Monetary Policy Regimes and Real Estate Prices

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November 17, 2016

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Introduction

Question

- Can real estate prices help us to learn about monetary policy regimes?

Approach

- Extend a partial equilibrium macro-finance model to price real estate assets
- Jointly estimate model of 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
- Possible implications for other asset classes

What is a Monetary Policy Regime?

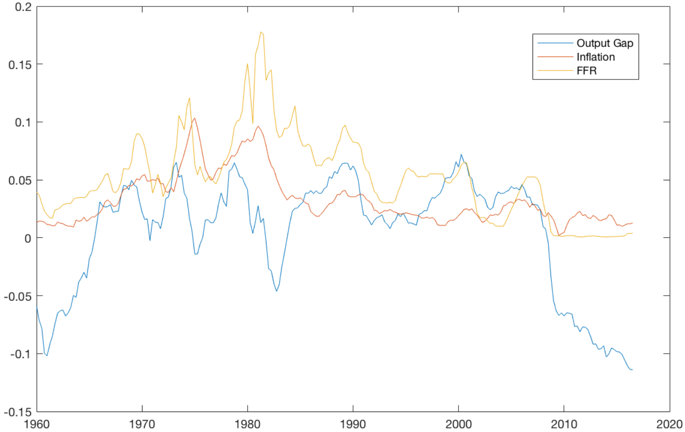
Taylor Rule

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

r_t :: target federal funds
π_t :: inflation measure
g_t :: perceived output gap
$s_t^m \in \{0, 1\}$ :: 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** does not respond strongly to inflation ($\alpha < 1$)

What Regime are We in Today?



Thought Experiment

Gordon Growth Model

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

D :: dividend

P :: price of asset

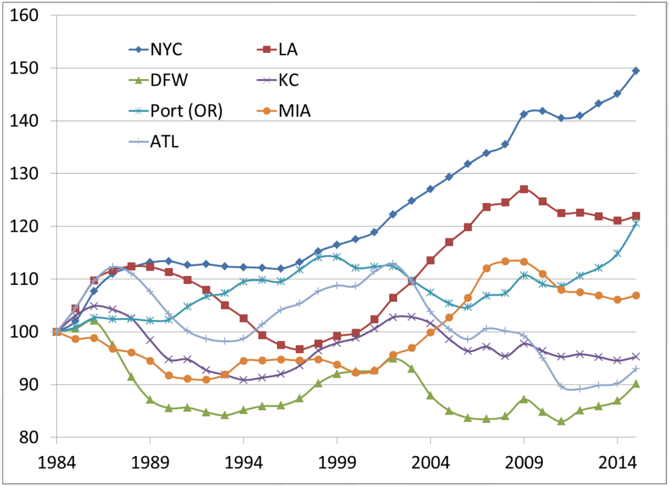
r :: cost of borrowing

g_d :: growth rate of dividends

Assume

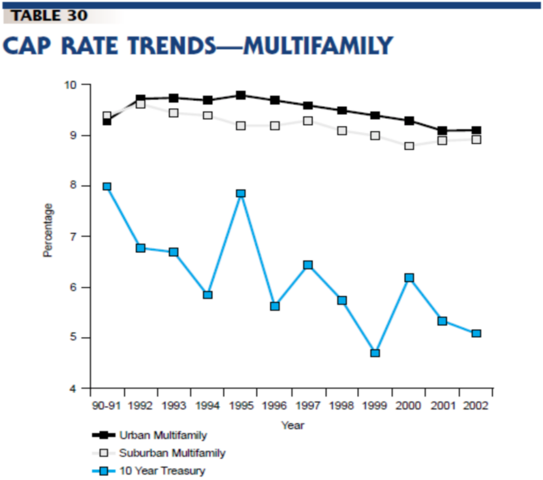
- $\rho(g_d, \pi) := corr(g_d, \pi) \approx 1$
- $\rho(r, \pi)$ is dependent on the monetary policy regime
  - If $s_t^m = 1$, $\rho(r, \pi) \approx 1 \Rightarrow \rho(\frac{D}{P}, \pi) \approx 0$
  - If $s_t^m = 0$, $\rho(r, \pi) \approx 0 \Rightarrow \rho(\frac{D}{P}, \pi) < 0$

Deflated Rent Index

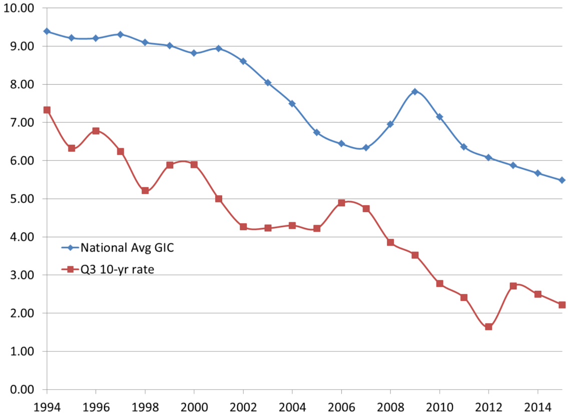


Source: St. Louis Fed

Cap Rate and Discount Rate: 1990 - 2002



Cap Rate and Discount Rate: 1994-2014



Model Check List

In order to empirically evaluate the proposed mechanism, we must build a model of. . .

1. Macroeconomic dynamics
   - Taylor rule
   - Forward-looking
   - Markov-switching
2. Term structure of interest rates
   - Affine term-structure model
3. Real estate prices
   - Macro factors
   - Local factors

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"
- Long-term yields are dependent on current and expected future short-term yields

$$r_t^n = [\Pi_{i=0}^{n-1}(1 + \mathbb{E}_t^{\mathbb{Q}}[r_{t+i}])]^{\frac{1}{n}} + rp_t^n + \epsilon_t \tag{3}$$

- (3) $\Rightarrow$ 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 $k \in \{m, d, e\}$

$$\Pi^{(k)}_{(i,j)} := Pr(s^k_{t+1} = j | s^k_t = i) \tag{4}$$

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

Macroeconomic Dynamics

Structural Framework

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

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

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

Forward-Looking Rational Expectations Solution

$$x_t = \mu(S_t) + \Phi(S_t)x_{t-1} + \Sigma(S_t)\epsilon_t \qquad (5)$$
$$s.t. \quad x_t = [g_t, \pi_t, r_t]'$$

Bond Prices & Yield Curve

The conditional price of an n-period face value bond

$$B_t^n(x_t, S_t) = \mathbb{E}^{\mathbb{Q}}[\exp\{-\sum_{i=0}^{n-1} r_{t+i}\}|x_t, S_t] \tag{6}$$

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

$$B_t^n(x, i) = \mathbb{E}^{\mathbb{Q}}[\exp\{-\xi_{t,n}\}|x_t = x, S_t = i] \tag{7}$$

$$\xi_{t,n} := \delta' \sum_{i=0}^{n-1} x_{t+i} \tag{8}$$

Finally, via the cumulant generating function the term structure is derived

$$r_t^n(x, i) = -\frac{1}{n}\log(B_t^n(x, i)) = -\frac{1}{n}\sum_{k=1}^{\infty}\frac{(-1)^k}{k!}\mu_n^{(k)}(x, i) \tag{9}$$

Takeaway

Model Features

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

Takeaway

- Econometrically equivalent to a MS-VAR(1), where the coefficient matrix is subject to non-linear constraints
- Lots of parameters, not so many covariates

Estimation Procedure

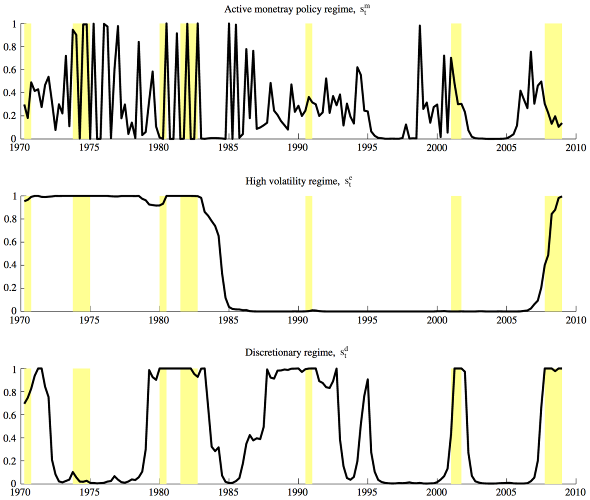
Maximum Likelihood

1. Draw 1,000,000 quasi-random 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

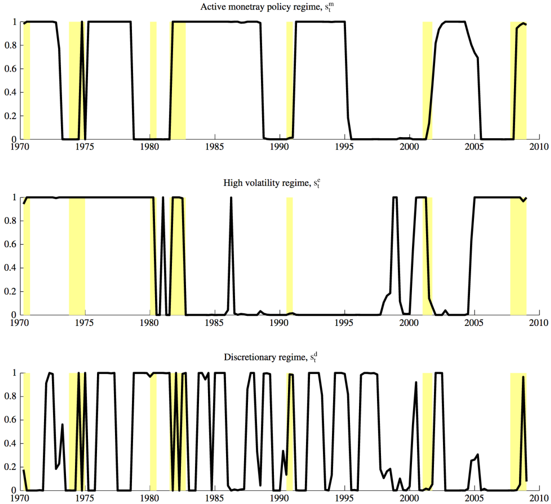
Highly Persistent Data

- Parametric bootstrap over 1,000 simulated data paths

Results: No Term Structure



Results: Term Structure Included



Real Estate Model

Cap Rate

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

$$\hat{Q}_{i,t} = \eta_{i,t}(1 + \mathbb{E}_t^{\mathbb{Q}}[\hat{Q}_{i,t+1}]) \tag{10}$$

$$\eta_{i,t} = \exp\{\lambda_i' x_t\} \tag{11}$$

- (12)-(13) $\Rightarrow$

$$\begin{aligned}\hat{Q}_{i,t} &= \eta_{i,t} + \mathbb{E}^{\mathbb{Q}}[\eta_{i,t}\eta_{i,t+1}] + \mathbb{E}^{\mathbb{Q}}[\eta_{i,t}\eta_{i,t+1}\eta_{i,t+2}] + \dots \\ &= \exp\{\lambda_i' x_t\} + \mathbb{E}^{\mathbb{Q}}[\exp\{\lambda_i'(x_t + x_{t+1})\}] \qquad (12) \\ &+ \mathbb{E}^{\mathbb{Q}}[\exp\{\lambda_i'(x_t + x_{t+1} + x_{t+2})\}] + \dots\end{aligned}$$

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 (14), and the treasury yields
3. For each initial state, the average across paths at a given time is an estimate of its expectation under the risk-neutral dynamics conditional on the initial regime and state vector
4. Finally, calculate model approximates and compare

Results: Simulated η

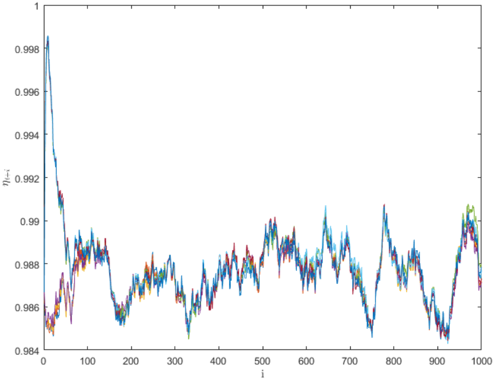


Figure: Simulated $\mathbb{E}^{\mathbb{Q}}[\eta_{t+i}|S_t = k, x_t = x]$

Results: Simulated $\hat{Q}$

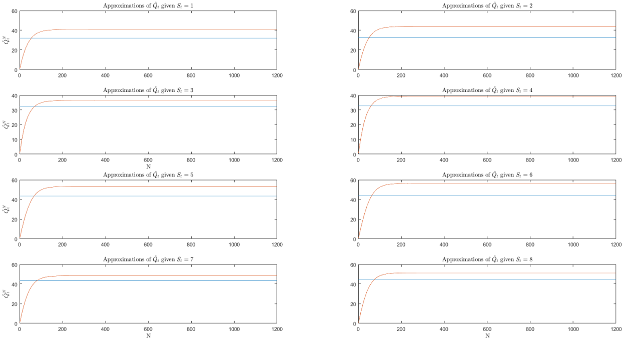


Figure: Simulated $\hat{Q}(S_t, x_t = x)$ (Blue) & Model Implied $\hat{Q}^N$ (Red) Using First N Terms

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
- Model is capable of producing significant variation based on the monetary policy regime alone

Thought & Ideas?