Volatility spillovers and the effect of news announcements

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Motivation

- The Crash of October 1987 has motivated a vast literature on volatility spillovers (Gagnon & Karolyi, 2006).

- The role of news announcements in explaining volatility spillovers has received little attention.
  - ❑ There is large literature on the effect of news releases on volatility per se.

- We examine the effect of scheduled macroeconomic news on *implied volatility* spillovers.
  - ❑ A forward-looking measure of volatility is employed.
  - ❑ We consider U.S. & European **implied volatility (IV) indices**.

Implied volatility (IV): Definition

- IV is the volatility level that has to be inserted into the Black-Scholes (BS, 1973) model to match the option's market price.

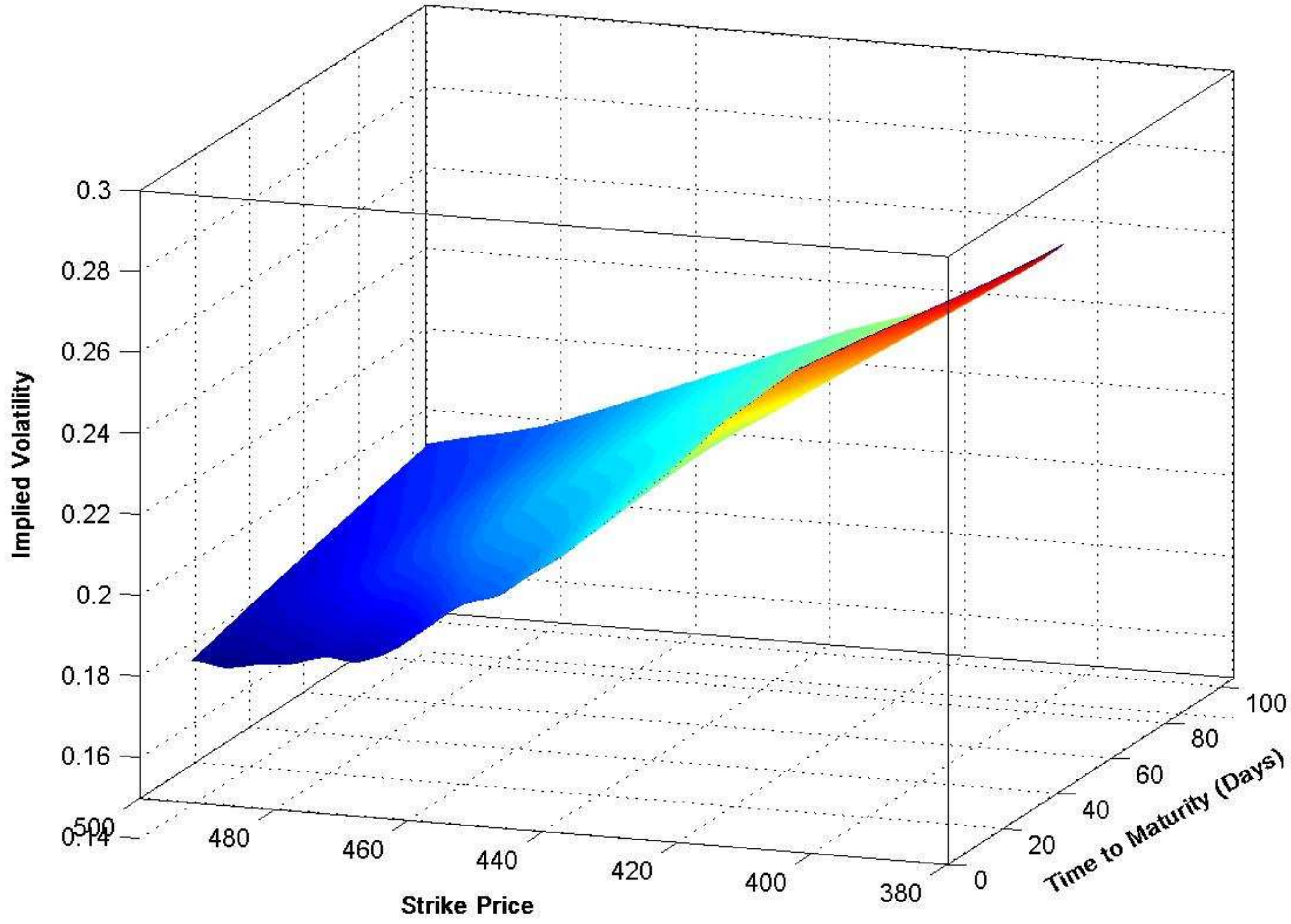
$$O_t^M = f_{BS}(S_t, K, r_{t,\tau}, \tau, \sigma_{imp,t})$$

- If the BS model was valid, then IV should be constant as a function of *K* & *τ* on any given date.

- However, it is not!

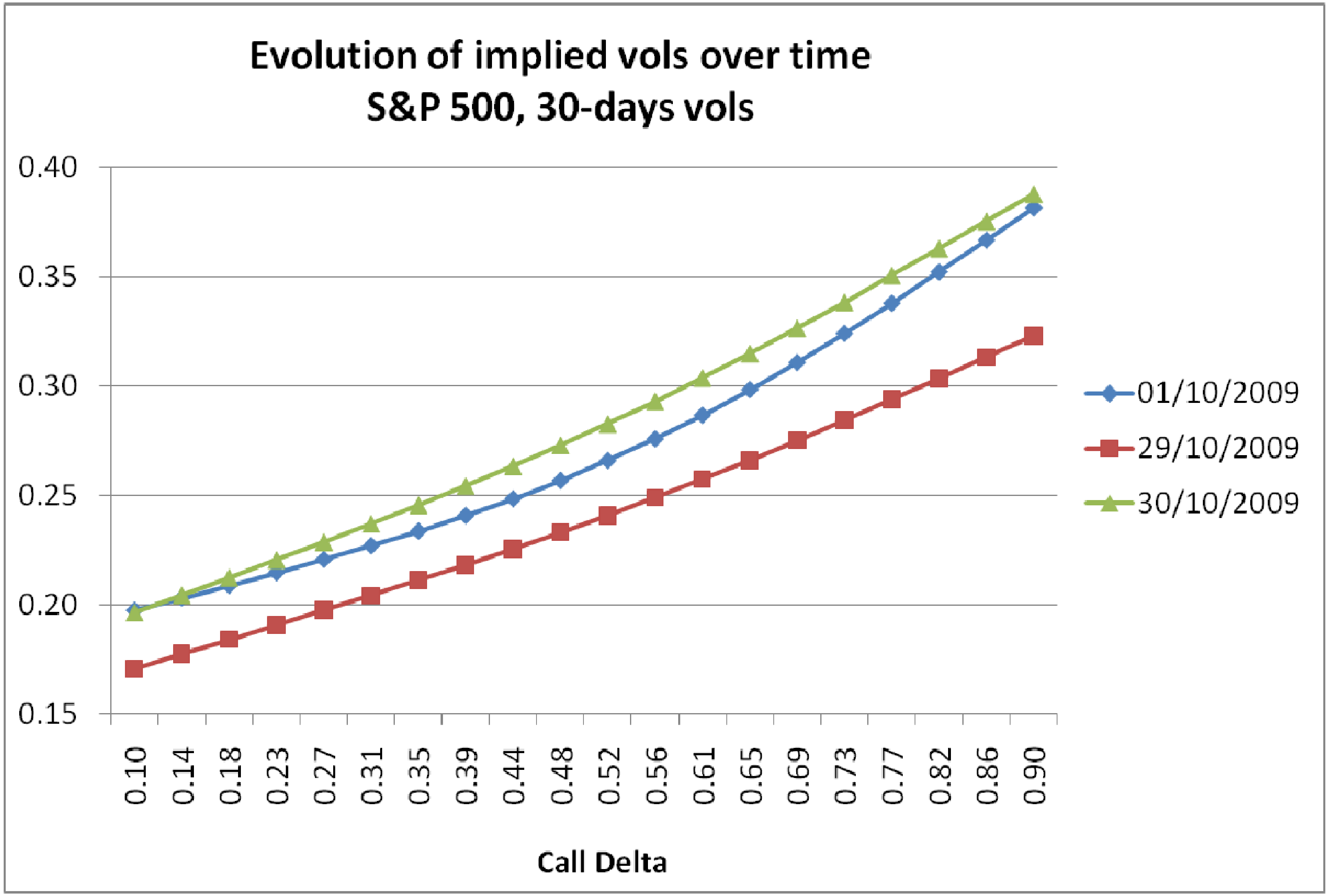
- It also moves stochastically over time (e.g., Skiadopoulos et al., 1999).

Empirical regularities of IV: Non-flat IV surface

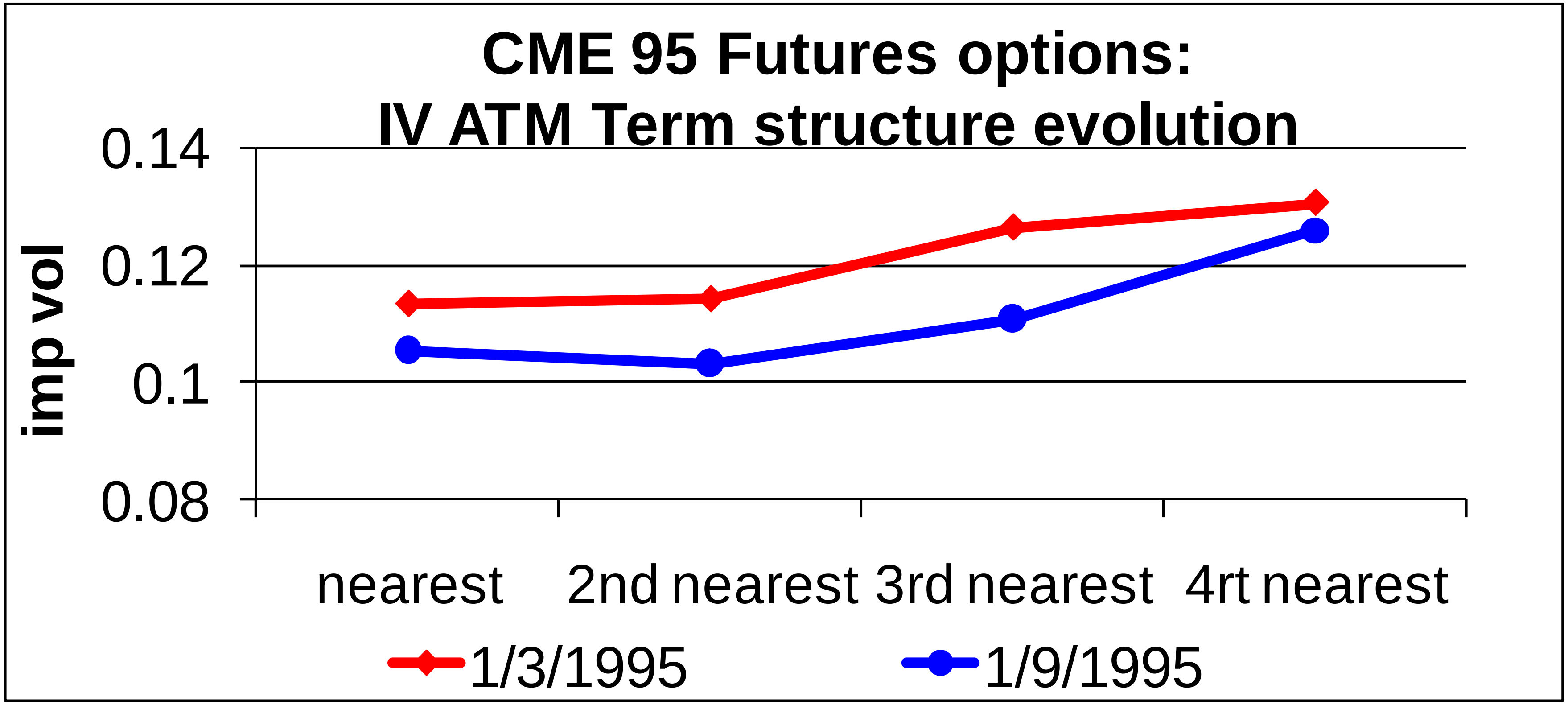


See e.g., Linaras and Skiadopoulos (2005)

Empirical regularities of IV: Change of the Skew



Empirical regularities of IV: Change of the term structure



IV indexes

- An IV index tracks the implied volatility of a synthetic option that has constant time to maturity (e.g., Konstantinidi, Skiadopoulos & Tzagkaraki, 2008).

- IV indices have mushroomed over the last years.
  - ❑ U.S.: VIX, VXO, VXN, VXD, RVX.
  - ❑ Europe: VDAX, VDAX-New, VSTOXX, VX1, VX6, VCAC, VAEX, VBEL, VSMI.

- They eliminate measurement errors & can be used
  - ❑ As the underlying asset to implied volatility derivatives.
  - ❑ As a leading indicator for the stock market.
  - ❑ To forecast the realised volatility.
  - ❑ To calculate Value-at-Risk.

Construction of IV indexes & Interpretation

- Since 2003, the construction of IV indices has changed.
  - ❑ Model-free approach has been adopted.
  - ❑ Information in the cross-section of option prices is exploited.

- IV indices can now be interpreted as the square root of the variance swap rate (Carr & Wu, 2006, Jiang & Tian, 2007).

- **Variance Swaps**: Forward contracts on annualized variance.
  - ❑ The payoff at expiration is: $(\sigma^2 - K_{\text{var}})\, N$

- It can be shown that: $IV^2 = K_{\text{var}} = E_t^Q(V)$

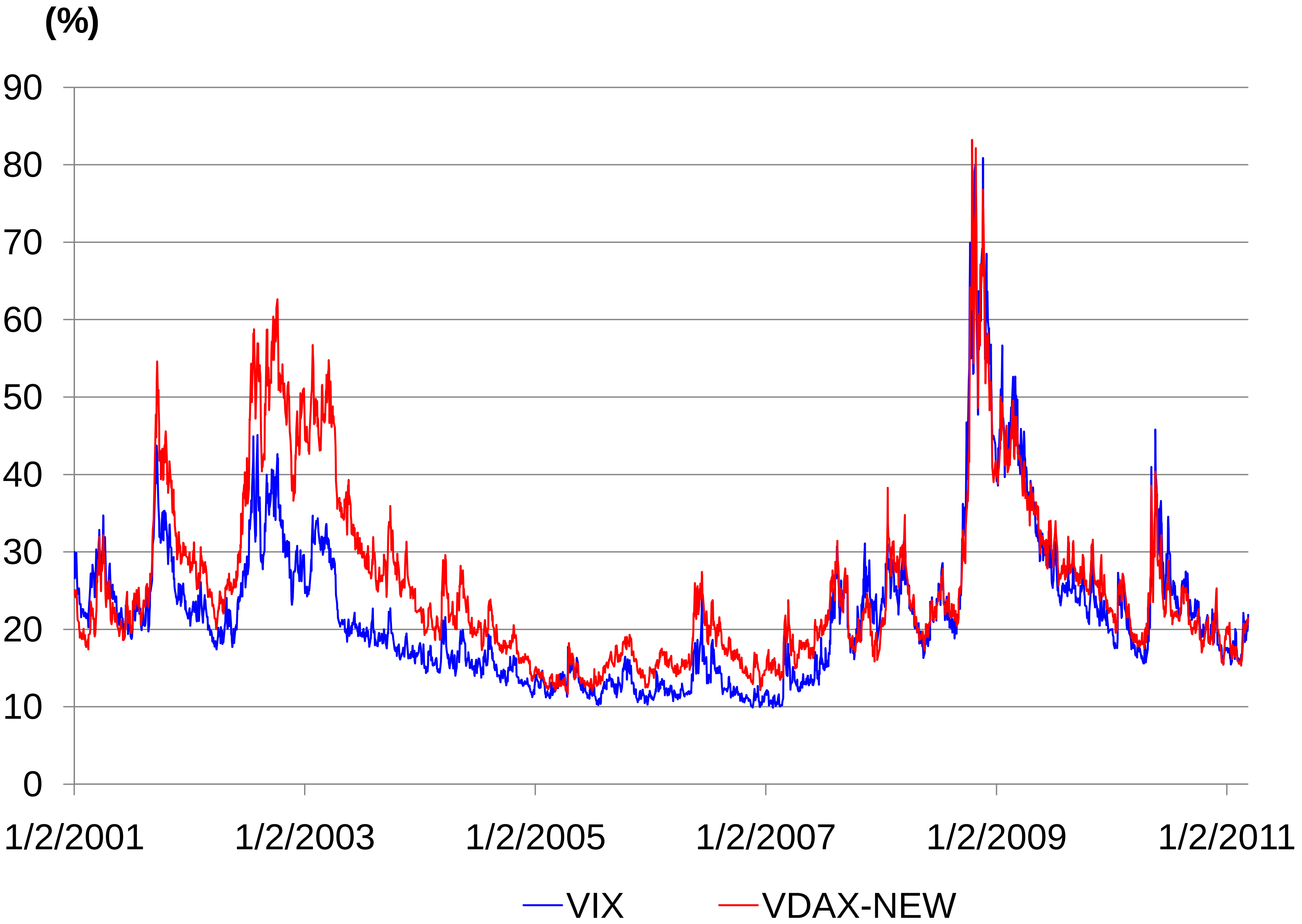
Construction of VIX

$$VIX^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{rT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2$$

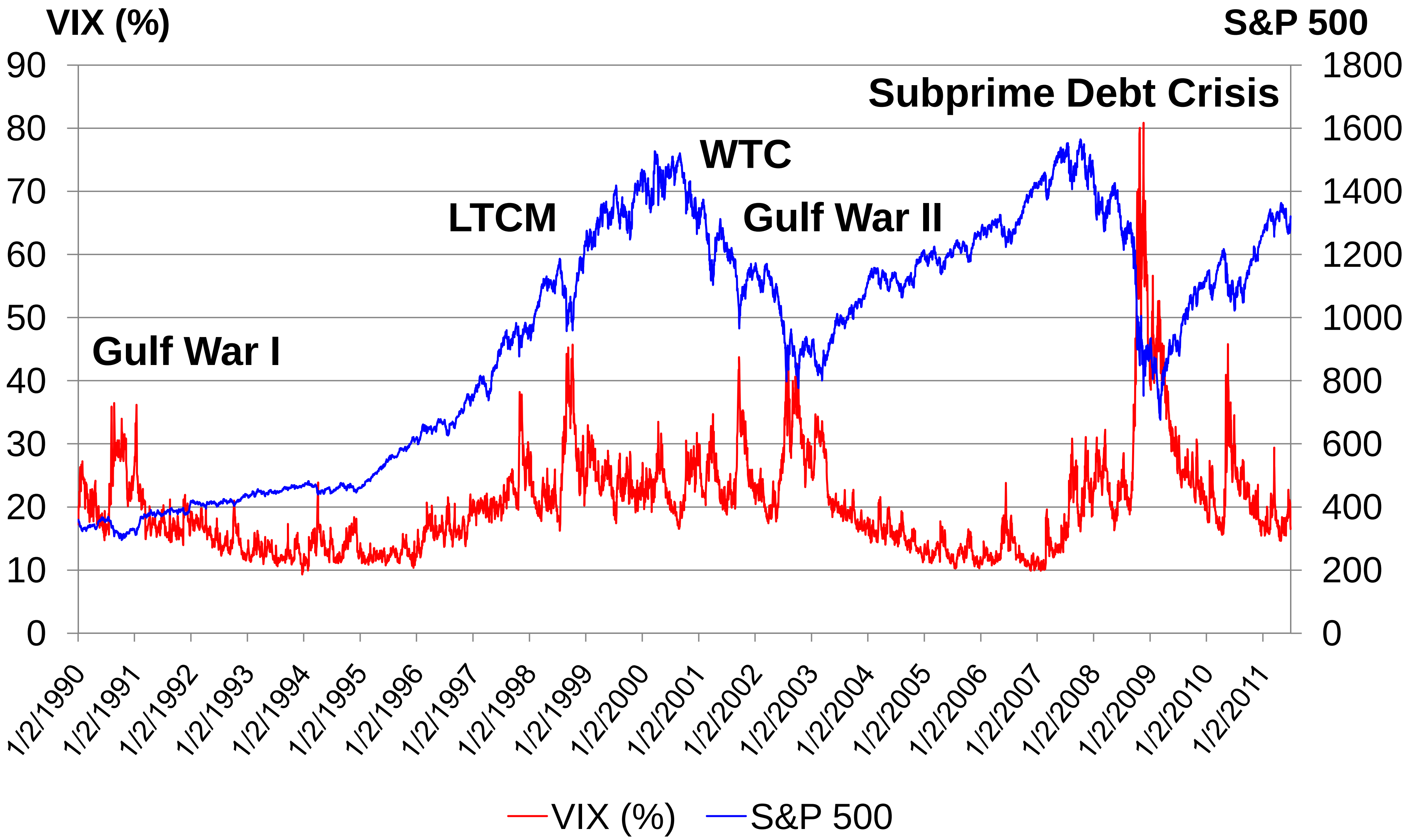
with:

T	Time to maturity (measured in minutes)
F	Forward index level derived from ATM option prices
$\boldsymbol{K_o}$	First strike below the forward index level *F*
$\boldsymbol{K_i}$	Strike price of i^{th} OTM option
$\boldsymbol{\Delta K_i}$	Interval between strike prices $\Delta K_i = ½ (K_{i+1}-K_{i-1})$
r	Risk-free rate of interest
$\boldsymbol{Q(K_i)}$	Mid-point of the bid-ask spread for each option with strike K_i

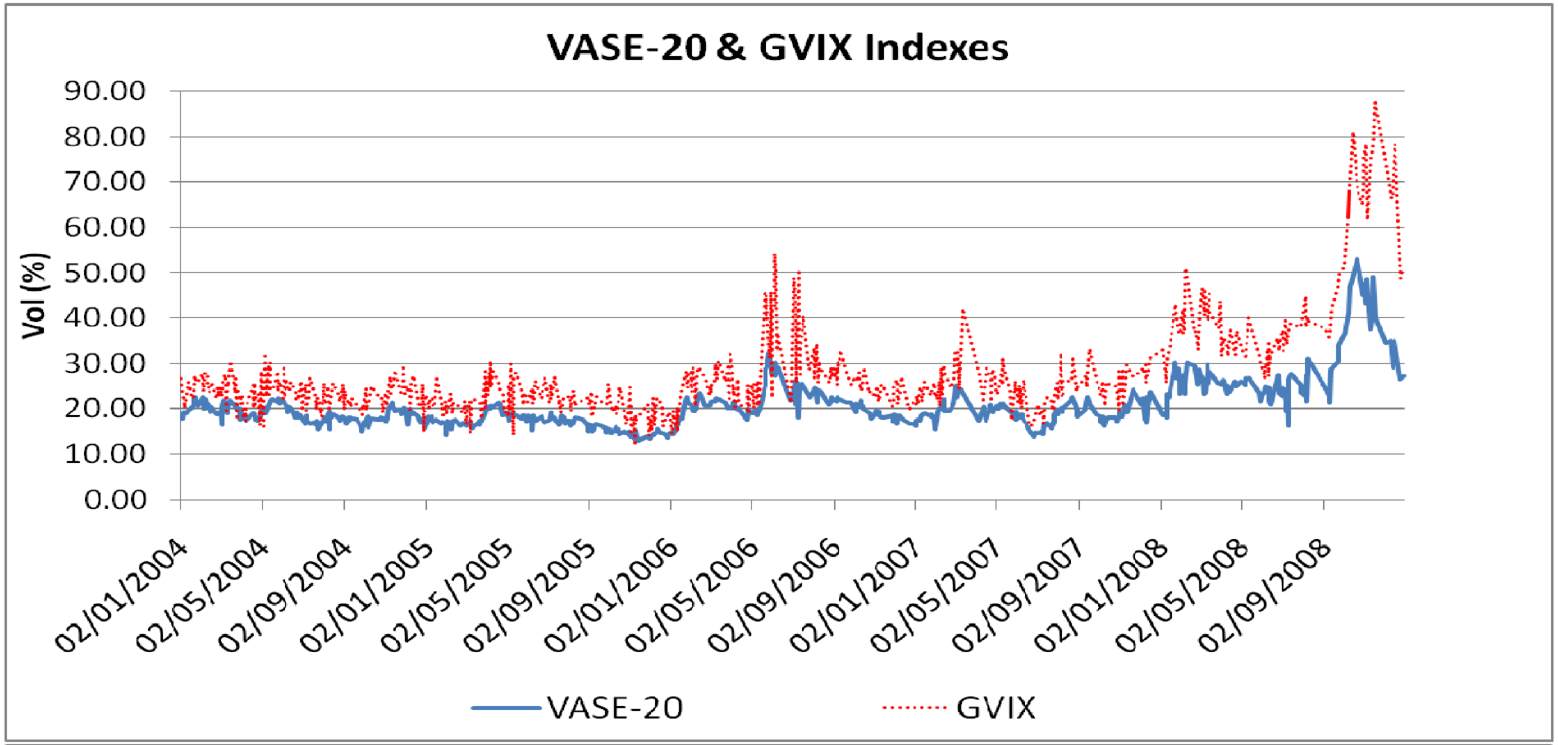
Indicative graph of VIX & VDAX-NEW

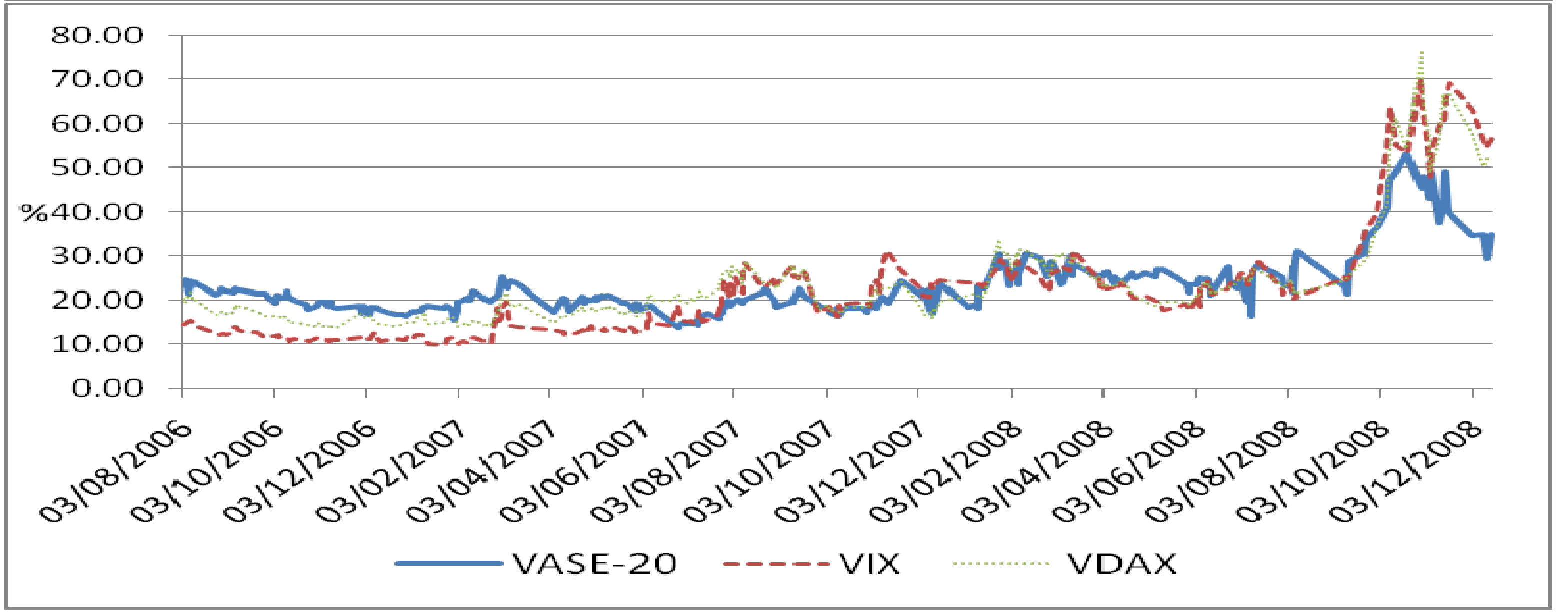


Interpretation of IV indexes: Investors' fear gauge

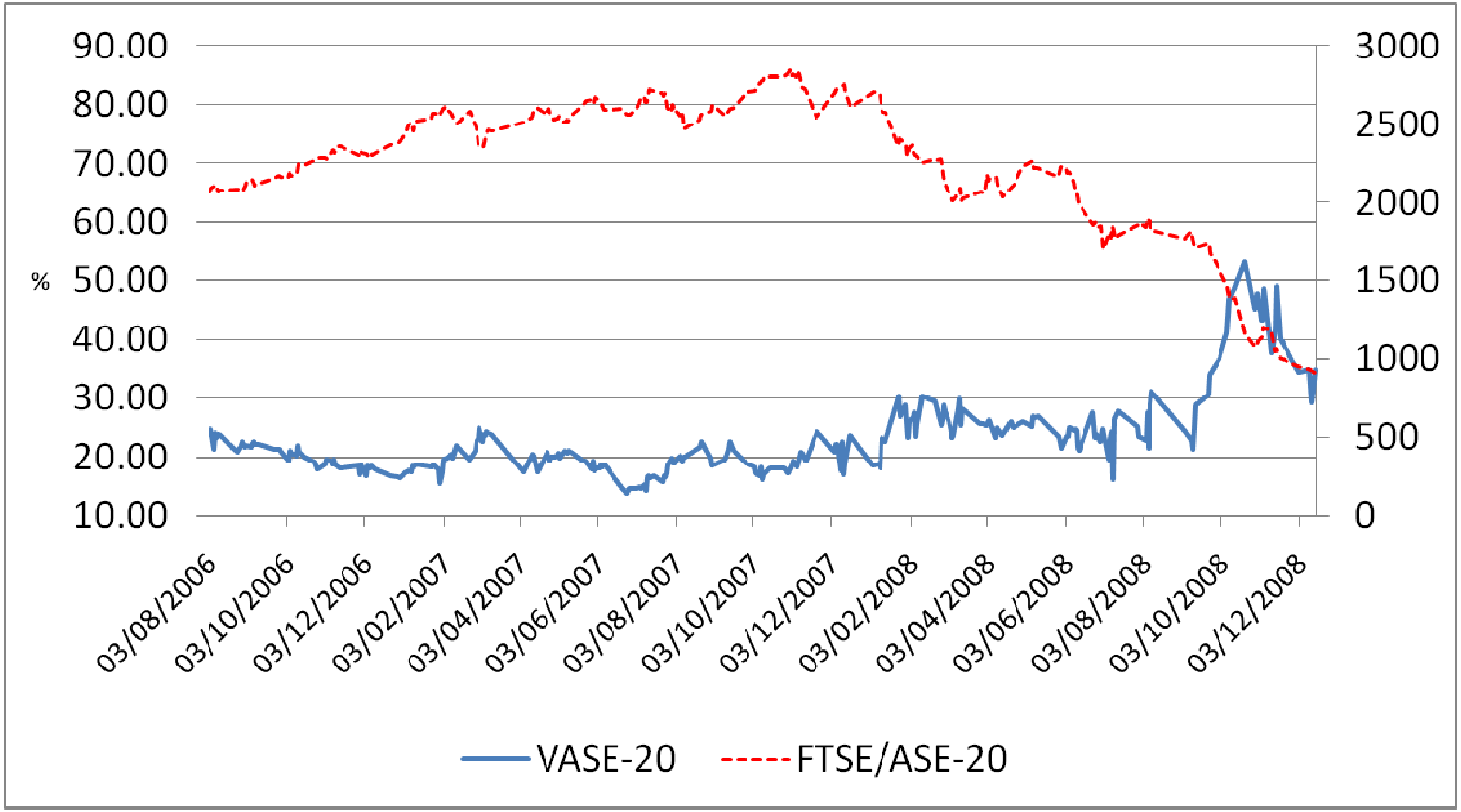


Greek IV indexes: Skiadopoulos (2004, 2011)



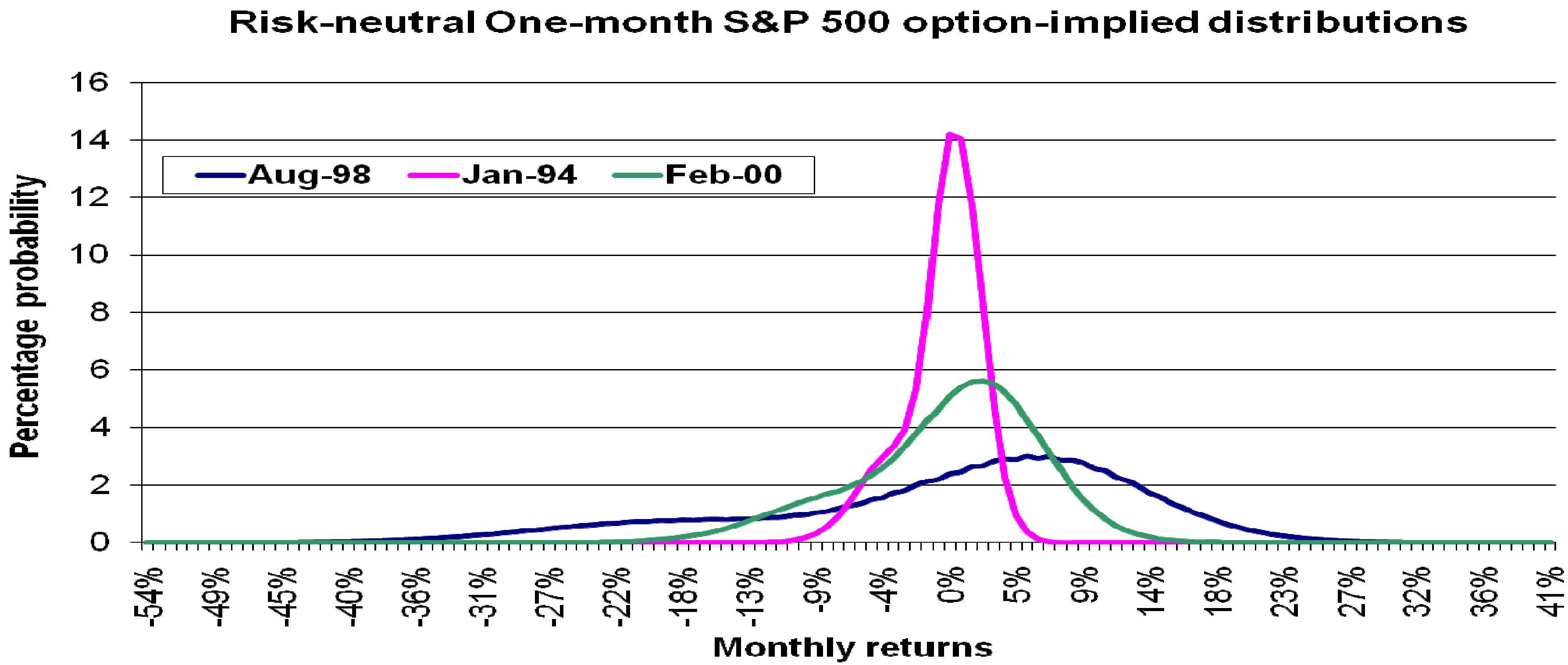


VASE-20 & Leverage effect: Skiadopoulos (2011)



...and all these are closely related to Risk-Neutral Distributions

$$f_t(S_T) = e^{r(T-t)} \frac{\partial^2 C}{\partial K^2}\Big|_{S_T=K}$$



See e.g., Panigirtzoglou & Skiadopoulos (2004), Kostakis, Panigirtzoglou & Skiadopoulos (2011)

Why are Risk-Neutral Distributions useful?

- Implied PDFs have been used
  - For economic policy purposes (Söderlind & Svensson, 1997).
  - Option pricing & risk management (Ait-Sahalia & Lo, 2000, Panigirtzoglou & Skiadopoulos, 2004, Alentorn & Markose, 2008),
  - Forecasting the underlying stock index price at a future date (Bliss & Panigirtzoglou, 2004, Anagnou-Basioudis et al., 2005).
  - Asset allocation (Ait-Sahalia and Brandt, 2008, DeMiguel et al., 2011, Kostakis, Panigirtzoglou & Skiadopoulos, 2011).

- There is a number of methods to extract implied PDFs (Jackwerth, 2004).

Outline

- Motivation & Introduction to volatility indexes
- Literature review – Research questions – Contributions.
- The dataset.
- IV spillovers: Non-synchronicity issue.
- Effect of news announcements on the dynamics of IV.
- Effect of news announcements on the magnitude of IV spillovers.
- Robustness over the 2007-2010 financial crisis.
- Summary & conclusions.

IV spillovers & news announcements: Literature

- IV spillovers are documented in a number of studies.
  - Gemmill & Kamiyama (2000), Aboura (2003), Skiadopoulos (2004), Nikkinen et al. (2006), Äijö(2008).

- IV is found to drop on the release within a single-country setting.
  - ATM IV: Patell & Wolfson (1979), Donders & Vorst (1996), Ederington & Lee (1996), Fornari & Mele (2001), Kim & Kim (2003), Fornari (2004).
  - 2nd moment of RND: Steeley (2004), Beber & Brandt (2006), Äijö (2008)
  - IV indices: Nikkinen & Sahlström (2004), Chen & Clements (2007).

- **Unanswered question:** What is the role of news announcements within an IV spillover framework?

- Our approach ties together these two streams of literature.

Research questions

- We answer three questions:
  1. Are shocks in volatility transmitted between U.S. & Europe?
  2. Do news announcements *account for* the volatility spillovers?
  3. Do news announcements affect the *size* of volatility spillovers?

- Answering these questions is of importance.
  - ❑ Resolution of uncertainty.
  - ❑ Market integration.
  - ❑ International portfolio management & risk management.
  - ❑ Margins.
  - ❑ Contagion.

Contributions

1. Allows understanding whether IV spillovers exist even after the effect of releases is taken into account (contagion).

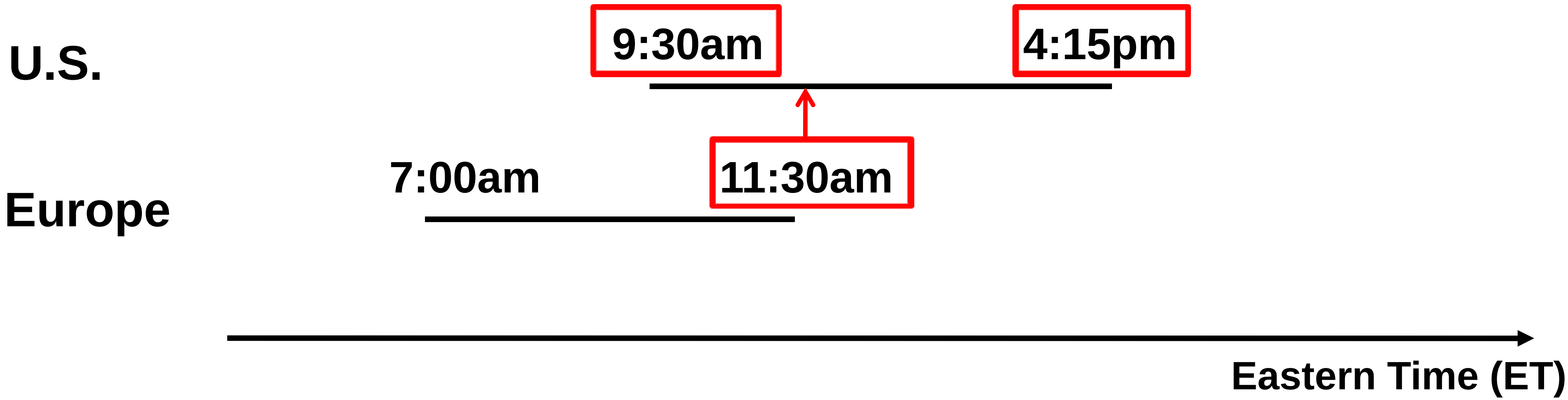
2. Sheds light on whether releases affect the size of IV spillovers.

3. Considers an extensive set of U.S. & European IV indices.
   - ❑ European & U.S. effect.

4. Employs a wide set of U.S. & European scheduled releases.
   - ❑ International news announcements.
   - ❑ Aggregate, regional & individual news announcement items.

The dataset

- Daily prices on IV indices.
  - *U.S.*: *VIX.*
  - *Europe*: *VDAX-New, VCAC, VAEX, VBEL, VSMI, VSTOXX.*
  - *Sample period*: *01/07/2003 – 31/12/2010.*



- U.S. & European news announcements.
  - *Bloomberg*: *Exact timing & survey forecasts of the releases.*

The dataset: News announcement items

U.S.	Europe
Gross domestic product (GDP)	Euro-zone GDP (EU-GDP)
FOMC rate decision (FOMC)	ECB interest rate (ECB)
Consumer price index (CPI)	Euro-zone CPI (EU-CPI)
Producer price index (PPI)	Euro-zone PPI (EU-PPI)
Consumer confidence (CCI)	Euro-zone consumer confidence (EU-CCI)
Retail sales less autos (RS)	Euro-zone retail sales (EU-RS)
Leading indicators (LI)	IFO business climate (IFO)
Change in non-farm payrolls (NFP)	ZEW survey (ZEW)
Durable goods orders (DGO)	
Initial jobless claims (IJC)	
New home sales (NHS)	

Implied volatility spillovers

Do IV spillovers exist?

- ***H1a*: IV does not spillover across markets.**

$$\Delta IV_t = C + \Phi \Delta IV_{t-1} + \varepsilon_t$$

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
C	-0.022	-0.031	-0.019	-0.034	0.004	-0.015
ΔVIX_{t-1}	0.046	**0.352****	**0.443****	**0.306****	**0.421****	**0.228****
$\Delta VDAX_{t-1}$	0.047	-0.074	**0.136***	**0.141****	**0.124****	**0.296****
$\Delta VCAC_{t-1}$	**-0.063***	0.052	**-0.317****	**-0.057***	-0.013	**0.066****
$\Delta VAEX_{t-1}$	**-0.146****	**-0.259****	0.014	**-0.400****	**-0.117****	**-0.334****
$\Delta VBEL_{t-1}$	**0.333****	**0.156****	**-0.088***	**0.106****	**-0.307****	**0.229****
$\Delta VSMI_{t-1}$	**-0.335****	-0.088	-0.082	0.012	-0.075	**-0.191****
Adj-R^2	**0.067**	**0.092**	**0.143**	**0.092**	**0.189**	**0.234**
H_0: $\varphi_{ij} = 0$ for $i \neq j$ 1245.62**						

U.S. versus European effect

- ***H1b*: There is no U.S. effect for the individual European indices once we control for the regional European effect.**

$$\Delta IV_{i,t} = c_i + \varphi_i \Delta IV_{i,t-1} + \alpha_i \Delta VIX_{t-1} + \beta_i PC^{EU}_{i,t-1} + \varepsilon_{i,t}$$

$$\Delta IV_{i,t} = c_i + \varphi_i \Delta IV_{i,t-1} + \alpha_i \Delta VIX_{t-1} + \beta_i \Delta VSTOXX_{t-1} + \varepsilon_{i,t}$$

	$\Delta VDAX_t$	**$\Delta VCAC_t$**	**$\Delta VAEX_t$**	**$\Delta VBEL_t$**	**$\Delta VSMI_t$**
			Panel A: PC model		
C	-0.032	-0.024	-0.038	0.002	-0.016
ΔIV_{t-1}	-0.149	**-0.314****	**-0.386****	**-0.309****	**-0.188****
ΔVIX_{t-1}	**0.316****	**0.469****	**0.317****	**0.431****	**0.209***
PC^{EU}_{t-1}	-0.025	-0.01	0.133	-0.057	**0.209****
Adj-R^2	**0.065**	**0.141**	**0.086**	**0.184**	**0.159**
			Panel B: VSTOXX model		
C	-0.034	-0.022	-0.036	0.001	-0.015
ΔIV_{t-1}	-0.164	**-0.384****	**-0.352****	**-0.383****	-0.11
ΔVIX_{t-1}	**0.314****	**0.377****	**0.298****	**0.359****	**0.214****
$\Delta VSTOXX_{t-1}$	-0.016	0.134	0.089	0.064	0.127
Adj-R^2	**0.062**	**0.141**	**0.081**	**0.176**	**0.143**

The effect of news announcements on IV spillovers

The effect of releases on IV spillovers

- We investigate the effect of releases on IV dynamics.
  - ❑ Aggregate, regional & individual news announcements.

- Surprise effect:
  - ❑ We consider the release time & content.
  - ❑ We employ standardized surprise variables.

- We employ a VAR model that allows the vector of constants to be affected by news announcements.

Standardized surprise variable: Definition

- The standardized surprise variable, S_{it}, of a release of news item i at time t is defined as (Balduzzi et al., 2001):

$$S_{it} = \frac{A_{it} - F_{it}}{\sigma_i}$$

A_{it} (F_{it})	Released (forecasted) value for the i-th economic variable between t-1 and t.
σ_{it}	Standard deviation of the unexpected component (i.e. A_{it}-F_{it}) of the announcement for the i-th economic variable over the whole sample period.

Aggregate & regional surprise variable: Definition

- We consider the absolute surprise component of releases.
  - Aggregate surprise variables.

- The aggregate surprise variable, $|S_t|$, at time t is defined as:

$$|S_t| = |S_t^{US}| + |S_t^{EU}|$$

$$|S_t^{US}| = \sum_{i=1}^{11} |S_{i,t}^{US}|$$

Aggregate surprise variable for the U.S. region

$$|S_t^{EU}| = \sum_{i=1}^{8} |S_{i,t}^{EU}|$$

Aggregate surprise variable for the European region

Effect of aggregate releases on IV dynamics

- ***H2:*** IV spillovers do not exist once we account for the surprise effect of ***aggregate*** releases.

$$\Delta IV_t = C + \Phi \Delta IV_{t-1} + A|S_t| + \varepsilon_t$$

Φ is significant & A is insignificant	➡	*Volatility contagion*
Φ is insignificant & A is significant	➡	*Releases drive IV*
Φ & A are significant	➡	*Releases account only for part of IV spillovers.*

Effect of aggregate releases on IV dynamics

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
C	0.026	0.001	0.024	0.027	0.052	0.028
ΔVIX_{t-1}	0.056	0.370**	0.466**	0.333**	0.422**	0.239**
$\Delta VDAX_{t-1}$	0.049	-0.072	0.138*	0.144**	0.125**	0.297**
$\Delta VCAC_{t-1}$	-0.071*	0.038	-0.334**	-0.077**	-0.014	0.057**
$\Delta VAEX_{t-1}$	-0.152**	-0.267**	0.005	-0.411**	-0.121**	-0.340**
$\Delta VBEL_{t-1}$	0.337**	0.163**	-0.078	0.117**	-0.305**	0.234**
$\Delta VSMI_{t-1}$	-0.332**	-0.088	-0.082	0.013	-0.071	-0.189**
$\lvert S_t \rvert$	-0.072	-0.051	-0.070	-0.095**	-0.066*	-0.065*
Adj-R^2	0.070	0.102	0.158	0.113	0.191	0.244
H_0: $\varphi_{ij} = 0$ for $i \neq j$	*1252.01***					

Effect of regional releases on IV dynamics

- ***H3:*** IV spillovers do not exist once we account for the surprise effect of ***regional*** releases.

$$\Delta IV_t = C + \Phi \Delta IV_{t-1} + A\left|S_t^{US}\right| + B\left|S_t^{EU}\right| + \varepsilon_t$$

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
C	0.023	-0.001	0.019	0.024	0.048	0.027
ΔVIX_{t-1}	0.055	**0.370****	**0.464****	**0.332****	**0.421****	**0.239****
$\Delta VDAX_{t-1}$	0.046	-0.074	**0.135***	**0.142****	**0.122****	**0.296****
$\Delta VCAC_{t-1}$	**-0.071***	0.038	**-0.334****	**-0.077****	-0.014	**0.056****
$\Delta VAEX_{t-1}$	**-0.148****	**-0.263****	0.012	**-0.408****	**-0.116****	**-0.337****
$\Delta VBEL_{t-1}$	**0.337****	**0.163****	-0.079	**0.117****	**-0.306****	**0.234****
$\Delta VSMI_{t-1}$	**-0.333****	-0.088	-0.083	0.013	-0.072	**-0.189****
$\|S^{US}_t\|$	-0.032	-0.02	0.005	-0.058	-0.008	-0.041
$\|S^{EU}_t\|$	**-0.145***	-0.112	**-0.205****	**-0.164****	**-0.171****	**-0.111***
Adj-R^2	**0.071**	**0.103**	**0.161**	**0.114**	**0.194**	**0.245**
H_0: $\varphi_{ij} = 0$ for $i \neq j$	**1253.52****					

Effect of individual releases on IV dynamics

- ***H4:*** IV spillovers do not exist once we account for the surprise effect of ***individual*** releases.

$$\Delta IV_t = C + \Phi \Delta IV_{t-1} + \left[\left(A_1 + B_1 D_{1t}^{US} \right) | S_{1t}^{US} | + \ldots + \left(A_{11} + B_{11} D_{11t}^{US} \right) | S_{11t}^{US} | \right] + \left[\left(\Gamma_1 + Z_1 D_{1t}^{EU} \right) | S_{1t}^{EU} | + \ldots + \left(\Gamma_8 + Z_8 D_{8t}^{EU} \right) | S_{8t}^{EU} | \right] + \varepsilon_t$$

$D_{it}^{US} \left(D_{jt}^{EU} \right)$ A sign dummy variable for the *i*-th individual U.S. (*j*-th individual European) announcement item that takes the value 1 when the $S_{it}^{US} < 0$ ($S_{jt}^{EU} < 0$) and zero otherwise.

Effect of individual releases on IV dynamics

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
$\lvert S_t^{CPI} \rvert$	-0.262	-0.297	0.248	-0.316	-0.122	**-0.431***
$\lvert S_t^{LI} \rvert$	0.281	-0.116	-0.336	-0.004	**-0.624****	**-0.471****
$\lvert S_t^{EU\text{-}CPI} \rvert$	**0.654***	0.18	-0.18	0.106	-0.014	0.028
$\lvert S_t^{CCI} \rvert D_t^{CCI}$	0.306	**1.024****	0.278	0.095	0.19	0.197
$\lvert S_t^{CPI} \rvert D_t^{CPI}$	0.641	**1.025****	-0.033	0.536	0.471	**0.731****
$\lvert S_t^{LI} \rvert D_t^{LI}$	0.147	0.371	**0.849***	0.386	**0.916****	**0.960****
$\lvert \hat{S}_t^{RS} \rvert D_t^{RS}$	**0.904***	0.601	-0.022	**0.940****	**0.683***	0.39
$\lvert S_t^{EU\text{-}CCI} \rvert D_t^{EU\text{-}CCI}$	0.038	-0.185	**-1.060****	-0.112	-0.133	-0.271
$\lvert S_t^{EU\text{-}CPI} \rvert D_t^{EU\text{-}CPI}$	**-0.880***	-0.394	-0.215	-0.352	-0.249	-0.274
$\lvert S_t^{IFO} \rvert D_t^{IFO}$	**-1.024****	-0.546	**-0.914***	-0.499	**-0.754***	-0.27
Adj. R^2	**0.081**	**0.119**	**0.171**	**0.117**	**0.204**	**0.258**
H_0: $\varphi_{ij} = 0$ for all $i \neq j$	**1219.83****					

The effect of news announcements on the magnitude of IV spillovers

The effect on the magnitude of IV spillovers

- We investigate the effect of news announcements on the magnitude of IV spillovers.
  - ❑ Surprise effect.
  - ❑ Aggregate & regional news announcements.

- We employ a VAR model that allows for the matrix of the coefficients of the AR terms to be affected by releases.

Aggregate releases & the size of IV spillovers

- ***H5:*** Aggregate releases do not have a surprise effect on the ***magnitude*** of IV spillovers

$$\Delta IV_t = C + \left(A + B\left|S_t\right|\right)\Delta IV_{t-1} + \varepsilon_t$$

A is significant & B is insignificant	→	*Releases do not affect the magnitude of IV spillovers*
Both A & B are significant	→	*Releases affect the magnitude of IV spillovers*

Aggregate releases: Size of spillovers from EU to U.S.

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
C	-0.024	-0.035	-0.019	-0.037	0.011	-0.011
ΔVIX_{t-1}	0.017	**0.355****	**0.414****	**0.367****	**0.380****	**0.220****
$\Delta VDAX_{t-1}$	-0.134	**-0.225****	-0.085	-0.022	-0.060	**0.156****
$\Delta VCAC_{t-1}$	0.032	0.048	**-0.400****	-0.007	0.022	0.043
$\Delta VAEX_{t-1}$	-0.105	**-0.151****	**0.150***	**-0.445****	-0.042	**-0.284****
$\Delta VBEL_{t-1}$	**0.435****	**0.284****	-0.079	**0.172****	**-0.304****	**0.254****
$\Delta VSMI_{t-1}$	**-0.408****	**-0.138***	0.115	0.074	0.061	-0.033
$\|S_t\|*\Delta VIX_{t-1}$	**0.089****	0.029	0.058	-0.031	**0.056***	0.009
$\|S_t\|*\Delta VDAX_{t-1}$	**0.205****	**0.164****	**0.205****	**0.171****	**0.172****	**0.123****
$\|S_t\|*\Delta VCAC_{t-1}$	**-0.112****	0.000	**0.065***	**-0.079****	**-0.053***	0.008
$\|S_t\|*\Delta VAEX_{t-1}$	-0.058	**-0.124****	**-0.174****	0.079	**-0.077***	-0.033
$\|S_t\|*\Delta VBEL_{t-1}$	**-0.103****	**-0.136****	-0.009	**-0.085***	-0.006	-0.043
$\|S_t\|*\Delta VSMI_{t-1}$	**0.099***	0.059	**-0.093***	**-0.083***	**-0.091***	**-0.137****
Adj. R^2	**0.109**	**0.124**	**0.178**	**0.124**	**0.206**	**0.255**

Aggregate releases: Size of spillovers within Euro area

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
C	-0.024	-0.035	-0.019	-0.037	0.011	-0.011
ΔVIX_{t-1}	0.017	**0.355****	**0.414****	**0.367****	**0.380****	**0.220****
$\Delta VDAX_{t-1}$	-0.134	**-0.225****	-0.085	-0.022	-0.060	**0.156****
$\Delta VCAC_{t-1}$	0.032	0.048	**-0.400****	-0.007	0.022	0.043
$\Delta VAEX_{t-1}$	-0.105	**-0.151****	**0.150***	**-0.445****	-0.042	**-0.284****
$\Delta VBEL_{t-1}$	**0.435****	**0.284****	-0.079	**0.172****	**-0.304****	**0.254****
$\Delta VSMI_{t-1}$	**-0.408****	**-0.138***	0.115	0.074	0.061	-0.033
$\lvert S_t\rvert * \Delta VIX_{t-1}$	**0.089****	0.029	0.058	-0.031	**0.056***	0.009
$\lvert S_t\rvert * \Delta VDAX_{t-1}$	**0.205****	**0.164****	**0.205****	**0.171****	**0.172****	**0.123****
$\lvert S_t\rvert * \Delta VCAC_{t-1}$	**-0.112****	0.000	**0.065***	**-0.079****	**-0.053***	0.008
$\lvert S_t\rvert * \Delta VAEX_{t-1}$	-0.058	**-0.124****	**-0.174****	0.079	**-0.077***	-0.033
$\lvert S_t\rvert * \Delta VBEL_{t-1}$	**-0.103****	**-0.136****	-0.009	**-0.085***	-0.006	-0.043
$\lvert S_t\rvert * \Delta VSMI_{t-1}$	**0.099***	0.059	**-0.093***	**-0.083***	**-0.091***	**-0.137****
Adj. R^2	**0.109**	**0.124**	**0.178**	**0.124**	**0.206**	**0.255**

Aggregate releases: Size of spillovers from U.S. to EU

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
C	-0.024	-0.035	-0.019	-0.037	0.011	-0.011
ΔVIX_{t-1}	0.017	**0.355****	**0.414****	**0.367****	**0.380****	**0.220****
$\Delta VDAX_{t-1}$	-0.134	**-0.225****	-0.085	-0.022	-0.060	**0.156****
$\Delta VCAC_{t-1}$	0.032	0.048	**-0.400****	-0.007	0.022	0.043
$\Delta VAEX_{t-1}$	-0.105	**-0.151****	**0.150***	**-0.445****	-0.042	**-0.284****
$\Delta VBEL_{t-1}$	**0.435****	**0.284****	-0.079	**0.172****	**-0.304****	**0.254****
$\Delta VSMI_{t-1}$	**-0.408****	**-0.138***	0.115	0.074	0.061	-0.033
$\|S_t\|*\Delta VIX_{t-1}$	**0.089****	0.029	0.058	-0.031	**0.056***	0.009
$\|S_t\|*\Delta VDAX_{t-1}$	**0.205****	**0.164****	**0.205****	**0.171****	**0.172****	**0.123****
$\|S_t\|*\Delta VCAC_{t-1}$	**-0.112****	0.000	**0.065***	**-0.079****	**-0.053***	0.008
$\|S_t\|*\Delta VAEX_{t-1}$	-0.058	**-0.124****	**-0.174****	0.079	**-0.077***	-0.033
$\|S_t\|*\Delta VBEL_{t-1}$	**-0.103****	**-0.136****	-0.009	**-0.085***	-0.006	-0.043
$\|S_t\|*\Delta VSMI_{t-1}$	**0.099***	0.059	**-0.093***	**-0.083***	**-0.091***	**-0.137****
Adj. R^2	**0.109**	**0.124**	**0.178**	**0.124**	**0.206**	**0.255**

Regional releases & the size of IV spillovers

- ***H6:*** Regional releases do not have a surprise effect on the magnitude of IV spillovers.

$$\Delta IV_t = C + \left(A + B\left|S_t^{US}\right| + \Gamma\left|S_t^{EU}\right|\right)\Delta IV_{t-1} + \varepsilon_t$$

A is significant and B & Γ are insignificant	→	*Releases <u>do not</u> affect the magnitude of IV spillovers*
Both A & B are significant	→	*US releases affect the magnitude of IV spillovers*
Both A & Γ are significant	→	*European releases affect the magnitude of IV spillovers*

Regional releases: Size of spillovers from EU to U.S.

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
C	-0.014	-0.034	-0.003	-0.034	0.015	-0.008
ΔVIX_{t-1}	0.018	**0.360****	**0.433****	**0.367****	**0.384****	**0.224****
$\Delta VDAX_{t-1}$	**-0.144***	**-0.228****	-0.085	-0.029	-0.067	**0.142****
$\Delta VCAC_{t-1}$	0.032	0.045	**-0.398****	-0.009	0.018	0.038
$\Delta VAEX_{t-1}$	-0.097	**-0.138****	**0.163****	**-0.439****	-0.031	**-0.262****
$\Delta VBEL_{t-1}$	**0.436****	**0.286****	-0.073	**0.169****	**-0.311****	**0.245****
$\Delta VSMI_{t-1}$	**-0.409****	**-0.153***	0.081	0.08	0.067	-0.027
$\|S^{US}_t\|*\Delta VIX_{t-1}$	**0.103****	**0.105****	0.055	0.003	**0.073****	**0.093****
$\|S^{US}_t\|*\Delta VDAX_{t-1}$	**0.122***	**0.122****	**0.138****	**0.150****	**0.162***	**0.083***
$\|S^{US}_t\|*\Delta VCAC_{t-1}$	**-0.077***	-0.027	0.051	**-0.101****	-0.046	-0.017
$\|S^{US}_t\|*\Delta VAEX_{t-1}$	-0.022	-0.094	-0.021	0.1	-0.002	**0.078***
$\|S^{US}_t\|*\Delta VBEL_{t-1}$	-0.06	**-0.219****	**-0.129***	-0.068	-0.056	**-0.138****
$\|S^{US}_t\|*\Delta VSMI_{t-1}$	0.08	**0.109***	-0.089	**-0.098***	**-0.163****	**-0.219****
$\|S^{EU}_t\|*\Delta VIX_{t-1}$	-0.033	**-0.141****	0.041	**-0.120***	-0.007	**-0.196****
$\|S^{EU}_t\|*\Delta VDAX_{t-1}$	**0.724****	**0.417****	**0.636****	**0.335****	**0.227***	**0.341****
$\|S^{EU}_t\|*\Delta VCAC_{t-1}$	**-0.131****	-0.061	0.025	-0.028	**-0.082***	-0.038
$\|S^{EU}_t\|*\Delta VAEX_{t-1}$	**-0.294****	-0.141	**-0.560****	0.005	**-0.173***	**-0.146***
$\|S^{EU}_t\|*\Delta VBEL_{t-1}$	**-0.260****	-0.03	0.121	**-0.185****	0.075	0.077
$\|S^{EU}_t\|*\Delta VSMI_{t-1}$	-0.01	-0.055	**-0.195***	-0.087	0.006	-0.048

Regional releases: Size of spillovers within Euro area

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
C	-0.014	-0.034	-0.003	-0.034	0.015	-0.008
ΔVIX_{t-1}	0.018	**0.360****	**0.433****	**0.367****	**0.384****	**0.224****
$\Delta VDAX_{t-1}$	**-0.144***	**-0.228****	-0.085	-0.029	-0.067	**0.142****
$\Delta VCAC_{t-1}$	0.032	0.045	**-0.398****	-0.009	0.018	0.038
$\Delta VAEX_{t-1}$	-0.097	**-0.138****	**0.163****	**-0.439****	-0.031	**-0.262****
$\Delta VBEL_{t-1}$	**0.436****	**0.286****	-0.073	**0.169****	**-0.311****	**0.245****
$\Delta VSMI_{t-1}$	**-0.409****	**-0.153***	0.081	0.08	0.067	-0.027
$\lvert S^{US}_t\rvert*\Delta VIX_{t-1}$	**0.103****	**0.105****	0.055	0.003	**0.073****	**0.093****
$\lvert S^{US}_t\rvert*\Delta VDAX_{t-1}$	**0.122***	**0.122****	**0.138****	**0.150****	**0.162***	**0.083***
$\lvert S^{US}_t\rvert*\Delta VCAC_{t-1}$	**-0.077***	-0.027	0.051	**-0.101****	-0.046	-0.017
$\lvert S^{US}_t\rvert*\Delta VAEX_{t-1}$	-0.022	-0.094	-0.021	0.1	-0.002	**0.078***
$\lvert S^{US}_t\rvert*\Delta VBEL_{t-1}$	-0.06	**-0.219****	**-0.129***	-0.068	-0.056	**-0.138****
$\lvert S^{US}_t\rvert*\Delta VSMI_{t-1}$	0.08	**0.109***	-0.089	**-0.098***	**-0.163****	**-0.219****
$\lvert S^{EU}_t\rvert*\Delta VIX_{t-1}$	-0.033	**-0.141****	0.041	**-0.120***	-0.007	**-0.196****
$\lvert S^{EU}_t\rvert*\Delta VDAX_{t-1}$	**0.724****	**0.417****	**0.636****	**0.335****	**0.227***	**0.341****
$\lvert S^{EU}_t\rvert*\Delta VCAC_{t-1}$	**-0.131****	-0.061	0.025	-0.028	**-0.082***	-0.038
$\lvert S^{EU}_t\rvert*\Delta VAEX_{t-1}$	**-0.294****	-0.141	**-0.560****	0.005	**-0.173***	**-0.146***
$\lvert S^{EU}_t\rvert*\Delta VBEL_{t-1}$	**-0.260****	-0.03	0.121	**-0.185****	0.075	0.077
$\lvert S^{EU}_t\rvert*\Delta VSMI_{t-1}$	-0.01	-0.055	**-0.195***	-0.087	0.006	-0.048

Regional releases: Size of spillovers from U.S. to EU

	ΔVIX_t	$\Delta VDAX_t$	$\Delta VCAC_t$	$\Delta VAEX_t$	$\Delta VBEL_t$	$\Delta VSMI_t$
C	-0.014	-0.034	-0.003	-0.034	0.015	-0.008
ΔVIX_{t-1}	0.018	**0.360****	**0.433****	**0.367****	**0.384****	**0.224****
$\Delta VDAX_{t-1}$	**-0.144***	**-0.228****	-0.085	-0.029	-0.067	**0.142****
$\Delta VCAC_{t-1}$	0.032	0.045	**-0.398****	-0.009	0.018	0.038
$\Delta VAEX_{t-1}$	-0.097	**-0.138****	**0.163****	**-0.439****	-0.031	**-0.262****
$\Delta VBEL_{t-1}$	**0.436****	**0.286****	-0.073	**0.169****	**-0.311****	**0.245****
$\Delta VSMI_{t-1}$	**-0.409****	**-0.153***	0.081	0.08	0.067	-0.027
$\|S^{US}_t\|*\Delta VIX_{t-1}$	**0.103****	**0.105****	0.055	0.003	**0.073****	**0.093****
$\|S^{US}_t\|*\Delta VDAX_{t-1}$	**0.122***	**0.122****	**0.138****	**0.150****	**0.162***	**0.083***
$\|S^{US}_t\|*\Delta VCAC_{t-1}$	**-0.077***	-0.027	0.051	**-0.101****	-0.046	-0.017
$\|S^{US}_t\|*\Delta VAEX_{t-1}$	-0.022	-0.094	-0.021	0.1	-0.002	**0.078***
$\|S^{US}_t\|*\Delta VBEL_{t-1}$	-0.06	**-0.219****	**-0.129***	-0.068	-0.056	**-0.138****
$\|S^{US}_t\|*\Delta VSMI_{t-1}$	0.08	**0.109***	-0.089	**-0.098***	**-0.163****	**-0.219****
$\|S^{EU}_t\|*\Delta VIX_{t-1}$	-0.033	**-0.141****	0.041	**-0.120***	-0.007	**-0.196****
$\|S^{EU}_t\|*\Delta VDAX_{t-1}$	**0.724****	**0.417****	**0.636****	**0.335****	**0.227***	**0.341****
$\|S^{EU}_t\|*\Delta VCAC_{t-1}$	**-0.131****	-0.061	0.025	-0.028	**-0.082***	-0.038
$\|S^{EU}_t\|*\Delta VAEX_{t-1}$	**-0.294****	-0.141	**-0.560****	0.005	**-0.173***	**-0.146***
$\|S^{EU}_t\|*\Delta VBEL_{t-1}$	**-0.260****	-0.03	0.121	**-0.185****	0.075	0.077
$\|S^{EU}_t\|*\Delta VSMI_{t-1}$	-0.01	-0.055	**-0.195***	-0.087	0.006	-0.048

The effect of the financial crisis

- The results are robust over the financial crisis period (Aug 2007- Dec 2010).

- IV spillovers are significant, after the effect of releases is considered.
  - Aggregate releases: Affect the dynamics of some European IV indices.
  - Regional releases: Only European releases affect IV indices.
  - Individual releases: Most release items are insignificant.
  - Volatility contagion is more pronounced over the crisis period.

- Releases affect the magnitude of IV spillovers.

The effect of the financial crisis

- **Alternative test of contagion (Bae et al., 2003).**
  - ❑ Impact of releases on the joint occurrence of extreme *positive* changes in IV (co-exceedances).

- Exceedance in IV: $\Delta IV > 95^{th}$ percentage point of the empirical marginal distribution of each IV index over the crisis period.

- (Co)-exceedances, *Y*: Counts the number of (co)-exceedances & takes the value *i* when there are exceedances in *i* IV indices jointly on day *t*.
  - ❑ U.S. & European indices, separately.
  - ❑ All indices jointly.

The effect of the financial crisis

$$P(Y=i|x)=\frac{e^{g_i(x)}}{\sum_{j=0}^{k} e^{g_j(x)}} \qquad g_i(x)=\ln\frac{P(Y=i|x)}{P(Y=0|x)}=c+\beta_i' x$$

- We consider two specifications for $g_i(x)$.

$$g_i(x_t)=c_i+\beta_{i1}Y_{t-1}^{US}+\beta_{i2}Y_{t-1}^{EU}+\beta_{i3}|S_t|$$

$$g_i(x_t)=c_i+\beta_{i1}Y_{t-1}^{US}+\beta_{i2}Y_{t-1}^{EU}+\beta_{i3}|S_t^{US}|+\beta_{i4}|S_t^{EU}|$$

	Panel A: Aggregate releases			Panel B: Regional releases		
	VIX	EU indices	All indices	VIX	EU indices	All indices
Constant	**655.426^{++}**	**1237.570^{++}**	**1268.340^{++}**	**655.143^{++}**	**1233.815^{++}**	**1266.555^{++}**
Y^{US}_{t-1}	187.375	**371.629^{++}**	**412.560^{++}**	186.088	**367.043^{++}**	**408.688^{++}**
Y^{EU}_{t-1}	**194.344^{++}**	**363.393^{++}**	**407.661^{+}**	**193.692^{++}**	**360.342^{++}**	**405.379^{+}**
$\|S_t\|$	188.73	356.137	403.076	-	-	-
$\|S_t^{US}\|$	-	-	-	185.524	351.663	396.232
$\|S_t^{EU}\|$	-	-	-	188.722	352.864	401.416

Conclusions

- IV spillovers exist.
  - U.S. volatility affects European IV indices.

- Effect of news announcements on IV spillovers.
  - The European releases are significant.
  - IV spillovers exist even after the effect of releases is considered.
  - IV drops where aggregate & regional releases are significant.

- Effect of news announcements on the size of IV spillovers.
  - Releases affect the size of IV spillovers.

- The results are robust over the 2007-2010 financial crisis.

Implications

- Volatility contagion is present.

- Resolution of uncertainty.
  - On announcement days VaR is expected to decrease.
  - High margins may appear to be too conservative.

- Private information may be more important than public information.

Thank you for your

attention & time!!!