News Implied Volatility and Disaster Concerns

Asaf Manela
Washington University in St. Louis

Alan Moreira
Yale University

April 3, 2013

Goal

- Options Implied Volatility (VIX) is a good measure of disaster concerns, but only available since 1986
- Measure disaster concerns over a long history to test the hypothesis that time-varying rare disaster concerns drive aggregate stock market returns
- Characterize time-series properties of the implied disaster probability process
- Our approach: Quantify disaster concerns using the frequency of words on the front-page of the *Wall Street Journal* available since 1890

Rare Disaster Asset Pricing

Theoretical Literature

- Our paper sheds light on the plausibility of the rare disaster asset pricing model pioneered by Rietz (1988) and resurrected by Barro (2006)
- Gabaix (2012), Gourio (2008, 2012), and Wachter (forthcoming) show that there are calibrations of time-varying disaster risk models that can account for asset pricing moments, such as the equity premium, the risk-free rate, the predictability of stock excess returns, and the excess volatility of returns over dividends
- "Is this calibration reasonable? This crucial question is hard to answer, since the success of this calibration is solely driven by the large and persistent variation in the disaster probability, which is unobservable." (Gourio, 2008)

Rare Disaster Asset Pricing

Empirical Literature

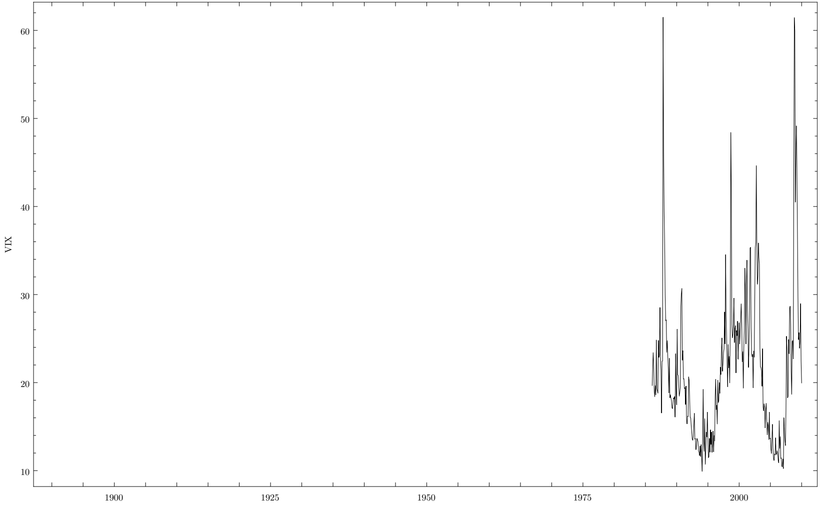
- We are the first to extend VIX back to 1890 using news data and use it to test disaster risk models
- Other papers have examined broadly defined "tail risk":
  - Bollerslev, Tauchen and Zhou (2009), Backus, Chernov and Martin (2011), Tudorov and Bollerslev (2012) all use options data to draw inferences about tail risk premia over time. Limited by the short options sample.
  - Kelly (2011) estimates time-varying tail risk from the cross-section of returns over a longer 1963-2010 sample. Finds this tail risk measure predicts market and cross sectional returns
- This literature is silent about the underlying drivers of disaster concerns which we can capture

Results Summary

- News-implied volatility (NVIX) captures well the disaster concerns of the average investor over this longer history
  - NVIX is particularly high during stock market crashes, times of policy-related uncertainty, world wars and financial crises
- Periods when people are more concerned with a rare disaster, as proxied by news, are either
  - followed by periods of above average stock returns, or
  - followed by periods of large economic disasters
- Our findings are consistent with the view that time-varying rare disaster risk is an important driver of asset prices
- Disaster probability swings quite a bit, but not as persistent as Wachter (forthcoming) and Gourio (2008,2012) calibrate

News Implied Volatility

VIX (VXO) is available only recently, 1986-present



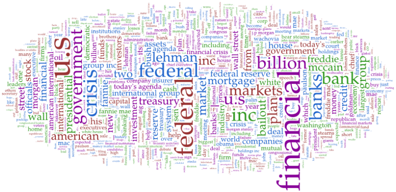
News Implied Volatility

We have news, front-page titles and abstracts of the *Wall Street Journal*, 1890-2009

Date	Title	Abstract
2008-09-16	AIG Faces Cash Crisis As Stock Dives 61%	American International Group Inc. was facing a severe cash ...
2008-09-16	AIG, Lehman Shock Hits World Markets ...	The convulsions in the U.S. financial system sent markets ...
2008-09-16	Business and Finance	Central banks around the world pumped cash into money ...
2008-09-16	Keeping Their Powder Dry: Draft Boards ...	The Selective Service System has the awkward task of ...
2008-09-16	Old-School Banks Emerge Atop New ...	Banks are heading "back to basics – to, if you like, the core ...
2008-09-16	World-Wide	Thailand's ruling party chose ousted leader Thaksin's ...

$$VIX_t - \overline{VIX} = w_0 + \mathbf{w} \cdot \mathbf{x}_t + v_t$$

September 2008:

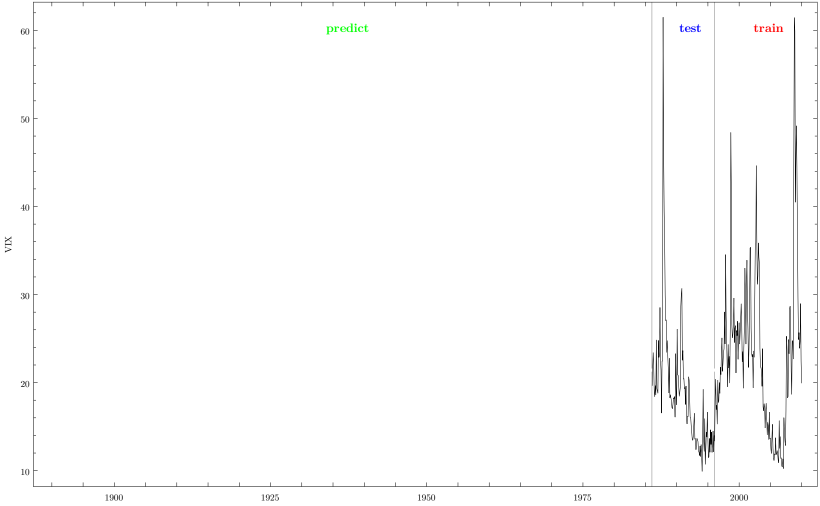


Raw word frequencies

Weighted word frequencies

News Implied Volatility

Split sample into *train*, *test*, and *predict* sub-samples



News Implied Volatility

Support Vector Regression Avoids Overfitting

- SVR regression estimates $\mathbf{w}$, a $K \gg T$ vector of regression coefficients

$$VIX_t - \overline{VIX} = w_0 + \mathbf{w} \cdot \mathbf{x}_t + \upsilon_t \qquad t = 1 \dots T \tag{1}$$

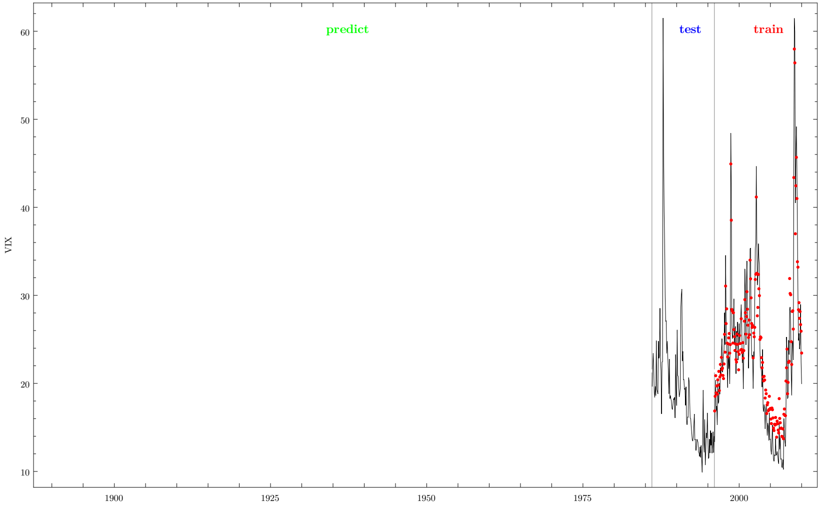
- $\mathbf{w}$ is restricted to be a weighted-average of regressors

$$\hat{\mathbf{w}}_{SVR} = \sum_{t \in train} \alpha_t \mathbf{x}_t \tag{2}$$

- Only the weights α_t of support vectors are non-zero
- Benefit: Reduces a hard problem $O(K)$, to an easy one $O(T)$
- Benefit: Method has been shown to predict well out-of-sample
- Cost: SVR cannot concentrate on $\mathbf{x}_t$ subspaces

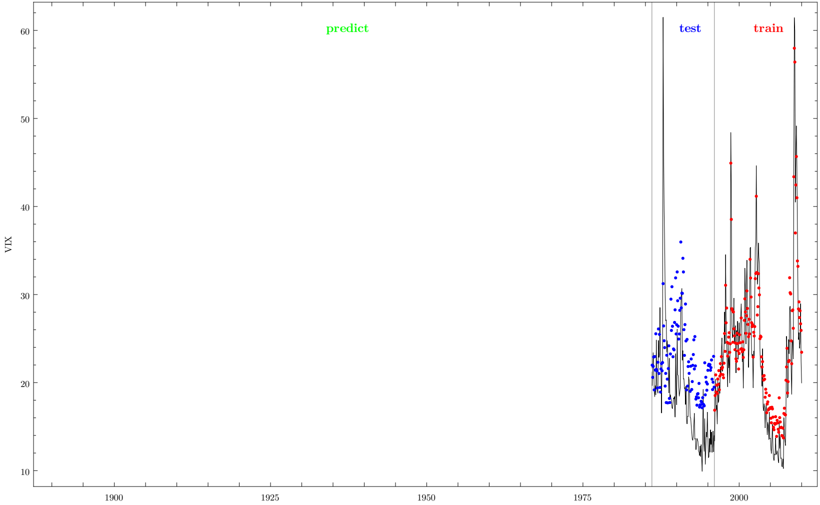
News Implied Volatility

Support Vector Regression: $VIX_t - \overline{VIX} = w_0 + \mathbf{w} \cdot \mathbf{x}_t + \upsilon_t$



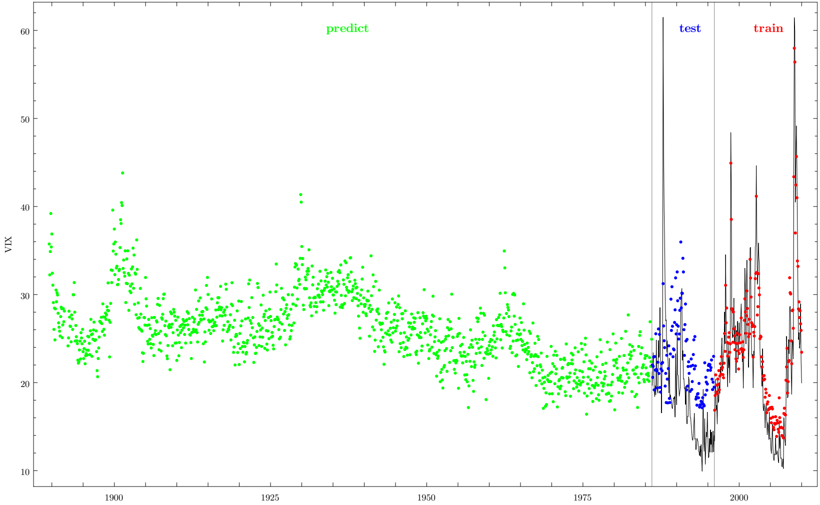
News Implied Volatility

Out-of-sample Fit: $R^2\,(test) = 0.34,\ RMSE\,(test) = 7.52$



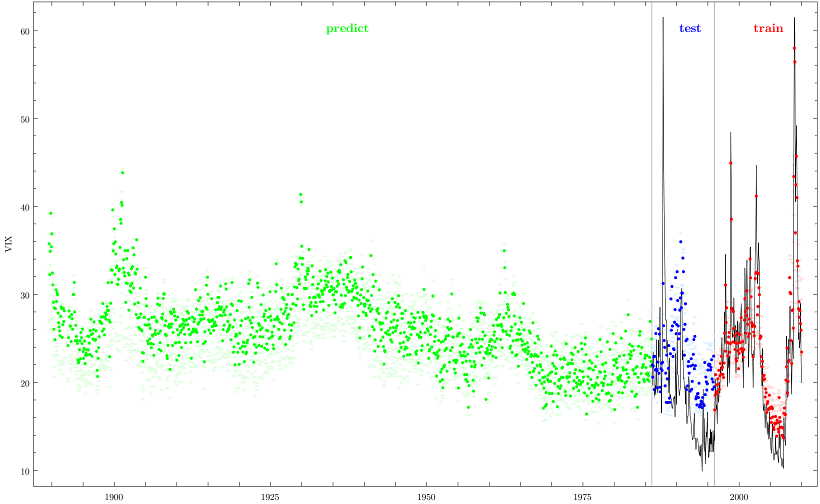
News Implied Volatility

NVIX captures well the fears of the average investor over this long history



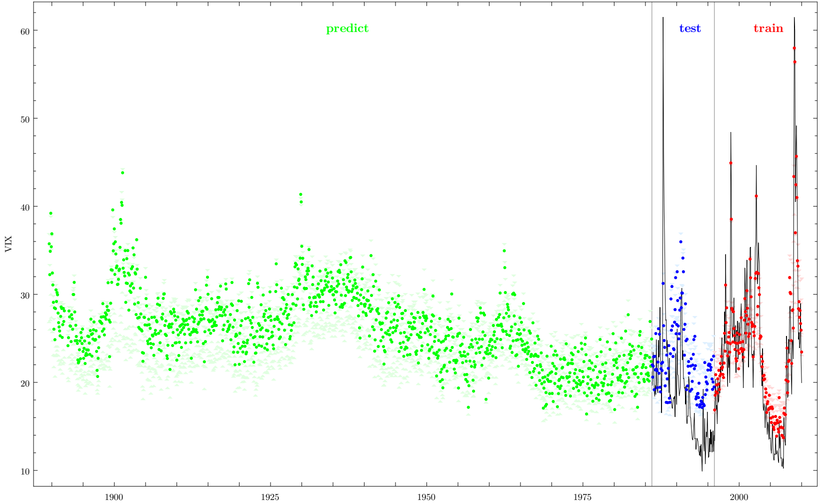
News Implied Volatility

Estimation is not sensitive to randomizations of the *train* subsample



News Implied Volatility

Estimation is not sensitive to randomizations of the *train* subsample



NVIX interactive chart on my website go

Is NVIX a Reasonable Proxy for Disaster Concerns?

Table 2: NVIX is particularly high during stock market crashes, times of policy-related uncertainty, world wars and financial crises

Decade	Peak Months	Noteworthy Events
1900s	04/1901	Railroad speculation leading up to "Northern Pacific Panic" a month later
1910s	11/1914	Start of WWI, temporary closing of U.S. markets
1920s	10/1929	Stock market crash leading up to a financial crisis and Great Depression
1930s	09/1937	Stock market crash, recession follows
1940s	01/1941	Start of WWII
1950s	12/1953	President Eisenhower's budget and tax policy
1960s	06/1962	Stock market crash
1970s	10/1979	Recession, inflation concerns, 50 year anniversary of 29 crash
1980s	10/1987	Stock market crash (Black Monday)
1990s	08/1990	Iraq invades Kuwait
	08/1998	Russia defaults, LTCM crisis
2000s	09/2001	September 11 terrorist attacks
	09/2002	U.S. makes it clear an Iraq invasion is imminent
	10/2008	Financial crisis

Word Categorization

- Classify n-grams into five broad categories of words: *Government*, *Intermediation*, *Natural Disasters*, *Securities Markets* and *War*
- Rely on Princeton's widely used WordNet project
- We select a few root word senses for each category, then expand to a set of similar words with WordNet:Similarity of at least 0.5
- Construct separate NVIX time-series implied by each category
- Measure the percentage of NVIX variance each category drives over the *predict* subsample

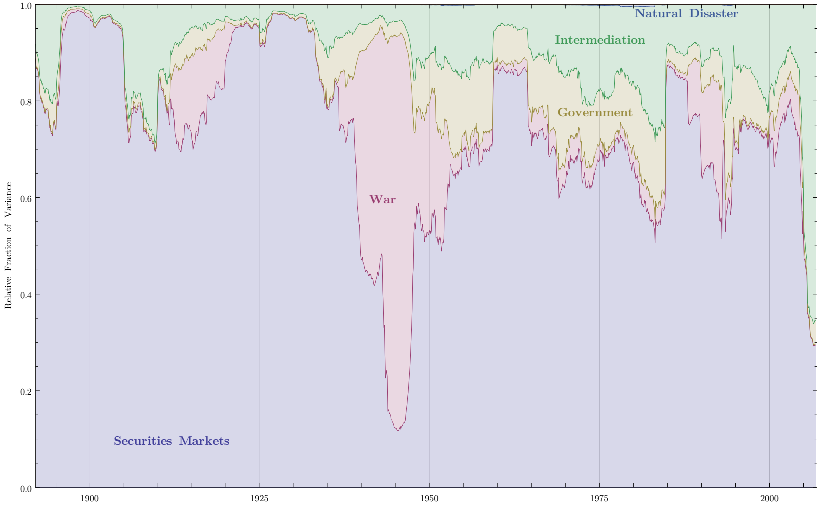
Categories Total Variance Share

Table 4: *Securities Markets* words explain over half the variation in NVIX, *War* words explain 6%

Category	Variance Share, %	n-grams	Top n-grams
Government	2.59	83	tax, money, rates
Intermediation	2.24	70	financial, business, bank
Natural Disaster	0.01	63	fire, storm, aids
Securities Markets	51.67	59	stock, market, stocks
War	6.22	46	war, military, action
Unclassified	37.30	373988	u.s, washington, gold

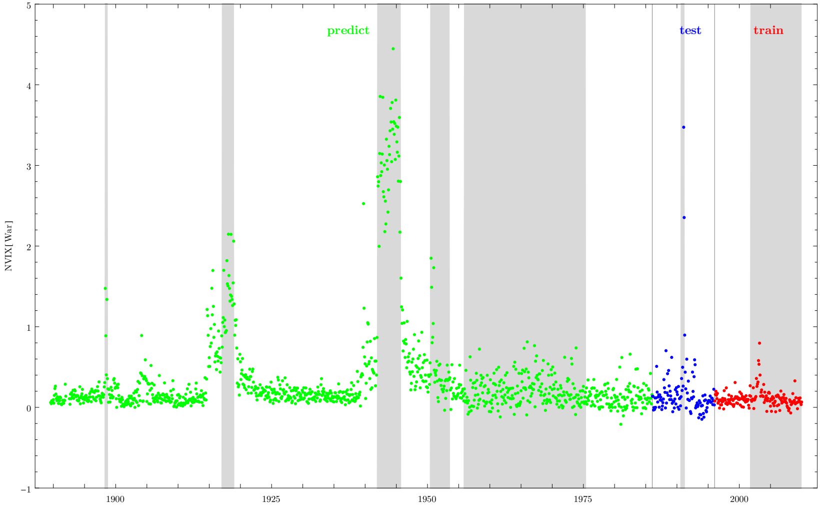
NVIX Variance Components over Time

Figure 2: The Spirit of the Times



NVIX due to War-related Words

Figure 3: Captures well not only whether the U.S. was engaged in war, but also the degree of concern about the future prevalent at the time



NVIX is a Reasonable Proxy for Disaster Concerns

- We find it quite plausible that changes in the disaster probability perceived by the average investor would coincide with stock market crashes, world wars and financial crises
- Since these are exactly the times when NVIX varies due to each of these concerns, we find it is a plausible proxy for disaster concerns

Data

- NVIX calculated from news data, front-page article titles and abstracts of the *Wall Street Journal*, 1890-2009
- DJIA monthly returns from Global Financial Data, 1871-2010
- DJIA daily returns to calculate realized volatility, 1896-2010
- Aggregate earnings from Robert Shiller's website, 1871-2010
- VXO and VIX options implied volatility indices from CBOE, 1986 and 1990-2009

Implied Volatility and Disaster Probabilities

- The CBOE constructs VIX as a weighted average of put/call prices

$$VIX_{t,\tau} = 100\sqrt{\frac{1}{\tau} V_{t,\tau}} \quad (3)$$

where

$$V_{t,\tau} = 2e^{r_f \tau}\left[\int_0^{F_0}\left(\frac{1}{k^2}\right) Put_{t,\tau,k}\, dk + \int_{k_0}^{\infty}\left(\frac{1}{k^2}\right) Call_{t,\tau,k}\, dk\right] \quad (4)$$

- The price of any asset can be decomposed

$$\begin{aligned} P_t &= E_t[m_{t,t+1}X_{t+1}] \quad (5) \\ &= p_t E\left[m_{t,t+1}X_{t+1}|I^D_{t,t+1}=1\right] + (1-p_t)\,E\left[m_{t,t+1}X_{t+1}|I^D_{t,t+1}=0\right] \end{aligned}$$

$\Rightarrow$ Neat link between VIX *squared* and disaster probabilities:

$$p_{t,\tau} = \frac{VIX^2_{t,\tau} - VIXND^2_{\tau}}{VIXD^2_{\tau} - VIXND^2_{\tau}} = \phi_0 + \phi_1 \tau\, VIX^2_{t,\tau} \quad (6)$$

Implied Volatility and Disaster Probabilities

- The CBOE constructs VIX as a weighted average of put/call prices

$$VIX_{t,\tau} = 100\sqrt{\frac{1}{\tau} V_{t,\tau}} \tag{3}$$

where

$$V_{t,\tau} = 2e^{r_f \tau}\left[\int_0^{F_0}\left(\frac{1}{k^2}\right) Put_{t,\tau,k}\, dk + \int_{k_0}^{\infty}\left(\frac{1}{k^2}\right) Call_{t,\tau,k}\, dk\right] \tag{4}$$

- The price of any asset can be decomposed

$$\begin{aligned} P_t &= E_t[m_{t,t+1}X_{t+1}] \qquad (5)\\ &= p_t E\left[m_{t,t+1}X_{t+1}|I^D_{t,t+1}=1\right] + (1-p_t)\, E\left[m_{t,t+1}X_{t+1}|I^D_{t,t+1}=0\right] \end{aligned}$$

⇒ Neat link between VIX *squared* and disaster probabilities:

$$p_{t,\tau} = \frac{VIX^2_{t,\tau} - VIXND^2_{\tau}}{VIXD^2_{\tau} - VIXND^2_{\tau}} = \phi_0 + \phi_1 \tau\, VIX^2_{t,\tau} \tag{6}$$

Implied Volatility and Disaster Probabilities

- The CBOE constructs VIX as a weighted average of put/call prices

$$VIX_{t,\tau} = 100\sqrt{\frac{1}{\tau} V_{t,\tau}} \tag{3}$$

where

$$V_{t,\tau} = 2e^{r_f \tau}\left[\int_0^{F_0}\left(\frac{1}{k^2}\right) Put_{t,\tau,k}\, dk + \int_{k_0}^{\infty}\left(\frac{1}{k^2}\right) Call_{t,\tau,k}\, dk\right] \tag{4}$$

- The price of any asset can be decomposed

$$\begin{aligned} P_t &= E_t[m_{t,t+1}X_{t+1}] \qquad (5)\\ &= p_t E\left[m_{t,t+1}X_{t+1}|I^D_{t,t+1}=1\right] + (1-p_t)\, E\left[m_{t,t+1}X_{t+1}|I^D_{t,t+1}=0\right] \end{aligned}$$

$\Rightarrow$ Neat link between VIX *squared* and disaster probabilities:

$$p_{t,\tau} = \frac{VIX^2_{t,\tau} - VIXND^2_{\tau}}{VIXD^2_{\tau} - VIXND^2_{\tau}} = \phi_0 + \phi_1 \tau\, VIX^2_{t,\tau} \tag{6}$$

Disaster Probabilities and Expected Returns

- Same pricing framework implies expected excess returns are approximately linear in disaster probabilities

$$E_t[R^e_{t+\tau}] \approx E^{ND}[R^e_{t+\tau}] - \left(\frac{E^D[m_{t,t+\tau} R^e_{t+\tau}]}{E^{ND}[m_{t,t+\tau}]} - E^D[R^e_{t+\tau}] \right) p_{t,\tau} \qquad (7)$$

- Estimation of these expected disaster losses is hard because they are rare
- Direct estimates of (7) are highly sensitive to the realized disasters in the sample

Disaster Probabilities and Expected Returns

- Same pricing framework implies expected excess returns are approximately linear in disaster probabilities

$$E_t[R^e_{t+\tau}] \approx E^{ND}[R^e_{t+\tau}] - \left(\frac{E^D[m_{t,t+\tau} R^e_{t+\tau}]}{E^{ND}[m_{t,t+\tau}]} - E^D[R^e_{t+\tau}] \right) p_{t,\tau} \qquad (7)$$

- Estimation of these expected disaster losses is hard because they are rare
- Direct estimates of (7) are highly sensitive to the realized disasters in the sample

Disaster Probabilities and Expected Returns

- A more informative approach is to decompose the test in two:

1. Test if disaster probabilities predict expected returns in paths without disasters

$$E_t^{ND}[R^e_{t+\tau}] = E^{ND}[R^e_{t+\tau}] - \left(\frac{E^D[m_{t,t+\tau}R^e_{t+\tau}]}{E^{ND}[m_{t,t+\tau}]}\right) p_{t,\tau} \quad (8)$$
$$= \beta_0^R + \beta_1^{R,\tau} VIX^2_{t,\tau}$$

only depends on the path of disaster concerns and not actual disaster realizations

2. Test the ex-post cash-flow effect by testing if disaster probabilities actually predict disasters

$$E_t[I^D_{t\to t+\tau}] = p_{t,\tau} = \beta_0^D + \beta_1^{D,\tau} VIX^2_{t,\tau} \quad (9)$$

- This more powerful approach requires judgment in identifying disasters

Disaster Probabilities and Expected Returns

- A more informative approach is to decompose the test in two:

1. Test if disaster probabilities predict expected returns in paths without disasters

$$E_t^{ND}[R^e_{t+\tau}] = E^{ND}[R^e_{t+\tau}] - \left(\frac{E^D[m_{t,t+\tau}R^e_{t+\tau}]}{E^{ND}[m_{t,t+\tau}]}\right) p_{t,\tau} \quad (8)$$
$$= \beta_0^R + \beta_1^{R,\tau} VIX^2_{t,\tau}$$

only depends on the path of disaster concerns and not actual disaster realizations

2. Test the ex-post cash-flow effect by testing if disaster probabilities actually predict disasters

$$E_t[I^D_{t\to t+\tau}] = p_{t,\tau} = \beta_0^D + \beta_1^{D,\tau} VIX^2_{t,\tau} \quad (9)$$

- This more powerful approach requires judgment in identifying disasters

Disaster Probabilities and Expected Returns

- A more informative approach is to decompose the test in two:

1. Test if disaster probabilities predict expected returns in paths without disasters

$$\begin{aligned} E_t^{ND}[R^e_{t+\tau}] &= E^{ND}[R^e_{t+\tau}] - \left(\frac{E^D[m_{t,t+\tau}R^e_{t+\tau}]}{E^{ND}[m_{t,t+\tau}]}\right) p_{t,\tau} \quad (8) \\ &= \beta_0^R + \beta_1^{R,\tau}\, VIX^2_{t,\tau} \end{aligned}$$

only depends on the path of disaster concerns and not actual disaster realizations

2. Test the ex-post cash-flow effect by testing if disaster probabilities actually predict disasters

$$E_t[I^D_{t\to t+\tau}] = p_{t,\tau} = \beta_0^D + \beta_1^{D,\tau}\, VIX^2_{t,\tau} \quad (9)$$

- This more powerful approach requires judgment in identifying disasters

Disaster Probabilities and Expected Returns

- A more informative approach is to decompose the test in two:

1. Test if disaster probabilities predict expected returns in paths without disasters

$$E_t^{ND}[R_{t+\tau}^e] = E^{ND}[R_{t+\tau}^e] - \left(\frac{E^D[m_{t,t+\tau}R_{t+\tau}^e]}{E^{ND}[m_{t,t+\tau}]}\right)p_{t,\tau} = \beta_0^R + \beta_1^{R,\tau}\,VIX_{t,\tau}^2 \quad (8)$$

only depends on the path of disaster concerns and not actual disaster realizations

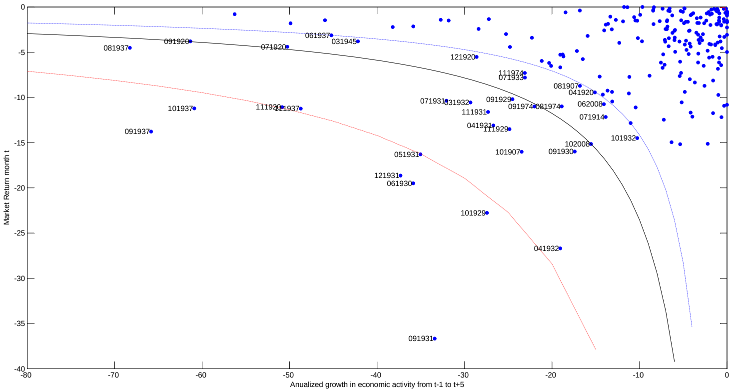
2. Test the ex-post cash-flow effect by testing if disaster probabilities actually predict disasters

$$E_t[I_{t\to t+\tau}^D] = p_{t,\tau} = \beta_0^D + \beta_1^{D,\tau}\,VIX_{t,\tau}^2 \quad (9)$$

- This more powerful approach requires judgment in identifying disasters

Economic Disasters Identification

Figure 4



- We call month t a disaster month if $r_t^m < 0$ and $r_t^m \times \Delta y_{t-1,t+5} \geq \kappa$
- Requires that big stock market drops be followed by large drops in economic activity

Empirical Predictions

1. Risk-Premium Channel: NVIX squared predicts future returns in paths without disasters:

$$r^e_{t\to t+\tau} = \beta_0^R + \beta_1^{R,\tau} NVIX_t^2 + \epsilon_{t+\tau} \text{ if } I^D_{t\to t+\tau} = 0 \tag{10}$$

2. Cash-Flow Channel: NVIX squared predicts future disasters

$$I^D_{t\to t+\tau} = \beta_0^D + \beta_1^{D,\tau} NVIX_t^2 + \epsilon_{t+\tau} \tag{11}$$

- $I^D_{t\to t+\tau} = 1$ if there is a month classified as a disaster during the period t to $t+\tau$

Return Predictability: Extended Sample Tests

$\sigma\left(NVIX_t^2\right) = 21.52$

$r^e_{t\to t+\tau} = \beta_0 + \beta_1 NVIX_t^2 + \epsilon_{t+\tau}$ if $I^D_{t\to t+\tau} = 0$				
Sample Period	1896-2009		1896-1995	
Independent Variable	β_1 $t(\beta_1)$	R^2 T	β_1 $t(\beta_1)$	R^2 T
$r^e_{t\to t+1}$	0.23**	0.74	0.29***	0.86
	[2.31]	1328	[3.14]	1151
$r^e_{t\to t+3}$	0.18***	1.23	0.21***	1.29
	[2.67]	1310	[2.67]	1135
$r^e_{t\to t+6}$	0.15***	1.86	0.17**	1.75
	[2.85]	1287	[2.31]	1115
$r^e_{t\to t+12}$	0.13**	2.49	0.15**	2.49
	[2.52]	1250	[2.04]	1084
$r^e_{t\to t+24}$	0.08*	1.95	0.09	2.10
	[1.71]	1178	[1.41]	1024

Return Predictability: Short Sample Tests

Table 6: Cannot conclude much from the short sample of options

$$r^e_{t\to t+\tau} = \beta_0 + \beta_1 X_t^2 + \epsilon_{t+\tau} \;\text{ if } I^D_{t\to t+\tau} = 0$$

Independent Var	NVIX				VXO		VIX	
Sample Period	1986-2009		1990-2009		1986-2009		1990-2009	
Dependent Var	β_1 $t(\beta_1)$	R^2 T	β_1 $t(\beta_1)$	R^2 T	β_1 $t(\beta_1)$	R^2 T	β_1 $t(\beta_1)$	R^2 T
$r^e_{t\to t+1}$	0.12	0.41	0.11	0.44	0.12	0.81	0.13	0.65
	[0.6]	284	[0.53]	236	[0.95]	285	[0.65]	237
$r^e_{t\to t+3}$	0.13	1.50	0.13	1.80	0.12*	2.36	0.16	3.29
	[1.21]	282	[1.14]	234	[1.75]	283	[1.59]	235
$r^e_{t\to t+6}$	0.12*	2.65	0.11	2.94	0.07	2.02	0.12*	4.14
	[1.72]	279	[1.59]	231	[1.56]	280	[1.92]	232
$r^e_{t\to t+12}$	0.07	1.84	0.08	2.84	0.05	1.71	0.08	2.94
	[1.07]	273	[1.3]	225	[1.09]	274	[1.32]	226
$r^e_{t\to t+24}$	0.04	0.95	0.03	0.77	0.02	0.41	0.02	0.30
	[0.64]	261	[0.56]	213	[0.39]	262	[0.29]	214

Disaster Predictability: Extended Sample Tests

Table 8: $\sigma\left(NVIX_t^2\right)$ change means the probability of a disaster next month increases from $.95\%$ to 4%

$I^D_{t\to t+\tau} = \beta_0 + \beta_1 NVIX_t^2 + \epsilon_t$						
Sample Period	1896-2009		1896-1994		1938-2009	
Dependent Var	$\beta_1(\times 100)$ $t(\beta_1)$	R^2 T	$\beta_1(\times 100)$ $t(\beta_1)$	R^2 T	$\beta_1(\times 100)$ $t(\beta_1)$	R^2 T
$I^D_{t\to t+1}$	0.14***	3.55	0.15***	2.45	0.08	4.39
	[3.49]	1367	[3.28]	1187	[1.30]	863
$I^D_{t\to t+3}$	0.19***	4.02	0.20***	3.32	0.09	2.81
	[3.52]	1367	[2.86]	1187	[1.26]	863
$I^D_{t\to t+6}$	0.24***	4.92	0.29***	4.95	0.08	1.60
	[3.2]	1367	[2.58]	1187	[1.15]	863
$I^D_{t\to t+12}$	0.28**	4.60	0.35**	5.23	0.07	0.63
	[2.49]	1367	[2.06]	1187	[0.80]	863
$I^D_{t\to t+24}$	0.24	2.30	0.38	4.08	-0.04	0.14
	[1.5]	1367	[1.59]	1187	[0.34]	863
N_D	13		12		2	

Gourio's Challenge

- "Is this calibration reasonable? This crucial question is hard to answer, since the success of this calibration is solely driven by the large and persistent variation in the disaster probability, which is unobservable." (Gourio, 2008)
- We estimate the risk-neutral disaster size and the volatility and persistence of p_t, the disaster probability process:

$$p_{t+1} = \rho_p p_t + \epsilon_{t+1} \tag{12}$$

Disaster Probability Persistence

- Insight: ratio of predictability coefficients at different horizons m_L and m_S recovers this persistence ρ_p
- If β_m^D is the disaster predictability coefficient on $NVIX^2$ at horizon m months

$$\frac{\beta_{m_L}^D}{\beta_{m_s}^D} = \frac{1-\rho_p^{m_L}}{1-\rho_p^{m_S}} \tag{13}$$

- If β_m^R is the return predictability coefficient on $NVIX^2$ at horizon m months

$$\frac{m_L\beta_{m_L}^R}{m_s\beta_{m_s}^R} = \frac{1-\rho_R^{m_L}}{1-\rho_R^{m_S}} \tag{14}$$

- Tradeoff: ρ_p is clean but noisy while ρ_R is well-estimated but in general different from ρ_p if expected returns are also driven by time-variation in other sources of uncertainty

Disaster Probability Persistence

Table 14: Persistent but considerably less than assumed in the literature

	(a) Disaster Probability Persistence				(b) Disaster Probability Persistence		
	$\rho_R = \left\{ x \middle\vert \frac{m_L \beta^R_{m_L}}{m_s \beta^R_{m_s}} = \frac{1-x^{m_L}}{1-x^{m_S}} \right\}$				$\rho_p = \left\{ x \middle\vert \frac{\beta^D_{m_L}}{\beta^D_{m_s}} = \frac{1-x^{m_L}}{1-x^{m_S}} \right\}$		
	$m_L = 3$	$m_L = 6$	$m_L = 12$		$m_L = 3$	$m_L = 6$	$m_L = 12$
$m_s = 1$	0.90	0.89	0.90	$m_s = 1$	>1	>1	>1
$m_s = 3$	-	0.88	0.91	$m_s = 3$	-	0.89	0.92
$m_s = 6$	-	-	0.92	$m_s = 6$	-	-	0.94

- Tight range of persistence estimates implied by the return predictability regressions: $\rho_p \in [0.88, 0.92]$
- Excluding one-month specifications, persistence estimates implied by disaster predictability are very similar $\rho_p \in [0.89, 0.94]$

Disaster Probability Volatility

Table 14: More volatile than assumed in the literature

- We can identify p_t volatility as

$$\hat{\sigma}_p^2 = (\beta_m^D)^2 \, Var(\widehat{VIX^2_{t,\tau}}) \tag{15}$$

(c) Disaster Probability and Expected Return Volatility		
	$\frac{12}{m}\sigma(E[p_{t,m}\vert N\widehat{VIX^2_{t,\tau}}])$	$\sigma(E^{ND}[r^e_{t+m}\vert N\widehat{VIX^2_{t,\tau}}])$
$m = 1$	4.2%	4.8%
$m = 3$	6.2%	4.3%
$m = 6$	5.7%	3.5%
$m = 12$	4.3%	2.8%

- Compared with the σ_p of 2.9% in Wachter (forthcoming), and 2.3% in Gourio (2012)

Risk-Neutral Disaster Size

Table 14: The amount of predictability we detect in expected returns is consistent with a reasonable calibration of rare disasters

(d) Risk Neutral Disaster Size		
	$\frac{E^D[m_{t,t+1} R^e_{t+1}]}{E^{ND}[m_{t,t+1}]}$	$= \frac{\frac{m}{12}\beta^R_m}{\beta^D_m}$
$m = 1$	132%	
$m = 3$	65%	
$m = 6$	64%	
$m = 12$	62%	

- Assuming all time-variation in expected returns detected by VIX is driven by variation in the disaster probability, the above ratio recovers the risk-adjusted disaster size
- Barro and Ursua (2008 AER) calibration implies a risk-neutral disaster size of 81%

Is NVIX just a Measure of Market Volatility?

Table 9: No. NVIX has substantial additional information after controlling for volatility

$$r^e_{t\to t+\tau} = \beta_0 + \beta_1 NVIX^2_t + \beta_2 X_t + \epsilon_t \quad \text{if } I^D_{t\to t+\tau} = 0$$

	Volatility		Truncation	
Dependent Variable	β_1 / $t(\beta_1)$	R^2 / T	$\beta_1 - \gamma$ / $t(\beta_1 - \gamma)$	R^2 / T
$r^e_{t\to t+1}$	0.17*	1.09	0.18*	0.74
	[1.67]	1328	[1.80]	1328
$r^e_{t\to t+3}$	0.12*	2.16	0.13**	1.23
	[1.67]	1310	[1.98]	1310
$r^e_{t\to t+6}$	0.13**	2.20	0.11**	1.86
	[2.28]	1287	[2.07]	1287
$r^e_{t\to t+12}$	0.10*	3.26	0.09*	2.49
	[1.90]	1250	[1.76]	1250
$r^e_{t\to t+24}$	0.07	2.19	0.04	1.95
	[1.44]	1178	[0.92]	1178

Does Truncation Explain Predictability?

Table 9: No. Results stand even after adjusting for truncation using a selection model

$$r^e_{t\to t+\tau} = \beta_0 + \beta_1 NVIX^2_t + \beta_2 X_t + \epsilon_t \text{ if } I^D_{t\to t+\tau} = 0$$

	Volatility		**Truncation**	
Dependent Variable	β_1 $t(\beta_1)$	R^2 T	$\beta_1 - \gamma$ $t(\beta_1 - \gamma)$	R^2 T
$r^e_{t\to t+1}$	0.17*	1.09	0.18*	0.74
	[1.67]	1328	[1.80]	1328
$r^e_{t\to t+3}$	0.12*	2.16	0.13**	1.23
	[1.67]	1310	[1.98]	1310
$r^e_{t\to t+6}$	0.13**	2.20	0.11**	1.86
	[2.28]	1287	[2.07]	1287
$r^e_{t\to t+12}$	0.10*	3.26	0.09*	2.49
	[1.90]	1250	[1.76]	1250
$r^e_{t\to t+24}$	0.07	2.19	0.04	1.95
	[1.44]	1178	[0.92]	1178

Are Rare Disasters the Whole Story?

Table 12: No. NVIX and P/E seem to measure different things

$$r^e_{t\to t+\tau} = \beta_0 + \beta_1 NVIX^2_t + \beta_2(\tfrac{P}{E})_t + \epsilon_t \text{ if } I^D_{t\to t+\tau} = 0$$

Sample Period	1896-2010			1896-1994		
Dependent Variable	β_1 $t(\beta_1)$	β_2 $t(\beta_2)$	R^2 T	β_1 $t(\beta_1)$	β_2 $t(\beta_2)$	R^2 T
$r^e_{t\to t+3}$	0.18***		1.23	0.21***		1.29
	[2.67]		1310	[2.67]		1135
		-0.50**	0.84		-0.67*	0.78
		[2.14]	1310		[1.81]	1135
	0.17**	-0.47**	1.98	0.24***	-0.81**	2.41
	[2.56]	[2.04]	1310	[2.93]	[2.17]	1135
$r^e_{t\to t+12}$	0.13**		2.49	0.15**		2.49
	[2.52]		1250	[2.04]		1084
		-0.56**	4.26		-0.79***	4.24
		[2.50]	1250		[2.59]	1084
	0.12**	-0.53**	6.27	0.17**	-0.86***	7.40
	[2.23]	[2.36]	1250	[2.33]	[2.93]	1084

Which Concerns?

Table 13: *War*, *Government*, and *Unclassified* categories stand out

$$r^e_{t\to t+\tau} = \beta_0 + \beta_1 NVIX^2[Category]_t + \beta_2\sigma_t + \epsilon_t \ \text{ if } I^D_{t\to t+\tau} = 0$$

Category:	*NVIX*		*War*		*Government*		*Intermediation*		*Natural Disaster*		*Securities M.*		*Unclassified*	
Dependent Variable	β_1 $t(\beta_1)$	R^2	β_1 $t(\beta_1)$	R^2	β_1 $t(\beta_1)$	R^2	β_1 $t(\beta_1)$	R^2	β_1 $t(\beta_1)$	R^2	β_1 $t(\beta_1)$	R^2	β_1 $t(\beta_1)$	R^2
$r^e_{t\to t+1}$	0.17*	1.09	1.25**	1.04	1.80**	0.99	-0.66	0.82	7.97	0.79	0.18	0.88	0.15	0.95
	[1.67]		[2.52]		[2.02]		[0.75]		[0.57]		[1.39]		[1.07]	
$r^e_{t\to t+3}$	0.12*	2.16	1.36***	2.64	1.82**	2.37	-0.03	1.72	4.44	1.73	0.05	1.74	0.12	2.03
	[1.67]		[3.23]		[2.47]		[0.04]		[0.46]		[0.44]		[1.33]	
$r^e_{t\to t+6}$	0.13**	2.20	1.37***	3.07	1.21*	1.68	-0.12	1.08	9.54	1.23	0.02	1.08	0.16***	2.31
	[2.28]		[3.41]		[1.72]		[0.18]		[1.11]		[0.13]		[2.62]	
$r^e_{t\to t+12}$	0.10*	3.26	1.21***	4.99	1.07	2.81	0.15	1.91	7.64	2.08	0.02	1.89	0.11**	3.11
	[1.9]		[3.78]		[1.46]		[0.31]		[1.07]		[0.13]		[2.01]	
$r^e_{t\to t+24}$	0.07	2.19	0.68**	3.20	1.22*	3.64	0.13	0.94	-0.39	0.90	0.02	0.93	0.06	1.74
	[1.44]		[2.18]		[1.79]		[0.33]		[0.08]		[0.2]		[1.37]	

Directions for Future Calibrations

- Univariate disaster concerns are not likely to be the whole story behind time-variation in expected returns
- A conjecture by Wachter is that different disaster concerns might move at different frequencies, generating return predictability at different frequencies
- We find that NVIX due to different categories have very different persistence and impact on expected returns
  - War-related concern have a long-lasting impact on expected returns
  - Government-related concerns are focused mostly in shorter horizons

Conclusion

- We propose a text-based method to extend options-implied measures of disaster concerns back to 1890
- NVIX is plausibly related with concerns about rare disasters
- NVIX predicts returns and large economic disasters
- Strong evidence in new data for an asset pricing model with a time-varying risk of rare disaster
- Provide guidance for future calibrations
- Our approach of extending via text regression an economically desirable variable, to periods or settings where it did not exist, can potentially be applied elsewhere

Alternative Text-based Analysis Approaches

- We use Support Vector Regression (SVR) to overcome the large dimensionality of the feature space
- Our approach lets the data speak
- Kogan et al (2009) use SVR to predict firm-specific volatility using 10-Ks
- Two alternative approaches suggested by previous literature:
    1. Create topic-specific compound full-text search statement and count the resulting number of articles
        - e.g. Baker et al (2012) searches for articles containing the term 'uncertainty' or 'uncertain', the terms 'economic' or 'economy' and one or more of the following terms: 'policy', 'tax', 'spending', 'regulation', 'federal reserve', 'budget', or 'deficit'
    2. Classifies words into word lists that share a common tone and count all occurrences of words in the text belonging to a particular word list
        - e.g. Loughran and McDonald (2011) develops a negative word list, along with five other word lists, that reflect tone in financial text and relate them to 10-Ks filing returns

Post Depression Sample *including* Disasters

Table 10: Estimates for 6 to 24 months keep magnitude and significance

$$r^e_{t\to t+\tau} = \beta_0 + \beta_1 NVIX^2_t + \epsilon_t$$

Sample Period	1896-2009		1938-2009	
	Excluding Disasters		Including Disasters	
Dependent Variable	β_1	R^2	β_1	R^2
	$t(\beta_1)$	T	$t(\beta_1)$	T
$r^e_{t\to t+1}$	0.23**	0.74	0.12	0.21
	[2.31]	1328	[0.89]	863
$r^e_{t\to t+3}$	0.18***	1.23	0.09	0.35
	[2.67]	1310	[0.69]	863
$r^e_{t\to t+6}$	0.15***	1.86	0.14**	1.65
	[2.85]	1287	[2.2]	863
$r^e_{t\to t+12}$	0.13**	2.49	0.11**	2.03
	[2.52]	1250	[2.49]	863
$r^e_{t\to t+24}$	0.08*	1.95	0.10**	3.38
	[1.71]	1178	[2.49]	863

Disaster Threshold Sensitivity

Table 11: Exactly as expected, including disasters biases downward

$$r^e_{t\rightarrow t+\tau} = \beta_0 + \beta_1 NVIX^2_t + \epsilon_t \text{ if } I^D_{t\rightarrow t+\tau} = 0$$

Threshold	$\kappa = 0.5\%$		$\kappa = 1\%$		$\kappa = 1.5\%$		$\kappa = 2\%$		$\kappa = 2.5\%$	
Dep Var	β_1	R^2	β_1	R^2	β_1	R^2	β_1	R^2	β_1	R^2
	$t(\beta_1)$	T	$t(\beta_1)$	T	$t(\beta_1)$	T	$t(\beta_1)$	T	$t(\beta_1)$	T
$r^e_{t\rightarrow t+1}$	0.13	0.24	0.16*	0.36	0.23**	0.74	0.24**	0.79	0.24**	0.80
	[1.4]	1349	[1.66]	1340	[2.31]	1328	[2.37]	1316	[2.36]	1304
$r^e_{t\rightarrow t+3}$	0.09	0.28	0.10	0.38	0.18***	1.23	0.18***	1.26	0.18***	1.35
	[1.01]	1340	[1.1]	1325	[2.67]	1310	[2.68]	1293	[2.74]	1276
$r^e_{t\rightarrow t+6}$	0.13**	1.23	0.12**	1.23	0.15***	1.86	0.14***	1.72	0.14***	1.81
	[2.39]	1328	[2.34]	1307	[2.85]	1287	[2.76]	1264	[2.71]	1242
$r^e_{t\rightarrow t+12}$	0.12***	2.23	0.13***	2.47	0.13**	2.49	0.12**	2.28	0.11**	2.15
	[2.72]	1313	[2.74]	1281	[2.52]	1250	[2.44]	1215	[2.28]	1192
$r^e_{t\rightarrow t+24}$	0.10**	3.32	0.10**	3.46	0.08*	1.95	0.07*	1.99	0.07	1.83
	[2.4]	1289	[2.34]	1233	[1.71]	1178	[1.65]	1129	[1.58]	1096
N_D	6		9		13		17		21	

Is NVIX just a Measure of Market Volatility?

Realized volatility (purple line) is different