Understanding Volatility Risk

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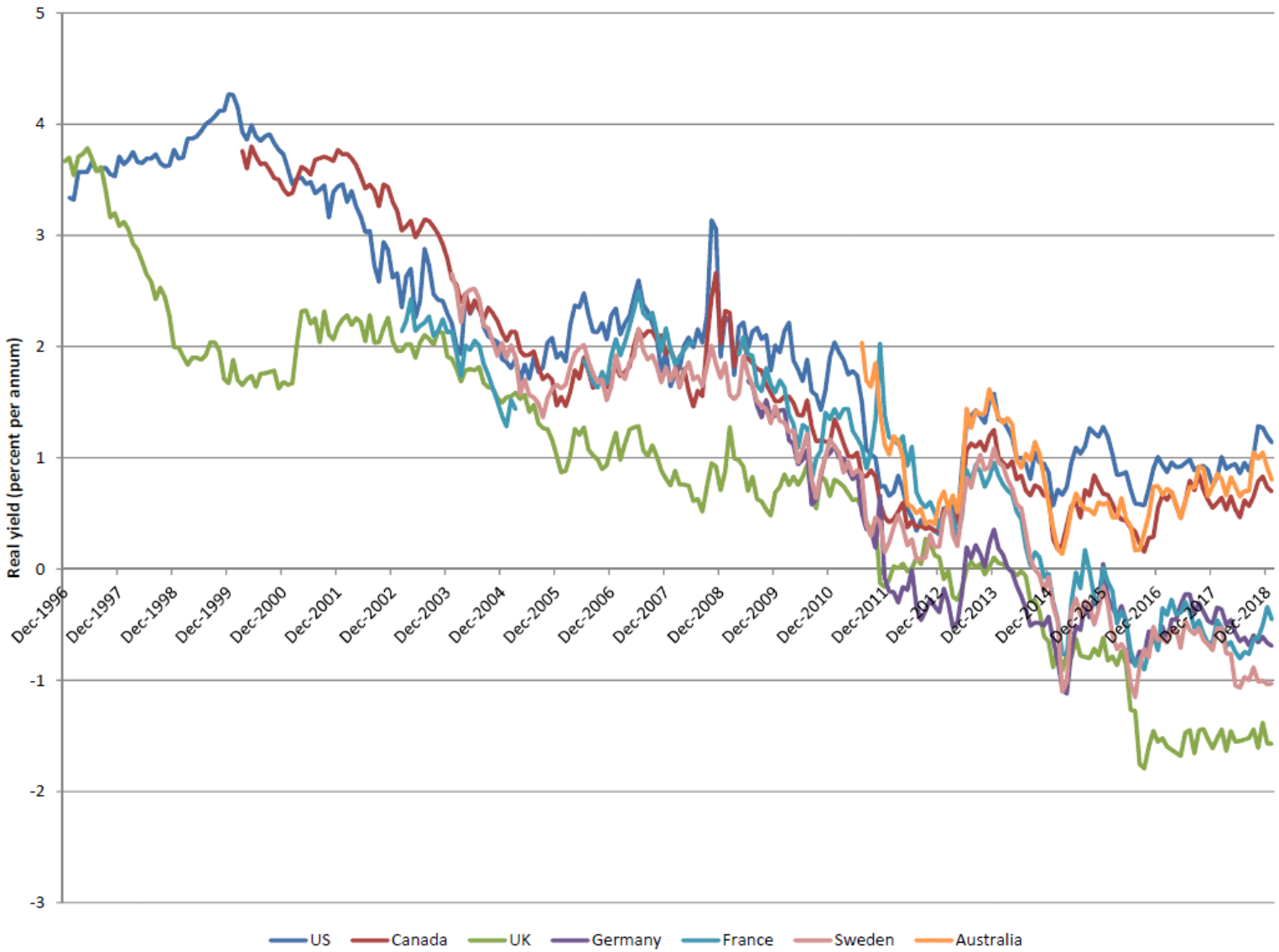
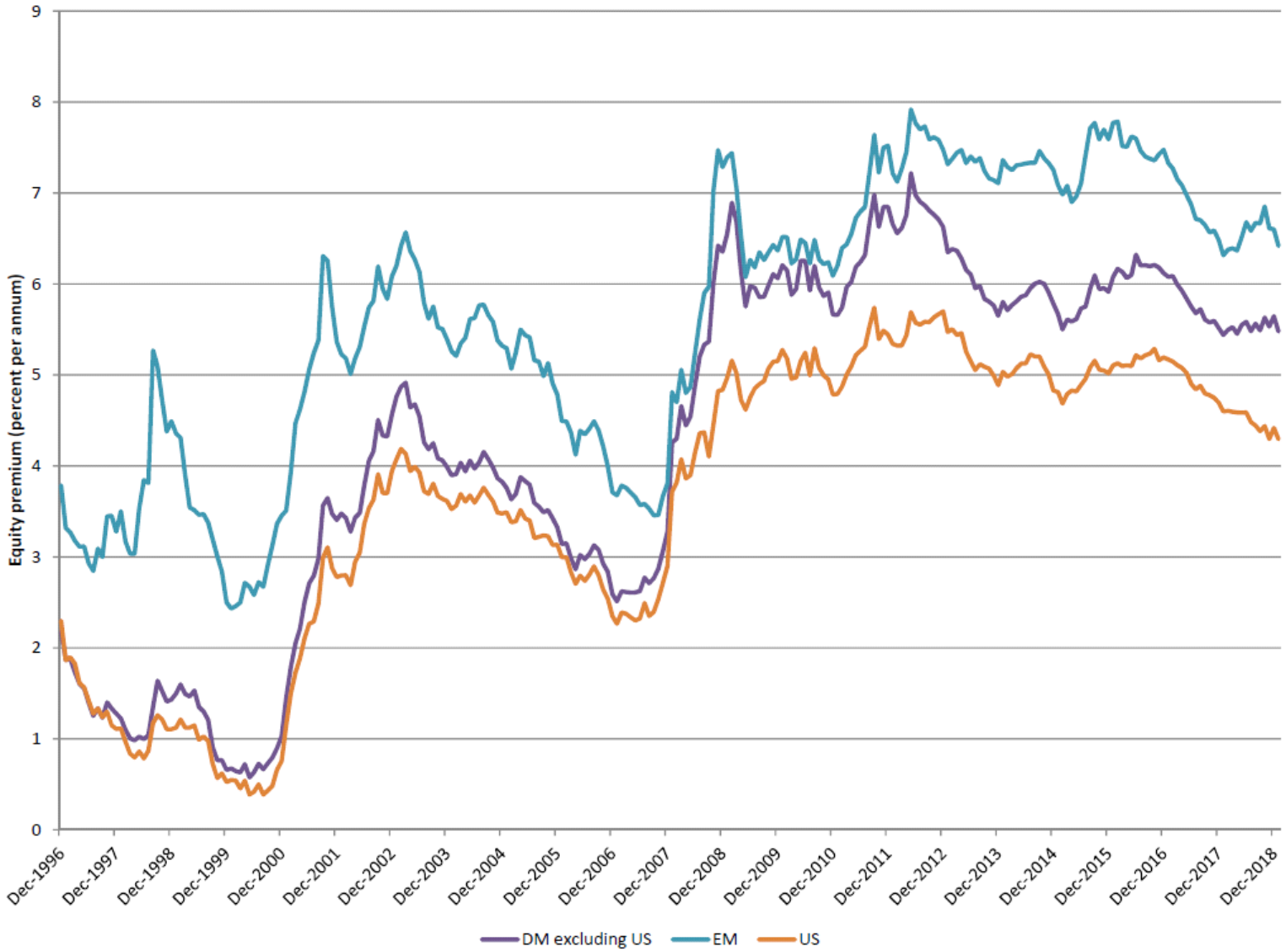
Financial Markets Are Interesting!

- Investment opportunities are not static, but change importantly over time.
- The 10-year riskless real interest rate has fallen worldwide:
  - In the US, from an average of 3.5% in the 1990s to around 1% today
  - Negative today in Europe and particularly the UK.
- The equity premium has risen from a historic low at the turn of the millennium to a level slightly below the historic norm today.
- Volatility was persistently low in the mid-2000s, shows frequent spikes today.

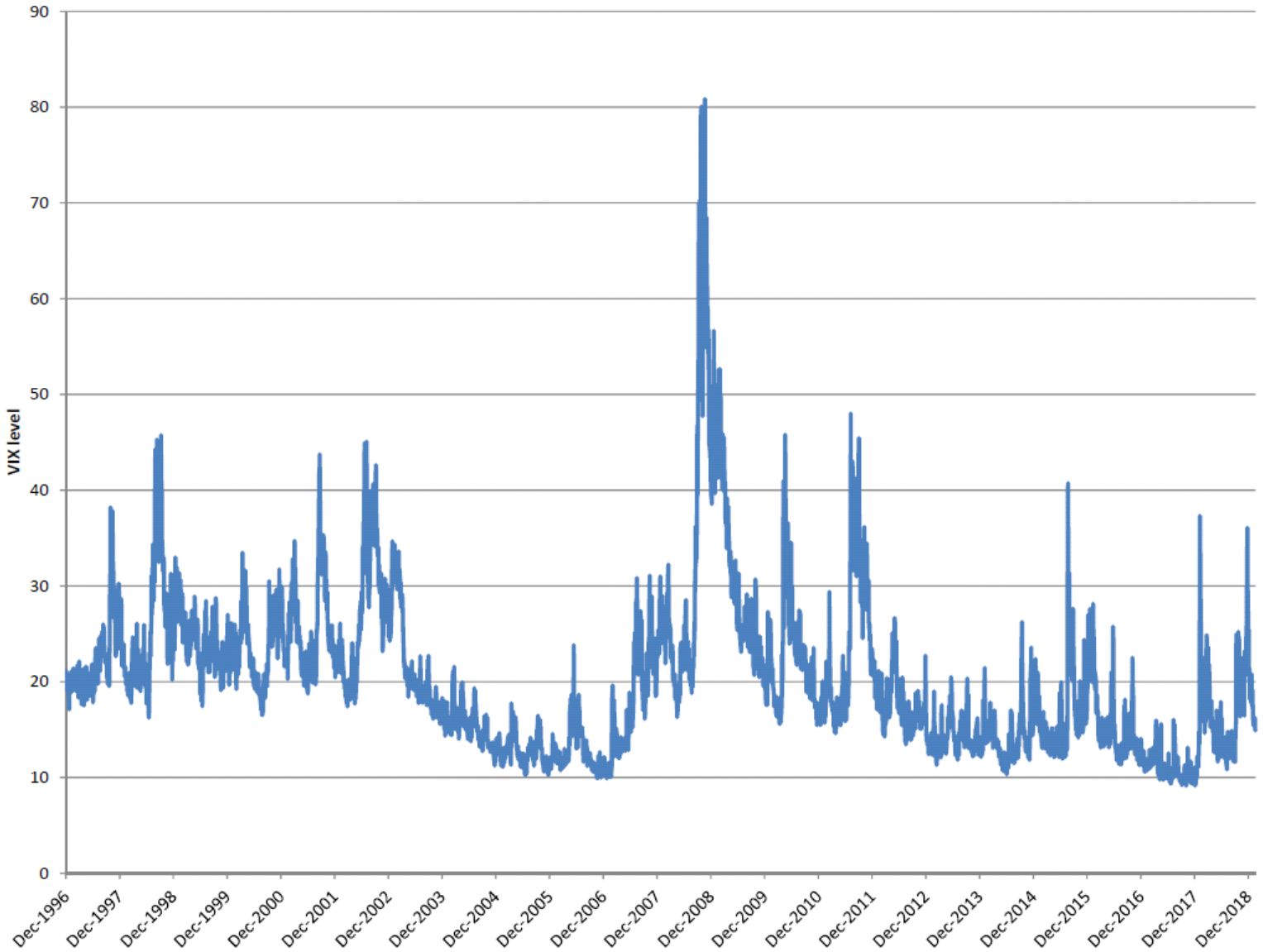
The Real Interest Rate



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?
  - Sustainable spending $C = R \times W$. Hence, to stabilize spending you need W to rise when R falls.
  - 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 assets are natural hedges:
  - Bonds hedge against interest rate declines.
  - Stocks hedge against declines in the expected stock return.

Bad Beta, Good Beta

- The market is driven both by permanent shocks to expected future profits (**cash-flow news**) and by changes in discount rates that temporarily move prices today even if cash flows are constant (**discount-rate news**).
- Campbell-Vuolteenaho (2004) accordingly break the CAPM beta into two components.
  - Beta with cash-flow news ("**bad beta**") should have a premium γ times higher than beta with discount-rate news ("**good beta**"). Here γ is risk aversion (reasonable values might be 5-10).
  - Intuition: losses driven by cash flows are permanent, losses driven by discount rates will be recovered eventually by long-term investors who will earn higher returns in the future.
  - Financial analogy: a bond portfolio can lose value because some bonds default, or because interest rates go up. The former is worse for a long-term investor.
  - Medical analogy: cholesterol as a single measure of heart attack risk has been replaced by LDL ("bad") and HDL ("good") cholesterol.

A Two-Beta Model of the Value Puzzle

- Campbell and Vuolteenaho show that the two-beta model helps to explain the value puzzle.
  - Value stocks have low CAPM betas and high average returns.
  - But value stocks have relatively high bad betas, while growth stocks have relatively high good betas.
  - Value stocks are riskier than they look to a short-term investor, while growth stocks are safer.
  - Caveat: a high level of risk aversion (about 15) is needed for the two-beta explanation to work.

Hedging Volatility

- What about hedging against shocks to volatility? Since an increase in volatility is bad news, an asset that does well when volatility increases is an attractive volatility hedge.
- 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 (CGPT), "An Intertemporal CAPM with Stochastic Volatility" (*Journal of Financial Economics* 2018) takes on the challenge.

From Two Betas to Three Betas

- 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).
  - But as risk aversion increases above one, other betas also matter.
- A stock's risk is determined by three betas:
  - Beta with **discount-rate news** has low risk price equal to variance of market return.
  - Beta with **cash-flow news** has risk price γ times higher (we estimate γ about 7).
  - Beta with **variance news** has risk price $\omega/2 = f(\gamma)$ times higher (we estimate ω about 25 so $\omega/2$ about 12.5).

Understanding the Three-Beta 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.

Summary of Empirical Findings

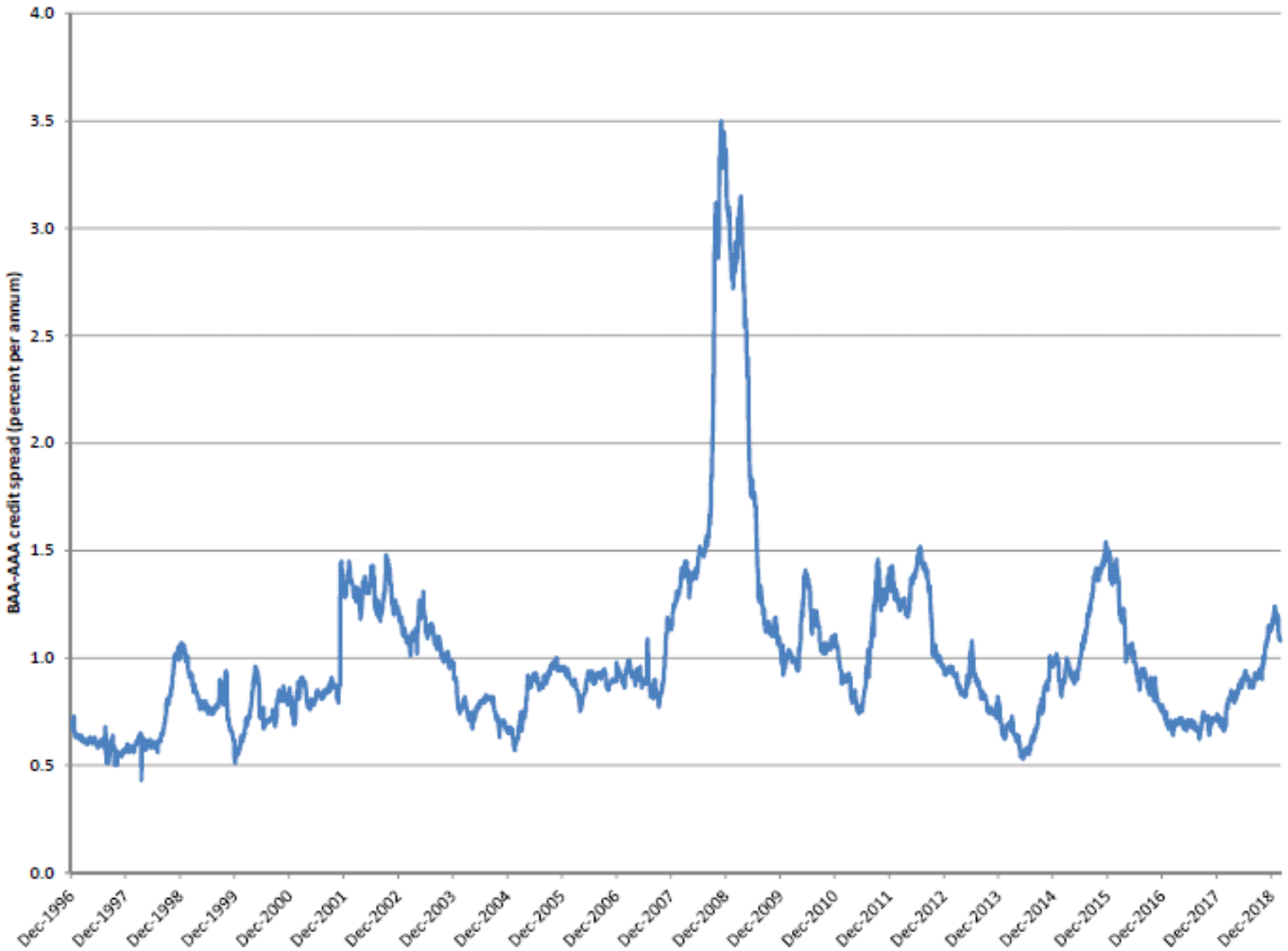
- There are low-frequency movements in market volatility (not just transitory spikes) that can be tied to the default spread.
- The low average returns on growth stocks are justified because these stocks hedge long-term investors against both declining expected stock returns, and increasing volatility.
- The addition of volatility risk to the model makes it consistent with a reasonable value of risk aversion (7 not 15).
- The same preference parameters fit average returns on risk-sorted equity portfolios.
- Volatility hedging is also relevant for other equity anomalies and for pricing options and corporate bonds.

Predictor Variables

Six variables, measured over the period 1926–2011:

- 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



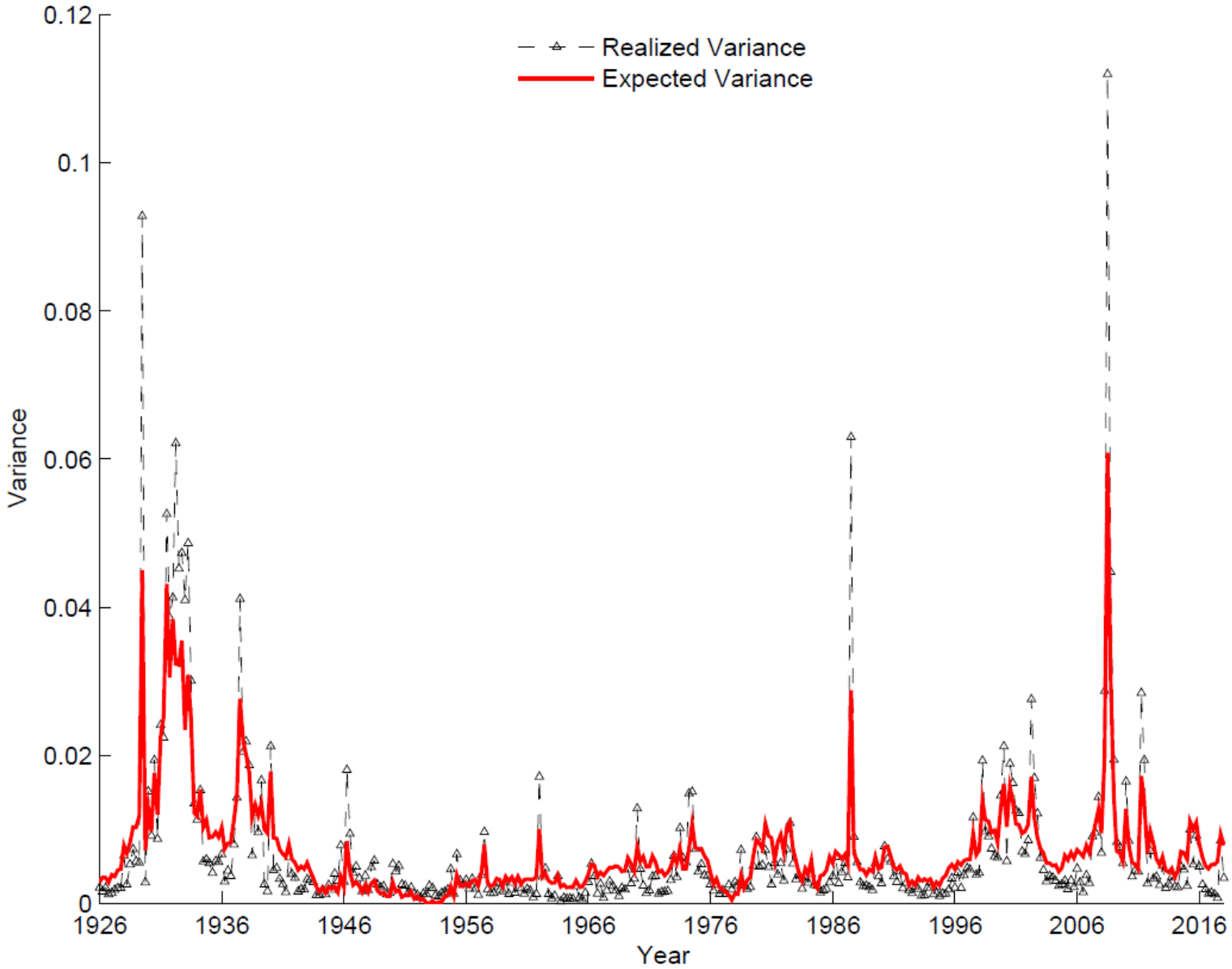
Forecasting Quarterly Realized Variance

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

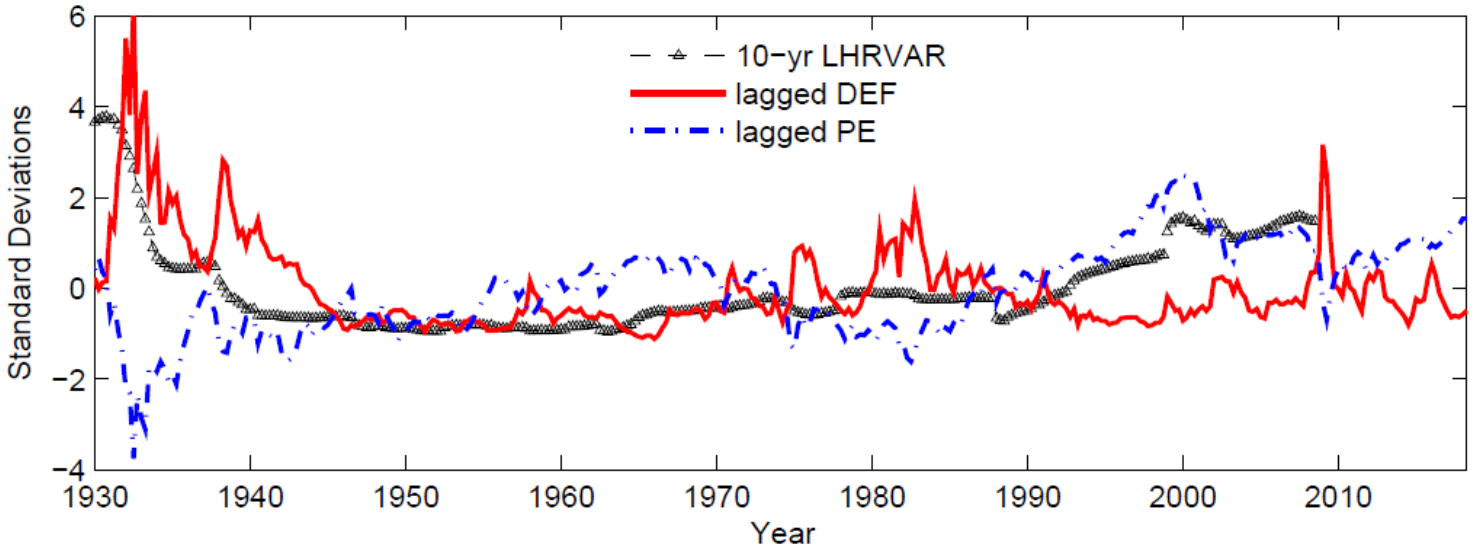
Constant	$r_{M,t}$	$RVAR_t$	PE_t	$r_{Tbill,t}$	DEF_t	VS_t	$R^2\%$
-0.020	-0.005	0.374	0.006	-0.042	0.006	0.000	37.80%
(0.009)	(0.005)	(0.066)	(0.002)	(0.057)	(0.001)	(0.003)	

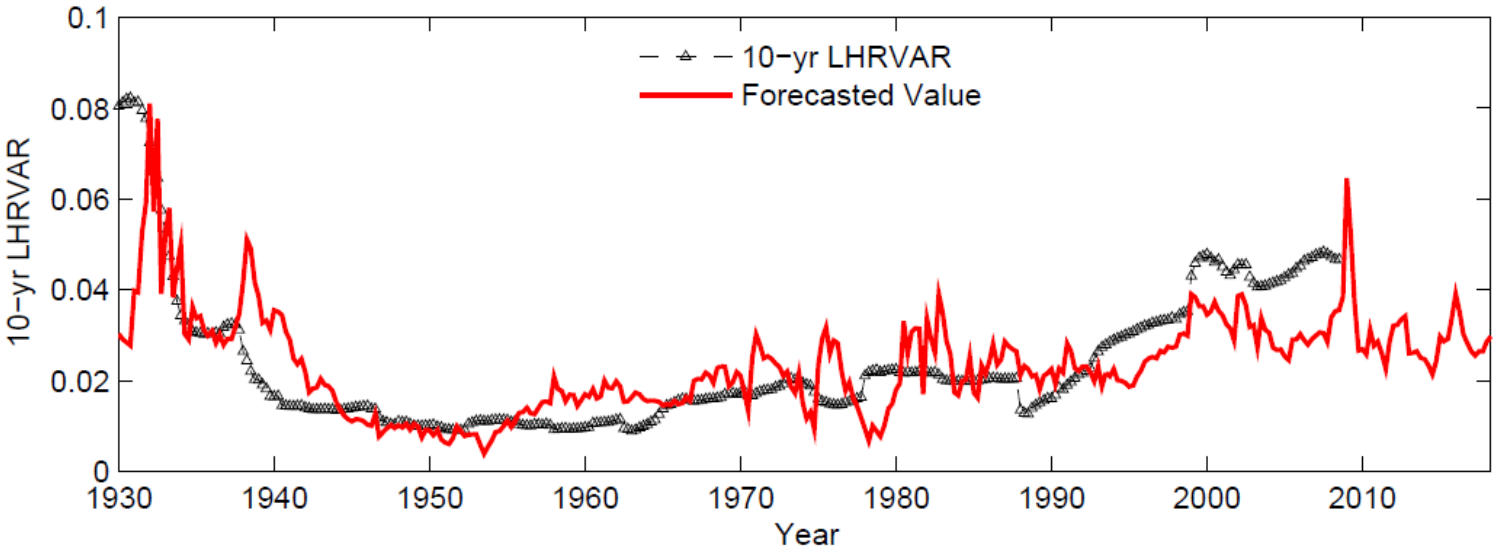
- This quarter's realized variance predicts next quarter's realized variance (unsurprising!)
- The *PE* ratio and the default spread both predict variance.
  - They are persistent so they dominate the long-run forecast.
  - They both have positive signs.

Quarterly Variance and Our Forecasts

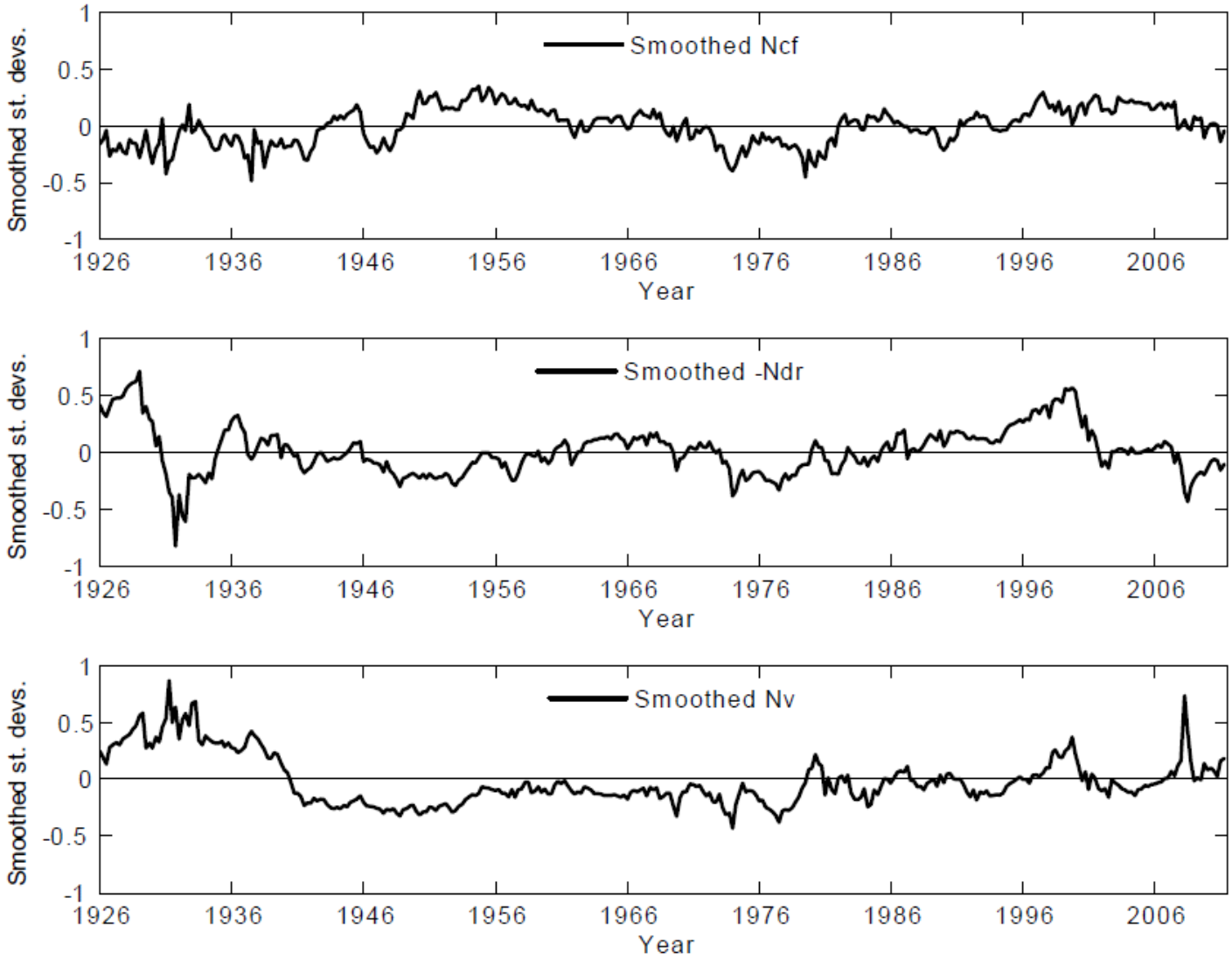


10-Year Variance and Our Forecasts





Implied News Histories



Test Assets

- 25 portfolios sorted by characteristics: size (market cap) and value (book-market ratio).
- 75 other portfolios sorted by risk measures, some of them "managed" to vary exposure in response to volatility.
- We also look at other equity and non-equity anomalies that have attracted attention from finance economists.
- We look at two sample periods, early (1931–1963) and modern (1963–2011). I will focus here on the modern period.

Characteristic-Sorted Betas

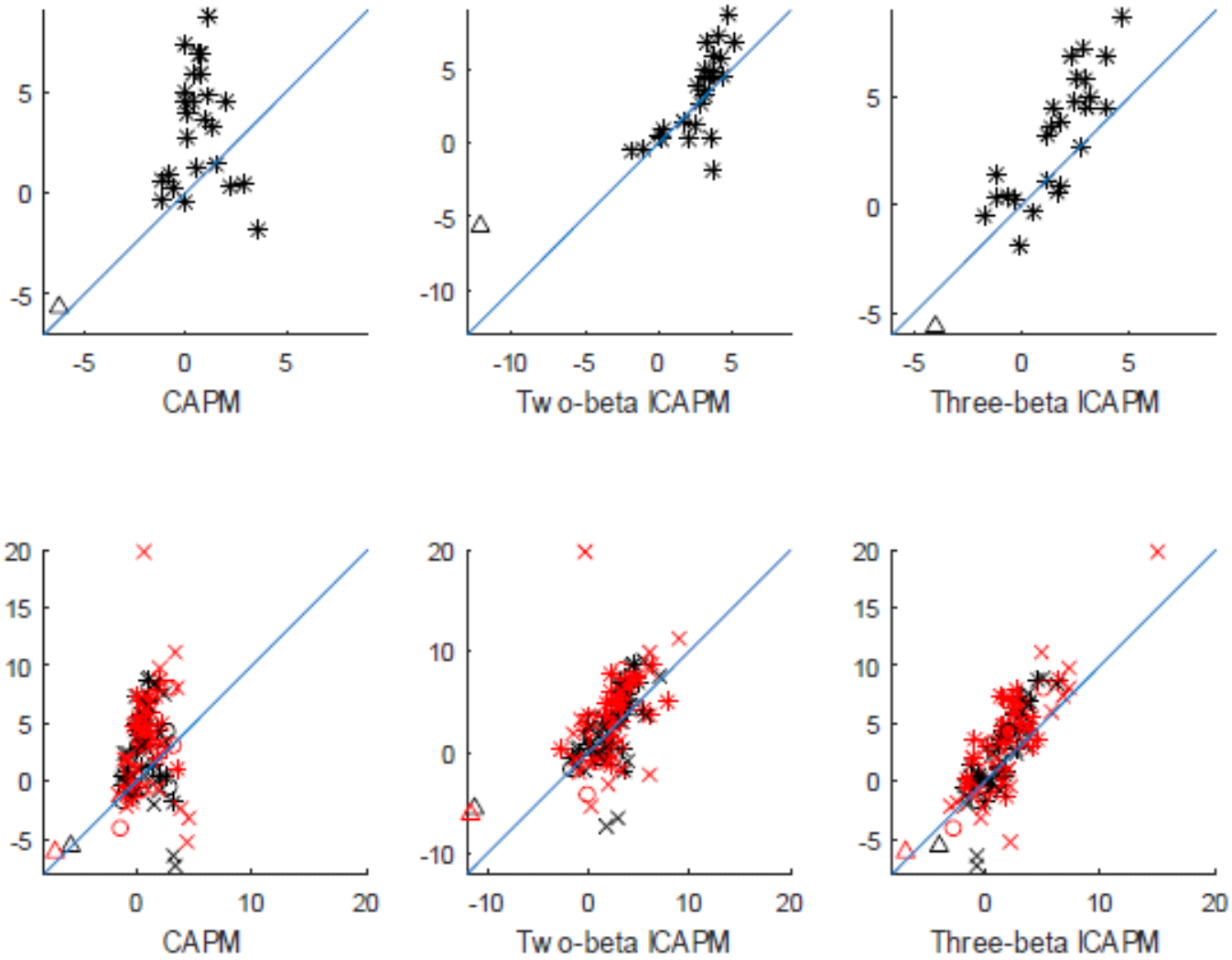
Panel B: Modern Period (1963:3-2011:4)

$\widehat{\beta}_{CF}$	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]		

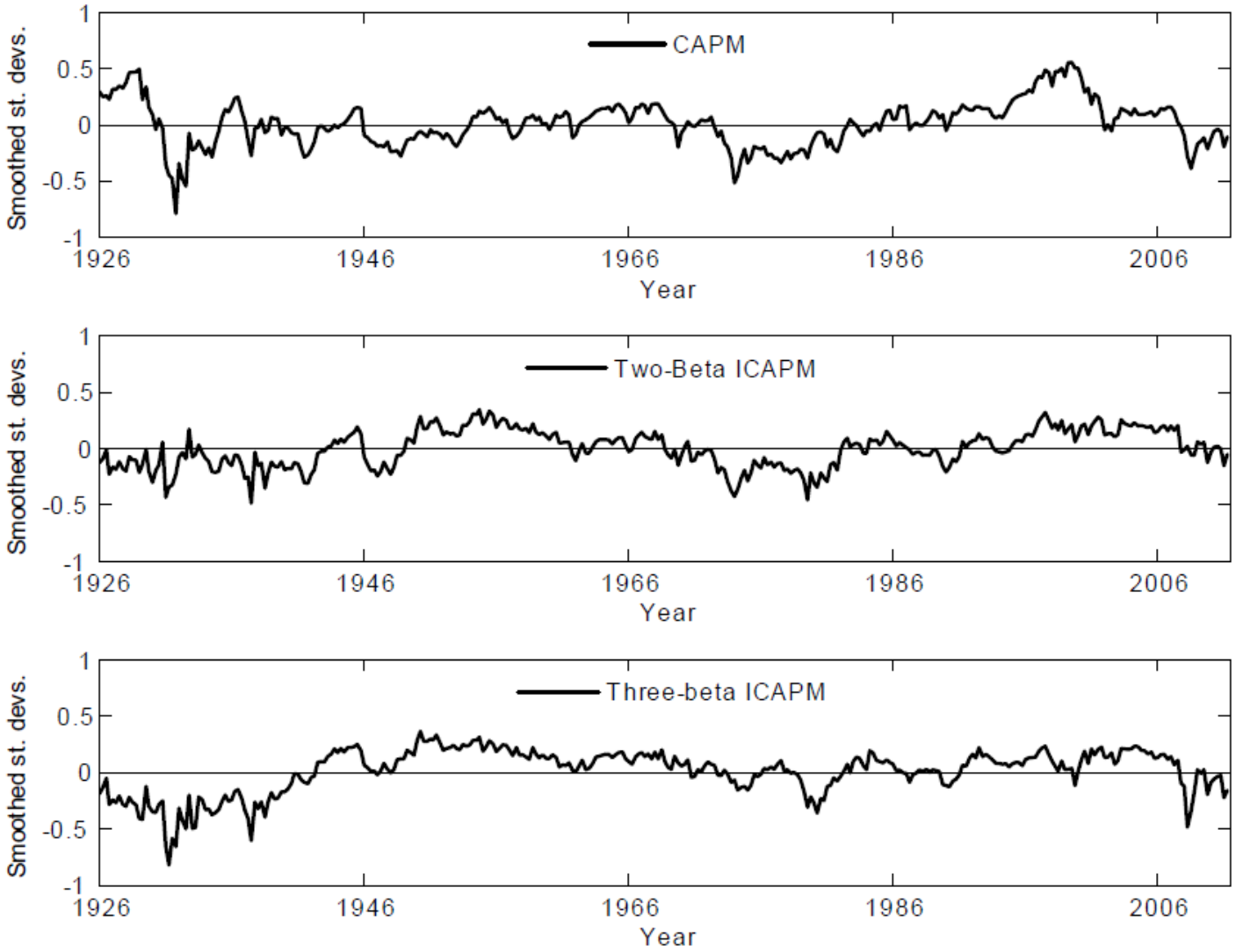
$\widehat{\beta}_{DR}$	Growth		3		Value		Diff	
Small	1.30	[0.11]	0.87	[0.07]	0.86	[0.09]	-0.44	[0.08]
3	1.11	[0.08]	0.73	[0.06]	0.69	[0.07]	-0.42	[0.08]
Large	0.82	[0.05]	0.60	[0.05]	0.64	[0.06]	-0.18	[0.06]
Diff	-0.48	[0.10]	-0.26	[0.06]	-0.23	[0.08]		

$\widehat{\beta}_{V}$	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: Average Returns vs. Predicted Returns



History of Good and Bad Times



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 low average returns of growth stocks:
  - These stocks hedge long-term investors against both declining expected stock returns, and increasing volatility.

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Textbook

- Campbell, John Y., 2018, *Financial Decisions and Markets: A Course in Asset Pricing*, Princeton University Press.