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The Joint Behavior of Credit Spreads, Stock Options and Equity Returns when Investors Disagree

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Merton (1974) structural model:

Corporate bonds and individual stock options can be replicated by a dynamic strategy in the underlying stock and the risk-free bond.

Credit spreads are monotonically

1. **decreasing** in the stock price
2. **increasing** in the option-implied stock volatility

Capital structure arbitrage:

One could buy / sell credit default swaps (CDS) and use equities (or a derivative on the equity) to dynamically delta hedge the position.

Unfortunately, 15% of the time this relationship is empirically violated.

May 2005

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General Motors (GM) and Ford get **downgraded** to junk status by S&P.

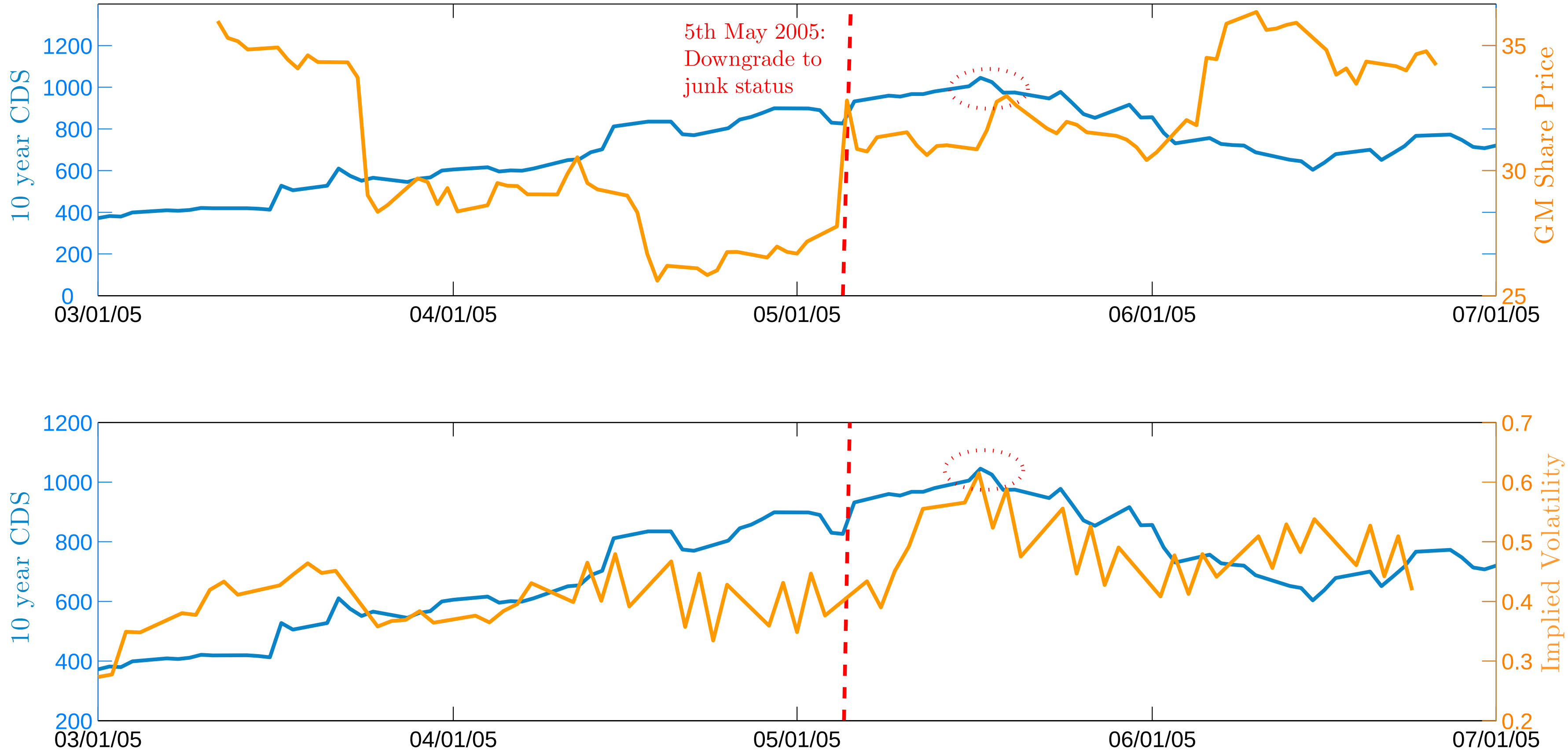
Before the downgrade:

- Many hedge funds **shorted** CDS on GM and hedged their exposure by shorting the equity.
- **Wider** credit spreads were expected to be accompanied by a **drop** in $S(t)$ and / or an **increase** in implied option volatility.

After the downgrade:

- Spreads on a 10 year CDS **increased** by 200 bp in one month.
- Implied Volatility of short-term ATM options on GM **increased** by 50% to reach 62.73%.
- But the stock price **rose** almost 25% up to USD 32.75.

Markets


5th May 2005:
Downgrade to
junk status
10 year CDS
GM Share Price
Implied Volatility
03/01/05
04/01/05
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Beliefs Disagreement

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The classical complete markets argument **misses a key priced risk factor**.

We think this is **uncertainty**, inducing a difference in beliefs.

During the GM's major credit event, for instance, beliefs disagreement on GMs future earnings:

more than doubled from 0.21 to 0.49.

This additional risk factor suggests the existence of a far less trivial link between credit, option, and stock markets.

Our goal:

We study theoretically and empirically the joint behavior of

- ☐ credit spreads,
- ☐ option implied volatility, and
- ☐ stock markets.

Theoretical Findings

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1. What is the economic importance of divergence of opinions for credit spreads?
   We extend the most recent literature on the "credit spreads puzzle". In a general equilibrium with divergence of opinions, we can support more realistic credit spreads, even for low levels of RRA.

2. Why do corporate credit spreads and the volatility of stock returns co-move?
   The model offers a simple structural explanation for the positive empirical link between the volatility of stock returns, the implied volatility of individual stock options, and corporate credit spreads.

3. How does divergence of opinions affect the shape of the implied volatility surface of single-stock options?
   We provide an economic rationale for why the slopes of individual stock option smiles can reverse sign.

4. Are no-arbitrage violations of one-factor models puzzling?
   Beliefs disagreement might explain no-arbitrage violations by single-factor models for credit spreads and individual stock-options.

Empirical Findings

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1. We find a strong positive relation between divergence of opinions and credit spreads.
   $\Rrightarrow$ Beliefs disagreement dominates other commonly used variables, in terms of explanatory power, such as option-implied volatilities and proxies for pure cash flows uncertainty.

2. We find that the relation between divergence of opinions and equity prices indeed depends on the leverage of the firm.
   $\Rrightarrow$ Beliefs disagreement dominates in terms of explanatory power other proxies of pure cash flows uncertainty.

3. Disagreement increases the implied volatility of at-the-money single-stock options.
   $\Rrightarrow$ Moreover, it impacts significantly on both the left and the right part of the smile.

4. The main model predictions are supported by the data.

Main Intuition

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In a standard economy with **common** beliefs dQ we have:

$$\sup_{c_1+c_2=A} \int U(c^1(t))dQ + \int U(c^2(t))dQ.$$

Optimal allocation condition implies that:

$$U'(c^1(t)) = U'(c^2(t)).$$

However, if agents **disagree**, then

$$\sup_{c_1+c_2=A} \int \left[U(c^1(t))dQ^1 + U(c^2(t))\frac{dQ^2}{dQ^1} \right] dQ^1$$

which implies that

$$U'(c^1(t)) = \lambda(t)U'(c^2(t)),$$

where $\lambda(t)$ is a **function of difference in beliefs**.

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Aggregation yields:

$$W = U(c^1(t)) + \underbrace{\lambda(t)}_{\text{stochastic}} \; U(c^2(t)).$$

Changes in difference in beliefs have **real effects**:

- $\xi(t)$ is affected by $\lambda(t) = \frac{dQ_2}{dQ_1}$: Uncertainty is **priced**.
- Implications for **Hansen-Jagannathan bounds**: If $\lambda(t)$ is volatile, asset prices can be violated.
- Agents have different beliefs, thus different efficient frontiers: In general, the CAPM will be **violated**.
- We are interested about the implications for **structural models**.

Related Literature

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Structural credit risk model: Merton (1974), Black and Cox (1976), Longstaff and Schwartz (1995), Leland and Toft (1996), Collin-Dufresne and Goldstein (2001), Schaefer and Strebulaev (2006), Cremers, Driessen, and Maenhout (2007).

$\Rrightarrow$ They document a systematic risk factor missing in structural models, such as Fama/French factors, flight-to-liquidity or jump risk.

Empirical option pricing: Bakshi, Cao, and Chen (2000), Pérignon (2006), Bakshi, Kapadia, and Madan (2003), Toft and Prucyk (1997), Buraschi and Jiltsov (2006).

$\Rrightarrow$ They document the differential pricing of index and individual options, and the importance of beliefs dispersion for pricing index options.

Heterogenous beliefs asset pricing: Detemple and Murthy (1994), Zapatero (1998), Scheinkman and Xiong (2003), Basak (2000), Buraschi and Jiltsov (2006), Dumas, Kurshev, and Uppal (2007).

$\Rrightarrow$ They study the equilibrium impact of disagreement with no particular focus on credit risk.

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- Start from simple G.E. Lucas economy with a single firm having a simple debt structure, identical preferences, and initial endowments.
- Assume that the growth rate of firm assets cash flows is stochastic, thus to be estimated, in an incomplete market setting.
- Suppose that two agents, 1 and 2, have different beliefs on this growth rate.
- The two agents select different portfolios and trading occurs.
- The more pessimistic agent buys protection from the optimistic against the default event.
- Beliefs disagreement drives simultaneously the firm value, equity, corporate bonds and individual options prices, as well as open interest.
- The model produces endogenously a firm value stochastic volatility and risk neutral skewness.

The Economy's State Variables

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Observed state space: Firm's exogenous cash flows $A(t)$, with dynamics:

$$\begin{aligned} d\log A(t) &= \mu_A(t)dt + \sigma_A dW_A(t), \\ d\mu_A(t) &= (a_{0A} + a_{1A}\mu_A(t))dt + e_A dW_{\mu_A}(t), \end{aligned}$$

and a signal $z(t)$, with dynamics:

$$\begin{aligned} dz(t) &= (\alpha\mu_A(t) + \beta\mu_z(t))dt + \sigma_z dW_z(t), \\ d\mu_z(t) &= (a_{0z} + a_{1z}\mu_z(t))dt + e_z dW_{\mu_z}(t). \end{aligned}$$

The growth rate of the firm cash flows and the signal are unobserved by agents in the economy.
$\Rrightarrow$ The subjective expected growth rate of cash flows and signals is:

$$m^i(t) := (m^i_A(t), m^i_z(t))' := E^i\left((\mu_A(t), \mu_z(t))' | \mathcal{F}^Y_t\right)$$

where $\mathcal{F}^Y_t := \mathcal{F}^{A,z}_t$.
$\Rrightarrow$ Agents might interpret the same information about $A(t)$ and $z(t)$ differently.

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Subjective beliefs: Let $Y(t) = (\log A(t), z(t))$. The beliefs dynamics of agent i have the functional form:

$$\begin{aligned} dm^i(t) &= (a_0 + a_1 m^i(t))dt + \gamma^i(t) A_1' B^{-1} dW_Y^i(t), \\ d\gamma^i(t)/dt &= a_1 \gamma^i(t) + \gamma^i(t) a_1' + bb' - \gamma^i(t) A_1' (BB')^{-1} A_1 \gamma^1(t), \end{aligned}$$

with initial conditions $m^i(0) = m_0^i$ and $\gamma^i(0) = \gamma_0^i$, where

$$dW_Y^i(t) := B^{-1}\left(dY(t) - \left(A_0 + A_1 m^i(t)\right) dt\right),$$

is the innovation process induced by investor's i belief and filtration.

Disagreement process: The process

$$\Psi(t) := \begin{pmatrix} \Psi_A(t) \\ \Psi_z(t) \end{pmatrix} = \begin{pmatrix} (m_A^1(t) - m_A^2(t))/\sigma_A \\ (m_z^1(t) - m_z^2(t))/\sigma_z \end{pmatrix}, \tag{1}$$

is the disagreement process in the economy.

$\Rightarrow$ $\Psi_A(t)$ ($\Psi_z(t)$) measures the disagreement about the expected growth rate of firm cash flows (signals). Both components are normalized by their risk.

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Preferences: Two groups of investors with life-time utility:

$$V^i = \sup_{c_i} \; E^i \left(\int_0^\infty e^{-\rho t} \frac{c_i(t)^{1-\gamma}}{1-\gamma} dt \, \Big| \mathcal{F}_0^Y \right), \qquad (2)$$

where $c_i(t)$ is the consumption of agent $i = 1, 2$ and $\rho \geq 0$ is the time preference rate.

Financial market: An incomplete market, completed by the firm's capital structure:

- A risk-free bond and a European stock option (in zero net supply)
- A senior, a junior corporate bond and a stock (in positive supply).

Definition 1 *An equilibrium consists of a unique stochastic discount factor such that*

1. *given equilibrium prices, all agents in the economy solve the optimization problem (2), subject to their budget constraint.*
2. *Good and financial markets clear.*

Aggregation of Equilibrium

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Equilibrium in our economy:

The probabilistic approach originally developed by Cox and Huang (1986) is extended to the case of heterogeneous beliefs; see among others Cuoco and He (1994), Karatzas and Shreve (1998), and Basak and Cuoco (1998).

$\Rrightarrow$ The equilibrium can be conveniently attained by constructing a representative investor with a stochastic weighting process that captures the impact of the beliefs disagreement:

Representative investors utility function:

$$U\left(c(t), \lambda(t)\right) = \sup_{c(t)=c_1(t)+c_2(t)} \left\{ \frac{c_1(t)^{1-\gamma}}{1-\gamma} + \lambda(t) \frac{c_2(t)^{1-\gamma}}{1-\gamma} \right\},$$

where $\lambda(t) > 0$ is the stochastic weight that captures the impact of beliefs heterogeneity.

Equilibrium: State Price Densities and Optimal Consumption

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Proposition 1 *In equilibrium, the individual state price densities of agent one and two are:*

$$\begin{aligned}\xi^1(t) &= \frac{e^{-\rho t}}{y_1} A(t)^{-\gamma}\left(1+\lambda(t)^{1/\gamma}\right)^{\gamma},\\ \xi^2(t) &= \frac{e^{-\rho t}}{y_2} A(t)^{-\gamma}\left(1+\lambda(t)^{1/\gamma}\right)^{\gamma}\lambda(t)^{-1},\end{aligned}$$

where the weighting process $\lambda(t) = y_1\xi^1(t)/(y_2\xi^2(t))$ *follows the dynamics:*

$$\frac{d\lambda(t)}{\lambda(t)} = -\Psi_A(t)dW_A^1(t) - \left(\alpha\Psi_A(t)\frac{\sigma_A}{\sigma_z} + \beta\Psi_z(t)\right)dW_z^1(t)\,. \quad (3)$$

The individual optimal consumption policies are:

$$c_1(t) = A(t)\left(1+\lambda(t)^{1/\gamma}\right)^{-1}, \quad c_2(t) = A(t)\lambda(t)^{1/\gamma}\left(1+\lambda(t)^{1/\gamma}\right)^{-1}.$$

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- The individual state price density and consumption are functions of the exogenous cash flow and disagreement processes $A(t)$ and $\lambda(t)$.

  $\Rrightarrow$ The **joint distribution** of $(A(t), \lambda(t))$ is needed to characterize the prices of financial assets.

- The correlation between cash flows and disagreement shocks depends on the sign of $\Psi(t)$; Given $\Psi_A(t) > 0$ a negative cash flow shock has two effects:

  1. Total wealth effect: Overall consumption decreases
  2. Relative wealth effect: $\lambda(t)$ increases, making the pessimist's consumption share relative larger.

  $\Rrightarrow$ Mr. Pareto plan (change in $\lambda(t)$) is implementable with OTM puts on the firm value.
  $\Rrightarrow$ The optimistic agent ex-ante insures the pessimistic agent against the hidden default risk in the economy.

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Equilibrium firm value:

$$V(t) = A(t)E_t^1\left(\int_t^\infty e^{-\rho(u-t)}\frac{\xi^1(u)}{\xi^1(t)}\frac{A(u)}{A(t)}du\right),$$

Price of senior bond:

$$B^s(t,T) = K_1 B(t,T) - E_t^1\left(e^{-\rho(T-t)}\frac{\xi^1(T)}{\xi^1(t)}\left(K_1 - V(T)\right)^+\right),$$

Price of junior bond (mezzanine):

$$B^j(t,T) = Call(V;K_1) - Call(V;K_1+K_2),$$

Price of equity:

$$S(t) = V(t) - B^s(t,T) - B^j(t,T)\ ,$$

Price of an European call option on the stock:

$$O(t,T) = E_t^1\left(e^{-\rho(T-t)}\frac{\xi^1(T)}{\xi^1(t)}(S(T)-K_e)^+\right).$$

Pricing of Financial assets cont'd

Proposition 2 *The Laplace transform of $A(t)$ and $\lambda(t)$ is given by:*

$$E_t^1\left(\left(\frac{A(T)}{A(t)}\right)^{\epsilon}\left(\frac{\lambda(T)}{\lambda(t)}\right)^{\chi}\right) = F_{m_A^1}(m_A^1, t, T; \epsilon) F_{\Psi_A, \Psi_z}(\Psi_A, \Psi_z, t, T; \epsilon, \chi),$$

where, for $\tau = T - t$:

$$\begin{aligned} F_{m_A^1}(m_A^1, t, T; \epsilon) &= \exp\left(\frac{\epsilon}{a_{1A}}\left(-a_{0A}\tau + \left(\frac{a_{0A}}{a_{1A}} + m_A^1\right)(e^{a_{1A}\tau} - 1)\right)\right. \\ &\quad + \frac{\epsilon(\epsilon-1)\sigma_A^2\tau}{2} \\ &\quad + \frac{\epsilon^2}{4a_{1A}^2}\left(\frac{\gamma_A^2(t)}{\sigma_A}\right)^2\left(3 - 4e^{a_{1A}\tau} + e^{2a_{1A}\tau} + 2a_{1A}\tau\right) \\ &\quad \left. + \frac{\epsilon^2\gamma_A^2(t)}{a_{1A}}\left(-\tau + \frac{1}{a_{1A}}(e^{a_{1A}\tau} - 1)\right)\right) \\ F_{\Psi_A, \Psi_z}(\Psi_A, \Psi_z, t, T; \epsilon, \chi) &= e^{A_0(\tau) + B_1(\tau)\Psi_A + B_2(\tau)\Psi_z + C_1(\tau)\Psi_A^2 + C_2(\tau)\Psi_z^2 + D_0(\tau)\Psi_A\Psi_z}, \end{aligned}$$

for some functions $A_0, B_1, B_2, C_1, C_2, D_0$ known in closed-form.

Pricing

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By computing the **closed-form** Laplace transform of $A(t)$ and $\lambda(t)$, we can now price the contingent claims in the economy by Fourier inversion method.

For instance, now the firm value can be simplified as follows:

$$V(t) = A(t) \int_t^{\infty} e^{-\rho(u-t)} F_{m_A^1}(m_A^1, t, u; 1-\gamma) G(t, u, 1-\gamma; , \Psi_A, \Psi_z) du.$$

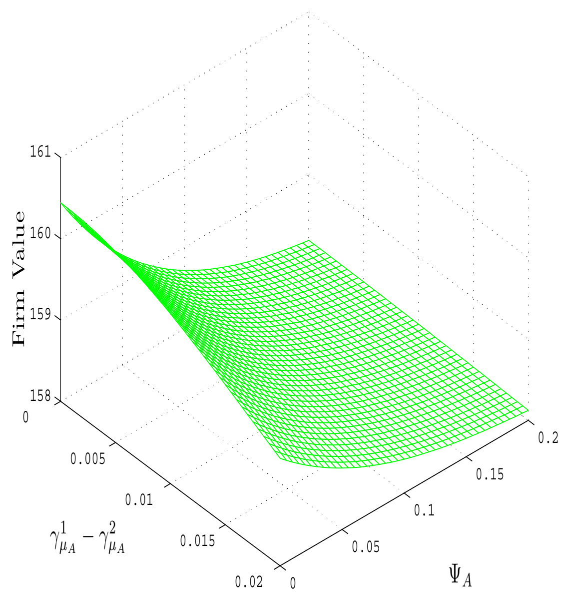
We hence obtain a **semi-explicit** description for the dependence of the prices of bonds, equity, and single-stock options on the disagreement about cash flows and the signal.

We use Fourier inversion instead of Monte Carlo, because it **decreases** computational time tremendously (240 secs for one data point on a Core 2 Quad 64 Bit processor).

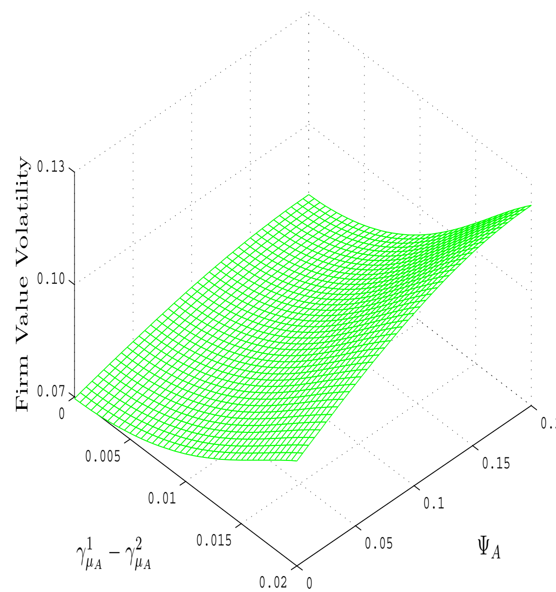
We set risk aversion equal to 2 and use a set of calibrated values. We then plot figures as a function of beliefs disagreement from zero to 0.2 (time-series average) and the difference in cash flow grow rate volatilities.

Firm Value and Firm Value Volatility

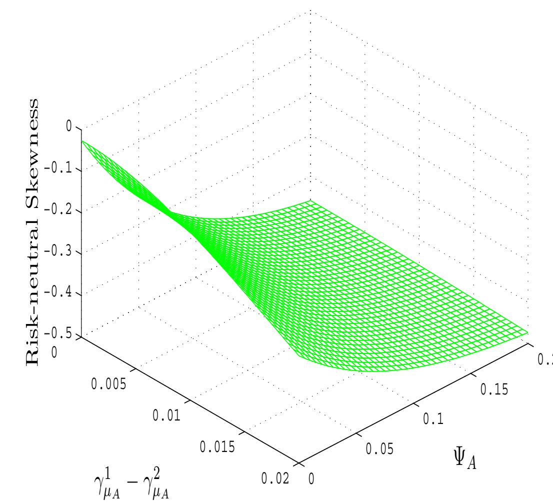
Firm Value



Firm Value Volatility



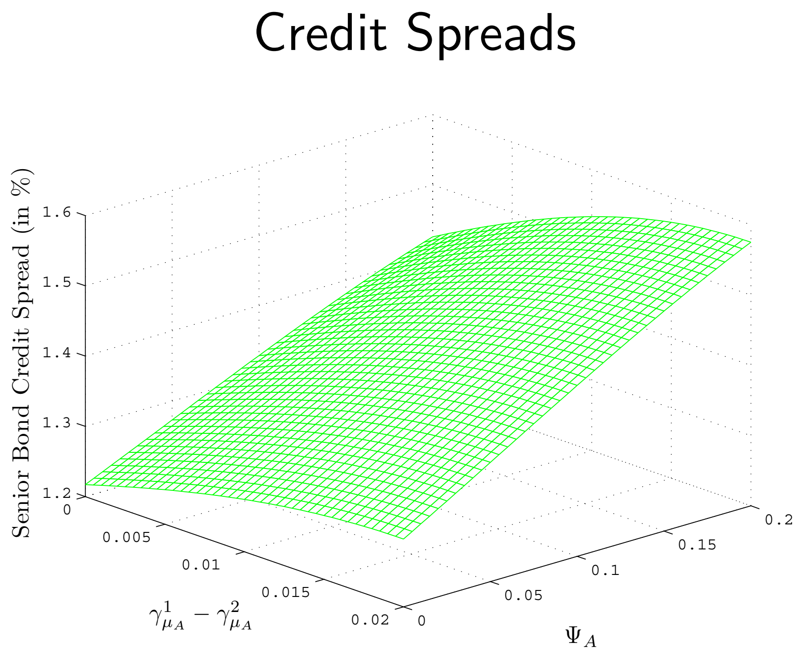
Firm Value Skewness

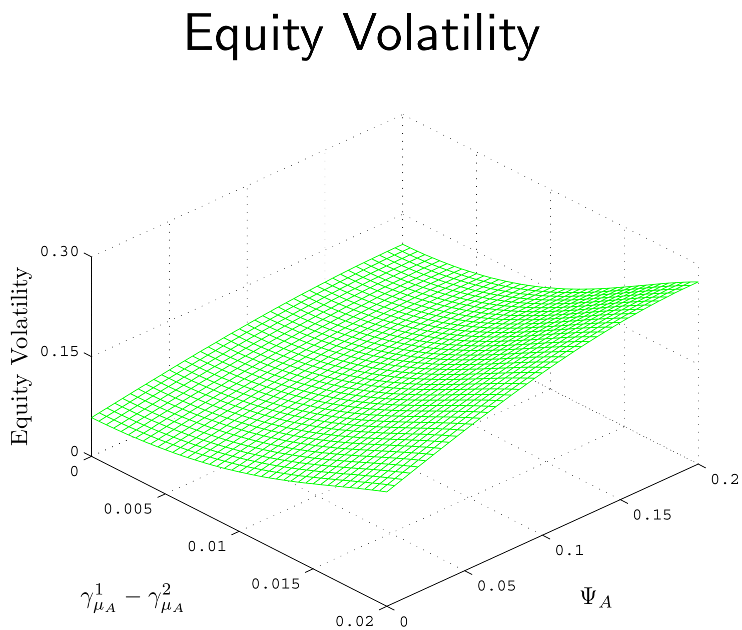


$\xi_i(t) = \frac{1}{y_i} e^{-\rho t} A(t)^{-\gamma} s_i(t)^{-\gamma}$, this is the stochastic discount factor for the optimist.

In good (bad) cash flow states the marginal utility of the optimist (pessimist) is lower, the present value is lower, which implies a lower equilibrium firm value.

Corporate Credit Spreads and Equity Volatility





Very important: Credit spreads and implied option volatility (endogenously) are positively correlated (Campbell and Taksler (2003), Cremers, Driessen, and Maenhout (2007))

Common factor is driving both: Difference in beliefs (see GM and Ford downgrade).

Equity = V - Debt

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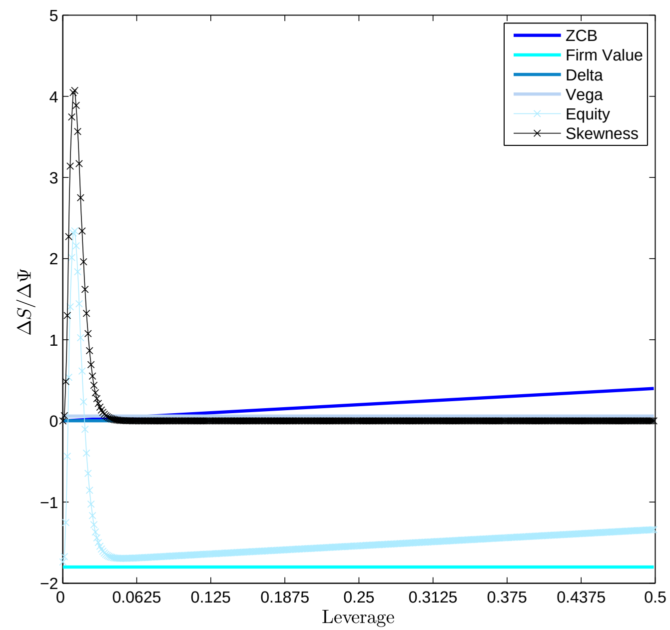

$$\underset{+/-}{\frac{dS}{d\Psi}} = \underset{-}{\frac{dV}{d\Psi}} - K_1 \cdot \underset{-}{\frac{dZCB}{d\Psi}} + \Big[\overbrace{\underset{-}{\frac{dP}{dV}} \cdot \underset{-}{\frac{dV}{d\Psi}}}^{\text{Delta: } +} + \overbrace{\underset{+}{\frac{dP}{d\sigma_V}} \cdot \underset{+}{\frac{d\sigma_V}{d\Psi}}}^{\text{Vega: } +} + \overbrace{\underset{-}{\frac{dP}{dSk_V}} \cdot \underset{-}{\frac{dSk_V}{d\Psi}}}^{\text{Skewness: } +} \Big].$$

V is monotonically **decreasing** in $\psi(t)$.

Put option effect dominates for low leverage because of **skewness effect**!

Equity Price and Risk-neutral Skewness

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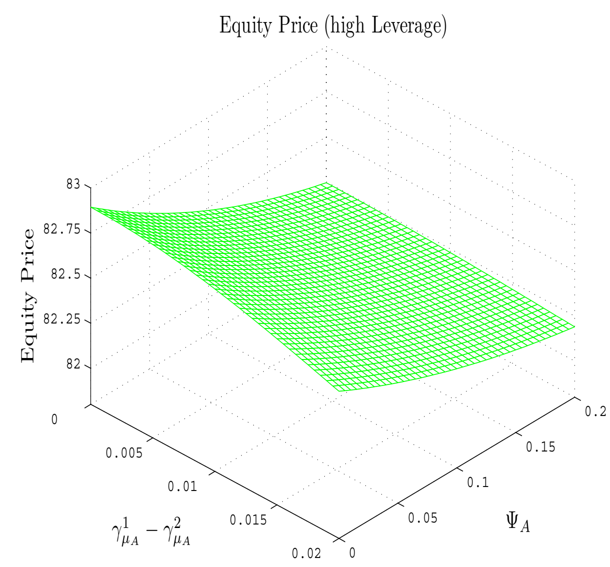
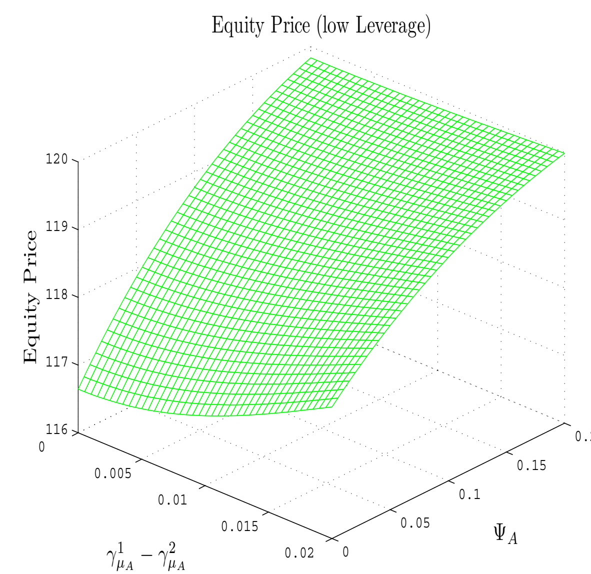
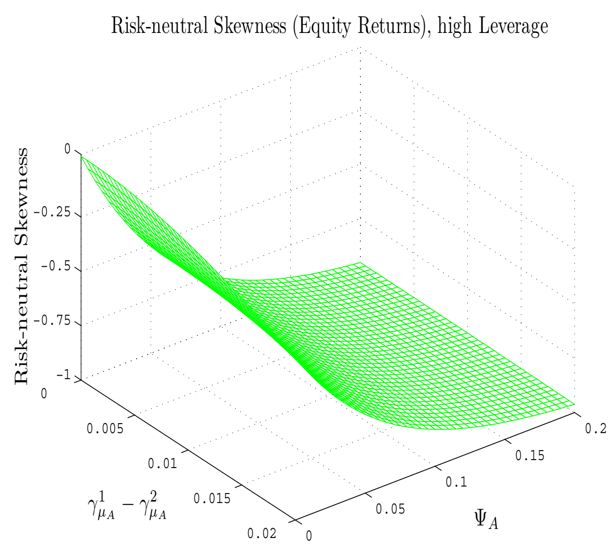
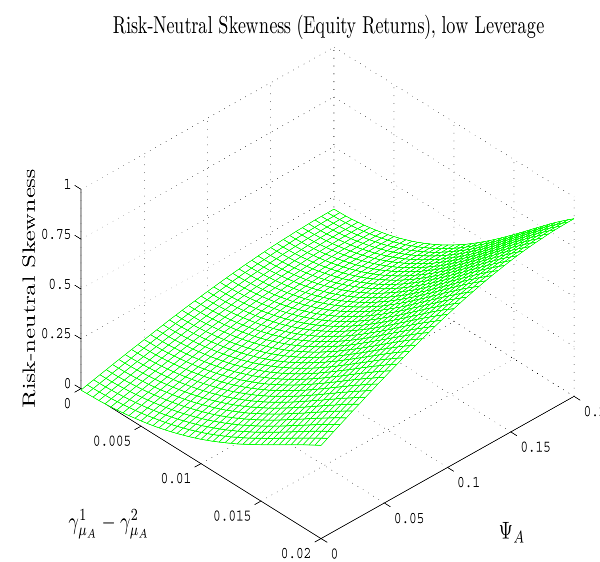
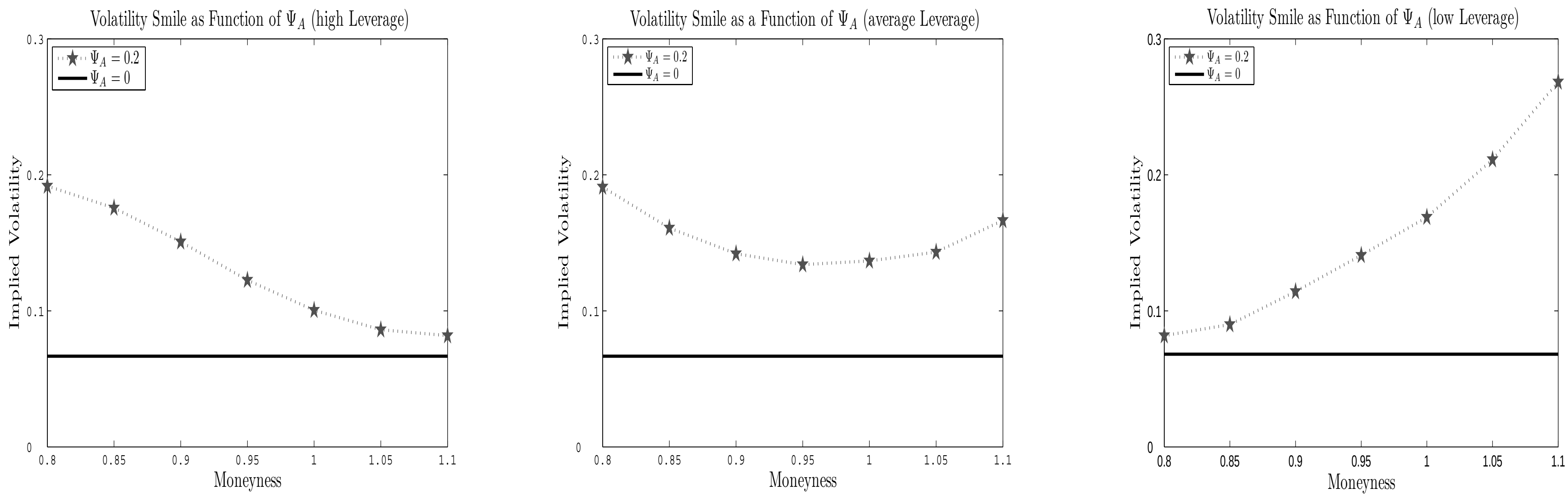








Option Implied Volatilities



In a standard Merton (1974) model ($\Psi(t) = 0$), the volatility is constant and the risk-neutral skewness of the stock returns is zero.

The different skewness patterns generate the smile in the implied volatilities of single-stock options.

An increase in $\psi(t)$ generates a skew / smile, even when the volatility of cash flows is constant.

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Merged data set:
Panel data of firm specific information on corporate bonds, implied volatility of stock options, stock returns and professional earning forecasts. The period runs from January 1996 to December 2004 and after merging all datasets we are left with 337 firms.

Bond data: The bond data is obtained from the Fixed Income Securities Database (FISD) on corporate bond characteristics and the National Association of Insurance Commissioners (NAIC) database on bond transactions.
$\Rrightarrow$ The FISD database contains issue and issuer-specific information for all U.S. corporate bonds.
$\Rrightarrow$ The NAIC data set contains all transactions on these bonds by life insurance, property and casualty insurance, and health maintenance companies.

Data Set cont'd

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Earning forecasts: We use analyst forecasts of earnings per share, from the Institutional Brokers Estimate System (I/B/E/S) database.
$\Rrightarrow$ This database contains individual analysts' forecasts organized by the date the forecasts was made and the last date the forecast was revised and confirmed as accurate.
$\Rrightarrow$ We proxy disagreement by the average difference in the available earnings forecasts, scaled by an indicator or earnings uncertainty.
$\Rrightarrow$ Since data on subjective earnings uncertainty are not available, we proxy earnings uncertainty by the cross-sectional standard deviation of earning forecasts.

Option data: Taken from OptionMetrics, LLC, database, which covers all exchange listed call and put options on US equities.
$\Rrightarrow$ In addition to the left skew, we also calculate the right skew of the smile.

Additional data: Stock returns and firm specific information, as well as macro-related and further control variables.

Empirical Results

Dependant	Cremers, Driessen and Maenhout	Collin-Dufresne, Goldstein, and Martin	Liquidity	Schaefer and Strebulaev	Full Model	Full Model w Disp
Constant	$140.57^{\star\star\star}$	$281.03^{\star\star\star}$	$217.70^{\star\star\star}$	$183.21^{\star\star\star}$	$-148.51^{\star\star\star}$	$111.21^{\star\star}$
Dispersion	$22.72^{\star\star}$	$16.69^{\star\star}$	$13.51^{\star\star}$	$28.91^{\star\star\star}$	$15.68^{\star\star\star}$	
Implied Volatility	49.49			168.45	14.12	$26.43^{\star\star\star}$
Implied Volatility Skew	-13.94				-6.16	$-15.09^{\star\star}$
Open Interest	$-0.17^{\star\star\star}$		$-0.13^{\star\star\star}$		$-0.10^{\star\star\star}$	$-0.15^{\star\star\star}$
Volume	$0.02^{\star\star\star}$		$0.01^{\star\star\star}$		$0.03^{\star\star\star}$	$0.03^{\star\star\star}$
Slope of Term Structure		$-6.06^{\star}$		3.65	-5.98	13.68
Risk-free Rate		$-25.42^{\star\star\star}$		$-22.85^{\star\star\star}$	-7.95	-10.64
S&P 500 Returns		-25.00			-3.91	-7.75
Non-Farm Payroll (/1000)		$-9.12^{\star\star\star}$			$-3.74^{\star\star\star}$	$-3.40^{\star\star\star}$
Stock Returns		-24.73		18.43	-30.12	-33.78
Stock Volume			10.35		8.85	5.25
Leverage (/1000)					$1.83^{\star\star\star}$	$2.06^{\star\star\star}$
Firm Size (/100)					$0.89^{\star\star\star}$	$0.57^{\star\star\star}$
Swap Rate (/100)			$-8.98^{\star\star\star}$		-0.38	-0.37
$R_m - R_f$				-0.57	-0.07	0.00
SMB				$0.84^{\star}$	0.14	0.05
HML				0.00	0.18	0.04
Adjusted R^2	0.77	0.69	0.81	0.79	0.91	0.87

Empirical Results cont'd

Dependant	Credit Spreads	Stock Returns	Implied Vola	Skewness (left)	Skewness (right)
Constant	$94.78^{\star\star\star}$	$0.04^{\star\star\star}$	$0.65^{\star\star\star}$	-0.14	2.21
Low Dispersion	$35.68^{\star\star\star}$	$0.04^{\star\star}$	0.24	$-0.11^{\star\star}$	$-0.56^{\star\star}$
Average Dispersion	$36.06^{\star\star}$	$-0.02^{\star\star}$	$0.33^{\star\star\star}$	$-0.16^{\star\star}$	$-0.94^{\star\star}$
High Dispersion	$38.48^{\star\star}$	$-0.03^{\star\star}$	$0.44^{\star\star\star}$	$-0.19^{\star\star}$	$-1.14^{\star\star}$
Low Implied Volatility	$16.27^{\star}$	-0.10		$1.29^{\star\star\star}$	$-5.10^{\star\star\star}$
Average Implied Volatility	15.92	-0.08		$1.22^{\star\star\star}$	$-5.23^{\star\star\star}$
High Implied Volatility	15.46	-0.07		$1.20^{\star\star}$	$-5.78^{\star\star\star}$
Low Implied Volatility Skew	-2.84	-0.04	$0.06^{\star\star}$		
Average Implied Volatility Skew	-6.84	-0.02	0.02		
High Implied Volatility Skew	-7.37	-0.01	0.01		
Low Implied Volatility Skew (right)			$-0.06^{\star\star\star}$		
Average Implied Volatility Skew (right)			-0.04		
High Implied Volatility Skew (right)			$-0.02^{\star\star\star}$		
Open Interest	$-0.03^{\star\star\star}$	-0.00	-0.00	$0.00^{\star\star\star}$	$-0.00^{\star\star}$
Volume	$25.28^{\star\star}$				
Call Option Volume		$-0.03^{\star\star\star}$	$-0.07^{\star}$	0.03	$0.83^{\star}$
Put Option Volume		$0.03^{\star\star\star}$	$0.08^{\star\star}$	-0.04	0.63
Slope of Term Structure	-8.87				
Risk-free Rate	-5.96				
S&P 500 Returns	-1.13	$-0.07^{\star\star}$			
Non-Farm Payroll (/1000)	$-3.52^{\star\star}$	0.00			
Stock Returns	-10.55				
Stock Volume	7.19				
Low Leverage	$6.73^{\star\star\star}$	0.19	$1.64^{\star\star}$	0.20	1.43
Average Leverage	$2.66^{\star\star\star}$	0.17	$1.78^{\star}$	0.16	1.57
High Leverage	$2.03^{\star\star\star}$	0.11	1.98	0.14	1.61
Firm Size	0.04				
Swap Rate (/100)	-4.10				
$R_m - R_f$	-0.29	$0.00^{\star\star\star}$			
SMB	0.42	$0.00^{\star\star\star}$			
HML	0.18	$0.00^{\star\star\star}$			
IV - RV			$0.15^{\star\star\star}$	$-0.24^{\star\star\star}$	$1.13^{\star\star\star}$
Treading Pressure			$-0.11^{\star}$	-0.11	$-1.69^{\star\star}$
Adjusted R^2	0.89	0.12	0.69	0.49	0.40

No-Arbitrage Violations

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According to Merton's (1974) model, a rise in credit spreads should go **pari passu** with a decrease in the stock price.

However, as we have seen, this is not always the case! $\Rightarrow$ General Motors and the large hedge fund losses!

The monotonicity property of options can be violated. Bakshi, Cao, and Chen (2000) find for index options that violations can occur as often as 12%.

We define three distinct violations by the Merton (1974) and Black and Scholes (1973) model:
Type 1 Violation: $\Delta CS \Delta S > 0$ that is either $\Delta CS > 0$ but $\Delta S > 0$, or $\Delta CS < 0$ but $\Delta S < 0$.
Type 2 Violation: $\Delta S \Delta C < 0$, that is either $\Delta S > 0$ but $\Delta C < 0$, or $\Delta S < 0$ but $\Delta C > 0$. Likewise for puts, either $\Delta S > 0$ but $\Delta P > 0$, or $\Delta S < 0$ but $\Delta P < 0$.
Type 3 Violation: Violation both in credit and option markets jointly.

Frequency of Arbitrage Violations

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Violation 1

	Low	Average	High
	18.9	15.4	14.3

Violation 2

		Low			Average			High		
		Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
OTM	Call	5.3	5.1	5.8	5.1	5.7	5.9	10.3	10.1	10.1
	Put	10.2	10.1	10.1	7.1	7.3	7.2	6.0	6.1	6.3
ATM	Call	4.0	4.0	4.3	4.3	4.5	4.0	3.8	3.2	3.7
	Put	4.2	4.1	4.0	4.5	4.6	4.5	3.6	3.3	3.1
ITM	Call	3.0	3.2	3.8	3.5	3.7	3.2	3.2	3.0	3.1
	Put	2.1	2.0	2.2	2.5	2.6	2.0	2.5	2.3	2.1

Violation 3

		Low			Average			High		
		Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
OTM	Call	4.1	4.2	4.3	6.3	6.2	6.8	7.1	7.2	7.7
	Put	5.2	3.3	4.1	2.1	1.2	2.2	3.2	2.1	1.2
ATM	Call	3.2	2.4	1.8	2.5	2.0	1.8	2.1	1.0	1.2
	Put	2.0	1.0	1.2	1.2	1.0	1.1	1.1	1.0	1.1
ITM	Call	2.3	2.4	2.8	2.8	2.9	2.1	3.0	1.2	1.8
	Put	1.0	1.1	1.2	1.2	1.0	1.0	1.1	1.2	1.0

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Dependant		Leverage	
	Low	Average	High
Constant	$-0.89^{\star\star\star}$	$-0.86^{\star\star\star}$	$-0.84^{\star\star\star}$
Dispersion	$0.23^{\star\star\star}$	$0.20^{\star\star\star}$	$0.18^{\star\star\star}$
Adjusted R^2	0.08	0.05	0.07

Panel A: Calls						
Dependant		Low			High	
	OTM	ATM	ITM	OTM	ATM	ITM
Constant	$-0.48^{\star\star\star}$	$-0.45^{\star\star\star}$	$-0.46^{\star\star\star}$	$-0.50^{\star\star\star}$	$-0.52^{\star\star\star}$	$-0.52^{\star\star\star}$
Moneyness	$1.18^{\star\star\star}$	$1.20^{\star\star}$	$1.22^{\star\star}$	$1.21^{\star\star}$	$1.25^{\star\star}$	$1.30^{\star\star}$
Maturity	$0.50^{\star\star\star}$	$0.51^{\star\star\star}$	$0.50^{\star\star\star}$	$0.56^{\star\star\star}$	$0.54^{\star\star\star}$	$0.57^{\star\star\star}$
Dispersion	$0.65^{\star\star\star}$	$0.60^{\star\star\star}$	$0.62^{\star\star\star}$	$0.62^{\star\star\star}$	$0.65^{\star\star\star}$	$0.66^{\star\star\star}$
Adjusted R^2	0.11	0.12	0.12	0.10	0.12	0.11

Panel B: Puts						
Dependant		Low			High	
	OTM	ATM	ITM	OTM	ATM	ITM
Constant	$-0.62^{\star\star\star}$	$-0.60^{\star\star\star}$	$-0.61^{\star\star\star}$	$-0.65^{\star\star\star}$	$-0.65^{\star\star\star}$	$-0.67^{\star\star\star}$
Moneyness	$1.02^{\star\star}$	$1.03^{\star\star}$	$1.04^{\star\star}$	$1.01^{\star\star}$	$1.05^{\star\star}$	$1.04^{\star\star\star}$
Maturity	$0.24^{\star\star\star}$	$0.21^{\star\star\star}$	$0.26^{\star\star\star}$	$0.20^{\star\star\star}$	$0.24^{\star\star\star}$	$0.23^{\star\star\star}$
Dispersion	$0.70^{\star\star\star}$	$0.71^{\star\star\star}$	$0.72^{\star\star\star}$	$0.72^{\star\star\star}$	$0.76^{\star\star\star}$	$0.68^{\star\star\star}$
Adjusted R^2	0.10	0.11	0.12	0.09	0.12	0.12

Simulated Occurrence of Violations

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Violation 1

	Low	Average	High
	15.3	14.2	12.2

Violation 2

		Low			Average			High		
		Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
OTM	Call	5.8	6.0	6.2	5.5	5.7	5.6	10.0	10.2	10.9
	Put	12.7	12.2	12.5	8.2	8.0	8.1	7.2	7.0	6.5
ATM	Call	3.8	3.0	3.1	2.7	2.6	2.5	2.0	2.1	2.0
	Put	3.5	3.0	2.0	2.0	2.1	2.1	2.0	2.1	2.2
ITM	Call	3.0	3.0	3.2	1.8	1.7	1.9	1.7	1.8	2.0
	Put	1.2	1.1	1.3	1.5	1.6	1.3	1.2	1.3	1.5

Violation 3

		Low			Average			High		
		Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
OTM	Call	4.2	4.1	3.7	4.2	3.7	3.6	7.2	6.5	7.8
	Put	8.4	7.6	7.3	6.5	6.1	5.4	5.2	5.4	5.7
ATM	Call	2.7	2.5	2.3	2.2	2.1	2.1	1.8	1.6	1.4
	Put	2.5	2.2	1.2	0.9	0.8	0.8	0.9	0.8	0.8
ITM	Call	1.8	1.6	1.6	1.5	1.4	1.5	1.5	1.6	1.4
	Put	0.8	0.6	0.8	0.8	0.8	0.7	0.7	0.6	0.7

Conclusion

Summary

- We have analyzed an economy where credit spreads, stock returns, option prices, their implied volatility surface, and optimal portfolios depend on a priced disagreement factor.

  $\Rrightarrow$ In contrast to the standard Merton (1974) model of credit risk, the firm value is endogenously driven by beliefs disagreement.

  $\Rrightarrow$ Beliefs disagreement highers credit spreads and the volatility of equity, but it can both higher or lower the price of equity, depending on the leverage of the firm.

- We obtain sharp implications for credit spreads and stock returns.

  $\Rrightarrow$ The option implied negative skewness can be pronounced, but can also be inverted in other cases.

- Using a comprehensive panel data set between 1996 and 2004, we find empirical evidence in favor of these model predictions.