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Week 11: Real Estate Cycles and Time Series Analysis

- The dynamic behavior of the 4-Q model: stability versus oscillations.

- Real Estate Pricing Behavior: backward or forward looking?

- Development Options and Competition

- Forecasting markets: Univariate analysis, Vector Auto regressions, structured models.

- The definition and evaluation of "risk"

What are Real Estate "cycles"

- A reaction to a "shock" in the underlying economic demand for the property: national or regional recessions and economic boom periods. [e.g. single family residential, industrial, apartments]

- A periodic "overbuilding" of the market - excess supply – that originates from capital or development activity and is not necessarily linked to demand movements. [e.g. office, hotels, retail?]

- Which markets/property types exhibit which? Are Markets changing?

Prefect Historic correlation between economic recessions and Housing Production – except for the last 5 years
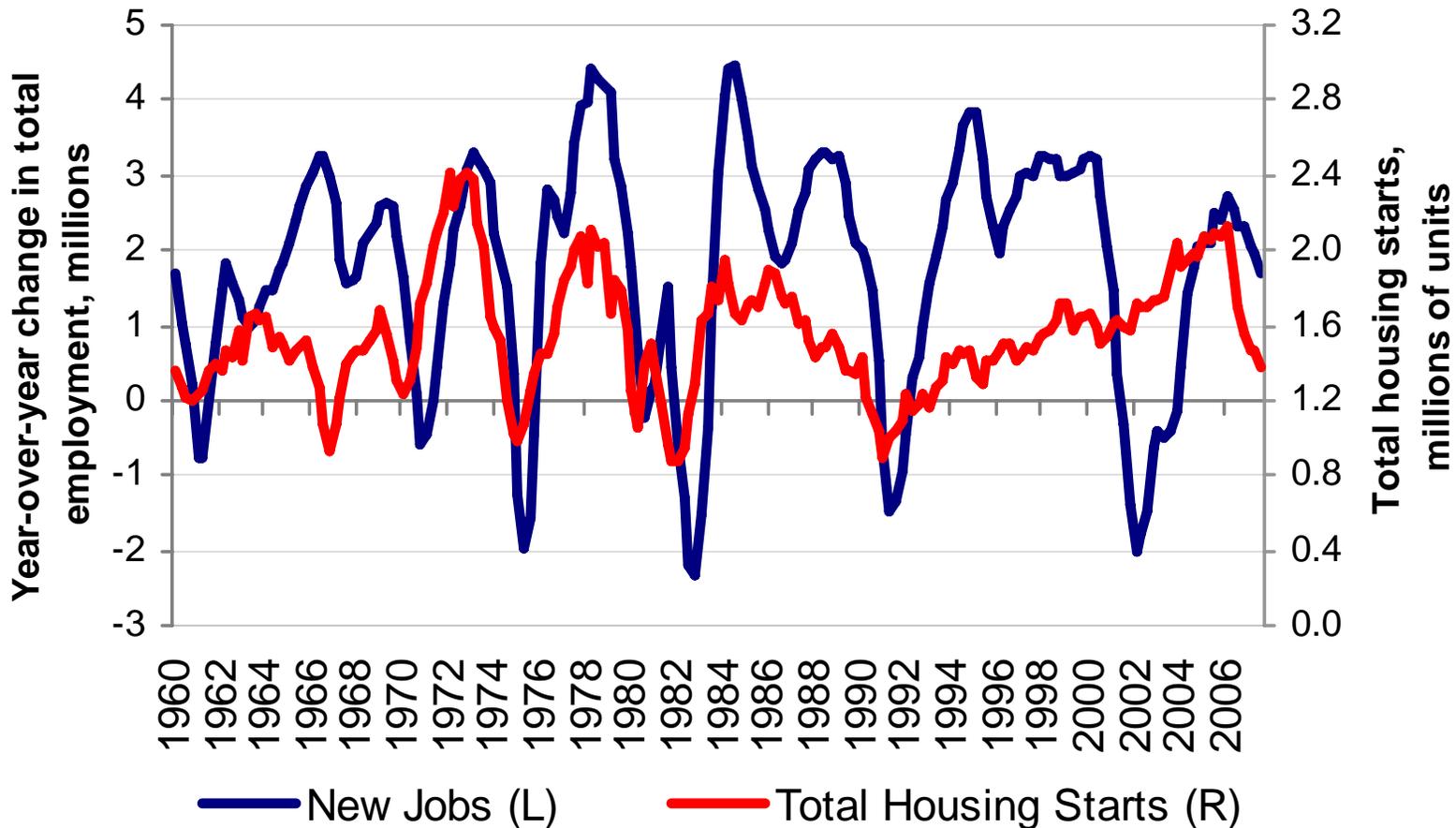
Sources: BLS, BOC, TWR.

National Office Market: Completions Rate, Real Rent, Job Growth
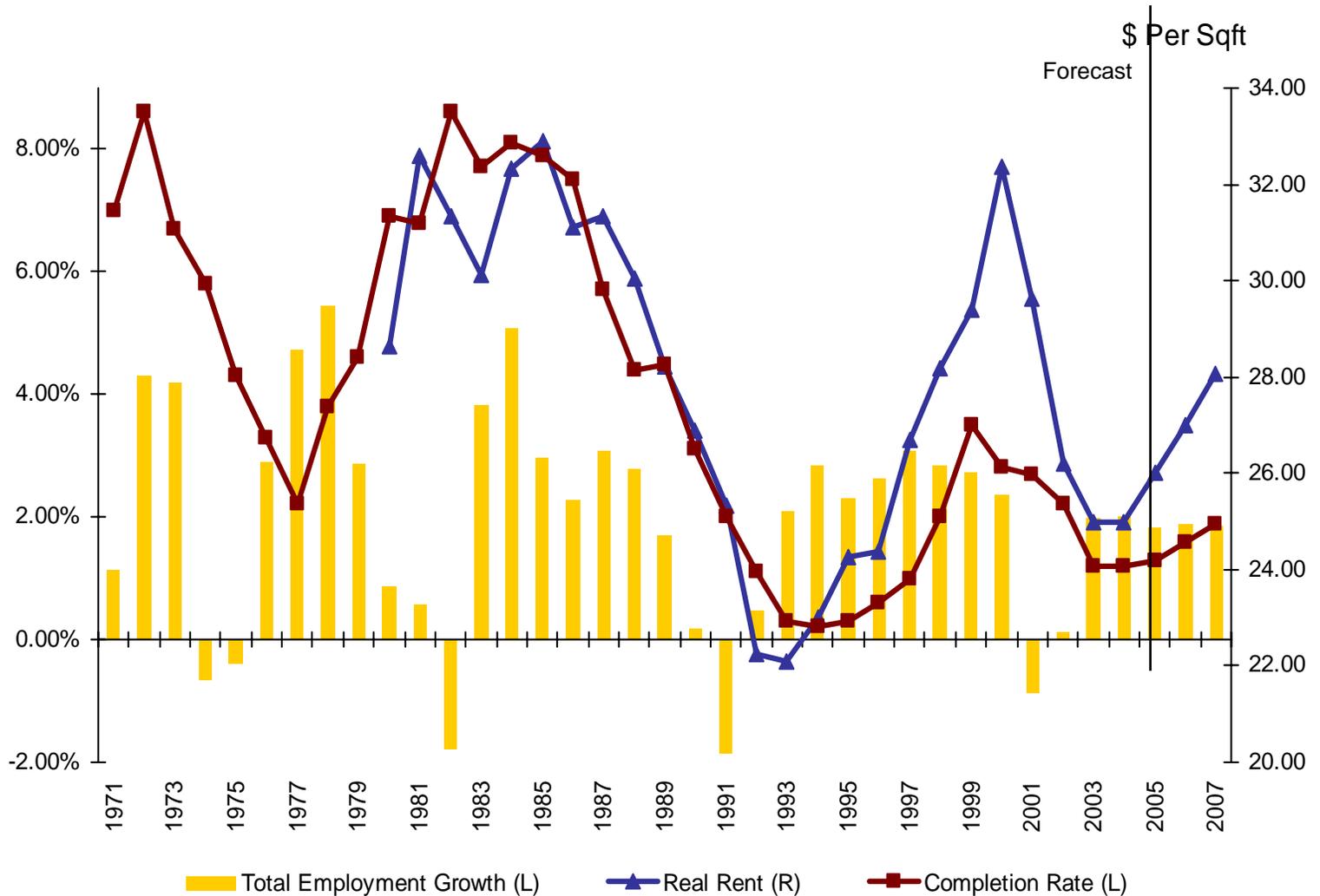
National Hotel Market (full service): Supply Growth Rate, Real ADR, Job Growth

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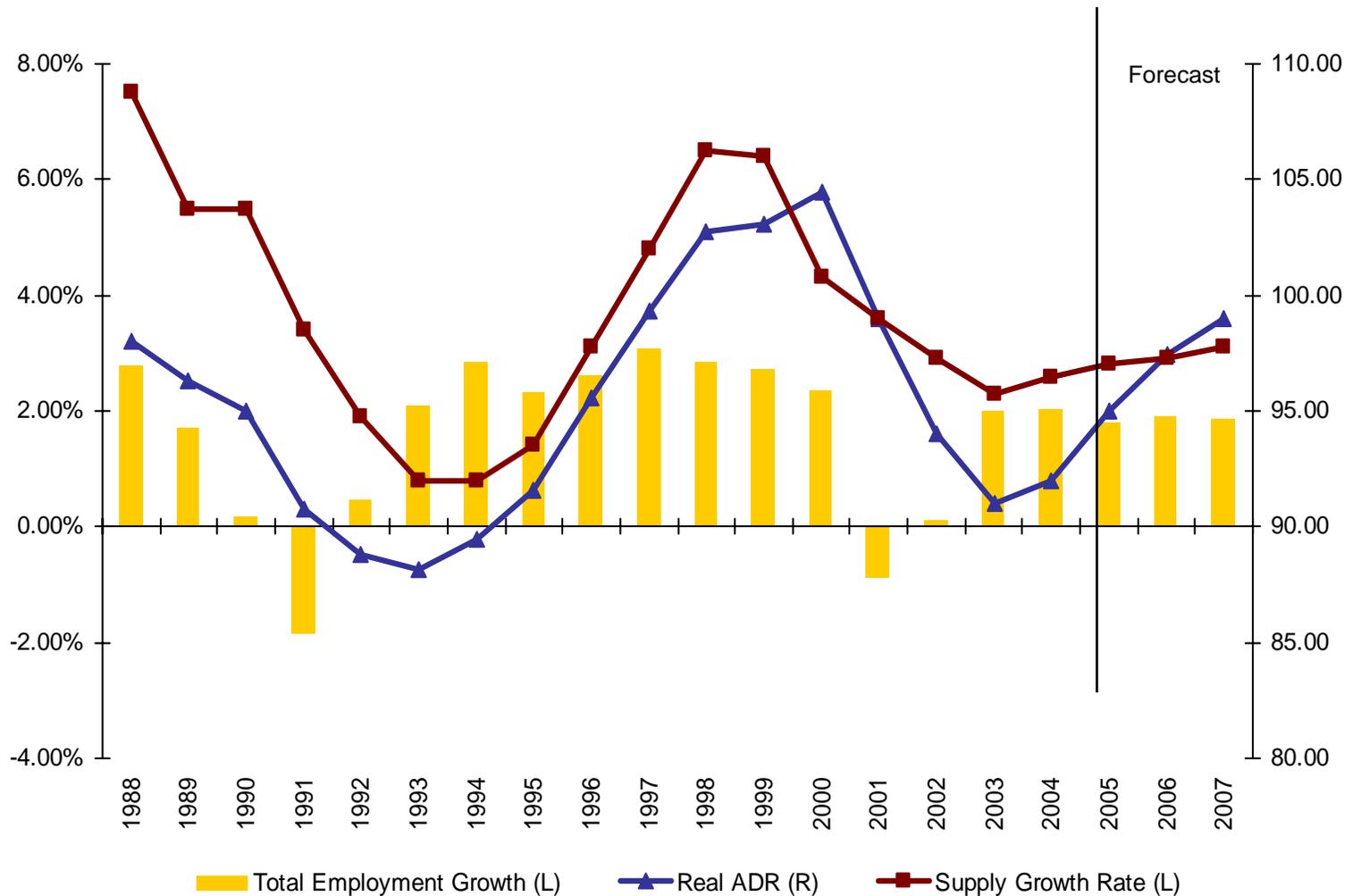
Dynamic 4-Q Model (t=time Period)

1). Office Demand$_t$ = $\alpha_1 E_t R_t^{-\beta 1}$

E_t = office employment

R_t = rent per square foot

β_1 = rental elasticity of demand:

[%change in sqft per worker/% change in rent]

2). Demand$_t$ = Stock$_t$ = S_t [Market clearing]

3). Hence: $R_t = (S_t / \alpha_1 E_t)^{-1/\beta 1}$

4). Office Construction rate:

$$C_{t-n}/S_t = \alpha_2 P_t^{\beta 2}$$

P_t = Asset Price per square foot

β_2 = price elasticity of supply:

[Perfect competition "Q" investment theory with n-period delivery lag. Projects begun n-periods back are based the "expected" value of asset prices *at the time of delivery*.]

5). Replacement version:

$$E = \text{fixed}$$

$$S_t/S_{t-1} = 1 - \delta + C_{t-n}/S_{t-1}$$

6). Steady Demand growth version:

$$E_t = [1 + \delta]\, E_{t-1}$$

$$S_t/S_{t-1} = 1 + C_{t-n}/S_{t-1}$$

[δ can represent the sum of employment growth and replacement demand]

7). Myopic (backward) behavior:

$$P_t = R_{t-n} / i$$

i = interest rate (discount rate)

[Extrapolate the future from the current/past]

8). Forward looking behavior (the *efficient market* theory):

$$P_t = \sum_{t'=t+1,\infty} R_{t'}/(1+i)^{t'-t}$$

or: $P_{t+1} - P_t = i\, P_t\ -\ R_t$ (if R is changing)

9). Market steady state solution: all variables are constant over time or are changing at the same rate as E_t grows.

$$\delta = C_{t-n}/S_{t-1} \; , \qquad S_t/S_{t-1} = 1 + \delta$$

$$P_t = (\delta/\alpha_2)^{1/\beta 2}, \quad R_t = iP_{t+1} = iP_t \; \text{ with}$$

either pricing model

10). What happens if E_t increases "Randomly" for one period – and then resumes its long term growth rate? Or interest rates decline?

11). Much depends on the pricing model.

Valuing Property:
Efficient Asset Pricing Principles

- Use future rent and income forecasts that are based upon the "model" (i.e. assume all market participants use the "model" to evaluate the change in E)

- Future Residual values are DCF from the residual date forward

- Since today's value is DCF until residual date plus residual value, the hold period is irrelevant: today's value is the in-perpetuity DCF.

- Result: Price Volatility low and less than income volatility since income volatility is only temporary (with mean reversion)

Valuing Property:
The traditional way (Myopic).

- Extrapolate current, past or "average" rent/income growth (what's wrong with ARGUS?)

- Residual value is capped Future NOI with cap at 50bps over initial period.

- Result: Price Volatility High and greater than income volatility.

Implication: when are Cap rates lowest?

- FINANCE 101: Cap rate = i-g+r

  i = risk free rate + capital expenditures

  g = expected future value/income growth

  r = real estate risk premium

- *Efficient* prices are lowest when the market is most *down*. With mean reversion, that's when expected rent/income growth is highest!

- With *traditional or extrapolative* pricing, cap rates are lowest when the market is strongest (continued rent/income growth) and highest when the market is down (continued decline).

**Efficient Market: Prices less volatile than income, cap rate is low when market is down (mean reversion).
Inefficient Market: Prices more volatile than income, cap rate is high when market is down (extrapolation).**
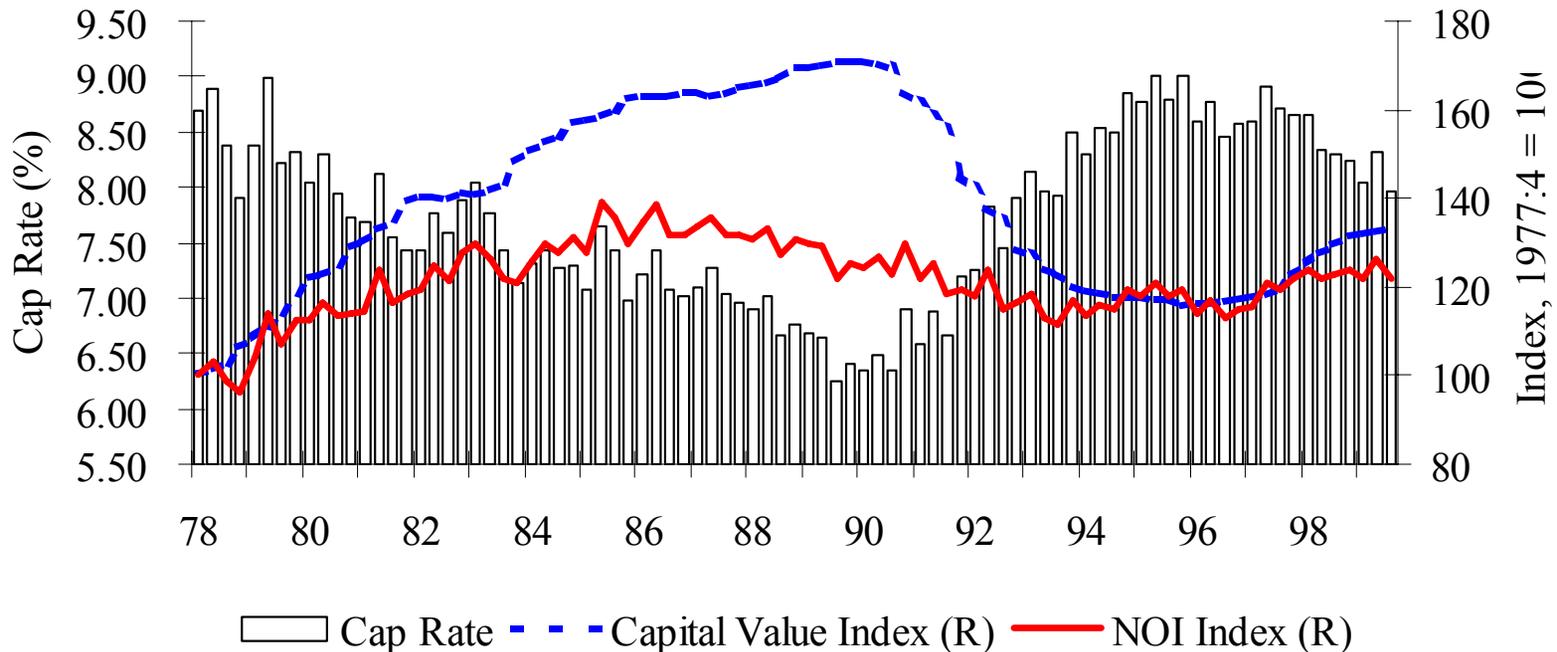
The "Shiller Test"

- If market pricing is "rational" cap rates should correlate *negatively* (if imperfectly) with *actual future* (subsequent) growth. Efficient markets can at least partially anticipate the future.

- Why weren't cap rate spreads higher in the late 1980s anticipating the tanking of the market, and lower in the early 1990s – anticipating the market recovery?

- The *implied growth* in today's cap rates: g (3.5%) =
i (5.0%) + Capex (2.0%) + r (3.0%) – Cap (6.5%)

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Pricing seems always based on expected growth that just matches inflation - not actual subsequent appreciation
(good for 100 years, but not 10!)

1991: 5.7%=7.8%+5.0%-7.1%

2004: 2.0%=4.5%+5.0%-7.5%

TWR Forecast

Legend: **implied future growth** — **3-Year Forward Appreciation** — **CPI inflation**
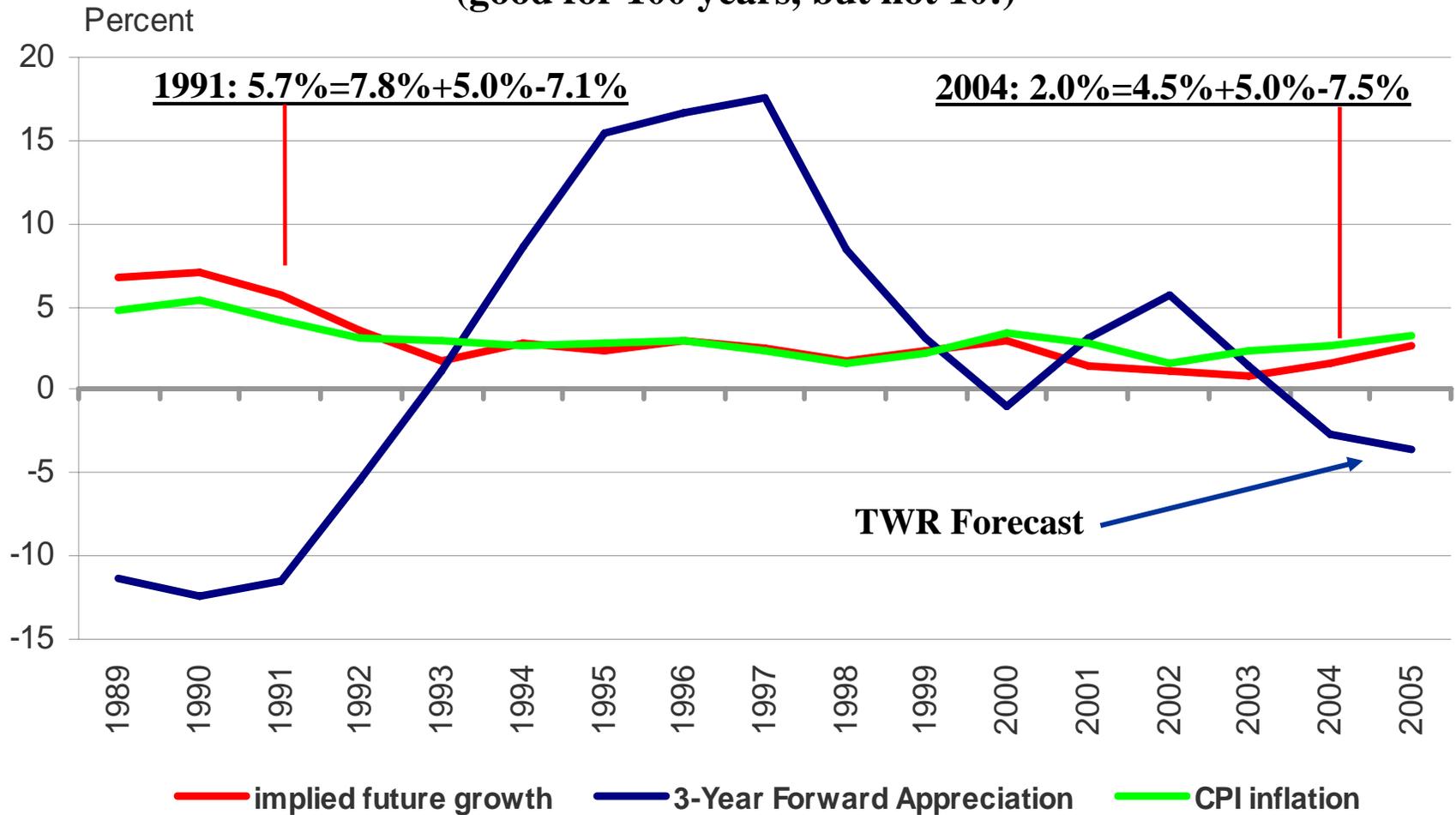
US Office Investment data.

Hence across the EU, 2000 cap rates did not reflect subsequent (2001-2005) growth in Fundamentals

European Cities, Average Annual Office Rent Growth % 2000q4 - 2005q4
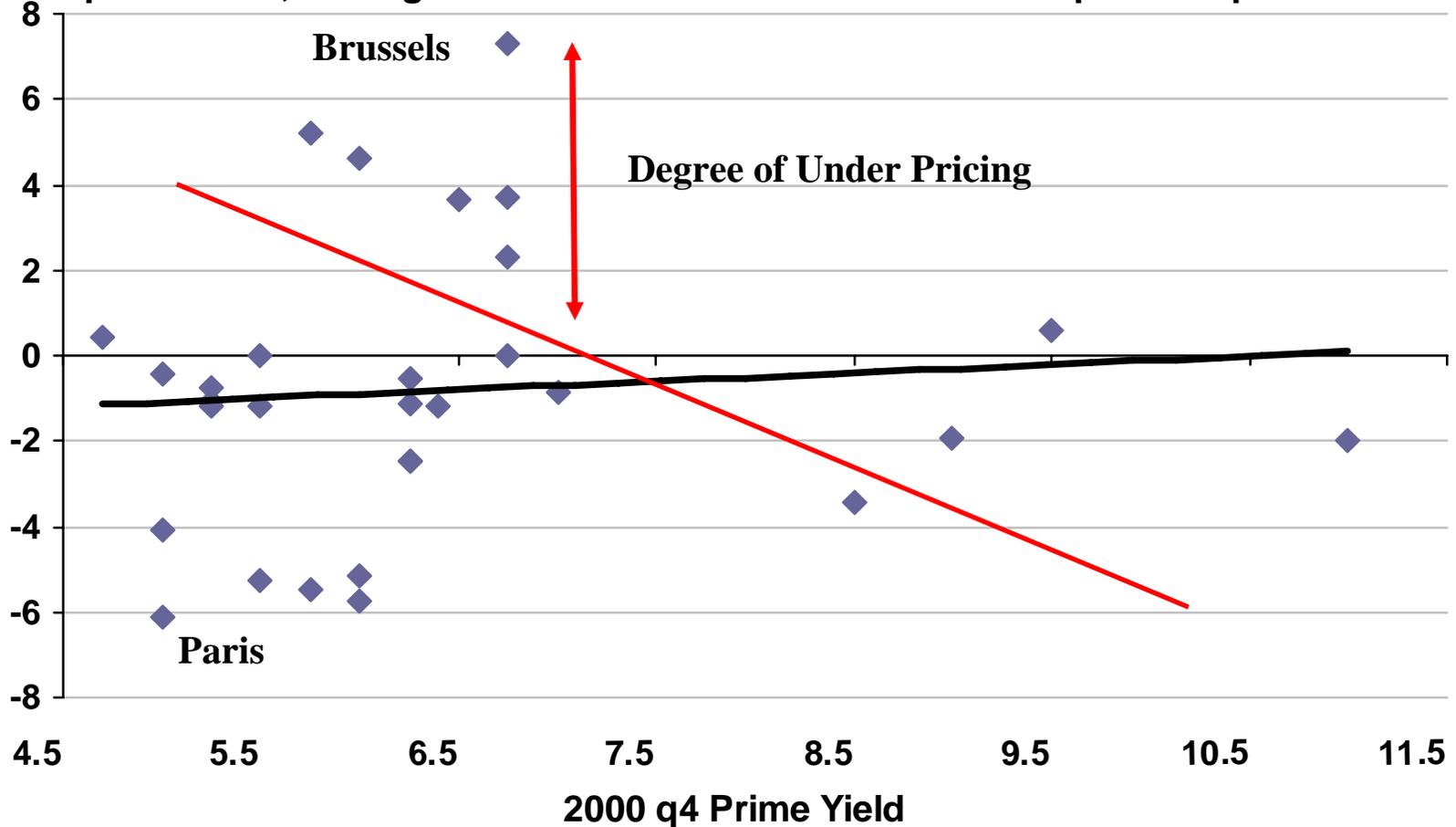
Source: Torto Wheaton Research

Impulse response to demand shock (increase in E) with "stable" market parameters. Holds for efficient pricing and *may* hold for extrapolative pricing: Intrinsic "mean reversion"

Market reaction to a 50% demand shock (lag: n = 5; depreciation-growth: $\delta = 0.05$: demand elasticity = 1.0; supply elasticity = 1.0).
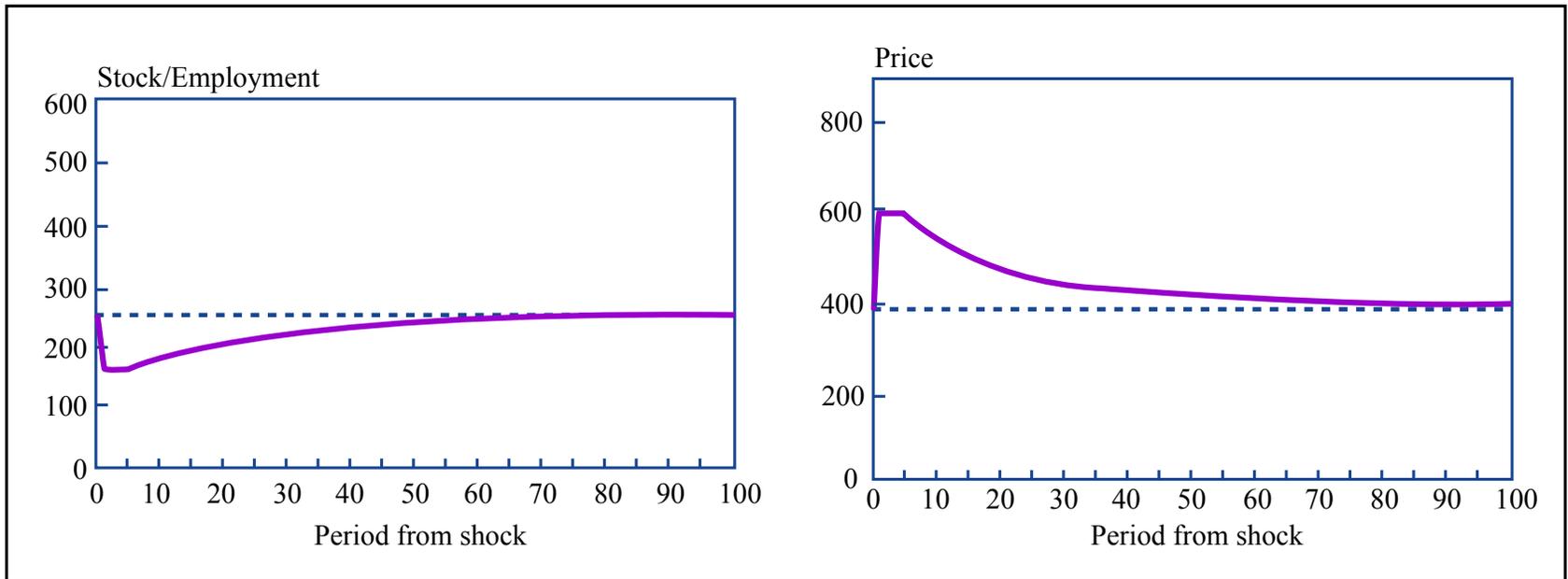
Figure by MIT OpenCourseWare.

Impulse response to demand "shock" with "unstable" market parameters. Holds *only* for extrapolative pricing *under certain situations*: "mean *over-reversion*".

Market reaction to a 50% demand shock (lag: n = 8; depreciation-growth: δ = 0.05: demand elasticity = 0.4; supply elasticity = 2.0).
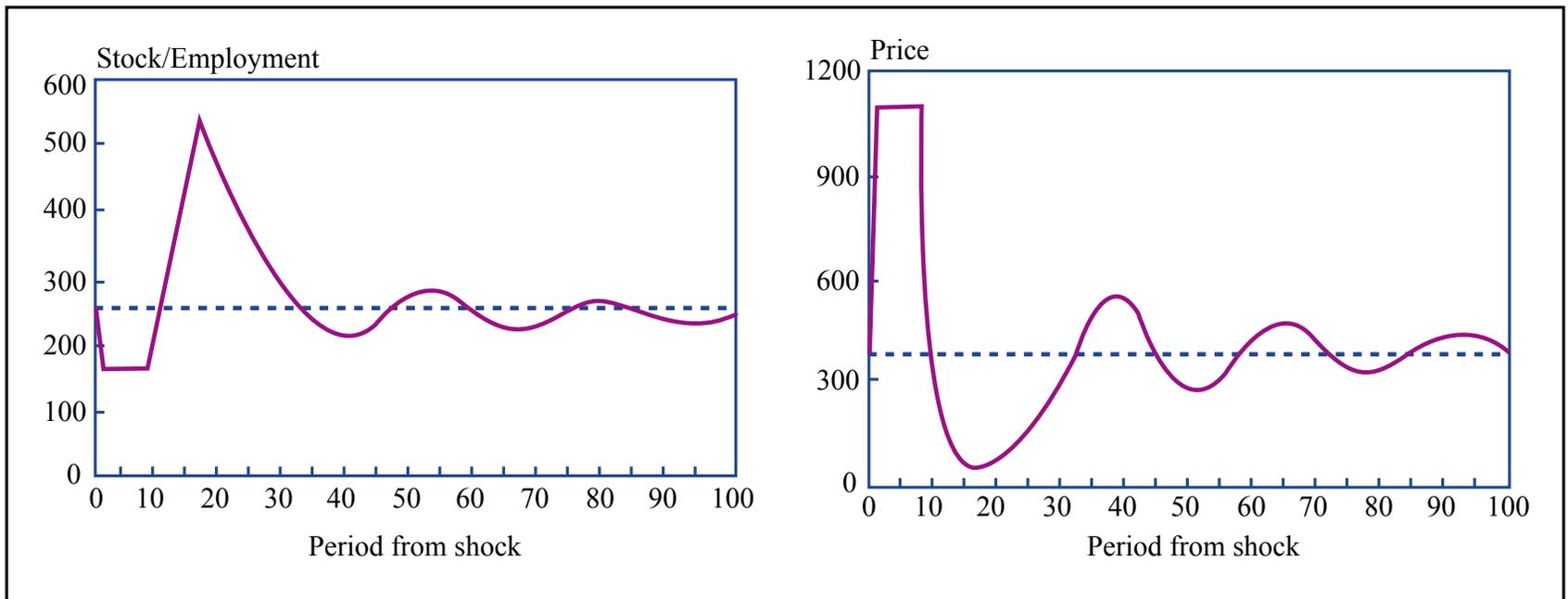
Figure by MIT OpenCourseWare.

What makes the model unstable?

- More elastic supply (β_2). and less elastic demand (β_1).

- A high rate of demand growth or rapid obsolescence of properties (δ)

- Long Delivery lags (n), "slow adjustment", delayed responses (regulation?)

- Extrapolative (backward) as opposed to forward, efficient expectations by investors/developers.

- Variation by property type?

- In any case, all models above have "mean reversion" and are not a random walks [Shiller].

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Historic Office Rent Volatility by Market: "Barriers to Entry" = more volatility!
(Barriers = lower supply elasticity or longer lags?)

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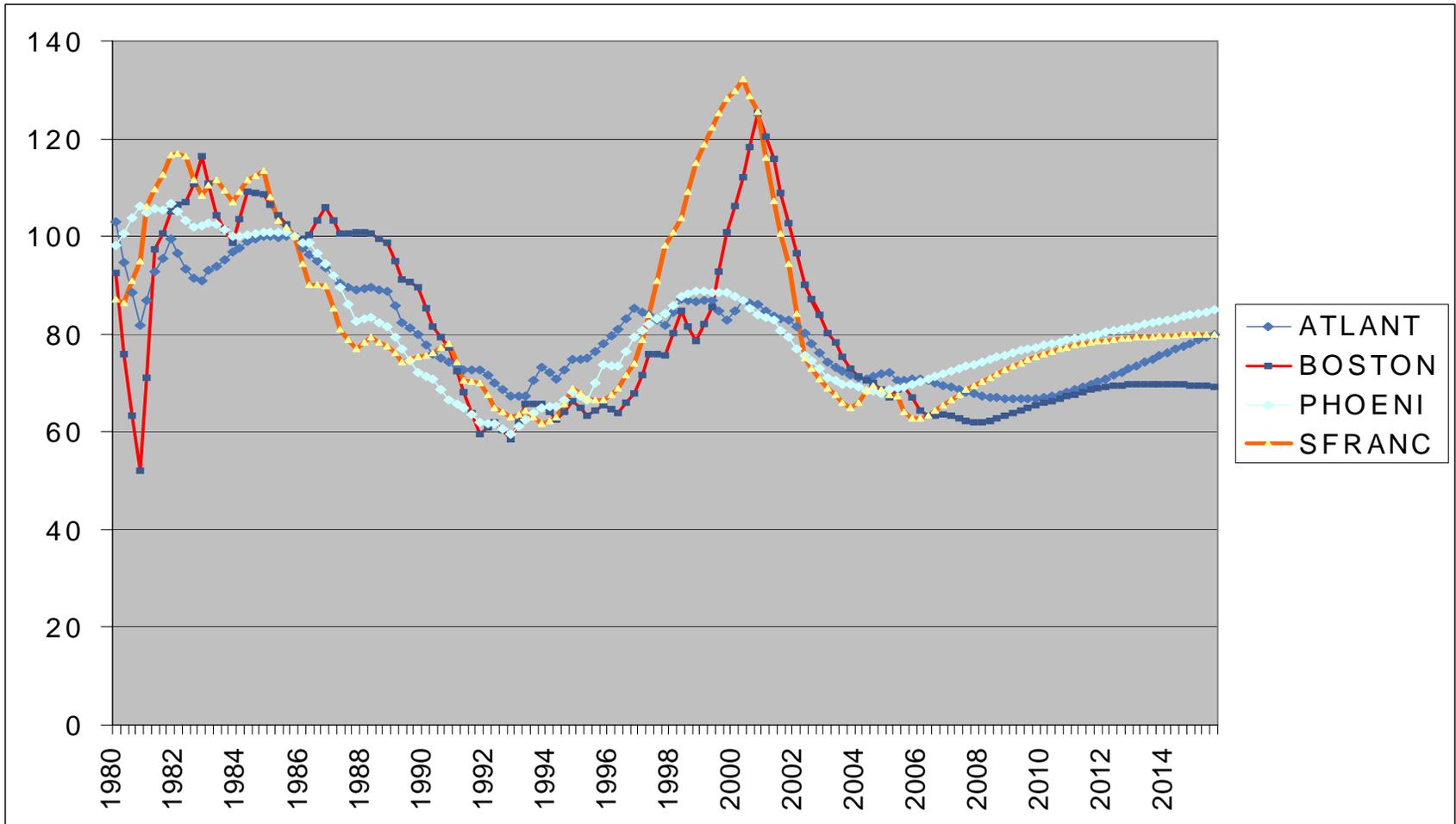
Historic Real Estate Price volatility: 1978-1998 By Property Type (Source: NCREIF)
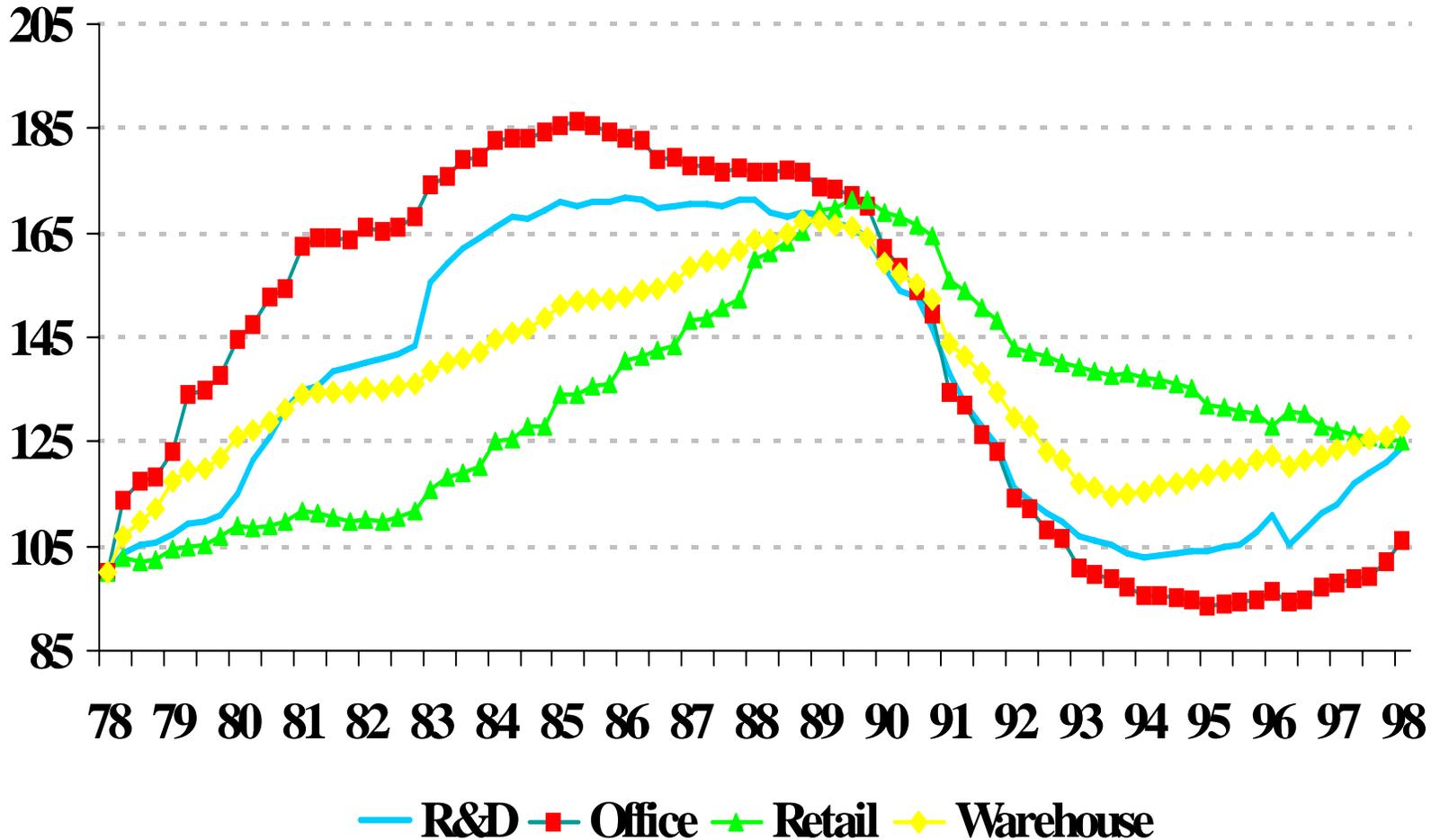
What if market participants "delay"? "Slow adjustment" increases instability

- Gradual adjustment of space demand to changes in employment and rents. Why? Only 20% or so of tenants can move each year given lease contracts.

- Gradual adjustment of rent to vacancy. Lease contracts make the leasing decision like an "investment" – there are option values to both parties to waiting [Grenadier]. Waiting pushes the supply response further into the future

- Example: the "Rental Adjustment" process.

  $R_t - R_{t-1} = \lambda_0 - \lambda_1 V_t$ (Rosen, 1980s).

  $\lambda_0 / \lambda_1 = $ "structural vacancy rate"

  $R_t - R_{t-1} = \lambda_0 - \lambda_1 V_t - \lambda_2 R_{t-1}$ (Wheaton, 1990s).

  $R^* = (\lambda_0 - \lambda_1 V_t) / \lambda_2$ "rent at which landlords indifferent to leasing versus waiting" (R constant)

"Waiting" = Development as a Real Option

- Competitive model (Tobin's Q): develop as soon as when Prices equal replacement cost.

- But what if prices are stochastic, uncertain?

- If wait and they go down – little lost.

- If wait and they go up – a lot gained!

- Hence wait. Until Prices cross a "hurdle" = replacement cost + "option value" = exercise price

- Greater uncertainty = higher option value = longer delay to development since exercise price is higher.

Development Options and Development Lags

- Lags are delays between when you exercise the option (commit) and when you realize the Price.

- Lags mean that the impact of uncertainty on the option value is less than without lags (develop sooner).
  - The option value of waiting is less because if good times occur, and it take you several years to build, by the time you build they may have vanished. Without lags you can immediately realize the good times value!

- However, for a given level of uncertainty the *hurdle value* is higher with lags than in a model with no construction lag (develop later).
  - Intuitively, the further into the future the realization of your investment return, the smaller its present value. Therefore, you optimally wait until the Price is higher (all else equal) in order to commence development when there are lags between exercise and realization of Price as opposed to instantaneous realization of Price upon exercise.

Development Options and Overbuilding

- When we all wait, its more likely that multiple players exercise the option at the same time.

- Exercising at the same time = a building "Cycle" (Grenadier).

- When there are more players (increased competition), the option value of waiting is eroded. Why? Because competitors can take your place and pre-empt you.

- If you are a monopolistic developer – there is no fear of this! (Schwartz and Torous)

- Are property types with more competition, or locations with more competition less prone to overbuilding, since no player waits? (Somerville).

- The Dynamic 4-Q model assumes competitive supply

Models be estimated empirically using real estate data together with Economic data

- Option #1 and #2: reduced form forecast – just evaluate and forecast rents with a model that has either a trend or Economic Demand variables.

- Option #3: forecast rents and new supply together. Assume market clearing. Base forecast conditional on Economic variables.

- Option #4: add in vacancy and assume that markets clear slowly = more variables and more equations. Better forecasts?

Model #1: Unconditional Univariate
(quarterly Boston data, 1979:1 - 2002:4)

$$R = 3.23 + .92R_{-1} - .01T$$

$$(2.5) \quad (22.1) \quad (.6)$$

$$R^2 = .933$$

- No trend in **real** office rents (.09 is not significant).

- Rents depend an awful lot on last periods rents (.92)!

- $R* = (3.23-.01T)/ (1-.92) = \$(40-.12T)$ (long term steady state rents in real dollars)

- How does this equation "work" when there is a lagged dependent variable on the right hand side?

Model #1: Implied Rental Adjustment

$R = 3.23 + .92R_{-1} - .01T$, is the same as:

$R - R_{-1} = .08 [(3.23 - .01T)/.08 - R_{-1}]$

$\qquad = .08 [R^* - R_{-1}]$

- Rents adjust slowly (8% quarterly or about 28% annually) to gap between: Steady state rent ($40-.12T) – current rent
- More rent lags = more zigs and zags in the adjustment process, but around what?
- Nice and clean, but what have we learned? Trend!
- How accurate from 2002:4 through 2005:4 (Red)?

Model #2: Conditional Univariate

(quarterly Boston data, 1979:1 - 2002:4)

$R = 13.2 + .94R_{-1} - .06$ FIRE $+ .023$ SER

(4.1)   (36.2)   (3.6)   (2.9)

$R^2 = .942$

- Trend is replaced with office employment. Does that work?

- Rents still depend an awful lot on last periods rents!

- Why is it that growth in FIRE jobs creates negative rent growth? Could FIRE firms build their own space?

- Why does Service grow have positive impact?

- Who forecasts FIRE and SER (and how?)

- Assumption: supply responds quickly

Model #3: Conditional Multivariate: Rent and Supply (like 4 Q)

- Suppose space Demand = 62,500 + 330FIRE + 155SER - 500R_{-1}

- Suppose Rent equates space demand to last period's stock (market clearing – as in 4Q diagram, dynamic model).

- Call that $R^* = 125 + .66FIRE + .33SER - .002S_{-1}$

- But then Suppose Rents adjust gradually:

- $R - R_{-1} = .06 [(125 + .66FIRE + .33SER - .0021S_{-1}) - R_{-1}]$

- Note that real rents still adjust slowly, but now to changes in employment or stock (6% quarterly or 22% annually). Also FIRE now has correct sign!

Model #3: Conditional Rent/Construction Multivariate (continued)

- The estimated demand side or rent equation becomes:

- $R = 7.6 + .94R_{-1} + .04FIRE + .02SER - .00013S_{-1}$

  (2.9)   (17.1)   (2.1)   (3.2)   (-3.9)

  $R^2 = .976$

- Also need a supply side equation:

- $C = 449 + 39.7R_{-10} - .007S_{-1}$

  (.9)   (2.9)   (-2.2) $R^2 = .41$

- $S = S_{-1} + C$

- *System will forecast rents and construction and the stock of space – given FIRE and SER forecasts. Who forecasts FIRE and SER? That's what is meant by conditional.*

Model #3: Conditional Rent Multivariate

- $R - R_{-1} = .06\,[(125 + .66FIRE + .33SER - .0021S_{-1})\ -R_{-1}\,]$

- For every 1000 FIRE jobs added to the economy, if we develop 307,000 more square feet then long term steady state real rents will be stable .

- For every 1000 Business Service jobs added to the economy, if we develop 157,000 more square feet then long term steady state real rents will be stable.

- Rents adjust to gap: Steady State - current rent

- If rents are at $35 real, then construction will average about 600,000 square feet each quarter or 2.4m annually.

- FIRE growth of 7,500 jobs annually or Business service growth of 15,000 jobs annually would justify this. But the forecast is for each to grow about ½ of these! Hence new supply exceeds demand, rents stagnate (Green)

Model #4: Multivariate:
Rent, Supply and Vacancy (slow response)

- Suppose firms desired occupied stock is:

$$OC^* = 4109 + 283FIRE + 118SER - 76R_{-1}$$

- But leasing constrains tenants so that only 10% can get to their desired stock in a period. Hence:

$$OC - OC_{-1} =$$

$$AB = .10\,[(4109 - 76R_{-1} + 283FIRE + 118SER) - OC_{-1}\,]$$

$$(30.6)\quad(2.1)\quad(-3.4)\quad(2.6)\quad\quad(1.9)$$

$$R^2 = .99$$

- $V = 1.0 - OC/S$

- Or rent determines vacancy.

Model #4: Multivariate with Vacancy

- But Landlords also determine rents as a function of vacancy. Why (bird in hand = 2 in bush)?

  $R = 6.5 + .81R_{-1} - .34V_{-1}$

      (6.0) (20.1)   (-6.9) $R^2 = .958$

  So in theory, with the pair of equations, there is a rent where vacancy is fixed (stable). And for supply:

- $S = S_{-1} + C$;

  $C = 1339 + 32.4R_{-10} - .006S_{-1} - 75.6V_{-18}$

      (.9)   (2.5)   (-2.0)   (-3.4) $R^2 = .54$

  Now the system is complete with both vacancy and rent also determining new supply.

Model #4 (continued)

- Behavioral implications of slow adjustment:

- Each 1000 FIRE workers needs 283,000 square feet and each Business Service worker 118,000. Adding this much square feet per new worker would also keeps vacancy (occupied square feet) constant in the long run.

- To get to these "targets", occupied square feet responds slowly – 10% quarterly or 35% yearly (leases).

- At current rents of $30 and vacancy of 16%, construction will add only 50,000 square feet quarterly (.2 m annually)

- And at 16% vacancy rents will fall below $30.

- This is far less than job forecast demand is!

- Hence market goes down and eventually recovers (blue).

Boston Office Market. Red: Univariate(#2); Green: Rent-only(#3); Blue: Rent & Vacancy(#4). Forecast from 2002:4

Actual and fitted values of real rents
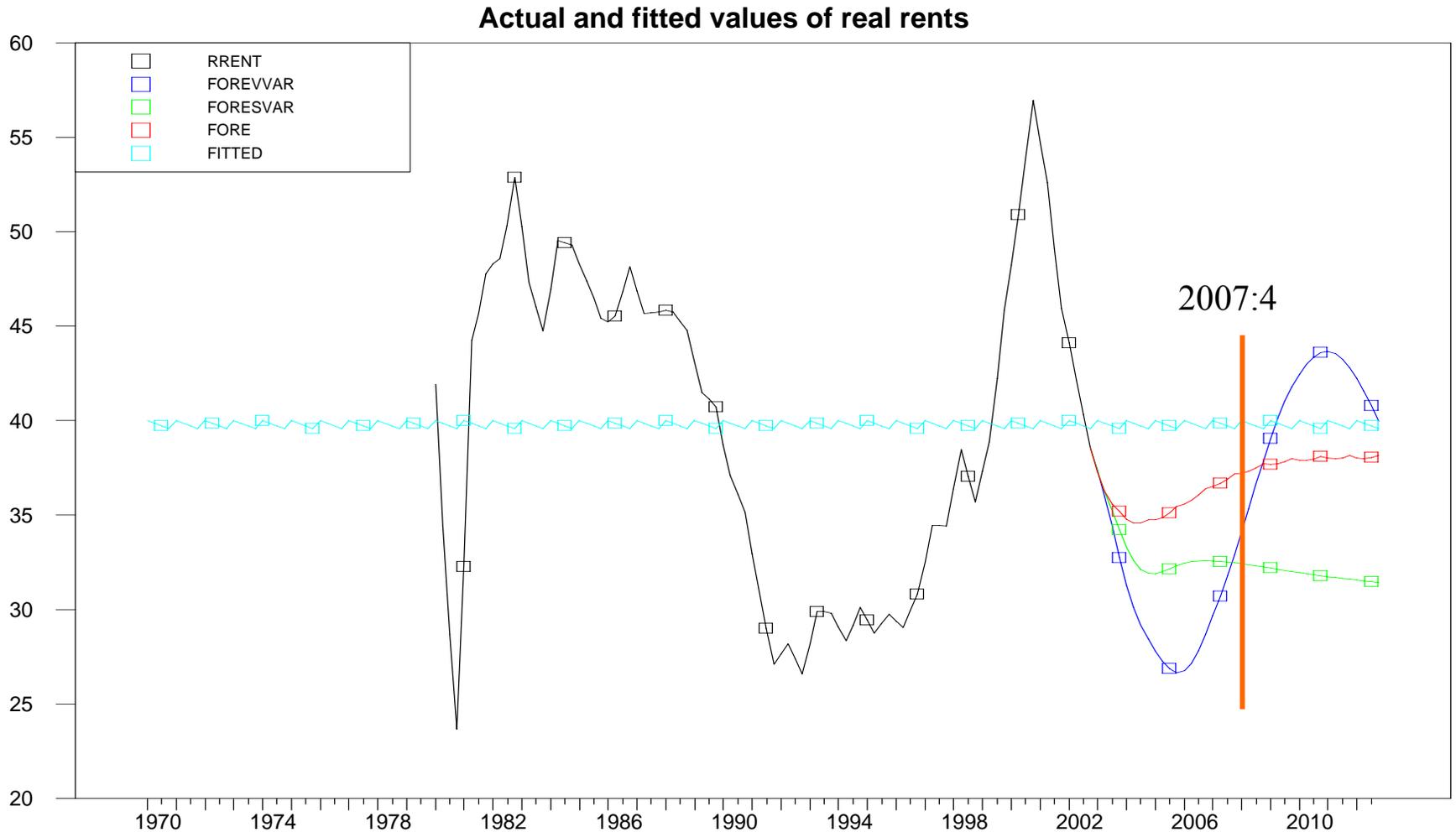
Boston Office Market: Rent only forecast(#3): green; Rent & vacancy(#4): blue. Forecast from 2002:4
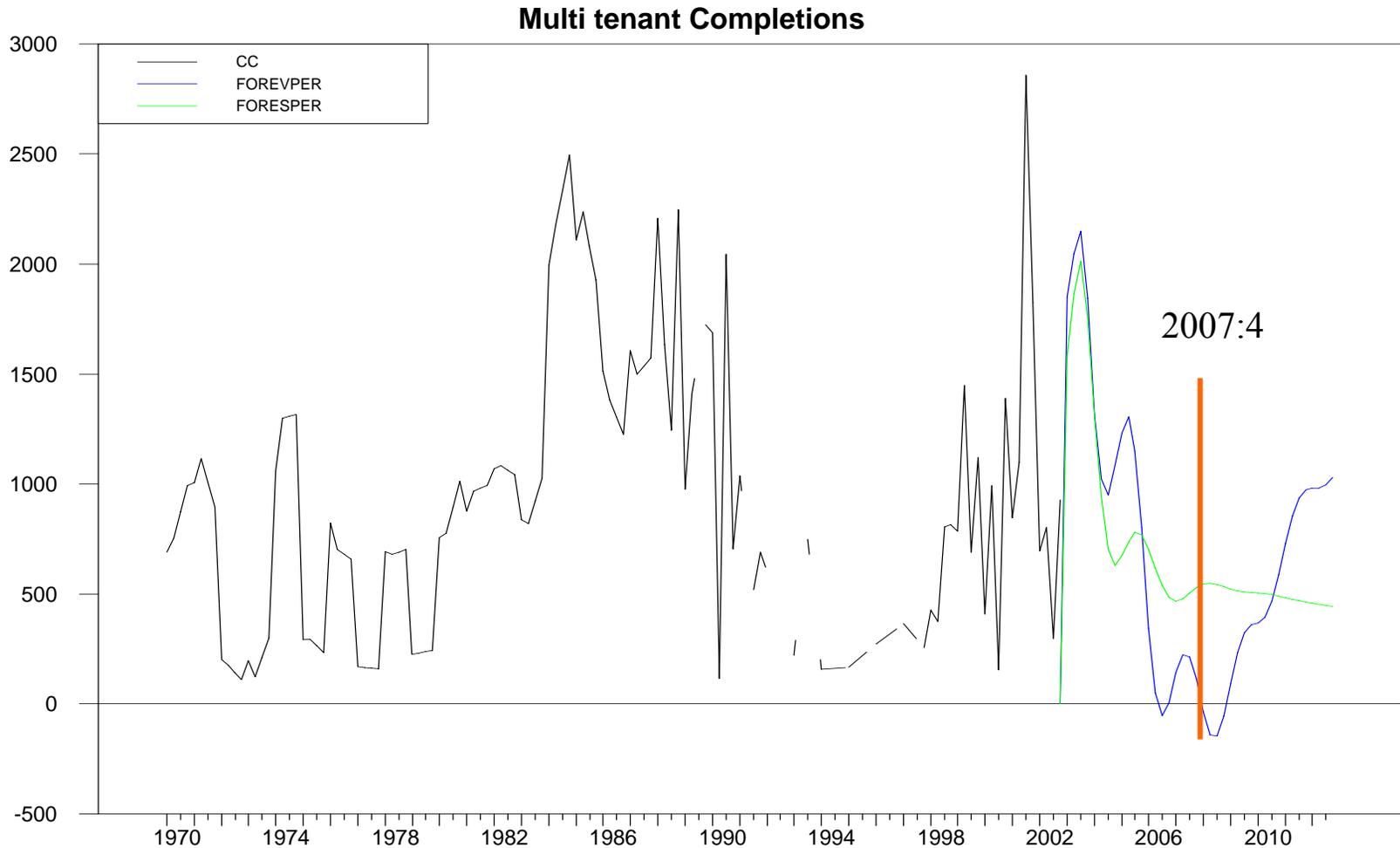
Boston Office Market: Full model (#4). Forecast from 2002:4
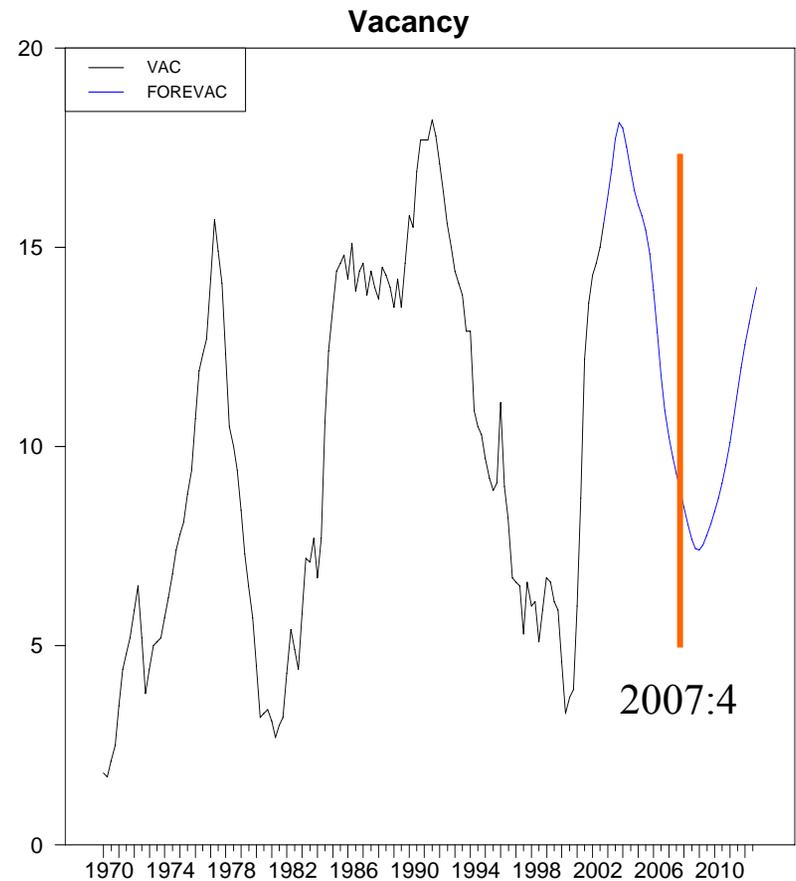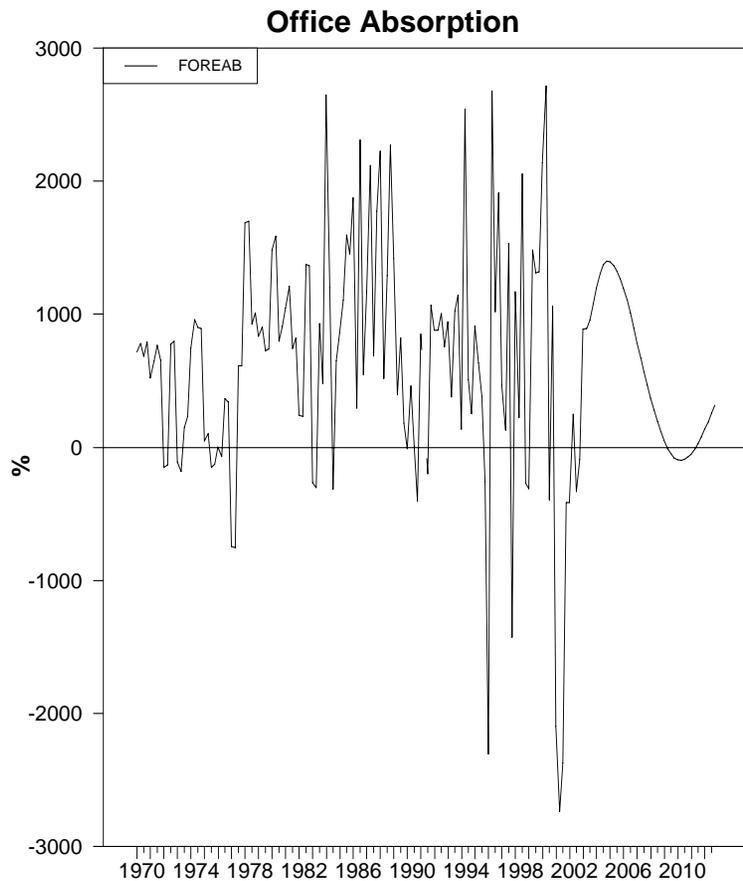
Additional criteria for evaluating models: "back testing"
This is a forecast for Boston house prices using a Univariate model
(#2). Why does this model work well here – but not for office?
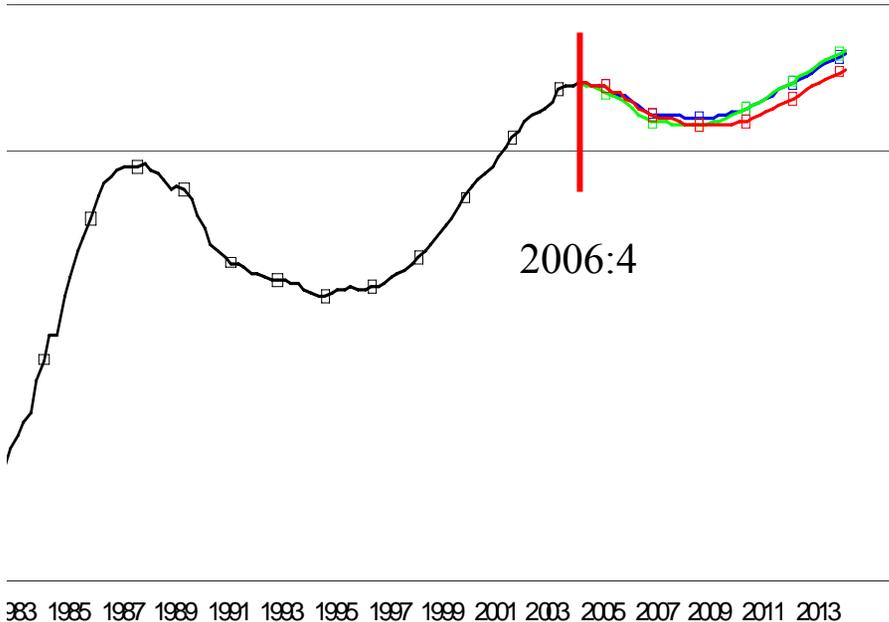
Forecast from 2006
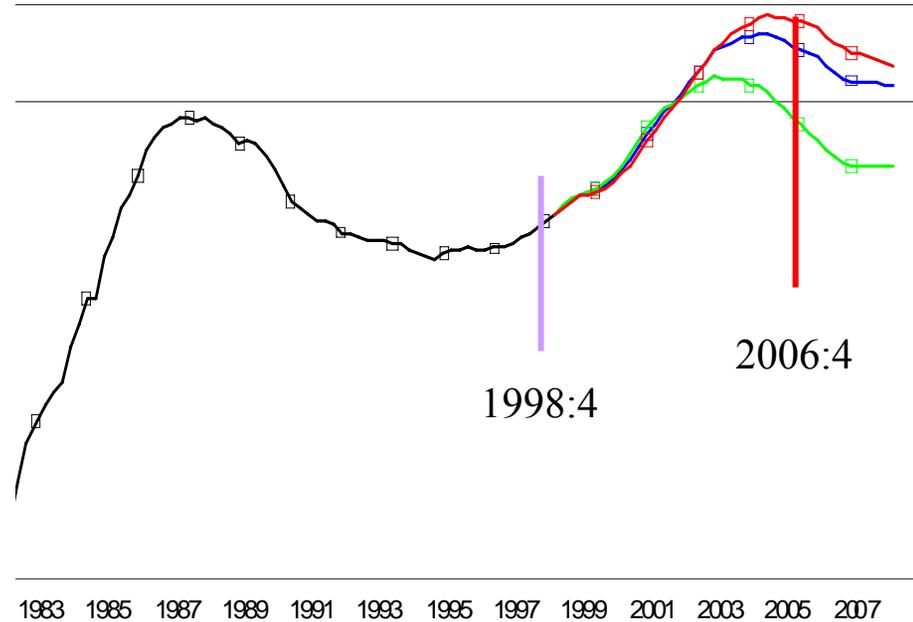
Forecast from 1998

Forecasting Lessons

- When supply adjusts quickly to prices or rents, then little is to be gained from a model that jointly forecasts the two – Just use a Univariate model (#2) (Single Family Housing)

- The slower supply responds and the more gradual prices and rents adjust, then the more you need to forecast both sides of the market (#3 or #4) to capture its momentum and cyclic swings. (Apartments, Office. Hotels, Retail)

Distribution of Forecast Outcomes

- A "forecast" is the mean value of the variable(s) being forecast. Any forecast has a probability distribution surrounding it.

- The further out you go the wider is the forecast probability distribution of possible outcomes. Why?

- Variables that are "random walks" are forecast with simulations – wherein the starting value plays no role. With mean reversion, real estate forecasts obviously depend on where the market currently is. Historic volatility not enough to estimate "risk".

What is Risk: Historic Variability vs. Forecast Uncertainty

(Notice true risk grows over time)
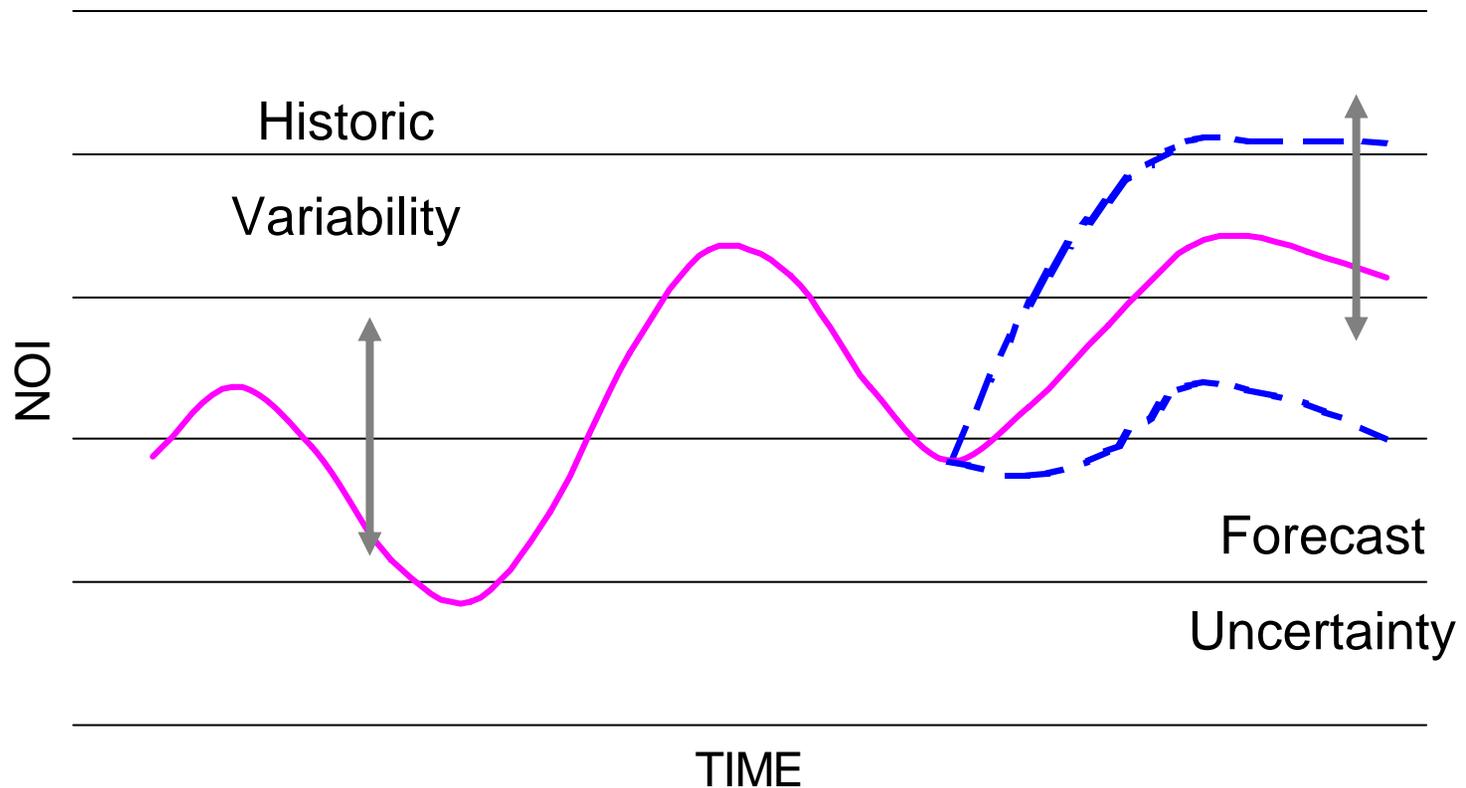
Forecasts give "standard errors" which can be used to generate confidence bands or the probability distribution of future income
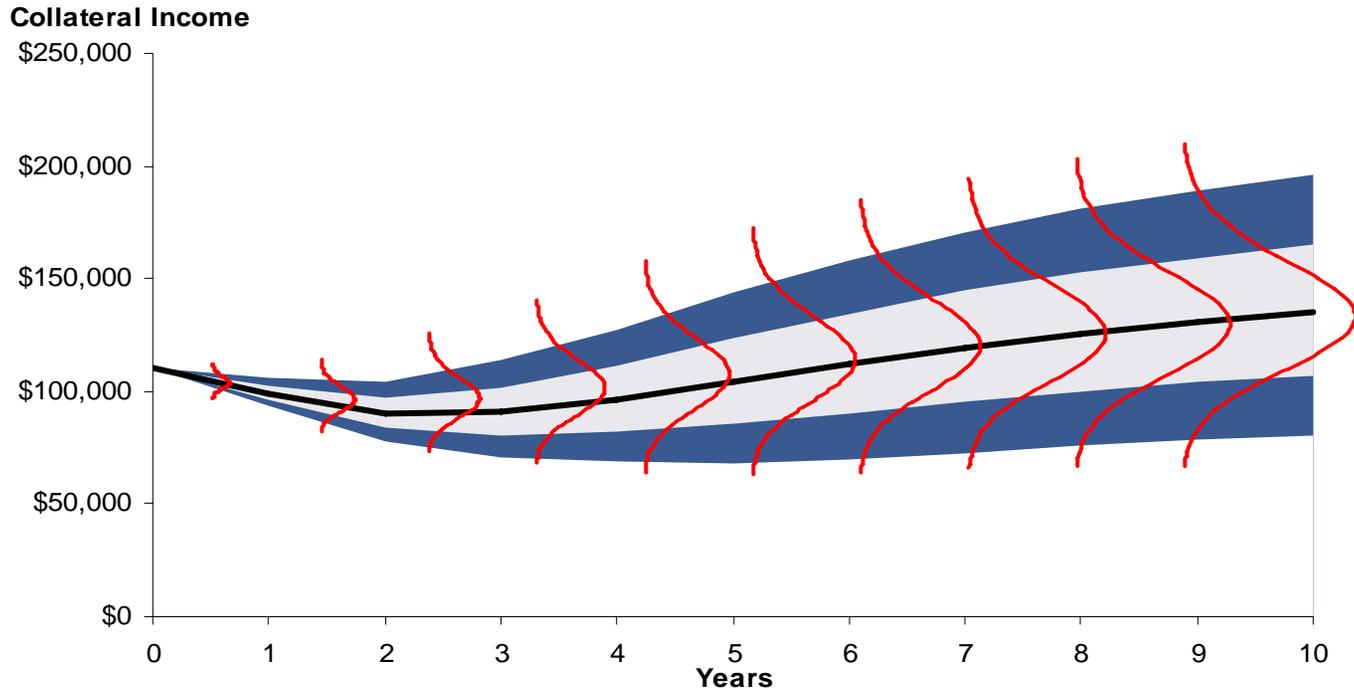
What determines confidence band width?

- A market with wide historic swings will tend to generate wider confidence bands in the future – unless you can "explain" these swings accurately.

- A "poor" model (low fit) means you do not understand the forces affecting the market. What you don't know = risk.

- Low quality data, missing observations, a short historic data series, no variables that capture what really drives the market = a "poor" model.

Atlanta Office *Risk* Calculated along probability "paths"
Yield = 7.1%, expected IRR = 7.3% (base case)
Std Deviation of IRR = 5.0

Standard Errors Away from Base Case	Average NOI Growth 2002-2007	Average Appreciation 2002-2007	IRR 2002-2007
-4	-16.6%	-20.9%	-15.1%
-3	-11.3%	-15.1%	-8.7%
-2	-6.6%	-9.7%	-3.0%
-1	-2.3%	-4.8%	2.3%
0	1.6%	-0.2%	7.3%
1	5.2%	4.2%	12.0%
2	8.6%	8.4%	16.6%
3	11.9%	12.4%	21.0%
4	14.0%	15.4%	24.4%

Is "forward risk" reflected in pricing?
Industrial markets: 2005-2012
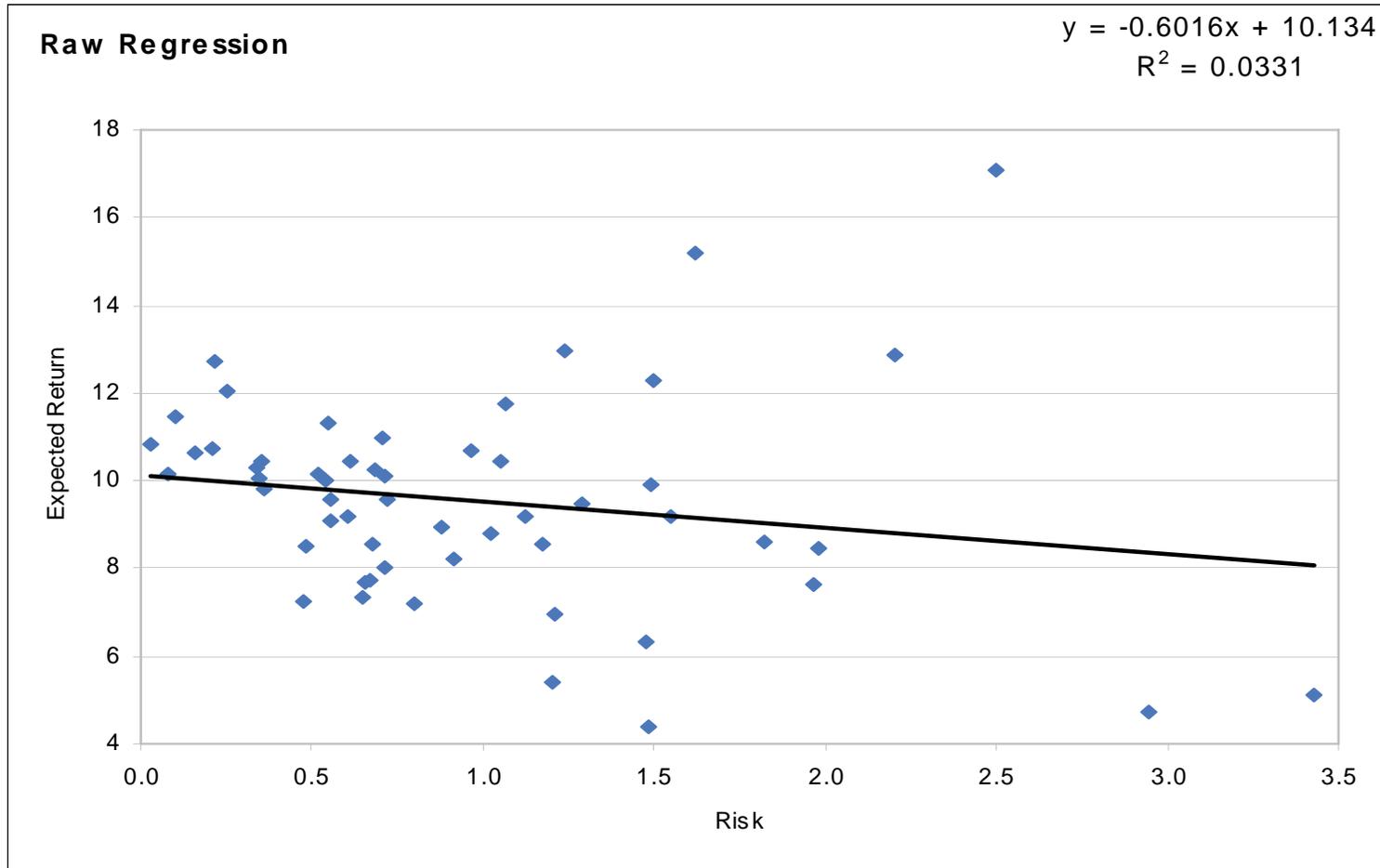
Confidence Bands can be compared to the Loan Obligations of a Commercial Mortgage

Debt Risk Metrics

- PD: Conditional (to getting there) Probability of Default. Area in the NOI probability distribution that represents outcomes< debt service.

- Loss at each outcome = Debt service - NOI

- Expected Loss: $\sum_{\text{outcomes}}$ probability of outcome x loss at that outcome

- Severity (Loss Given Default, LGD) = EL/PD

- Value-at-Risk: Loss (e.g. Loan Balance – value) associated with a particular point in the probability distribution (e.g. 95% confidence = 5% worst outcome).

Debt Risk Metrics (continued)

- What about time? There are 10 years in which loan can default.

- D_t: *Unconditional* likelihood of Default at time t. The likelihood that the loan defaults and that the default occurs in year t.

- $D_t = S_{t-1} \times PD_t$.

- $S_t = S_{t-1} \times (1 - PD_t)$, $S_0 = 1$. (recursive equations)

- "Hazard" function: a competing risk over time.

- Lifetime Default $= \sum D_t$

- The Basel Agreement is coming!

Forecast Risk Metrics:
The next wave of Risk Management (and Basel Compliance)

Risk measures over 3-year term

Future default frequency	Loss given default	Expected loss	Unexpected loss at 95%	Rating	Yeld degradation
0.98%	$ 100,295	$ 983	$ 0	2	10

Risk measures by year

Year	Default frequency	Loss given default	Expected loss	Unexpected loss at 95%
1	0.86%	$ 98,934	$ 851	$ 0
2	0.77%	$ 97,794	$ 753	$ 0
3	1.29%	$ 102,695	$ 1,325	$ 0
4	1.43%	$ 120,935	$ 1,729	$ 0
5	1.24%	$ 149,784	$ 1,857	$ 92,547
6	0.94%	$ 138,057	$ 1,298	$ 93,931
7	0.44%	$ 112,738	$ 496	$ 94,043
8	0.35%	$ 104,450	$ 366	$ 94,145
9	0.32%	$ 89,791	$ 287	$ 94,239
10	0.20%	$ 85,301	$ 171	$ 94,327

Figure by MIT OpenCourseWare.
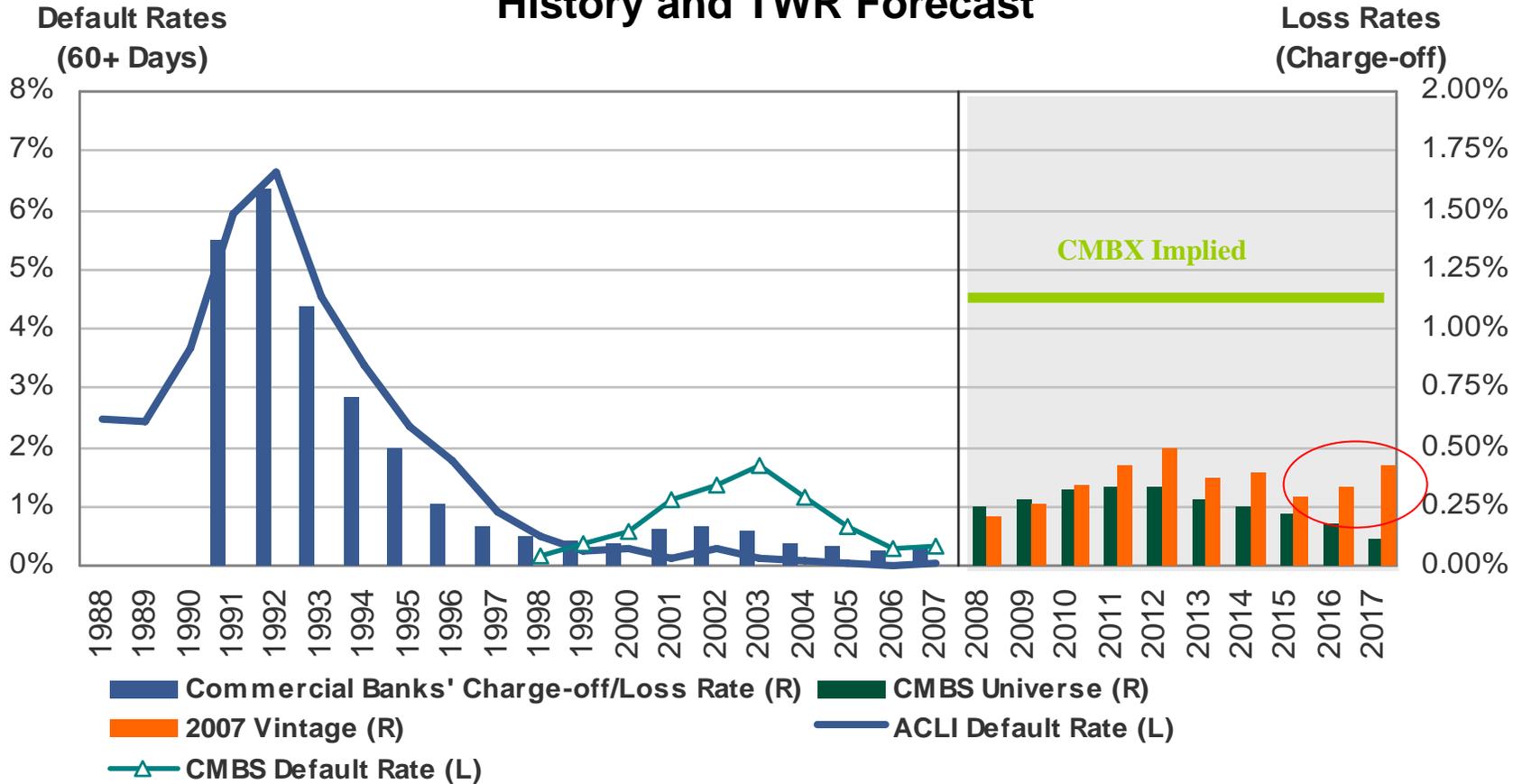
Sources: ACLI, FDIC, Trepp , Moody's, CBRE Torto Wheaton Research