Monetary Policy and Commercial Real Estate Price Dynamics

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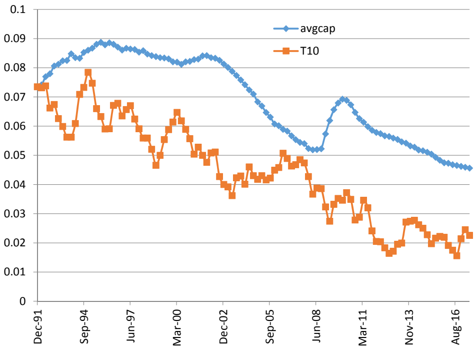
The \$10T question

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:
  - 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:

Pre-1999Q3				
	r	r10	pi	g
ca	0.444	-0.034	-0.017	-0.657
ci	0.604	-0.006	-0.044	-0.696
co	0.496	0.067	0.118	-0.608
cr	0.681	-0.575	-0.825	-0.339
cm	-0.06	0.706	0.772	-0.274
r		0.02	-0.442	-0.396
r10			0.669	0.089
pi				-0.098
Post-1999Q3				
	r	r10	pi	g
ca	0.404	0.617**	-0.127	-0.164**
ci	0.285	0.603**	-0.137	-0.358*
co	0.259	0.57*	-0.057	-0.362
cr	0.299*	0.586***	-0.12***	-0.302
cm	-0.625**	-0.769***	-0.158***	-0.261
r		0.801***	0.576***	0.643***
r10			0.299*	0.294
pi				0.606***

"stars" reject the null of unchanged correlations

* p<0.05, **p<0.01, ***p<0.001

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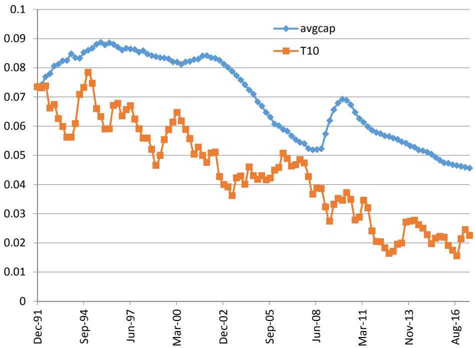

A Mickey-Mouse monetary policy (MP) theory....

Is NOI related to macro fundamentals?

NCREIF quarterly NOI

1992-2016	Apt	Ind	Off	Ret
pi	0.11	-0.49**	-0.77***	0.04
g	0.59***	0.67***	0.66***	0.35***
Adj R2	0.33	0.32	0.25	0.19

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- 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

This paper

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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: $\sim$ \$27T
- Business RE: $\sim$ \$25T
- Potential institutional grade CRE: $\sim$ \$9T
- CRE owned by investment institutions: $\sim$ \$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

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- 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)

Model: Macroeconomic Dynamics

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

g_t = output gap; π_t = inflation rate; r_t = 3m rf-rate

$\varepsilon_t^i \sim^{iid} N(0,1)$, s_t^m & s_t^d MP regimes (each 2-state Markov, indep).

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

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

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

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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.

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

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$u_{j,t} \sim N\big(0, \sigma_j(\omega_t^j)\big)$, indep of ε_t's

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For the four real estate assets: $\omega_t^j \equiv \omega_t^{re}$, and

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

$w_{j,t}, Z_t, u_{m=\text{market}}$ uncorrelated

Asset pricing

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

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

where

$$\begin{aligned} m^{\mathbb{Q}}(S_t) =& m(S_t) - \Sigma(S_t)\Sigma'(S_t)\Pi_0 \\ \Phi^{\mathbb{Q}}(S_t) =& \Phi(S_t) - \Sigma(S_t)\Sigma'(S_t)\Pi_x, \end{aligned}$$

and

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

Mkt: $\ell_j(\omega_t^j) = \lambda_m \sigma_{m,u}(\omega_t^m)$; RE: $\ell_j(\omega_t^j) = \lambda_Z \sigma_{j,W}(\omega_t^{re})$.

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:

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

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Consequently:

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

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

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

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: $s_t^m, s_t^d, \omega_t^{re}, \omega_t^m$

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We calculate:

- $\hat{Q}_{j,t}$ (approximately)
- Bond prices

Parameter symbol	# parameters	Notes
macro fundamentals	30	
m_i	2	drift $(i = g, \pi)$
μ_i	2	smoothing $(i = g, \pi)$
ϕ	1	output gap response to real cost of capital
σ_i	2	shock volatility $(i = g, \pi)$
δ	1	inflation reaction to output gap
$\text{Prob}(s^m \| s^m)$	2	probability of staying in current regime (s^m=Passive or Active)
$\text{Prob}(s^d \| s^d)$	2	probability of staying in current regime (s^d=Flexible or Rigid)
$m_r(s^m)$	2	regime-dependent rate drift
$\rho(s^m)$	2	regime-dependent rate smoothing
$\hat{\alpha}(s^m)$	2	regime-dependent rate response to inflation
$\hat{\beta}(s^m)$	2	regime-dependent rate response to output gap
$\sigma_r(s^d)$	2	regime-dependent rate deviation from smoothed target
σ_y	1	pricing (measurement) error in bond yields
$\Pi_{0,i}$	2	static risk premia $(i = g, r)$
$\Pi_{x,ii'}$	5	drift risk-adjustment $(ii' = gg, \pi\pi, rr, \pi r, gr)$
asset fundamentals	64	
$\text{Prob}(\omega^{re} \| \omega^{re})$	2	Probability of staying in current RE regime
$\text{Prob}(\omega^{mkt} \| \omega^{mkt})$	2	Probability of staying in current market regime
$a_j(\omega)$	10	asset income drift $(j = A, I, O, R, m)$
$\gamma_{j,\pi}(\omega)$	10	asset income inflation sensitivity $(j = A, I, O, R, m)$
$\gamma_{j,g}(\omega)$	10	asset income output gap sensitivity $(j = A, I, O, R, m)$
$\sigma_{j,W}(\omega^{re})$	8	real estate income idiosyncratic volatility $(j = A, I, O, R)$
$\sigma_{j,Z}(\omega^{re})$	8	real estate income common shock volatility $(j = A, I, O, R)$
$\sigma_{m,u}(\omega^{mkt})$	2	market income volatility $(j = A, I, O, R)$ (net of macro fundamentals)
$\sigma_{j,Q}$	5	pricing (measurement) error in asset $(j = A, I, O, R, m)$
$\sigma_{j,\nu}$	5	measurement error in expected asset income growth $(j = A, I, O, R, m)$
λ_Z	1	real estate risk Sharpe ratio (net of macro fundamentals)
λ_m	1	market risk Sharpe ratio (net of macro fundamentals)

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 (CAP(Apts)$_0$)
- Allow RE regime to be independent of s_t^m (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
-

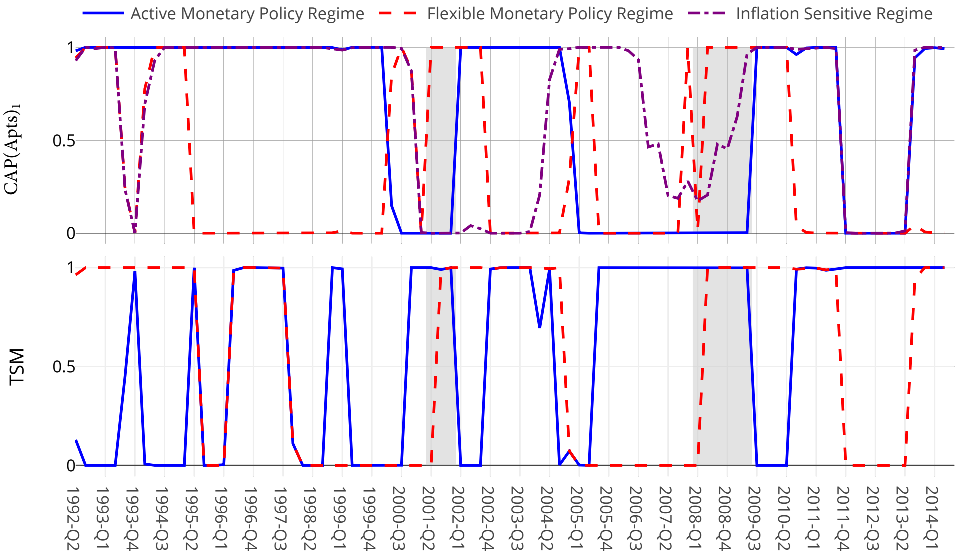


Fig. 3: Smoothed regime probabilities for the TSM and CAP(Apts)_1 models. The smoothed probabilities for the CAP(Apts)_0 are very close to those of the TSM model.

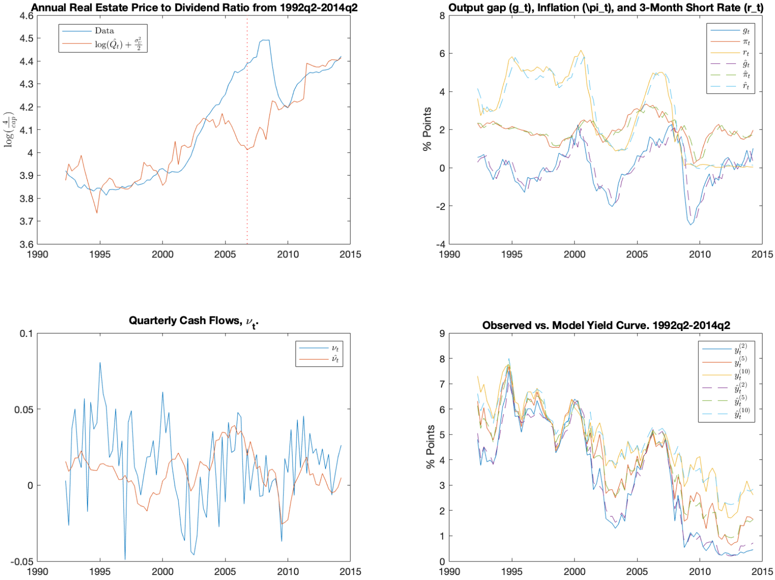


Fig. 4: Depiction of the CAP(Apts)$_0$ model fit to the data. We exclude real state cap rate data from 2006q1-2008q4 in our estimation.

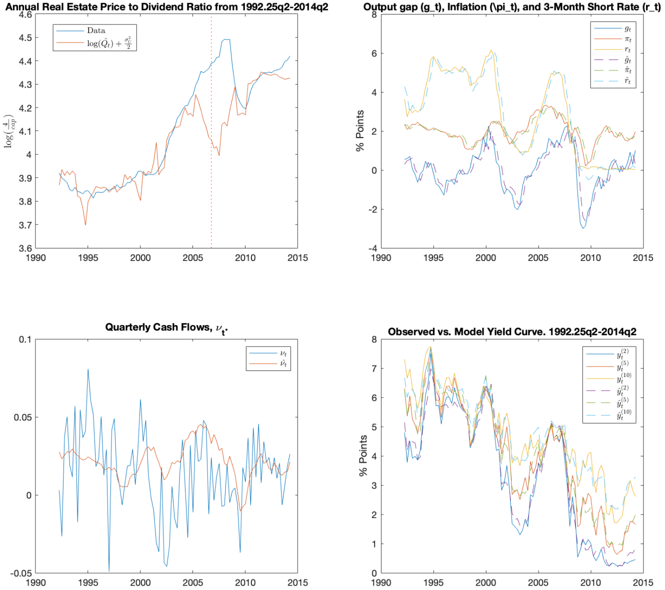


Fig. 5: Depiction of the CAP(Apts)$_1$ model fit to the data. We exclude real state cap rate data from 2006q1-2008q4 in our estimation.

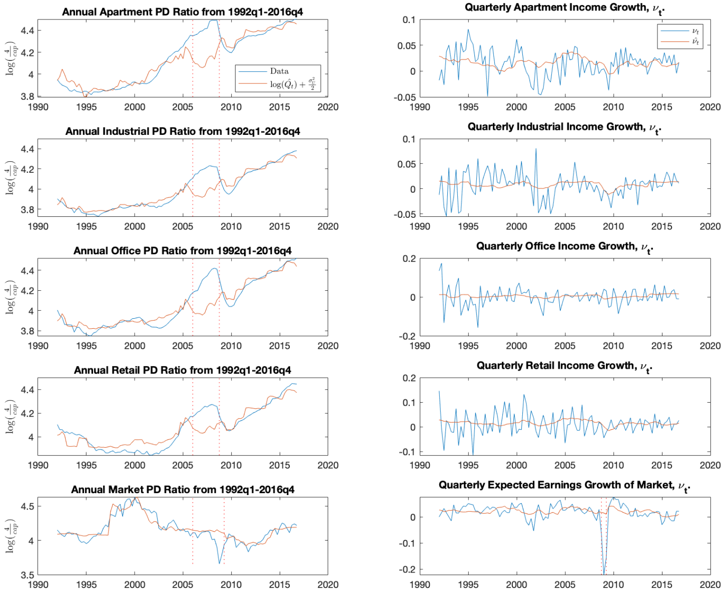


Fig. 6: Depiction of a preliminary full model fit to the data. We exclude real state cap rate data from 2006q1-2008q4 and exclude stock market data from 2009q1 and 2009q2 in our estimation.

Model predictions

The model is ready-made for

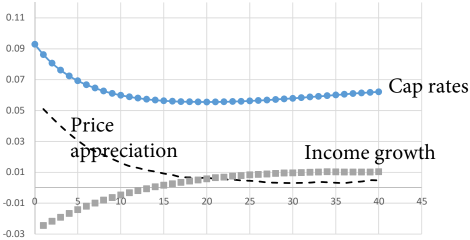
- Analyzing price dynamics in the various regimes
- Assessing impact of changing monetary policy regimes
- Quantitative risk analysis

Regime dynamics: CAP(Apts)$_1$ model

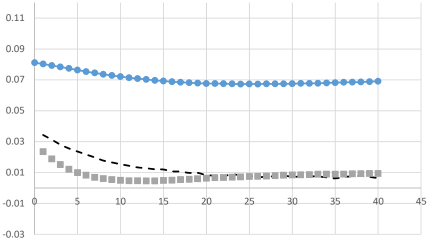
In each of 8 compound regimes: $s^m \times s^{re} \times s^m$

- 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

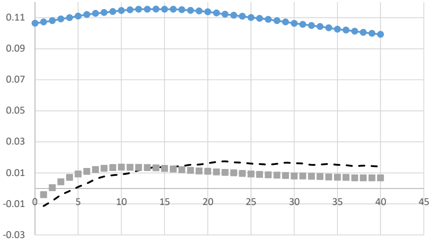
Regime	g	π	r	ZCB_{10} Yield
AHF	-1.81	-0.63	4.63	6.64
AHR	-2.57	2.11	4.88	7.13
ALF	3.47	1.93	4.86	8.29
ALR	2.67	1.65	4.86	6.92
PHF	-1.76	1.02	3.24	6.67
PHR	-4.33	2.01	3.49	6.17
PLF	4.21	3.76	3.87	8.73
PLR	4.95	4.31	3.93	7.85



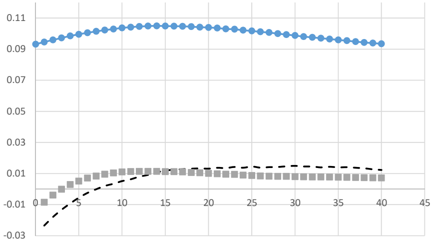
(a) MP Regimes: Active, Flexible. RE Regime: High.



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



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



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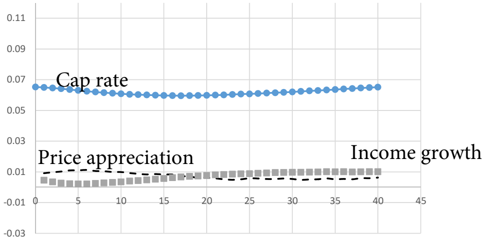

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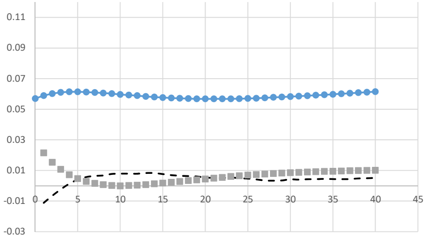

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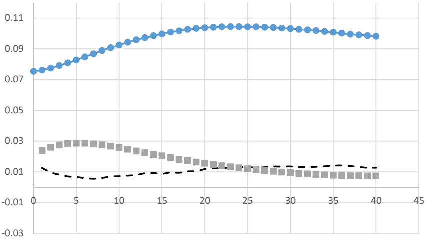

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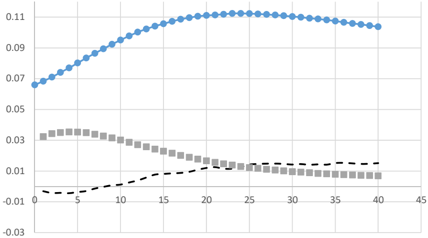

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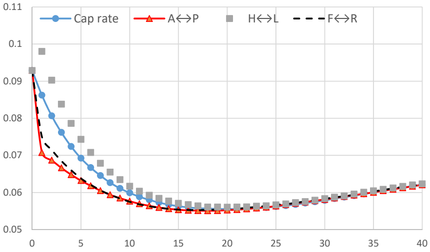
Impact of regime changes

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



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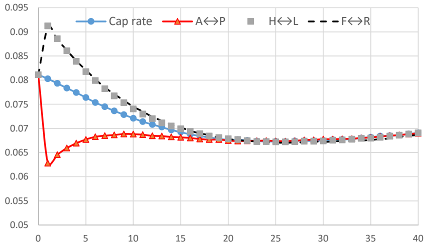

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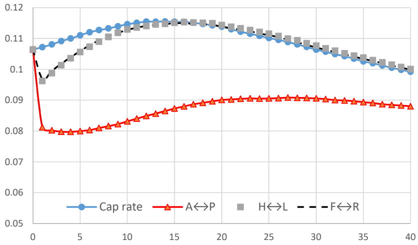

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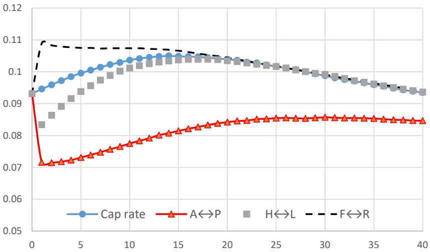

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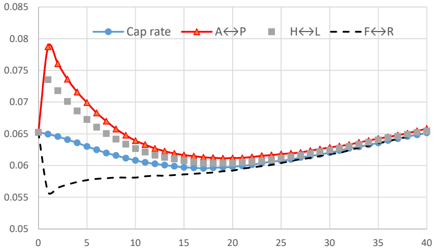

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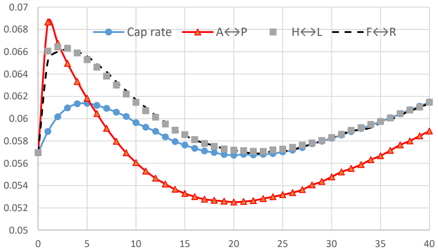

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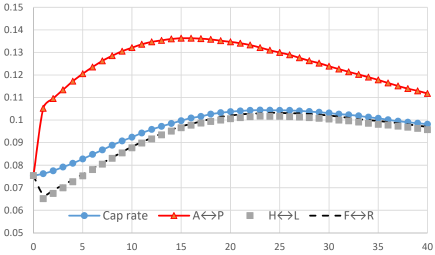
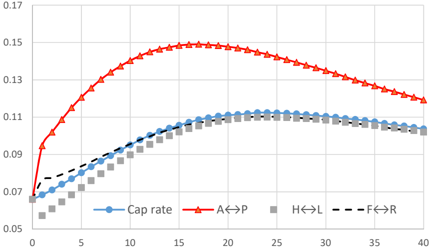


(c) MP Regimes: Passive, Flexible. RE Regime: Low.

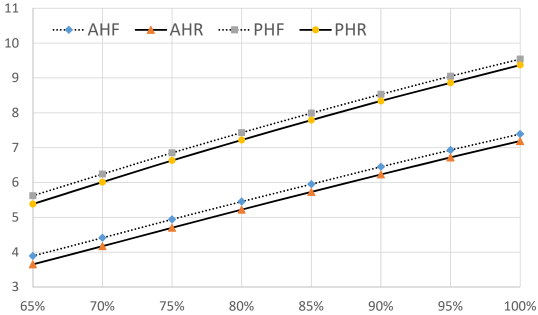


(d) MP Regimes: Passive, Rigid. RE Regime: Low.

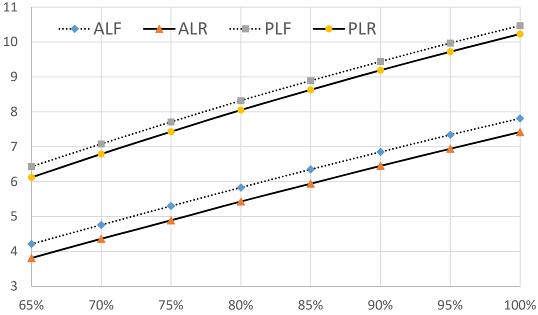
Quantitative risk analysis

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.

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- Remaining work
  - Polish estimation methodology
  - Explore different proxies for RE fundamentals
  - Other suggestions?