega h_{t+j} + (1-\omega)s_{t+j})) = 0\)\(^{10}\), we obtain:
\[
x_t - (\omega h_t + (1-\omega)s_t) \approx \frac{\rho \kappa}{1 - \rho} + \sum_{j=1}^{\infty} \rho^j(\omega r^h_{t+j} + (1-\omega)r^s_{t+j} - \Delta x_{t+j})
\] (9)

The above equation implies that log ratio of excess consumption-asset ratio is stationary since the right hand side is stationary. This suggests that if the excess consumption-asset ratio goes above its long-run value, either expected excess consumption growth will decline in future or expected housing return or expected stock return will go up in future. If one takes expectations at time t, it yields the following expression:
\[
x_t - (\omega h_t + (1-\omega)s_t) \approx \frac{\rho \kappa}{1 - \rho} + E_t \sum_{j=1}^{\infty} \rho^j(\omega r^h_{t+j} + (1-\omega)r^s_{t+j} - \Delta x_{t+j})
\] (10)

\(^9\)For detailed derivation see Kishor and Kumari (2011).
\(^{10}\)This condition is similar to transversality condition.
The above model is central to the estimation of expected housing return. There are two ways to estimate the unobserved expected return: the conventional approach and the unobserved component approach. The conventional approach uses finite lags of excess consumption growth, realized housing return and realized stock return or estimate cointegrating relationship between consumption, labor income, housing wealth and stock market wealth and use the cointegrating residual. The second approach is to use the unobserved component model to estimate the unobserved returns on assets and expected excess consumption growth. Since expected returns and future expected excess consumption growth rate are unobserved, an unobserved component model is more suitable to model the present value model of consumption. Since the estimate of expected housing returns in the unobserved component model uses more information than the conventional finite lag approach, it should yield a better forecast of realized housing returns. Following Campbell (1991), we model expected housing asset returns, expected financial asset returns, and expected excess consumption growth rate as AR(1) process.\textsuperscript{11} \textsuperscript{12} \textsuperscript{13}

\begin{align}
\omega r_{t+1}^{he} &= \delta_0 + \delta_1 (\omega r_t^{he} - \delta_0) + \epsilon_r^{he}\quad (11) \\
(1 - \omega)r_{t+1}^{se} &= \psi_0 + \psi_1((1 - \omega)r_t^{se} - \psi_0) + \epsilon_r^{se}\quad (12) \\
\Delta x_{t+1}^{se} &= \gamma_0 + \gamma_1(\Delta x_t^{se} - \gamma_0) + \epsilon_x^{se}\quad (13)
\end{align}

where $r_{t+1}^{he} \equiv E_t(r_t^{he})$, $r_{t+1}^{se} \equiv E_t(r_t^{se})$, and $\Delta x_{t+1}^{se} \equiv E_t(\Delta x_{t+1})$. The shocks $\epsilon_r^{he}$, $\epsilon_r^{se}$, and $\epsilon_x^{se}$ are independent and identically distributed. Realized housing asset return and financial asset return is equal to expected housing asset

\textsuperscript{11}Similar approach has been applied in a series of papers such as Binsbergen and Koijen (2010), Fama and French (1988), and Pastor and Stambaugh (2009) among others.

\textsuperscript{12}The one question that immediately comes to mind is whether AR(1) assumption is sufficient to capture the dynamics of these variables. To that end, we also perform ARIMA modeling of the realized housing asset return, realized financial asset return and realized excess consumption growth and the results suggest that AR(1) model is sufficient to capture the dynamics.

\textsuperscript{13}In order to convert the present value model in equation (10) into a linear measurement equation of a state space system, it is important that the unobserved variables follow a stationary process. Therefore, we model unobserved variables as an autoregressive process instead of a random walk process.
return and expected financial asset return plus an idiosyncratic shock.\textsuperscript{14}

$$\omega r_{t+1}^h = \omega r_{t}^e + \epsilon_{t+1}^h$$

$$ (1 - \omega)r_{t+1}^s = (1 - \omega)r_{t}^{se} + \epsilon_{t+1}^s$$

The realized excess consumption growth rate is equal to expected excess consumption growth rate plus an idiosyncratic shock.

$$\Delta x_{t+1} = \Delta x_t^e + \epsilon_{t+1}^x$$

Substituting equations (11-13) into equation (10) and solving we get:

$$x_t - a_t = \frac{\rho}{1 - \rho} \kappa + \frac{\rho(\delta_0 + \psi_0 - \gamma_0)}{1 - \rho} + \frac{\rho \delta_1 (\omega r_{t}^he - \delta_0)}{1 - \rho \delta_1} - \frac{\rho \psi_1 ((1 - \omega)r_{t}^{se} - \psi_0)}{1 - \rho \psi_1} - \frac{\rho \gamma_1}{1 - \rho \gamma_1} (\Delta x_t^e - \gamma_0)$$

Let $A = \frac{\rho}{1 - \rho} \kappa + \frac{\rho(\delta_0 + \psi_0 - \gamma_0)}{1 - \rho}$, $B_1 = \frac{\rho \delta_1}{1 - \rho \delta_1}$, $B_2 = \frac{\rho \psi_1}{1 - \rho \psi_1}$, and $B_3 = \frac{\rho \gamma_1}{1 - \rho \gamma_1}$.

Equation (14) can be rewritten as:

$$x_t - a_t = A + B_1(\omega r_{t}^he - \delta_0) + B_2((1 - \omega)r_{t}^{se} - \psi_0) - B_3(\Delta x_t^e - \gamma_0)$$

The above equation is a linear relationship between log of excess consumption-assets ratio, expected housing asset returns, expected financial asset returns, and expected excess consumption growth rate.\textsuperscript{15} There are five shocks in the above model: shock to expected excess consumption growth rate ($\epsilon_{t+1}^{xe}$), shock to expected housing asset returns ($\epsilon_{t+1}^{rh}$), shock to expected financial asset returns ($\epsilon_{t+1}^{se}$), shock to realized excess consumption growth rate ($\epsilon_{t+1}^x$) and shock to realized return on housing assets ($\epsilon_{t+1}^h$). These shocks have a mean zero and have the following variance-covariance matrix:

$$\sum = \text{var} \begin{bmatrix} \epsilon_t^{xe} \\ \epsilon_t^{rh} \\ \epsilon_t^{se} \\ \epsilon_t^x \\ \epsilon_t^h \end{bmatrix} = \begin{bmatrix} \sigma_{xe}^2 & \sigma_{xe}^{he} & \sigma_{xe}^{se} & \sigma_{xe}^{x} & \sigma_{xe}^{h} \\ \sigma_{xe}^{he} & \sigma_{he}^2 & \sigma_{he}^{se} & \sigma_{he}^{x} & \sigma_{he}^{h} \\ \sigma_{xe}^{se} & \sigma_{he}^{se} & \sigma_{se}^2 & \sigma_{se}^{x} & \sigma_{se}^{h} \\ \sigma_{xe}^{x} & \sigma_{he}^{x} & \sigma_{se}^{x} & \sigma_{x}^2 & \sigma_{x}^{h} \\ \sigma_{xe}^{h} & \sigma_{he}^{h} & \sigma_{se}^{h} & \sigma_{x}^{h} & \sigma_{h}^2 \end{bmatrix}$$

\textsuperscript{14}One of the possible interesting extensions of this model is to allow the persistence parameter of the asset returns to vary with business cycles. In this paper, we abstract from this extension.

\textsuperscript{15}Even though $\omega$ enters the measurement equation, it doesn’t affect the estimated dynamics of expected return on housing and stock.
In the general correlation structure, some of the parameters may be unidentiﬁed. Following Cochrane (2008) and Morley et al. (2003) we impose restrictions on the covariance structure to achieve identiﬁcation. We followBinsbergen and Koijen (2010) identiﬁcation strategy and assume that covariance between realized return on housing assets and realized excess consumption growth is uncorrelated with shocks to the unobserved state variables. This implies that \( \sigma_{x^e h} = \sigma_{h^e x} = \sigma_{s^e h} = \sigma_{s^e x} = \sigma_{x h^e} = 0 \). In addition, we assume that shocks to realized excess consumption growth and realized return on housing assets are uncorrelated, that is \( \sigma_{x v h} = 0 \).

To summarize, our approach converts the present-value model as represented by equation (10) into a linear measurement equation of state space system represented by equation (15). To do so, we assume a simple autoregressive structure for unobserved variables: expected return on housing \((r_{he})\), expected return on ﬁnancial asset \((r_{se})\) and expected excess consumption growth \((\Delta x_t^e)\).

4 Data Description

We use quarterly data starting in the ﬁrst quarter of 1952. The sample period runs through the last quarter of 2006\textsuperscript{17}. The data in this paper includes excess consumption-assets ratio, return on housing assets, return on ﬁnancial assets, and excess consumption\textsuperscript{18}. Our measure of consumption includes outlays on durable goods\textsuperscript{19}. The data on consumption has been obtained from the National Income and Product Account (NIPA) Tables. Labor income has been constructed using data from the NIPA, and according to the procedure deﬁned in Lettau and Ludvigson (2001)\textsuperscript{20}. Labor income is wages and salaries.

\textsuperscript{16}Alternatively, we can impose zero covariance restriction on one of the covariances between shocks to expected excess consumption growth, expected housing return and expected stock returns. In the empirical section, we also explore this approach.

\textsuperscript{17}Since the present-value model is based on log-linearization around steady state, we don’t consider the current sample period that covers big changes in the housing market. It would be a stretch to consider the changes in housing market beyond 2007 sample period as a deviation around steady state.

\textsuperscript{18}In NIPA, consumption and labor income series are reported on an annualized basis. Therefore, the excess consumption series constructed using data from NIPA is divided by four. This adjusts the excess consumption series to arrive at the correct ﬁgure for the average reduction in assets per quarter due to consumption in excess of labor income.

\textsuperscript{19}Our measure of consumption is based on Whelan’s (2008) approach.

\textsuperscript{20}Whelan (2008) also follows the same approach.
plus transfer payments plus other labor income minus personal contributions for social insurance minus labor taxes. Labor taxes are defined by imputing a share of personal tax and non-tax payments to labor income with the share calculated as the ratio of wages and salaries to the sum of wages and salaries, proprietors’ income, and rental, dividend, and interest income.

The data on housing asset returns and financial asset returns is based on the Federal Reserve Board’s flow of funds net worth series. Net housing assets equals real estate minus home and commercial mortgages and outlays on durable goods\textsuperscript{21}. Net financial assets equals financial assets minus financial liabilities. Asset returns are calculated as quarterly changes in log of asset values.

All data on asset valuation, consumption and labor income is in nominal terms. We deflate consumption, housing assets, financial assets, and labor income series by the price index of total personal consumption expenditure to obtain real consumption, asset returns, and income\textsuperscript{22}. We also examine the predictive ability of popular forecasting variables in explaining the variation in housing returns as compared to our filtered measure of expected housing asset returns. We include data on mortgage rates, price-rent ratio, real GDP growth rate, excess consumption-assets ratio, yield spread, and \textit{cay}\textsuperscript{23}. Data on mortgage rates and yield spread has been obtained from the Federal Reserve Bank of St. Louis’s Fred data set\textsuperscript{24}. The data on the price-rent ratio has been obtained from Davis et. al (2008), who combine different data sources and provide a measure of the price-rent ratio for the US economy that goes back to 1961. We obtain real GDP data from the National Income and Product accounts data (NIPA). The data on \textit{cay} has been obtained from Martin Lettau’s website\textsuperscript{25}.

\textsuperscript{21}We also include data on equipment and software owned by nonprofit organizations

\textsuperscript{22}Whelan (2008) also deflates asset returns, consumption and labor income series by the price index of personal consumption expenditure. Also, see Palumbo, Rudd, and Whelan (2006).

\textsuperscript{23}Lettau-Ludvigson (2001) use estimated residual from a cointegrating regression of consumption, labor income and wealth (\textit{cay}) as a proxy for expected asset returns.

\textsuperscript{24}The data on mortgage rate is available from 1971 Q2

\textsuperscript{25}http://faculty.haas.berkeley.edu/lettau/data.
5 Model Estimation

5.1 State Space Representation

The model in equation (15) has three latent or state variables: expected return on housing assets, expected return on financial assets, and expected excess consumption growth rate. We define the demeaned state variables as

\[
\Delta x_t^e = \gamma_0 + \Delta \tilde{x}_t^e \\
\omega r_t^{he} = \delta_0 + \omega \tilde{r}_t^{he} \\
(1 - \omega) r_t^{se} = \psi_0 + (1 - \omega) \tilde{r}_t^{se}
\]

There are three transition equations associated with the demeaned latent variables

\[
\Delta \tilde{x}_t^e = \gamma_1 \Delta \tilde{x}_t^e + \epsilon_{t+1}^e \\
\omega \tilde{r}_t^{he} = \delta_1 \omega \tilde{r}_t^{he} + \epsilon_{t+1}^{he} \\
(1 - \omega) \tilde{r}_t^{se} = \psi_1 (1 - \omega) \tilde{r}_t^{se} + \epsilon_{t+1}^{se}
\]

Three measurement equations are:

\[
\Delta x_{t+1} = \gamma_0 + \Delta \tilde{x}_t^e + \epsilon_{t+1}^x \\
\omega r_{t+1}^{h} = \delta_0 + \omega \tilde{r}_t^{he} + \epsilon_{t+1}^{h} \\
x_t - a_t = A + B_1 \omega \tilde{r}_t^{he} + B_2 (1 - \omega) \tilde{r}_t^{se} - B_3 \Delta \tilde{x}_t^e
\]

The measurement equation for excess consumption growth rate, return on housing assets, and excess consumption-assets ratio implies the measurement equation for the return on financial assets. We can estimate the above state space system using the maximum likelihood estimation via the Kalman filter. This model provides us estimates of expected return on housing assets \(r_t^{he}\), expected return on financial assets \(r_t^{se}\), and expected excess consumption growth \(\Delta x_t^e\).

\[26\] The measurement and transition equations for the state space model are derived in Appendix.
6 Estimation Results

The estimated hyperparameters from the state space system described by equations (16-21) are shown in Table 1. The estimated AR parameter for return on financial assets is highly persistent with a coefficient of 0.97. The high persistence of expected financial asset returns is consistent with a variety of economic models in which the expected returns varies overtime. Binsberg and Koijen (2010), Fama and French (1988), Campbell (1991), Campbell and Cochrane (1989), Pastor and Stambaugh (2009), and Rytchkov (2008) have also found expected return on stocks to be highly persistent. The corresponding estimate of the AR parameter for expected return on housing assets and excess consumption growth is 0.78 and -0.34 respectively.

Our results suggest that expected return on financial assets and excess consumption growth rate are highly positively correlated at 0.93. This implies that households raise their excess consumption in anticipation of higher than expected return on financial assets. The expected return on housing assets and financial assets are negatively correlated. The direction of such linkage could be due to the fact that the substitution effect and wealth effect point in opposite directions and substitution effect dominates the wealth effect during the sample period\(^27\). There is a negative but insignificant correlation between expected excess consumption growth and expected return on housing assets. We also estimate correlation between shock to realized excess consumption growth and shock to realized housing return by restricting the correlation between expected excess consumption growth and expected return on housing assets to be zero. The estimated correlation between realized excess consumption growth and realized housing return is positive and insignificant and the likelihood value is lower than the original model. The other estimated parameters remain qualitatively similar. The insignificant correlation may arise due to the fact that the realized excess consumption growth is very close to a white noise, whereas realized housing return is highly persistent. Therefore a shock to realized excess consumption growth disappears immediately, whereas a shock to realized housing return may take some time to dissipate. Table 2 shows the estimated value of the present-

\(^{27}\) A substitution effect predicts a negative relationship between the prices of the two assets, as the high return in one market tends to cause investors to leave the other market. A wealth effect, by contrast, predicts a positive relationship because the high return in one market will increase the total wealth of investors and their capability of investing in other assets.
value parameters, where $B_i$'s represent the loadings on expected returns on housing assets, financial assets, and excess consumption growth. These loadings depend positively on the persistence parameter of the unobserved state variables. As reported in table 2, these loadings are statistically significant.

Figure 1 plots the realized housing asset return along with the filtered return from the latent-variables approach, as well as the fitted return from the excess consumption-asset ratio. It is evident from the graph that the filtered return from the latent variable approach tracks the realized returns much more closely than the predicted returns from excess consumption-asset ratio\(^{28}\). The simple contemporaneous correlation between expected housing return and realized return is 0.84, whereas the corresponding correlation between mortgage rate and the realized housing return is -0.16. In fact, the filtered return tracks realized return better than other predictors. Our analysis in the next section shows this result in a greater detail.

6.1 Forecasting Housing Asset Return

6.1.1 In-Sample Evidence

Our approach yields us an estimate of expected housing return that in theory should have better predictive power in forecasting realized housing return than finite lags of excess consumption-assets ratio. We test this hypothesis by comparing the forecasting performance of expected return on housing obtained from the present-value model with excess consumption-assets ratio. In addition, we also compare the forecasting performance of our measure with other popular predictors of housing market, for example, among others, mortgage rate, the price-rent ratio, GDP growth, and yield spread. Table 3 reports the results for this exercise. The first row of the table is the regression of realized housing asset returns on its own lag. This model predicts about 13% of the next quarter’s variation in realized housing asset returns. If expected housing return is used as a predictor of realized housing asset returns, then we find that it explains 18% of the variation. This implies that our preferred measure contains an extra 5 percent explanatory power as compared to the lagged housing returns. It should be noted that our measure of expected housing return co-varies positively with future housing asset returns, and is procyclical. It is also positively correlated with GDP, with a

\(^{28}\)Ryychkov (2008) and Binsbergen and Koijen (2010) also compare the filtered series of state variables with the forecasts based on conventional predictive regression.
correlation coefficient of 0.23. This measure tends to increase during expansions and decline in recessions. The statistical properties of expected housing return from our approach matches well with the overall developments in the housing market as well as the macroeconomic environment in the US.

Our results show lagged real GDP growth rate explains around 3% of the variation in realized return on housing wealth. The estimation results show that there is a positive relationship between GDP growth and realized return on housing. Whelan (2008) and Kishor and Kumari (2011) find that excess consumption-assets ratio is a significant predictor of total asset returns, however, our findings suggest that it is an insignificant predictor for returns on housing wealth. We use the cointegrating residual between consumption, labor income and assets, \( \hat{c_{ay}} \), as one of the predictors. Our results suggest that the cointegrating residual, \( \hat{c_{ay}} \), is a significant predictor of one period ahead return on housing assets and explains around 5% of the variation. The mortgage rate explains only 2.47% of the variation in housing asset returns and is insignificant. Business cycle literature suggests that the yield spread, which is the difference between 10-year and 1-year treasury bond is a significant predictor of business cycle, though its predictive power has declined recently. We also use yield spread as one of the predictors of housing markets, but we don't find any significant relationship between yield spread and one-period-ahead housing asset returns. Similarly, we also find that the price-rent ratio is not a significant predictor of one-period-ahead housing asset returns and explains only 1.5% of variation. Regression of realized housing asset returns on its own lag and on one lag of expected return on housing assets produce an \( R^2 \) of 18%, so that adding last quarter’s value of \( \hat{r_{h}} \) to the model allows the regression to predict an additional 5.3% of the variation in next period’s real housing asset returns.

In addition to examining the in-sample predictive power of different predictors separately, we also examine whether the inclusion of lagged expected housing return in a prediction equation with other predictors improve the explanatory power of realized housing return. For example, as shown in row 9, if we augment the prediction model of realized housing return with its own lag by including lagged expected housing return, R-squared increases from 12.9% to 18.2% implying an increase of 5.3%. Similarly, if we augment the model of lagged mortgage rate with lagged expected housing return, R-squared increases by almost 24%. The results also suggest that in the presence of lagged expected return on housing, own lag of realized housing return and lag of mortgage rate becomes insignificant. Rows 11-15 of Table...
3 represent results when lagged expected return on housing is included in a regression with lagged real GDP growth rate, excess consumption assets ratio, yield, $cay$, and price-rent ratio. Adding $\hat{r}h$ significantly improves the degree of variation in 1-quarter ahead realized housing return.

Therefore, the results presented in this section suggests that the filtered expected returns obtained from the present-value model contains additional information about the future movements in housing returns that is not already present in the alternative predictors discussed here.

6.1.2 Out-of-Sample Evidence

The results presented in the previous section suggests that expected housing return obtained from the present-value model dominates other competing predictors in forecasting realized housing returns within the whole sample period. In this section, we examine one-period-ahead out-of-sample forecasting ability of estimated filtered returns and compare it with other alternative models. Each model is first estimated using data from the second quarter of 1953 through the third quarter of 1963. We use recursive regressions to re-estimate the forecasting model each period, adding one quarter at a time till the end of the sample and calculating a series of one-step-ahead forecasts. Our forecasting sample ends in 2006:04.

In our forecasting experiment, we compare the mean-squared error from a series of one-quarter-ahead out of sample forecasts obtained from a prediction equation that includes $\hat{r}h$ as the sole forecasting variable, to a variety of forecasting equations that use different predictors. Table 4 reports the ratio of MSE of the forecasts generated using filtered housing asset returns as a regressor in the forecasting equation to MSE of the forecasts generated using an alternative regressor. The ratio below unity represents superior forecasting performance of expected housing asset returns relative to the alternative predictors. The results in Panel A indicate that MSE of forecasts generated with the expected housing asset returns does a superior job in predicting housing asset returns out-of-sample. For example, MSE-ratio of 0.828 implies that forecasts from the model with filtered housing asset returns has 17.2 percent lower MSE than the corresponding forecasts of housing asset returns obtained from the mortgage rate. The other alternative predictors are real GDP growth, excess consumption-assets ratio, yield spread, $cay$, and price-rent ratio. In all cases, the reduction in MSE is around 20%.

We also perform another forecasting experiment in which we compare the
mean-squared error from a series of one-quarter-ahead out of sample forecasts obtained from a prediction equation that includes \( r^h \) as the sole forecasting variable, to another model which includes all other predictors, except the return on housing assets. Panel B in Table 4 reports the results. The ratio of MSEs is below unity, which reflects the superior forecasting performance of expected housing asset returns relative to the alternative model. The MSE ratio of 0.802 implies that forecasts from the model with filtered housing asset returns has around 20% lower MSE than the corresponding forecasts of housing asset returns obtained from Model 3.

To test the significance of forecast accuracy, we perform a statistical forecast comparison test. Since the forecasts in question are non-nested, we use Diebold and Mariano (1995) and West (1996) type of forecast evaluation test. This test statistic is referred to as the modified Diebold-Mariano (MDM) test statistic and is estimated with the Newey-West corrected standard errors that allow for heteroscedastic/autocorrelated errors. The null hypothesis of this test implies that the forecast accuracy of our preferred model and the alternative forecasts are not significantly different from each other. The P-values for this test are reported in Table 4. The results suggest that the forecasts of housing asset returns generated using expected housing asset returns as a predictive variable significantly outperforms the forecasts from alternative predictors.

7 Conclusions

The literature on the relationship between housing market wealth and consumption has mainly focused on estimating the consumption response to changes in housing market wealth. Rather than estimating the impact of housing wealth on consumption spending, the goal of this paper is to exploit the information in consumption, income and observable assets to estimate expected return on housing wealth, as the life cycle model suggests that household’s consumption responds to expected changes in housing market wealth and financial market wealth. To do so, we combine a present-value model with an unobserved component model to write down the observed excess-consumption asset ratio as a linear function of unobserved expected return on housing assets and financial assets and unobserved excess consumption growth. By assuming a simple autoregressive process for the unobserved variables, we apply Kalman filter to extract the unobserved expected return
on housing from the present-value model.

Our results show that expected housing return from a present-value model is a superior predictor of realized housing asset returns as compared to the other popular predictors both in-sample and out-of-sample. The estimated expected housing return explains 18% of the variation in one-period ahead housing assets returns. The results suggest that the filtered returns dominates popular predictors like mortgage rate, price-rent ratio, yield spread, cay and real GDP growth. The superior predictive ability of the filtered returns is not surprising since the unobserved component approach uses information from the whole history of the variables in the information set, as compared to the traditional approach where only finite lags are used for forecasting. To examine whether the differences in the forecasting performance of forecast obtained from our approach is significantly superior to that of the traditional predictors, we also perform non-nested forecast comparison tests. The modified Diebold-Mariano (MDM) test suggests that the mean squared errors of the forecasts generated from the expected return on housing asset from the present-value model is significantly lower than the mean squared error of the forecasts generated from predictors like the mortgage rate, price-rent ratio, among others.

The results obtained in this paper re-inforces the strong relationship between household’s consumption decision and the performance of the housing market. Our paper shows that one can utilize the information from the consumption-wealth ratio and extract household’s expectation about changes in housing market wealth. We also show that the estimated housing returns extracted from household’s life-cycle budget constraint is a better measure of realized housing return than the ones obtained by the usual VAR approach.
References


Appendix: State Space Model

Equations (16-21) can be represented in a state space form. The measurement equation can be written as

\[
\begin{bmatrix}
\Delta x_{t+1} \\
\hat{r}_{t+1} \\
x_t - a_t
\end{bmatrix} = \begin{bmatrix}
\gamma_0 \\
\delta_0 \\
A
\end{bmatrix} + \begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
-B_3 & B_1 & B_2
\end{bmatrix} \begin{bmatrix}
\Delta \hat{x}_t \\
\hat{r}_{t} \\
\hat{r}_{se}
\end{bmatrix} + \begin{bmatrix}
\epsilon_{x_{t+1}} \\
\epsilon_{\hat{r}_{t+1}} \\
0
\end{bmatrix}
\]

The transition equation is represented as

\[
\begin{bmatrix}
\Delta \hat{x}_t \\
\hat{r}_{t} \\
\hat{r}_{se}
\end{bmatrix} = \begin{bmatrix}
\gamma_1 & 0 & 0 \\
0 & \delta_1 & 0 \\
0 & 0 & \psi_1
\end{bmatrix} \begin{bmatrix}
\Delta \hat{x}_{t-1} \\
\hat{r}_{t-1} \\
\hat{r}_{se}
\end{bmatrix} + \begin{bmatrix}
\epsilon_{\hat{x}} \\
\epsilon_{\hat{r}} \\
\epsilon_{\hat{r}_{se}}
\end{bmatrix}
\]

Variance- Covariance matrix of the transition equation errors are

\[
\Sigma = \text{var} \begin{bmatrix}
\epsilon_{\hat{x}} \\
\epsilon_{\hat{r}} \\
\epsilon_{\hat{r}_{se}}
\end{bmatrix} = \begin{bmatrix}
\sigma_{x}^2 & \sigma_{x'h} & \sigma_{x'se} \\
\sigma_{x'h} & \sigma_{h}^2 & \sigma_{h'se} \\
\sigma_{x'se} & \sigma_{h'se} & \sigma_{se}^2
\end{bmatrix}
\]

Variance-Covariance matrix of the measurement equation errors are

\[
\Sigma = \text{var} \begin{bmatrix}
\epsilon_{x_{t+1}} \\
\epsilon_{\hat{r}_{t+1}} \\
0
\end{bmatrix} = \begin{bmatrix}
\sigma_{x}^2 & \sigma_{x'h} & 0 \\
\sigma_{x'h} & \sigma_{h}^2 & 0 \\
0 & 0 & 0
\end{bmatrix}
\]
Table 1: **Maximum Likelihood Estimates of Hyperparameters**

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<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
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Table 2: **Implied Present-Value Model Parameters**

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Figure 1: Comparison of realized housing returns with forecasts from the unobserved component approach and the OLS approach
The table reports regression results of realized housing asset returns on lagged variables. $\hat{r}_h$ is the expected return on housing assets computed via the filtering approach, $mg$ is the mortgage rate, $rgdp$ is the real GDP growth rate, $xa$ is the excess consumption-assets ratio, $yield$ is the spread between 10 year and 1 year Treasury bill rate, $cay$ is the cointegrating residual between consumption, assets, and labor income, and $rent$ is the price-rent ratio. The sample covers the period 1953 Q2-2006 Q4. The numbers in the parentheses are P-values based on the Newey-West standard errors.

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Table 4: **One-Quarter-Ahead Forecasts of Housing Assets Returns: Nonnested Comparisons**

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<th>$\frac{MSE_1}{MSE_2}$</th>
<th>MDM P-value</th>
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</tbody>
</table>

The table reports the results of one-quarter-ahead nonnested forecast comparisons. The dependent variable is return on housing assets. In Panel A two models are compared. Model 1 always uses lagged $\hat{rh}$ as a predictive variable. Model 2 uses one of several alternate variables labeled in the second column. The column labeled $MSE_1/MSE_2$ reports the ratio of the mean squared error of Model 1 to Model 2. The first row uses the lagged mortgage rate as a predictive variable; the model denoted gdp uses lagged real GDP growth rate as a predictive variable; the model denoted xa uses lagged excess consumption-assets ratio as a predictive variable; the fourth row uses lagged yield spread; the model denoted cay uses lagged value of cay and the last row uses change in price-rent ratio as a predictive variable. The fourth column reports the P-values of modified Diebold-Mariano test statistic. The null hypothesis is that Model 2 encompasses Model 1. In Panel B, Model 1 is compared with Model 3. Model 3 uses alternate variables such as lagged mortgage rate, lagged real GDP growth rate, lagged excess consumption-assets ratio, lagged value of cay and lagged price-rent ratio as predictive variables. Model 3 does not include $\hat{rh}$ as a predictor. The fourth column reports the P-values of the test statistic, where the null hypothesis is that Model 3 encompasses Model 1. In both the panels, each model is first estimated using data from the second quarter of 1953 to the third quarter of 1963. It is recursively re-estimated each period until 2006 Q4, adding one quarter at a time and calculating a series of one-step-ahead forecasts.