The VIX Premium

Online Appendix

This Online Appendix has supplementary material for "The VIX Premium." Section A contains supplementary figures and tables in the paper. Section B repeats the trader group definitions from the CFTC's Trader in Financial Futures report. Section C solves the model of hedging discussed in Section 3.3.

A. Supplementary figures and tables

The following is a table of contents of Figures and Tables in this Online Appendix. An "x" in the "Risk" column indicates that the tables relate to results using the VVIX, a (risk-neutral) measure of volatility-of-volatility, and measures of jump risk such as the implied volatility skew. As discussed in Sections 1.4 and 1.5, volatility-of-volatility and jump risk are closer to the sources of risk described by models of volatility premiums.

Table or Figure	Referencing Section	Risk
	Table 12	
Table A.20. US corporate credit spreads	Section 4 Table 12	
Table A.21. Sovereign CDS spreads	Section 4 Table 12	
Table A.22. Hedge effectiveness	Hedging model	

The following are additional notes for tables and figures.

a. Figure A.2

Figure A.2 plots the response of the VIX premium to weekly realized volatility shocks, calculated from two-variable VARs with the VIX premium ordered first, for the weekly frequency. By construction, there is no contemporaneous effect of a risk shock on premiums, but a strong negative effect at one lag.

b. Table A.2

Du and Kapadia (2012) argue that the difference between the Bakshi, Kapadia, and Madan (2003; BKM) “V” measure of risk-neutral quadratic variation and the VIX formula is a direct measure of jump risk. They formulate the difference between V and the VIX (V-IV) and the 22-day moving average of the difference, denoted JTIX. This table estimates Equation 3 for the BKM V, V-IV, JTIX measures. It also reports results when measuring risk using the IV skew in VIX options, measured analogously to the SPX IV skew except using calls rather than puts.

c. Table A.6

Panel A reports estimates of direct forecast models of the VIX using the rolling futures price and the VVIX, estimated over the “in-sample” period with futures prices (March 2004-November 2015). I expand the HAR2 and ABH8 direct forecast models, which were the “winning” forecast models considered in Table 3, to include these variables and forecast the VIX ahead at all horizons $T(t) - t$. Panel A reports the estimated model at the 34-trading-day horizon. Conditional on other predictors, futures prices and the VVIX typically enter with negative signs, rather than a positive sign (through the expectations channel, a higher futures price should forecast a higher VIX; a higher VVIX should if anything forecast a higher VIX as it does in the univariate setting). The coefficients for futures prices and the VVIX are not statistically reliably different from zero conditional on the full set of predictors, save for one specification where the futures price is statistically significant with a negative sign. Panel B reports estimates of Equation 3 using premiums calculated from these forecast models for the realized volatility and VVIX risk measures, and show little evidence of an immediate increase in premiums.

d. Table A.8

Instead of rolling the 1-month ahead contract, I also construct premiums associated with rolling n-month ahead contracts for n up to 5 as Section 1 describes. I focus on the sample starting in November 2006, when there is a continuous term structure available each day. The first principal component of premiums explains 96% of their variation, while the second premium component explains another 3.5%. As usual, there is a “level, slope, and curvature” pattern to the loadings.

e. Table A.18

This table shows that VIX futures can be reasonably hedged by options strategies that approximately mimic forward variance. Given any trading date t, let T_m denote the month associated with futures expiration date $T(t)$ held by the 1-month rolling futures strategy. A forward variance strategy takes a short variance swap position expiring in month T_m and a long position in one expiring in $T_m + 1$.

One can form option portfolios that are part of the (approximate) synthetic replicating strategy for each of these variance swaps. (In practice there is a slight difference between the SPX option expiration date and VIX futures expiration date in a given month which I ignore – the former is a Friday, the latter is a Wednesday). The replicating strategy for each swap calls for dynamic trading in the S&P 500 but is static in the option portfolio.

The exercise benchmarks monthly VIX futures returns against monthly returns to these options strategies plus a position in the S&P 500. I do not explicitly calculate the gains from the dynamically rebalanced delta-hedge; including the S&P 500 allows the hedge to instead capture returns to an approximate delta-hedge. Because the dependent variable and all right-hand-side variables are excess returns, the coefficients are portfolio weights.

Columns 1-3 report results where the hedge portfolio includes ATMF calls and puts. Using these simple strategies hedge up to 90% of the variation in monthly returns to the 1-month rolling VIX futures strategy. Columns 4 and 5 consider the returns to synthetic variance swaps, calculated as follows. Let $SVS_t(s,T)$ denote the time-t value of the option portfolio expiring at T, where the option portfolio was formed on $s \leq t$. Its value equals:

$$SVS_t(s,T) = 2 \sum_{i(s)} \frac{\Delta K_{i,s}}{K_i^2} e^{r_{f,s}(T-s)} Q_{i,t},$$

where Q_i is the mid-price of each option (put if $K_i < F_{t,T}$, call if $K_i > F_{t,T}$, average put and call for K_{ATMF}), and the summation is over all OMTF puts, calls, and the ATMF put and call. On the portfolio formation date s, I use that day's S&P 500 forward price, $F_{t,T}^{SP500}$, option bid prices, and discretization grid, to determine which options are held, much as with the VIX formula; hence the summation $i(s)$ and strike gaps $\Delta K_{i,s}$ are subscripted with s.

For $t > s$, I do not re-balance the portfolio if the discretization grid, ATMF strike change, or strike range change. Only the option prices $Q_{i,t}$ are updated through time. In principle, one should use a forward rate curve to determine $e^{r_{f,s}(T-s)}$, but this changes little. For simplicity, I opt to use the spot 30-day rate as of date s. As a rule, for any futures expiration date T, $SVS_T(T, T+1) = VIX_T^2$ up to approximation error from OptionMetrics and the ATMF discretization adjustment. The monthly excess return is $SVSER_t^T = \frac{SVS_t(t-1,T)}{SVS_{t-1}(t-1,T)} - R_t^f$.

Columns 4 and 5 show that up to 93% of the variation in monthly returns to the 1-month rolling futures strategy can be hedged with a long position in options expiring 1 month after the futures expiration date (date 2), and a short position in options expiring on the futures expiration date itself (date 1).

f. Table A.19

This table runs a horse race of whether 30-day VRP estimates or VIX premium estimates predict the stock market. Columns 1-3 report results without controlling for conditional forecasts, while columns 4-6 report results with these as controls. Save for Column 1, neither the VRP nor VIX premium have strong predictive power for the stock market when including both.

g. Table A.21

These are the Bloomberg tickers used in the analysis of sovereign CDS spreads.

Country	CDS	Currency	Stock market	Foreign reserves (Datastream)
Brazil	CBRZ1U5 Curncy	BRL CMPN Curncy	GDLEBRAF Index	BRI.1D.SA
Bulgaria	CBULG1U5 Curncy	BGN CMPN Curncy	MSEIBGLG Index	BLI.1D.SA
Chile	CCHIL1U5 Curncy	CLP CMPN Curncy	GDLESCH Index	CLI.1D.SA
China	CCHIN1U5 Curncy	CNY CMPN Curncy	GDLETCF Index	CHI.1D.SA
Colombia	CCOL1U5 Curncy	COP CMPN Curncy	GDLESCO Index	CBI.1D.SA
Croatia	CCROA1U5 Curncy	HRK CMPN Curncy	MSEICRLG IndeX	CTI.1D.SA
Hungary	CHUN1U5 Curncy	HUF CMPN Curncy	GDLESHG Index	HNI.1D.SA
Israel	CISR1U5 Curncy	ILS CMPN Curncy	GDLESIS Index	ISI.1D.SA
Japan	CJGB1U5 Curncy	JPY CMPN Curncy	GDDLJN Index	JPI.1D.SA
S Korea	CKREA1U5 Curncy	KRW CMPN Curncy	GDLESKO Index	KOI.1D.SA
Malaysia	CMLAY1U5 Curncy	MYR CMPN Curncy	GDDLMAF Index	MYI.1D.SA
Mexico	CMEX1U5 Curncy	MXN CMPN Curncy	GDLETMXF Index	MXI.1D.SA
Panama	CPAN1U5 Curncy	PAB CMPN Curncy	IDFPPAUP Index	PAI.1D.SA
Peru	CPERU1U5 Curncy	PEN CMPN Curncy	GDLESPR Index	PEI.1D.SA
Philippines	CPHIL1U5 Curncy	PHP CMPN Curncy	GDLESPHF Index	PHI.1D.SA
Poland	CPOLD1U5 Curncy	PLN CMPN Curncy	GDLESPO Index	POI.1D.SA
Qatar	CQTA1U5 Curncy	QAR CMPN Curncy	MGCLQAG Index	QAI.1D.SA
Romania	CROA1U5 Curncy	RON CMPN Curncy	MSEIROUG Index	RMI.1D.SA
Russia	CRUSS1U5 Curncy	RUB CMPN Curncy	GDLESRUS Index	RSI.1D.SA
Slovak	CSLVK1U5 Curncy	SKK CMPN Curncy	IDFTSRTL Index	SXI.1D.SA
Safrica	CSOAF1U5 Curncy	ZAR CMPN Curncy	GDLESSA Index	SAI.1D.SA
Thailand	CTHAI1U5 Curncy	THB CMPN Curncy	GDLESTHF Index	THI.1D.SA
Turkey	CTURK1U5 Curncy	TRY CMPN Curncy	GDLESTK Index	TKI.1D.SA
Ukraine	CUKR1U5 Curncy	UAH CMPN Curncy	MSEIUKLG Index	URI.1D.SA
Venezuela	CVENZ1U5 Curncy	VEF CMPN Curncy	GDLESVZF Index	VEI.1D.SA

B. Trader definitions from the Traders in Financial Futures report

The Financial COT Explanatory Notes may be found online at http://www.cftc.gov/MARKETREPORTS/COMMITMENTSOFTRADERS/ssLINK/tfmexplanatorynotes (last accessed: December 2014). I reproduce the definitions below:

- **Dealer/Intermediary.** These participants are what are typically described as the "sell side" of the market. Though they may not predominately sell futures, they do design and sell various financial assets to clients. They tend to have matched books or offset their risk across markets and clients. Futures contracts are part of the pricing and balancing of risk associated with the products they sell and their activities. These include large banks (U.S. and non-U.S.) and dealers in securities, swaps and other derivatives.

- **Asset Manager/Institutional.** These are institutional investors, including pension funds, endowments, insurance companies, mutual funds and those portfolio/investment managers whose clients are predominantly institutional.
- **Leveraged Funds.** These are typically hedge funds and various types of money managers, including registered commodity trading advisors (CTAs); registered commodity pool operators (CPOs) or unregistered funds identified by CFTC.3 The strategies may involve taking outright positions or arbitrage within and across markets. The traders may be engaged in managing and conducting proprietary futures trading and trading on behalf of speculative clients.
- **Other Reportables.** Reportable traders that are not placed into one of the first three categories are placed into the "other reportables" category. The traders in this category mostly are using markets to hedge business risk, whether that risk is related to foreign exchange, equities or interest rates. This category includes corporate treasuries, central banks, smaller banks, mortgage originators, credit unions and any other reportable traders not assigned to the other three categories.

C. A model of hedging (Section 3.3)

This hedging model clarifies intuitions for how hedging demand and risk premiums vary as a function of underlying risk, the effectiveness of a hedge, and risk appetite. The model begins with ingredients similar to Hirshleifer (1988), where I have adapted the interpretation to a setting of financial dealers. The model also clarifies that the main empirical challenge in identifying why dealers reduce their hedges is the unobservability of the underlying risk. The model is intentionally stylized to capture the effects of interest and is a generic model of hedging rather than a specific model of volatility hedging.

Consider a representative dealer H in a one-period model who engages in a generic risky activity which generates return R. In this model, R is the underlying risk, and positive exposure to R earns expected return $\bar{R}$ with variance σ_R^2. One can interpret R as the return to outright exposure to volatility risk, or the return earned from residual risk, such as compensation for dealers bearing unhedgeable volatility or jump risk when making markets (Gârleanu, Pedersen, and Poteshman, 2009). I abstract from the microfoundations of financial intermediation and simply assume that the dealers represent a supply of capital in the market distinct from other actors in the model. VIX futures pay V-F dollars at time 1 where F is the time-zero futures price and where V has expectation $E[V]$ and variance σ_V^2. As a pure sign convention, I assume that a long VIX futures hedges a long position in R: $\sigma_{VR} < 0$. The risk-free rate is zero.

Dealers select their dollar exposure X_H^R to the risky activity and the number of contracts X_H^V to maximize mean-variance expected utility $E[U_H]$:

$$\max E[U_H] = E[W_H] - \frac{1}{2\eta_H} Var[W_H],$$
$$s.t.\ W_H = W_0 - (F - V)X_H^V + X_H^R R,$$

where W_H and W_0 are period-1 and period-0 wealth and η_H is the risk-tolerance of the dealers (1/risk aversion). The first-order conditions for demand X_H^V and X_H^R are:

$$X_H^V = \frac{-\eta_H E[F - V] - X_H^R \sigma_{VR}}{\sigma_V^2}, \tag{A.1}$$

$$X_H^R = \frac{\eta_H \bar{R} - X_H^V \sigma_{VR}}{\sigma_R^2}. \tag{A.2}$$

where $\bar{R}$ is the expected return of the risky security.

A representative speculator (hedge fund) takes the other side of forward contracts. Speculators trade only in futures and do not trade in the risky activity. They also have mean-variance utility with risk-tolerance η_S and thus have futures demand:

$$X_S^V = -\eta_S \frac{E[F - V]}{\sigma_V^2}. \tag{A.3}$$

Market-clearing in the futures market requires $X_H^V + X_S^V = 0$, so that premiums satisfy:

$$E[F - V] = \frac{-\sigma_{VR}}{\eta_H + \eta_S} X_H^R. \tag{A.4}$$

To close the model, I consider two cases for what determines demand of the risky activity *R*.

Case 1: Exogenous demand for *R*. In the first case, the "long R" dealer activity is selling volatility risk to customers, who have unmodeled long demand for volatility insurance and are "short *R*". Dealers can go long VIX futures to hedge their "long R" risk (recall $\sigma_{VR} < 0$). In the model, this corresponds to exogenously fixing $X_H^R = -\xi > 0$, where $\xi < 0$ is the exogenous customer demand for *R*, and where *R* is held in zero net supply. This makes the model similar to classic fixed output hedging models in that the underlying risk is exogenous.

Market-clearing in futures requires $X_H^V + X_S^V = 0$. Together with Equations A.1-A.4 and $X_H^R = -\xi$, equilibrium premiums and positions equal:

$$X_H^V = \xi \left(\frac{\sigma_{VR}}{\sigma_V^2}\right)\left(\frac{\eta_S}{\eta_H + \eta_S}\right) > 0, \tag{A.5}$$

$$X_H^R = -\xi, \tag{A.6}$$

$$E[F - V] = \frac{\xi \sigma_{VR}}{\eta_H + \eta_S} > 0, \tag{A.7}$$

$$\bar{R} = \frac{-\xi \sigma_R^2}{\eta_H}\left(1 - \frac{\sigma_{VR}^2}{\sigma_V^2 \sigma_R^2}\left(\frac{\eta_H}{\eta_H + \eta_S}\right)\right) \tag{A.8}$$

From Equation A.5 and A.7 and the observation that $\sigma_{VR} = \rho \sigma_V \sigma_R$, premiums $E[F - V]$ and hedging demand X_H^V increase when there is an increase in risk σ_R or a decline in dealer risk appetite η_H. To the extent that increases in market volatility correlate with either of these, the results in Table 9 are a puzzle.

On the other hand, the model makes two clear predictions about what might drive a decline in hedging demand:

> **Prediction 1: Customer demand hypothesis.** Hedging premiums and positions fall together when customer demand for the risky activity falls (ξ becomes smaller in absolute value).

> **Prediction 2. Hedge effectiveness hypothesis.** Hedging positions fall if the hedge effectiveness (σ_{VR}/σ_V^2) falls.

If R represents customer demand for long volatility insurance, I can test whether Prediction 2 explains the decline in hedging demand in response to market volatility in Table 9 by examining whether σ_{VR}/σ_V^2 varies with market realized volatility σ_M. Table A.22 reports the results of the daily-frequency regression:

$$R = (\alpha_0 + \alpha_1\sigma_M) + (\beta_0 + \beta_1\sigma_M)\, R_{futures} + \varepsilon,$$

during the post-crisis (2010+) period, where $R_{futures}$ is the daily return to the rolling VIX futures strategy, R is the daily return to the VXX, and σ_M is 21-day realized volatility, where I have standardized σ_M to be in terms of *z*-scores. If the effectiveness of the hedge weakens, we should expect β_0 is the opposite sign of β_1, but there is very little evidence of this. Alternatively, if the underlying risk *R* is exposure to the market itself, I can perform a similar exercise where *R* is the stock market return. Again, Table A.22 shows that β_0 has if anything the same sign as β_1.

Case 2: Endogenous demand for *R*. The key difference from Case 1 is that, rather than endowing dealers with a fixed exposure to *R* that they wish to hedge, I allow their exposure to be an endogenous function of their risk tolerance. The key prediction from this case is that large decreases in risk appetite can lead dealers to "close all positions" and eliminate both risky positions and their hedges, leading to a decline in hedging premiums as well.

Instead of assuming exogenous demand, I introduce mean-variance investors in the market for *R*, whom I label "outside investors." Outside investors trade only *R* (and not forwards), have mean-variance utility with risk-tolerance η_O, and thus have demand:

$$X_O^R = \eta_O \frac{\bar{R}}{\sigma_R^2}. \tag{A.9}$$

To give these investors an incentive to hold *R*, I now assume it is a security which is held in positive net supply *S*. Market clearing requires $X_H^R + X_O^R = S$, which, together with Equations A.1-A.4 define a new equilibrium:

$$X_H^V = \frac{\sigma_R^2}{-\sigma_{VR}} \frac{\eta_H}{\eta_O} \frac{\kappa}{1-\kappa} S. \tag{A.10}$$

$$X_H^R = \left(\frac{1}{1-\kappa}\right) \frac{\eta_H}{\eta_O + \eta_H} S. \tag{A.11}$$

$$E[F - V] = \left(\frac{1}{1-\kappa}\right) \frac{-\sigma_{VR}}{\eta_H + \eta_S} \frac{\eta_H}{\eta_O + \eta_H} S. \tag{A.12}$$

$$\bar{R} = \left(1 - \frac{\eta_H}{\eta_O}\frac{\kappa}{1-\kappa}\right)\frac{S\sigma_R^2}{\eta_O + \eta_H}. \tag{A.13}$$

where $\kappa \equiv \frac{\sigma_{VR}^2}{\sigma_V^2\sigma_R^2}\frac{\eta_S}{\eta_H+\eta_S}\frac{\eta_O}{\eta_O+\eta_H}$ characterizes the interaction of hedge effectiveness and the degree of risk-sharing across both markets. Since $\kappa \in (0,1)$, we have $X_H^V > 0$ and $E[F-V] > 0$.

Direct algebraic manipulation shows that, for $\eta_H < \bar{\eta}_H \equiv \sqrt{\eta_S\eta_O\left(1 - \frac{\sigma_{VR}^2}{\sigma_V^2\sigma_R^2}\right)}$, we have $\frac{\partial X_H^V}{\partial \eta_H} > 0$ and $\frac{\partial E[F-V]}{\partial \eta_H} > 0$, leading to:

Prediction 3. Risk-appetite hypothesis. Hedging premiums and positions fall together when dealer risk appetite falls significantly.

Intuitively, as dealers become extremely risk averse, positions and premiums decline as they withdraw from both the risky security and hedging markets due to basis risk in the hedge. To illustrate, the figure below plots equilibrium positions and premiums for $\{\sigma_V, \sigma_R, \sigma_{VR}, S, \eta_O, \eta_S\} = \{0.18, 0.04, -0.00432, 100, 0.5, 0.5\}$ as a function of η_H, where σ_{VR} was determined by fixing the correlation of V and R and -60%. The vertical line denotes $\bar{\eta}_H = 0.4$. The figure shows that when dealer risk tolerance is high, decreases in risk tolerance have the standard effect: dealers take on less exposure to the risky asset, but also wish to hedge more. But when dealer risk tolerance is low, or alternatively when there is a large decrease in dealer risk tolerance, dealers "close the books" and decrease both exposure to the risky asset along with hedges, even though the expected return $\bar{R}$ is rising. The figure re-scales all equilibrium quantities to clarify these qualitative effects.

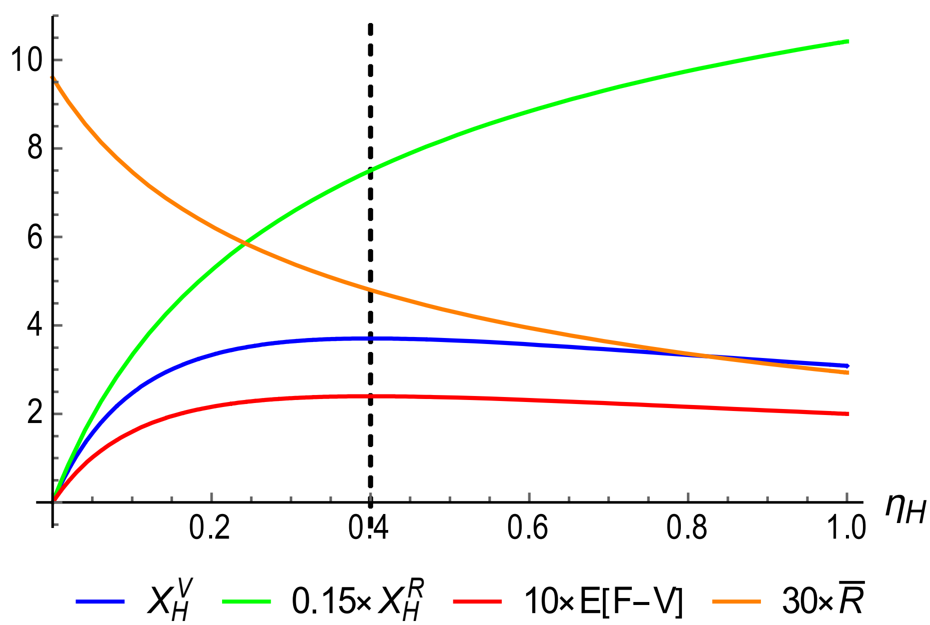
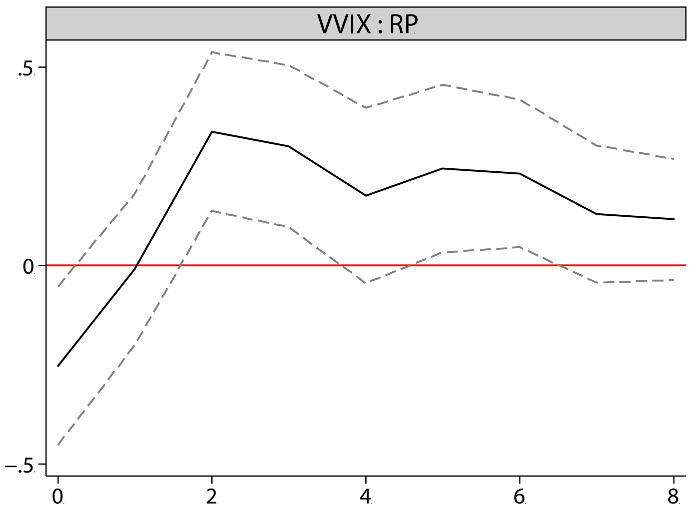


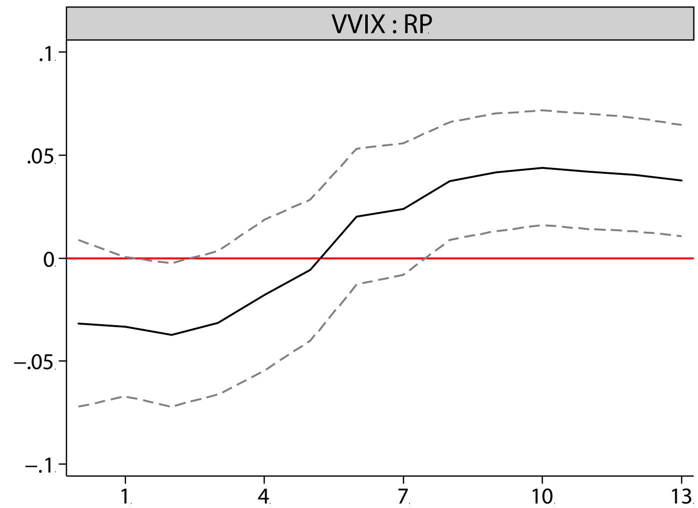
Figure A.1. VAR impulse responses of the VIX premium to VVIX and IV Skew. Panel A plots orthogonalized impulse response functions of a 1-standard deviation shock from the VVIX to the VIX premium from 4-lag monthly VARs and 8-lag weekly two-variable VARs. Panel B plots responses for the SPX IV skew. The dashed lines mark 95% confidence intervals based on bootstrapped standard errors.

Panel A: VVIX

Monthly (*T*=113)

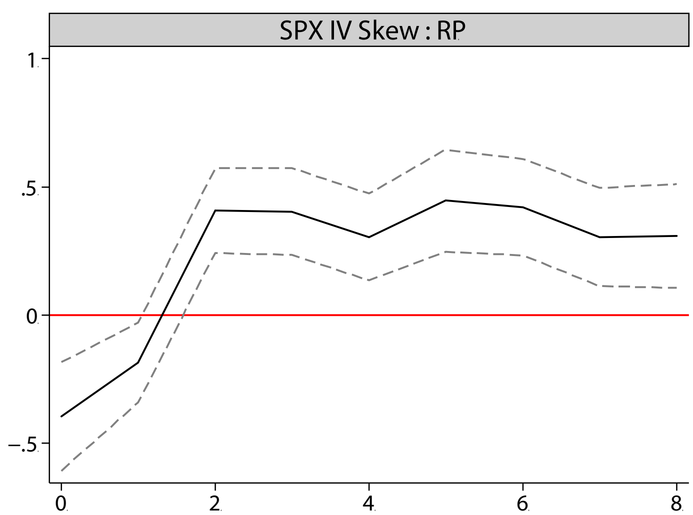


Weekly (*T*=483)



Panel B: SPX IV Skew

Monthly (*T*=134)



Weekly (*T*=591)

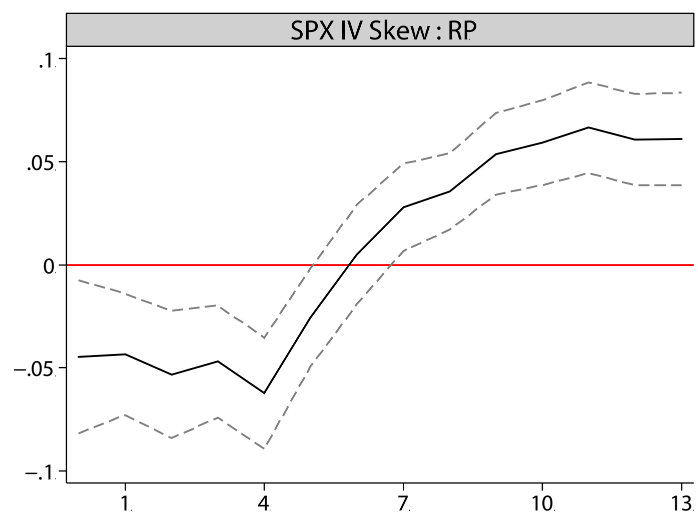


Figure A.2. VAR impulse response of the VIX premium to realized volatility shock, with the VIX premium ordered first. This figure plots the orthogonalized impulse response function of a 1-standard deviation shock from weekly realized volatility to the VIX premium from an 8-lag weekly two-variable VARs, with the VIX premium ordered first. The dashed lines mark 95% confidence intervals based on bootstrapped standard errors.

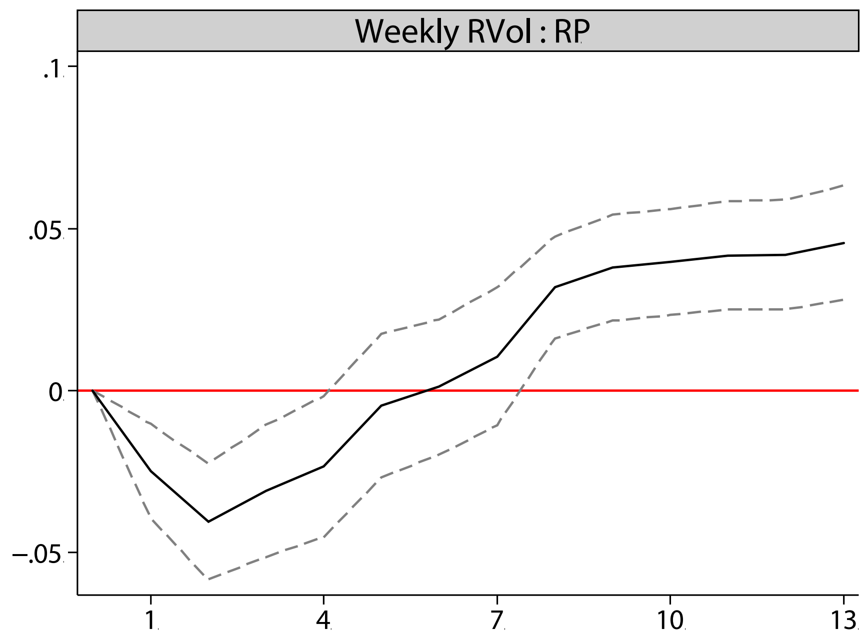


Figure A.3. VAR impulse responses of net positions to VVIX shocks. This figure plots responses of positions to VVIX shocks calculated from orthogonalized impulse response functions of four different eight-lag weekly VARs with two variables. Each VAR orders the risk variable first and the net position of the trader group position second. Units are in thousands of contracts, which are also the net notional position in $ millions. The sample begins in 2010 with 299 observations. The dashed lines mark 95% confidence intervals based on bootstrapped standard errors.

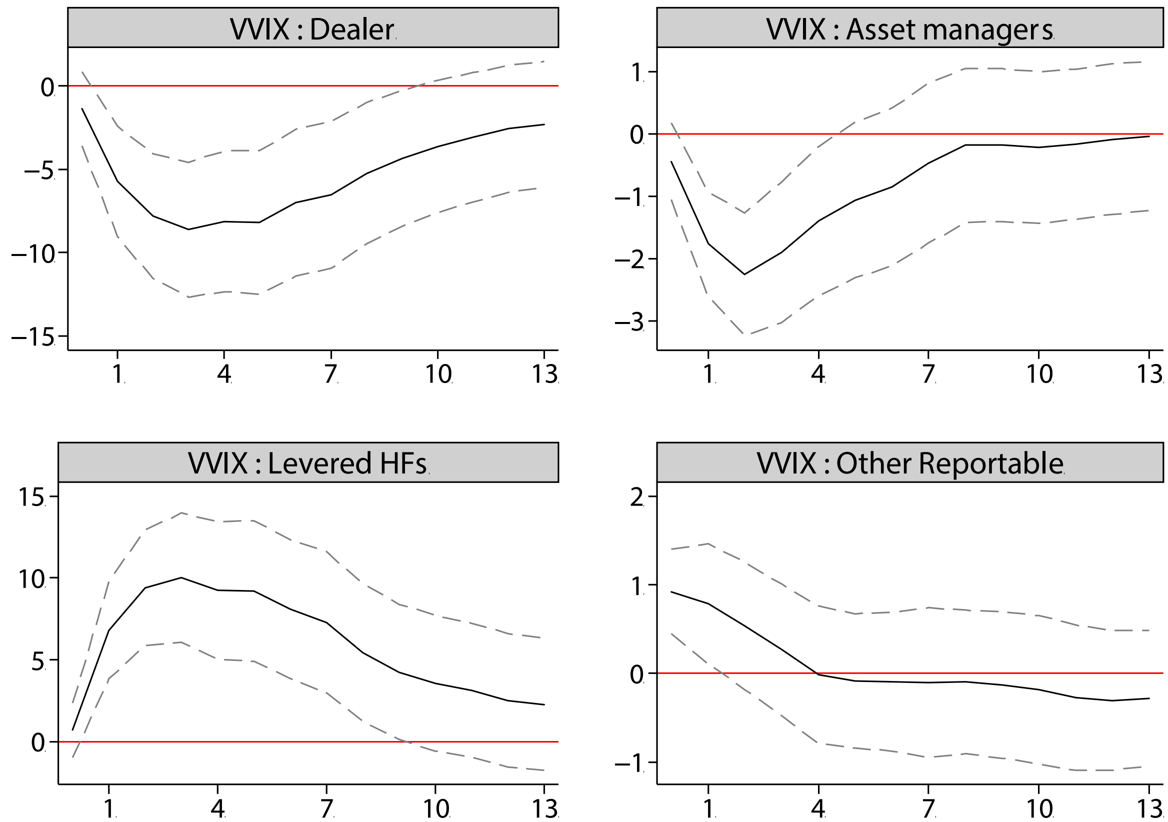


Figure A.4. VAR impulse responses of net positions to risk shocks, with positions ordered first. This figure plots responses of positions to realized volatility (Panel A) and VVIX shocks (Panel B) calculated from orthogonalized impulse response functions of four different eight-lag weekly VARs with two variables. Each VAR orders the net position of each trader group first and the risk variable second. Units are in thousands of contracts, which are also the net notional position in $ millions. The sample begins in 2010 with 299 observations. The dashed lines mark 95% confidence intervals based on bootstrapped standard errors.

Panel A: Realized volatility

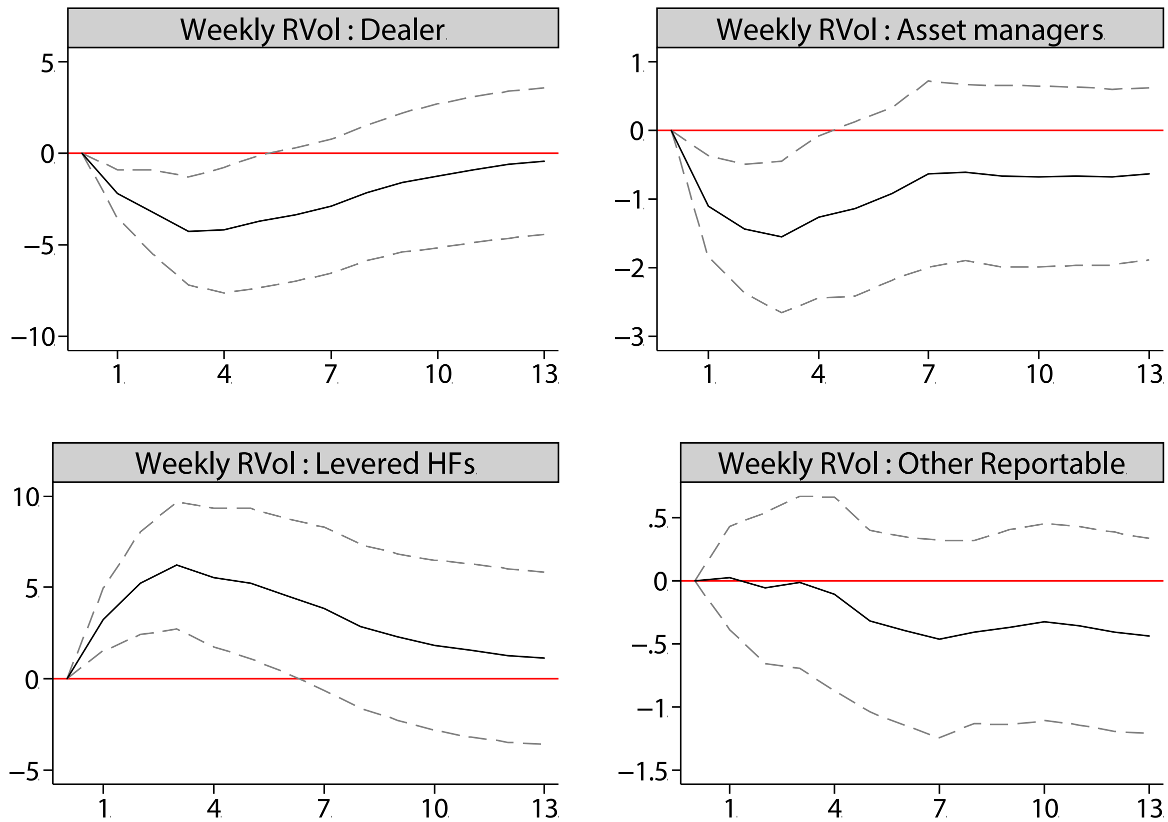


Figure A.4, continued.

Panel B: VVIX

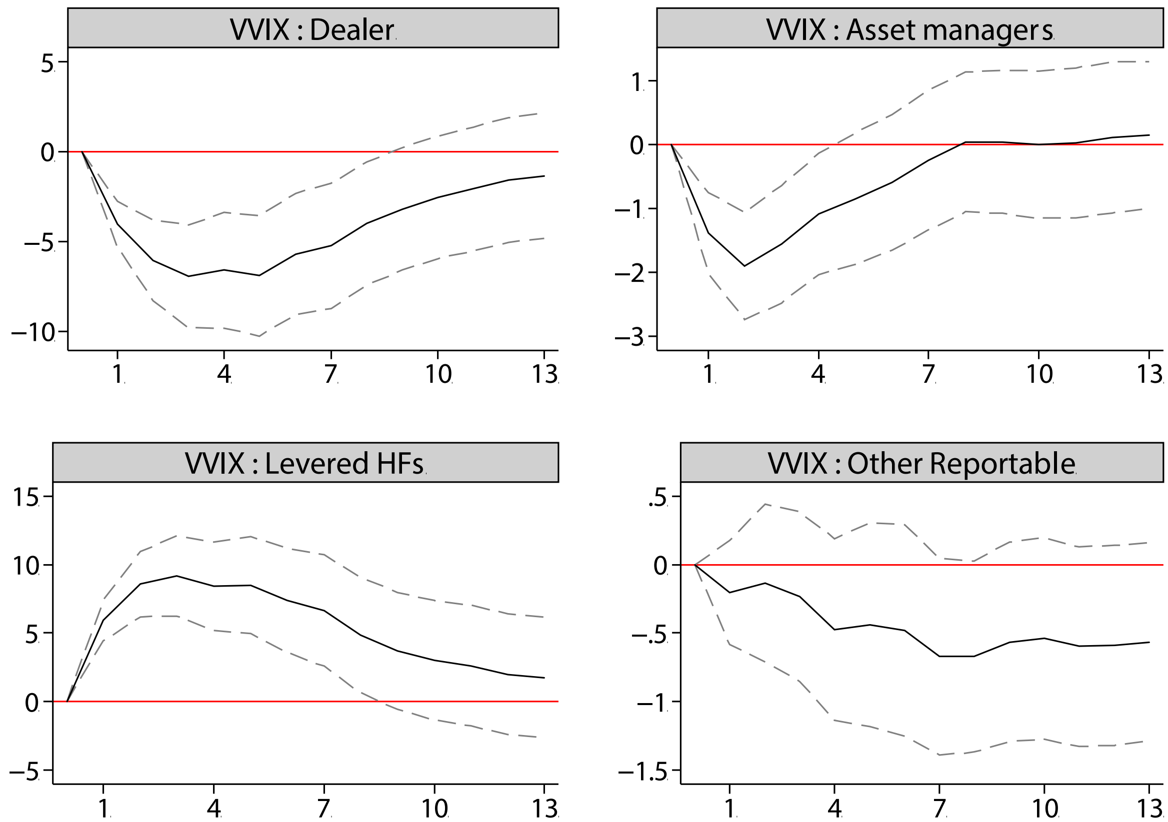


Table A.1. VIX ARMA forecast models. This table reports the results from estimated ARMA models for the VIX at the daily frequency. Panel A reports results for the sample January 1990 through the end of December 2003. Panel B reports results for the full sample. μ denotes the estimated mean, ρ_i denotes the *i*-th order estimated AR term, and φ_i denotes the *i*-th order estimated MA term. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Panel A: Pre-2004

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ARMA	(1,0)	(1,1)	(1,2)	(1,3)	(2,0)	(2,1)	(2,2)	(2,3)	(3,0)	(3,1)
μ	**20.137**	**20.132**	**20.115**	**20.103**	**20.133**	**20.083**	**20.083**	**20.083**	**20.121**	**20.084**
	(1.050)	(1.087)	(1.213)	(1.306)	(1.079)	(1.537)	(1.496)	(1.502)	(1.166)	(1.493)
ρ_1	**0.980**	**0.982**	**0.986**	**0.988**	**0.952**	**1.761**	**1.651**	**1.675**	**0.949**	**1.725**
	(0.005)	(0.005)	(0.004)	(0.003)	(0.027)	(0.052)	(0.099)	(0.134)	(0.027)	(0.070)
ρ_2					0.030	**-0.763**	**-0.654**	**-0.677**	-0.052	**-0.785**
					(0.026)	(0.051)	(0.098)	(0.133)	(0.035)	(0.068)
ρ_3									**0.085**	0.056
									(0.026)	(0.029)
φ_1		-0.037	-0.049	-0.051		**-0.856**	**-0.714**	**-0.738**		**-0.789**
		(0.032)	(0.028)	(0.027)		(0.041)	(0.102)	(0.137)		(0.068)
φ_2			**-0.099**	**-0.102**			-0.064	**-0.065**		
			(0.029)	(0.029)			(0.033)	(0.033)		
φ_3				-0.067				0.008		
				(0.031)				(0.039)		
Log LH	-5826.2	-5824.3	-5809.1	-5802.3	-5824.6	-5799.9	-5795.7	-5795.6	-5811.7	-5795.8
BIC	11676.8	11681.2	11659.0	11653.5	11681.9	11640.7	11640.4	11648.5	11664.2	11640.6
AIC	11658.3	11656.6	11628.2	11616.5	11657.2	11609.9	11603.4	11605.3	11633.3	11603.6
T	3529	3529	3529	3529	3529	3529	3529	3529	3529	3529

Table A.1, continued.

Panel B: Full sample

ARMA	(1) (1,0)	(2) (1,1)	(3) (1,2)	(4) (1,3)	(5) (2,0)	(6) (2,1)	(7) (2,2)	(8) (2,3)	(9) (3,0)	(10) (3,1)
μ	**19.842**	**19.842**	**19.842**	**19.841**	**19.842**	**19.840**	**19.840**	**19.840**	**19.842**	**19.840**
	(0.990)	(1.106)	(1.241)	(1.321)	(1.076)	(1.482)	(1.472)	(1.471)	(1.164)	(1.471)
ρ_1	**0.981**	**0.985**	**0.988**	**0.990**	**0.896**	**1.648**	**1.600**	**1.597**	**0.889**	**1.631**
	(0.006)	(0.005)	(0.005)	(0.004)	(0.028)	(0.065)	(0.134)	(0.125)	(0.028)	(0.082)
ρ_2					**0.087**	**-0.651**	**-0.603**	**-0.600**	0.012	**-0.654**
					(0.027)	(0.065)	(0.133)	(0.124)	(0.043)	(0.070)
ρ_3									**0.083**	0.020
									(0.038)	(0.036)
φ_1		**-0.108**	**-0.112**	**-0.115**		**-0.781**	**-0.724**	**-0.721**		**-0.754**
		(0.035)	(0.031)	(0.031)		(0.054)	(0.138)	(0.124)		(0.080)
φ_2			**-0.100**	**-0.098**			-0.024	-0.024		
			(0.044)	(0.043)			(0.047)	(0.047)		
φ_3				-0.053				-0.001		
				(0.031)				(0.044)		
Log LH	-12047.5	-12017.6	-11990.2	-11981.7	-12022.8	-11970.3	-11969.4	-11969.4	-12000.0	-11969.4
BIC	24121.4	24070.4	24024.4	24016.0	24080.7	23984.5	23991.5	24000.3	24043.9	23991.5
AIC	24101.1	24043.2	23990.4	23975.3	24053.5	23950.6	23950.8	23952.8	24009.9	23950.8
T	6537	6537	6537	6537	6537	6537	6537	6537	6537	6537

Table A.2. VIX premiums and additional risk measures. This table reports estimates of Equation 3 in the monthly time series. The table organizes columns by risk variable *X* and reports Newey and West (1987) standard errors with three lags. I thank Nikunj Kapadia for sharing the data for BKM V, V-IV, and JTIX. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dependent variable: ΔRP, *t*				
X:	VIX IV Skew	BKM V	BKM V-IV	BKM JTIX
	(1)	(2)	(3)	(4)
ΔX, *t*	-0.010	**-10.851**	**-67.674**	**-68.926**
	(0.019)	(4.088)	(12.216)	(14.235)
ΔX, *t*-1	-0.016	3.982	20.293	**80.153**
	(0.015)	(3.396)	(13.205)	(12.237)
ΔX, *t*-2	-0.010	**6.851**	**65.416**	33.563
	(0.016)	(2.821)	(20.743)	(26.559)
ΔX, *t*-3	-0.025	6.207	**51.136**	**52.048**
	(0.015)	(3.124)	(18.063)	(18.038)
ΔRP, *t*-1	0.029	-0.201	**-0.233**	-0.229
	(0.162)	(0.108)	(0.116)	(0.121)
ΔRP, *t*-2	**-0.291**	**-0.281**	**-0.227**	**-0.307**
	(0.070)	(0.115)	(0.114)	(0.131)
ΔRP, *t*-3	0.124	0.285	0.311	0.264
	(0.089)	(0.154)	(0.159)	(0.142)
Constant	-0.008	0.009	0.012	0.010
	(0.080)	(0.070)	(0.073)	(0.079)
T	81	91	91	91
R^2	0.225	0.565	0.558	0.547

Table A.3. Components of premium reaction to VVIX, IV Skew, VIX, and CBOE SKEW. Panel A reports estimates of Equation 3 but with changes in futures prices and the VIX forecast as dependent variables for several different risk measures *X*. Panel B modifies Equation 3 to control for changes in futures prices and changes in the VIX forecast separately instead of controlling for changes in the premium. I report Newey and West (1987) standard errors with three lags. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Panel A

X:	VVIX		SPX Skew		VIX		SKEW	
	Futures	Forecast	Futures	Forecast	Futures	Forecast	Futures	Forecast
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔX, *t*	**0.095**	**0.120**	**0.716**	**0.946**	**0.359**	**0.433**	-0.084	-0.038
	(0.019)	(0.023)	(0.083)	(0.089)	(0.034)	(0.030)	(0.058)	(0.065)
ΔX, *t*-1	0.024	0.025	0.163	0.178	0.043	0.020	-0.035	-0.002
	(0.018)	(0.016)	(0.140)	(0.118)	(0.046)	(0.035)	(0.041)	(0.044)
ΔX, *t*-2	**0.049**	0.031	**0.290**	0.073	0.045	-0.019	-0.037	-0.029
	(0.021)	(0.017)	(0.107)	(0.085)	(0.035)	(0.032)	(0.040)	(0.038)
ΔX, *t*-3	0.023	0.005	**0.294**	0.134	**0.119**	**0.055**	0.029	0.034
	(0.016)	(0.014)	(0.112)	(0.086)	(0.035)	(0.026)	(0.040)	(0.045)
ΔRP, *t*-1	**-0.910**	**-0.774**	**-0.656**	-0.366	**-0.594**	**-0.350**	**-0.973**	**-0.874**
	(0.261)	(0.273)	(0.255)	(0.215)	(0.209)	(0.170)	(0.361)	(0.402)
ΔRP, *t*-2	-0.090	0.247	-0.179	-0.014	-0.406	-0.085	-0.215	0.220
	(0.194)	(0.203)	(0.244)	(0.192)	(0.168)	(0.137)	(0.260)	(0.307)
ΔRP, *t*-3	-0.086	-0.264	0.141	-0.215	0.007	-0.252	-0.326	-0.442
	(0.226)	(0.223)	(0.275)	(0.219)	(0.188)	(0.155)	(0.297)	(0.308)
Constant	-0.016	-0.006	-0.020	-0.008	-0.026	-0.010	-0.006	0.000
	(0.183)	(0.170)	(0.115)	(0.087)	(0.090)	(0.061)	(0.172)	(0.164)
T	113	113	134	134	137	137	137	137
R^2	0.385	0.458	0.430	0.589	0.576	0.709	0.155	0.129

Table A.3, continued.

Panel B: Control for futures and forecast changes separately

X:	R.Vol.		VVIX		SPX Skew		VIX		SKEW	
	Futures	Forecast	Futures	Forecast	Futures	Forecast	Futures	Forecast	Futures	Forecast
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔX, *t*	**0.239**	**0.310**	**0.090**	**0.114**	**0.727**	**0.969**	**0.366**	**0.442**	-0.070	-0.034
	(0.023)	(0.018)	(0.018)	(0.022)	(0.081)	(0.074)	(0.033)	(0.019)	(0.060)	(0.068)
ΔX, *t*-1	**0.313**	**0.329**	0.031	**0.038**	**0.780**	**0.888**	**0.394**	**0.425**	-0.060	-0.033
	(0.053)	(0.046)	(0.019)	(0.017)	(0.202)	(0.162)	(0.065)	(0.049)	(0.044)	(0.044)
ΔX, *t*-2	**0.136**	**0.148**	**0.054**	**0.047**	**0.806**	**0.649**	**0.283**	**0.272**	-0.055	-0.058
	(0.054)	(0.042)	(0.024)	(0.021)	(0.246)	(0.201)	(0.088)	(0.056)	(0.045)	(0.043)
ΔX, *t*-3	0.068	0.051	-0.007	-0.010	0.314	0.258	0.123	0.111	0.035	0.021
	(0.040)	(0.033)	(0.019)	(0.017)	(0.190)	(0.162)	(0.085)	(0.059)	(0.038)	(0.042)
ΔFutures, *t*-1	-0.083	0.210	**-0.998**	**-0.825**	-0.231	0.090	**-0.381**	-0.109	**-1.280**	**-1.118**
	(0.201)	(0.190)	(0.272)	(0.306)	(0.215)	(0.166)	(0.161)	(0.115)	(0.394)	(0.464)
ΔFutures, *t*-2	-0.156	0.251	-0.358	-0.017	0.009	0.230	**-0.397**	-0.048	**-0.570**	-0.225
	(0.231)	(0.199)	(0.232)	(0.209)	(0.212)	(0.166)	(0.172)	(0.117)	(0.287)	(0.262)
ΔFutures, *t*-3	0.293	0.070	-0.074	-0.331	0.259	-0.026	0.058	-0.178	-0.284	-0.565
	(0.281)	(0.227)	(0.249)	(0.257)	(0.258)	(0.193)	(0.168)	(0.105)	(0.296)	(0.320)
ΔForecast, *t*-1	**-0.510**	**-0.908**	**0.986**	**0.727**	-0.276	**-0.693**	-0.357	**-0.746**	**1.114**	0.868
	(0.234)	(0.211)	(0.278)	(0.316)	(0.290)	(0.212)	(0.230)	(0.141)	(0.433)	(0.495)
ΔForecast, *t*-2	-0.144	**-0.674**	0.299	-0.140	-0.390	**-0.629**	-0.087	**-0.536**	**0.514**	0.024
	(0.259)	(0.221)	(0.189)	(0.179)	(0.307)	(0.251)	(0.284)	(0.183)	(0.255)	(0.243)
ΔForecast, *t*-3	-0.184	-0.061	0.410	0.521	-0.209	-0.012	-0.073	0.048	0.516	0.660
	(0.295)	(0.242)	(0.302)	(0.314)	(0.309)	(0.250)	(0.237)	(0.158)	(0.333)	(0.372)
Constant	-0.020	-0.005	-0.008	-0.003	-0.038	-0.029	-0.035	-0.022	-0.019	-0.008
	(0.123)	(0.110)	(0.171)	(0.186)	(0.134)	(0.117)	(0.100)	(0.078)	(0.183)	(0.198)
T	137	137	113	113	134	134	137	137	137	137
R^2	0.571	0.710	0.461	0.499	0.539	0.706	0.700	0.845	0.230	0.211

Table A.4. Weekly premiums and realized volatility. This table reports estimates of Equation 3 in the weekly time series for realized volatility, both before 2010 and after 2010. I report Newey and West (1987) standard errors with three lags. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dependent variable: ΔRP, *t*	Post- (1)	Pre- (2)
ΔRVol, *t*	**-0.016**	**-0.018**
	(0.005)	(0.004)
ΔRVol, *t*-1	**-0.011**	**-0.006**
	(0.003)	(0.003)
ΔRVol, *t*-2	-0.005	**-0.013**
	(0.003)	(0.005)
ΔRVol, *t*-3	-0.004	-0.003
	(0.003)	(0.005)
ΔRP, *t*-1	**-0.412**	**-0.230**
	(0.078)	(0.078)
ΔRP, *t*-2	**-0.198**	-0.052
	(0.076)	(0.102)
ΔRP, *t*-3	-0.007	-0.159
	(0.055)	(0.104)
Constant	-0.003	0.001
	(0.009)	(0.010)
T	307	297
R^2	0.278	0.302

Table A.5. Alternative VIX premium estimates and SPX IV Skew, VIX, and CBOE SKEW. This repeats the analysis of Table 3, Panel C for the SPX IV skew, VIX, and CBOE SKEW risk measures. I report Newey and West (1987) standard errors with three lags. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Panel A: SPX IV Skew and VIX

X:	SPX IV Skew						VIX					
Model:	HAR1	HAR2	AC	ABH8	ABH11	ABHL	HAR1	HAR2	AC	ABH8	ABH11	ABHL
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔX, *t*	**-0.192**	**-0.145**	**-0.218**	**-0.162**	**-0.105**	**-0.220**	-0.057	-0.039	-0.069	-0.043	-0.015	-0.071
	(0.053)	(0.040)	(0.073)	(0.060)	(0.051)	(0.073)	(0.029)	(0.024)	(0.041)	(0.035)	(0.031)	(0.041)
ΔX, *t*-1	-0.054	0.063	0.032	0.028	0.051	0.018	0.000	**0.051**	**0.043**	0.040	**0.048**	0.039
	(0.044)	(0.039)	(0.049)	(0.047)	(0.042)	(0.050)	(0.017)	(0.016)	(0.021)	(0.021)	(0.019)	(0.023)
ΔX, *t*-2	**0.193**	**0.093**	**0.120**	**0.123**	**0.115**	**0.114**	**0.065**	0.015	0.022	0.028	0.028	0.020
	(0.052)	(0.039)	(0.053)	(0.048)	(0.051)	(0.053)	(0.023)	(0.018)	(0.026)	(0.024)	(0.022)	(0.026)
ΔX, *t*-3	**0.139**	-0.007	0.009	-0.003	-0.017	0.007	**0.052**	0.004	0.008	0.006	0.000	0.010
	(0.048)	(0.034)	(0.043)	(0.037)	(0.040)	(0.042)	(0.021)	(0.018)	(0.025)	(0.022)	(0.019)	(0.025)
ΔRP, *t*-1	**-0.301**	**-0.457**	**-0.501**	**-0.474**	**-0.461**	**-0.486**	**-0.254**	**-0.455**	**-0.530**	**-0.504**	**-0.478**	**-0.527**
	(0.084)	(0.086)	(0.109)	(0.109)	(0.105)	(0.107)	(0.086)	(0.082)	(0.106)	(0.114)	(0.108)	(0.108)
ΔRP, *t*-2	**-0.162**	**-0.462**	**-0.412**	**-0.399**	**-0.402**	**-0.403**	**-0.298**	**-0.514**	**-0.453**	**-0.450**	**-0.447**	**-0.444**
	(0.092)	(0.085)	(0.082)	(0.086)	(0.089)	(0.084)	(0.091)	(0.092)	(0.085)	(0.087)	(0.089)	(0.087)
ΔRP, *t*-3	**0.359**	0.072	0.096	0.131	0.103	0.114	**0.273**	0.013	-0.020	0.048	0.057	-0.011
	(0.096)	(0.093)	(0.074)	(0.090)	(0.107)	(0.077)	(0.099)	(0.086)	(0.082)	(0.089)	(0.099)	(0.088)
Constant	-0.010	-0.015	-0.026	-0.017	-0.009	-0.027	-0.015	-0.018	-0.021	-0.018	-0.018	-0.020
	(0.051)	(0.057)	(0.070)	(0.065)	(0.065)	(0.070)	(0.056)	(0.060)	(0.077)	(0.071)	(0.069)	(0.076)
T	134	134	134	134	134	134	137	137	137	137	137	137
R^2	0.563	0.525	0.499	0.491	0.448	0.492	0.448	0.478	0.418	0.417	0.398	0.423

Table A.5, continued.

Panel B: CBOE SKEW

X:	SKEW					
Model:	HAR1 (1)	HAR2 (2)	AC (3)	ABH8 (4)	ABH11 (5)	ABHL (6)
ΔX, *t*	**-0.043**	**-0.042**	**-0.043**	**-0.046**	**-0.050**	**-0.044**
	(0.014)	(0.011)	(0.018)	(0.016)	(0.014)	(0.019)
ΔX, *t*-1	-0.027	**-0.039**	-0.026	**-0.032**	**-0.042**	-0.028
	(0.016)	(0.013)	(0.017)	(0.014)	(0.015)	(0.016)
ΔX, *t*-2	-0.009	-0.008	-0.003	-0.010	-0.015	-0.007
	(0.015)	(0.016)	(0.020)	(0.018)	(0.017)	(0.021)
ΔX, *t*-3	0.007	-0.009	0.000	-0.002	-0.003	-0.003
	(0.014)	(0.012)	(0.014)	(0.012)	(0.012)	(0.014)
ΔRP, *t*-1	-0.124	**-0.482**	**-0.470**	**-0.475**	**-0.492**	**-0.466**
	(0.130)	(0.080)	(0.153)	(0.102)	(0.095)	(0.106)
ΔRP, *t*-2	**-0.409**	**-0.588**	**-0.520**	**-0.513**	**-0.510**	**-0.508**
	(0.121)	(0.090)	(0.077)	(0.078)	(0.087)	(0.072)
ΔRP, *t*-3	**0.146**	-0.072	-0.072	-0.007	-0.001	-0.063
	(0.073)	(0.095)	(0.073)	(0.070)	(0.075)	(0.085)
Constant	-0.008	-0.014	-0.018	-0.013	-0.012	-0.016
	(0.071)	(0.062)	(0.081)	(0.074)	(0.070)	(0.081)
T	137	137	137	137	137	137
R^2	0.269	0.423	0.346	0.376	0.388	0.340

Table A.6. VIX premiums estimated in-sample using futures prices and the VVIX. Panel A reports estimates of direct forecast models of the VIX that expand the HAR2 and ABH8 models to include the rolling futures price and VVIX. I estimate the models for the 34-trading-day horizon (i.e., all variables are at a 34-day lag) using the full daily time series. The sample with the VVIX begins in February 2006. For descriptions of VIX(*s*) and C(*s*), see the caption in Table 3 of the main text. The table reports Newey and West (1987) standard errors with 44 lags. Panel B reports repeats the analysis of Table 3, Panel B of monthly data using premiums computed from these forecast models for realized volatility and the VVIX. It reports Newey and West (1987) standard errors with three lags. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Panel A: Forecast model estimates

Dependent variable: VIX Forecast model: (All right-hand-side variables at 34-day lag)	FUT1 (1)	FUT2 (2)	FUT3 (3)	FUT4 (4)
VIX(1)	**0.602**	**0.403**	**0.771**	**0.546**
	(0.227)	(0.185)	(0.262)	(0.192)
VIX(5)	**0.420**	0.069	**0.464**	0.179
	(0.193)	(0.291)	(0.193)	(0.308)
VIX(22)	-0.432	-0.614	-0.477	-0.736
	(0.361)	(0.587)	(0.355)	(0.616)
VIX(10)	0.283	0.292	0.243	0.205
	(0.274)	(0.288)	(0.282)	(0.296)
VIX(66)	**0.445**	0.546	0.363	0.502
	(0.205)	(0.283)	(0.192)	(0.263)
C(1)		0.151		0.143
		(0.179)		(0.169)
C(5)		0.534		0.378
		(0.491)		(0.483)
C(22)		0.878		1.174
		(1.239)		(1.297)
Futures price, T(*t*-34)	-0.599	-0.283	**-0.656**	-0.337
	(0.345)	(0.350)	(0.315)	(0.363)
VVIX			-0.099	-0.083
			(0.068)	(0.059)
Constant	**6.052**	**6.606**	**15.249**	**14.891**
	(1.120)	(1.426)	(6.003)	(5.766)
N	2907	2907	2355	2355
R^2	0.562	0.568	0.546	0.552
RMSE	6.278	6.232	6.731	6.681
MAE	3.787	3.811	4.295	4.284
MAPE	18.662	18.915	20.367	20.423

Table A.6, continued.

Panel B: Relationship to risk

Dependent variable: ΔRP, *t*

X:	Realized volatility				VVIX			
Forecast model:	FUT1	FUT2	FUT3	FUT4	FUT1	FUT2	FUT3	FUT4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔX, *t*	**-0.079**	**-0.074**	-0.055	-0.056	**-0.039**	**-0.026**	0.005	0.010
	(0.036)	(0.031)	(0.040)	(0.037)	(0.013)	(0.013)	(0.016)	(0.015)
ΔX, *t*-1	0.019	0.039	0.033	**0.061**	0.002	0.006	**0.029**	**0.037**
	(0.017)	(0.023)	(0.017)	(0.020)	(0.011)	(0.012)	(0.010)	(0.011)
ΔX, *t*-2	0.015	-0.000	0.054	0.025	0.015	**0.022**	**0.046**	**0.050**
	(0.024)	(0.025)	(0.029)	(0.030)	(0.011)	(0.011)	(0.012)	(0.012)
ΔX, *t*-3	0.012	0.015	0.022	0.029	**0.020**	0.017	**0.030**	**0.028**
	(0.022)	(0.024)	(0.021)	(0.024)	(0.010)	(0.009)	(0.012)	(0.011)
ΔRP, *t*-1	**-0.491**	**-0.580**	**-0.452**	**-0.502**	**-0.435**	**-0.619**	**-0.408**	**-0.548**
	(0.090)	(0.113)	(0.090)	(0.099)	(0.082)	(0.096)	(0.084)	(0.094)
ΔRP, *t*-2	**-0.538**	**-0.542**	**-0.430**	**-0.436**	**-0.511**	**-0.556**	**-0.465**	**-0.499**
	(0.098)	(0.103)	(0.092)	(0.090)	(0.074)	(0.075)	(0.070)	(0.068)
ΔRP, *t*-3	0.013	-0.058	0.081	0.028	0.041	-0.061	0.038	-0.008
	(0.095)	(0.100)	(0.080)	(0.086)	(0.084)	(0.086)	(0.086)	(0.084)
Constant	-0.032	-0.025	0.002	0.007	-0.018	-0.010	-0.009	-0.002
	(0.101)	(0.096)	(0.132)	(0.127)	(0.120)	(0.120)	(0.133)	(0.129)
T	137	137	111	111	113	113	111	111
R^2	0.460	0.502	0.380	0.432	0.483	0.473	0.363	0.409

Table A.7. VIX premiums estimated from a rolling ARMA forecast model. This table reports results from the paper using premiums which incorporate forecasts $\widehat{VIX}_t^{T(t)}$ estimated using daily VIX data available through date t-1. Panel A reports the results of Table 2 with Newey and West (1987) standard errors with three lags. Panel B reports the results of Table 4. Panel C reports the results of Table 5 using Newey and West (1987) standard errors with three lags. Panel D reports the results of Table 8 using Newey and West (1987) standard errors with six lags. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Panel A: Relationship to risk

Dependent variable: ΔRP, *t*

	Full sample					2010-onwards				
X:	R.Vol.	VVIX	SPX Skew	VIX	SKEW	R.Vol.	VVIX	SPX Skew	VIX	SKEW
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(7)	(2)	(8)
ΔX, *t*	**-0.102**	**-0.037**	**-0.334**	**-0.119**	**-0.052**	-0.042	**-0.024**	**-0.191**	**-0.054**	**-0.038**
	(0.027)	(0.012)	(0.068)	(0.036)	(0.022)	(0.023)	(0.008)	(0.047)	(0.022)	(0.017)
ΔX, *t*-1	-0.001	-0.005	-0.073	0.013	**-0.036**	0.029	-0.001	0.030	0.023	**-0.055**
	(0.013)	(0.008)	(0.054)	(0.021)	(0.017)	(0.019)	(0.008)	(0.059)	(0.020)	(0.018)
ΔX, *t*-2	**0.042**	0.010	**0.191**	**0.052**	-0.004	**0.048**	0.019	**0.206**	**0.061**	-0.016
	(0.016)	(0.007)	(0.060)	(0.026)	(0.017)	(0.018)	(0.010)	(0.052)	(0.020)	(0.020)
ΔX, *t*-3	**0.057**	**0.016**	**0.184**	**0.081**	-0.012	**0.066**	**0.024**	**0.244**	**0.095**	-0.017
	(0.017)	(0.007)	(0.061)	(0.026)	(0.015)	(0.011)	(0.009)	(0.049)	(0.015)	(0.018)
ΔRP, *t*-1	**-0.260**	-0.076	**-0.276**	**-0.199**	-0.053	**-0.307**	-0.257	**-0.347**	**-0.337**	-0.196
	(0.090)	(0.143)	(0.105)	(0.097)	(0.143)	(0.122)	(0.134)	(0.126)	(0.103)	(0.147)
ΔRP, *t*-2	**-0.363**	**-0.401**	**-0.185**	**-0.340**	**-0.484**	**-0.231**	-0.134	-0.076	-0.226	**-0.214**
	(0.079)	(0.124)	(0.090)	(0.087)	(0.147)	(0.093)	(0.112)	(0.118)	(0.126)	(0.079)
ΔRP, *t*-3	**0.258**	0.103	**0.286**	**0.243**	0.068	**0.291**	**0.322**	**0.498**	**0.345**	0.102
	(0.096)	(0.074)	(0.074)	(0.081)	(0.083)	(0.094)	(0.131)	(0.096)	(0.085)	(0.153)
Constant	-0.016	-0.008	-0.009	-0.015	-0.007	-0.035	-0.035	-0.030	-0.027	-0.016
	(0.058)	(0.090)	(0.055)	(0.060)	(0.085)	(0.080)	(0.079)	(0.063)	(0.074)	(0.099)
T	137	113	134	137	137	67	67	64	67	67
R^2	0.604	0.426	0.673	0.587	0.303	0.396	0.394	0.601	0.527	0.238

Table A.7, continued.

Panel B: Return predictability

	Forecast regression dependent variable	Predictor	β	s.e.(β)	R^2	T	SE	Model
(1)	Futures return, *t*+1	*VIXR*	**0.992**	(0.337)	0.091	140	N-W (3)	Rolling
(2)	…weekly frequency	*VIXR*	**0.832**	(0.225)	0.028	607	N-W (6)	Rolling
(3)	…daily frequency	*VIXR*	**1.068**	(0.233)	0.009	2939	N-W (20)	Rolling

Panel C: Ex-post volatility

	Full sample		2010-onwards	
ΔY:	Strategy	Market	Strategy	Market
	(1)	(2)	(3)	(4)
ΔRP, *t*-1	**-12.973**	**-2.654**	**-31.011**	-2.355
	(4.172)	(0.908)	(10.123)	(1.222)
ΔRP, *t*-2	-1.649	-0.694	**-21.001**	**-2.103**
	(3.049)	(0.448)	(8.683)	(1.025)
ΔRP, *t*-3	**-7.972**	-0.908	**-19.028**	-1.424
	(2.731)	(0.644)	(7.538)	(0.865)
ΔY, *t*-1	**-0.695**	**-0.385**	**-0.877**	**-0.439**
	(0.095)	(0.096)	(0.108)	(0.088)
ΔY, *t*-2	**-0.295**	**-0.243**	**-0.410**	**-0.262**
	(0.078)	(0.113)	(0.121)	(0.128)
ΔY, *t*-3	-0.130	0.016	-0.126	0.059
	(0.083)	(0.090)	(0.110)	(0.133)
Constant	0.898	-0.011	0.034	-0.198
	(3.053)	(0.493)	(5.317)	(0.580)
T	136	137	67	67
R^2	0.338	0.171	0.469	0.219

Table A.7, continued.

Panel D: Position changes and premium changes

Dep. Var.: ΔGroup Y net positions, *t*	Dealers	A Mgr	HF	Other	NR
	(1)	(2)	(3)	(4)	(5)
ΔVIXP, *t*	**9.865**	3.657	**-9.333**	**-2.044**	-1.317
	(4.026)	(2.214)	(2.479)	(0.882)	(0.796)
ΔVIXP, *t*-1	**10.123**	**6.437**	**-13.149**	**-3.502**	**-1.329**
	(3.258)	(1.985)	(4.947)	(1.692)	(0.599)
ΔVIXP, *t*-2	**5.657**	**4.940**	**-10.200**	**-1.877**	-0.010
	(2.834)	(1.775)	(3.563)	(0.860)	(0.598)
ΔVIXP, *t*-3	**9.668**	1.963	**-11.101**	-1.359	0.597
	(2.056)	(1.791)	(3.095)	(0.796)	(0.485)
ΔY, *t*-1	**0.306**	-0.108	**0.292**	0.098	**-0.268**
	(0.058)	(0.078)	(0.059)	(0.064)	(0.068)
ΔY, *t*-2	0.031	-0.076	-0.073	**-0.320**	-0.067
	(0.068)	(0.071)	(0.070)	(0.145)	(0.057)
ΔY, *t*-3	-0.058	-0.000	0.058	-0.072	-0.027
	(0.059)	(0.059)	(0.068)	(0.043)	(0.051)
Constant	0.027	0.108	-0.083	-0.008	-0.030
	(0.563)	(0.294)	(0.648)	(0.184)	(0.121)
T	303	303	303	303	303
R^2	0.197	0.068	0.179	0.142	0.090

Table A.8. VIX premiums and risk across the term structure. This table reports estimates of Equation 3 in the monthly time series for all premiums $VIXP_t^n$ up to n=5. The table organizes columns by risk variable X and reports Newey and West (1987) standard errors with three lags. The sample starts in November when there is a continuous term structure each day. The sample size varies somewhat across n because some months have missing lags at the start of the series. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

X:	Realized volatility				VVIX				SPX IV Skew			
n:	2	3	4	5	2	3	4	5	2	3	4	5
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ΔX, *t*	**-0.037**	**-0.017**	-0.009	-0.003	**-0.015**	**-0.007**	-0.005	-0.001	**-0.144**	**-0.064**	**-0.040**	-0.020
	(0.011)	(0.007)	(0.006)	(0.005)	(0.005)	(0.003)	(0.002)	(0.002)	(0.025)	(0.019)	(0.014)	(0.012)
ΔX, *t*-1	**0.022**	**0.019**	**0.015**	**0.013**	0.004	0.004	0.003	**0.004**	0.042	**0.032**	**0.028**	**0.028**
	(0.008)	(0.004)	(0.004)	(0.002)	(0.005)	(0.003)	(0.002)	(0.002)	(0.023)	(0.015)	(0.011)	(0.009)
ΔX, *t*-2	**0.030**	**0.020**	**0.013**	**0.011**	**0.013**	**0.010**	**0.007**	**0.006**	**0.134**	**0.079**	**0.042**	**0.038**
	(0.009)	(0.006)	(0.005)	(0.004)	(0.006)	(0.004)	(0.003)	(0.003)	(0.033)	(0.021)	(0.015)	(0.012)
ΔX, *t*-3	**0.029**	**0.017**	**0.015**	**0.010**	**0.014**	**0.010**	**0.008**	**0.006**	**0.103**	**0.058**	**0.048**	**0.032**
	(0.009)	(0.006)	(0.005)	(0.004)	(0.005)	(0.003)	(0.003)	(0.002)	(0.031)	(0.019)	(0.014)	(0.012)
ΔRP, *t*-1	**-0.277**	-0.123	-0.161	0.034	-0.165	-0.063	-0.103	0.098	**-0.316**	-0.152	-0.145	0.049
	(0.108)	(0.106)	(0.104)	(0.088)	(0.135)	(0.125)	(0.125)	(0.101)	(0.107)	(0.093)	(0.113)	(0.086)
ΔRP, *t*-2	-0.152	-0.090	-0.055	**-0.167**	**-0.179**	-0.122	-0.051	**-0.168**	0.009	-0.024	-0.027	-0.130
	(0.087)	(0.072)	(0.084)	(0.080)	(0.090)	(0.070)	(0.064)	(0.065)	(0.088)	(0.082)	(0.082)	(0.078)
ΔRP, *t*-3	**0.248**	**0.400**	**0.354**	**0.354**	0.133	**0.323**	**0.297**	**0.306**	**0.333**	**0.442**	**0.368**	**0.339**
	(0.092)	(0.100)	(0.090)	(0.091)	(0.075)	(0.075)	(0.084)	(0.078)	(0.095)	(0.096)	(0.088)	(0.092)
Constant	0.001	0.001	0.001	0.001	0.003	-0.001	-0.001	-0.000	0.002	-0.003	0.000	0.001
	(0.041)	(0.029)	(0.024)	(0.019)	(0.049)	(0.034)	(0.027)	(0.021)	(0.039)	(0.031)	(0.026)	(0.021)
T	108	106	107	106	108	106	107	106	105	103	104	103
R^2	0.454	0.440	0.347	0.347	0.305	0.309	0.244	0.257	0.588	0.484	0.364	0.361

Table A.9. Dynamics of premium responses to risk shocks. This table reports impulse responses of the VIX premium to risk shocks estimated from the 8-lag weekly VARs. Columns 1-3 report results measuring risk using weekly realized volatility and correspond to the impulse response plotted in Figure 4 Panel A of the main text (T=600). Columns 4-6 report results measuring risk using the VVIX for the shorter sample starting in 2006 corresponding to Figure A.1 Panel A (T=483). I estimate the VAR using bootstrapped standard errors. "Lower" and "upper" indicate the lower and upper endpoints of a 95% confidence interval. "Point" indicates the point estimate.

	Realized volatility			VVIX		
Lag	Lower	Point	Upper	Lower	Point	Upper
0	-0.116	-0.080	-0.045	-0.072	-0.032	0.009
1	-0.103	-0.073	-0.043	-0.067	-0.033	0.000
2	-0.116	-0.084	-0.052	-0.074	-0.037	0.000
3	-0.098	-0.068	-0.038	-0.066	-0.031	0.003
4	-0.084	-0.057	-0.029	-0.053	-0.018	0.017
5	-0.055	-0.030	-0.006	-0.037	-0.006	0.025
6	-0.049	-0.023	0.002	-0.014	0.020	0.054
7	-0.021	0.001	0.023	-0.008	0.024	0.056
8	-0.001	0.017	0.035	0.006	0.038	0.069
9	0.009	0.028	0.047	0.010	0.042	0.074
10	0.012	0.031	0.050	0.012	0.044	0.075
11	0.016	0.036	0.057	0.011	0.042	0.073
12	0.016	0.037	0.057	0.011	0.041	0.071
13	0.021	0.043	0.064	0.009	0.038	0.066

Table A.10. VIX futures factor exposures. This table reports regressions of the monthly VIX futures returns as the dependent variable and contemporaneous excess market returns, HML, SMB, Momentum, Moskowitz, Ooi and Pedersen (2012) time-series momentum, Pastor-Stambaugh (2003) liquidity innovations (ending December 2013), and short-term reversals in columns 1-6. Columns 7-8 report loadings on the market and percentage changes in the VIX. Columns 9-10 report loadings on measures of realized and conditional volatility using data from Zhou (2009) (ending December 2014). Conditional volatility measured in column 11 comes from a GARCH(1,1) model of log changes in the S&P 500. I report Newey and West (1987) standard errors with two lags. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dependent variable: Futures returns, *t*	Market (1)	3-Factor (2)	Momentum (3)	TS Mom (4)	Liq:P/S (5)	Liq:StRev (6)	Market & VIX (7)	VIX Only (8)	Realized (9)	Condtnl. (10)	GARCH (11)
Excess market, *t*	**-3.173**	**-3.368**	**-3.485**	**-3.388**	**-3.141**	**-3.356**	**-1.620**		**-2.464**	**-2.831**	**-2.759**
	(0.473)	(0.482)	(0.487)	(0.501)	(0.527)	(0.484)	(0.577)		(0.332)	(0.362)	(0.367)
HML, *t*		0.814	0.580	0.792	0.484	0.626					
		(0.607)	(0.629)	(0.604)	(0.618)	(0.617)					
SMB, *t*		0.348	0.411	0.375	0.008	0.467					
		(0.433)	(0.438)	(0.458)	(0.501)	(0.450)					
UMD, *t*			-0.387		-0.305	**-0.399**					
			(0.197)		(0.191)	(0.172)					
TS momentum, *t*				-0.118							
				(0.305)							
Liquidity, *t*					-0.110	-0.496					
					(0.174)	(0.372)					
VIX, % change, *t*							**0.413**	**0.606**			
							(0.060)	(0.041)			
Volatility, % chg, *t*									**0.129**	**0.125**	**0.376**
									(0.020)	(0.053)	(0.079)
Constant	-0.015	-0.014	-0.013	-0.013	-0.020	-0.014	**-0.034**	**-0.049**	**-0.028**	**-0.022**	**-0.024**
	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)	(0.012)	(0.011)	(0.009)	(0.009)	(0.009)	(0.008)
T	140	140	140	138	117	139	140	140	129	129	139
R^2	0.587	0.600	0.609	0.597	0.616	0.615	0.760	0.676	0.671	0.635	0.682

Table A.11. Conditional CAPM predictability. This table reports the results of predicting ex-post returns to the futures investment strategy using ex-ante estimated VIX premiums controlling for factor exposures, in the following regression:

$$r_t = (\alpha_0 + \alpha_1 \, VIXR_{t-1}) + (\beta_0 + \beta_1 \, VIXR_{t-1}) \times r_{M,t} + \varepsilon_t,$$

where $r_{M,t}$ is the excess return to the market. I allow for more factors by expanding the regression appropriately. I report Newey and West (1987) standard errors with 3 lags in parentheses. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dependent variable: Futures return, *t*	CAPM (1)	3-Factor (2)	Momentum (3)	Liq:PS (4)	VIX (5)	Realized (6)
VIXR, t-1	**0.614**	**0.644**	**0.736**	**0.752**	**0.762**	**0.602**
	(0.161)	(0.146)	(0.157)	(0.179)	(0.108)	(0.116)
Market excess return, *t*	**-3.453**	**-3.666**	**-3.904**	**-3.537**	**-1.877**	**-2.684**
	(0.282)	(0.304)	(0.326)	(0.285)	(0.240)	(0.254)
HML, *t*		0.693	0.138	0.154		
		(0.697)	(0.661)	(0.719)		
SMB, *t*		0.527	0.736	0.235		
		(0.420)	(0.395)	(0.456)		
Momentum, *t*			**-0.995**	-0.743		
			(0.396)	(0.430)		
Liquidity, *t*				-0.265		
				(0.156)		
Volatility, % change, *t*					**0.401**	**0.175**
					(0.044)	(0.039)
Interaction terms:						
VIXR x …						
Market excess return, *t*	**-14.060**	**-12.607**	**-14.838**	**-15.226**	**-16.787**	**-12.960**
	(2.961)	(2.824)	(3.135)	(3.526)	(2.924)	(3.021)
HML, *t*		-3.651	-8.368	-5.216		
		(7.776)	(7.742)	(7.803)		
SMB, *t*		-1.717	-0.808	-1.960		
		(6.050)	(5.951)	(6.246)		
Momentum, *t*			**-8.595**	-6.088		
			(4.179)	(4.573)		
Liquidity, *t*				-1.629		
				(2.560)		
Volatility, % change, *t*					-1.221	0.266
					(1.019)	(0.475)
Constant	-0.005	-0.004	0.004	-0.003	**-0.022**	**-0.018**
	(0.010)	(0.011)	(0.013)	(0.014)	(0.008)	(0.008)
T	140	140	140	117	140	140
R^2	0.677	0.695	0.714	0.754	0.865	0.777

Table A.12. Time series predictability across the term structure. This table reports results from predicting monthly futures returns from Equation 5 from rolling *n*-month ahead contracts using the corresponding *n*-month VIX premium. The sample begins in November 2006. I report Newey and West (1987) standard errors with 3 lags in parentheses. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

n=	2	3	4	5
Risk premium, *t*	**1.124**	**1.118**	**1.051**	**0.943**
	(0.399)	(0.359)	(0.340)	(0.338)
Constant	0.021	0.023	0.017	0.014
	(0.023)	(0.019)	(0.016)	(0.014)
T	108	108	108	108
R^2	0.102	0.095	0.081	0.063

Table A.13. Predicting returns through expiration. This table reports the results from the regression,

$$r^i_{T_i-k,T_i} = \alpha + \beta\, VIXR^i_{T_i-k} + \varepsilon_i,$$

where $r^i_{T_i-k,T_i}$ is the excess return of contract *i* expiring at date T_i between dates $T_i - k$ and T_i, and $VIXR^i_{T_i-k}$ is the unscaled VIX premium for contract *i* computed *k* calendar days ahead of expiration,

$$VIXR^i_{T_i-k} = \frac{\widehat{VIX_{T_i-k,T_i}}}{F^{T_i}_{T_i-k}} - 1.$$

where forecasts come from the baseline ARMA(2,2) model. I compute returns through expiration accounting for the special quotation of SPX options which forms the basis of the final settlement value of the futures contract:

$$r^i_{T_i-k,T_i} = \frac{FinalSettlement^i_{T_i}}{F^{T_i}_{T_i-k}} - 1.$$

In case $T_i - k$ falls on a non-trading day, I take the first trading day after $T_i - k$. Final settlement values are available from the CBOE website. I report HC3 standard (small sample heteroskedasticity-robust) errors. The sample starts with contracts expiring in December 2006 onwards. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

k (days):	30	60	90
	(1)	(2)	(3)
VIXR	**0.995**	**0.904**	**0.941**
	(0.497)	(0.350)	(0.227)
Constant	0.008	0.006	0.014
	(0.037)	(0.042)	(0.040)
N	108	108	108
R^2	0.076	0.082	0.080

Table A.14. Trading profits and the conditional CAPM. This table breaks down the profitability of trading strategy using state-dependent loadings that vary with the VVIX by reporting OLS estimates of:

$$r_t^{strategy} = (\alpha_0 + \alpha_1\, \mathbf{1}[HighVVIX_t]) + (\beta_0 + \beta_1\, \mathbf{1}[HighVVIX_t]) r_t^{MKT},$$

where $r_t^{strategy}$ is the excess return to each strategy across the columns, r_t^{MKT} is the excess return to the market, and where this equation has been appropriately expanded for the four-factor model including SMB, HML and Momentum. The variable $\mathbf{1}[HighVVIX_t]$ is an indicator variable that is 1 if the VVIX at *t* is higher than the sample median. In this framework, the strategy opens and closes positions on date *t*-1 based on a trading signal dated *t*-2, and realized returns occur on date *t*. Units for alpha are annualized in percent/100. Newey and West (1987) standard errors with 20 lags are in parentheses. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Strategy:	L/L	S/S	L/C	C/S	L/S
	(1)	(2)	(3)	(4)	(5)
Excess market	**-0.695**	**0.690**	**-0.262**	**0.625**	**0.343**
	(0.039)	(0.038)	(0.056)	(0.046)	(0.060)
SMB	-0.003	-0.004	0.003	0.017	0.016
	(0.048)	(0.047)	(0.045)	(0.057)	(0.058)
HML	0.014	-0.024	**0.105**	0.046	0.101
	(0.045)	(0.043)	(0.051)	(0.062)	(0.071)
Momentum	**-0.098**	**0.092**	**-0.105**	0.025	-0.043
	(0.029)	(0.030)	(0.038)	(0.035)	(0.042)
High VVIX	**0.384**	**-0.361**	0.172	**-0.301**	-0.138
	(0.094)	(0.100)	(0.117)	(0.103)	(0.124)
Interaction terms:					
High VVIX x …					
Excess market	**-0.186**	**0.304**	**-0.419**	-0.089	-0.339
	(0.094)	(0.086)	(0.101)	(0.121)	(0.133)
SMB	-0.137	0.071	**0.206**	**0.317**	**0.386**
	(0.100)	(0.097)	(0.101)	(0.103)	(0.105)
HML	-0.052	0.047	0.029	0.079	0.082
	(0.121)	(0.126)	(0.137)	(0.147)	(0.162)
Momentum	**-0.223**	**0.279**	-0.173	0.146	0.006
	(0.054)	(0.063)	(0.121)	(0.114)	(0.156)
Constant	**-0.268**	**0.239**	0.009	**0.273**	**0.224**
	(0.041)	(0.041)	(0.046)	(0.048)	(0.053)
T	2389	2389	2389	2389	2389
R^2	0.611	0.622	0.282	0.362	0.074

Table A.15. Trading profits, 2010-onward sample. This table reproduces Table 6 for the trading strategy during the sample beginning in January 2010. Units for alpha are annualized in percent/100. Newey and West (1987) standard errors with 20 lags are in parentheses. Bold coefficients and means indicate those that are statistically reliably different from zero at the 5% level.

Panel A: Summary statistics

Strategy:	SPXT	L/L	S/S	L/C	C/S	L/S
	(1)	(2)	(3)	(4)	(5)	(6)
Mean	**0.139**	**-0.186**	0.170	0.063	**0.217**	**0.211**
…standard error	(0.053)	(0.085)	(0.088)	(0.072)	(0.082)	(0.077)
Standard deviation	0.159	0.227	0.240	0.209	0.227	0.221
Daily skew	-0.351	0.852	-0.806	2.388	-0.338	0.170
Daily kurtosis	7.159	8.375	11.917	31.137	10.524	8.014
Sharpe ratio	0.874	-0.819	0.708	0.301	0.956	0.955

Panel B: Factor loadings

	L/L	S/S	L/C	C/S	L/S
	(1)	(2)	(3)	(4)	(5)
Excess market	**-1.161**	**1.224**	**-0.676**	**0.889**	0.296
	(0.049)	(0.054)	(0.146)	(0.123)	(0.183)
HML	0.034	-0.043	**0.349**	0.193	**0.367**
	(0.067)	(0.082)	(0.105)	(0.110)	(0.134)
SMB	**0.176**	**-0.208**	**0.403**	0.097	**0.324**
	(0.054)	(0.067)	(0.104)	(0.073)	(0.109)
Momentum	-0.074	0.116	-0.100	-0.013	-0.075
	(0.053)	(0.063)	(0.089)	(0.090)	(0.114)
Constant	-0.019	-0.009	**0.168**	0.096	**0.179**
	(0.056)	(0.061)	(0.077)	(0.069)	(0.087)
T	1488	1488	1488	1488	1488
R^2	0.660	0.656	0.232	0.445	0.107

Table A.16. Position changes and risk shocks before 2010. This table reproduces Table 9 for pre-crisis sample. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level. I report Newey and West (1987) standard errors with 6 lags in parentheses. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dep. Var.: ΔGroup Y net positions, *t*	Dealer	A Mgr	HF	Other	NR
	(1)	(2)	(3)	(4)	(5)
ΔRVol, *t*	**0.076**	0.001	-0.025	-0.003	**-0.086**
	(0.036)	(0.013)	(0.037)	(0.004)	(0.020)
ΔRVol, *t*-1	**0.167**	-0.021	-0.072	-0.008	**-0.101**
	(0.070)	(0.018)	(0.062)	(0.004)	(0.024)
ΔRVol, *t*-2	0.054	0.011	-0.077	-0.001	-0.030
	(0.044)	(0.018)	(0.042)	(0.004)	(0.024)
ΔRVol, *t*-3	0.007	0.015	0.011	-0.001	-0.041
	(0.040)	(0.021)	(0.033)	(0.006)	(0.028)
ΔF, *t*-1	0.073	-0.036	-0.165	0.022	0.067
	(0.134)	(0.069)	(0.141)	(0.016)	(0.073)
ΔF, *t*-2	0.144	-0.030	-0.069	-0.022	-0.049
	(0.128)	(0.079)	(0.101)	(0.019)	(0.079)
ΔF, *t*-3	-0.099	0.099	0.039	-0.026	0.007
	(0.169)	(0.109)	(0.147)	(0.026)	(0.073)
ΔY, *t*-1	**0.205**	0.147	0.171	-0.152	**-0.286**
	(0.100)	(0.089)	(0.089)	(0.153)	(0.138)
ΔY, *t*-2	-0.038	-0.088	**-0.140**	0.006	**-0.181**
	(0.050)	(0.070)	(0.057)	(0.064)	(0.089)
ΔY, *t*-3	-0.176	0.118	-0.198	-0.044	-0.079
	(0.128)	(0.100)	(0.102)	(0.081)	(0.097)
Constant	0.360	-0.193	-0.154	0.013	-0.020
	(0.251)	(0.123)	(0.190)	(0.028)	(0.113)
T	125	125	125	125	125
R^2	0.204	0.066	0.164	0.063	0.206

Table A.17. Position changes and the VVIX. This table reproduces Table 9 but using changes in the VVIX as the measure of risk. The categories are net futures positions for dealers (Dealers), asset managers (A Mgr), leveraged hedge funds (HF), other reportable traders (Other), nonreportable traders (NR). Units are in thousands of futures contracts, which are also the net notional position in $ millions. The sample runs from 2010 onwards. I report Newey and West (1987) standard errors with 6 lags in parentheses. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dep. Var.: ΔGroup Y net positions, *t*	Dealers	A Mgr	HF	Other	NR
	(1)	(2)	(3)	(4)	(5)
ΔVVIX, *t*	-0.163	-0.044	0.065	**0.113**	0.033
	(0.131)	(0.052)	(0.102)	(0.039)	(0.019)
ΔVVIX, *t* -1	**-0.468**	**-0.198**	**0.659**	0.041	-0.008
	(0.115)	(0.059)	(0.124)	(0.035)	(0.019)
ΔVVIX, *t* -2	**-0.187**	**-0.151**	**0.286**	0.055	-0.028
	(0.081)	(0.060)	(0.086)	(0.038)	(0.020)
ΔVVIX, *t*-3	**-0.203**	-0.025	**0.240**	0.029	-0.008
	(0.069)	(0.047)	(0.086)	(0.030)	(0.013)
ΔF, *t* -1	-0.191	0.067	0.058	-0.115	0.085
	(0.343)	(0.205)	(0.362)	(0.111)	(0.078)
ΔF, *t* -2	-0.679	-0.092	0.704	-0.053	**0.190**
	(0.393)	(0.146)	(0.389)	(0.125)	(0.076)
ΔF, *t* -3	0.352	-0.310	0.117	-0.119	-0.043
	(0.349)	(0.145)	(0.335)	(0.149)	(0.078)
ΔY, *t*-1	**0.257**	-0.122	**0.262**	**0.151**	**-0.264**
	(0.049)	(0.084)	(0.049)	(0.060)	(0.070)
ΔY, *t*-2	0.032	-0.068	-0.077	**-0.311**	-0.065
	(0.061)	(0.070)	(0.060)	(0.141)	(0.057)
ΔY, *t*-3	0.019	-0.007	0.105	-0.039	-0.027
	(0.064)	(0.062)	(0.060)	(0.044)	(0.049)
Constant	-0.095	0.013	0.135	-0.074	0.034
	(0.572)	(0.301)	(0.614)	(0.202)	(0.129)
T	303	303	303	303	303
R^2	0.273	0.111	0.330	0.183	0.095

Table A.18. Hedging VIX futures. This table reports results relating monthly VIX futures excess returns as the left-hand side variable to excess returns from 1) an S&P 500 delta-hedge (calculated from the S&P 500 Total Return index, SPXT), 2) a delta-hedge plus zero-beta at-the-money-forward (ATMF) straddle, 3) ATMF puts and calls plus a delta-hedge, 4) option-synthetic variance swap portfolios, and 5) option-synthetic variance swap portfolios plus a delta-hedge. I consider the excess returns to rolling the 1-month VIX futures contract. An option-synthetic variance swap portfolio approximately mimics a variance swap, and I define these formally in the Online Appendix. I form the hedge portfolio at the end of month *t*-1 that invests in options expiring the same month as the VIX futures contract (expiring T_m, "date 1"), as well as one month after (T_m+1, "date 2"), holding them over month *t.* I calculate moneyness as the strike-to-futures ratio on the portfolio formation date and take the options with strike closest to but greater than 100% as the ATMF. I compute no-arbitrage S&P 500 forward prices by taking the strike with the closest put-and-call price plus the time-scaled difference in the call minus put price within each option maturity, following how CBOE computes the forward price when computing the VIX. Because my OptionMetrics data end in August 2015, there are 135 potential months of index option returns. I report HC3 standard errors in parentheses. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dep. variable: Futures returns, *t*	SPXT (1)	SPXT+S (2)	SPXT +PC (3)	SVS (4)	SPXT +SVS (5)
SPXT ER, *t*	**-3.243**	**-2.414**	-0.165		**-0.963**
	(0.459)	(0.231)	(0.435)		(0.234)
Options expiring $T_m + 1$:					
ATMF Straddle ER, *t*		**1.767**			
		(0.187)			
ATMF Call ER, *t*			**0.596**		
			(0.097)		
ATMF Put ER, *t*			**1.340**		
			(0.156)		
Synthetic VS ER, *t*				**1.010**	**0.844**
				(0.110)	(0.107)
Options expiring T_m:					
ATMF Straddle ER, *t*		**-0.815**			
		(0.116)			
ATMF Call ER, *t*			**-0.262**		
			(0.070)		
ATMF Put ER, *t*			**-0.651**		
			(0.108)		
Synthetic VS ER, *t*				**-0.538**	**-0.447**
				(0.103)	(0.086)
Constant	-0.015	**0.042**	**0.042**	0.015	0.013
	(0.011)	(0.013)	(0.011)	(0.015)	(0.011)
T	140	135	135	135	135
R^2	0.587	0.841	0.902	0.898	0.925

Table A.19. Stock market predictability with VRP and VIX premiums. This table extends Table 12, Panel A by reporting regressions predicting month *t*+1 US equity market excess returns using estimates of the 30-day VRP, conditional variance forecast (CV), VIX premium (VIXP), and conditional VIX forecast (CVIX). BTZ references the variance risk premium from Bollerslev, Tauchen, and Zhou (2009), while BH Model 8 and Model 11 reference the "winning" conditional variance models from Bekaert and Hoerova (2014), both of which I update through November 2015. Newey and West (1987) standard errors with three lags are denoted in parentheses. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

	BTZ	BH 8	BH 11	BTZ	BH 8	BH 11
	(1)	(2)	(3)	(4)	(5)	(5)
VRP	**0.724**	-0.008	0.036	0.936	0.954	0.755
	(0.265)	(0.516)	(0.527)	(0.774)	(1.290)	(1.192)
VIXP	1.949	8.004	7.703	2.478	2.288	2.870
	(3.894)	(4.887)	(5.576)	(4.111)	(4.064)	(4.847)
CV				0.130	**-0.590**	-0.388
				(0.440)	(0.258)	(0.286)
CVIX				6.230	0.726	2.968
				(13.365)	(14.553)	(15.941)
Constant	-3.290	1.917	1.370	-9.984	0.915	0.555
	(4.226)	(6.815)	(6.177)	(22.651)	(23.930)	(24.265)
T	140	140	140	140	140	140
R^2	0.117	0.049	0.049	0.122	0.098	0.089

Table A.20. US corporate credit spreads. This table provides full results underlying Table 12, Panel B; Columns 1-4 in that table correspond to Columns 2, 3, 4 and 5. I report Newey and West (1987) standard errors with 2 lags in parentheses. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dependent variable: BAML BBB Spread	(1)	(2)	(3)	(4)	(5)
IV skew	-0.054	0.011	0.054	0.008	0.083
	(0.109)	(0.130)	(0.116)	(0.109)	(0.098)
10Y-1Y premium	0.592	0.497	0.507	0.443	0.445
	(0.410)	(0.350)	(0.348)	(0.281)	(0.258)
10Y yield	**-1.501**	**-1.249**	-1.173	**-1.108**	-0.931
	(0.718)	(0.586)	(0.602)	(0.507)	(0.485)
10Y yield squared	0.110	0.091	0.087	0.086	0.078
	(0.078)	(0.068)	(0.070)	(0.060)	(0.060)
VIX	**0.037**	0.019	**0.028**		
	(0.011)	(0.010)	(0.014)		
S&P 500 return		-2.765	-2.188	**-3.084**	-2.157
		(1.570)	(1.716)	(1.485)	(1.348)
VIX premium			0.064		**0.113**
			(0.038)		(0.040)
Realized volatility				**0.070**	**0.128**
				(0.031)	(0.043)
VIX - Realized				-0.001	0.009
				(0.009)	(0.009)
VXV-VIX					
Constant	-0.003	0.018	0.016	0.021	0.017
	(0.027)	(0.033)	(0.032)	(0.031)	(0.027)
T	136	136	136	136	136
R^2	0.412	0.452	0.476	0.538	0.607
Adjusted R^2	0.390	0.426	0.448	0.512	0.582

Table A.21. Sovereign CDS spreads. This table reports full results for the panel analysis in Table 12, Panel C. Standard errors are clustered by month. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dependent variable: ΔCDS, *t*	(1)	(2)	(3)	(4)
Local stock return	**-2.439**	**-2.376**	**-2.427**	**-2.318**
	(0.462)	(0.441)	(0.458)	(0.427)
Exchange rate, % change	1.403	1.078	1.416	1.099
	(1.503)	(1.510)	(1.526)	(1.518)
Currency reserve, % change	-0.003	-0.005	-0.003	-0.007
	(0.017)	(0.018)	(0.017)	(0.018)
VIX, change	**2.330**	**3.057**		
	(0.809)	(0.728)		
VIX premium, change		**7.033**		**7.733**
		(2.491)		(2.459)
Realized volatility, change			**8.149**	**11.148**
			(3.005)	(2.910)
VIX-Realized, change			**2.225**	**2.699**
			(0.727)	(0.657)
Observations	3198	3198	3198	3198
R^2	0.155	0.165	0.156	0.166
T	140	140	140	140
Country FE	Y	Y	Y	Y

Table A.22. Hedge effectiveness. This table reports the results of the regression:

$$R = (\alpha_0 + \alpha_1 \sigma_M) + (\beta_0 + \beta_1 \sigma_M)\, R_{futures} + \varepsilon,$$

during the post-crisis (2010+) period at the daily frequency, where $R_{futures}$ is the daily return to the rolling VIX futures strategy, R is the daily return to either VXX or the stock market (S&P 500 total return), and σ_M is 21-day realized volatility, where I have standardized σ_M to be in terms of z-scores. I report Newey and West (1987) standard errors with 20 lags in parentheses. Units are in percentage points. Bold coefficients indicate those that are statistically reliably different from zero at the 5% level.

Dependent variable:	VXX	SPXT
α_0	**-0.063**	-0.067
	(0.019)	(0.048)
α_1	0.026	0.023
	(0.029)	(0.014)
β_0	**0.886**	**-0.094**
	(0.018)	(0.018)
β_1	0.017	**-0.021**
	(0.013)	(0.005)
T	1488	1488
R^2	0.903	0.684
Adjusted R^2	0.902	0.683