Monetary Policy Regimes and Real Estate Prices

David Leather [1] Jacob Sagi [2]

[1] *Department of Economics*; UNC Chapel Hill

[2] *Kenan-Flagler Business School;* UNC Chapel Hill

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Introduction

Question

- Can we learn about monetary policy regime beliefs from real estate prices?
- If so, do real estate prices contain additional information than what can already be learned from the yield curve?

Future Approach

- Extend a partial equilibrium macro-finance model to price a certain class of real estate assets
- Jointly estimate macroeconomic dynamics, the yield curve, & real estate prices in a ML framework

Value

- Identifying monetary policy regime switches has never been more difficult
- Post-Great Recession interest in the real estate sector

What is a Monetary Policy Regime?

Taylor Rule

$$r_t = \alpha(s_t^m)\pi_t + \beta(s_t^m)g_t + \sigma\epsilon_t \tag{1}$$

r_t :: the federal funds rate in time period t

π_t :: inflation rate during time period t

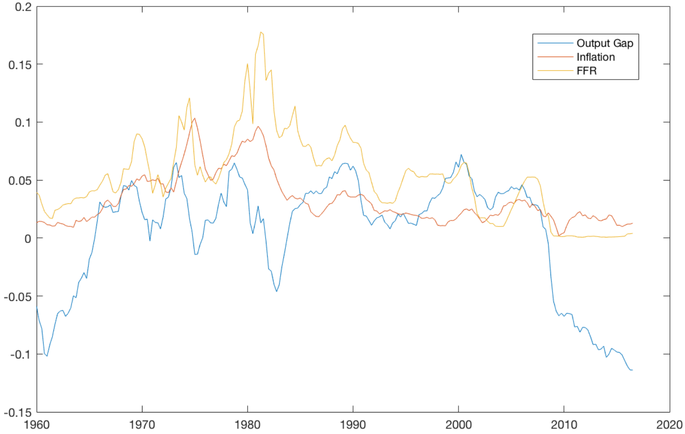
g_t :: the perceived output gap during time period t

$s_t^m \in \{1, 2\}$ :: the monetary policy regime

$\epsilon_t \sim$ *Gaussian*

- An **aggressive monetary policy regime** responds strongly to inflation ($\alpha \geq 1$)
- A **passive monetary policy regime** aggressively targets the output gap ($\alpha < 1$)

What Regime are We in Today?



Thought Experiment

Gordon Growth Model

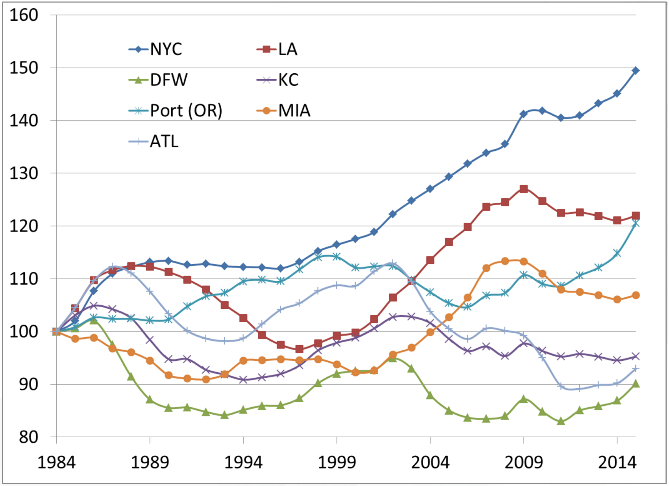
$$\frac{D}{P} = r - g \tag{2}$$

D :: dividend paid next period
P :: current price of asset
r :: constant cost of borrowing
g :: constant growth rate of dividends

Assume

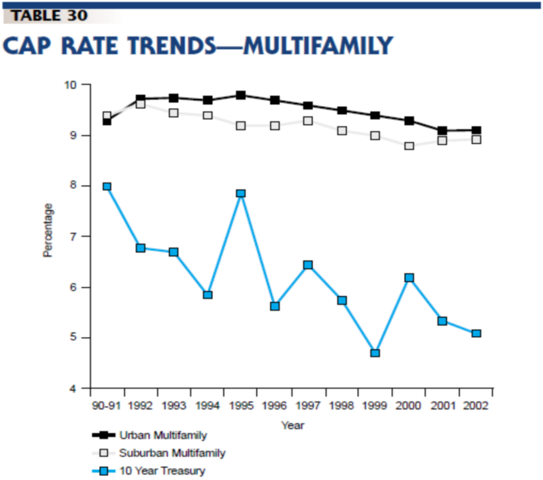
- $\rho(g, \pi) \approx 1$
- $\rho(r, \pi)$ is dependent on the monetary policy regime
  - If $s_t^m = 1$, $\rho(r, \pi) \approx 1 \Rightarrow \rho(\frac{D}{P}, \pi) \approx 0$
  - If $s_t^m = 2$, $\rho(r, \pi) \approx 0 \Rightarrow \rho(\frac{D}{P}, \pi) < 0$

Deflated Rent Index

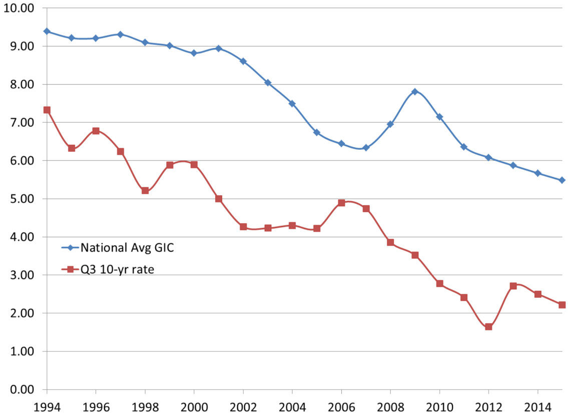


Source: St. Louis Fed

Cap Rate and Discount Rate: 1990 - 2002



Cap Rate and Discount Rate: 1994-2014



Bikbov & Chernov (2013, Journal of Econometrics)

- **Argues** "monetary policy regimes may not be estimated precisely if ones uses information from the short interest rate only"
- The **Expectations Hypothesis** (EH) states that long-term yields are dependent on current and expected future short-term yields
- EH $\Rightarrow$ long-term yields contain market expectations of current, and future monetary policy regimes
- **Finds** the econometrician's ex post regime probability through time resembles more of a binary process when including higher term yields than when not

Hidden State Dynamics

Three Binary Regime Variables

- s_t^m :: Monetary policy rule regime
- s_t^d :: Discretionary monetary policy regime
- s_t^e :: Real volatility regime

Transition Dynamics

- Each regime follows Markov process w/ transition matrix $\Pi^{(k)}$ for $k \in \{m, d, e\}$

$$\Pi_{(i,j)}^{(k)} := Pr(s_{t+1}^k = j | s_t^k = i) \tag{3}$$

- Equivalent to having single compound-regime variable, $S_t \in \{1, \ldots, 8\}$

Macroeconomic Dynamics

Structural Framework

$$g_t = m_g + (1-\mu_g)g_{t-1} + \mu_g \mathbb{E}_t g_{t+1} - \phi(r_t - \mathbb{E}_t \pi_{t+1}) \\ + \sigma_g(s_t^e)\epsilon_t^g$$

$$\pi_t = m_\pi + (1-\mu_\pi)\pi_{t-1} + \mu_\pi \mathbb{E}_t \pi_{t+1} + \delta g_t + \sigma_\pi(s_t^e)\epsilon_t^\pi$$

$$r_t = m_r(s_t^m) + (1-\rho(s_t^m))[\alpha(s_t^m)\mathbb{E}_t\pi_{t+1} + \beta(s_t^m)g_t] \\ + \rho(s_t^m)r_{t-1} + \sigma_r(s_t^d)\epsilon_t^r$$

$$\epsilon_t^k \sim^{iid} N(0,1)\ \forall t, \forall k \in \{m, d, e\}$$

Forward-Looking Rational Expectations Solution

$$x_t = \mu(S_t) + \Phi(S_t)x_{t-1} + \Sigma(S_t)\epsilon_t \tag{4}$$

Risk

Standard Preferences for Risk

- Affine risk preferences

$$\log M_{t,t+1} = -r_t - \frac{1}{2}\Lambda'_{t,t+1}\Lambda_{t,t+1} - \Lambda'_{t,t+1}\epsilon_{t,t+1} \quad (5)$$

$$\Lambda_{t,t+1} = \Sigma'(S_{t+1})(\Pi_0 + \Pi_x x_t) \quad (6)$$

- Volatility of state variable are priced
- Regime shifts are not priced directly

Bond Prices

The conditional price of an n-period face value bond

$$B_t^n(x_t, S_t) = \mathbb{E}^{\mathbb{Q}}[\exp\{-\sum_{i=0}^{n-1} r_{t+i}\}|x_t, S_t] \tag{7}$$

Let $\delta = (0,0,1)'$, then $r_t = \delta' x_t$ and Equation (7) is transformed:

$$B_t^n(x, i) = \mathbb{E}^{\mathbb{Q}}[\exp\{-\xi_{t,n}\}|x_t = x, S_t = i] \tag{8}$$

$$\xi_{t,n} := \delta' \sum_{i=0}^{n-1} x_{t+i} \tag{9}$$

Finally, via the characteristic function of the log-normal distribution the term structure is derived

$$Y_t^n(x, i) = -\frac{1}{n}\log(B_t^n(x, i)) = -\frac{1}{n}\sum_{k=1}^{\infty}\frac{(-1)^k}{k!}\mu_n^{(k)}(x, i) \tag{10}$$

Summary of Model Features

- Markov-Switching,
- Forward-Looking Rational Expectations,
- Macro-Finance Model of Macroeconomic Dynamics & the Yield Curve

Estimation Procedure

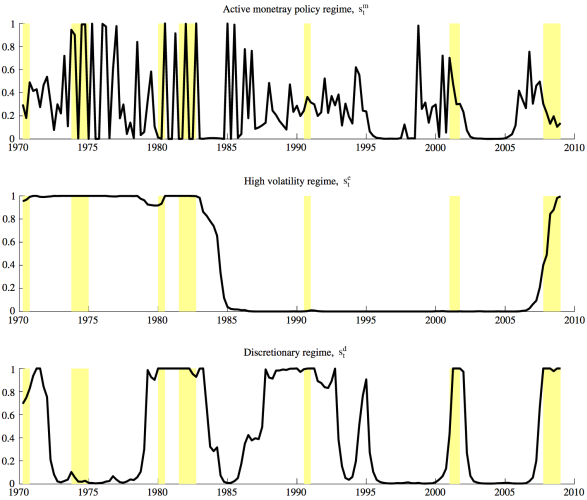
Maximum Likelihood

1. Draw 1,000,000 Sobol points from constrained parameter space
2. Evaluate each draw
3. Keep highest 10% of initial draw
4. Perform local optimization using each remaining draw of initial parameter guess

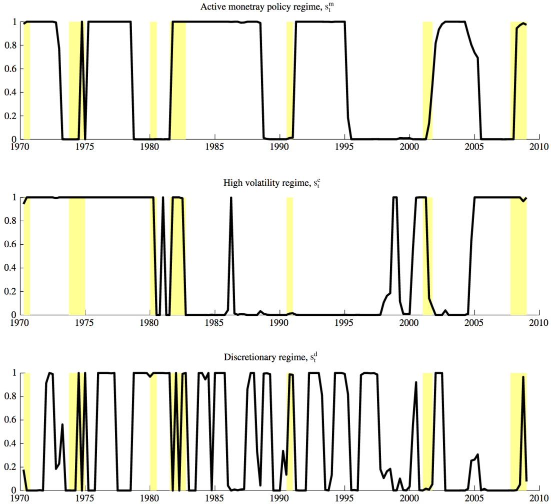
Highly Persistent Data

- Parametric bootstrap over 1,000 simulated data paths

Results


Active monetray policy regime, s_t^m
1
0.8
0.6
0.4
0.2
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
High volatility regime, s_t^e
Discretionary regime, s_t^d

Results



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Real Estate Model

Cap Rate

- Real estate is similar to equity in the sense that they are both assets with stochastic cash flows potentially in perpetuity

$$\hat{Q}_{i,t} = \eta_{i,t}(1 + \mathbb{E}_t^{\mathbb{Q}}[\hat{Q}_{i,t+1}]) \tag{11}$$

$$\eta_{i,t} = \exp\{\lambda_i' x_t\} \tag{12}$$

- (11) $\Rightarrow$

$$\begin{aligned} \hat{Q}_{i,t} &= \eta_{i,t} + \mathbb{E}^{\mathbb{Q}}[\eta_{i,t}\eta_{i,t+1}] + \mathbb{E}^{\mathbb{Q}}[\eta_{i,t}\eta_{i,t+1}\eta_{i,t+2}] + \ldots \\ &= \exp\{\lambda_i' x_t\} + \mathbb{E}^{\mathbb{Q}}[\exp\{\lambda_i'(x_t + x_{t+1})\}] \\ &+ \mathbb{E}^{\mathbb{Q}}[\exp\{\lambda_i'(x_t + x_{t+1} + x_{t+2})\}] + \ldots \end{aligned} \tag{13}$$

Simulation Methodology

Conditional Monte-Carlo

1. Conditioning on each initial regime and some state vector, simulate 1,000 time series under the risk-neutral dynamics using the parameter estimates from Bikbov & Chernov (2013, JOE)
2. Along each path, calculate realizations of each component of Equation (13), and the treasury yields
3. For each initial state, the average across paths at a given time is equivalent to its expectation under the risk-neutral dynamics conditional on the initial regime and state vector
4. Finally, calculate model approximates and compare

Results

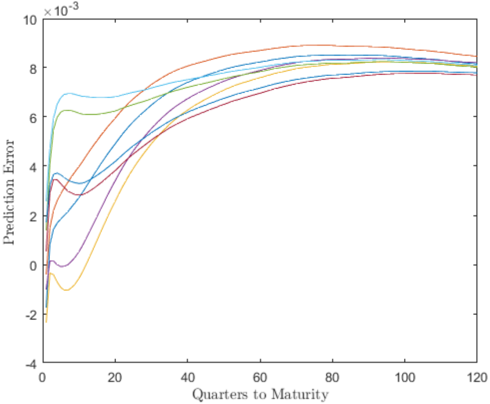

Figure: Simulated Yields - Model Implied Yields Across Regimes

Results

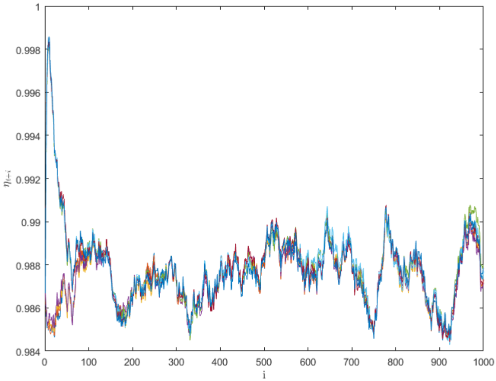

Figure: Simulated $\mathbb{E}^{\mathbb{Q}}[\eta_{t+i}|S_t = i, x_t = x]$

Results

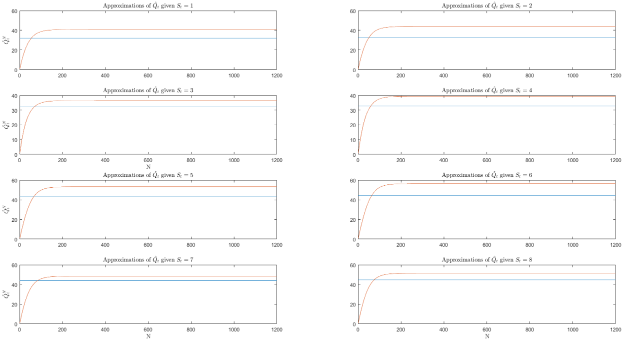

Figure: Simulated $\hat{Q}(S_t, x_t = x)$ (Blue) & Model Implied $\hat{Q}^N$ Using First N Terms

Current Challenges

Computational

- Likelihood function is costly to evaluate
- Slow convergence
- Feasibility of bootstrap
    - Metropolis-Hastings

Model Problems

- Approximation of cap. rate worse than yields
    - Approximate continuous state model in discrete state-space

Conclusion

- It is theoretically feasible that real estate prices contain information regarding current & future expected monetary policy regimes
- The idea has potential value to both policy makers and real estate investors who are interested in the feedback loop between monetary policy and the real estate cycle
- Properly estimating such a mechanism requires a model framework that justifies its complexity & computational challenges

Thought & Ideas?