Is There Excess Comovement in the U.S. Real Estate Markets?

by

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Motivation

- The recent performance of the U.S. residential real estate market:
  - A protracted period of increasing housing prices
  - followed by a massive and expensive correction
    - July 2007: Robert Shiller observed that such a correction may cost trillions of dollars
- Observers quickly labeled it a "*housing bubble*"
  - Yet, is it due to irrationality of investors or fundamentals?
  - The former is more popular than the latter: E.g., Wikipedia:
    - "*The housing bubble in the U.S. was caused by historically low interest rates, poor lending standards, and a mania for purchasing houses* [and] *is related to the stock market or dot-com bubble of the* 1990s."

The research question

⇒ What explains the **comovement** among U.S. residential real estate prices over the last two decades?

- Existing literature links financial crises to **excess** covariation among asset prices
  - Covariation that cannot be explained by common exposures to fundametal pricing factors
  - E.g., Loretan & English (2000); Forbes & Rigobon (2002); Bekaert et al. (2005)
- Excess comovement may be related to market irrationality or investors’ trading activity
  - E.g., Kodres & Pritsker (2002); Pasquariello (2007)

⇒ In essence, we find that domestic residential real estate markets within the U.S. have become more *fundamentally* integrated

Data description

⇒ Housing price data

- Monthly returns for S&P/Case-Shiller Home Price Indices (CSI, r_{kt}) between 01/1987 and 10/2006
  - $K = 14$ individual metropolitan markets:
    - Los Angeles, San Diego, San Francisco, Denver, DC, Miami, Tampa, Chicago, Boston, Charlotte, Las Vegas, New York, Cleveland, Portland
  - Based on *actual* transactions:
    - Price changes between two arms-length sales of the same single-family home
    - Filters to ensure constant-quality
    - Lower weights to adjust for extreme price changes, physical changes, local neighborhood effects

Table 1. Descriptive statistics

Index	N	μ	σ	Skew	Kurt	$\widehat{\rho}_1$	$LB(5)$
Composite	237	0.537%†	0.66%	0.11	-0.40	1.230†	427.91†
				Metropolitan Markets			
Los Angeles	237	0.645%†	1.03%	0.25	-0.08	0.961†	279.04†
San Diego	237	0.631%†	0.97%	0.73†	1.82†	0.594†	120.29†
San Francisco	237	0.646%†	1.03%	0.54†	0.38	1.139†	347.60†
Denver	237	0.429%†	0.54%	0.01	0.33	0.689†	205.65†
Washington	237	0.563%†	0.80%	0.53†	0.35	0.898†	219.22†
Miami	237	0.592%†	0.72%	0.61†	1.30†	0.469†	139.34†
Tampa	237	0.467%†	0.70%	0.88†	1.29†	0.501†	149.40†
Chicago	237	0.484%†	0.62%	0.34*	1.55†	0.556†	129.29†
Boston	237	0.388%†	0.79%	-0.07	0.05	0.874†	207.52†
Charlotte	237	0.298%†	0.43%	0.27*	1.13†	0.475†	132.81†
Las Vegas	237	0.531%†	1.00%	2.15†	9.57†	0.654†	120.67†
New York	237	0.444%†	0.69%	0.06	-0.40	1.057†	347.22†
Cleveland	237	0.348%†	0.49%	0.18	0.03	0.485†	105.03†
Portland	237	0.627%†	0.62%	0.74†	1.33†	0.593†	157.89†

- Montly returns are positive and large: greater than nationwide monthly inflation (0.25% for CPI excluding shelter)

Measuring excess comovement

⇒ A multi-step approach similar to Kallberg & Pasquariello (2007):

1. Fundamental comovement

- A multi-factor (f_t) model of real assets' returns with time-varying sensitivities (β_{kt}):

$$r_{kt} = \alpha_{kt} + f_t \beta_{kt} + e_{kt}$$

- Nationwide shocks in real estate, financial, real markets
  - Composite CSI (r_{mt}), S&P500 (r_{SPt}), 30-year conventional mortgage rate (MTG_t), slope of yield curve (SLP_t), inflation ex-shelter (CPI_t)
    - *Real* analysis yields similar inference
- Nationwide economic and demographic shocks
  - % change in unemployment (UNE_t), population (POP_t), disposable income (INC_t), nominal GDP (GDP_t)

Measuring excess comovement (2)

⇒ A multi-step approach similar to Kallberg & Pasquariello (2007):

2. Latent comovement

- From a stacked version of above model over $[t - N + 1, t]$:

$$E[e_t e_t'] = V_t = \begin{bmatrix} \sigma_{11t} & \sigma_{12t} & \cdots & \sigma_{1Kt} \\ \sigma_{21t} & \sigma_{22t} & \cdots & \sigma_{2Kt} \\ & & \vdots & \\ \sigma_{K1t} & \sigma_{K2t} & \cdots & \sigma_{KKt} \end{bmatrix} \otimes I = \Sigma_t \otimes I$$

  - when $E[e_{kt} e_{ns}'] = O$ across observations ($t \neq s$);

- Σ_t is of interest to this paper
- $OLS = FGLS$ since f_t is common to all k (Greene, 1997)
  - FGLS (OLS) under (alternative) (null) hypothesis of e_{kt} (not) comoving

Measuring excess comovement (3)

⇒ A multi-step approach similar to Kallberg & Pasquariello (2007):

3. Excess comovement: *are return residuals correlated*?

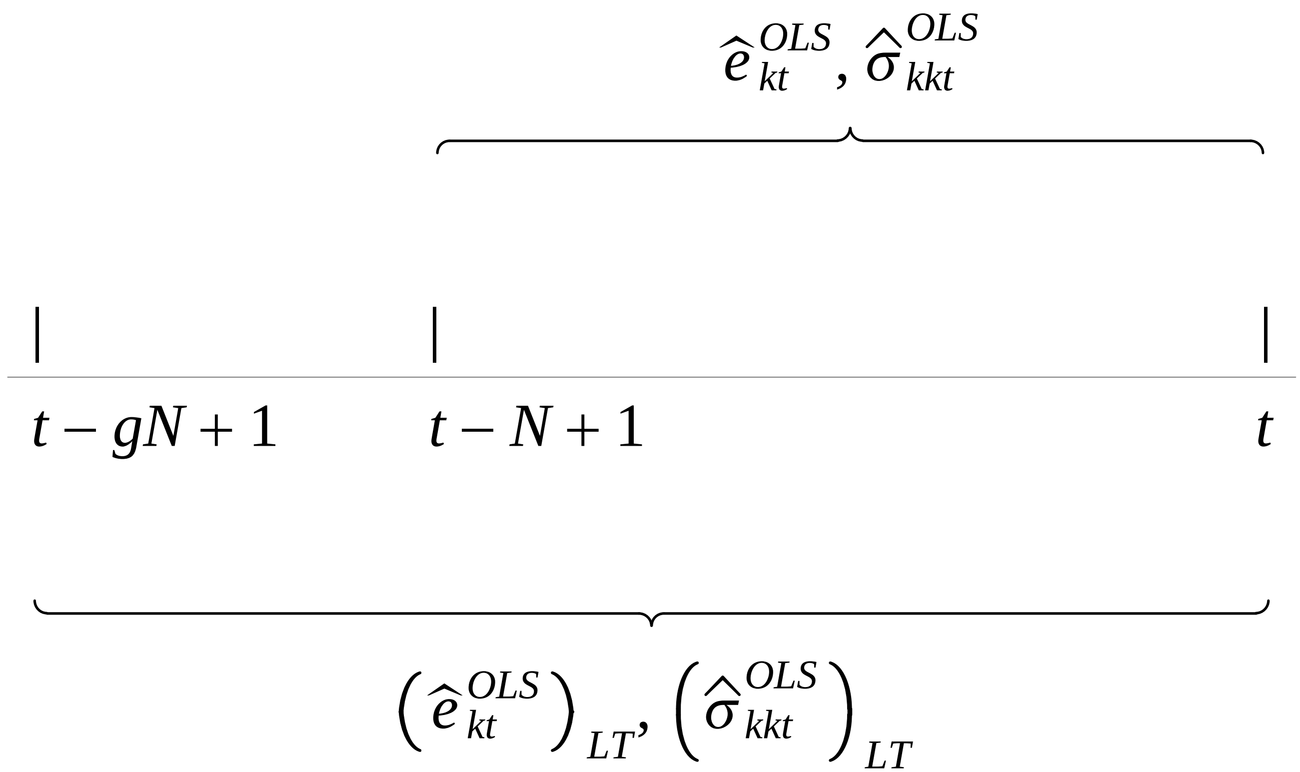
- Using $\widehat{\sigma}_{knt}^{OLS} = \frac{\left(\widehat{e}_{kt}^{OLS}\right)'\widehat{e}_{nt}^{OLS}}{N}$, we compute excess comovement:

$$\widehat{\rho}_{knt}^{OLS*} = \frac{\widehat{\rho}_{knt}^{OLS}}{\left\{1+\left[\frac{\widehat{\sigma}_{kkt}^{OLS}}{\left(\widehat{\sigma}_{kkt}^{OLS}\right)_{LT}}-1\right]\left[1-\frac{\left(\widehat{\sigma}_{knt}^{OLS}\right)^2}{\widehat{\sigma}_{kkt}^{OLS}\widehat{\sigma}_{nnt}^{OLS}}\right]\right\}^{\frac{1}{2}}}$$

- to control for heteroskedasticity biasing *conditional* $\widehat{\rho}_{knt}^{OLS}$ upward (Forbes & Rigobon, 2002)
- Excess *square*, *significant* correlation (at 10% using *t*-ratio tests for $\widehat{\rho}_{knt}^{OLS}$) over each metro area & U.S.:
    - No sign in $\widehat{\rho}_{knt}^{OLS}$'s directional moves & sample variation

$$\hat{\rho}_{kt}^{OLS*} = \frac{1}{K-1}\sum_{\substack{n=1\\ n\neq k}}^{K}\left(\hat{\rho}_{knt}^{OLS*}\right)^2 I_{knt}^{OLS} \;\&\; \hat{\rho}_{t}^{OLS*} = \frac{1}{K}\sum_{k=1}^{K}\hat{\rho}_{kt}^{OLS*}$$

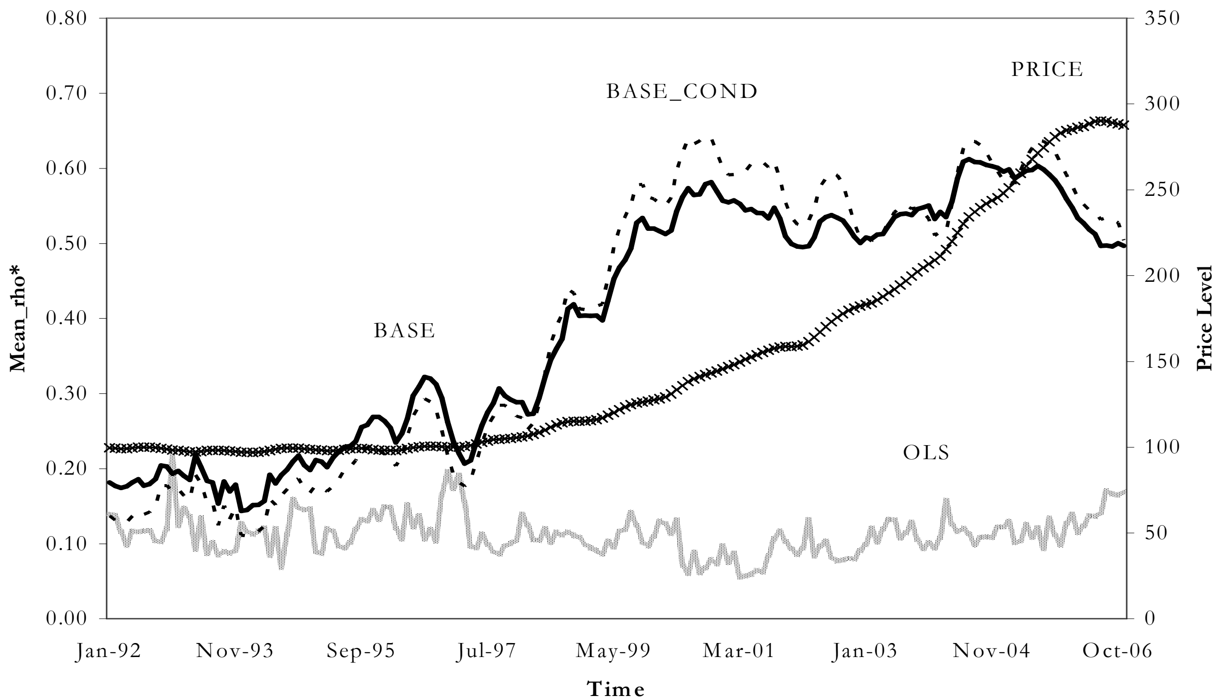
- Model is estimated over rolling windows of length N and gN



  - E.g., Campbell et al. (2001)

OLS comovement

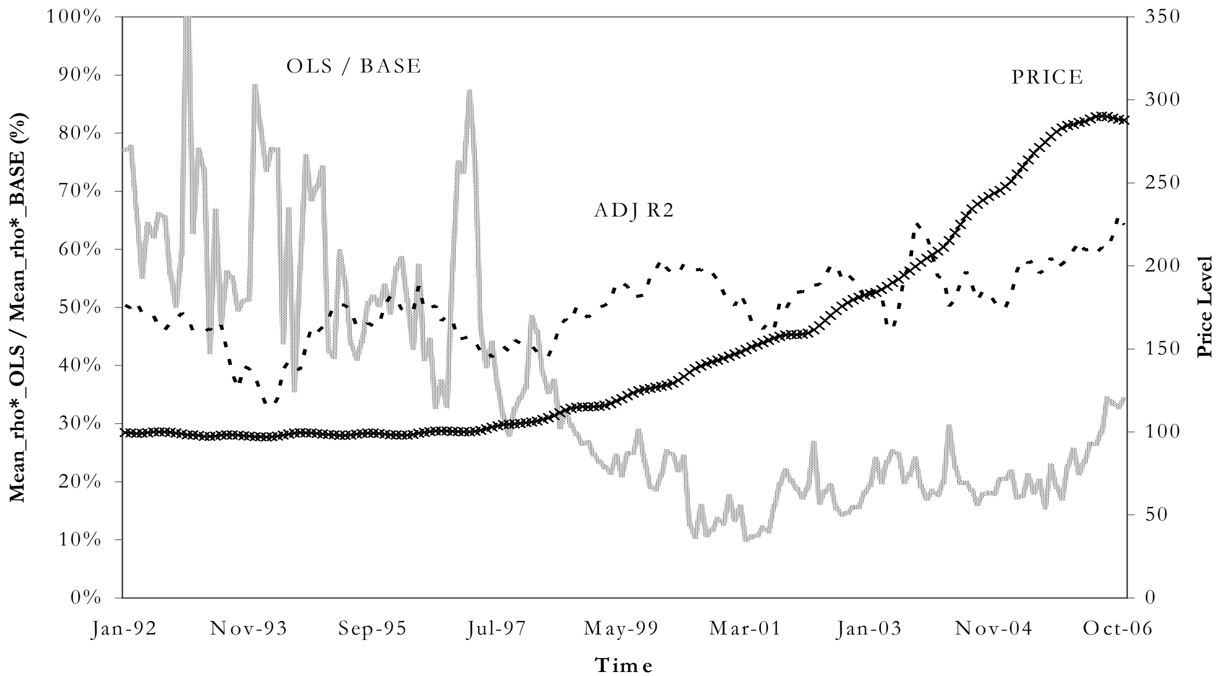
- $\widehat{\rho}_t^{OLS*}$ & $\widehat{\rho}_t^{BASE*}$ (benchmark, using raw returns)
  - $N = 30$ (2.5 years) & $g = 2$: 01/1992 to 10/2006



- Raw comovement doubles in late 1990s, especially on Coasts

OLS comovement (2)

- $\widehat{\rho}_t^{OLS*}$ & $\widehat{\rho}_t^{BASE*}$ (benchmark, using raw returns)
  - Dynamics may be due to common fundamentals

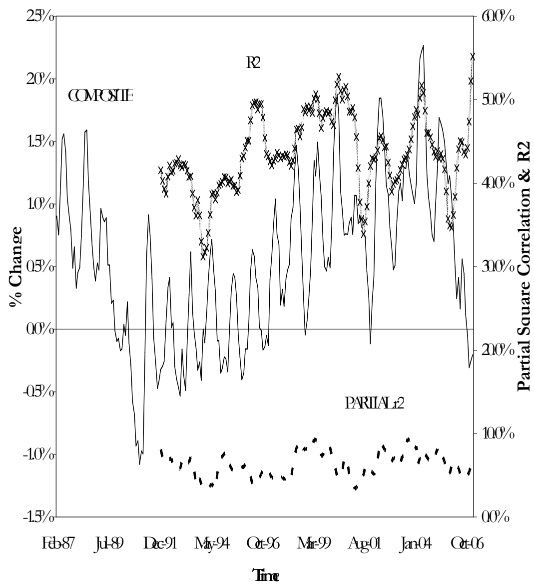


- Average $\overline{R}_{at}^2$ steadily increases toward 70% in late 1990s

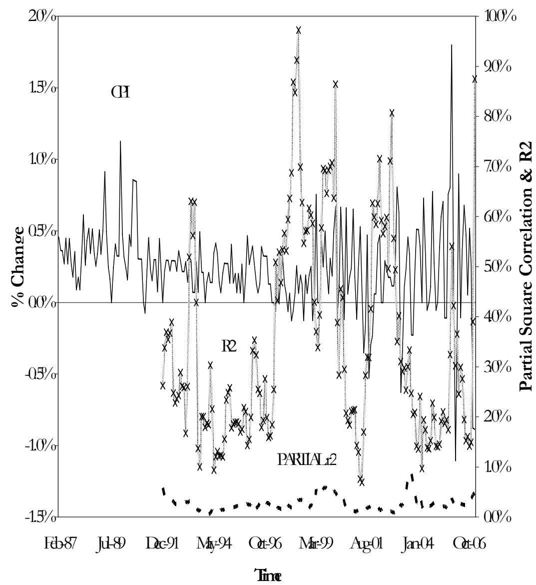
OLS comovement (3)

- Which common factors play the most porminent role?
  - Average individual $\overline{R}^2_{f_{it}}$ and square partial correlations $\bar{r}^2_{f_{it}}$

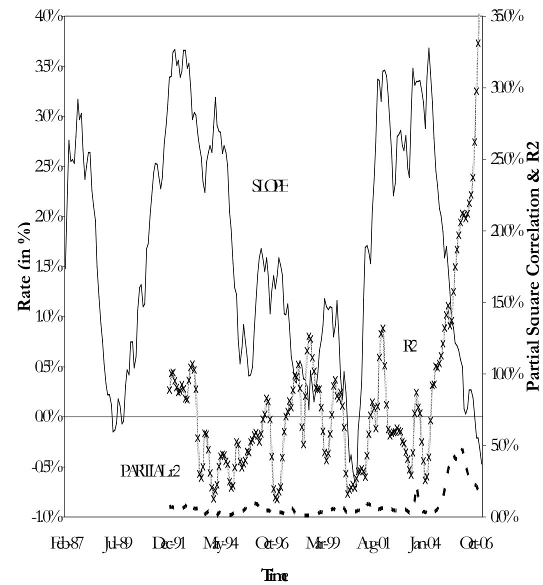
Composite CS



CPI



Slope



- Common real estate shocks, realized inflation, and slope

OLS comovement (4)

- Yet, there is excess comovement in the U.S. residential market
  - E.g., 43% of square $\widehat{\rho}_{knt}^{OLS*}$ are significant at 10% level

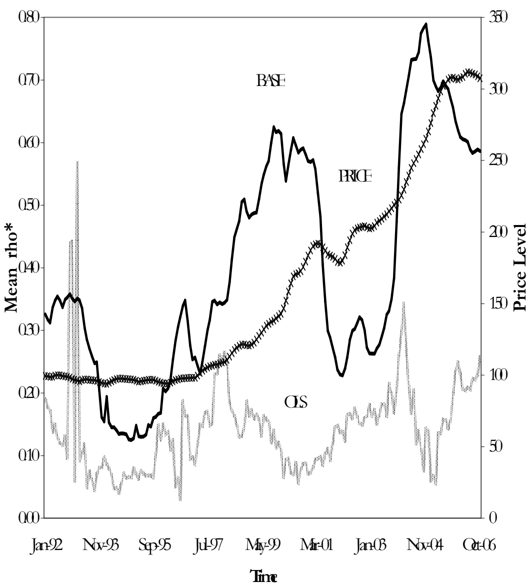
Index	$\widehat{\rho}_t^{OLS*}$ μ	$\widehat{\rho}_t^{OLS*}$ σ	$B\rho$	$R\rho$	$T\rho$	$F\rho^{*2}$	$\widehat{\rho}_t^{BASE*}$ μ	$\widehat{\rho}_t^{BASE*}$ σ	$T\rho$	$F\rho^{*2}$
Nationwide	0.112†	0.027	-0.238	28%	33%	43%	0.396†	0.159	81%	83%
Metropolitan Markets										
Los Angeles	0.133†	0.073	0.065	29%	40%	50%	0.455†	0.206	79%	81%
San Diego	0.104†	0.063	-0.049	24%	35%	44%	0.430†	0.205	78%	81%
San Francisco	0.142†	0.074	0.225	35%	39%	49%	0.401†	0.186	82%	86%
Denver	0.099†	0.070	0.038	21%	31%	43%	0.465†	0.209	86%	85%
Washington	0.113†	0.075	-0.114	26%	34%	43%	0.441†	0.187	82%	86%
Miami	0.116†	0.101	-0.032	32%	31%	43%	0.361†	0.187	76%	78%
Tampa	0.096†	0.092	-0.159	30%	26%	31%	0.327†	0.200	72%	72%
Chicago	0.098†	0.070	-0.020	22%	29%	43%	0.450†	0.183	84%	86%
Boston	0.096†	0.090	-0.002	20%	27%	35%	0.470†	0.182	89%	89%
Charlotte	0.086†	0.039	-0.011	31%	34%	42%	0.277†	0.134	81%	81%
Las Vegas	0.128†	0.091	0.105	47%	32%	42%	0.275†	0.182	71%	75%
New York	0.131†	0.045	-0.074	28%	41%	52%	0.462†	0.165	89%	90%
Cleveland	0.102†	0.070	0.024	27%	32%	41%	0.374†	0.116	89%	91%
Portland	0.131†	0.144	0.035	36%	31%	44%	0.363†	0.157	82%	83%

- $\widehat{\rho}_t^{OLS*}$ important for $\widehat{\rho}_t^{BASE*}$ up to mid-1990s ($R\rho > 50\%$) but decouples from it in late 1990s (low $R\rho$)

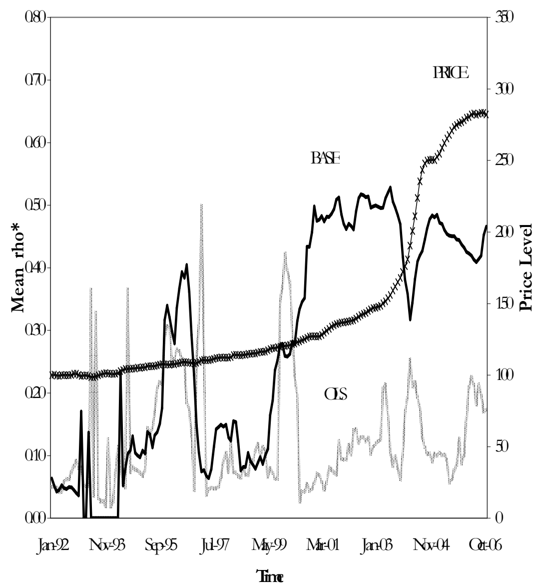
OLS comovement (5)

- Dynamics of (excess) comovement differ across metro areas

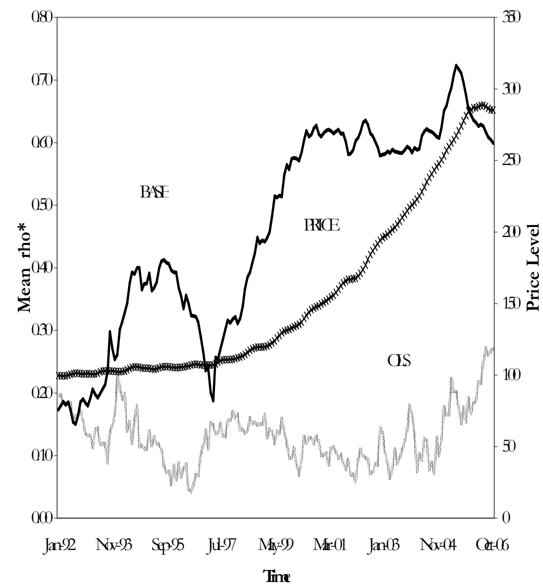
San Francisco



Las Vegas



New York



- E.g., in San Francisco & Las Vegas $\widehat{\rho}_{knt}^{OLS*}$ matters more, while in New York & San Diego $\widehat{\rho}_{knt}^{OLS*}$ matters less

Robustness tests

- Absolute, not *square* correlations
- Tests for sample variation
  - LM test strongly rejects the null that Σ_t is diagonal
  - 10%, 5%, or no significance threshold for $\hat{\rho}_{knt}^{OLS}$
- Different N and g
- No control for heteroskedasticity
- From Normality to Multivariate t (Zhou, 1993) for e_{kt}
  - Simulations: our test does not reject the null of no excess comovement "too often"

$\Rightarrow$ Our inference is unaffected

Regime shift in comovement?

⇒ When & to what extent do $\widehat{\rho}_t^{BASE*}$ & $\widehat{\rho}_t^{OLS*}$ decouple?

- A more rigorous test for a break date for

$$\widehat{\rho}_t^{BASE*} = a + b\widehat{\rho}_t^{OLS*} + \varepsilon_t$$

  - Bai et al. (1998): *nonparametric* test for a regime shift in *a*, *b*, or both based upon a *Wald* statistic of their distance at any possible break date over the sample period

$$\widehat{\rho}_t^{BASE*} = a + b\widehat{\rho}_t^{OLS*} + \left(\Delta a + \Delta b\widehat{\rho}_t^{OLS*}\right)d_t(\tau) + \varepsilon_t$$

    - where $d_t(\tau) = 1$ if $t \geq \tau$ and zero otherwise
    - Confidence interval around break date τ
    - Bekaert et al. (2002): test displays satisfactory finite-sample properties

Regime shift in comovement? (2)

- Large, statistically significant breaks between $\widehat{\rho}_t^{BASE*}$ & $\widehat{\rho}_t^{OLS*}$
  - Average nationwide $\widehat{\rho}_t^{BASE*}$ is 144% higher after 09/1998

Index	$F(\hat{\tau})$	$\hat{\tau}^-$	$\hat{\tau}$	$\hat{\tau}^+$	R^2_a	$\hat{a}$	$\hat{b}$	$\widehat{\Delta a}$	$\widehat{\Delta b}$
Nationwide	1337.32†	Sep-98	Sep-98	Sep-98	88.95%	0.224†	0.050	0.324†	-0.204
Metropolitan Markets									
Los Angeles	837.43†	May-98	Jun-98	Jun-98	82.57%	0.196†	0.336†	0.335†	0.334
San Diego	1769.35†	Sep-98	Sep-98	Sep-98	90.91%	0.074†	1.233†	0.550†	-1.514†
San Francisco	167.90†	Dec-03	Jan-04	Jan-04	50.85%	0.305†	0.241	0.478†	-0.854*
Denver	742.00†	Jun-97	Jul-97	Jul-97	80.70%	0.161†	0.602†	0.453†	-0.672†
Washington	1152.89†	Jun-99	Jun-99	Jun-99	86.84%	0.273†	-0.045	0.345†	0.018
Miami	459.04†	Aug-98	Sep-98	Sep-98	72.07%	0.171†	0.120	0.294†	0.250
Tampa	792.11†	May-99	Jun-99	Jun-99	82.33%	0.167†	-0.190*	0.331†	0.302*
Chicago	557.08†	Apr-98	May-98	May-98	75.80%	0.244†	0.223*	0.280†	0.486*
Boston	876.94†	May-98	Jun-98	Jun-98	83.16%	0.290†	-0.110	0.328†	0.078
Charlotte	290.97†	Jul-98	Aug-98	Aug-98	61.94%	0.160†	-0.001	0.147†	0.768*
Las Vegas	843.88†	Apr-00	May-00	May-00	82.80%	0.066†	0.499†	0.423†	-0.783†
New York	957.50†	Feb-99	Mar-99	Mar-99	84.44%	0.407†	-0.752†	0.166†	1.016†
Cleveland	447.25†	Apr-98	May-98	May-98	71.53%	0.294†	-0.344†	0.152†	0.444†
Portland	559.65†	May-99	Jun-99	Jun-99	75.90%	0.199†	0.189†	0.284†	-0.065

- $\widehat{\rho}_t^{OLS*}$ plays no role in shift ($\widehat{\Delta b} \approx 0$) except locally in a few cases

Further properties of comovement

- Raw comovement ($\widehat{\rho}_t^{BASE*}$) is *greater* during NBER recessions & prolonged U.S. stock market declines
  - Especially in Los Angeles, Las Vegas, Boston
    - Pavlova & Rigobon (2007): output shocks alter relative prices
  - $\widehat{\rho}_t^{BASE*}$ is *higher* during upward momentum in CSI indices
    - Herding, imitation, momentum speculators

	Panel A: $\widehat{\rho}_t^{BASE*}$ and $\widehat{\rho}_{kt}^{BASE*}$								
Index	Constant	d_t^R	d_t^+	d_t^-	d_{SPt}^+	d_{SPt}^-	d_{kt}^+	d_{kt}^-	R_a^2
Nationwide	0.264†	0.071†	0.191†	-0.042	0.019	0.060†			41.39%
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			

	Panel B: $\widehat{\rho}_t^{OLS*}$ and $\widehat{\rho}_{kt}^{OLS*}$								
Index	Constant	d_t^R	d_t^+	d_t^-	d_{SPt}^+	d_{SPt}^-	d_{kt}^+	d_{kt}^-	R_a^2
Nationwide	0.114†	-0.031†	-0.007	0.021*	0.007	0.002			22.57%
	[illegible]	[illegible]	-1.17	[illegible]	1.44	[illegible]			

- Less clear picture for excess comovement ($\widehat{\rho}_t^{OLS*}$)
  - *Higher* (*lower*) during CSI downturns (NBER recessions)

Conclusions

⇒ First empirical analysis of extent & dynamics of comovement among U.S. residential real estate markets in 1987-2006

- Multi-step approach as in Kallberg & Pasquariello (2007)

1. *Raw* comovement is economically significant

- U.S. metro areas are **more** *fundamentally integrated*
    - Via mortgage rates, realized & expected inflation, GDP
    - Higher in NBER recessions, upward CSI momentum

2. *Excess* comovement exists but is **small**

3. The dynamics of former are **weakly** related to those of latter, especially after 1998 & 1999

⇒ *Contagion* played only a **minor role** in U.S. real estate price dynamics during the "bubble"