January 24, 2015 (unfinished); Comments are welcome!

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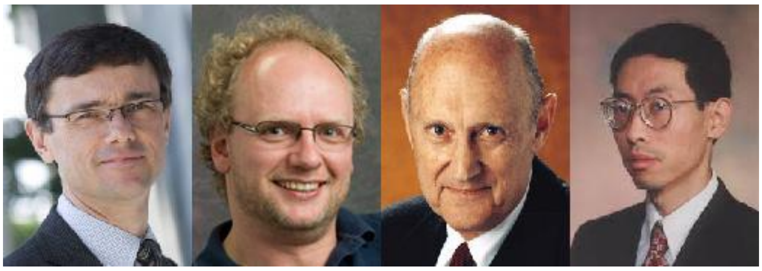
Campbell, John Y., Martin Lettau, Burton G. Malkiel and Yexiao Xu, 2011, "Have Individual Stocks Become More Volatile? An Empirical Exploration of Idiosyncratic Risk," *Journal of Finance,* vol. 56, no. 1, pp. 1-44



Abstract

1. Disaggregated approach to study σ: market, industry and firm levels
2. Noticeable ↑ in firm-level σ relative to market σ: 1962-1997
   3.1. ρ among individual stocks, explanatory power of the market model ↓
   3.2. # of stocks needed to achieve a given level of diversification ↑
4. σ moves counter-cyclically; helps to predict GDP growth
5. Market σ leads the other σ

Introduction

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I. Estimation of Volatility Components

A. Volatility Decomposition

Return on "typical" stock = market-wide return + industry residual + firm residual

Construct time-series of volatility measures of 3 components for a typical firm

Define σ w/o keeping track of covariances; w/o estimating βs for firms or industries

Subscript i for industries, j for firms, t for period, R for simple excess return; T-bill rate

w for weight; market value weights in this application

$$R_{it} = \sum_{j \in i} w_{jit} R_{jit}$$

$$R_{mt} = \sum_i w_{it} R_{it}$$

Decomposition based on CAPM; modify it for empirical implementation

$$\begin{aligned} R_{it} &= \beta_{im} R_{mt} + \tilde{\epsilon}_{it} \\ \Rightarrow R_{jit} &= \beta_{ji} R_{it} + \tilde{\eta}_{jit} \\ &= \beta_{ji}\beta_{im} R_{mt} + \beta_{ji}\tilde{\epsilon}_{it} + \tilde{\eta}_{jit} \end{aligned}$$

$$\sum_i w_{it}\beta_{im} = 1, \sum_{j\in i} w_{jit}\beta_{ji} = 1$$

By above, different components are orthogonal to one another. Hence

$$\begin{aligned} \mathrm{Var}(R_{it}) &= \beta_{im}^2 \mathrm{Var}(R_{mt}) + \mathrm{Var}(\tilde{\epsilon}_{it}) \\ \mathrm{Var}\left(R_{jit}\right) &= \beta_{jm}^2 \mathrm{Var}(R_{mt}) + \beta_{ji}^2 \mathrm{Var}(\tilde{\epsilon}_{it}) + \mathrm{Var}\left(\tilde{\eta}_{jit}\right) \\ \text{where } \beta_{jm} &= \beta_{ji}\beta_{im} \end{aligned}$$

It requires knowledge of firm-specific βs that are difficult to estimate.

Simplified model that does not require any information about βs

$$R_{it} = R_{mt} + \epsilon_{it}, \text{where } \epsilon_{it} \neq \tilde{\epsilon}_{it}$$

According to Campbell, Lo and MacKinlay (1997), this is “market-adjusted-return model.”

$$\epsilon_{it} = \tilde{\epsilon}_{it} + (\beta_{im} - 1) R_{mt}$$

Since R_{mt} and ϵ_{it} are not orthogonal, the covariance is not ignorable.

$$\begin{aligned} \mathrm{Var}(R_{it}) &= \mathrm{Var}(R_{mt}) + \mathrm{Var}(\epsilon_{it}) + 2\mathrm{Cov}(R_{mt}, \epsilon_{it}) \\ &= \mathrm{Var}(R_{mt}) + \mathrm{Var}(\epsilon_{it}) + 2(\beta_{im} - 1)\mathrm{Var}(R_{mt}) \end{aligned}$$

By taking weighted average, the third term can be eliminated.

$$\begin{aligned} \sum_i w_{it} \mathrm{Var}(R_{it}) &= \sum_i w_{it} [\mathrm{Var}(R_{mt}) + \mathrm{Var}(\epsilon_{it}) + 2(\beta_{im} - 1)\mathrm{Var}(R_{mt})] \\ &= \sum_i w_{it} \mathrm{Var}(R_{mt}) + \sum_i w_{it} \mathrm{Var}(\epsilon_{it}) + \sum_i w_{it} [2(\beta_{im} - 1)\mathrm{Var}(R_{mt})] \\ &= \mathrm{Var}(R_{mt}) \sum_i w_{it} + \sum_i w_{it} \mathrm{Var}(\epsilon_{it}) + 2\sum_i w_{it}\beta_{im} \mathrm{Var}(R_{mt}) - 2\sum_i w_{it} \mathrm{Var}(R_{mt}) \\ &= \mathrm{Var}(R_{mt}) + \sum_i w_{it} \mathrm{Var}(\epsilon_{it}) + 2\mathrm{Var}(R_{mt}) \sum_i w_{it}\beta_{im} - 2\mathrm{Var}(R_{mt}) \sum_i w_{it} \\ &= \mathrm{Var}(R_{mt}) + \sum_i w_{it} \mathrm{Var}(\epsilon_{it}) + 2\mathrm{Var}(R_{mt}) - 2\mathrm{Var}(R_{mt}) \\ &= \mathrm{Var}(R_{mt}) + \sum_i w_{it} \mathrm{Var}(\epsilon_{it}) \end{aligned}$$

$$= \sigma_{mt}^2 + \sigma_{\epsilon t}^2$$

Similarly,

$$R_{jit} = R_{it} + \eta_{jit}, \text{where } \eta_{jit} \neq \tilde{\eta}_{jit}$$

$$\eta_{jit} = \tilde{\eta}_{jit} + (\beta_{ji} - 1)R_{it}$$

$$\Rightarrow \mathrm{Var}(R_{jit}) = \mathrm{Var}(R_{it}) + \mathrm{Var}(\eta_{jit}) + 2\mathrm{Cov}(R_{it}, \eta_{jit})$$

$$= \mathrm{Var}(R_{it}) + \mathrm{Var}(\eta_{jit}) + 2(\beta_{ji} - 1)\mathrm{Var}(R_{it})$$

$$\Rightarrow \sum_{j\in i} w_{jit}\mathrm{Var}(R_{jit}) = \sum_{j\in i} w_{jit}[\mathrm{Var}(R_{it}) + \mathrm{Var}(\eta_{jit}) + 2\mathrm{Cov}(R_{it}, \eta_{jit})]$$

$$= \mathrm{Var}(R_{it}) + \sum_{j\in i} w_{jit}\mathrm{Var}(\eta_{it})$$

$$= \mathrm{Var}(R_{it}) + \sigma_{\eta it}^2$$

$$\Rightarrow \sum_i w_{it}\left[\sum_{j\in i} w_{jit}\mathrm{Var}(R_{jit})\right] = \sum_i w_{it}\mathrm{Var}(R_{it}) + \sum_i w_{it}\left[\sum_{j\in i} w_{jit}\mathrm{Var}(\eta_{jit})\right]$$

$$= \sigma_{mt}^2 + \sigma_{\epsilon t}^2 + \sum_i w_{it}\sigma_{\eta it}^2$$

$$= \sigma_{mt}^2 + \sigma_{\epsilon t}^2 + \sigma_{\eta t}^2$$

Further insight

$$\epsilon_{it} = \tilde{\epsilon}_{it} + (\beta_{im} - 1)R_{mt}$$

$$\Rightarrow \mathrm{Var}(\epsilon_{it}) = \mathrm{Var}[\tilde{\epsilon}_{it} + (\beta_{im} - 1)R_{mt}]$$

$$= \mathrm{Var}(\tilde{\epsilon}_{it}) + (\beta_{im} - 1)^2\mathrm{Var}(R_{mt})$$

$$\Rightarrow \sum_i w_{it}\mathrm{Var}(\epsilon_{it}) = \sigma_{\epsilon t}^2$$

$$= \sum_i w_{it}[\mathrm{Var}(\tilde{\epsilon}_{it}) + (\beta_{im} - 1)^2\mathrm{Var}(R_{mt})]$$

$$= \sum_i w_{it}\mathrm{Var}(\tilde{\epsilon}_{it}) + \sum_i w_{it}(\beta_{im} - 1)^2\mathrm{Var}(R_{mt})$$

$$= \tilde{\sigma}_{\epsilon t}^2 + \mathrm{CSV}_t(\beta_{im})\sigma_{mt}^2$$

$$\Rightarrow \sum_i w_{it}\sum_{j\in i} w_{jit}Var(\eta_{jit}) = \sigma_{\eta t}^2$$

$$= \tilde{\sigma}_{\eta t}^2 + \mathrm{CSV}_t(\beta_{jm})\sigma_{mt}^2 + \mathrm{CSV}_t(\beta_{ji})\tilde{\sigma}_{\epsilon t}^2$$

$\mathrm{CSV}_t(\beta_{im})=\Sigma_i w_{it}(\beta_{im}-1)^2$ is the cross-sectional variance of industry βs across industries.

$\mathrm{CSV}_t(\beta_{jm})=\Sigma_i w_{it}\Sigma_{j\in i} w_{jit}(\beta_{jm}-1)^2$ is the cross-sectional variance of firm βs on the market across all firms in all industries.

$CSV_t(\beta_{ji})=\Sigma_i w_{it}\Sigma_{j\in i} w_{jit}(\beta_{ji}-1)^2$ is the cross-sectional variance of firm βs on industry shocks across all firms in all industries.

Common movements in σ_{mt}^2, $\sigma_{\epsilon t}^2$ and $\sigma_{\eta t}^2$ by cross-sectional variation in βs

B. Estimation

Firm-level return data in the CRSP data set; NYSE, AMEX and NASDAQ

49 industries according to the classification scheme in Fama and French (1997)

July 1962 (2,047 firms) to December 1997 (8,927 firms)

Most firms on average: Financial Services with 628 firms (from 43 to 1,525)

Fewest firms on average: Defense with 8 firms (from 3 to 12)

3 largest industries based on average market capitalization: Petroleum/Gas (11%), Financial Services (7.8%) and Utilities (7.4%)

30-day T-bill return divided by the # of trading days in a month

Subscript *s* (not s for plural!): the interval of *R*s measurement

Daily *R*s in this paper, but weekly and monthly *R*s are considered as well

Subscript *t*: the interval of volatility construction, monthly in this paper

$$\mathrm{MKT}_t = \hat{\sigma}_{mt}^2 = \sum_{s\in t}(R_{ms}-\mu_m)^2$$

μ_m: the average of R_{ms}

R_{ms}: the weighted ($t-1$ market capitalization) average using all firms

$$\hat{\sigma}_{\epsilon it}^2 = \sum_{s\in t}\epsilon_{is}^2$$

$$\Rightarrow \mathrm{IND}_t = \sum_i w_{it}\hat{\sigma}_{\epsilon it}^2$$

$$\hat{\sigma}_{\eta jit}^2 = \sum_{s\in t}\eta_{jis}^2$$

$$\hat{\sigma}_{\eta it}^2 = \sum_{j\in i} w_{jit}\hat{\sigma}_{\eta jit}^2$$

$$\Rightarrow \mathrm{FIRM}_t = \sum_i w_{it}\hat{\sigma}_{\eta it}^2$$

MKT, IND, FIRM: market σ, industry σ, firm σ, respectively

II. Measuring Trends in Volatility

A. Graphical Analysis

Figure 1. Yearly standard deviation of value-weighted stock index based on monthly data

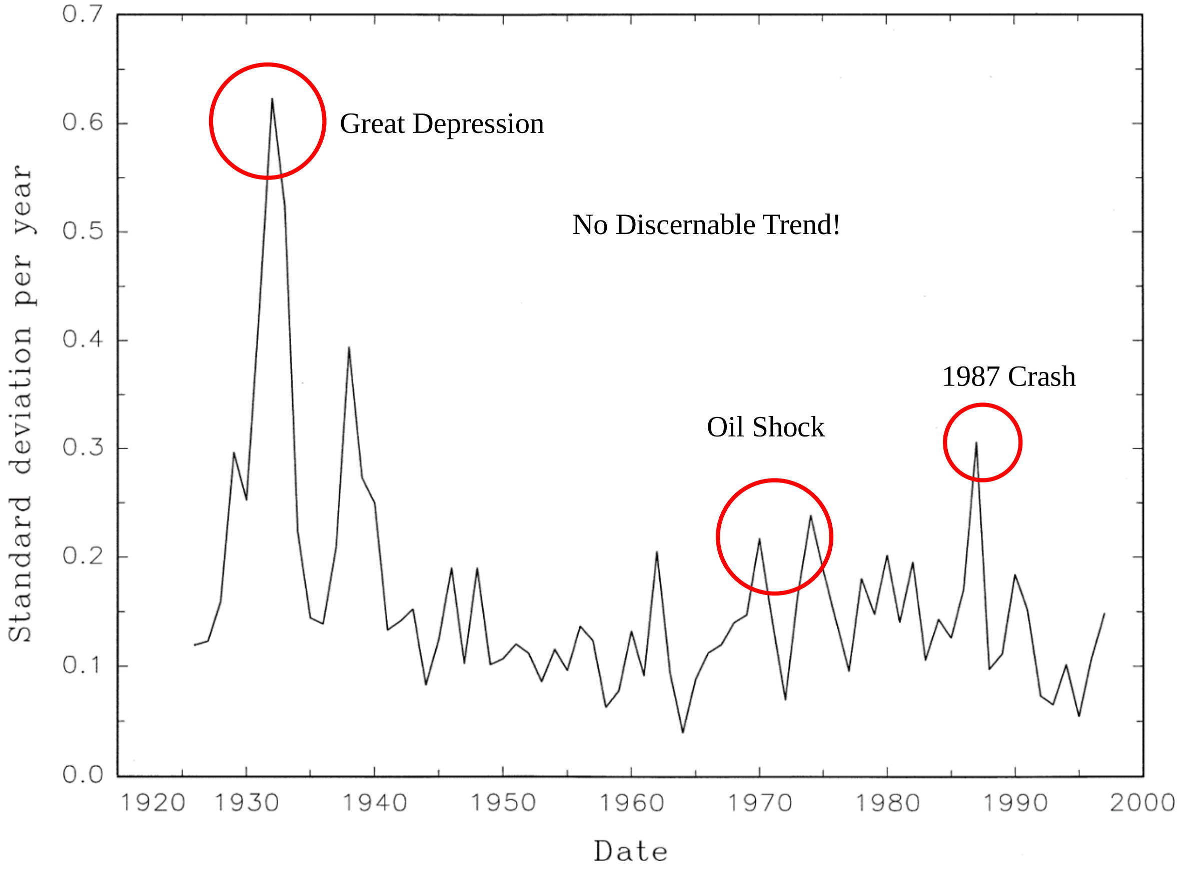
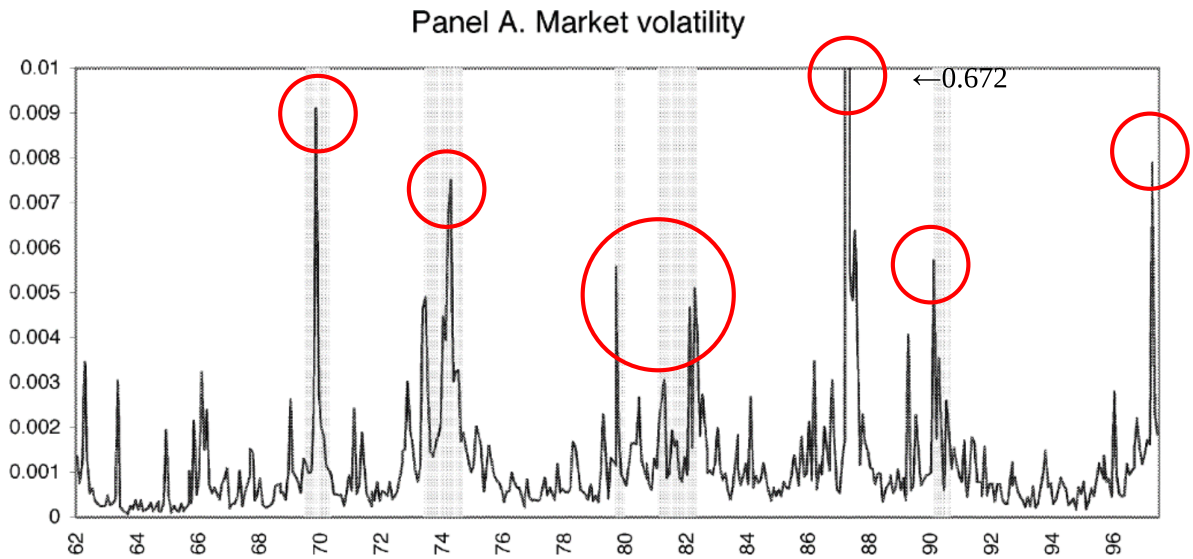


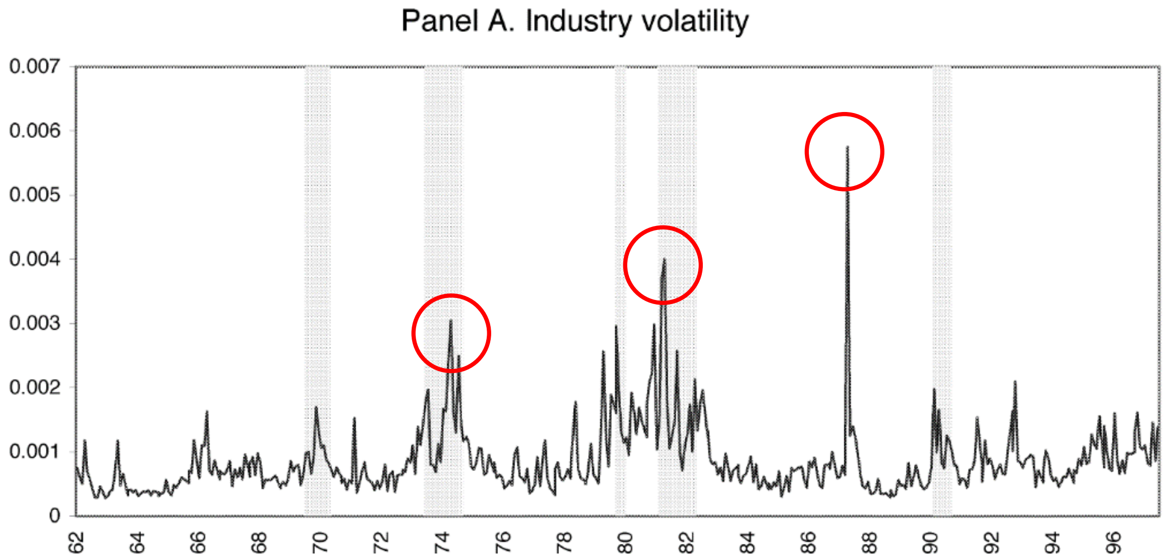
Figure 2. {MKT_t}, annualized (×12), Panel B. (Moving Average) is omitted.



Shade: NBER Recession

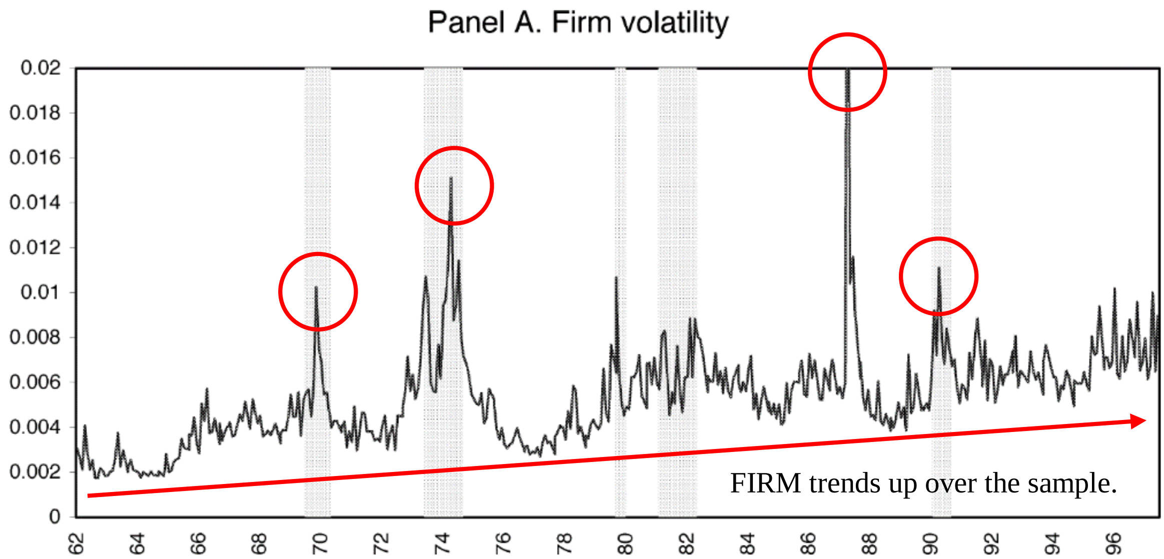
Casually, market volatility increases in recessions.

Figure 3. {IND_t}



Lower than market volatility on average

Figure 4. {$FIRM_t$}



Much higher than MKT and IND on average—the largest component of the total σ

MKT and IND: no visible upward slope

Stock market has become more volatile—on a firm level instead of a market or industry level

The different σ measures tend to move together, particularly at lower frequencies

The crash in October1987: a significant effect on all three σ series

October 1987 observation is winsorized (down-weighted) by the second largest observation

B. Stochastic versus Deterministic Trends

Whether such a trend is stochastic or deterministic in nature

Table 1. Auto-ρ?

	Raw Data			Downweighted Crash		
Autocorrelation	MKT	IND	FIRM	MKT	IND	FIRM
ρ_1	0.149	0.529	0.591	0.494	0.591	0.776
ρ_2	0.115	0.419	0.560	0.383	0.463	0.727
ρ_3	0.113	0.393	0.514	0.313	0.438	0.686
ρ_4	0.020	0.364	0.418	0.160	0.415	0.584
ρ_6	0.069	0.339	0.414	0.183	0.384	0.572
ρ_{12}	0.004	0.275	0.340	0.087	0.316	0.471

The enormous and short-lived effect of the 1987 crash

$\exists$ unit roots?

Table 2. Dickey–Fuller Test

	Raw Data			Downweighted Crash		
	MKT	IND	FIRM	MKT	IND	FIRM
Constant						
ρ-test	−328	−103	−80.3	−175	−88.5	−46.5
t-test	−12.17	−4.59	−3.98	−8.55	−4.28	−3.29
Lag order	2	5	5	1	4	5
Constant & trend						
ρ-test	−330	−125	−145	−177	−91.7	−79.1
t-test	−12.24	−5.60	−6.35	−8.60	−4.36	−4.34
Lag order	1	3	2	1	4	5

“Yes. There exist unit-roots in MKT, IND and FIRM.”

Table 3. Statistics

	Raw Data			Downweighted Crash		
	MKT	IND	FIRM	MKT	IND	FIRM
Daily						
Mean $* 10^2$	1.542	1.032	6.436	1.409	1.027	6.383
Std. dev. $* 10^2$	3.500	0.663	2.912	1.469	0.623	2.446
Std. dev. $* 10^2$ detrended	3.488	0.663	2.536	1.463	0.619	2.013
Linear trend $* 10^5$	0.156	0.062	0.965	0.090	0.060	0.939
PS-statistic	0.261	0.086	1.005	0.144	0.082	0.958
Confidence interval	(−0.07, 0.60)	(−0.10, 0.27)	(0.55, 1.47)	(−0.12, 0.41)	(−0.10, 0.27)	(0.49, 1.42)
Weekly						
Mean $* 10^2$	1.897	1.218	5.842	1.858	1.218	5.842
Std. dev. $* 10^2$	2.522	0.727	2.210	2.158	0.727	2.210
Std. dev. $* 10^2$ detrended	2.522	0.724	1.923	2.158	0.721	1.919
Linear trend $* 10^5$	0.003	0.053	0.737	−0.017	0.053	0.737
PS-statistic	0.116	0.096	0.410	0.082	0.096	0.410
Confidence interval	(−0.33, 0.56)	(−0.13, 0.32)	(0.13, 0.69)	(−0.36, 0.52)	(−0.13, 0.32)	(0.13, 0.69)
Monthly						
mean $* 10^2$	N/A	1.269	5.039	N/A	1.269	5.039
Std. dev. $* 10^2$	N/A	1.032	2.203	N/A	1.032	2.203
Std. dev. $* 10^2$ detrended	N/A	1.032	1.930	N/A	1.032	1.929
Linear trend $* 10^5$	N/A	0.026	0.720	N/A	0.026	0.720
PS-statistic	N/A	0.094	0.780	N/A	0.093	0.780
Confidence interval	N/A	(−0.20, 0.39)	(0.28, 1.28)	N/A	(−0.20, 0.39)	(0.28, 1.28)
Daily—large firms						
Mean $* 10^2$	1.599	1.090	5.877	1.145	1.086	5.828
Std. dev. $* 10^2$	3.675	0.744	2.671	1.507	0.675	2.210
Std. dev. $* 10^2$ detrended	3.464	0.693	2.557	1.498	0.658	2.080
Linear trend $* 10^5$	0.185	0.087	0.524	0.116	0.085	0.499
PS-statistic	0.296	0.111	0.590	0.172	0.107	0.055
Confidence interval	(−0.06, 0.65)	(−0.08, 0.31)	(0.03, 1.15)	(−0.10, 0.45)	(−0.09, 0.30)	(−0.02, 1.11)
Daily—EW						
Mean $* 10^2$	1.211	1.251	33.903	1.149	1.251	33.903
Std. dev. $* 10^2$	2.619	0.554	23.112	1.718	0.412	23.112
Std. dev. $* 10^2$ detrended	2.612	0.554	14.116	1.704	0.554	14.116
Linear trend $* 10^5$	−0.114	0.022	12.386	−0.145	0.022	12.386
PS-statistic	−0.076	−0.004	11.231	−0.132	−0.004	11.219
Confidence interval	(−0.33, 0.17)	(−0.15, 0.14)	(5.29, 17.17)	(−0.38, 0.11)	(−0.15, 0.14)	(5.30, 17.14)

Annually, $MKT^{1/2}$=12.3%/year(0.015), $IND^{1/2}$=10%/year(0.010), $FIRM^{1/2}$=25%/year(0.064)

Market model R^2=0.015/0.089=17%

Down-weight: Std. dev. for daily MKT↓—from 3.500 to 1.469

PS-statistic for FIRM: positive and statistically significant—for all three horizons

Effects of de-trend: FIRM↓—from 2.912 (2.446) to 2.536 (2.013)

PS-statistic: large firms↓, equally weighted series↑ (the effect of firm size)

C. Individual Industries

$$R_{it} = \beta_{im} R_{mt} + \tilde{\epsilon}_{it}, \text{where } \mathrm{Cov}(R_{mt}, \tilde{\epsilon}_{it}) = 0$$

$$R_{jit} = \beta_{im} R_{mt} + \tilde{\epsilon}_{it} + \eta_{jit}$$

$$\Rightarrow \mathrm{Var}(R_{it}) = \beta_{im}^2 \mathrm{Var}(R_{mt}) + \tilde{\sigma}_{it}^2$$

$$\Rightarrow \mathrm{Var}(R_{jit}) = \mathrm{Var}(R_{it}) + \mathrm{Var}(\eta_{jit}) + 2\mathrm{Cov}(R_{it}, \eta_{jit})$$

$$= \mathrm{Var}(R_{it}) + \mathrm{Var}(\eta_{jit}) + 2(\beta_{ji} - 1)\mathrm{Var}(R_{it})$$

$$\Rightarrow \sum_{j \in i} w_{jit} \mathrm{Var}(R_{jit}) = \sum_{j \in i} w_{jit} [\mathrm{Var}(R_{it}) + \mathrm{Var}(\eta_{jit}) + 2(\beta_{ji} - 1)\mathrm{Var}(R_{it})]$$

$$= \mathrm{Var}(R_{it}) + \sum_{j\in i} w_{jit}\mathrm{Var}(\eta_{jit}) + 2\mathrm{Var}(R_{it}) \sum_{j\in i} w_{jit}(\beta_{ji} - 1)$$

$$= \mathrm{Var}(R_{it}) + \sum_{j\in i} w_{jit}\mathrm{Var}(\eta_{jit})$$

$$= \beta_{im}^2 \mathrm{Var}(R_{mt}) + \tilde{\sigma}_{it}^2 + \sigma_{\eta it}^2$$

Table 4. Industries (OLS full-sample β with monthly data)

			IND				FIRM			
Industry	Weight	β	Mean	s.d.	Trend	PS-stat	Mean	s.d.	Trend	PS-stat
Petroleum/Gas	11.031	0.86	1.013	0.302	0.249	**0.334**	5.498	0.774	0.583	0.946
Fin. Services	7.833	0.97	0.362	0.102	−0.125	**−0.158**	6.361	0.871	0.224	0.484
Utilities	7.446	0.66	0.311	0.097	0.033	0.030	4.032	0.500	0.125	0.228
Consumer Goods	6.117	1.02	0.562	0.122	0.016	0.026	4.590	0.598	−0.006	0.157
Telecomm.	5.699	0.70	0.811	0.176	−0.065	−0.067	3.729	0.826	1.555	**1.334**
Computer	4.995	1.06	1.654	0.398	0.070	−0.001	6.123	1.536	2.867	**2.311**
Retail	4.596	1.09	0.586	0.132	0.049	0.028	7.332	0.919	1.367	**1.465**
Auto	4.295	1.02	1.115	0.231	0.138	**0.117**	4.862	0.695	0.754	**0.922**
Pharmaceutical	4.206	1.00	0.792	0.228	0.167	**0.133**	6.126	0.745	0.780	**0.578**
Chemical	3.812	1.05	0.517	0.103	0.077	**0.064**	5.281	0.618	0.448	**0.655**

FIRM>IND on average—IND substantially varies across industries; FIRM does not

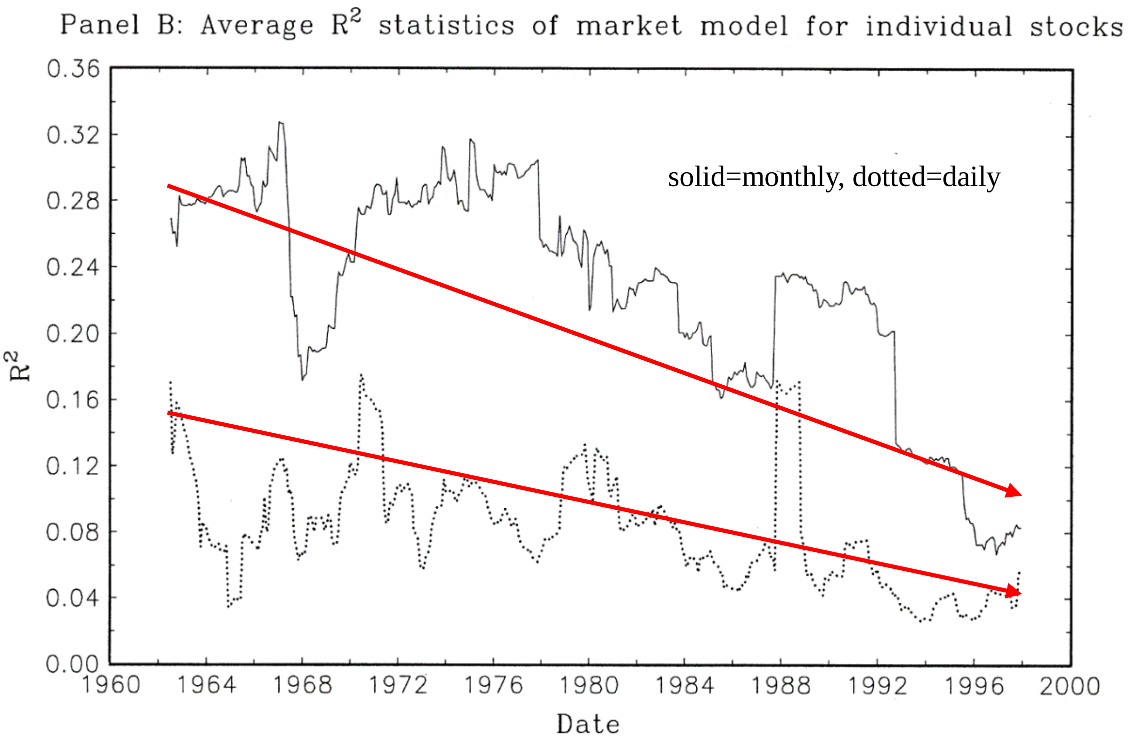
$\rho(\mathrm{IND}_i,\mathrm{FIRM}_i)>0$, $\rho(\mathrm{Weight}_i,\mathrm{IND}_i)<0$, $\rho(\mathrm{Weight}_i,\mathrm{FIRM}_i)<0$

Shocks to large industries→move the market?

Unit-root tests on all IND and FIRM series—reject the null hypothesis $\forall i$

III. Portfolio Implications of the Increase in Idiosyncratic Volatility

Figure 5. Decline of the market model



ρ↓ ⇒the benefits of diversification↑

Figure 6. Diversification benefits

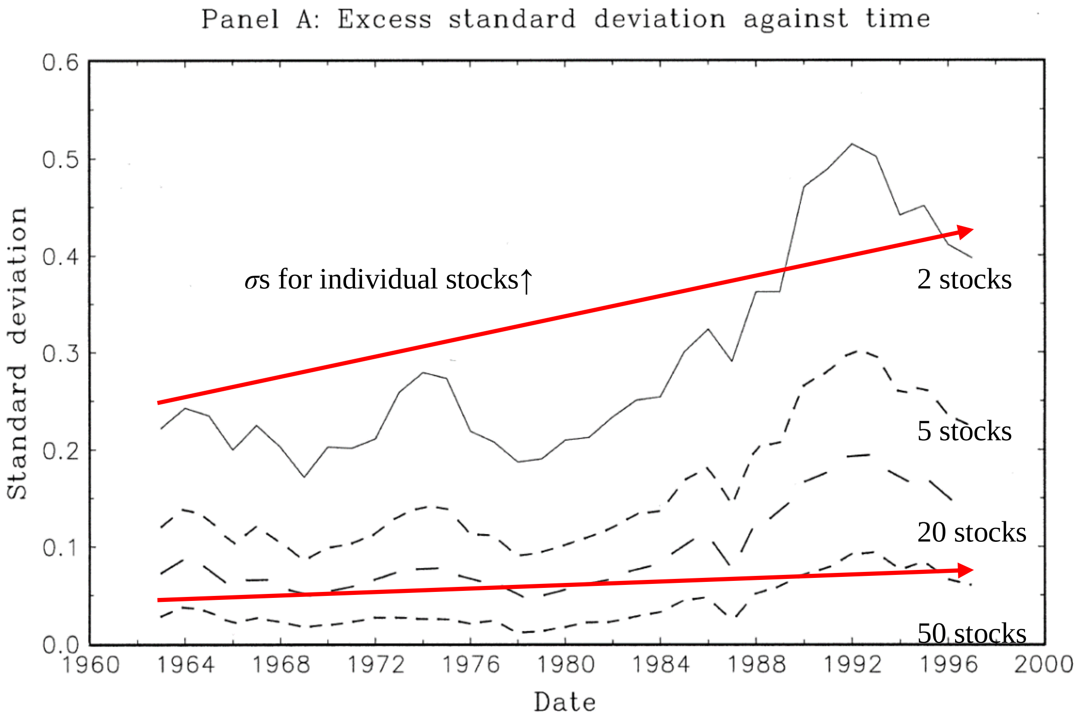
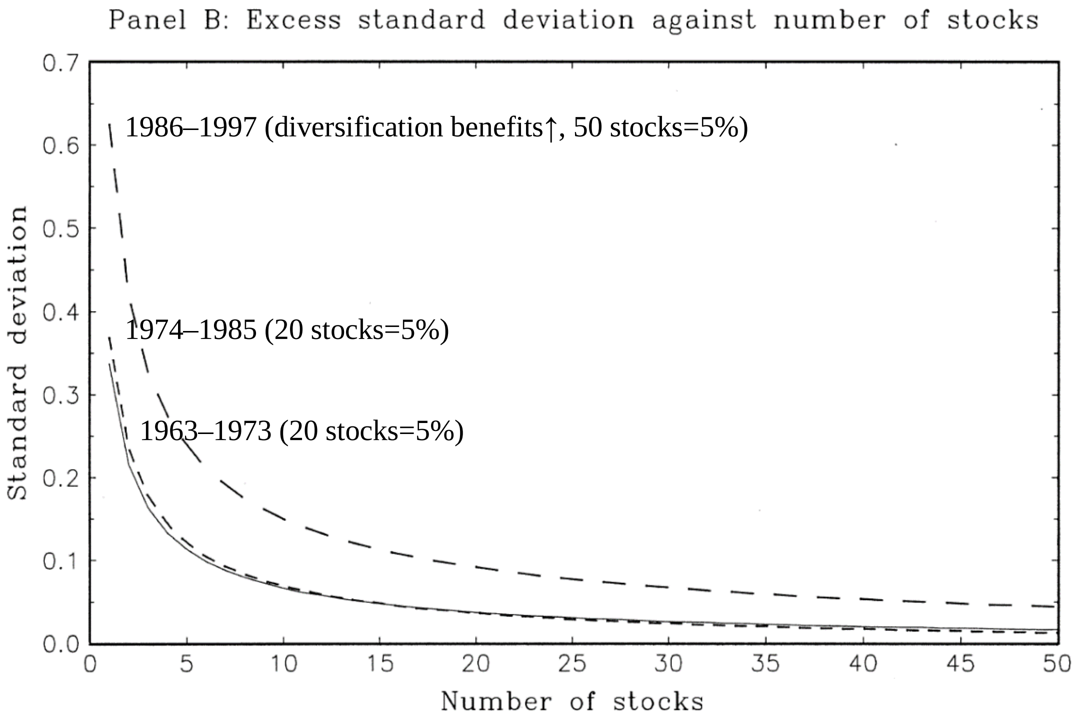


Figure 6. (Continued)



Idiosyncratic σ↑ ⇒# of stocks to reduce excess σ↑

IV. Short-Run Volatility Dynamics

A. Covariation and Lead-Lag Relationships

Table 6. Mean decomposition + variance decomposition

	MKT	IND	FIRM
Mean			
7/62–12/97	0.160	0.116	0.724
7/62–6/71	0.162	0.126	0.712
1/88–12/97	0.134	0.097	0.769
Variance			
Raw series			
MKT	0.149	0.081	0.328
IND		0.027	0.133
FIRM			0.282
Conditional means			
MKT	0.099	0.067	0.334
IND		0.026	0.137
FIRM			0.337

$$1=E(MKT_t)/E\sigma_{rt}^2+E(IND_t)/E\sigma_{rt}^2+E(FIRM_t)/E\sigma_{rt}^2$$

$$1=Var(MKT_t)/Var(\sigma_{rt}^2)+Var(IND_t)/Var(\sigma_{rt}^2)+Var(FIRM_t)/Var(\sigma_{rt}^2)$$

$$+2Cov(MKT_t,IND_t)/Var(\sigma_{rt}^2)+2Cov(MKT_t,FIRM_t)/Var(\sigma_{rt}^2)+2Cov(IND_t,FIRM_t)/Var(\sigma_{rt}^2)$$

Mean: linear trend decomposition X, variance linear trend decomposition O

Conditional means: VAR(4) model—$v_t = E_{t-1}v_t + \xi_t$, $v \in$ {MKT, IND, FIRM}

σ(FIRM,MKT), σ(FIRM IND), σ(FIRM,FIRM) account for about 80% of the total variation

Table 7. Granger causality?

Bivariate VAR			
	MKT_t	IND_t	$FIRM_t$
MKT_{t-l}	—	0.000	0.000
		(5)	(4)
IND_{t-l}	0.548	—	0.472
	(5)		(5)
$FIRM_{t-l}$	0.008	0.002	—
	(2)	(5)	
Trivariate VAR			
	MKT_t	IND_t	$FIRM_t$
MKT_{t-l}	—	0.027	0.004
IND_{t-l}	0.416	—	0.155
$FIRM_{t-l}$	0.016	0.108	—
	(4)	(5)	(5)

2-variable and 3-variable VAR, p-values, lags in parentheses determined by AIC

2-variable: $MKT_{t-l} \rightarrow IND_t$, $MKT_{t-l} \rightarrow FIRM_t$, $FIRM_{t-l} \rightarrow MKT_t$, $FIRM_{t-l} \rightarrow IND_t$

3-variable: $MKT_{t-l} \rightarrow IND_t$, $MKT_{t-l} \rightarrow FIRM_t$, $FIRM_{t-l} \rightarrow MKT_t$

B. Cyclical Behavior of Aggregate Volatility Measures

Table 8. Cyclical behavior? $\sigma\leftrightarrow$NBER recession? $\sigma\leftrightarrow$GDP growth?

Volatility Lead (Months)	Correlation with NBER Dates								
	MKT			IND			FIRM		
	v_t	$E_{t-1}v_t$	ξ_t	v_t	$E_{t-1}v_t$	ξ_t	v_t	$E_{t-1}v_t$	ξ_t
+12	−0.091	−0.075	−0.063	−0.208	−0.178	−0.120	−0.125	−0.080	−0.098
+6	−0.162	−0.149	−0.098	−0.320	−0.310	−0.155	−0.230	−0.196	−0.126
+3	−0.354	−0.346	**−0.198**	−0.436	−0.454	**−0.182**	−0.434	−0.363	**−0.246**
+1	−0.413	−0.466	−0.192	−0.461	−0.518	−0.159	**−0.515**	−0.487	−0.230
0	**−0.420**	**−0.498**	−0.178	**−0.472**	−0.529	−0.164	−0.508	−0.525	−0.180
−1	−0.381	−0.498	−0.131	−0.438	**−0.533**	−0.116	−0.477	**−0.529**	−0.129
−3	−0.316	−0.417	−0.099	−0.328	−0.425	−0.094	−0.399	−0.452	−0.098
−6	−0.248	−0.322	−0.085	−0.280	−0.335	−0.076	−0.330	−0.368	−0.085
−12	−0.083	−0.135	−0.008	−0.163	−0.170	−0.066	−0.175	−0.192	−0.046

Volatility Lead (Quarters)	Correlation with GDP Growth								
	MKT			IND			FIRM		
	v_t	$E_{t-1}v_t$	ξ_t	v_t	$E_{t-1}v_t$	ξ_t	v_t	$E_{t-1}v_t$	ξ_t
+4	−0.021	−0.022	−0.001	−0.060	−0.003	−0.059	−0.023	0.033	−0.037
+2	−0.226	−0.023	−0.260	−0.262	−0.103	−0.260	−0.223	−0.048	−0.253
+1	**−0.359**	−0.208	**−0.289**	−0.399	−0.227	**−0.328**	**−0.381**	−0.180	**−0.345**
0	−0.321	−0.335	−0.162	**−0.412**	−0.368	−0.214	−0.342	**−0.341**	−0.146
−1	−0.258	**−0.369**	−0.073	−0.328	**−0.369**	−0.102	−0.297	−0.312	−0.114
−2	−0.216	−0.352	−0.038	−0.214	−0.324	0.006	−0.235	−0.292	−0.053
−4	−0.151	−0.278	0.033	−0.254	−0.285	−0.073	−0.195	−0.262	−0.018

All (−) sign: high σ with downturns

Particularly, recession→MKT↑—even well diversified portfolio is exposed to more σ

Table 9. $\sigma_{t-1}\uparrow\rightarrow$GDP growth$_t\updownarrow$?

GDP_{t-1}	RVW_{t-1}	MKT_{t-1}	IND_{t-1}	$FIRM_{t-1}$	R^2 (p-value)
0.330	0.020				0.143
(4.200)	(2.548)				
0.251	0.012	−0.701			0.190
(2.947)	(1.367)	(−2.383)			
0.211	0.015		−1.841		0.213
(2.270)	(1.762)		(−2.432)		
0.238	0.014			−0.477	0.206
(2.536)	(1.583)			(−2.999)	
0.199	0.013	−0.314	−1.470		0.219
(2.308)	(1.415)	(−0.883)	(−1.625)		(0.002)
0.236	0.013	−0.073		−0.441	0.206
(2.561)	(1.659)	(−0.180)		(−1.710)	(0.008)
0.201	0.013		−1.239	−0.250	0.222
(2.339)	(1.481)		(−1.184)	(−0.997)	(0.002)
0.200	0.013	−0.058	−1.237	−0.222	0.222
(2.135)	(1.532)	(−0.138)	(−1.249)	(−0.735)	(0.006)

RVW=quarterly return on CRSP value-weighted portfolio

Coefficients for MKT, IND and FIRM are significant when they are separately included.

Together, individuals are not significant, but they are jointly significant—R^2 and F-test

C. Cyclical Behavior of Volatility Measures in Individual Industries

Table 10. Correlation between volatility measures and industry output?

All negative signs

	IND		FIRM	
Industry	Contemporaneous	Lagged	Contemporaneous	Lagged
Petroleum/gas	−0.297	−0.132	−0.165	−0.270
Fin. services	−0.153	0.090	−0.332	−0.042
Utilities	−0.153	−0.032	−0.094	0.020
Consumer goods	−0.290	−0.308	−0.201	−0.272
Telecomm.	−0.142	−0.124	−0.457	−0.176
Computer	−0.021	0.109	0.162	0.303
Retail	−0.287	−0.212	−0.215	−0.305
Auto	−0.272	0.245	−0.308	0.133
Pharmaceutical	−0.045	−0.108	0.281	−0.054
Chemical	0.101	−0.002	−0.139	0.018

Almost all estimates are negative—countercyclical.

(29) Regression: ‘the only significant variable is firm-specific σ’

V. What Might Explain Increasing Idiosyncratic Volatility?

(<u>PLEASE FILL THIS BLANK!</u>)

VI. Concluding Comments

Characterize the behavior of stock market σ

Using daily data to construct realized monthly σ

Define volatility components → construct total σ of typical firm by adding up components

Positive deterministic trend in idiosyncratic firm-level σ

Not because of # of firms or changes in the serial ρ of daily data

The ρ among individual returns ↓; R^2 of the market model ↓; # of stocks to diversify ↑

Firm-level σ explains the most; market-level σ mostly varies over time and leads the others

σs are countercyclical; tend to lead GDP variations

σs forecast GDP growth; diminish the predictability of stock index return

Similar results for individual industries; using industry βs on the aggregate market

Presents statistical descriptions rather than structural economic models

Asking 'why?' will be fascinating; but possible answers may be just tentative now.

(Ex. changes in corporate governance? institutionalization of equity ownership?)