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The influence of publicly-traded REITs and market-based inflation expectations on daily-priced private commercial real estate returns

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Abstract

Investors requiring daily Net Asset Values (NAV) represent a large and growing source of capital for the private institutional real estate asset class. Defined contribution and other daily-valued vehicles are increasing their investments into private, direct commercial real estate through funds that estimate changes to income and values in order to mark a daily NAV. Utilizing nine years of daily data from the NCREIF Fund Index – Daily Priced, we optimize a generalized autoregressive conditional heteroskedasticity model with generalized error distribution parameterization (GARCH-GED) to better understand the influence of publicly-traded real estate securities and changes in market-implied inflation expectations on daily private real estate returns. Bai-Perron and Markov Switching regressions are used to compare periods of shifting influences on private real estate volatility in the aftermath of the Global Financial Crisis.

Keywords: private commercial real estate, daily priced, NCREIF, defined contribution

JEL codes: R30, R33, G11

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I. Introduction

The scope of this paper is to examine the influence of changes in publicly-traded real estate securities and inflation expectations on the private daily real estate returns. Publicly-traded real estate securities and market-based inflation measures experienced growth in maturity and daily-trading volume in the 1990s and mid-2000s, respectively. More than 40 years after the first major US institution experimented with daily-pricing a private real estate fund, the daily valuation practice continues to evolve with daily-priced data at the industry-level only released to market participants in 2014. To facilitate daily pricing with some level of daily liquidity, holders of relatively illiquid real estate properties must model daily net asset values (NAV), marking the assets to model and truing up the values when appraisals occur. No single, standardized approach exists to model the daily-prices of private commercial real estate. As discussed by Wincott (2012), daily valuations processes include one-by-one appraisal adjustments with income reconciliations, flow-through real-time income changes for large assets, and incorporating macro forecasting models.

Daily-priced real estate funds are expected to receive a growing allocation in inflation-protection strategies for target date funds and other savings plans. Generally, savings plan investors have long-term, potentially multi-decade investment horizons. Defined contribution and other savings plans invest in private, direct commercial real estate strategies via daily-priced vehicles with a predefined, limited level of daily liquidity that varies by fund but is typically 15% to 30% of the investment. Typically, this liquidity sleeve builds upon an allocation to daily-liquid Real Estate Investment Trust (REIT) indices and cash. Thus, equity REIT returns should affect the daily-priced private real estate return series.

Given the ability to grow the income with inflation and the positive correlation between expected inflation and the quarterly real estate return series overtime, it seems reasonable to assume that daily-priced commercial real estate can be effective in hedging inflation. Glascock et al. (2002) cites numerous empirical studies confirming private commercial real estate as an inflation hedge and gives evidence that change in monetary policy partially explain a perceived but sporadic negative relationship between REIT returns and

expected inflation. Historically, researchers only had daily REIT or quarterly private real estate time series to test against hypotheses about the impact of inflation expectations on private real estate return. Our paper helps develop a better understanding of how daily measures of inflation expectations, public-market performance, short-term interest rates influence a daily private real estate return.

The remainder of the paper is organized as follows. Section II provides an overview of the literature. Section III describes the daily data series for private real estate and other variables. Section IV provides empirical evidence with interesting implications for future research outlined in Section V. Conclusions are summarized in Section VI.

II. Literature overview

Prior to the release of the daily-priced return series in 2014, quarterly private returns with embedded effects from seasonality and appraisal smoothing were the highest frequency data series available to track private real estate performance. As noted in Geltner et al. (2003), the value of private, direct real estate investments is derived overwhelmingly from appraisals, as the underlying assets are not traded on a regular basis. Thus, the quarterly returns are subject to appraisal-smoothing. Since 2000, the frequency of appraisals in the NCREIF Property database increased as demanded by investors and facilitated by advancements in technology and data transparency. More frequent valuation reduces the impact of appraisal smoothing but does not eliminate smoothing or the seasonality embedded the valuation data, per Hoesli et al. (2008). Additionally, given the low frequency of the traditional quarterly series, it has been difficult to amass enough observations to apply General Autoregressive Conditional Heteroskedasticity (GARCH) models to the private real estate asset class.

Institutional-quality commercial real estate is a durable good with measurable defensive and accretive capital expenditures, contractual lease payments, and long-term investment horizons. Property revenue growth should outpace expense growth via value-add repositioning strategies and lease payment escalations. Performance of this asset class should correlate positively with inflation over time. The

presumed positive correlation as noted by Huang and Hudson-Wilson (2009), between private commercial real estate return and inflation secured it a place in inflation-hedge strategies.

Hoesli et al. (2008) further dissect private real estate performance against expected and unexpected inflation and short run and long run correlations. Hoesli et al. estimate a Vector Error Correction Model (VECM) utilizing quarterly private commercial real estate returns from NCREIF (National Council of Real Estate Investment Fiduciaries) to distinguish short run adjustments and long-term relationship between inflation and real estate. The authors segment inflation into expected and unexpected series by comparing the expectation of inflation embedded in breakeven inflation (BEI) and actual realized inflation over time with the difference referred to as unexpected. Long run models showed significant, positive coefficients between expected inflation and real estate returns the coefficient for private real estate significantly less than unity. Little evidence of short run influence was found except when the authors used a transaction-based index instead of an appraisal-based index to proxy private real estate performance. In the transaction-based data, the short run adjustment process showed the sign of the coefficients for expected and unexpected inflation switch to negative, suggesting time-varying behavior related potentially to economic and monetary policy shifts, which the authors propose as a subject for further research.

In the universe of investment options into real estate, direct ownership of tangible properties is the least liquid exposure and publicly-traded Real Estate Investment Trusts are the most liquid, offering daily trading on public exchanges. REIT share prices may trade at discounts or premiums to the underlying net asset values of the underlying real estate, as prices adjust for equity market volatility, management decisions, and ownership of developer or operating entities among other items. Helge Haß et al (2012) present the key benefits of investing in open-end real estate funds as portfolio diversification and the availability of some liquidity, and a key downside is that liquidity can be suspended if values begin to fall.[1]

[1] I acknowledge there are major differences in the regulation of valuation policies in Germany, which is the focus of the Helge Haß et al (2012) paper, and of those in the United States; however, the conclusion reached by the paper, that when values fall, liquidity provided by open-end funds diminishes, holds true in both countries.

Much of the attention of commercial real estate research focused on the publicly-traded REITs, which offer numerous, easily-accessible data points but are influenced in the short-term by equity market volatility. Glascock et al. (2002) test Impulse Response Functions (IRF) and Vector Error Correction Models (VECM) on monthly REIT returns. Separating inflation into expected and unexpected inflation they show REIT returns impact changes in the components of inflation negatively and REITs respond quickly to shocks in expected and unexpected inflation. The authors define expected inflation as the rate on the one-month Treasury bill minus the historical 12-month average difference between the one-month Treasury rate from the previous month and change in the monthly Consumer Price Index (CPI). Unexpected inflation is the difference between the observed change in CPI and the calculated expected inflation rate. Statistically significant results are found when the Federal Funds Rate is included in their model as a proxy for monetary policy changes, reflecting the sensitivity of REIT returns to short-term interest rate changes. REITs are used as a proxy for investable real estate by Amenc et al. (2009) when they find real estate provides a partial hedge to inflation over the long run. Public REIT returns are the basis of Knight et al. (2005) when they conclude that the distribution of real estate returns tends to be peaked and fat-tailed.

A few papers have been written on investment by defined contribution plans into daily-priced real estate. Wincott (2012) writes an overview of the growing field of daily-priced private commercial real estate from an appraiser's perspective. Esrig et al. (2013) provide evidence for the wide-spread acceptance of private commercial real estate in defined benefit (DB) plans, noting that in 2013 the average DB plan held 8.4% of its assets in commercial real estate with over 90% of the allocation in private or direct real estate strategies. The growth in the universe of daily-priced private real estate funds is evidence of the growing demand for real estate options from defined contribution plans. In 2009, NCREIF was only tracking three notable funds in the US. As of September 2018, the universe grew to eight contributing funds.

III. Descriptions of the data

Daily real estate return

In September 2014, the NCREIF, released the NCREIF Fund Index – Daily Priced (NFI-DP), the first multi-manager index reporting the daily returns of funds invested in private commercial real estate. Historical data for the NFI-DP begins on October 1, 2009. Exhibit 1 provides summary statistics on the return series with 2248 return observations. NFI-DP returns are leptokurtic with a high peak and many data points clustered around the mean, implying that there is elevated tail-risk. The daily returns data are negatively skewed, implying that slightly more observations are below the mean of 3.6 basis points.

… insert Figure 1…

Daily real estate return describes the percentage change in an equal-weight index reported by NCREIF net of fund manager fees and referred to in our calculations as ΔlogNFIDP. Since there are no corresponding bond yields for weekends or holidays, we removed these days from the daily return series, which is reported with a return for all calendar days. Due to technology and process delays, NCREIF publishes the complete daily dataset once per month.

… insert Table 1…

NFI-DP fund investments were 83.8% concentrated in domestic private-equity real estate strategies as reported by NCREIF in September 2018 and shown in detail in Table 1. Private real estate debt had a small 2.4% allocation. The balance of the index was a daily-liquidity component comprised of 10.0% publicly-traded real estate and 3.8% cash. It is unknown how much operating and fund-level leverage is placed at the property or fund-level, as this metric is not currently reported. The four major property types represented in the private index are office, multifamily, retail and industrial with a small allocation to niche real estate sectors such as self-storage, hotels, and mortgages. This differs from the broad market for publicly-traded real estate, which offers more exposure to niche property types. Different property types

have different lease terms and relationships with inflation over time, important considerations when assessing real estate as an inflation hedge as noted by Huang and Hudson-Wilson (2007).

… insert Figure 2…

Daily Real Estate Investment Trust returns

To estimate the influence of publicly-traded real estate performance on the private daily series, we used the Wilshire US REIT Price Index, a diversified value-weighted index of US equity REITs with a book value of at least $100 million. Figure 2 compares a dual axis wealth graph with the private real estate index on the left axis and the publicly-traded real estate index on the right axis. Cointegration exists between the public and private indices. Not only are the underlying assets the public firms invest in similar to the private market investment selections but also, in order to offer some level of daily liquidity, private real estate fund managers maintain a portion of their portfolios in REIT securities and cash.

Daily breakeven inflation rates

Breakeven inflation (BEI), shown in Figure 3, refers to inflation expectations imbedded in the rates of constant-maturity five- or 10-year US Treasury notes. Based on Fama and Gibbons (1984) and Hoesli et al. (2008), we use the market measure of expected inflation derived from nominal Treasury rates.[2]

$T_{t-1} = E(R)_{t-1} + E(I)_{t-1}$ by rearranging the variables, we find the equation for expected inflation.

$$E(I)_{t-1} = T_{t-1} - E(R)_{t-1} \quad (1.1)$$

Breakeven inflation (BEI), the spread of nominal US Treasury rates over same-maturity Treasury Inflation-Protected Securities (TIPS) as shown in equation 1.1, is used in this research to test the influence of changes in inflation expectations on the private real estate return. Breakeven inflation is a market-derived measure of participants' expectations for changes in the general level of prices in the economy over time. Given that BEI is capital-market derived, utilizing this measure in our model may bias results toward capital

[2] Federal Reserve Bank of St. Louis, 5-Year Breakeven Inflation Rate retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/T5YIE, September 28, 2018.

appreciation component of the return as suggested by Hoesli et al. (2008). Bias is mitigated with the use of private index total return, which is the sum of the income and capital returns of the underlying properties.

…insert Figure 3…

90-day Treasury bill rate

In our model, the short-term interest rate should capture some of the impact of holding cash and reflect changes in monetary policy. Most daily-priced real estate funds will need to hold cash, as it is difficult to match flows into the underlying property funds and to maintain some liquidity for investors. Additionally, information about monetary policy should be reflected in the 90-day Treasury rate, as the difference between it and the effective Federal Funds Rate averaged only -4 basis points during the study period. From 2009 until 2015, the rate on the 90-day Treasury remained near zero. In mid-2015, the market began to price in an interest rate increase that the Fed implemented in December 2015. Continued periodic interest rate increases by the Fed pushed up short-term interest rates until late 2018, as shown in Figure 4. We tested the 30-day Treasury bill rate in the model instead of the 90-day Treasury rate and found similar results. Ultimately, the 90-day Treasury rate was selected to match the typical appraisal lag on the underlying private property valuations.

… insert Figure 4…

IV. Underlying Model and Empirical Estimation

Daily-priced real estate data are leptokurtic, and outliers are present in the series, which suggests a GARCH process to model variance conditional on innovations and persistency in volatility. To allow for time-varying marginal behavior and consistent with the findings of Knight et al. (2005), the marginal distributions of daily-priced real estate returns exhibit GARCH(p,q) volatility and t-distributed residuals. In all models, the Generalized Error Distribution (GED) term is less than 2.0, confirming that the error distribution is subject to pronounced tail-risks, an important indicator that Gaussian-based processes would not be appropriate with daily-priced real estate returns.

For daily-priced real estate returns a GARCH(2,2) process with GED is optimal with a minimized Schwarz Information Criterion (SC). Figure 5 gives coefficient significance and diagnostic statistics for six GARCH(2,2) models. Model 5 minimizes the SC and has the percentage change in NFI-DP return as a function of a lagged term, the percentage change in equity REIT return, the change in the rate of expected inflation and the change in the 90-day Treasury bill plus the conditional variance equation with two lags. Since REITs are a component of the liquidity sleeve of the daily-priced real estate return series, we test Model 6 without the lagged dependent variable. In excluding the lagged dependent variable, the coefficients and diagnostic statistics are similar to Model 5; however, Model 6 is not optimized.

… insert Figure 5…

Description of the optimized GARCH (2,2) model

Conditional mean equation:

$$\Delta logNFIDP_t = \beta_0 + \beta_1 \Delta logEREIT_t + \beta_2 \Delta BEI10_t + \beta_3 RATE3M_t + \varepsilon_t \qquad (2.1)$$

Conditional variance equation:

$$\sigma_t^2 = \gamma_0 + \gamma_{11}\, \varepsilon_{t-1}^2 + \gamma_{12}\, \varepsilon_{t-2}^2 + \gamma_{21}\, \sigma_{t-1}^2 + \gamma_{22}\, \sigma_{t-2}^2 + \varepsilon_t \qquad (2.2)$$

Where:

β_0 and γ_0 are constants
ε^2 is the ARCH term
σ^2 is the GARCH term
ε_t is an error term
ΔlogNFIDP is the percentage change in the daily-priced private commercial real estate index
ΔlogEREIT is the percentage change in the publicly-traded REIT index
ΔBEI10 is the percentage change in 10-year breakeven inflation expectations
RATE3M is the rate on the 90-day Treasury Bill

In the conditional mean equation, all coefficients are positive except the short-term interest rate. A 1% change in equity REIT return corresponds to a 9.5% in the NFI-DP return on the same day. A change in 10-year breakeven inflation of 1% corresponds to 15.5% change in the NFI-DP return. The 90-day Treasury rate is included without additional transformation. If the 90-day Treasury rate rose 1.0%, the corresponding response would be a 0.4% decline in the percentage change in the NFI-DP return and vice

versa for a decline in the Treasury rate. All coefficients are significant at the 1% level. The strength of significance of the inflation expectation coefficient is an important finding. Historically, it has been difficult to identify a strong empirical relationship between private real estate and inflation using quarterly-smoothed return data.

In the conditional variance equation, the constant is close to zero and significant at the 10% level. The ARCH coefficients imply that shocks in the error are exaggerated at first, and the effect reverses over time. The GARCH terms offer information about the impact of persistency in volatility. In our model, the current day's volatility persistency is intensified by the previous day's movement with a positive GARCH(1) coefficient of 1.5. Volatility persistency partially self-corrects with a GARCH(2) coefficient of -0.5. Volatility shocks show only minor compression with the sum of ARCH and GARCH coefficients close to but slightly below 1.0.

Conditional variance in Figure 6 is shaded to show Bai-Perron breakpoints correspond with periods of high-to-diminishing conditional variance, a finding consistent with Markov Switching regressions. If this pattern holds in the future, analysis of the changing significance of the exogenous variables may help identify triggers for changes of regime. The observations outlined in this paper regarding coefficient signs and significance during Downturn, Uncertain Recovery and Expansionary periods serve as good starting point for hypothesizing about changes in regimes.

… insert Figure 6…

A considerable amount of testing compared use of the five and 10-year breakeven inflation expectations as determinants of variability in private real estate returns. Consistent with Orlowski and Soper (2019), five-year breakeven inflation is theorized to be more reflective of economic news and forecasts, while 10-year breakeven inflation is less volatile and likely a real-time reflection of the market's perception of the Fed's ability to control inflation, i.e. the effectiveness of monetary policy. Applying that to real estate, property appraisals backing the property-level valuations within the daily return series most often reflect a 10-year discounted cash flow valuation with a reversion assumption in the 11th year. However, 10-year holding periods may not be reflective of average lease lengths or actual holding periods, which influence

real estate fund returns over time. As such, the shorter five-year BEI time series may be a less-smoothed, market-based estimation of inflation expectations and can offer an appropriate comparison to daily-priced real estate data. Testing GARCH processes using the five-year BEI and 10-year BEI series confirms that either variable is significant as shown in Figure 5; however, the less volatile 10-year BEI optimizes GARCH models with consistently lower information criteria.

Impulse response functions

Initially, Impulse Response Functions (IRF) are tested to confirm and understand the transmission of shocks. Vector autoregressions (VAR) show significant coefficients influencing the $\Delta logNFIDP_t$ at lags of slightly more than a week, implying a delay in the transmission of some information. Unrestricted VAR(7) models are determined as the base for IRFs. The primary independent variables are the percentage change in equity REIT returns, change market-based inflation expectations and 90-day Treasury bill rate. VAR and IRF further confirm serial correlation in the private real estate return series.

…insert Figure 7…

Figure 7 shows unaccumulated impulse response functions, which offer insights on the transmission of shocks to NFI-DP returns over the three business weeks following a shock. During the first day following a one standard deviation shock in REIT return, 90-day Treasury rates and five-year BEI, we see minimal response in the return of the NFI-DP. Response to medium-term inflation expectations and short-term interest rates reverberates but remains muted over time. In the week and half following a shock, private real estate return responds inversely to the publicly-traded real estate market. In a more mature daily-traded market, there may be signs of rebalancing between the two asset classes; however, in the private market, limitations on data transparency and price discovery on the underlying properties suggest rebalancing is not a meaningful factor at this time. Even though reactions to shocks transmit negatively to private real estate return, long-term correlation between public and private real estate return is positive.

Unlike the response to the other daily variables, the change in real estate return responds in the same direction over the first few days following a one standard deviation change in 10-year breakeven inflation. However, the second week shows a strong reversal of that impact. There is likely information about market confidence in the Fed's ability to control inflation in the 10-year BEI. Initially, a shock in the change of 10-year BEI is magnified in private real estate return, perhaps reflecting findings that private real estate is a good hedge for long-term expected inflation, especially if market participants doubt the Fed's ability to keep inflation around a target. Overtime, the impact gets absorbed into the return.

Data delays likely plague the private return series from the top-down and the bottom-up. With the advancement of high-speed data flow technologies, the structure of the current models for estimating daily real estate returns could be improved to include more real-time market indicators as well as more real-time changes in the income expectations. As reflected in impulse response functions, it takes days to transmit top-down market information to the daily real estate returns. Slow innovation in appraisal practices noted by Wincott (2012) means information likely transmits slowly from the bottom-up, such as from properties to fund index returns. When a large tenant renegotiates a long-term lease in a large office building, new expenses and renegotiated rent should influence the Net Asset Value (NAV) of the real estate fund on the day the lease is signed rather than waiting for a manual flagging of change in cash flow expectations or for the next official appraisal on that property. The inclusion of more real-time information could open private real estate returns to more volatility, but in daily-returns, faster data transfer would better reflect the risk of the investment as of the day the NAV is marked.

Bai-Perron and Markov Switching regressions

Using Bai-Perron breakpoint regressions shows all independent variables are significant during the downturn, see Figure 8. In the wake of the 2008-2009 recession, Bai-Perron regressions suggest a negative constant, all exogenous variables strongly significant and the coefficients exaggerated compared to calmer periods. Changes in inflation expectations and short-term Treasury rates caused the strong responses in the private real estate return in the same direction. From 2011 to 2013, an uncertain recovery was characterized

by oscillating fears of a double-dip recession, government debt ceiling debates, and the June 2013 announcement of the tapering of Quantitative Easing by the US Federal Reserve (Fed). During the uncertain recovery, coefficients diminished relative to the downturn and short-term interest rates were near zero and not significant.

… insert Figure 8…

After mid-2013, markets entered a period of relative calm expansion. Neither the lagged private real estate return nor the change in breakeven inflation were significant variables. During the period 2009 to 2013, 10-year BEI was above 2% most of the time and a showed an increasing trend; however, breakeven inflation trended lower from 2013 to early 2016 and trended toward 2% through September 2018. Only the percentage change in equity REIT return and the short-term interest rate show statistical significance to private real estate returns during expansion. A negative relationship emerges between short-term interest rates and private real estate returns during the expansion, consistent with changes in monetary policy. The 90-day Treasury rate finally began increasing in mid-2015, as the Fed foreshadowed expected increases in the Federal Funds Rate (FFR). The Fed first increased the target FFR by 25 basis points to an upper limit of 0.50% in December 2015.

Consistent findings between the Bai-Perron breakpoint and Markov Switching models identify district periods or regimes in the data and reinforce the robustness of the findings, see Figure 9. Regime 1 is identified as Expansion. Regime 2 is a period of Uncertain Recovery. Regime 3 is a Downturn. Markov Switching probabilities show how likely it is that the series will stay in a Regime or switch into another Regime. Downturns are rare in private commercial real estate. As per the major association for private real estate firms, NCREIF, the related quarterly private fund return series only shows two negative total return periods over the past 30 years, and accordingly, the likelihood of remining in the Expansionary regime once it is attained is over 99% during our sample period.

… insert Figure 9…

Regime probabilities and durations are given in Figure 10 for informational purposes; however, caution is warranted in drawing conclusions from the expected number of days in regime durations. Private daily return data start reporting in October 2009, after the 2008-09 recession, and there is only one major downturn in the nine-year history of the daily time series. During this period, the capital and real estate markets continued to turn down, but the US economy was in recovery by July 2008. We would prefer to observe a few more downturns in the daily-private real estate series before generalizations can be made about regime durations.

… insert Figure 10…

V. Notable findings for future research

Other daily-frequency variables were found to be significant but are out of the scope of this paper. The findings summarized here may lay the groundwork for future research. The term spread, which reflects the difference between short and long-term government bond rates, was significant at 1%. We tested the difference between the daily prevailing constant maturity rates on 10-year Treasury bonds and 90-day Treasury bills to represent the term spread. Bai-Perron breakpoint regressions suggest that the term spread was most significant during the recession and steady expansion. Further research could explore the influence of a negative term spread on private real estate performance, as it has been a good predictor of US recessions.

The percentage change in the SP500 equities index is significant at 1% during the recession and uncertain recovery periods. However, during the expansion, a period of relative calm stock markets, the significance of movements in the SP500 diminishes. One caveat is that as of February 2019, equity REITs comprise 3% of the SP500.[3] Future research should control for or diminish the influence of REITs as a component of the SP500.

[3] Calculated using lists of SP500 REITs from www.reit.com and market capitalization data from Yahoo! Finance.

An interesting finding for further research is the extent of cointegration and Granger causality between daily private and public real estate market returns. If data transfer speeds increased and private market data could be observed daily instead of monthly in arrears, the data could be sold to equity analysts, traders and portfolio managers. More timely observations of daily data would make it easier to create indices on individual property types, creating further potential for volatility in the daily series and improving the prospect for a private real estate swaps market.

VI. Conclusions

Change in public-market REIT returns, long-term inflation expectations and short-term interest rates affect daily returns in the private real estate market. Public-market REIT returns, which comprise only around 10% of the daily-priced index over time can exert a strong influence in the private series. It takes a little over a week for shocks in public-market return to reveal themselves in the private-market performance. REIT returns move in the same direction and are found to have a significant impact on private real estate returns under risk-on and risk-off market conditions. Inflation expectations were only significant during periods of distress or heightened uncertainty and show no significant effect on private real estate return during a period of relatively calm expansion. Short-term interest rates may transmit information on cash return and monetary policy to private real estate performance. During expansionary periods, an increase in the 90-day Treasury rate corresponds to a small decrease in private real estate return, consistent with upward pressure on interest rates putting downward pressure on prices. However, the effect is small as it is likely offset somewhat by expectations for positive economic and property-level income growth. During a downturn, rates on Treasuries and real estate returns moved in the same direction. In the transition period between expansion and downturn, no relationship is apparent.

Private commercial real estate remains in a period of relative calm; however, when making decisions, investors should be mindful of the turbulent periods from 2009 to 2011, identified in this paper as a downturn, and from 2011 to 2013, when recovery went hand-in-hand with heightened uncertainty. Modeling conditional variance may help determine whether private real estate returns are moving between

regimes, which can offer investors insight into which determinants of return may be moving the private market and in what direction. Improving technology and transmission of information from the property-level to the fund-level over time may cause volatility but improve daily accuracy. The response of real estate return to shocks takes more than a week to transmit to the private series today. As information speeds improve, expect more concentrated responses in the daily private real estate return.

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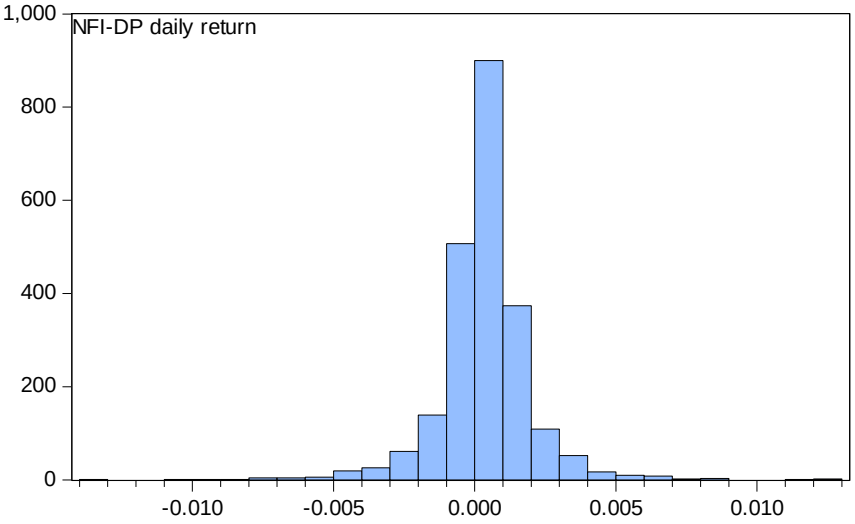
Figure 1 – Summary statistics and histogram of daily real estate returns



Series: NFIDPRETN	
Sample 10/01/2009 9/28/2018	
Observations 2248	
Mean	0.000362
Median	0.000377
Maximum	0.012862
Minimum	-0.013290
Std. Dev.	0.001667
Skewness	-0.081640
Kurtosis	13.32612
Jarque-Bera	9990.062
Probability	0.000000

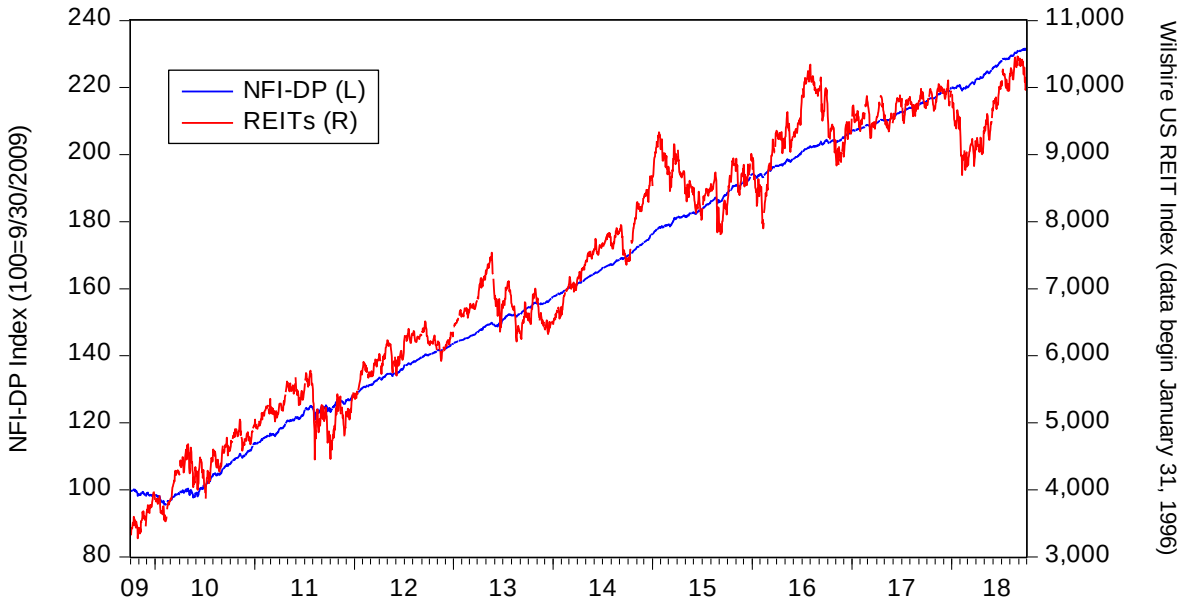
Source: NCREIF Fund Index-Daily Priced as of September 28, 2018. Note: for comparison to other series, these NFI-DP data exclude weekends and holidays, which appear in the raw observations from NCREIF.

Table 1 – NFI-Daily Priced investment allocations

%	Private debt real estate	Private equity real estate	Public equity real estate	Public debt	Cash
September 28, 2018	2.45%	83.84%	9.95%	0.00%	3.76%
Average Sept 2014 to Sept 2018	2.38%	84.47%	9.32%	0.04%	3.80%
High	3.12%	87.01%	11.08%	1.88%	5.30%
Low	1.57%	81.61%	7.56%	0.00%	2.21%

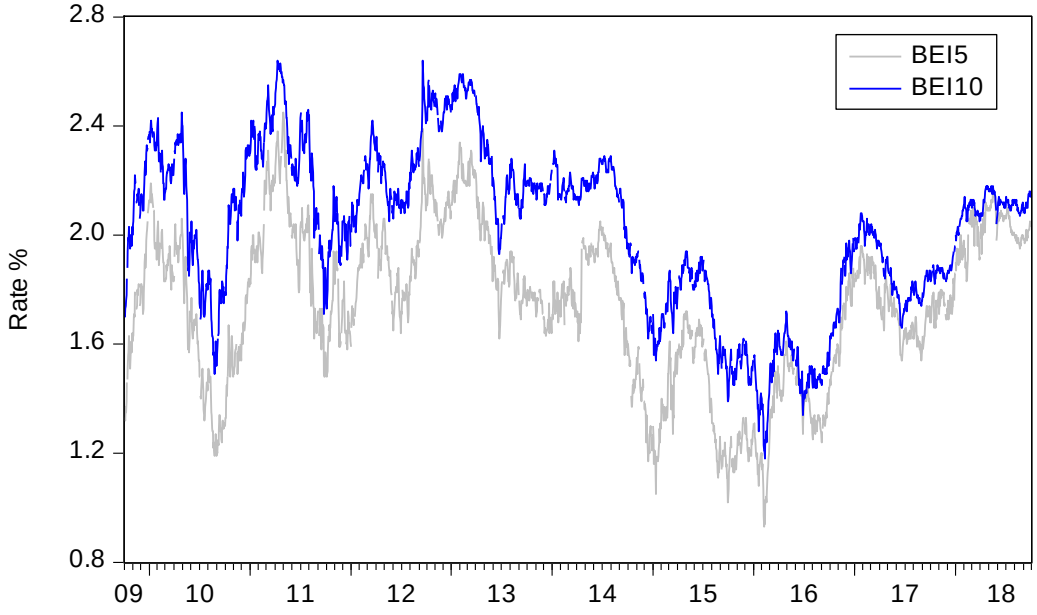
Source: NCREIF Fund Index-Daily Priced monthly diversification report as of September 30, 2018. Monthly diversification data is only available starting in September 2014.

Figure 2 – Daily-priced real estate fund index and equity REIT index



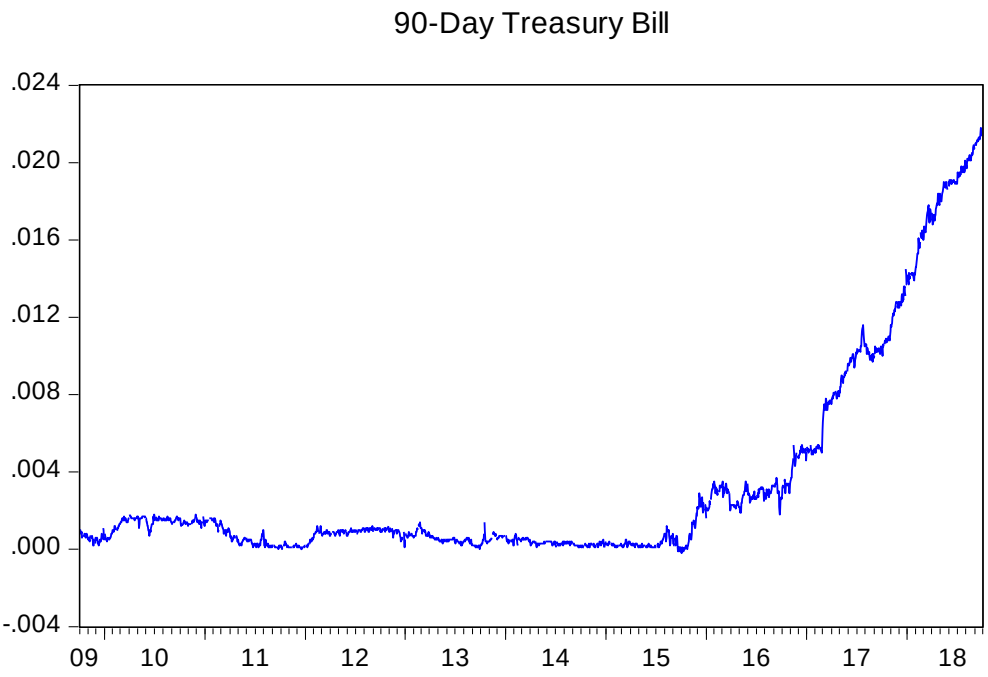
Source: NCREIF Fund Index – Daily Priced and Wilshire Associates, Wilshire US Real Estate Investment Trust Price Index (retrieved from FRED, Federal Reserve Bank of St. Louis) as of September 28, 2018.

Figure 3 – 5-year and 10-year Breakeven Inflation



Source: FRED, Federal Reserve Bank of St. Louis as of September 28, 2018.

Figure 4 – 90-day Treasury bill rate %



Source: FRED, Federal Reserve Bank of St. Louis as of September 28, 2018.

Figure 5 - GARCH (2,2) equations

Conditional mean equations					Optimal min(SC)	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	ΔlogNFIDP	ΔlogNFIDP	ΔlogNFIDP	ΔlogNFIDP	ΔlogNFIDP	ΔlogNFIDP
ΔlogNFIDP(-1)	0.0304 ***	0.0302 ***	0.0252 ***	0.0305 ***	0.0289 ***	N/A
	4.92	4.86	4.09	4.91	4.68	
ΔlogEREIT	0.0943 ***	0.0941 ***	0.0955 ***	0.0944 ***	0.0956 ***	0.0956 ***
	150.59	150.28	153.20	150.67	152.68	150.46
ΔBEI5	N/A	0.0693 ***	0.0728 ***	N/A	N/A	N/A
		4.26	4.50			
ΔBEI10	N/A	N/A	N/A	0.1444 ***	0.1547 ***	0.1518 ***
				5.78	6.21	6.02
rate3m	N/A	N/A	-0.0040 ***	N/A	-0.0040 ***	-0.0042 ***
			-5.04		-5.01	-5.21
c	0.0003 ***	0.0003 ***	0.0003 ***	0.0003 ***	0.0003 ***	0.0003 ***
	43.05	43.27	36.44	43.38	36.18	38.62
Conditional variance equations						
$RESID(-1)^2$	0.1716 ***	0.1735 ***	0.1673 ***	0.1777 ***	0.1688 ***	0.1644 ***
	4.50	4.50	4.49	4.44	4.50	4.49
$RESID(-2)^2$	-0.1646 ***	-0.1666 ***	-0.1612 ***	-0.1700 ***	-0.1626 ***	-0.1586 ***
	-4.46	-4.46	-4.46	-4.39	-4.47	-4.46
GARCH(-1)	1.5192 ***	1.5215 ***	1.5583 ***	1.4754 ***	1.5466 ***	1.5560 ***
	15.01	15.32	16.69	13.43	16.29	16.53
GARCH(-2)	-0.5270 ***	-0.5292 ***	-0.5652 ***	-0.4842 ***	-0.5537 ***	-0.5627 ***
	-5.32	-5.44	-6.18	-4.50	-5.95	-6.10
c	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
	1.67	1.74	1.70	1.74	1.71	1.75
G.E.D. parameter	1.0172 ***	1.0221 ***	1.0166 ***	1.0243 ***	1.0202 ***	1.0344 ***
	34.57	34.55	34.42	34.69	34.58	34.51
Diagnostic statistics:						
Adjusted R-squared	0.7851	0.7870	0.7928	0.7916	0.7963	0.7967
Schwartz Criterion	-12.5464	-12.5486	-12.5563	-12.5547	-12.5621	-12.5574
Durban-Watson	1.98	1.98	1.97	1.98	1.98	1.86

Significance levels: ***=1%, **=5%, and *=10%
Note: z-statistic is given beneath each coefficient.

Figure 6 – Conditional variance for GARCH (2,2)

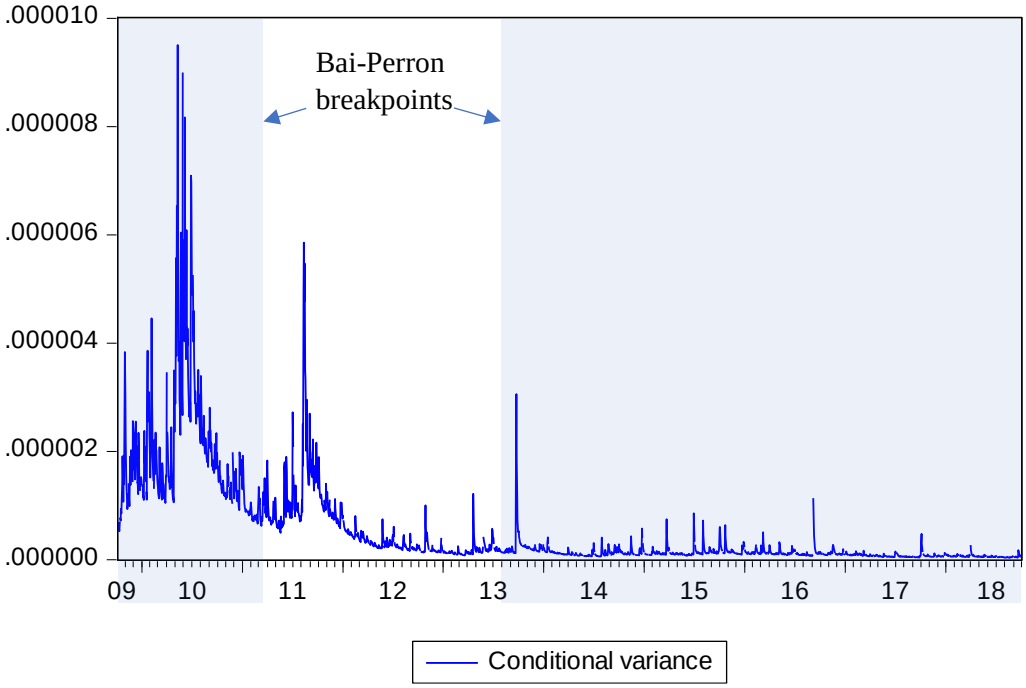
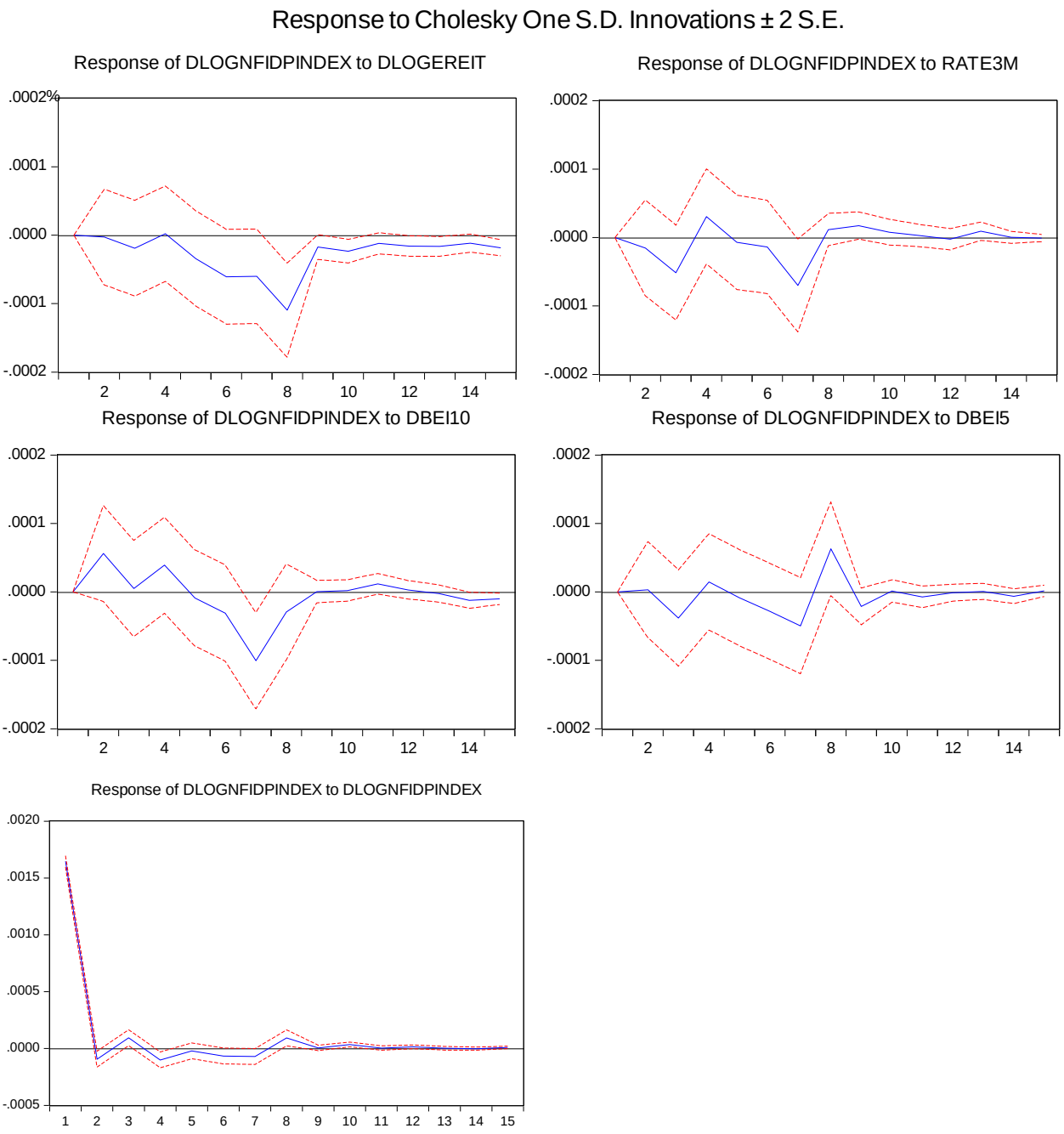


Figure 7 – Unaccumulated Impulse Response Functions over 10 days



Note: variation in the y-axis scale and DLOGNFIDPINDEX is the same as $\Delta logNFIDP$ in the text

Figure 8 – Bai-Perron breakpoint regressions

October 5, 2009 to March 15, 2011	# of observations	360
	ΔlogNFIDP	
DLOGNFIDPINDEX(-1)	0.0335	***
	3.33	
DLOGEREIT	0.1510	***
	82.09	
DBEI10	0.6987	***
	8.48	
RATE3M	1.1163	***
	15.60	
C	-0.0012	***
	-12.57	

March 16, 2011 to July 22, 2013	# of observations	587
	ΔlogNFIDP	
DLOGNFIDPINDEX(-1)	0.0391	***
	3.35	
DLOGEREIT	0.1291	***
	75.52	
DBEI10	0.2441	***
	3.46	
RATE3M	0.0438	
	0.66	
C	0.0003	***
	7.21	

July 23, 2013 to Sept 28, 2018	# of observations	1299
	ΔlogNFIDP	
DLOGNFIDPINDEX(-1)	0.0157	
	0.93	
DLOGEREIT	0.0883	***
	54.84	
DBEI10	0.0512	
	0.78	
RATE3M	-0.0049	**
	-2.11	
C	0.0003	***
	15.90	

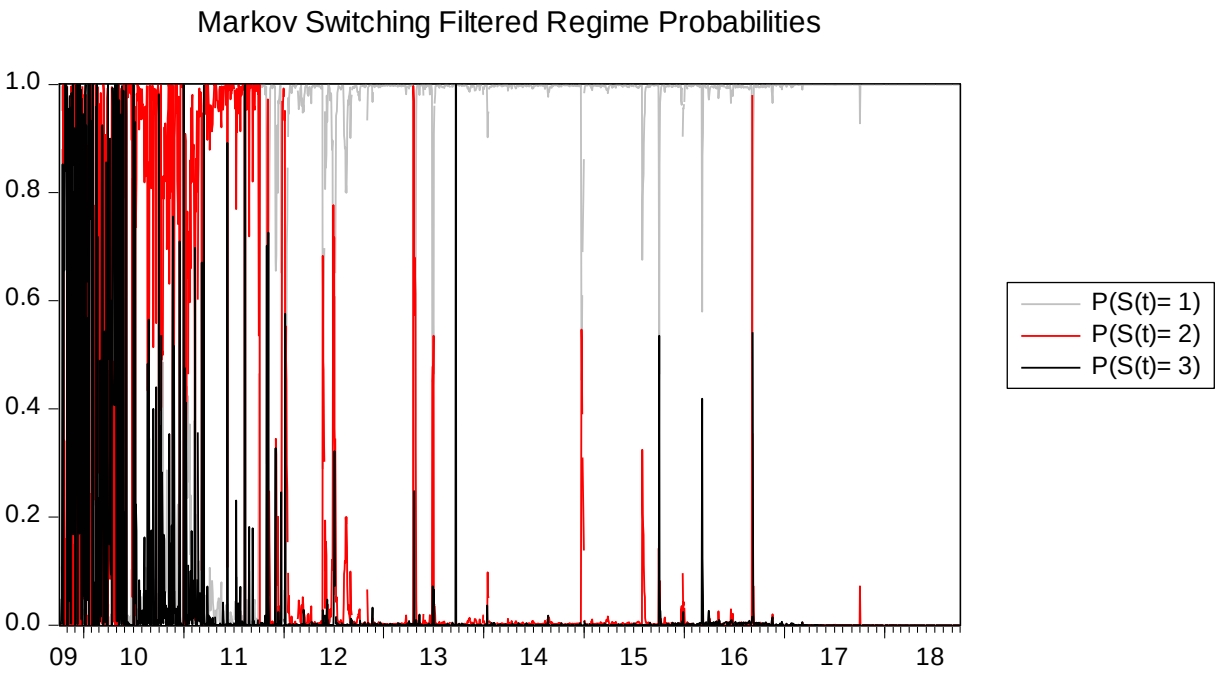
Diagnostic statistics:

Adjusted R-squared	0.8967
F-statistic	1,392.37
Schwarz criterion	-12.18
Durbin-Watson stat	1.87

Significance levels: ***=1%, **=5%, and *=10%

Note: t-statistic is given beneath each coefficient.

Figure 9 – Markov Switching regimes



Note: capital and real estate markets were already in a downturn when this series began in late 2009.

Figure 10 –Markov Switching regime transition probabilities and durations in days

Constant transition probabilities:
P(i, k) = P(s(t) = k | s(t-1) = i)
(row = i / column = j)

Regimes:

	Expansion	**Uncertain recovery**	**Downturn**
	1	**2**	**3**
1	0.9961	0.0013	0.0026
2	0.0115	0.8702	0.1182
3	0.0215	0.4049	0.5736

Constant expected durations:

Regimes:

	1	**2**	**3**
Days	257.3	7.7	2.3