JACOBS LEVY EQUITY MANAGEMENT CENTER
FOR QUANTITATIVE FINANCIAL RESEARCH

The Common Factor in Idiosyncratic Volatility:
Quantitative Asset Pricing Implications

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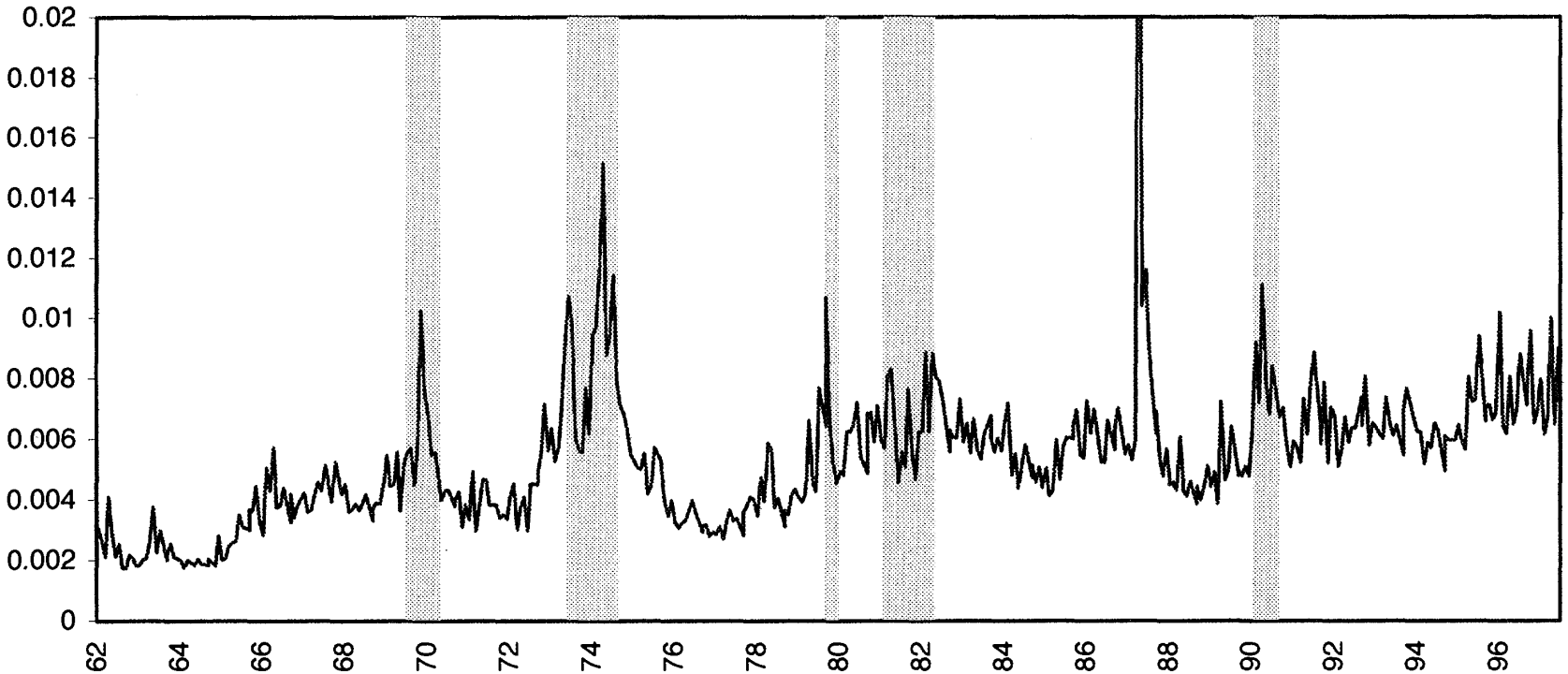
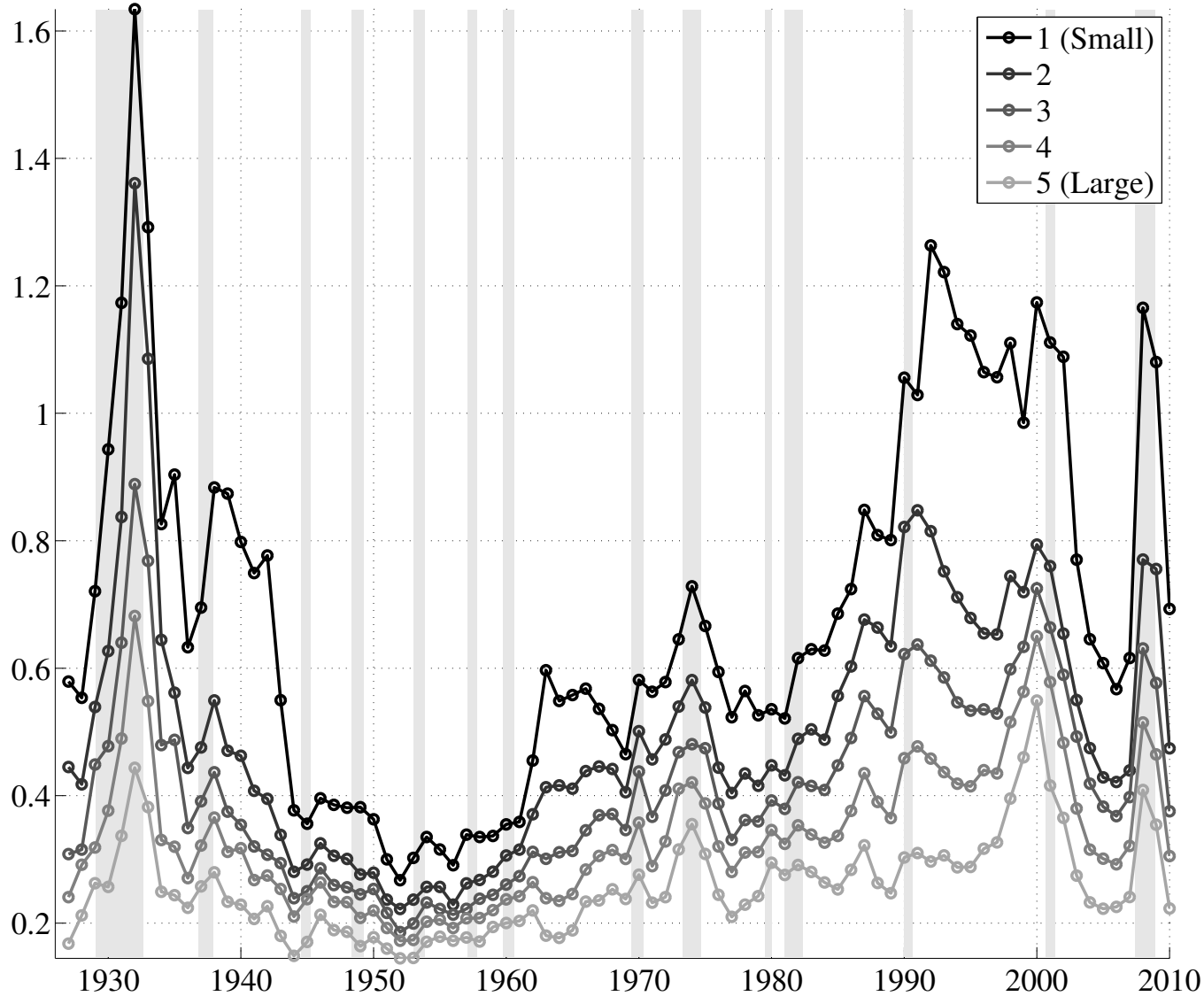
Average Firm Volatility

Campbell et al. (2001)



Average Firm Volatility

Idiosyncratic Volatility by Size Quintile



This Paper

- Strong comovement of individual stock return volatilities
  - Idiosyncratic volatility
  - Firm cash flows
- Shocks to this common component of idiosyncratic volatility (CIV) are priced
  - Idiosyncratic volatility
  - Sorting stocks on their CIV-beta produces return spread of about 6%
  - Survives typical battery of factors
- Establish empirical connection between CIV and household income risk
- Model with heterogeneous investors whose income risk is linked to firm performance accounts for all three facts

Outline

1. Common idiosyncratic volatility (CIV) facts
2. Firm risk and household risk
3. CIV and stock returns
4. Heterogeneous agent model with common idiosyncratic volatility
5. Firm volatility in dynamic networks

Volatility Factor Structure

Facts:

1. Firm-level volatility obeys a strong factor structure
   - Both in returns and in cash-flow growth rates
   - Both total volatility and residual volatility

2. Not due to omitted factors in return/growth rate model
   - Among uncorrelated residuals (e.g. from 10 PCs), strong factor structure in *volatilities* remains intact

3. A common idiosyncratic volatility factor (CIV) captures much of the covariation (factor is *not* market volatility)

$$r_{i,t} = \gamma_{0,i} + \boldsymbol{\gamma}_i' \boldsymbol{F}_t + \sigma_{i,t}^2 \varepsilon_{i,t}$$

$$\sigma_{i,t}^2 = \sigma_i^2 + \delta_i CIV_t + \nu_{i,t}$$

* Return to discussion of potential mechanisms at the end

Firm-Level Volatility Matters

Why might this matter?

- Pass-through in labor markets: substantial fraction of firm-level volatility ends up being passed through to workers

What can investors do?

- Build portfolios that hedge their income risk

This paper:

Commonality in firm vol
+
Labor income pass-through
= Important price effects

The Basic Volatility Facts

Calculations

Return volatility (year-firm panel, CRSP 1926-2010)

- "Total" volatility: Std dev of daily stock returns within calendar year
- "Idiosyncratic" volatility: Daily factor model in each calendar year

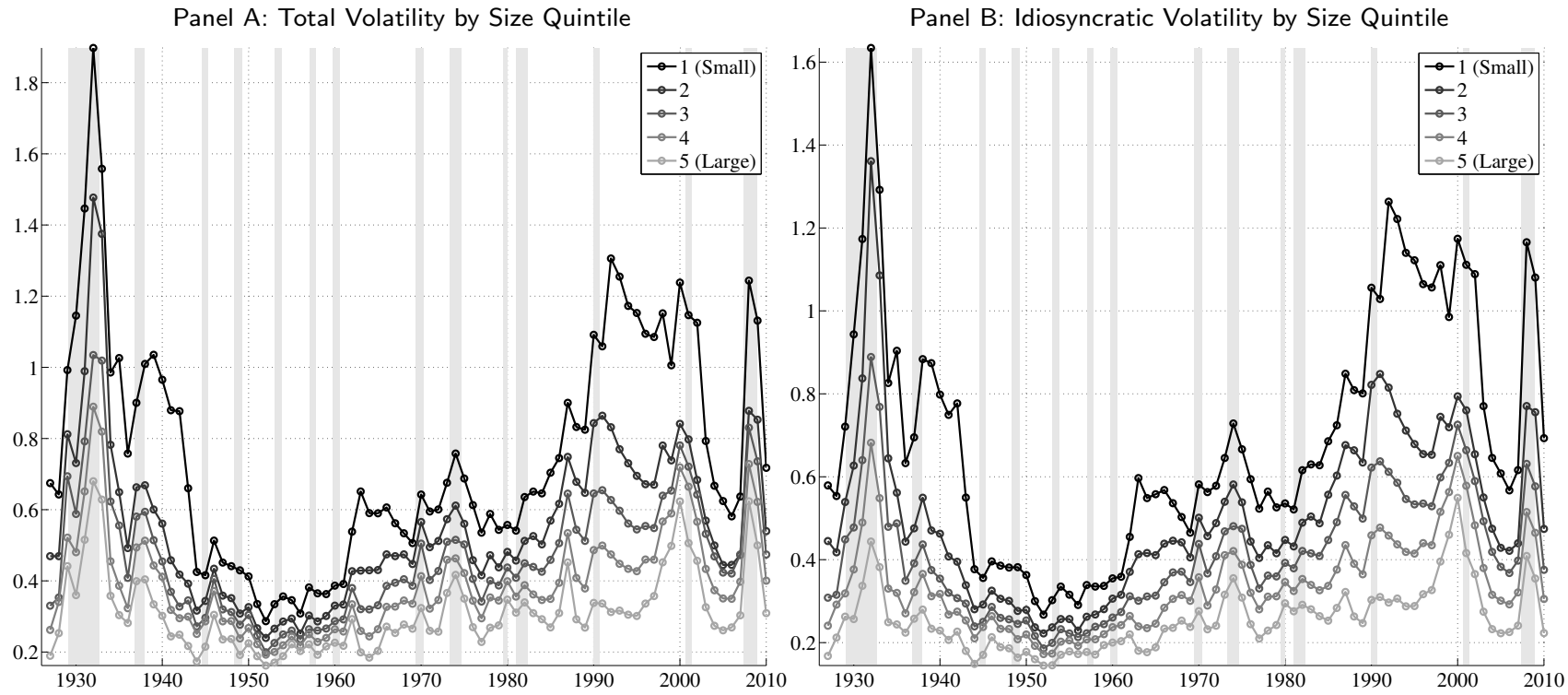
$$r_{i,t} = \gamma_{0,i} + \boldsymbol{\gamma}_i' \boldsymbol{F}_t + \varepsilon_{i,t}$$

- $\boldsymbol{F}_t$ can be mkt, FF3, 5PCs, 10PCs
- Extensions: Monthly panel, monthly returns, portfolios, etc.

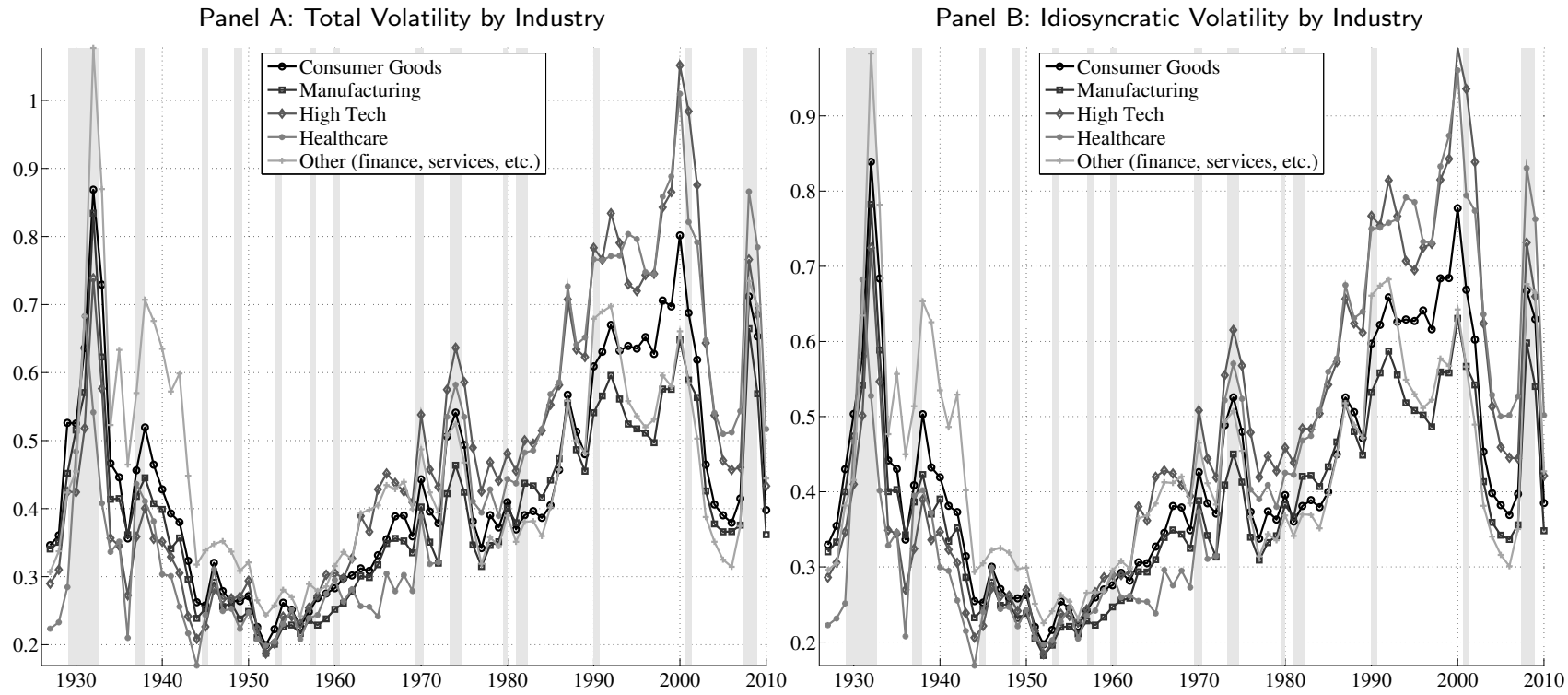
Fundamental volatility (year-firm panel, CRSP/Compustat 1975-2010)

- "Total" volatility: Std dev of 20 qtrly yoy sales growth observations for calendar years $\tau - 4$ to τ
- "Idiosyncratic" volatility: Qtrly factor model in 5-year window (PCs)
- Extensions: Cash flows, estimation window, etc.

Common Factor in Total and Residual Volatility



Common Factor in Total and Residual Volatility



Again, These are *Residual* Volatilities

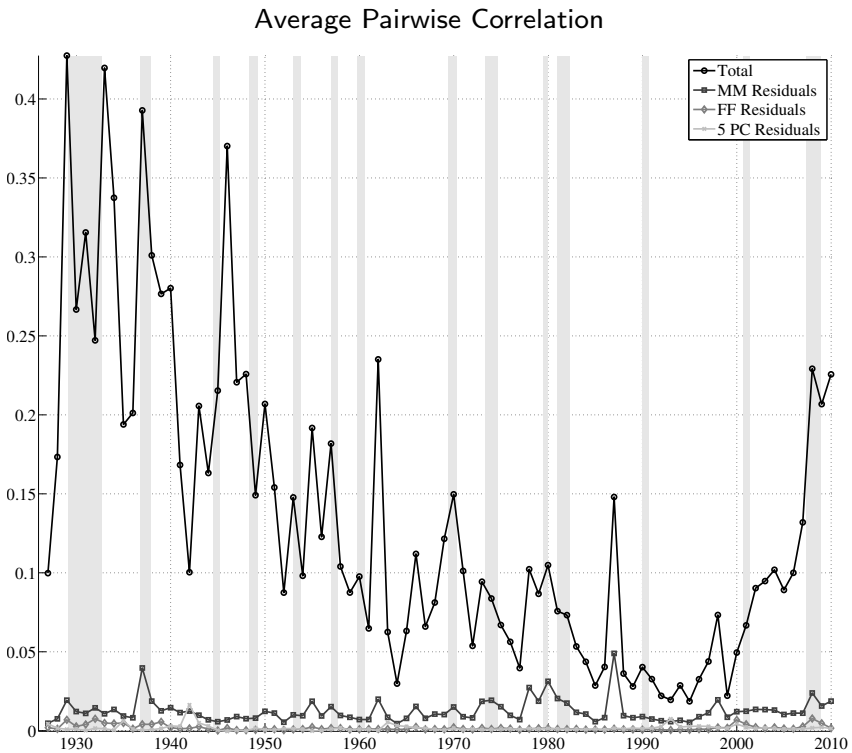
For each stock i

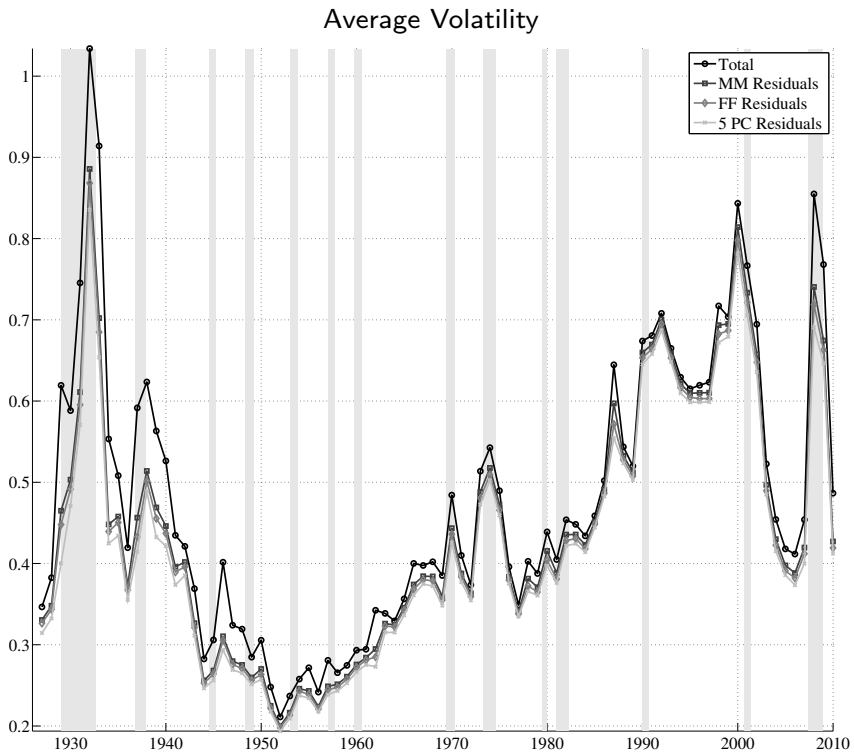
1. Run time series regression

$$r_{i,t} = \alpha_i + \beta_M r_{M,t} + \beta'_{FF} FF_t + \text{any other factors you want} + \varepsilon_{i,t}$$

2. Study residuals $\varepsilon_{i,t}$
   - Check if they cross-correlated
   - Build their variances
   - Does their volatility comove?

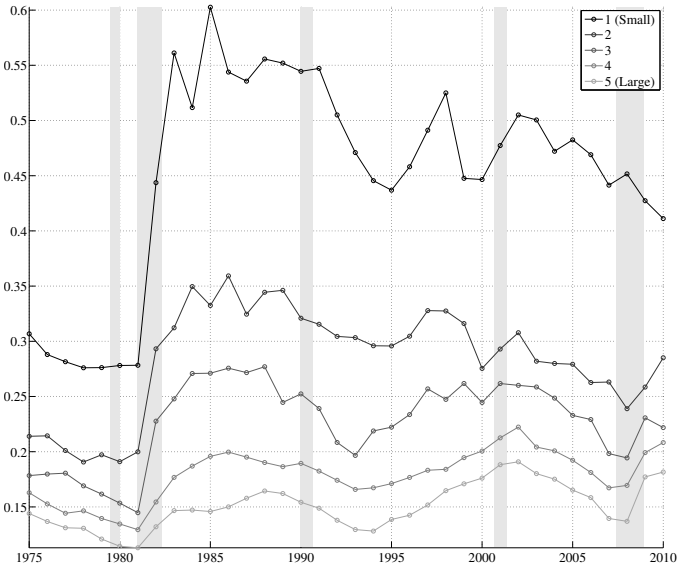
Correlation and Volatility





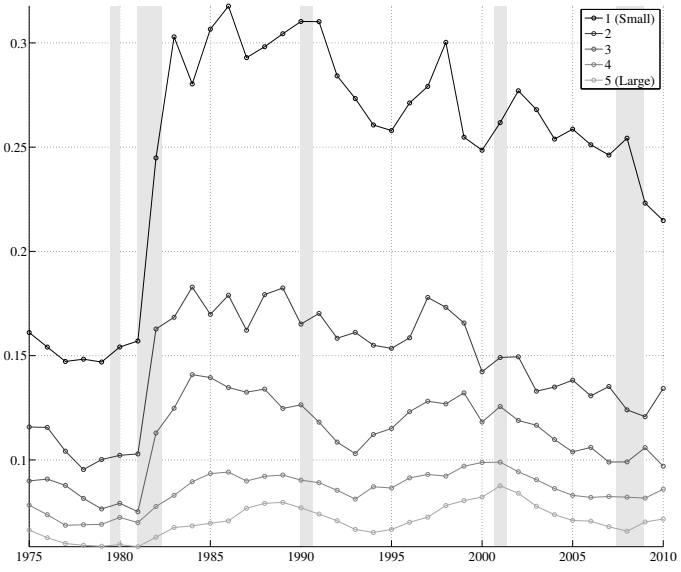
Comovement in Fundamental Volatilities

Panel A: Total Volatility by Size Quintile



Panel B: Total Volatility by Industry

Panel C: Idiosyncratic Volatility by Size Quintile



Panel D: Idiosyncratic Volatility by Industry

Quantifying the Factor Structure

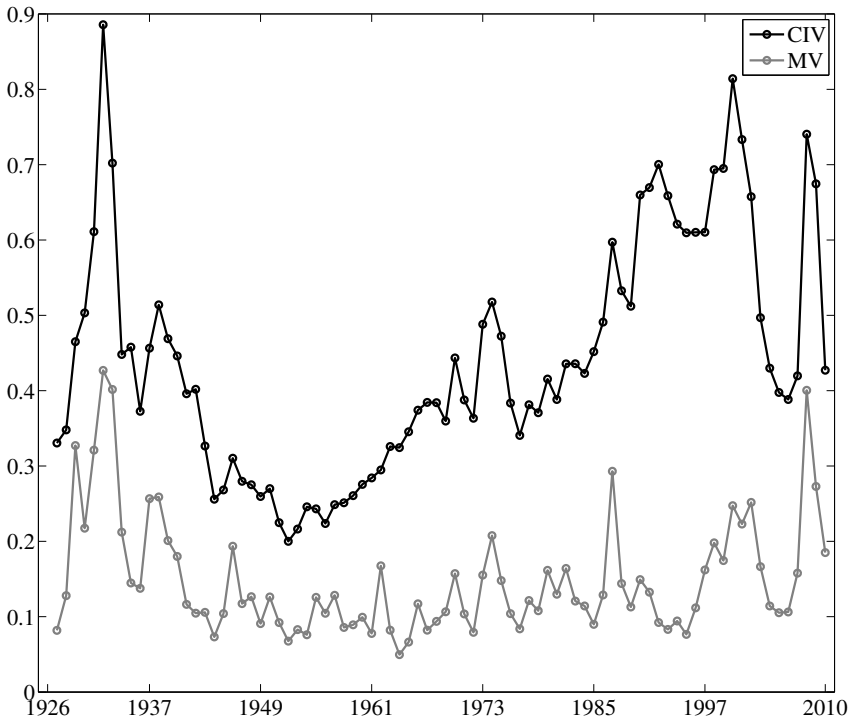
- Panel regression of firm vol on equally-weighted average vol across firms

	Panel A: Returns			
	Total	MM	FF	5 PCs
Loading (average)	1.012	1.024	1.032	1.031
Intercept (average)	0.006	0.005	0.004	0.004
R^2 (average univariate)	0.362	0.347	0.346	0.348
R^2 (pooled)	**0.345**	0.337	0.339	**0.347**

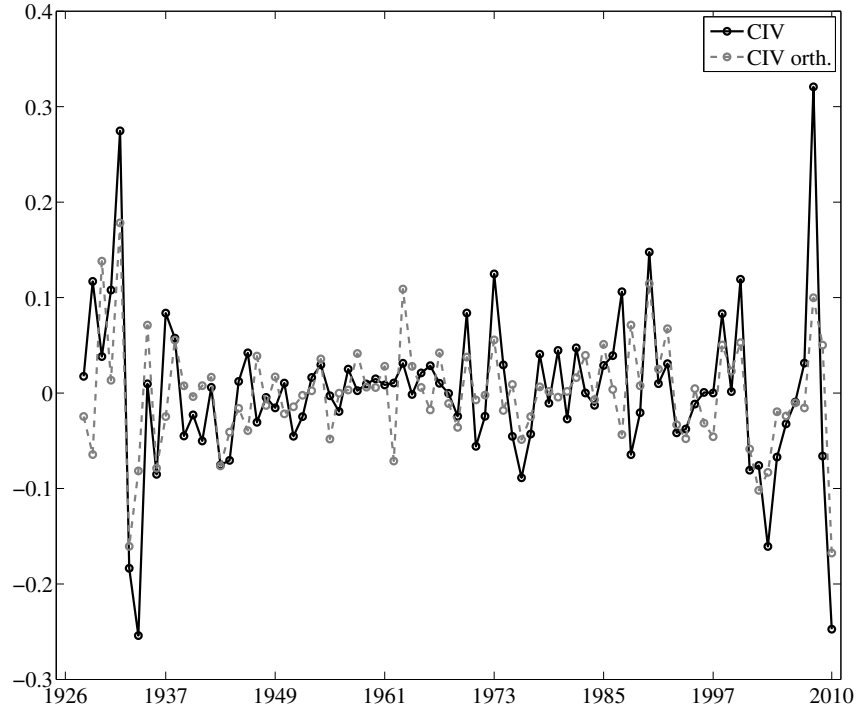
	Panel B: Sales Growth			
	Total (5yr)	1 PC (5yr)	5 PCs (5yr)	Total (1yr)
Loading (average)	0.885	1.149	1.249	0.884
Intercept (average)	0.044	-0.018	-0.024	0.030
R2 (average univariate)	0.293	0.299	0.299	0.178
R2 (pooled)	**0.303**	0.315	**0.304**	0.168

CIV, MV, and CIV Innovations

Panel A: Volatility Level



Panel B: Volatility Changes



- Common idios. volatility (CIV) and market volatility (MV) correlated
- Nonetheless, shocks to CIV and shocks to MV are distinct: 67% correlation between CIV changes and CIV changes orthogonalized to MV changes

Implications of Volatility Comovement

- This talk: Equity risk premia
- Ongoing work:
  - Valuing and hedging options book
  - Understanding and valuing joint tail risk

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2. **Firm risk and household risk**
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CIV and Individual Income Risk

- Many of persistent, idiosyncratic income shocks experienced by households begin with firm/employer from which income is derived
  - Job displacement: "a plant closing, an employer going out of business, a layoff from which he/she was not recalled" (Kletzer 1989,1990)
  - Firm-specific human capital "... cost of and the return to the investment will be shared by the worker and the employer" (Becker 1962)
  - Direct exposure to equity risk of employer for incentive reasons... (Jensen and Meckling 1976, Murphy 1985, Morck, Shleifer, and Vishny 1988, Kole 1995, etc.)
  - ...and for non-incentive reasons (Benartzi 2001, Cohen 2009, Van Nieuwerburgh and Veldkamp 2006)

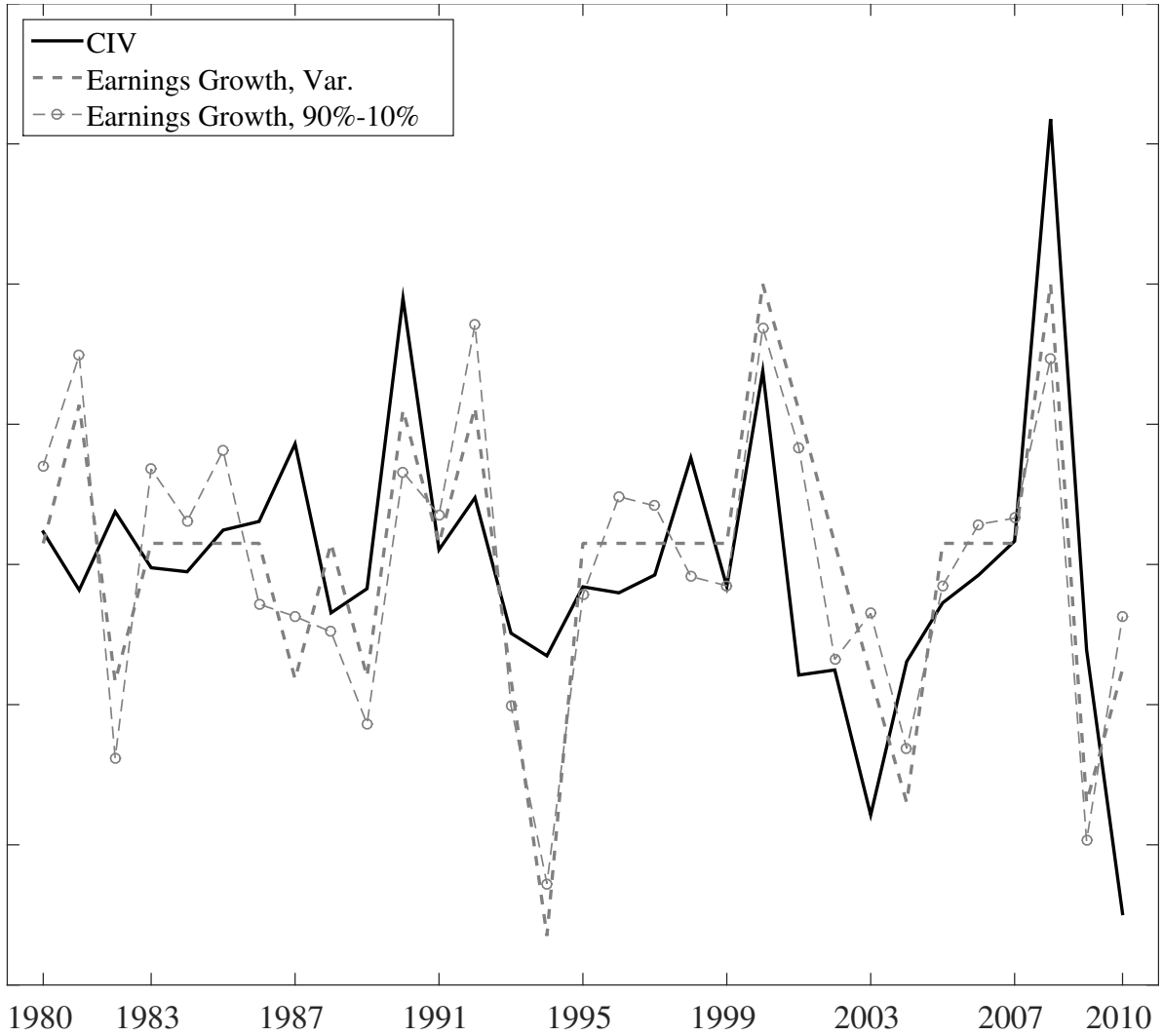
CIV and Individual Income Risk

- Consensus view in the literature: Households can't fully insulate their consumption from persistent shocks to labor income. $> 40\%$ of permanent labor income shocks are passed to consumption (Cochrane 1991, Attanasio and Davis 1996, Blundell, Pistaferri, and Preston 2008, Heathcote, Storesletten, and Violante 2013)
- Firms provide employees with some temporary insurance against idiosyncratic shocks, little protection against persistent shocks which ultimately affect compensation through wages or layoffs (Berk, Stanton, and Zechner 2010, Lustig, Syverson, and Nieuwerburgh 2011)

Data: Proxies for Household Income Risk

1. Dispersion in income growth from (US Social Security Admin)
2. Dispersion in employment growth growth at U.S. public firms (Compustat)
3. Dispersion in employment growth for U.S. industries (Fed)
4. Dispersion in regional wage growth and house price growth (BEA)

CIV and Individual Income Risk



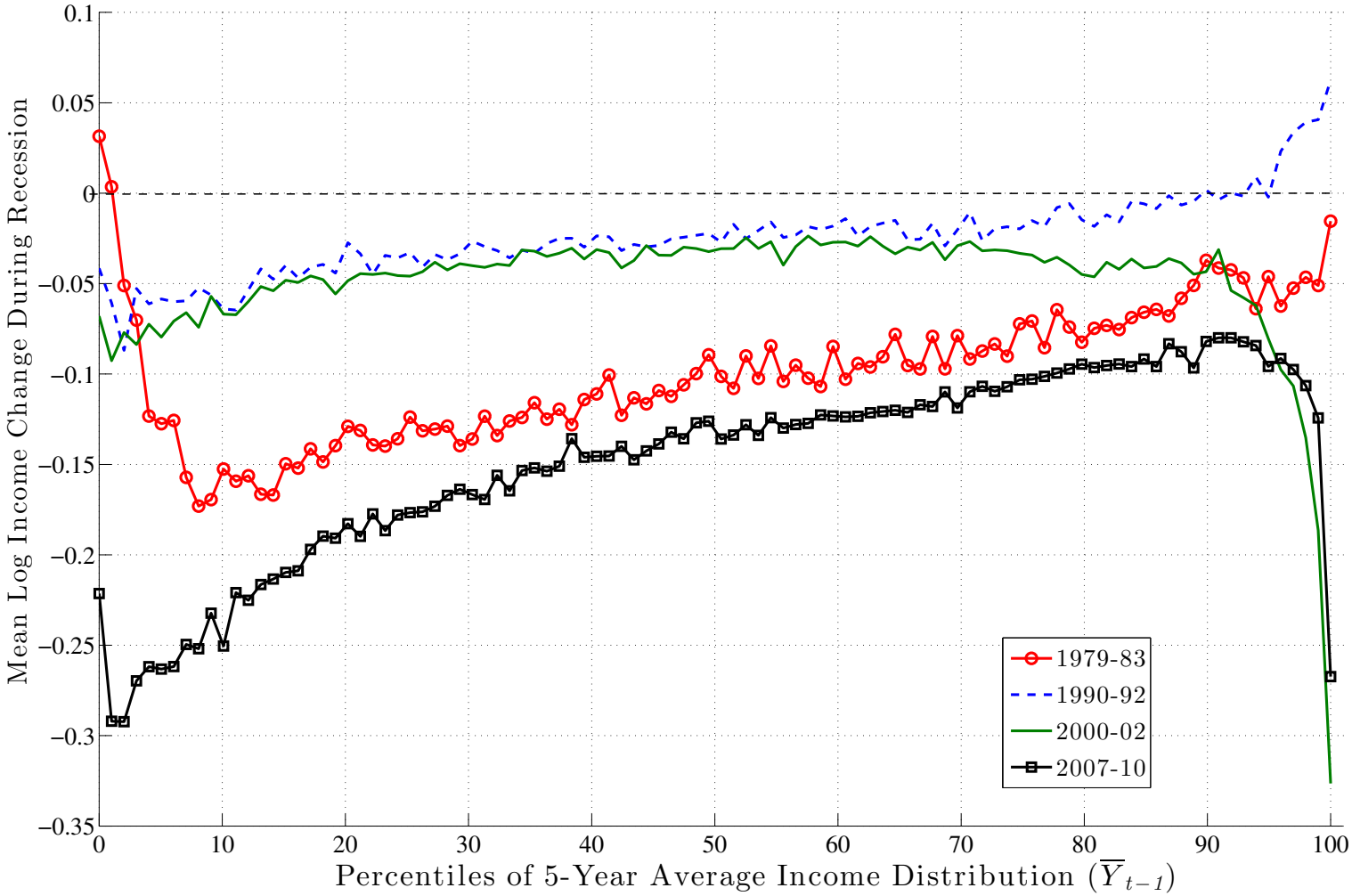
- Individual income growth from SSA, annual cross section stdev 1980-2010 from Guvenen et al. (2014)
- 53% correlation (t=3.4) between annual CIV and this measure (in changes)

CIV and Individual Income Risk

- CIV associated with employment risk (public firms)
  - IQR of firm-level employment growth rates growth for U.S. publicly-listed firms from 1975-2010
  - CIV has 33.5% correlation ($t = 2.7$) with employment growth dispersion (in changes)
- Similar employment risk result for public+private universe
  - Federal Reserve reports monthly total employment for over 100 sectors beginning in 1991
  - We calculate dispersion of sector-level employment growth
  - CIV has 44.2% correlation ($t = 2.0$) with employment growth dispersion (in changes)
- CIV associated with regional house price and wage risk
  - Quarterly house price data from Federal Housing Financing Agency and wage data from BEA
  - Dispersion in house price and wage growth across MSAs, 1969-2009, 386 regions
  - Correlation with quarterly changes in CIV of 23.2% ($t = 2.6$) for HP and 16.6% ($t = 1.9$) for wage growth

This is *Not* Just Low/Middle Income Risk

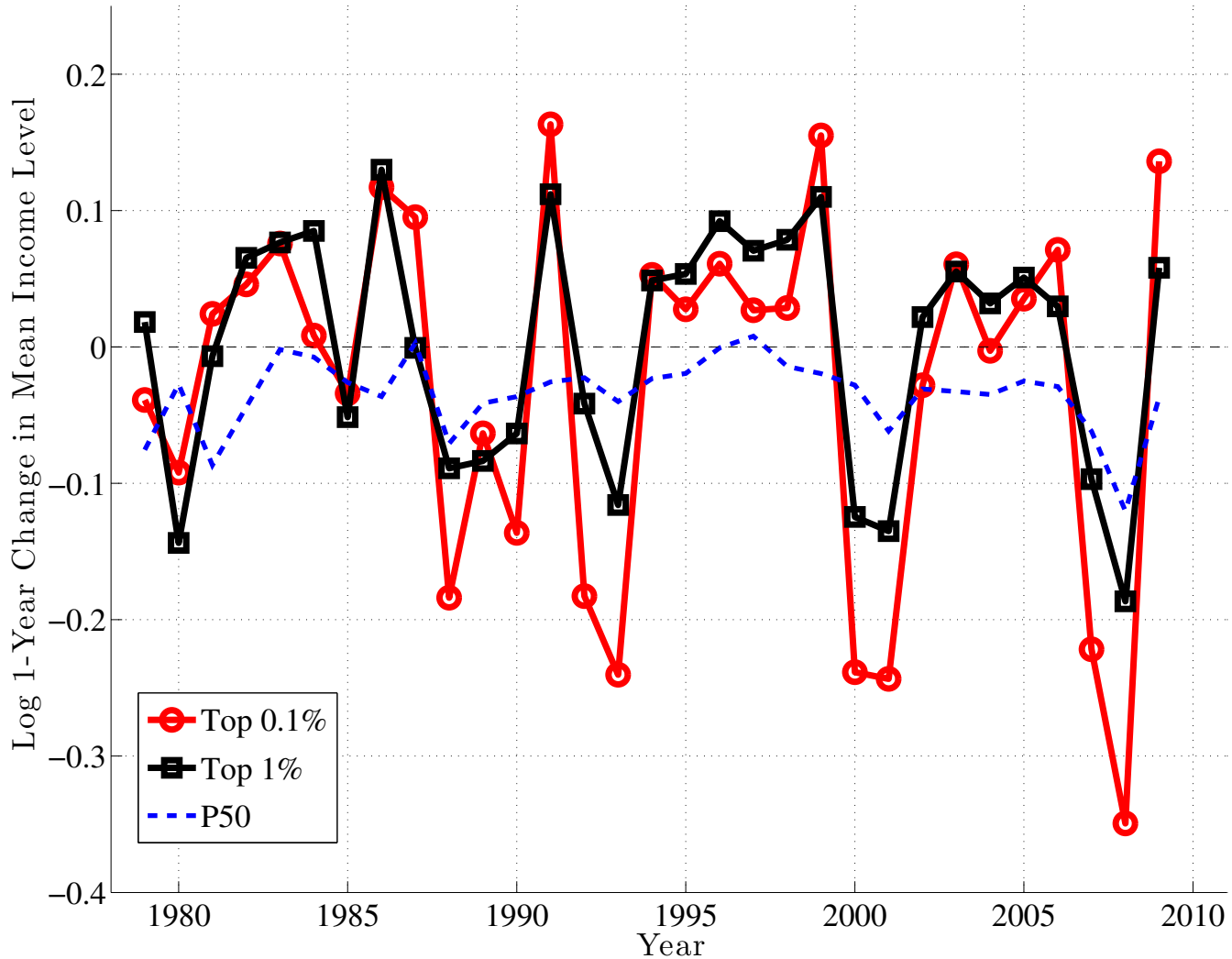
Income Growth During Recessions Across Income Distribution



Source: Guvenen, Ozkan, and Song

This is *Not* Just Low/Middle Income Risk

1-Year Income Growth, Top 1%



Source: Guvenen, Ozkan, and Song

Summary: CIV and Household Risk

- CIV shocks correlated with shocks to households' uncertainty about income growth, job security, house prices
- Interpretation: Households' income growth directly exposed to shocks to employers
- Fact: Households cannot insure away all income risk, esp. not the permanent shocks; consumption growth is affected
- Traction for households where equity participation is high
- Implication: With incomplete markets, CIV shocks affect consumption growth distribution and should be priced

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β_{CIV} Portfolios

- Shocks to CIV are priced: High $\beta_{i,CIV} \Leftrightarrow$ low $E[R_i]$
- Factor: Shocks to CIV, orthogonalized w.r.t. MV shocks
- Betas from past 60 months, returns are first post-formation month (annualized)

	CIV beta						
	1 (Low)	2	3	4	5 (High)	5-1	t(5-1)
$E[R]$	15.23	12.39	11.71	10.55	8.80	-6.44	-3.42
α_{CAPM}	3.38	1.47	1.14	0.27	-1.95	-5.33	-2.91
α_{FF}	2.32	0.84	0.94	0.22	-1.97	-4.28	-2.33

- Results hold in subsamples
- Results hold for various double sorts (next slides)

β_{CIV} Portfolios

CIV vs. MV Exposure

	1 (Low)	2	3	4	5 (High)	5-1	t(5-1)
			Panel A: Two-way sorts on CIV beta and MV beta				
MV beta							
1 (Low)	16.05	14.50	11.72	11.60	9.37	-6.69	-2.55
2	14.47	13.42	11.55	11.49	10.25	-4.22	-1.91
3	16.67	12.98	13.51	11.27	10.91	-5.76	-2.48
4	17.17	11.26	10.81	9.26	9.12	-8.05	-2.95
5 (High)	14.48	12.88	10.84	10.86	8.72	-5.76	-1.96
5-1	-1.57	-1.63	-0.87	-0.73	-0.64		
t(5-1)	-0.54	-0.52	-0.29	-0.25	-0.22		
			Panel B: One-way sorts on CIV beta, no orthogonalization				
$E[R]$	14.81	12.75	11.60	10.32	9.70	-5.11	-2.53
α_{CAPM}	2.66	1.43	0.97	0.13	-0.68	-3.34	-1.77
α_{FF}	1.97	0.97	0.68	0.00	-0.98	-2.96	-1.63
			Panel C: One-way sorts on MV beta				
$E[R]$	11.06	11.76	12.15	9.86	10.64	-0.42	-0.17
α_{CAPM}	-1.51	0.41	1.46	-0.30	0.84	2.34	1.09
α_{FF}	-1.20	0.29	1.10	-0.85	-0.13	1.06	0.58

CIV Pricing of Anomaly Portfolios

Fama MacBeth Analysis

	Panel A: 10 BM			Panel B: 10 ME		
Constant	0.009	0.014	0.012	−0.008	−0.004	0.004
t-stat	0.971	5.048	3.774	−4.816	−2.348	1.130
Rm-Rf	−0.003	−0.009	−0.007	0.013	0.009	0.001
t-stat	−0.280	−3.292	−2.190	8.955	5.568	0.366
CIV	–	−0.069	−0.069	–	−0.020	−0.033
t-stat	–	−9.934	−8.855	–	−7.265	−6.777
MV	–	–	−0.005	–	–	−0.025
t-stat	–	–	−0.621	–	–	−4.286
R^2	0.013	0.796	0.837	0.839	0.919	0.955
RMSE	1.886	0.857	0.768	0.543	0.386	0.287

- CIV "prices" a number of other anomaly portfolios
- Notable exceptions: Momentum and idiosyncratic vol
- Corroborative results for income distribution "mimicking" portfolio

CIV Pricing Facts

Subsample Robustness

	1 (Low)	2	3	4	5 (High)	5-1	t(5-1)
	Panel A: One-way sorts on CIV beta, 1986-2010						
$E[R]-r_f$	12.82	11.12	10.12	8.19	5.81	−7.00	−3.21
α_{CAPM}	4.82	4.34	4.01	2.25	−0.92	−5.73	−2.72
α_{FF}	2.74	2.11	1.69	0.26	−2.21	−4.94	−2.57
	Panel B: One-way sorts on CIV beta, 1963-1985						
$E[R]-r_f$	11.29	10.63	9.79	9.26	7.62	−3.67	−2.29
α_{CAPM}	6.07	5.98	5.31	4.56	2.49	−3.57	−2.22
α_{FF}	−0.97	−0.08	−0.02	−0.11	−2.15	−1.18	−0.75

CIV Pricing Facts

Robustness: Additional Double Sorts

	CIV beta						
	1 (Low)	2	3	4	5 (High)	5-1	t(5-1)
Panel A: Two-way sorts on CIV beta and log market equity							
1 (low)	14.77	14.22	12.67	11.86	9.97	−4.80	−2.80
2	10.40	11.03	11.66	10.64	6.89	−3.50	−2.45
3	11.56	11.14	10.07	8.93	7.60	−3.96	−2.72
4	10.39	9.89	9.48	8.44	6.35	−4.04	−2.88
5 (high)	8.23	7.62	6.69	6.02	5.00	−3.23	−2.33
5-1	−6.54	−6.60	−5.99	−5.84	−4.97	–	–
t(5-1)	−2.17	−2.42	−2.32	−2.35	−1.84	–	–
Panel B: Two-way sorts on CIV beta and idiosyncratic variance							
1 (low)	9.52	9.50	7.92	7.66	7.43	−2.08	−2.09
2	13.20	10.99	10.12	9.09	8.65	−4.56	−4.24
3	14.49	13.12	11.69	11.27	8.97	−5.52	−4.25
4	14.32	12.44	11.12	10.44	9.34	−4.98	−3.42
5 (high)	8.31	7.01	7.21	5.24	3.36	−4.94	−2.70
5-1	−1.21	−2.49	−0.71	−2.42	−4.07	–	–
t(5-1)	−0.37	−0.81	−0.24	−0.84	−1.20	–	–

CIV Pricing Facts

Robustness: Additional Double Sorts

Panel C: Two-way sorts on CIV beta and VIX beta							
1 (low)	17.67	14.01	10.33	10.11	8.24	−9.43	−2.44
2	16.59	13.05	13.37	11.79	9.84	−6.75	−1.94
3	16.72	14.40	12.22	10.61	8.83	−7.89	−2.72
4	16.12	11.69	9.63	7.72	7.19	−8.93	−3.24
5 (high)	13.26	8.21	8.64	5.89	6.74	−6.52	−1.92
5-1	−4.41	−5.80	−1.69	−4.22	−1.49	–	–
t(5-1)	−0.95	−1.17	−0.34	−0.85	−0.28	–	–
Panel D: Two-way sorts on CIV beta and PS liquidity beta							
1 (low)	11.89	9.76	8.02	6.31	5.20	−6.69	−3.51
2	11.27	9.66	8.57	7.93	5.53	−5.73	−3.59
3	11.99	10.85	9.40	8.17	6.63	−5.36	−3.48
4	11.85	10.94	10.41	8.19	6.11	−5.74	−3.86
5 (high)	10.30	9.81	9.90	8.83	6.25	−4.06	−2.45
5-1	−1.58	0.05	1.88	2.53	1.05	–	–
t(5-1)	−0.80	0.03	0.87	1.19	0.51	–	–

CIV Pricing Facts

Income Risk "Mimicking" Portfolio

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	10 GID-beta			10 BM			10 ME		
Constant	0.003	0.003	0.006	0.009	0.015	0.015	−0.008	0.005	0.006
t-stat	4.841	2.631	2.517	0.971	5.252	2.748	−4.816	2.051	2.825
Rm-Rf	0.007	0.007	0.002	−0.003	−0.008	−0.008	0.013	0.002	−0.000
t-stat	10.058	6.900	0.653	−0.280	−2.787	−1.498	8.955	0.872	−0.058
GIDtr	–	−0.001	−0.001	–	−0.011	−0.011	–	−0.004	−0.012
t-stat	–	−4.157	−3.053	–	−2.959	−2.381	–	−8.474	−3.899
MVtr	–	–	−0.006	–	–	−0.005	–	–	0.005
t-stat	–	–	−2.244	–	–	−1.002	–	–	1.662
b_{MV}	–	–	−3.309	–	–	−0.152	–	–	8.698
t-stat	–	–	−1.540	–	–	−0.031	–	–	2.542
R^2	0.602	0.606	0.652	0.013	0.479	0.480	0.839	0.809	0.874
RMSE	0.788	0.784	0.737	1.886	0.739	0.739	0.543	0.656	0.533

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Heterogeneous agent model

- Goal: Coherent framework to understand three sets of facts
- Follow Constantinides and Duffie (1996), Constantinides and Ghosh (2014), and others
  - Key state variable: Dispersion in household consumption growth rates
- New feature: Household consumption growth has common idiosyncratic volatility with the same factor structure as that in firms' cash flow growth
- Positive shocks to CIV increases cross-sectional dispersion of equilibrium consumption growth; CIV shocks carry negative price of risk
- Stocks with positive return exposure to CIV innovations are hedges and should carry low average returns, magnitudes rationalized with firm volatility level/comovement data

Idiosyncratic Vol Comovement: Potential Mechanisms

- Dynamic models (especially with learning), e.g. Pastor and Veronesi (05,06), Menzly, Santos, and Veronesi (04): Idiosyncratic vol driven by common state variables
  - Idios vol not focus in these models, quantification TBD
  - Cash flow vs. return vol
  - CIV vs. market vol

- Granular networks

  "Firm Volatility in Granular Networks"

  Kelly, Lustig, Van Nieuwerburgh

  - Factors vs. networks: Network dynamics govern firm vols, "aggregate" shocks provide poor description of firm-level shocks
  - Focus on cash flow vol

- We are agnostic in this paper
  - Firm vols comove $\rightarrow$ household inheritance of common risks (limited hedgibility) $\rightarrow$ pricing in asset markets

More work to be done...

Conclusion

- Strong factor structure in firm volatility $\Rightarrow$ "Common Idiosyncratic Volatility" factor (CIV)

  (returns, cash flows, stocks, portfolios, various frequencies, etc.)

- Empirical link between dispersion in income growth across households and CIV

- Stocks whose returns covary more negatively with CIV innovations carry higher average returns

- Heterog. agent asset pricing model with CIV quantitatively matches CIV risk premium and volatility facts