Understanding Volatility Risk

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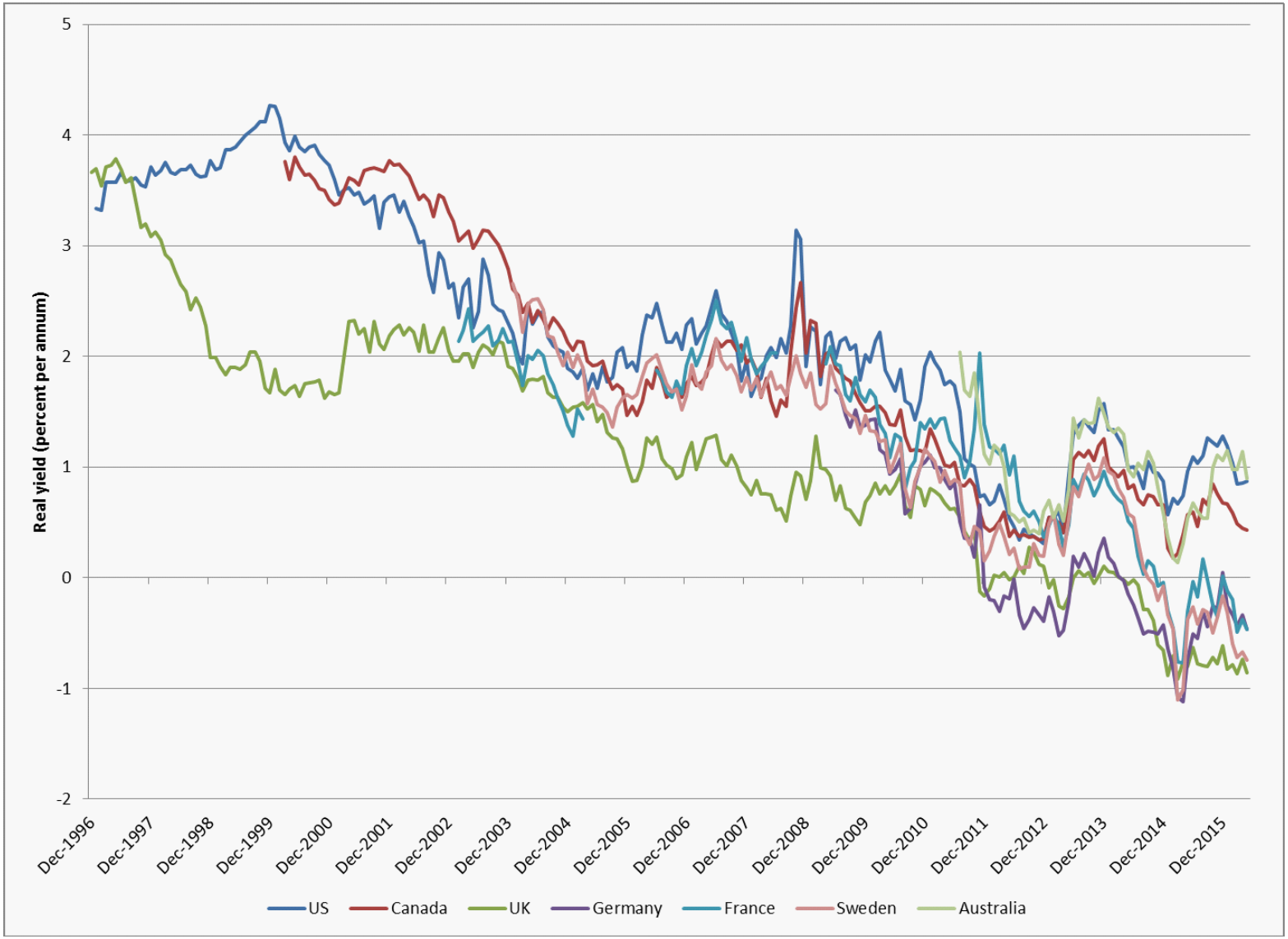
Financial Markets Are Interesting!

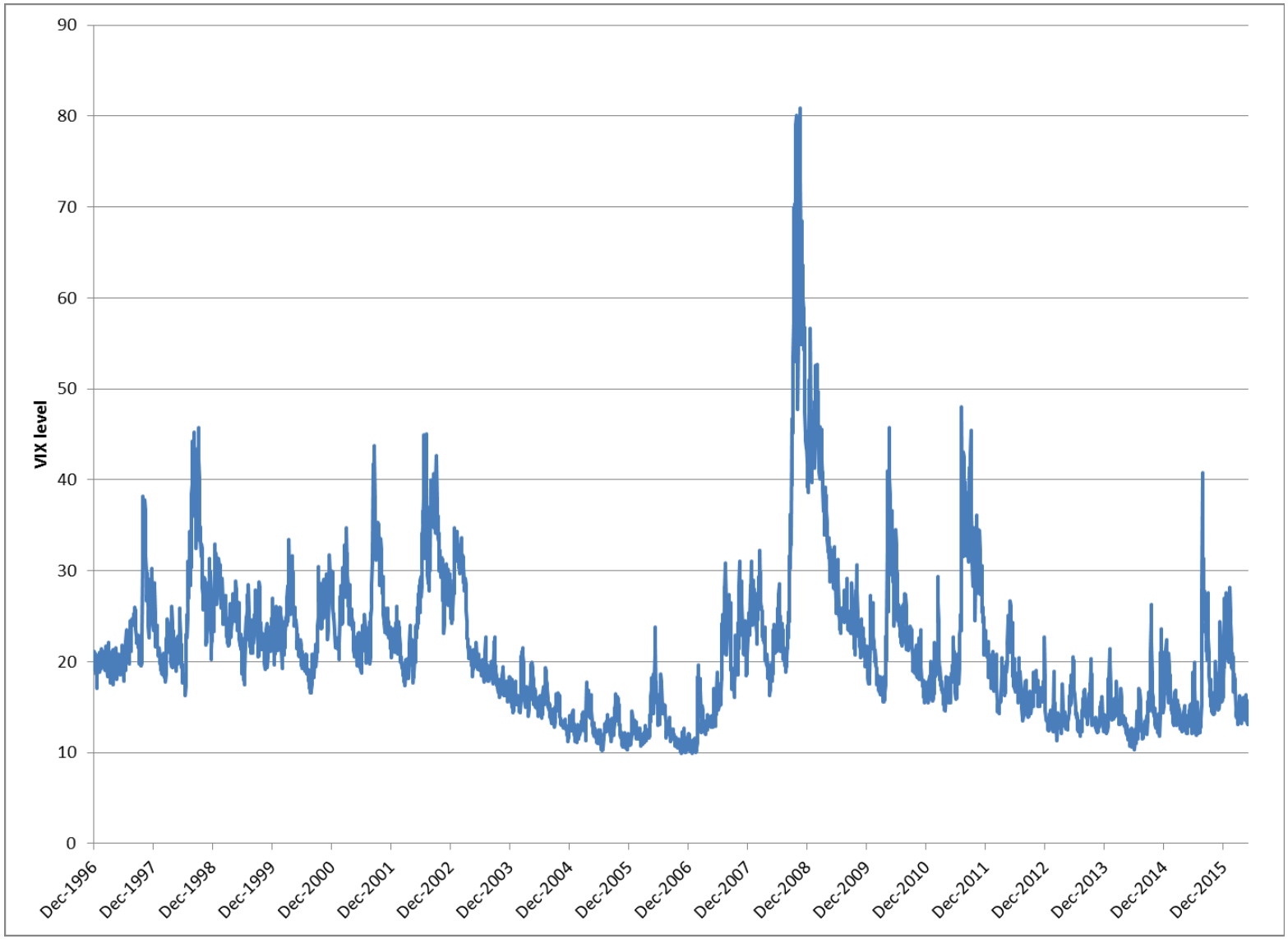
- Investment opportunities are not static, but change importantly over time.
- The 10-year riskless real interest rate has fallen from an average of 3.5% in the 1990s to close to zero today.
- The equity premium has risen from a historic low at the turn of the millennium to roughly the historic norm today.
- Volatility was low in the mid-1990s and mid-2000s, high and unstable today.

The Real Interest Rate



The Equity Premium

Unstable Volatility



What Does This Mean for Investors?

- Changing investment opportunities have many implications.
- In a world of low safe real rates,
  - Claims to safe real income (DB pensions) are far more valuable than before.
  - Institutions and individuals living on investment income must reduce return expectations, increase risk, or both
  - This requires unprecedented flexibility.
- Long-term investors must plan for the inevitable fluctuations in investment opportunities that will occur in the future:
  - Declining real rates are bad news.
  - Declining expected stock returns are bad news.
  - Increasing volatility is bad news.

Intertemporal Hedging

- How can long-term investors hedge against these shocks to investment opportunities?
  - Merton (1973) intertemporal CAPM (ICAPM).
  - Over the past 20 years I have developed the empirical implications in a series of papers with Chan, Giglio, Polk, Turley, Viceira, and Vuolteenaho, and a book with Viceira.
- Long-term asset classes are natural hedges:
  - Bonds hedge against interest rate declines.
  - Stocks hedge against declines in the expected stock return.
- Within the stock market, growth stocks have hedge value:
  - Campbell-Vuolteenaho (2004) break the CAPM beta into two components.
  - Beta with permanent cash-flow shocks to the market ("**bad beta**") should have a premium $\gamma = RRA$ times higher than beta with temporary discount-rate shocks to the market ("**good beta**").
  - Value stocks have relatively high bad betas; growth stocks have relatively high good betas.

Hedging Volatility

- What about hedging against shocks to volatility?
- The desire to hedge volatility may explain many patterns in asset returns:
  - Low returns on options ("variance risk premium").
  - High returns on corporate bonds.
  - Low returns on growth stocks.
- However there are challenges to understanding this:
  - We need to find a **tractable** intertemporal model with stochastic volatility.
  - There must be **persistent** variation in volatility for intertemporal hedging to be important.
- Campbell, Giglio, Polk, and Turley, "An Intertemporal CAPM with Stochastic Volatility" takes on the challenge.

Our Model

- We look at risk from the point of view of a long-term investor holding the market index.
  - The CAPM tells us that the measure of risk for a short-term investor holding the market is the beta of a stock with the market.
  - Our model says that is also true if a long-term investor is risk-tolerant enough (risk aversion of one, log utility).
  - But as risk aversion increases, other betas also matter.
- A stock's risk is determined by three betas:
  - Beta with discount-rate shocks has low risk price equal to variance of market return.
  - Beta with cash-flow shocks has risk price γ times higher (we estimate γ about 7).
  - Beta with variance shocks has risk price $\omega/2 = f(\gamma)$ times higher (we estimate ω about 25 so $\omega/2$ about 12.5).

Understanding Our Model

- All shocks are to the discounted forecasts to an infinite horizon, not near-term forecasts.
  - Long-run market conditions are what matter to a long-horizon investor.
- Discount-rate and cash-flow shocks add up to the unexpected return on the market.
- When $\gamma = 1$, the model gives us the CAPM:
  - When $\gamma = 1$, the first two betas have the same risk price so they collapse to the single CAPM beta.
  - When $\gamma = 1$, $\omega = 0$ so the variance beta is irrelevant.
- In general, our model has three dimensions of risk, but all three risk prices are determined by a single free parameter, risk aversion γ.

Our Empirical Findings

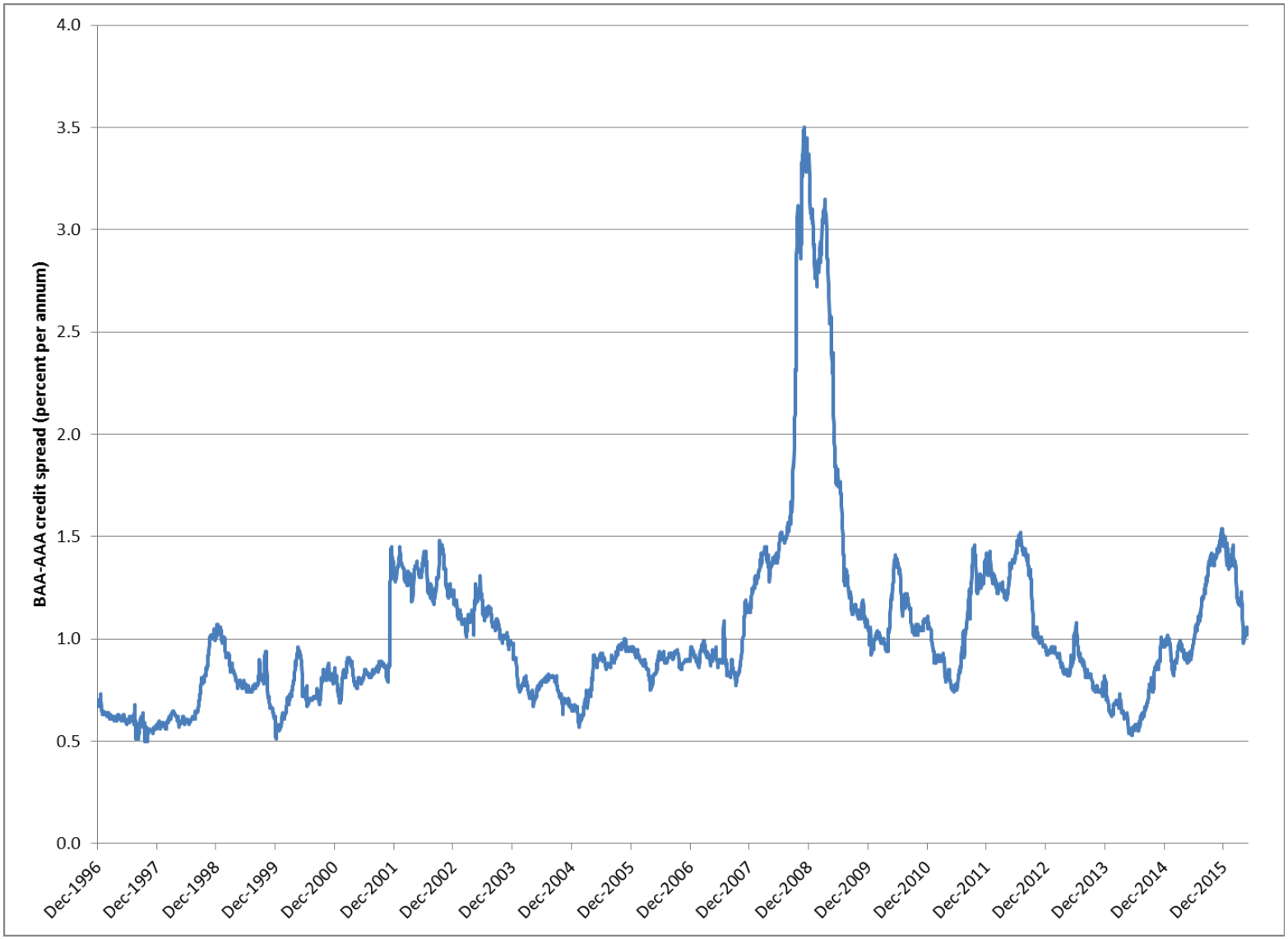
- Novel low-frequency movements in market volatility can be tied to the default spread.
- The low average returns on growth stocks are justified because these stocks hedge long-term investors against both declining expected stock returns, and increasing volatility.
- The addition of volatility risk to the model helps it to deliver a moderate, economically-reasonable value of risk aversion.
- The same preference parameters fit average returns on risk-sorted equity portfolios.
- Volatility hedging is also relevant for other equity anomalies and non-equity anomalies.

VAR Data: 1926:2-2011:4

Six variables:

- Log real return on the CRSP value-weighted index (r_M).
- Expected market return variance ($EVAR$) generated from a regressing forecasting within-quarter realized variance ($RVAR$).
- Log ratio of S&P index to 10-year smoothed earnings (avoiding earnings interpolation) (PE).
- Term spread in Treasury yields (10 years to 3 months) (TY).
- Small-stock value spread (difference in log B/M for small growth and small value portfolios) (VS).
- Default spread (BAA to AAA bonds) (DEF): this is the key variable for predicting volatility over the long run.

Recent History of the Default Spread



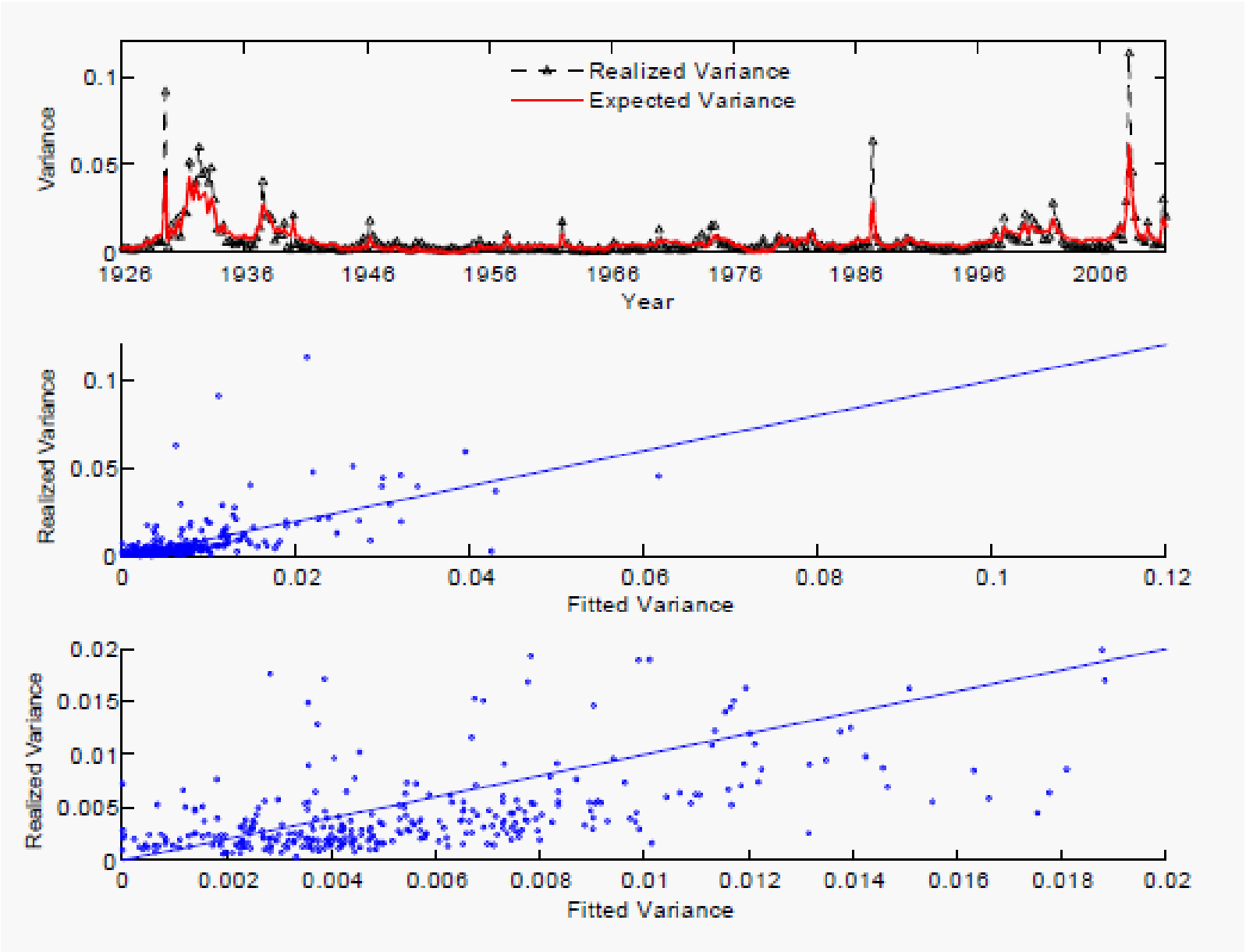
Forecasting Realized Variance

Panel A: Forecasting Quarterly Realized Variance ($RVAR_{t+1}$)

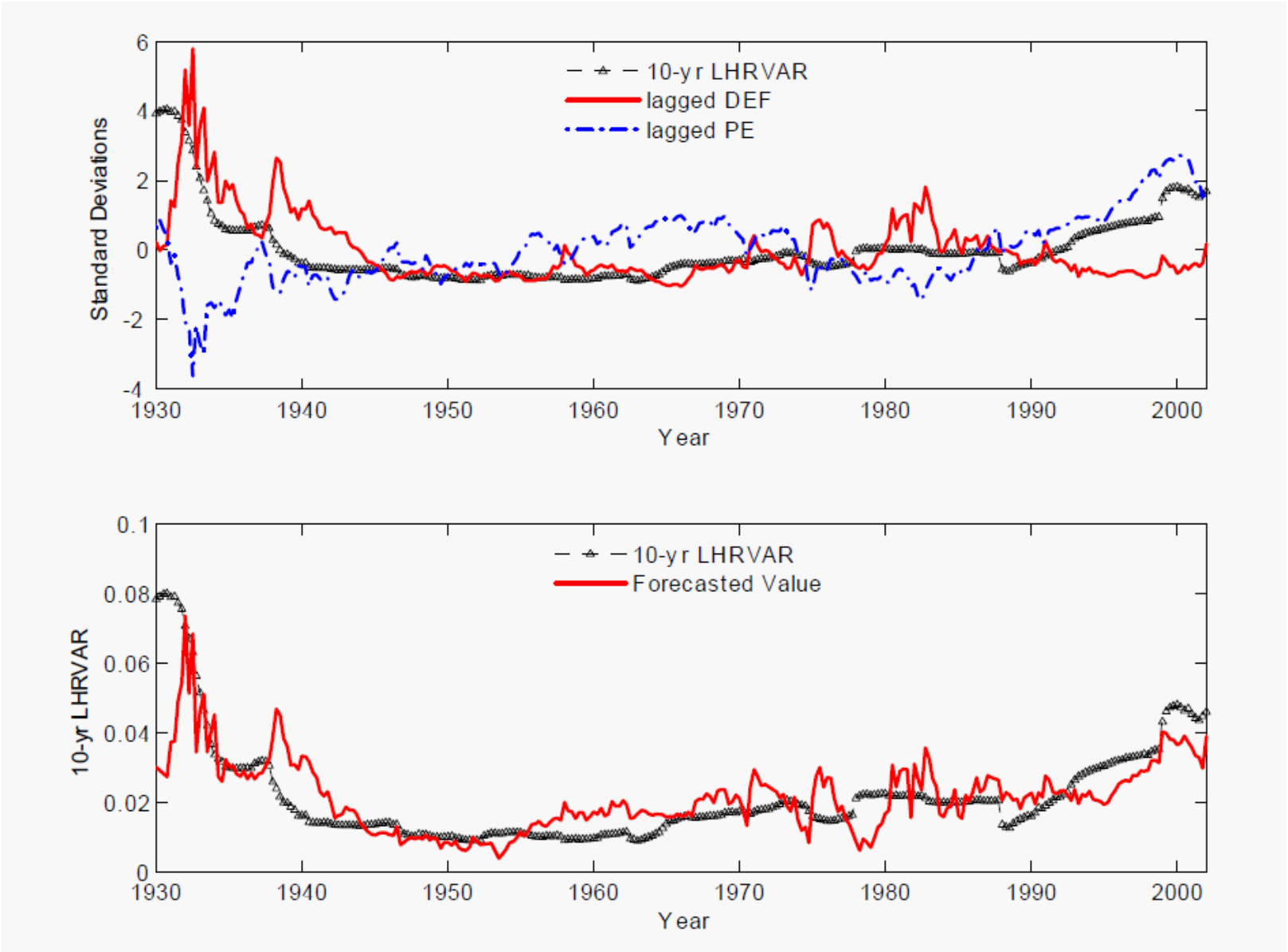
Constant	$r_{M,t}$	$RVAR_t$	PE_t	$r_{Tbill,t}$	DEF_t	VS_t	$R^2\%$
-0.020	-0.005	0.374	0.006	-0.042	0.006	0.000	37.80%
(0.009)	(0.005)	(0.066)	(0.002)	(0.057)	(0.001)	(0.003)	

- This quarter's realized variance predicts next quarter's realized variance (unsurprising).
- The *PE* ratio and the default spread both predict variance.
  - They are persistent so they dominate the long-run forecast.
  - They both have positive signs.

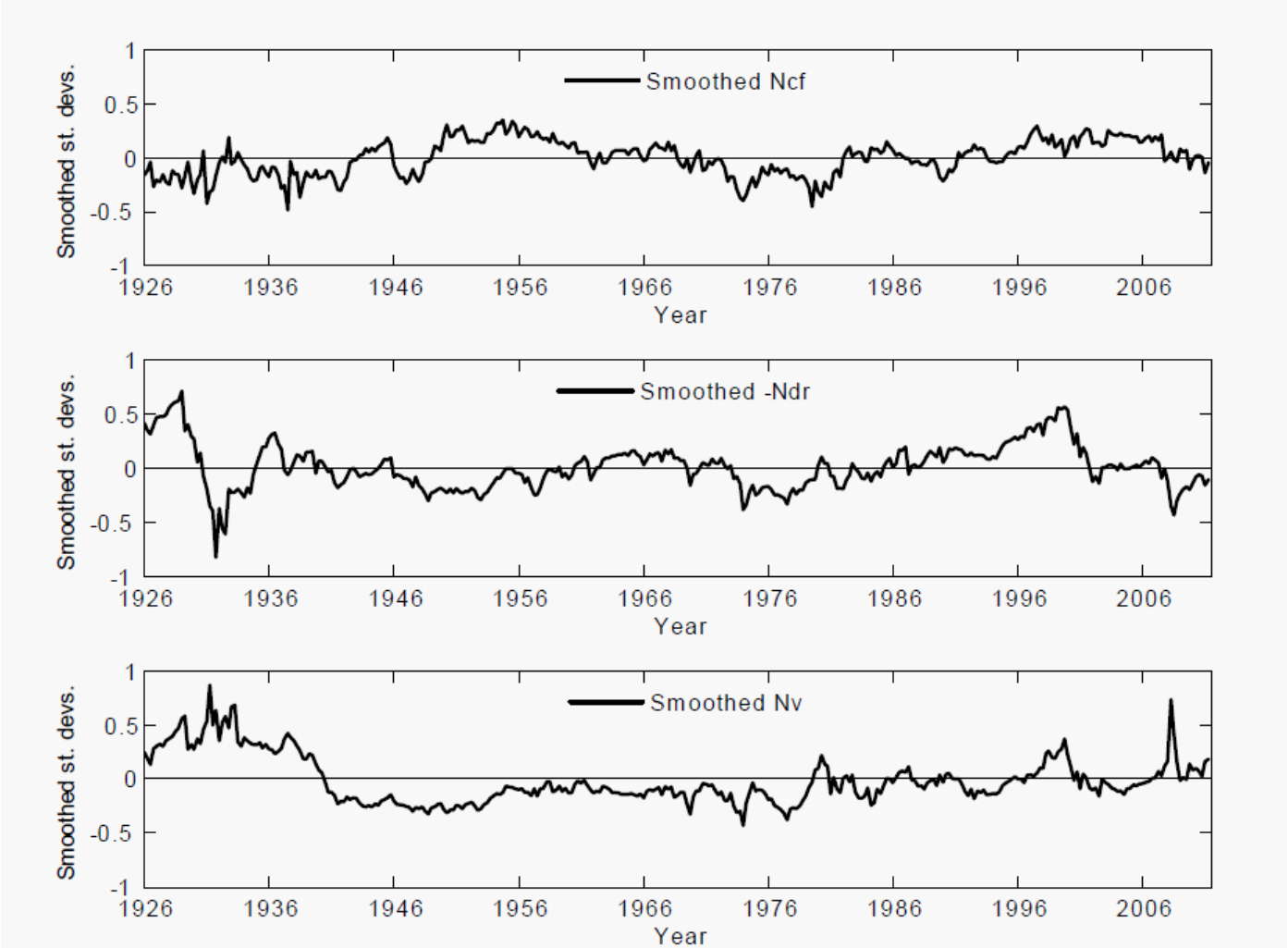
Forecasting 3-Month Realized Variance



Forecasting 10-Year Realized Variance



Implied News Histories



News volatilities: $\sigma(N_{CF}) = 4.9\%$, $\sigma(N_{DR}) = 9.2\%$, $\sigma(N_V) = 2.5\%$
News correlations: $\rho(N_{CF}, N_{DR}) = -0.04$, $\rho(N_{CF}, N_V) = -0.12$, $\rho(N_{DR}, N_V) = -0.03$

Test Asset Data: 1931:3-2011:4

- 25 size- and BE/ME-sorted portfolios from Ken French, plus a Treasury bill (a total of 26).
  - But Daniel and Titman (1997, 2012) and Lewellen, Nagel, and Shanken (2010) argue that characteristic-sorted portfolios are "too easy" because they are likely to show some spread in betas identified as risk by almost any model.
- In response we "raise the bar" by looking at other portfolios (a total of 100).
  - 6 risk-sorted portfolios.
  - 18 portfolios double-sorted on characteristics and risk.
  - "Managed" versions of all the above portfolios that vary exposure in response to volatility.
- We also look at other equity and non-equity anomalies that have attracted attention in the literature.

Subsamples

- Previous work has shown that
  - The CAPM betas of value stocks are high in the first part of our sample, and low in the second.
  - The CAPM fits the characteristic-sorted portfolios well in the first part of the sample, and very poorly in the second.

- Accordingly we break our sample into two subsamples, early (1931:3-1963:2), and modern (1963:3-2011:4).
  - We would like our models to explain both subsamples with stable preference parameters.
  - Given limited time I will only show modern-period results.

Characteristic-Sorted Betas

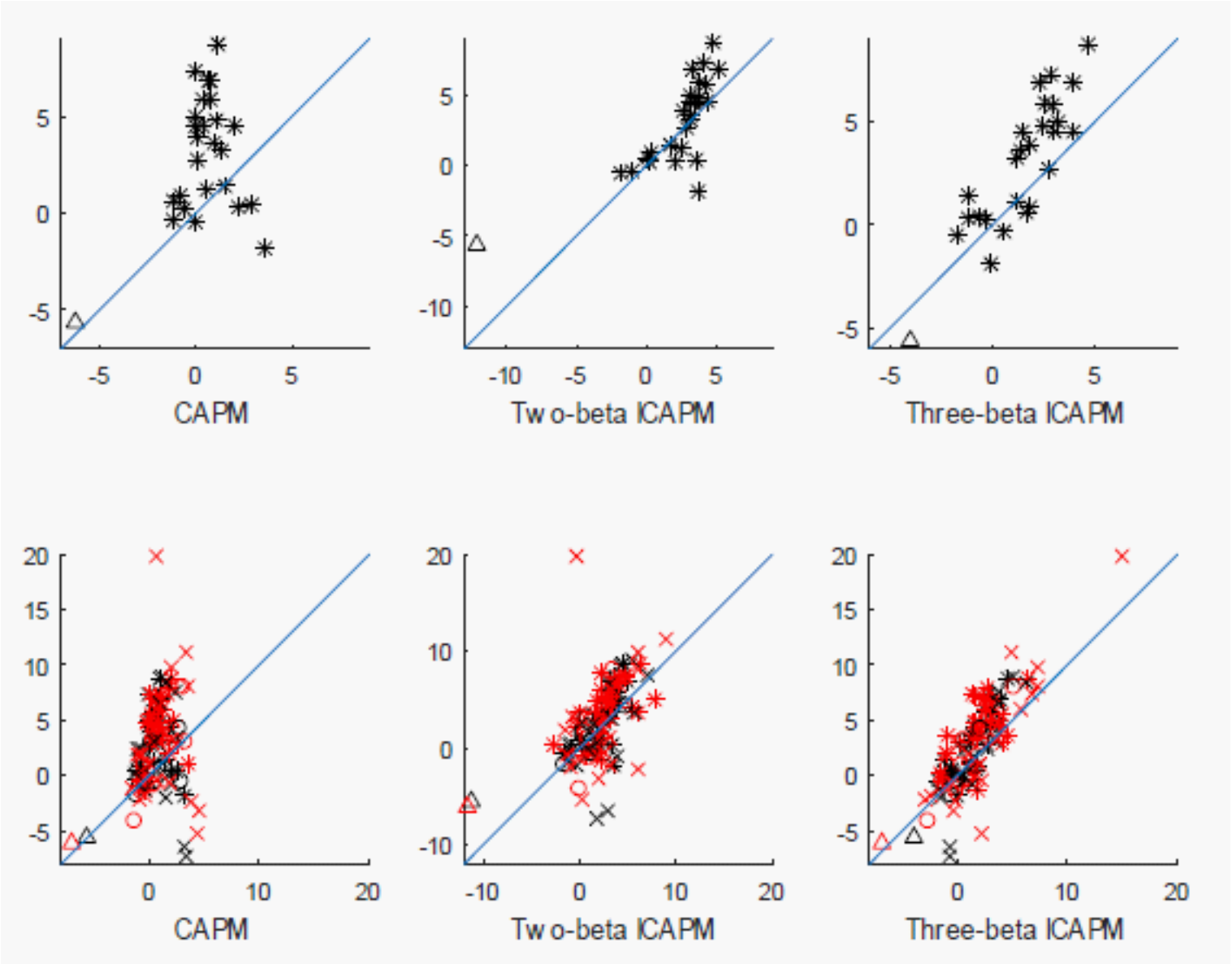
Panel B: Modern Period (1963:3-2011:4)

$\widehat{\beta}_{CF}$	Growth		3		Value		Diff	
Small	0.23	[0.06]	0.26	[0.05]	0.28	[0.05]	0.05	[0.04]
3	0.21	[0.05]	0.24	[0.05]	0.27	[0.05]	0.06	[0.03]
Large	0.15	[0.04]	0.18	[0.03]	0.20	[0.04]	0.05	[0.03]
Diff	-0.08	[0.04]	-0.08	[0.03]	-0.07	[0.03]		

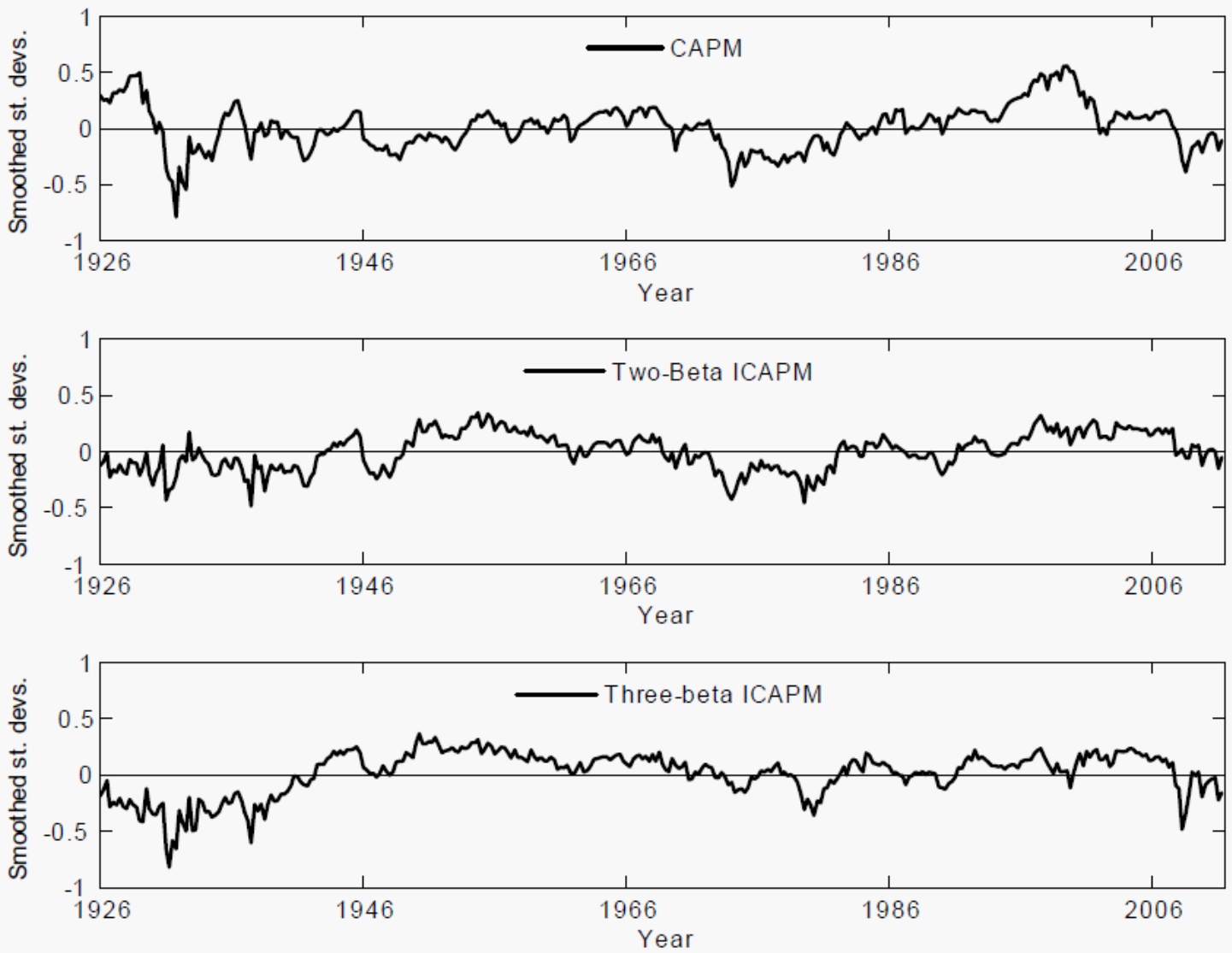
$\widehat{\beta}_{DR}$	Growth		3		Value		Diff	
Small	1.30	[0.11]	0.87	[0.07]	0.86	[0.09]	-0.44	[0.08]
3	1.11	[0.08]	0.73	[0.06]	0.69	[0.07]	-0.42	[0.08]
Large	0.82	[0.05]	0.60	[0.05]	0.64	[0.06]	-0.18	[0.06]
Diff	-0.48	[0.10]	-0.26	[0.06]	-0.23	[0.08]		

$\widehat{\beta}_{V}$	Growth		3		Value		Diff	
Small	0.13	[0.07]	0.05	[0.05]	0.01	[0.07]	-0.13	[0.03]
3	0.14	[0.06]	0.05	[0.05]	0.04	[0.04]	-0.10	[0.03]
Large	0.09	[0.05]	0.03	[0.04]	0.02	[0.04]	-0.08	[0.02]
Diff	-0.04	[0.03]	-0.02	[0.02]	0.01	[0.03]		

Model Fit for 26 and 100 Test Assets



History of Good and Bad Times



Other Equity Anomalies

FACTORS	μ	σ	$\widehat{\beta}_{DR}$	$\widehat{\beta}_{CF}$	$\widehat{\beta}_{V}$	λ_{DR}	λ_{CF}^{2-BETA}	λ_{CF}^{3-BETA}	λ_{V}	α_{CAPM}	α_{ICAPM}^{2-BETA}	α_{ICAPM}^{3-BETA}
RMRF	1.39%	8.69%	0.78	0.19	0.07	0.60%	2.44%	1.06%	-0.70%	0.00%	-1.64%	0.44%
SMB	0.78%	5.65%	0.22	0.06	0.02	0.17%	0.73%	0.32%	-0.17%	0.35%	-0.13%	0.45%
HML	1.18%	5.92%	-0.26	0.05	-0.10	-0.20%	0.60%	0.26%	0.94%	1.50%	0.78%	0.18%
RMW	0.83%	4.17%	-0.09	-0.01	0.01	-0.07%	-0.15%	-0.07%	-0.10%	0.99%	1.05%	1.06%
CMA	1.02%	4.21%	-0.21	0.02	-0.05	-0.16%	0.23%	0.10%	0.47%	1.30%	0.95%	0.61%
UMD	2.18%	7.78%	-0.14	-0.03	0.03	-0.11%	-0.38%	-0.16%	-0.26%	2.46%	2.67%	2.71%
BETA	-0.20%	10.90%	-0.74	-0.08	-0.05	-0.57%	-0.99%	-0.43%	0.50%	1.01%	1.36%	0.30%
STR	1.58%	5.66%	0.15	0.05	-0.01	0.12%	0.60%	0.26%	0.07%	1.28%	0.87%	1.14%
LTR	0.92%	5.27%	-0.09	0.05	-0.05	-0.07%	0.61%	0.26%	0.47%	0.97%	0.38%	0.26%
ACC	1.14%	4.29%	-0.08	-0.03	-0.02	-0.06%	-0.37%	-0.16%	0.21%	1.29%	1.57%	1.15%
NI	1.19%	5.59%	-0.21	-0.03	-0.02	-0.16%	-0.36%	-0.16%	0.21%	1.57%	1.71%	1.30%
IVOL	1.02%	11.61%	-0.76	-0.07	-0.05	-0.58%	-0.94%	-0.41%	0.52%	2.26%	2.55%	1.50%

Strategies	Scaled	Average	Absolute	Alpha
All	N	1.25%	1.30%	0.92%
All	Y	1.78%	1.74%	1.31%
Three-factor model	N	0.62%	0.85%	0.36%
Three-factor model	Y	0.91%	1.00%	0.47%
Five-factor model	N	0.83%	0.91%	0.55%
Five-factor model	Y	1.50%	1.43%	0.98%

Non-Equity Anomalies

FACTORS	μ	σ	$\widehat{\beta}_{DR}$	$\widehat{\beta}_{CF}$	$\widehat{\beta}_{V}$	λ_{DR}	λ_{CF}^{2-BETA}	λ_{CF}^{3-BETA}	λ_{V}	α_{CAPM}	α_{ICAPM}^{2-BETA}	α_{ICAPM}^{3-BETA}
HY-IG	0.23%	4.47%	0.25	0.01	-0.06	0.19%	0.17%	0.07%	0.61%	-0.27%	-0.13%	-0.65%
CARRY	1.48%	5.37%	0.19	0.01	-0.07	0.15%	0.13%	0.06%	0.72%	1.11%	1.19%	0.55%
STRADDLE	21.66%	47.10%	1.90	0.18	-0.29	1.53%	2.38%	1.03%	2.89%	17.71%	17.76%	16.21%
VIXF2-VIXF0	26.84%	48.41%	2.74	0.24	-0.25	2.77%	3.97%	1.72%	3.20%	24.56%	20.09%	19.14%

Strategies	Scaled	Average Absolute Alpha		
All	N	10.91%	9.79%	9.14%
All	Y	2.50%	2.27%	2.15%

Discussion of Results

- Many anomalies in the equity market look smaller from the point of view of a conservative long-term investor who wants to hedge volatility.
  - Low-investment CMA, low-beta BETA, long-term reversal LTR, and low idiosyncratic volatility IVOL are considerably less attractive to such an investor.
- Volatility hedging also helps explain the high returns to the carry trade, but the effect is too small to explain the extremely high returns to option-writing strategies.
- We explore variations of the basic VAR specification:
  - Results are robust to different estimation methods, to different measures of the market's valuation ratio, and to different variables in the VAR.

Conclusion

- We extend the ICAPM to allow for stochastic volatility.
  - A conservative long-horizon equity investor will wish to hedge against both a decline in the expected equity return and an increase in equity market volatility.
  - Though our model has three dimensions of risk, the coefficient of relative risk aversion pins down all risk prices.
  - The addition of volatility risk helps the model fit the data with a moderate, economically reasonable value of risk aversion.
- We uncover new persistent variation in market volatility via DEF/PE.
  - Very different from the VIX!
- We justify the negative post-1963 CAPM alphas of growth stocks:
  - These stocks hedge long-term investors against both declining expected stock returns, and increasing volatility.
- The model fits the average returns on risk-sorted equity portfolios, and reduces the magnitude of many other equity and non-equity anomalies.