Pricing Corporate Default Risk

Lecture 2, Clarendon Lectures in Finance, 2004

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Outline of Clarendon Lectures

1. Corporate default probabilities.
2. Pricing corporate default risk.
3. Default correlation.

Pricing Corporate Default Risk

A. Overview.

B. Default recovery.

C. Static relationship between Moodys-KMV EDF and market default-swap (CDS) rates.

D. Time-series model of actual default intensities from EDFs.

E. Time-series model of risk-neutral default intensities from EDF and CDS data.

A. Overview

- How much are investors in corporate debt paid for taking default risk, above their expected default loss?
- Our analysis is based on Moodys KMV estimates of default probabilities and CIBC data on default swap (CDS) prices.
- The default risk premium is much bigger, per dollar of expected default loss, for high-quality firms.
- The default risk premium has been dramatically reduced since August 2002.

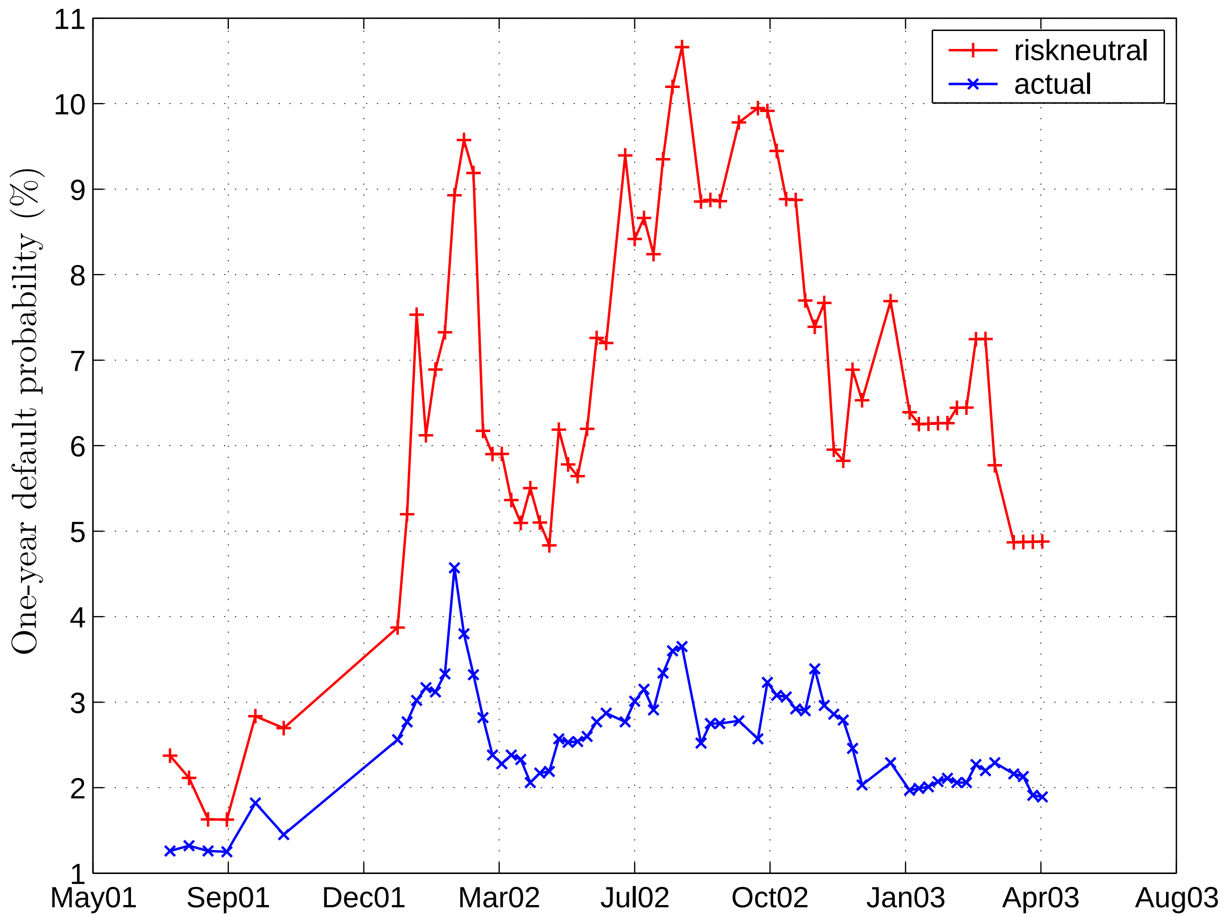

Figure 1: Estimated 1-year actual and risk-neutral default probabilities for Vintage Petroleum. Sources: Moody's KMV and CIBC.

Simple Version of the Key Calculation

- At constant risk-neutral default intensity λ^*, a par credit spread S is, roughly, the risk-neutral mean loss rate $\lambda^* L^*$.
- We can infer λ^* from the spread S, given an estimate of the risk-neutral mean loss given default L^*.
- We estimate λ from Moody's KMV EDF, an industry measure of one-year default probability.
- So, with credit spread data, we can estimate the default risk premium,

$$p = \frac{\lambda^*}{\lambda}.$$

- We study how p varies across time, credit quality, and sector.

Table 1: From Huang-Huang (2002) estimated risk premia

Initial Rating	Premium (ratio)	$P^*(\tau < 5)$ (percent)	$P(\tau < 5)$ (percent)
Aaa	1.7497	0.04	0.02
Aa	1.7947	0.09	0.05
A	1.7322	0.25	0.15
Baa	1.4418	1.22	0.84
Ba	1.1658	9.11	7.85
B	1.1058	25.61	23.41

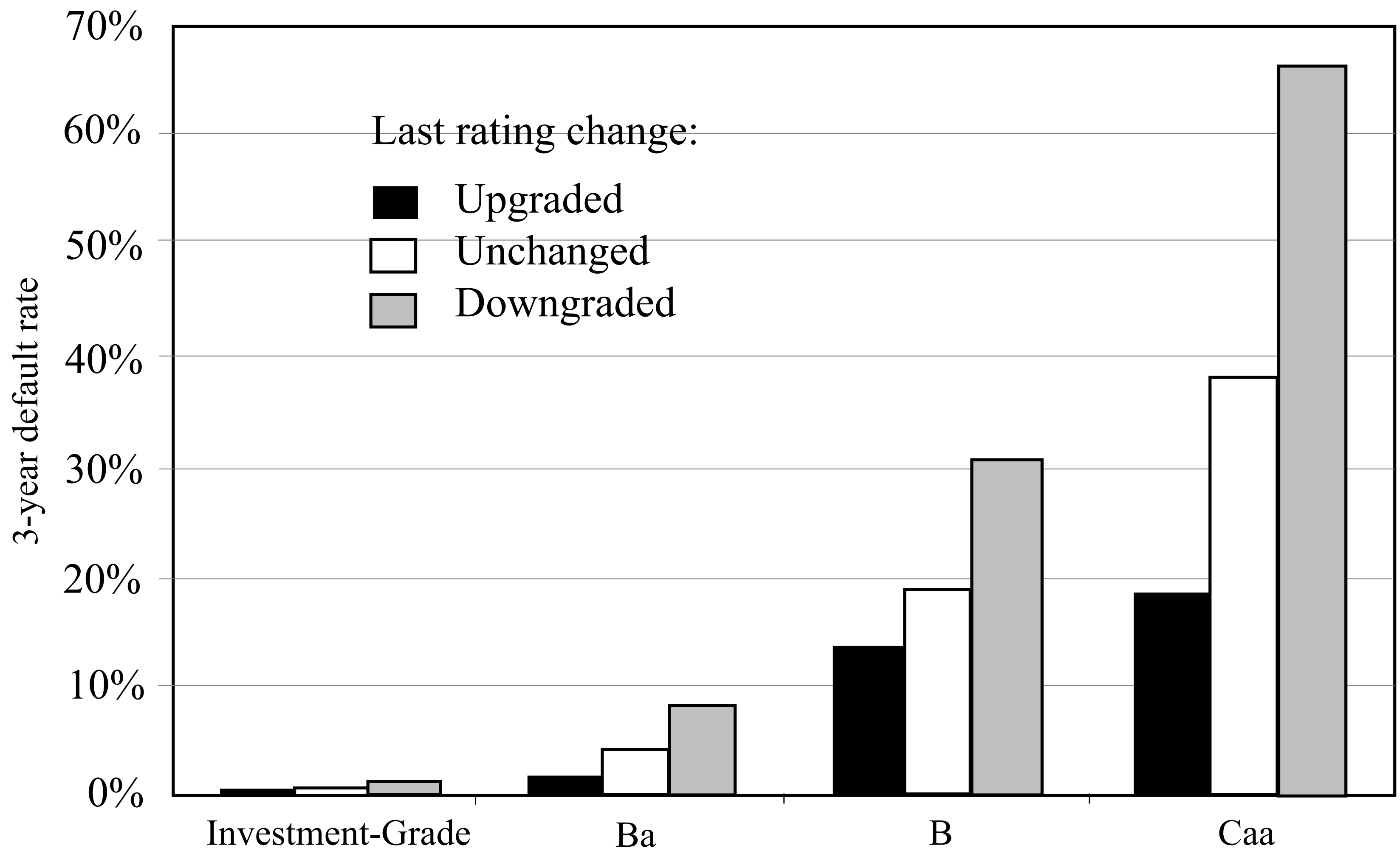

Figure 2: Upgrade-downgrade momentum (1996-2003 data). Source: Moody's, 2004.

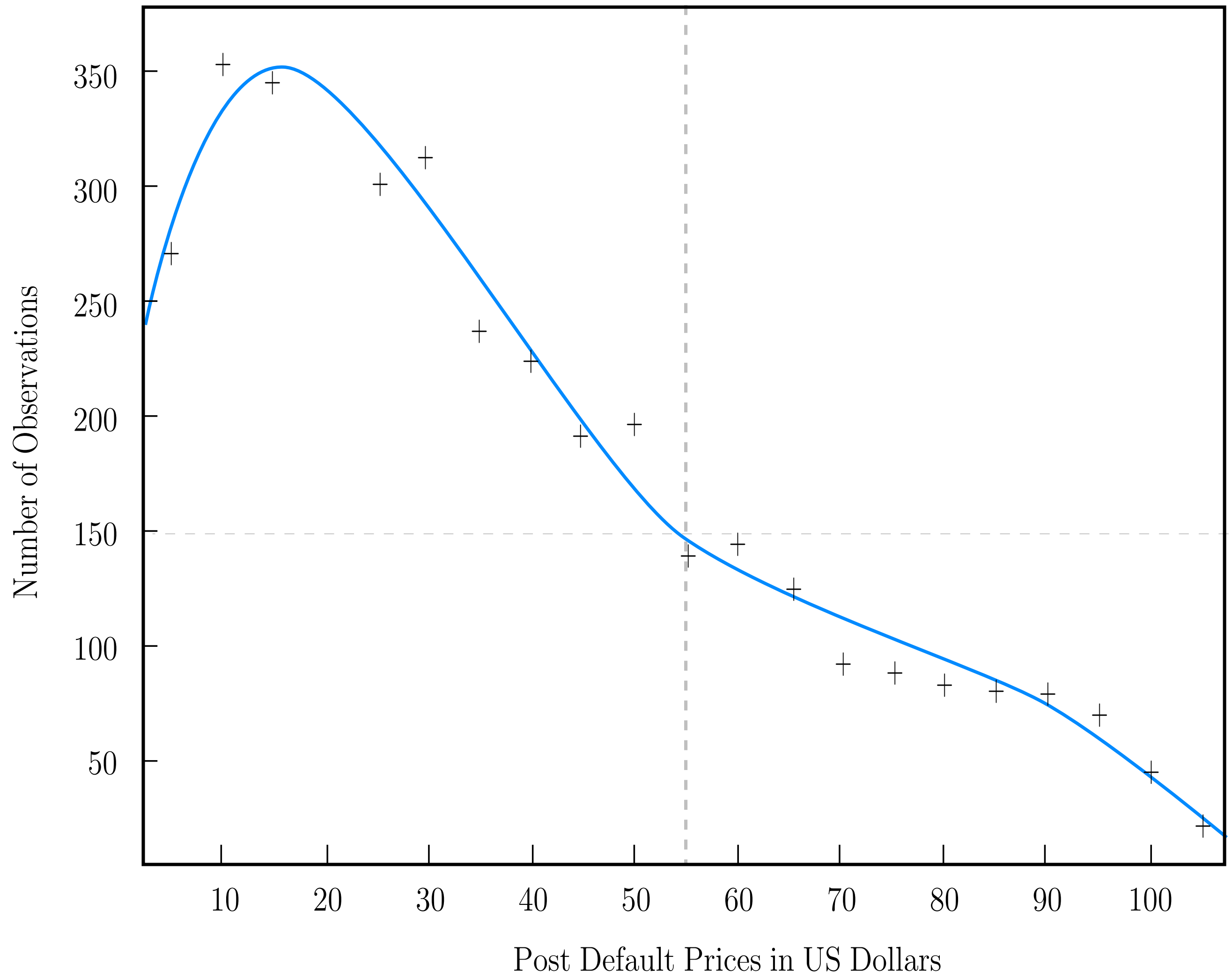

Figure 3: Distribution of senior unsecured recovery rates, 1982 - 2002. Source: Moody's Default and Recovery Report (2003).

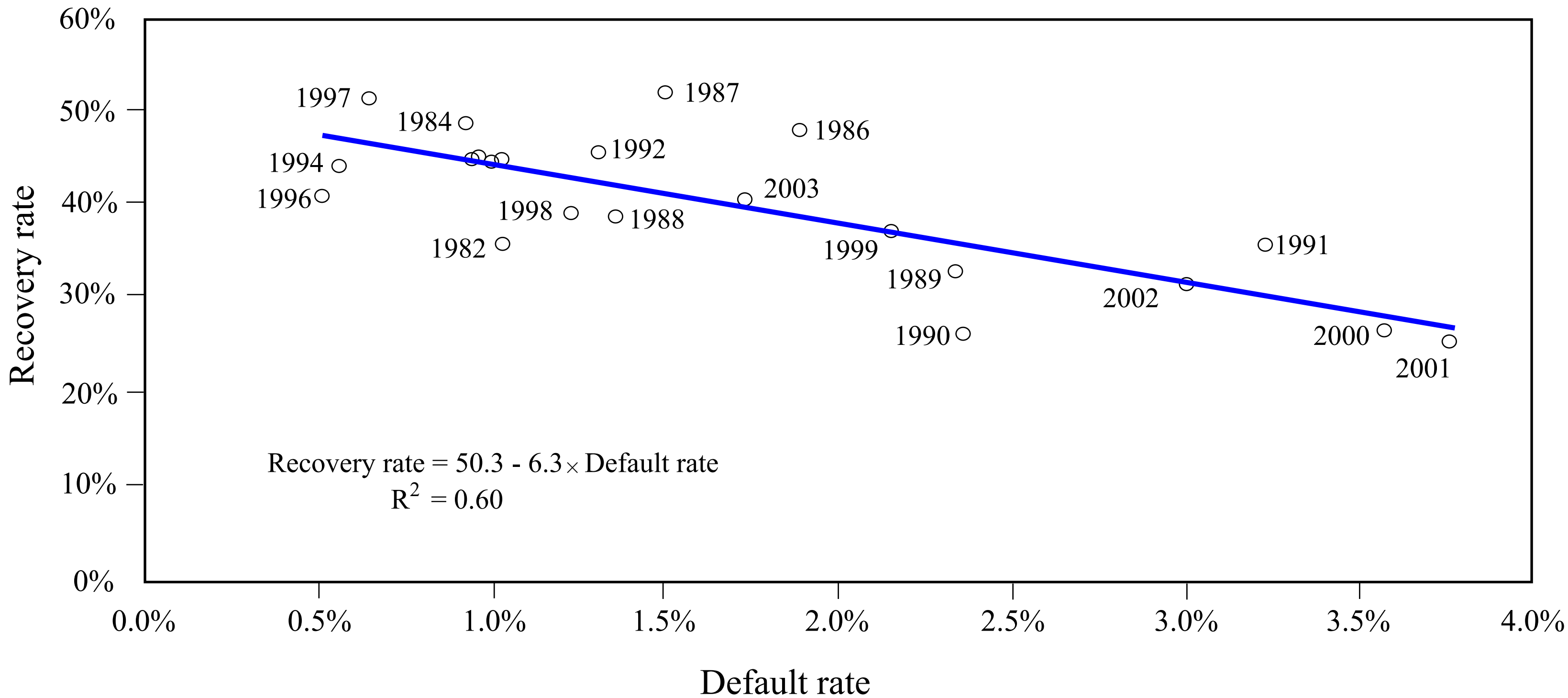

Figure 4: Correlation of Speculative Grade Default and Recovery Rates. Source: Moodys Default and Recovery Report (2004).

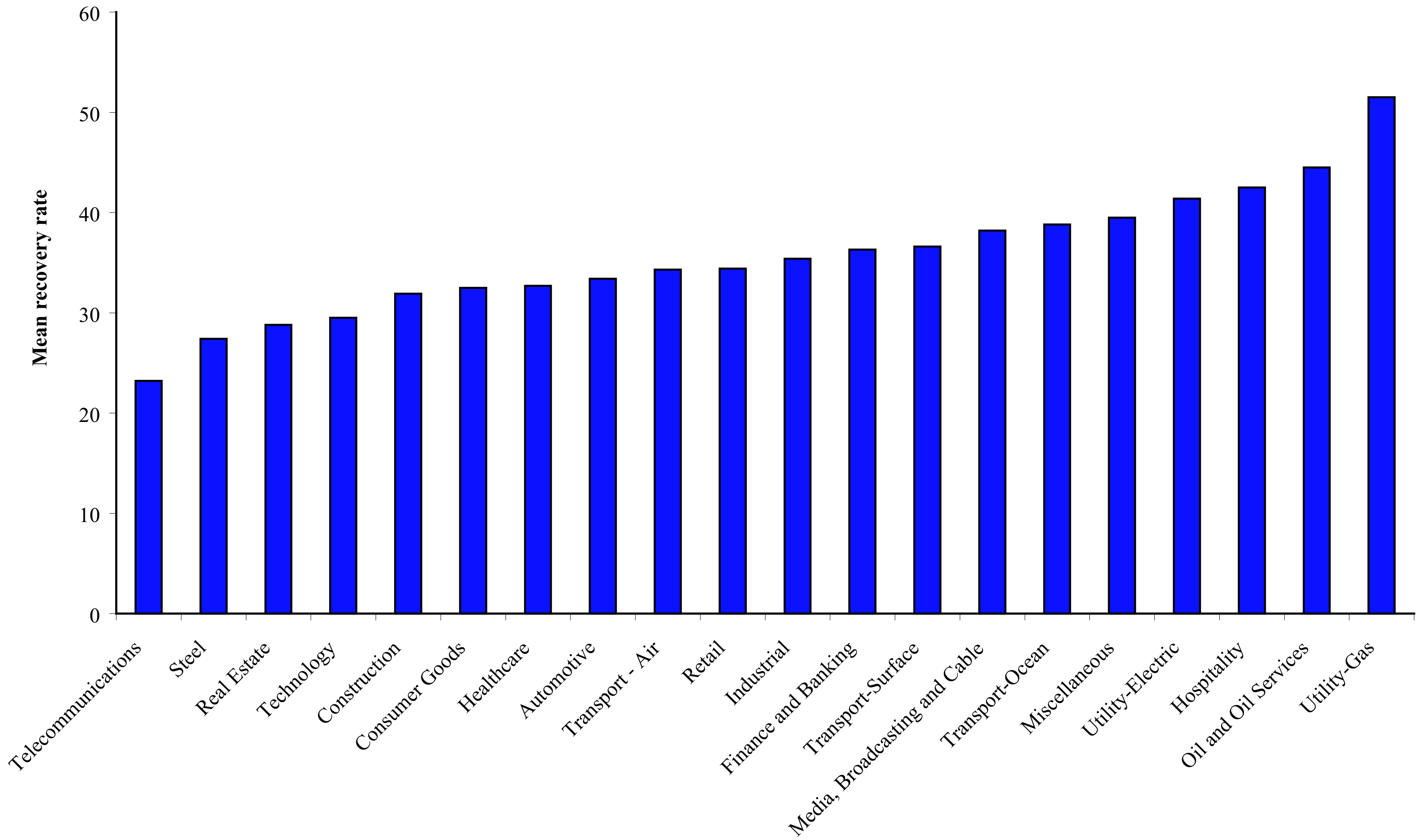

Figure 5: Mean Recovery Rates by sector, 1982-2003. Source: Moody's.

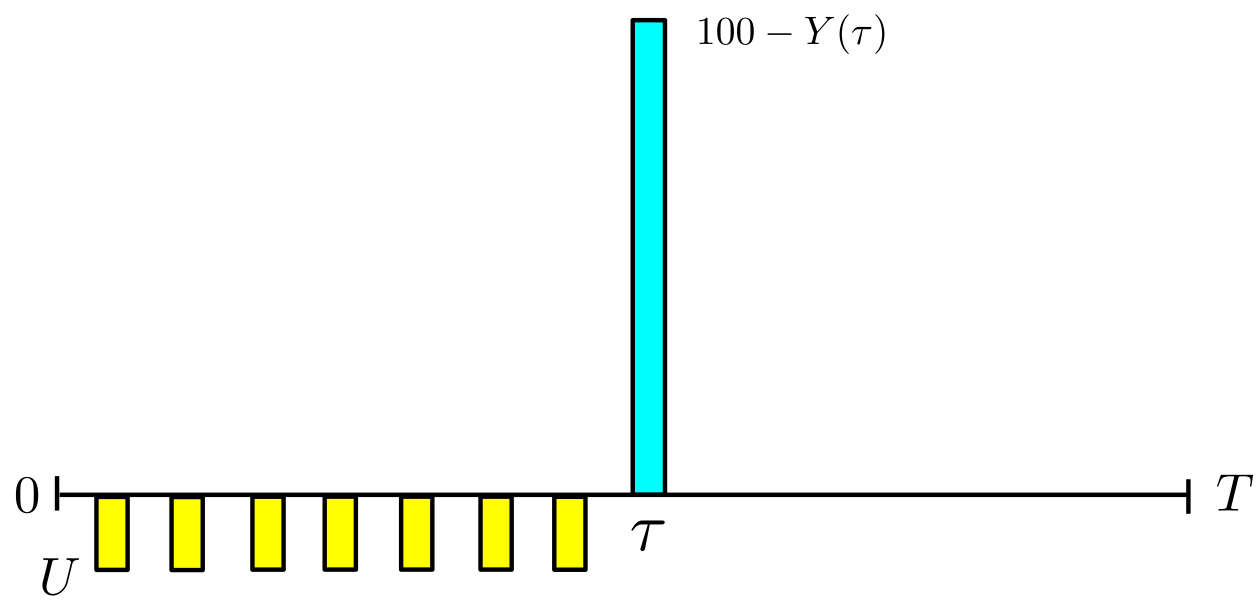

Figure 6: Default swap: buyer of protection pays the CDS rate U quarterly, and at the default time τ delivers bond worth $Y(\tau)$ in exchange for notional (100).

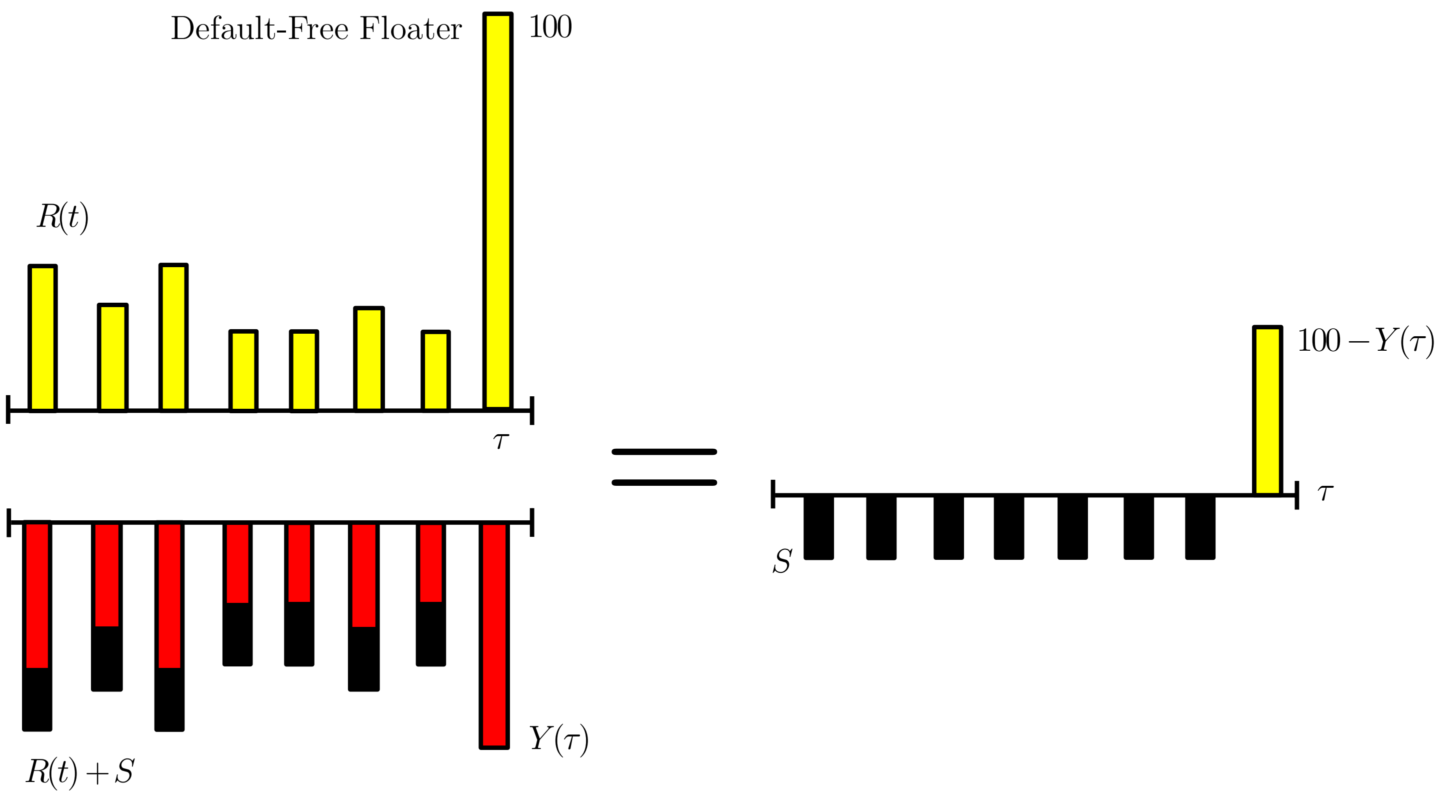

Figure 7: Synthetic default swap: Short a par floater on underlying name; buy a default-free par floater, "almost" replicates a default swap. By "arbitrage," the CDS rate U is approximately the credit spread S.

Table 2: CDS quote frequency, three sectors (CIBC data)

	Sum	Median	Average	Count	Min	Max
Banks	34462	871	2872	12	116	9523
Brokers	15030	620	1503	10	147	5431
All	49492	702	2250	22	116	9523

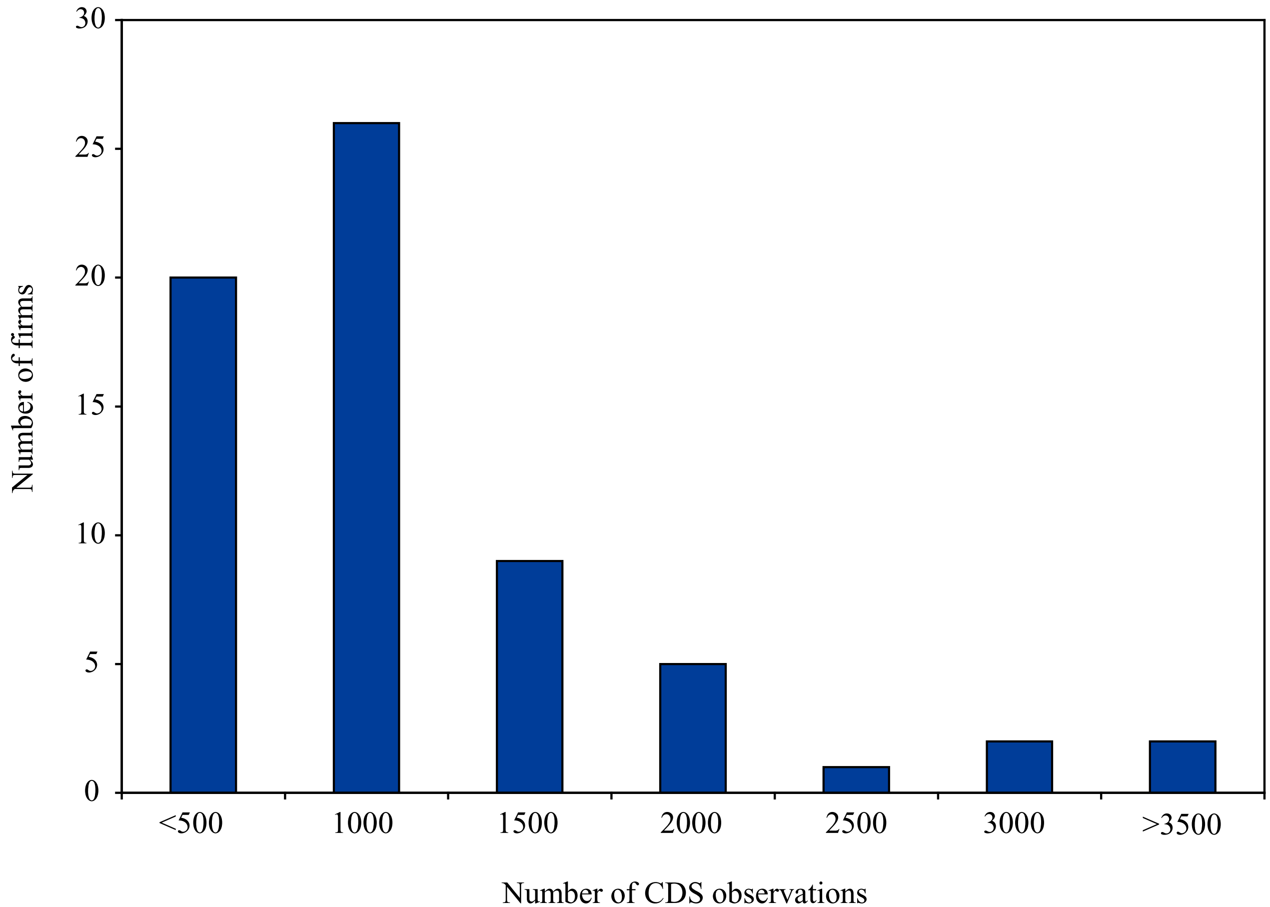

Figure 8: Distribution of firms by number of CDS quotes.

Table 3: Statistics (medians) for broadcasting/entertainment

Name of Firm	**EDF**	**Rating**	**Quotes**
Adelphia Communications	349	B2	279
Time Warner	11	Baa1	3447
Charter Communications	281	B3	444
Clear Channel Communications	29	Baa3	1698
Comcast	39	Baa3	1043
COX Communications	36	Baa1	2153
Disney	7	Baa1	2745
Insight Communications	173	B3	303
Liberty Media	21	Baa3	515
Mediacom Communications	286	Caa1	168
Primedia Inc.	65	Ba3	325
Royal Caribbean Cruises	134	Baa2	462
Viacom Inc.	13	Baa1	2458

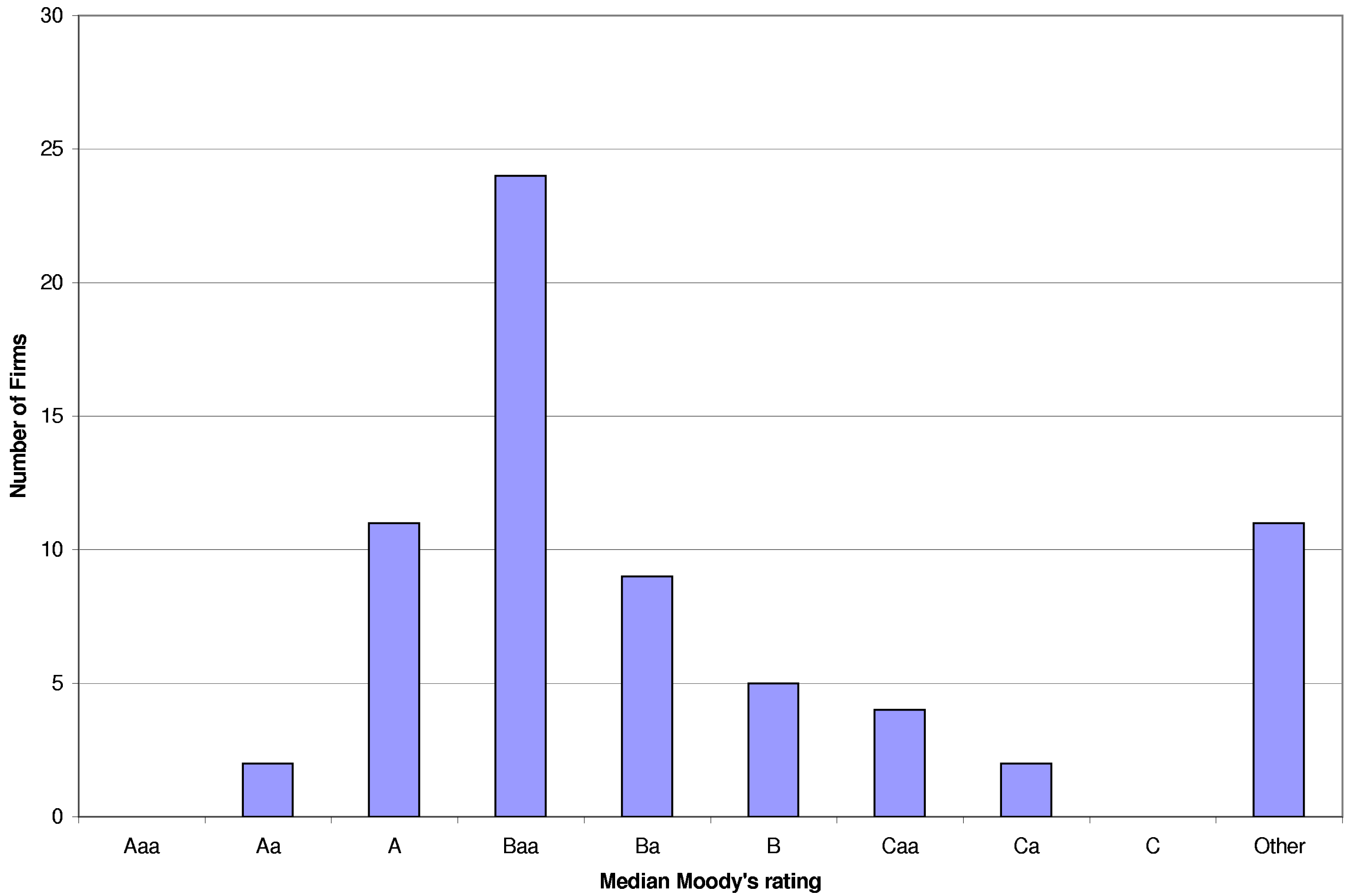

Figure 9: Distribution of firms by median credit rating during the sample period (CIBC data)

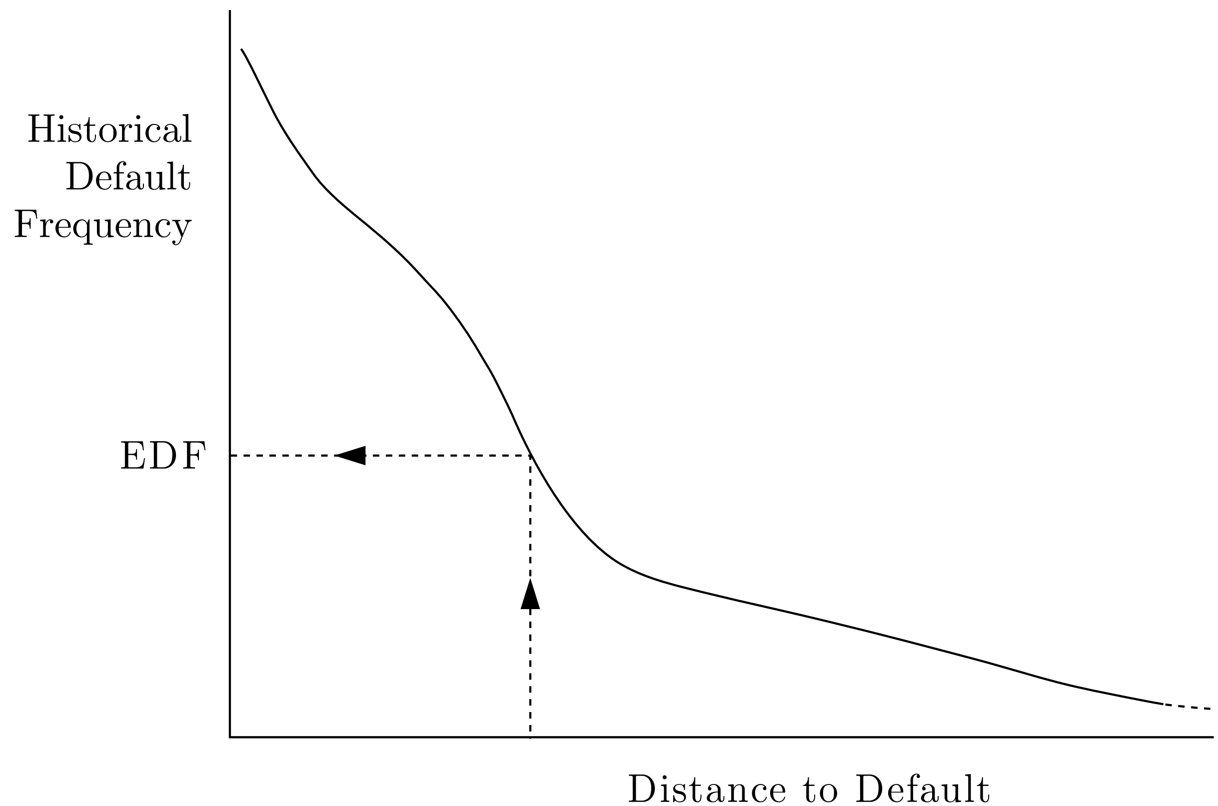

Figure 10: Mapping Distance to Default to EDF, using Historical Default Frequency

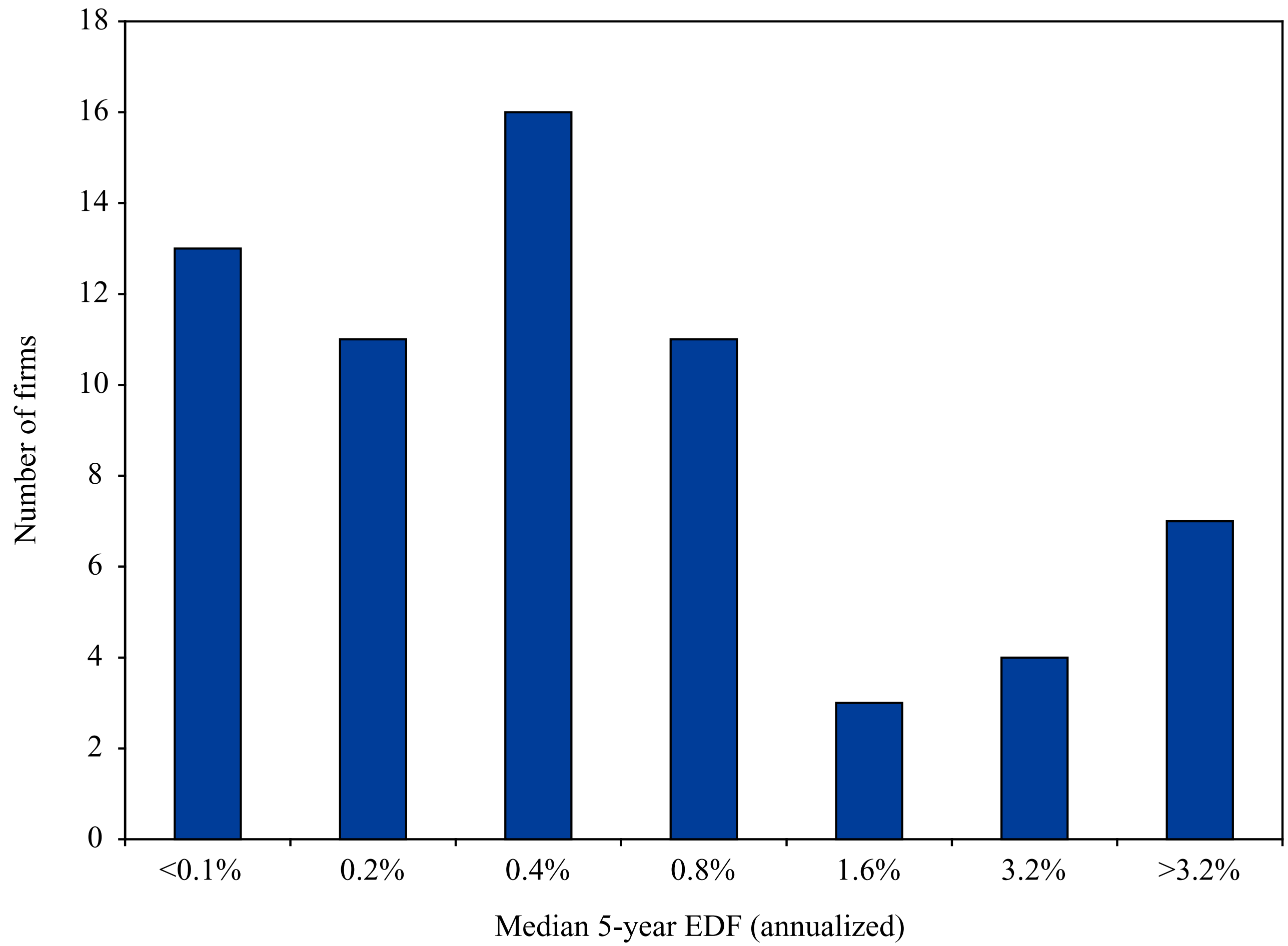

Figure 11: Distribution of firms by median 5-year EDF.

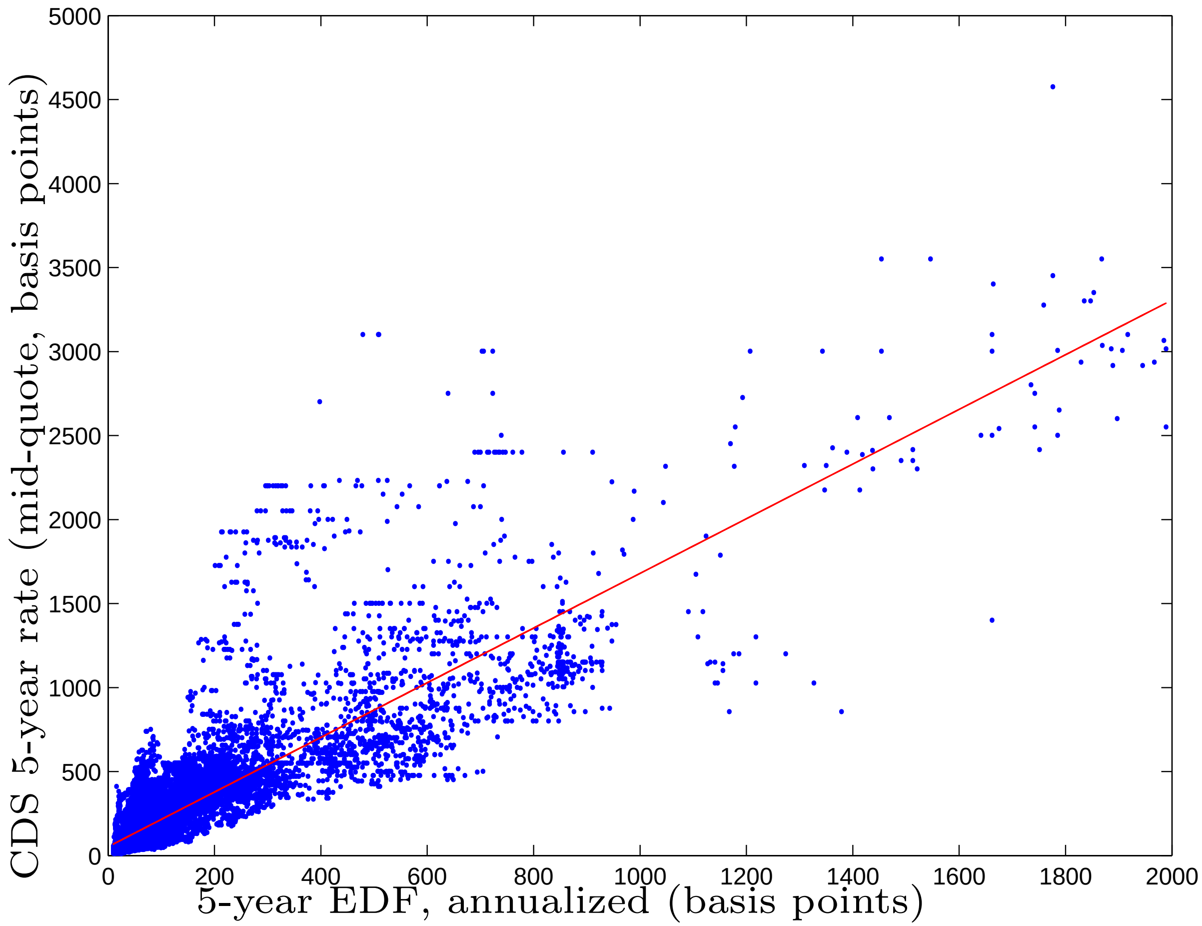

Figure 12: Scatter plot of EDF and CDS observations and OLS fitted relationship. Data from CIBC (CDS) and Moody's KMV (EDF).

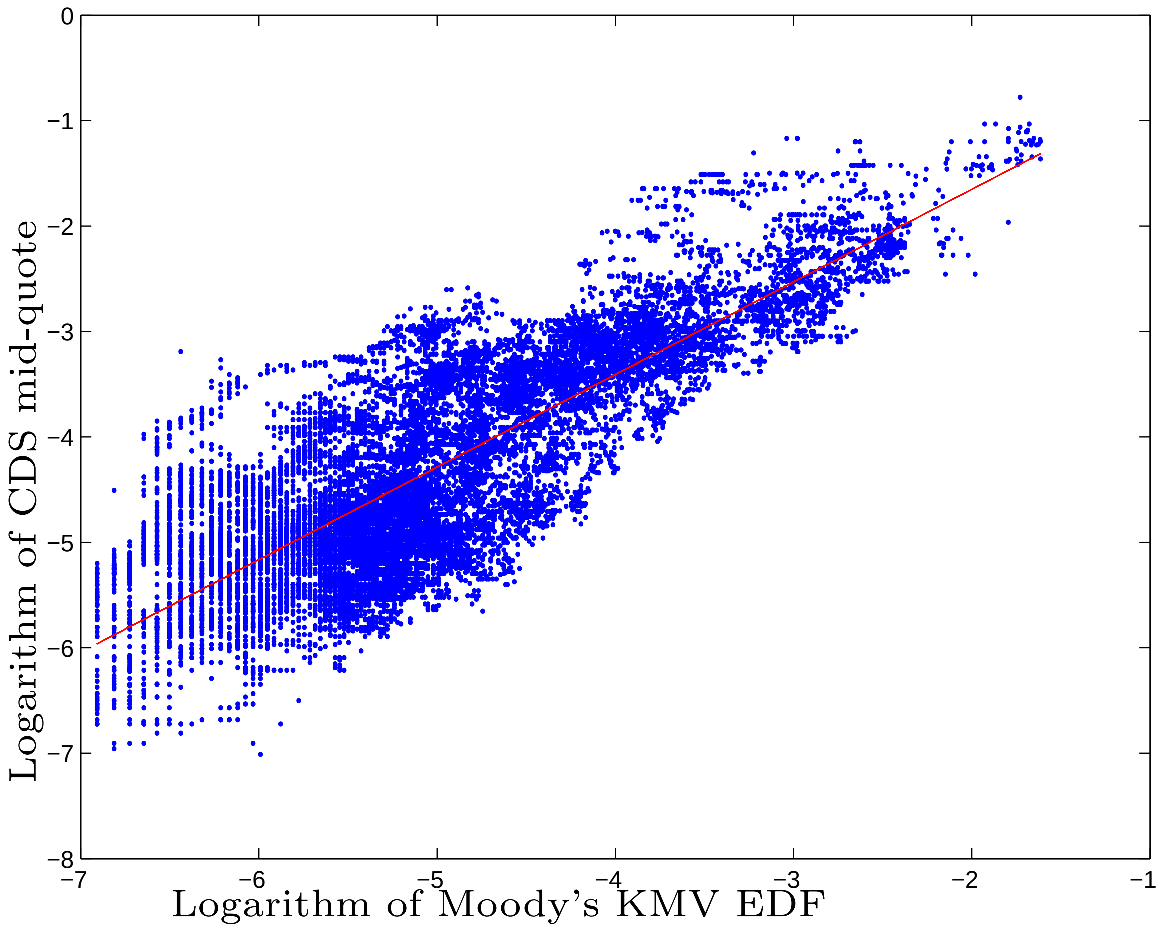

Figure 13: Scatter plot of EDF and CDS observations, logarithmic, and OLS fitted relationship. Data: CIBC, Moody's KMV.

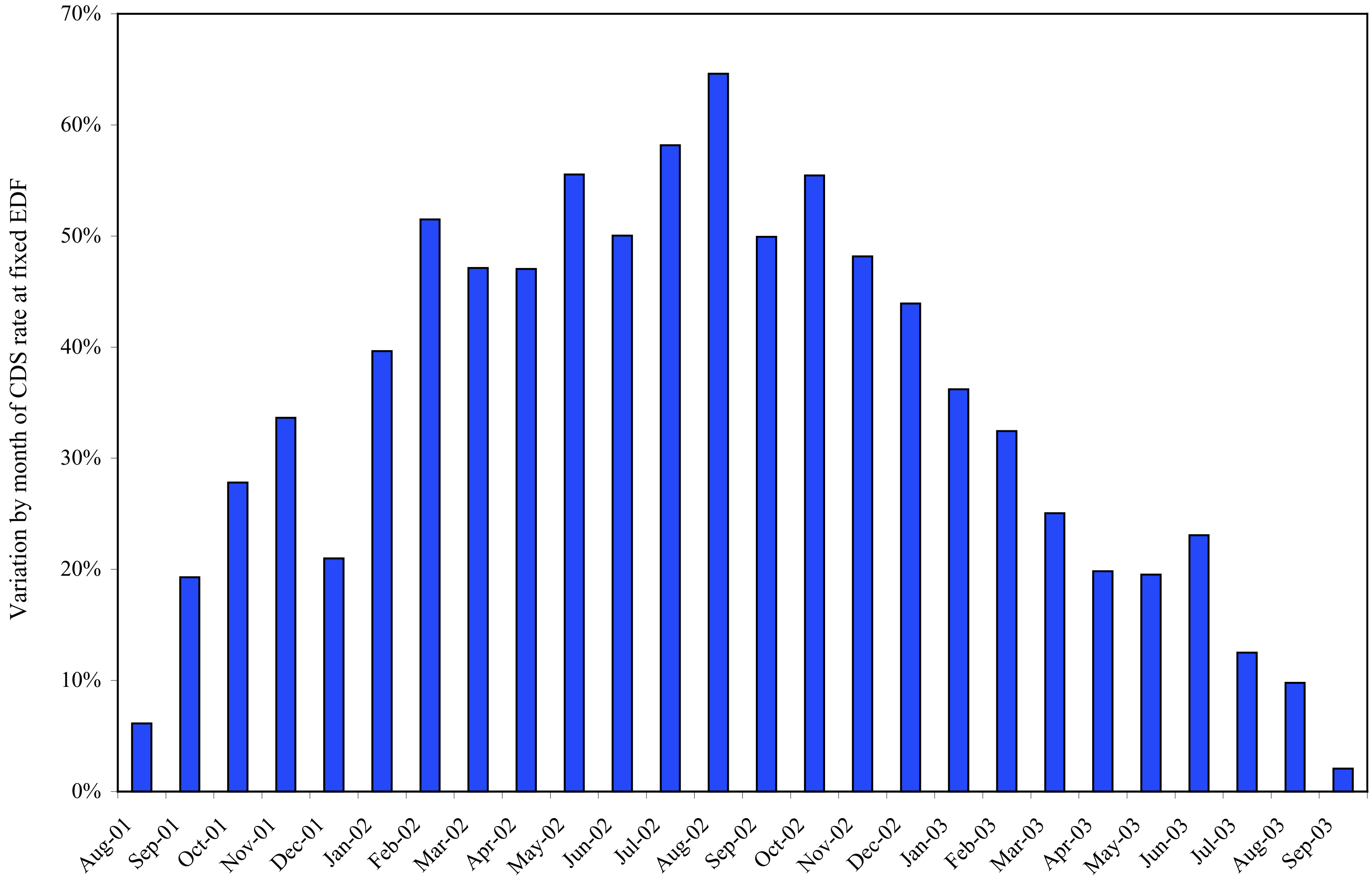

Figure 14: Monthly risk-premium multipliers in CDS-to-EDF fit.

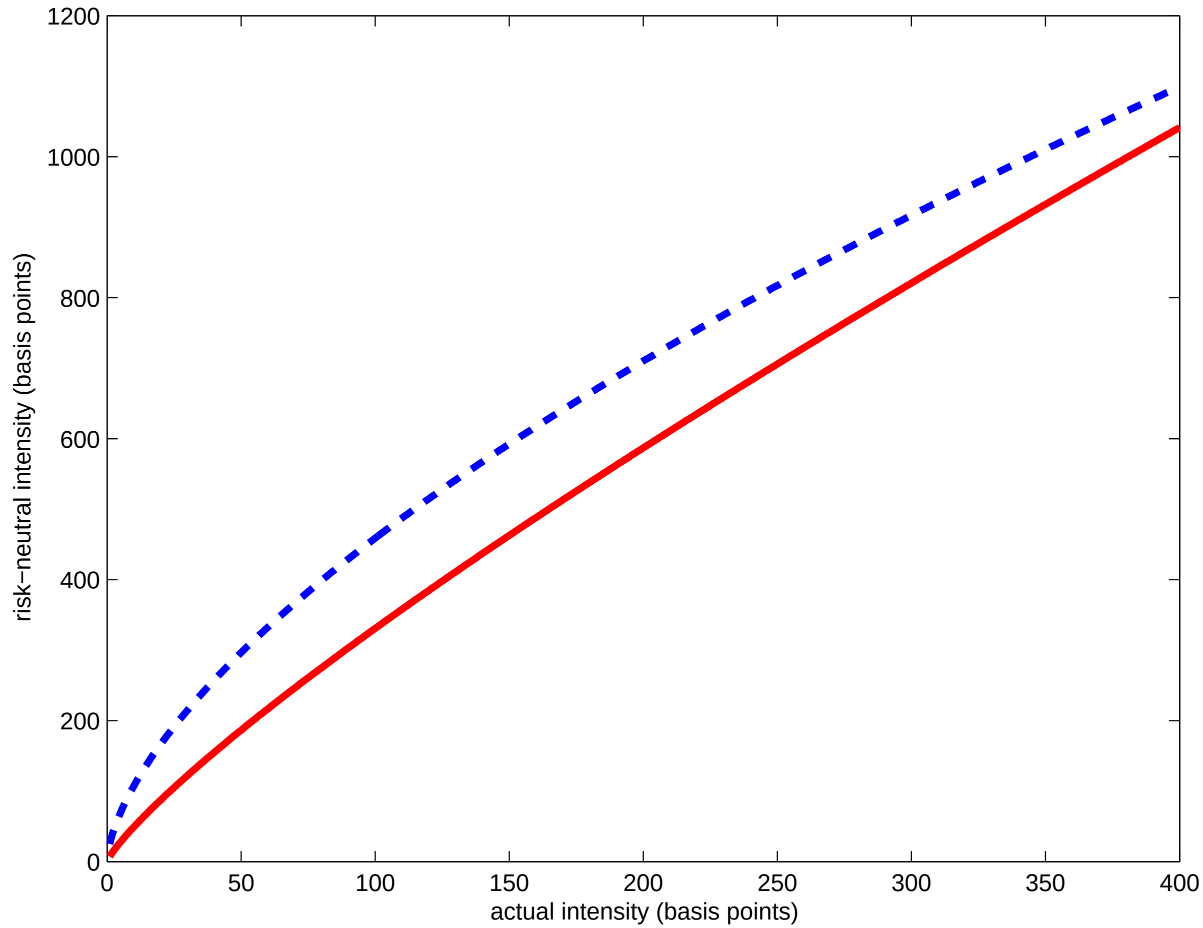

Figure 15: Relationship in healthcare sector between actual and risk-neutral default probabilities. Dashed: Time-series model of intensities. Solid: From regression of log CDS on log EDF at highest-risk-premium month (August, 2002).

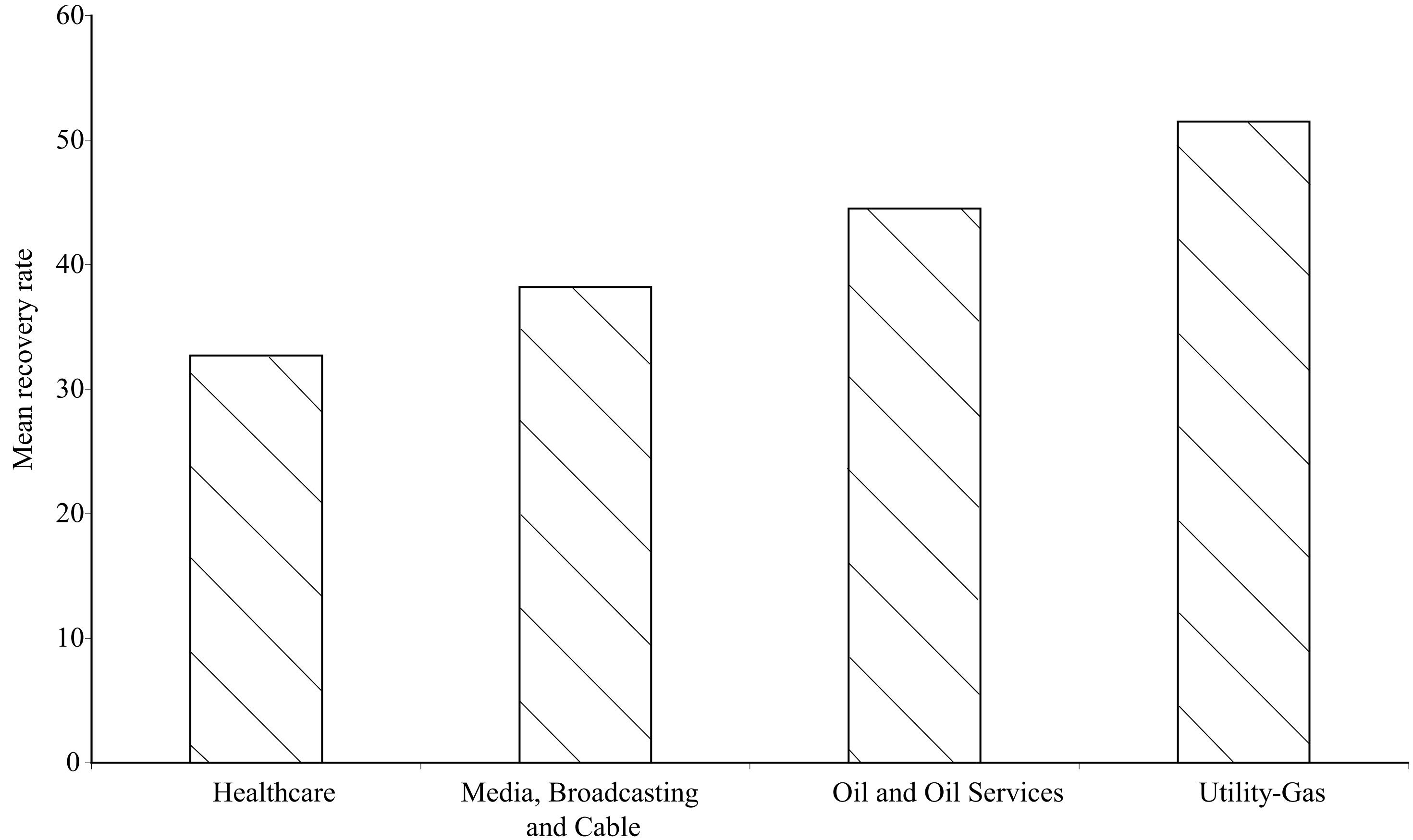

Figure 16: Sectoral recovery differences.

Time-Series Model for Default Intensity

- We observe 10 years of one-year EDFs, monthly. (5-year EDFs are almost perfectly correlated with 1-year EDFs).
- The standard doubly-stochastic model:
EDF$= g(\lambda_t) \equiv 1 - E_t\left(e^{-\int_t^{t+1} \lambda(s)\, ds}\right)$.
- We assume Black-Karasinski intensities,

$$\log \lambda_{t+1} - \lambda_t = \kappa(\theta - \log \lambda_t) + \sigma\epsilon_{t+1}.$$

- We fit mean reversion (κ), long-run mean (θ), and volatility (σ), by maximum likelihood, for each of 63 firms.
- Median mean reversion (κ) is 50%. Median vol (σ) is 135%.
- This provides MLE default intensity estimates
$\hat{\lambda}_t = f(\text{EDF}_t; \hat{\kappa}, \hat{\sigma}, \hat{\theta})$ from EDF data.

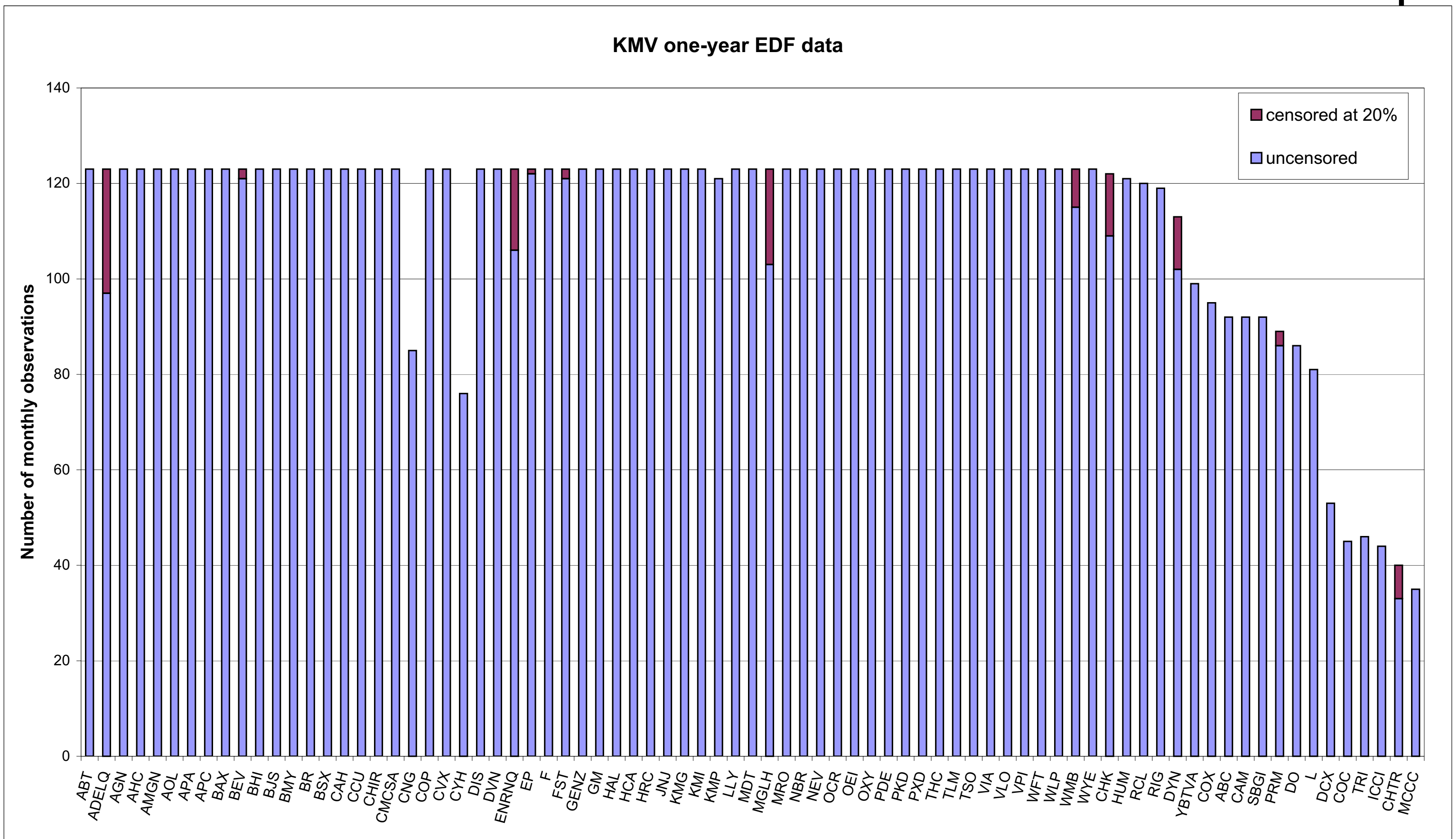

Figure 17: Number of EDF observations by firm.

Table 4: Sector EDF-implied MLE default intensity parameters.

	mean($\hat{\theta}$)	$\hat{\kappa}$	$\hat{\sigma}$	$\hat{\rho}$	Firms
Oil and Gas	3.3309	0.54	1.40	0.11	32
Healthcare	3.3784	0.35	1.18	0.26	17
Broadcast/Entertainment	4.2625	0.55	1.35	0.23	14

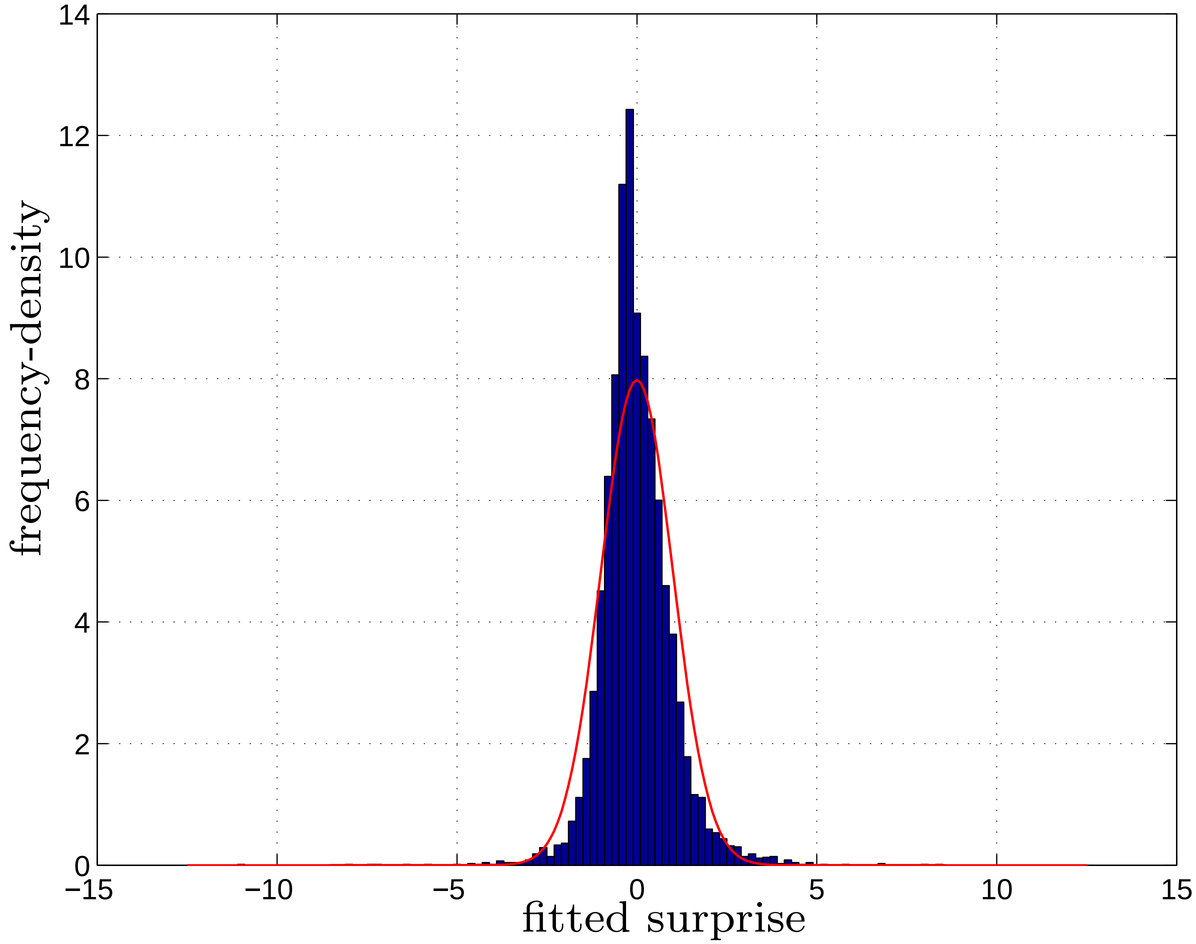

Figure 18: $\log \lambda$ suprise frequency vs normality.

Risk-Neutral Default Intensity Time-Series Model

- Model implied CDS rates from zero-recovery price (Lando): $E_t^*\left(e^{-\int_t^{t+M}[r(s)+\lambda^*(s)]\,ds}\right)$, and a given risk-neutral mean loss given default. (We use $L^* = 0.75$.)
- We suppose that

$$\log \lambda_t^* = \alpha + \beta \log \lambda_t + u_t,$$

  where u is Ornstein-Uhlenbeck, independent of λ.
- Actual and risk-neutral Ornstein-Uhlenbeck parameters for $\log \lambda_t$ and u_t are estimated by MLE.
- From this, and a parameter vector γ, we can invert the pricing of the CDS to get $\lambda_t^* = f(\mathrm{CDS}_t, \lambda_t, r_t; \gamma)$.
- Sample average of Healthcare risk premium λ_t^*/λ_t is 5.6.

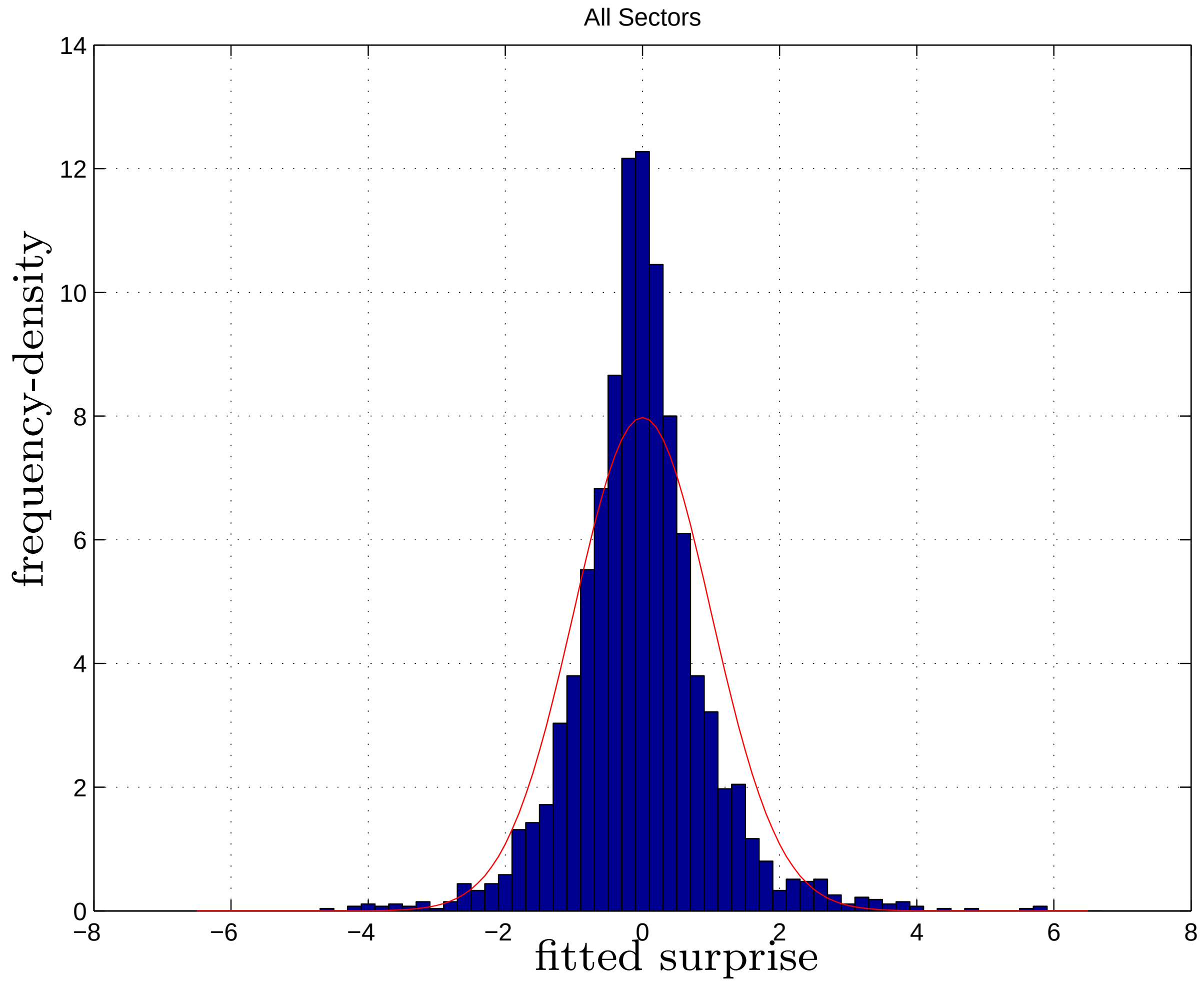

Figure 19: $\log \lambda^*$ suprise frequency vs normality.

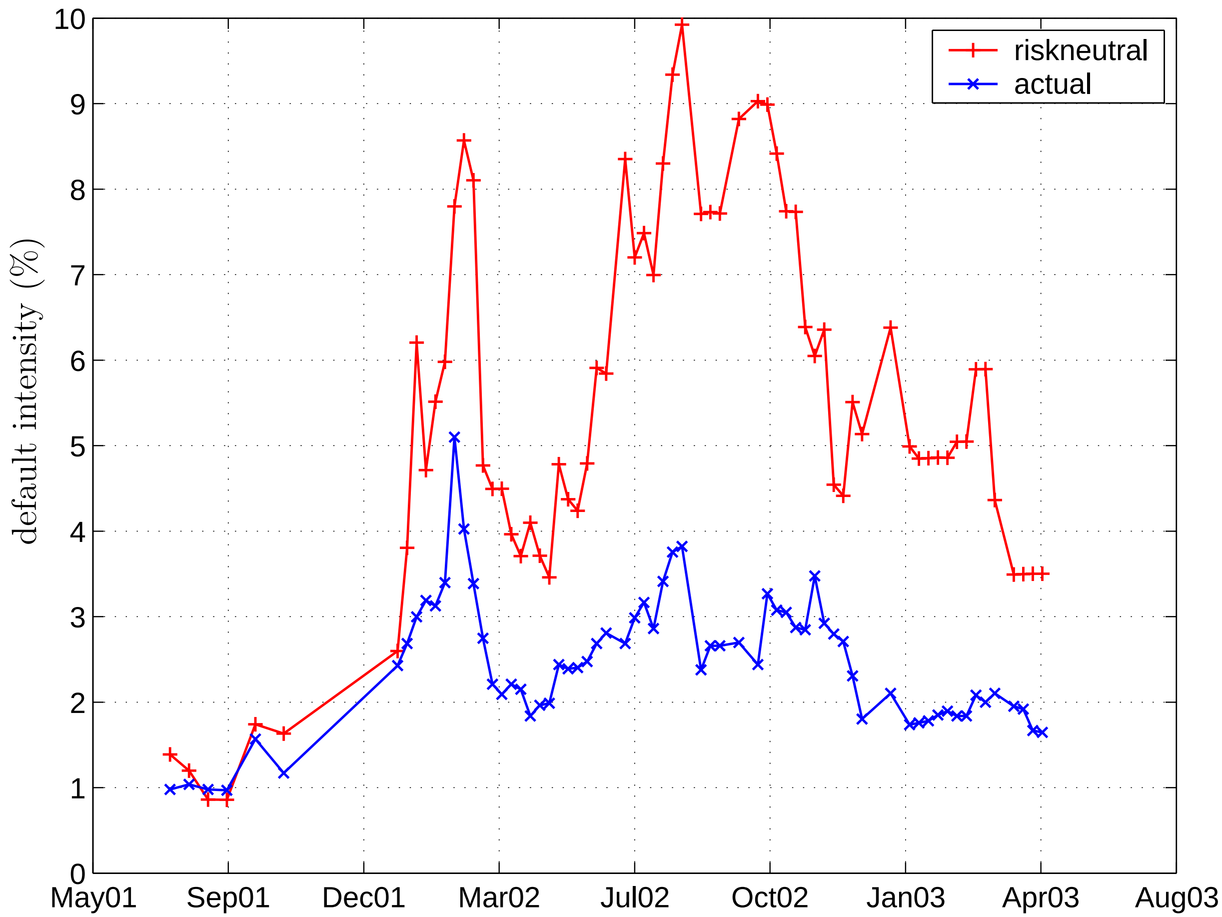

Figure 20: Estimated default intensities, λ and λ^*, for Vintage Petroleum. Data sources: Moody's KMV and CIBC.

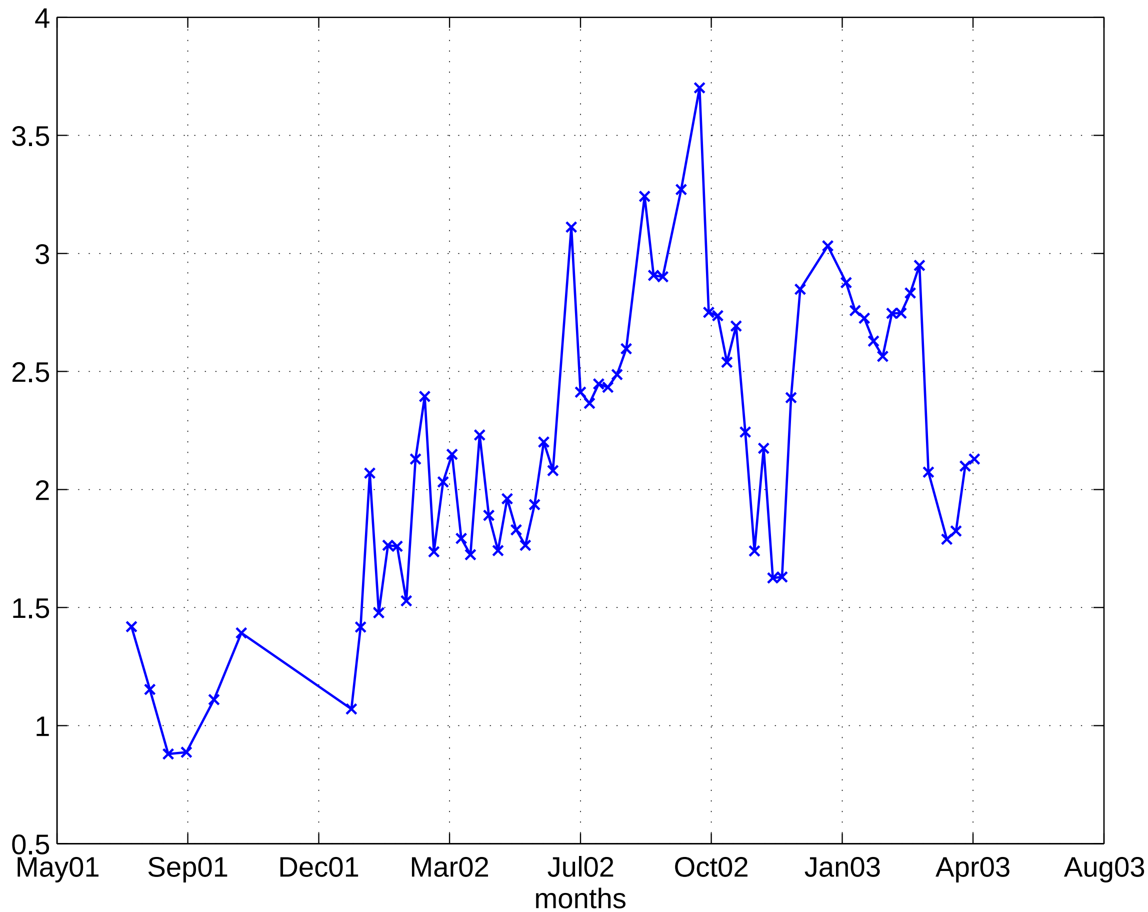

Figure 21: Estimated default risk premia, λ^*/λ, for Vintage Petroleum.