Monetary Policy and Commercial Real Estate Price Dynamics

David Leather and Jacob S. Sagi

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Commercial real estate (CRE) is RE held for rental income & capital gains

- Large investment asset class
- Not as well understood as other major asset classes (lack of data)
- E.g., A key pricing variable (cap rate) often viewed statically via the Gordon-Williams growth model:
  \[ \text{cap rate} = r - g \approx T10 + rp + lp - g \]
  - doesn’t hold up well to regression analysis
- Cap rates have been near historic lows. That has lots of folks worried.
The $10T question

What will happen to cap rates when interest rates “go back to normal?”
Correlations:

<table>
<thead>
<tr>
<th>Pre-1999Q3</th>
<th>r</th>
<th>r10</th>
<th>pi</th>
<th>g</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Post-1999Q3</th>
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<th>r10</th>
<th>pi</th>
<th>g</th>
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<tr>
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<td>-0.057</td>
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<td>cr</td>
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<td>0.586***</td>
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<tr>
<td>cm</td>
<td>-0.625**</td>
<td>-0.769***</td>
<td>-0.158***</td>
<td>-0.261</td>
</tr>
</tbody>
</table>

"stars" reject the null of unchanged correlations
* p<0.05, **p<0.01, ***p<0.001
The $10T$ question

What will happen to cap rates when interest rates “go back to normal?”

A Mickey-Mouse monetary policy (MP) theory....
Is NOI related to macro fundamentals?

NCREIF quarterly NOI

<table>
<thead>
<tr>
<th></th>
<th>Apt</th>
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<th>Off</th>
<th>Ret</th>
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<td>-0.49**</td>
<td>-0.77***</td>
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<td>g</td>
<td>0.59***</td>
<td>0.67***</td>
<td>0.66***</td>
<td>0.35***</td>
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<td>Adj R2</td>
<td>0.33</td>
<td>0.32</td>
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The problem with Mickey Mouse

Though one can test and find a structural break....

- A one data-point hind-insight
- If MP policy mattered, future policy changes would be baked into current prices
The problem with Mickey Mouse

Though one can test and find a structural break....

- A one data-point hind-insight
- If MP policy mattered, future policy changes would be baked into current prices
  - Need a dynamic REE

**Dynamic income has to be consistently capitalized to arrive at dynamic prices**
We employ a dynamic REE-consistent econometric specification where
This paper

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- Relationship between macro fundamentals can experience regime changes (Sims, 2001; Bianchi, 2013; Bikbov & Chernov, 2013)
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- Asset fundamentals depend on macro fundamentals
  - Allow for structural breaks here too
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We employ a dynamic REE-consistent econometric specification where

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- Asset fundamentals depend on macro fundamentals
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- Prices capitalize asset fundamentals
  - Discount rate depends on macro fundamentals
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In a joint estimation, we find evidence that

- CRE prices exhibit profound dependence on MP regime
- Key drivers appears to be income growth sensitivity to infl & output gap
This paper

Our structural model can be used to

- Analyze expected price dynamics given any initial conditions
- Assess impact of policy experiments
- Quantify risk and its sources
  - E.g., mortgage pricing and default risk
Who cares?

CRE size in context

- Household residential stock: $27T
- Business RE: $25T
- Potential institutional grade CRE: $9T
- CRE owned by investment institutions: $3T
- Apartment and non-resi CRE mortgages: $4T
- CRE loans vs. total loans for banks with < $10B in assets: 35%
- National crisis attributed to CRE: S&L Crisis
Who cares?

Key interested parties

- Regulators (e.g., the Fed)
- Banks (especially small & regional banks)
- Large investors (especially in the "Alt" space)
- Consumers
  - Residential rents and rental inventory are linked to owned owner-occupied stock and valuation
- Firms
  - RE makes up a significant part of tangible collateral in their capital base (Tuzel, 2010; Cvijanovic, 2014)

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Bikbov-Chernov (2013): Regime switching REE-consistent model of macro fundamentals

\( g_t = \) output gap; \( \pi_t = \) inflation rate; \( r_t = 3m \) rf-rate

\( \varepsilon_t^i \sim iid \ N(0, 1) \), \( s^m_t \) \& \( s^d_t \) MP regimes (each 2-state Markov, indep).
Model: Macroeconomic Dynamics

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(IS) \[ g_t = m_g + (1 - \mu_g)g_{t-1} + \mu_g \mathbb{E}_t g_{t+1} - \phi(r_t - \mathbb{E}_t \pi_{t+1}) + \sigma_g \varepsilon^g_t \]

(PC) \[ \pi_t = m_\pi + (1 - \mu_\pi)\pi_{t-1} + \mu_\pi \mathbb{E}_t \pi_{t+1} + \delta g_t + \sigma_\pi \varepsilon^\pi_t \]

(MP) \[ r_t = m_r(s^m_t) + \rho(s^m_t)r_{t-1} + \hat{\alpha}(s^m_t)\mathbb{E}_t \pi_{t+1} + \hat{\beta}(s^m_t)g_t + \sigma_r(s^d_t)\epsilon^r_t \]
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\( \Rightarrow \) VAR with constraints: \( x_t = (g_t, \pi_t, r_t), \)

\[ x_t = m(S_t) + \Phi(S_t)x_{t-1} + \Sigma(S_t)\varepsilon_{t+1}, \]
Asset fundamentals

Five assets: Stock market & four real estate categories.
Asset fundamentals

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Asset $j$ has **expected** income growth rate:

$$\nu_{j,t} = a_j(\omega^j_t) + \gamma_{j,\pi}(\omega^j_t)\pi_t + \gamma_{j,g}(\omega^j_t)g_t + u_{j,t},$$

$$u_{j,t} \sim N(0, \sigma_j(\omega^j_t)), \text{ indep of } \varepsilon_t \text{’s}$$

$\omega^j_t$ an asset-specific regime (2-state Markov, indep)
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$\omega^j_t$ an asset-specific regime (2-state Markov, indep)

For the four real estate assets: $\omega^j_t \equiv \omega^{re}_t$, and

$$u_{j,t} = w_{j,t} + \sigma_j Z(\omega^{re}_t)Z_t, \quad j \in \{A, I, O, R\},$$

$w_{j,t}, Z_t, u_m = \text{market}$ uncorrelated
Asset pricing

Under the $\mathbb{Q}$-measure:

$$x_t^Q = m^Q(S_t) + \Phi^Q(S_t)x_{t-1} + \Sigma(S_t)\varepsilon_t^Q,$$

(1)

where

$$m^Q(S_t) = m(S_t) - \Sigma(S_t)\Sigma'(S_t)\Pi_0$$

$$\Phi^Q(S_t) = \Phi(S_t) - \Sigma(S_t)\Sigma'(S_t)\Pi_x,$$

and

$$\nu_{j,t}^Q = a_j(\omega_t^j) + \gamma_{j,\pi}(\omega_t^j)\pi_t^Q + \gamma_{j,g}(\omega_t^j)g_t^Q - \ell_j(\omega_t^j) + u_{j,t}^Q,$$

Mkt: $\ell_j(\omega_t^j) = \lambda_m \sigma_{m,u}(\omega_t^m); \quad$ RE: $\ell_j(\omega_t^j) = \lambda_Z \sigma_{j,\omega_t^{re}}.$
Asset pricing: Sneaky stuff

Only shocks to expected growth rates of income are priced.

I.e., **level shocks to income are not priced**

This is consistent with the long-run risk literature:

\[
\mathbb{E}_t\left[\frac{D_{t+1}}{D_t}\right] = \mathbb{E}_t^Q\left[\frac{D_{t+1}}{D_t}\right] = e^{\nu_t}.
\]
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Consequently:

\[ PV_t \left[ \{ D_{\tau} \}_{\tau=t+1}^N \right] = D_t \sum_{\tau=t+1}^{N} \mathbb{E}_t^Q \left[ e^{\sum_{s=t}^{\tau-1} (\nu_s - r_s)} \right]. \]

and the (presumably stationary) price-to-earnings ratio (inverse “cap rate”) is:

\[ Q_t \equiv \frac{PV_t \left[ \{ D_{\tau} \}_{\tau=t+1}^N \right]}{D_t} = \sum_{\tau=t+1}^{N} \mathbb{E}_t^Q \left[ e^{\sum_{s=t}^{\tau-1} (\nu_s - r_s)} \right]. \]
Observable vs model variables

We observe:

- With measurement error $\nu_{j,t}, Q_{j,t}, B_{t,\tau}$
  - 3 bond time series (2-, 5-, 10-yr ZCBs)
  - 5 income & 5 cap rate time series
- Without measurement error (assumption): $x_t = (g_t, \pi_t, r_t)$
  - 3 times series
- We must filter: $s_t^m, s_t^d, \omega_t^{re}, \omega_t^m$
Observable vs model variables

We observe:

- With measurement error $\nu_{j,t}, Q_{j,t}, B_{t,T}$
  - 3 bond time series (2-, 5-, 10-yr ZCBs)
  - 5 income & 5 cap rate time series
- Without measurement error (assumption): $x_t = (g_t, \pi_t, r_t)$
  - 3 times series
- We must filter: $s_{t,m}, s_{t,d}, \omega_{t, re}, \omega_{t,m}$

We calculate:

- $\hat{Q}_{j,t}$ (approximately)
- Bond prices
Table 3: Model parameters. The macro fundamentals are modeled as in Bikbov and Chernov (2013). There are two monetary policy regime variables: \( s_m \) corresponding to a passive versus active policy, and \( s_d \) corresponding to whether the monetary authorities are “Flexible” or “Rigid” about adhering to their smoothed policy targets. We consider four real estate asset categories: Apartments (A), Industrial (I), Office (O), and Retail (R) and the stock market (m). Asset cash flow expected growth rates are modeled as

\[
\nu_{j,t} = a_j(\omega_{j,t}) + \gamma_{j,\pi}(\omega_{j,t})\pi_t + \gamma_{j,g}(\omega_{j,t})g_t + u_{j,t}.
\]

Income dynamics can shift between two sets of parameters. The shift is driven by the regime variable \( \omega_{re} \) for real estate assets and regime variable \( \omega_{mkt} \) for the stock market.

<table>
<thead>
<tr>
<th>Parameter symbol</th>
<th># parameters</th>
<th>Notes</th>
</tr>
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<tbody>
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<td><strong>macro fundamentals</strong></td>
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<tr>
<td>( m_i )</td>
<td>2</td>
<td>drift ((i = g, \pi))</td>
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<tr>
<td>( \mu_i )</td>
<td>2</td>
<td>smoothing ((i = g, \pi))</td>
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<td>( \phi )</td>
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<td>output gap response to real cost of capital</td>
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<td>( \sigma_i )</td>
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<td>shock volatility ((i = g, \pi))</td>
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<td>( \delta )</td>
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<td>Prob((s^m</td>
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<td>Prob((s^d</td>
<td>s^d))</td>
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<td>( m_r(s^m) )</td>
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<td>( \rho(s^m) )</td>
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<td>drift risk-adjustment ((ii' = gg, \pi\pi, rr, \pi r, gr))</td>
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<td>Prob((\omega^{re}</td>
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<td>Prob((\omega^{mkt}</td>
<td>\omega^{mkt}))</td>
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<td>( \gamma_{j,\pi}(\omega) )</td>
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<td>asset income inflation sensitivity ((j = A, I, O, R, m))</td>
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<td>( \gamma_{j,g}(\omega) )</td>
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<td>asset income output gap sensitivity ((j = A, I, O, R, m))</td>
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<td>( \sigma_{j,W}(\omega^{re}) )</td>
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<td>real estate income idiosyncratic volatility ((j = A, I, O, R))</td>
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<td>( \sigma_{j,Z}(\omega^{re}) )</td>
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<td>real estate income common shock volatility ((j = A, I, O, R))</td>
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<td>( \sigma_{m,u}(\omega^{mkt}) )</td>
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<td>market income volatility ((j = A, I, O, R)) (net of macro fundamentals)</td>
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<td>pricing (measurement) error in asset ((j = A, I, O, R, m))</td>
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<td>( \sigma_{j,\nu} )</td>
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<td>measurement error in expected asset income growth ((j = A, I, O, R, m))</td>
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<td>( \lambda_Z )</td>
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<td>real estate risk Sharpe ratio (net of macro fundamentals)</td>
</tr>
<tr>
<td>( \lambda_m )</td>
<td>1</td>
<td>market risk Sharpe ratio (net of macro fundamentals)</td>
</tr>
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</table>
Estimation approach

Maximum likelihood

- Omit 2006-2008 for RE prices
- Omit 2009q1-q2 for stock market income/prices

Simulate $10^6$ points inside a hypercube of parameter space
Evaluate log-likelihood function at each point
Find local stationarity-constrained optima near top 1000 points
Select highest local optimum
Bootstrap confidence interval
Data

- Real Estate: NCREIF
  - NPI Assets
  - Categorized as: Apartments, Industrial, Office, Retail
  - Aggregated quarterly NOI growth, market values
- Stock market: Datastream I/B/E/S 12m-Fwd aggregate earnings and PE ratio
- Bond market: Fama-Bliss 3m, 2yr, 5yr, 10yr ZCBs
- Output gap: Hodrick-Prescott filter using real quarterly GDP
- Inflation: Annual log change of personal consumption expenditures
Results

We estimate four versions of the model (report only first three)

- Only assets are bonds (TSM)
- Add apartments, but force RE regime to coincide with $s_t^{m_0}$ (CAP(Apts)_0)
- Allow RE regime to be independent of $s_t^{m_1}$ (CAP(Apts)_1)
- Similar to last, but use all five assets ($4 \times RE + Mkt$)
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Let’s look at

- Estimated regimes
- Fit to asset prices
Fig. 3: Smoothed regime probabilities for the TSM and CAP(Apts)\_1 models. The smoothed probabilities for the CAP(Apts)\_0 are very close to those of the TSM model.
Fig. 4: Depiction of the CAP(Apts) model fit to the data. We exclude real state cap rate data from 2006q1-2008q4 in our estimation.
Fig. 5: Depiction of the CAP(Apts) model fit to the data. We exclude real state cap rate data from 2006q1-2008q4 in our estimation.
Fig. 6: Depiction of a preliminary full model fit to the data. We exclude real state cap rate data from 2006q1-2008q4 and exclude stock market data from 2009q1 and 2009q2 in our estimation.
Model predictions

The model is ready-made for

- Analyzing price dynamics in the various regimes
- Assessing impact of changing monetary policy regimes
- Quantitative risk analysis
Regime dynamics: CAP(Apts) model

In each of 8 compound regimes: $s^m \times s^{re} \times s^m$

- Calculate the mean and variance of macro variables ($x$) conditional only on being in regime
- Draw $x$ from each distribution 10,000 times and calculate each $Q(x)$
- Find median $Q$ and corresponding $x$
- Use as starting point & simulate evolution over 10 years
- Track: Average $Q$ (cap rate), income growth, price appreciation
### Table 7: Parameter estimates: Asset-market income parameters.

The CAP(Apts) estimates incorporate apartment income and prices with parameters that can vary with the monetary policy regime. The CAP(Apts) estimates instead allow for real estate coefficient to vary with an independent regime. In both CAP(Apts), the real estate shock risk premium is set to zero. An active (passive) MP regime is denoted by "A" ("P"). A high (low) real estate inflation sensitive regime is denoted by "H" ("L").

<table>
<thead>
<tr>
<th>Regime</th>
<th>$g$</th>
<th>$\pi$</th>
<th>$r$</th>
<th>$ZCB_{10}$</th>
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<tr>
<td>PLR</td>
<td>4.95</td>
<td>4.31</td>
<td>3.93</td>
<td>7.85</td>
<td></td>
</tr>
</tbody>
</table>

### Table 8: Model imputed statistics for macro economic fundamentals.

Each row corresponds to a different regime. There are four monetary policy regimes (Active/Passive and Flexible/Rigid) and two real estate regimes (High/Low prices). For each regime, the expected value of the macro state variables is calculated as well as the yield on a ten-year zero-coupon bond (ZCB). All units are annualized percentage points.

<table>
<thead>
<tr>
<th>Regime</th>
<th>$g$</th>
<th>$\pi$</th>
<th>$r$</th>
<th>$ZCB_{10}$</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHF</td>
<td>-1.81</td>
<td>-0.63</td>
<td>4.63</td>
<td>6.64</td>
<td></td>
</tr>
<tr>
<td>AHR</td>
<td>-2.57</td>
<td>2.11</td>
<td>4.88</td>
<td>7.13</td>
<td></td>
</tr>
<tr>
<td>ALF</td>
<td>3.47</td>
<td>1.93</td>
<td>4.86</td>
<td>8.29</td>
<td></td>
</tr>
<tr>
<td>ALR</td>
<td>2.67</td>
<td>1.65</td>
<td>4.86</td>
<td>6.92</td>
<td></td>
</tr>
<tr>
<td>PHF</td>
<td>-1.76</td>
<td>1.02</td>
<td>3.24</td>
<td>6.67</td>
<td></td>
</tr>
<tr>
<td>PHR</td>
<td>-4.33</td>
<td>2.01</td>
<td>3.49</td>
<td>6.17</td>
<td></td>
</tr>
<tr>
<td>PLF</td>
<td>4.21</td>
<td>3.76</td>
<td>3.87</td>
<td>8.73</td>
<td></td>
</tr>
<tr>
<td>PLR</td>
<td>4.95</td>
<td>4.31</td>
<td>3.93</td>
<td>7.85</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 7: Estimated model dynamics of real estate prices and fundamentals. The blue circles, gray squares, and dashed line correspond, respectively, to expected apartment cap rates, quarterly income growth and quarterly price appreciation. Each period represents one quarter. Quarter 0 is initialized to the expected value of macro-fundamentals conditional on the regime.

(a) MP Regimes: Active, Flexible. RE Regime: High.

(b) MP Regimes: Active, Rigid. RE Regime: High.

(c) MP Regimes: Active, Flexible. RE Regime: Low.

(d) MP Regimes: Active, Rigid. RE Regime: Low.
Fig. 8: Estimated model dynamics of real estate prices and fundamentals. The blue circles, gray squares, and dashed line correspond, respectively, to expected apartment cap rates, quarterly income growth and quarterly price appreciation. Each period represents one quarter. Quarter 0 is initialized to the expected value of macro-fundamentals conditional on the regime.

(a) MP Regimes: Passive, Flexible. RE Regime: High.

(b) MP Regimes: Passive, Rigid. RE Regime: High.

(c) MP Regimes: Passive, Flexible. RE Regime: Low.

(d) MP Regimes: Passive, Rigid. RE Regime: Low.
Impact of regime changes

Same procedure as before, but....

- At $t = 1$, force a regime change (flip one of $s^m$, $s^{re}$ or $s^m$)
- Proceed as before
(a) MP Regimes: Active, Flexible. RE Regime: High.

(b) MP Regimes: Active, Rigid. RE Regime: High.

(c) MP Regimes: Active, Flexible. RE Regime: Low.

(d) MP Regimes: Active, Rigid. RE Regime: Low.
Fig. 10: Quarterly (apartment) cap rate dynamics following a regime shock. The initial (quarter 0) regime is denoted in each subfigure title and initialized to the expected value of macro-fundamentals conditional on that regime. The regime is then "shocked" into making a single switch (one of (A)ctive $\leftrightarrow$ (P)assive monetary policy, (H)igh RE pricing $\leftrightarrow$ (L)ow RE pricing, or (F)lexible $\leftrightarrow$ (R)igid monetary policy). The blue circles connected by a line corresponds to the case where a regime shock was not forced in the first quarter.

(a) MP Regimes: Passive, Flexible. RE Regime: High.

(b) MP Regimes: Passive, Rigid. RE Regime: High.

(c) MP Regimes: Passive, Flexible. RE Regime: Low.

(d) MP Regimes: Passive, Rigid. RE Regime: Low.
Quantitative risk analysis

Regional banks have significant exposure to CRE through lending

- If RE income is uncorrelated with interest rates then rising rates mean lower collateral value
- If RE income is correlated with interest rates (via inflation) then effect above is moderated
- We can estimate collateral value as a function of macro fundamentals and regime
- Example: Assess impact of MP on mortgage spreads
  - Initialize regimes as before
  - Simulate zero-coupon 10-year mortgage payoffs at various LTVs
(a) MP Regimes: Passive/Active, Flexible/Rigid. RE Regime: High.

(b) MP Regimes: Passive/Active, Flexible/Rigid. RE Regime: Low.
Conclusions & remaining work

- Conclusions

MP has profound impact on RE prices

Structural breaks are important

Need more than canned term-structure model of interest rates

Joint estimation of prices & fundamentals can

Better pin down noisy proxies for variables with slow-moving trends

Clarify relationship between asset prices and asset + macro fundamentals

Remaining work

Polish estimation methodology

Explore different proxies for RE fundamentals

Other suggestions?

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Conclusions & remaining work

Conclusions

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Remaining work

- Polish estimation methodology
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Conclusions & remaining work

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