QUANTITATIVE PORTFOLIO
MANAGEMENT CONFERENCE

Credit Risk – Modeling Default Probability

Attakrit Asvanunt
POINT Portfolio Modeling
Index, Portfolio and Risk Solutions Group

April 8, 2010

PLEASE SEE ANALYST CERTIFICATIONS AND IMPORTANT DISCLOSURES AFTER SLIDE 25.

BARCLAYS CAPITAL

Agenda

- Motivation
- Overview of default probability
- Two major approaches to modeling corporate default probabilities
  - Structural approach – Value-based model
  - Reduced-form approach – Econometric model
- Hybrid approach
- Macro default rate forecast
- Applications
  - Risk management
  - Portfolio construction
- Conclusion
- Appendix – Measure model performance

Motivation

- Credit measures for risk management
  - Credit securities and loans
  - Exposed to both market risk and default risk
  - Default risk is contagion and cannot be completely diversified
- Beyond risk management
  - Portfolio constructions, trading strategies, capital structure arbitrage, etc.
- Agency rating
  - Based on fundamental analysis
- Credit spread
  - Bond option-adjusted-spread, credit-default-swap spread
  - Market driven
- Default probability
  - Rapidly gaining popularity
  - Driven by both market and fundamental information

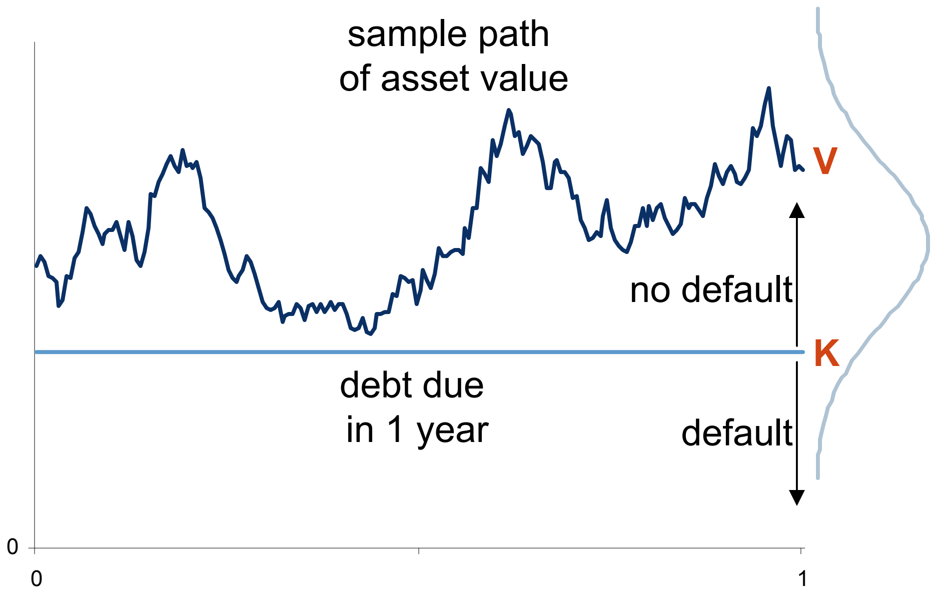
What Is Default Probability?

- Likelihood that a firm will default on its debt obligation over a specified time period (e.g., next one year)
  - Issuer specific – Generally a firm defaults on all of its outstanding debt instruments
  - Potentially large loss upon default – Historical average is as high as 60% (of notional) for senior unsecured bonds
- The two “measures”
  - Risk-neutral probability
    - Incorporates risk premium
    - Used to price securities (with appropriate recovery assumption)
    - Can be inferred from bond or CDS spreads
    - Not useful for risk management
  - Real-world probability
    - Risk managers are interested in real-world probability
    - Value-at-risk, expected shortfall, default risk, etc.

QUANTITATIVE PORTFOLIO
MANAGEMENT CONFERENCE

Modeling Approaches

Structural Approach



- Value-based approach
- Merton's model – Application of option-pricing theory
- Asset value follows standard assumptions of Black-Scholes model

$$dV_t = \mu V_t dt + \sigma_V V_t dW_t$$

- Default if the firm cannot repay its debt at maturity, i.e., if asset value V is below the face value of debt K

- Probability of default is given by

$$P_t\{V_T < K\} = \Phi(-DD_t) \qquad DD_t = \frac{\ln(V_t/K) + (\mu - \sigma^2/2)(T-t)}{\sigma\sqrt{(T-t)}}$$

where DD_t is known as "distance to default"

- Asset value (V), drift (μ), and volatility (σ) are not observed

Structural Approach

- Asset value can be inferred from equity market based on Black-Scholes framework
  - Equity claims is equivalent to call option on underlying asset value

$$E_t = CallOption(V_t, K, \sigma_V, r, T)$$

- Relationship between equity and asset volatility can be derived

$$\sigma_E E_t = \Phi(d_1) \cdot \sigma_V V_t$$

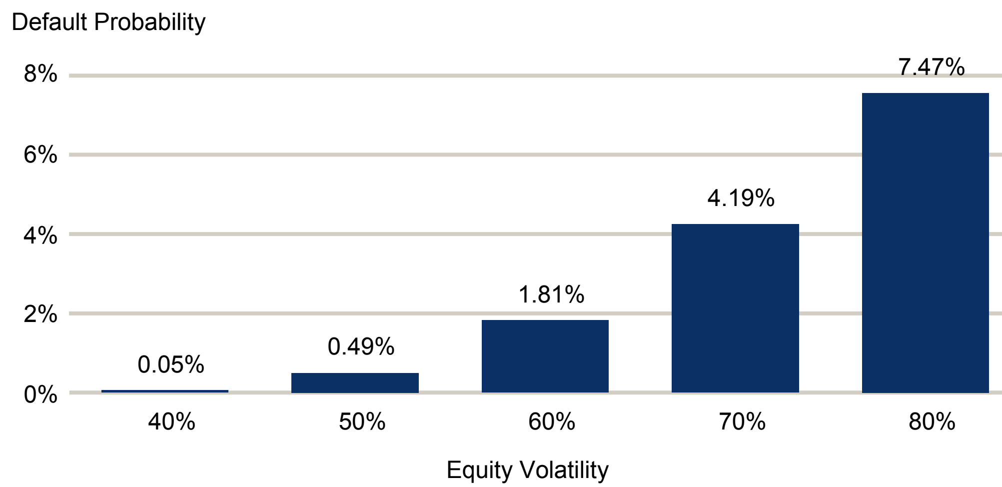
- Asset value drift or growth rate
  - Risk-neutral probability
    - Risk-free rate
  - Real-world probability
    - Expected growth of the company
    - Weighted average cost of capital (WACC)

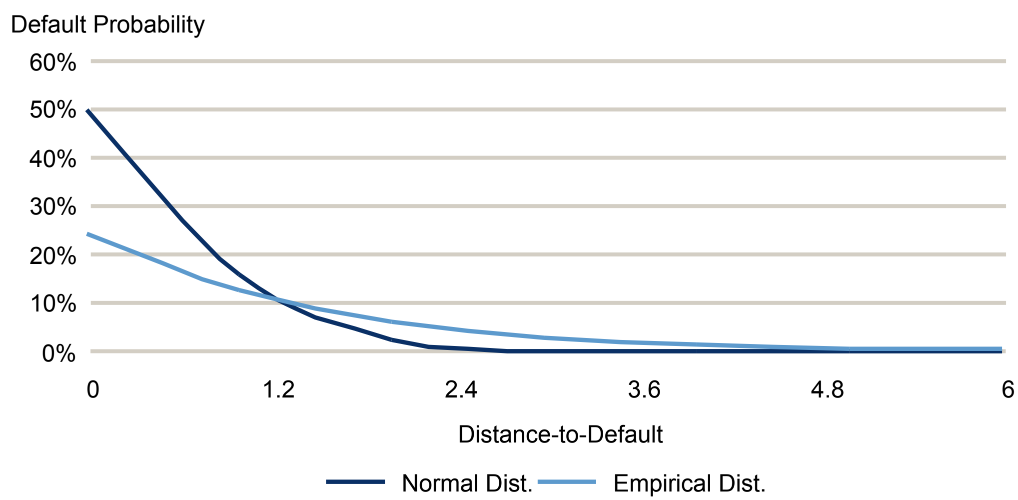
Shortcomings of Simple Merton's Model

- Overly simplistic assumptions
  - Standard Black-Scholes assumptions
  - Default occurs only at maturity
  - No interest payment or other cash payouts
  - These limitations can be addressed by using advanced pricing models, exotic derivative structures, and/or complex computational methods
- Empirical evidence shows under-prediction of default frequencies
- Log-normal process for asset values
- Default probability estimates are highly sensitive to estimated parameters such as asset volatility and default boundary
- Some important financial information CANNOT be captured in the structural framework regardless of complexity

Example

- A K Steel
  - Market cap: $2.22bn
  - Default boundary: $2.54bn
  - Equity volatility: 40%–80%
  - Default probability ranges from 0.05% to 7.47%, equivalent to A to CCC, with above volatility input range
- Defaults happen much more often than predicted by normal distribution
  - E.g., DD = 4 means firm is 4 st dev away from default – Normal distribution would imply ~0% – Historically, we observed ~1%
- Both problems caused by the fact that empirical distribution is very different from normal





Source: Barclays Capital.

BARCLAYS CAPITAL

Reduced-Form Approach

- Econometric approach – Estimate probability by directly establishing statistical relationship between hazard rate and state variables (firm-specific and macro)

$$P_t\{default\} = f(x_{1,t},\ldots,x_{n,t})$$

- Predictive variables typically include leverage, liquidity, coverage ratio, profitability, size, industry, market conditions, volatility, etc.
- Preferred by practitioners for pricing
- No specific assumptions on capital structure
- Can be calibrated to
  - Market spreads for risk-neutral probability
  - Historical default events for real-world probability
- Disadvantages
  - Purely statistical
  - Offers no information on relationship between debt and equity values

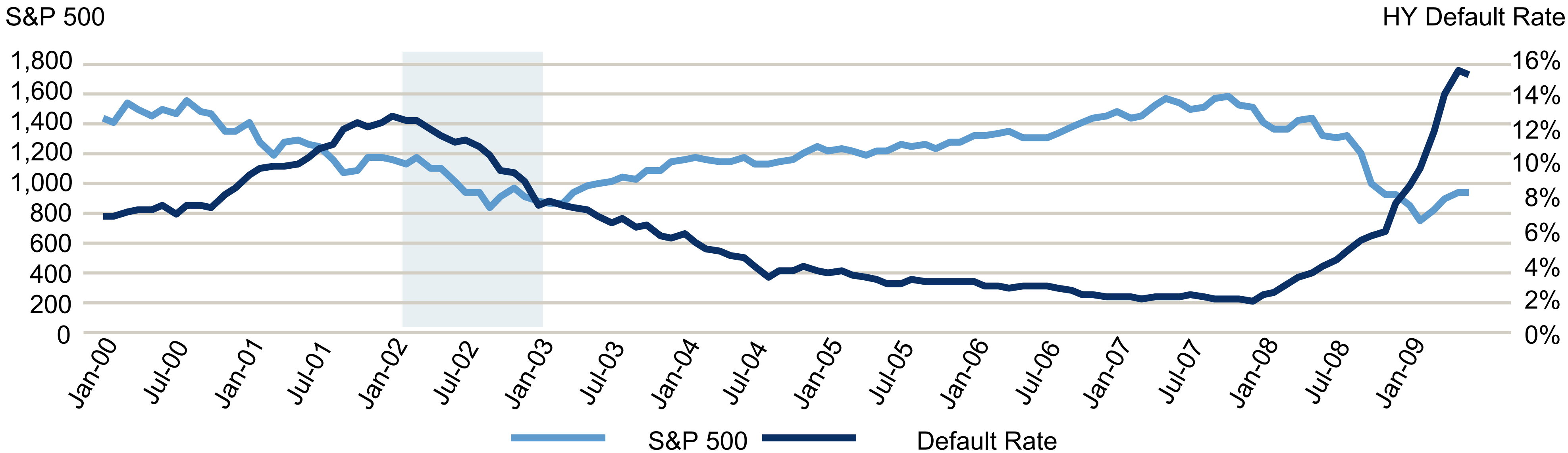
Hybrid Solution

- In reduced-form approach, distance to default (DD) (from structural model) turns out to be the most significant variable
- Using DD in reduced-form model, calibrated to historical defaults, solves the normal distribution problem
  - Establishes empirical relationship (distribution) between DD and default intensity
  - Captures fat tails
  - Corrects sensitivities to estimated parameters
- Explanatory power of DD improved with
  - Better treatment of accounting data to construct default boundary
  - Allowing default to occur any time (i.e., down-and-out call option)
  - More robust method for computing volatilities
- Other information not captured by the structural framework can be included (coverage ratio, size, industry, etc.)

Aggregate Default Rate

Remaining problem

- Aggregate default probabilities do not always agree with economy-wide default rate
- Aggregate level is largely driven by overall DD from the structural model, which is, in turn, driven by the equity market
- E.g., aggregated default probability estimates increased throughout 2002 due to declining equity market and increasing volatility, while default rate continued to drop

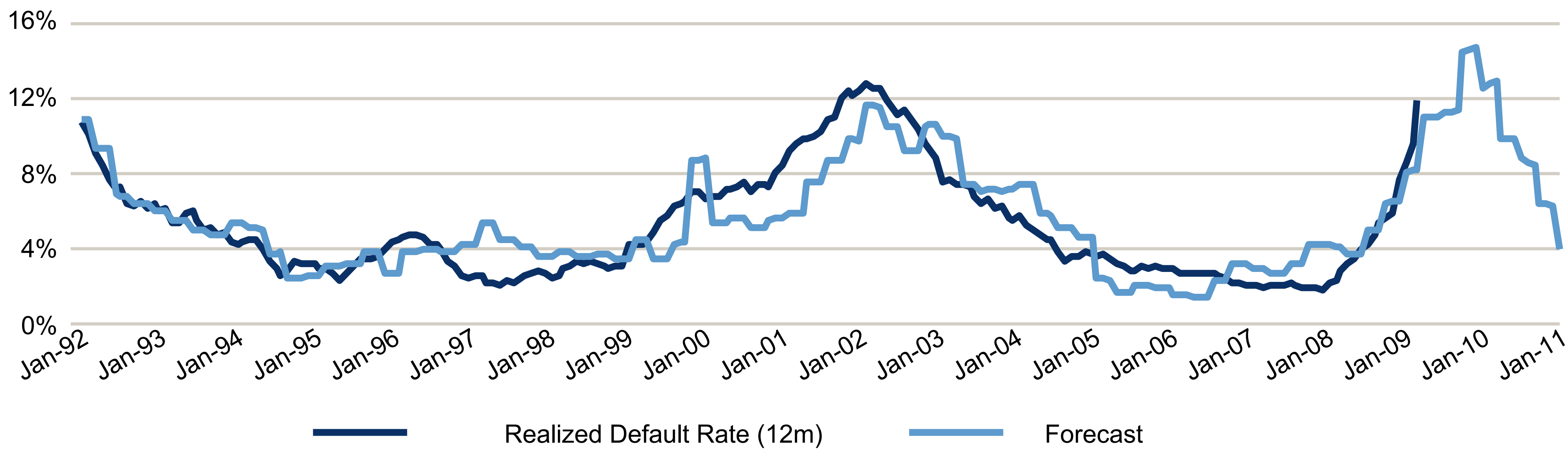


Source: Barclays Capital, Moody's Investors Service.

Incorporating Macro View

- Aggregated default rate can be forecast using macro variables
- Strong relationship between default rate and national activity index, distress level in high-yield market, delinquency rate, lending standards, and more …
- Adjust default probability estimates such that they aggregate to appropriate level

HY Default Rate



Source: Barclays Capital, Moody's Investors Service.

QUANTITATIVE PORTFOLIO
MANAGEMENT CONFERENCE

Applications

Risk Management

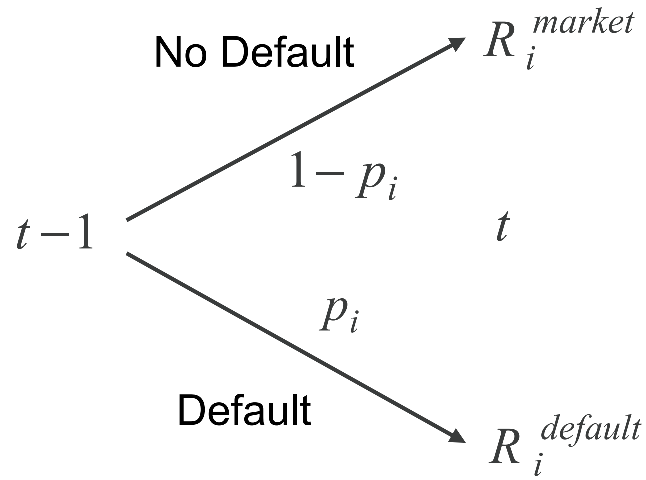
- Credit default risk
- Model market risk and default risk simultaneously
- p_i is the default probability of security i
- $R_i^{default}$ is the loss-given default, estimated by our recovery model

$$LGD = \frac{recovery}{price} - 1$$

- Default TEV of a single security is approximately

$$DTEV \approx \sqrt{p(1-p)} \cdot LGD$$

- Default probability also used to estimate
  - Default correlations for portfolio default risk
  - Loss distribution for VaR and ES



Risk Management

- Equity portfolio TEV
- Default probability has much stronger explanatory power than traditional measures of leverage in forecasting future volatility
- Construct portfolio based on quintiles of default probability, debt-to-total asset and debt-to-equity ratios
- Standard deviation (volatility) of monthly return for each quintile
  - Volatility increases most prominently with default probability

	Default Probability	Debt-to-Total Asset	Debt-to-Equity
Q1 – low	**0.88%**	1.63%	1.77%
Q2	**0.88%**	0.88%	0.79%
Q3	**0.94%**	0.82%	0.95%
Q4	**1.40%**	1.07%	0.82%
Q5 – high	**2.10%**	1.08%	1.09%

Source: Barclays Capital.

Applications in Portfolio Construction

- Default probabilities can be used to help portfolio managers construct portfolios
- Relative value in credit
  - Exploit mispricing in credit market
  - Identify rich / cheap CDS contracts
  - Long / short signal for Credit Index or CDX / iTraxx
- Filter to identify “true” value in equity
  - Distinguish cheap versus distressed
  - E.g., high book-to-market can imply value or about to go bust

Credit

- Disparity between CDS spreads and default probability
- High disparity = high spread relative to default probability
- Annualized monthly returns for selling protection in each bucket
  - "High" bucket yields highest return across all sub-periods

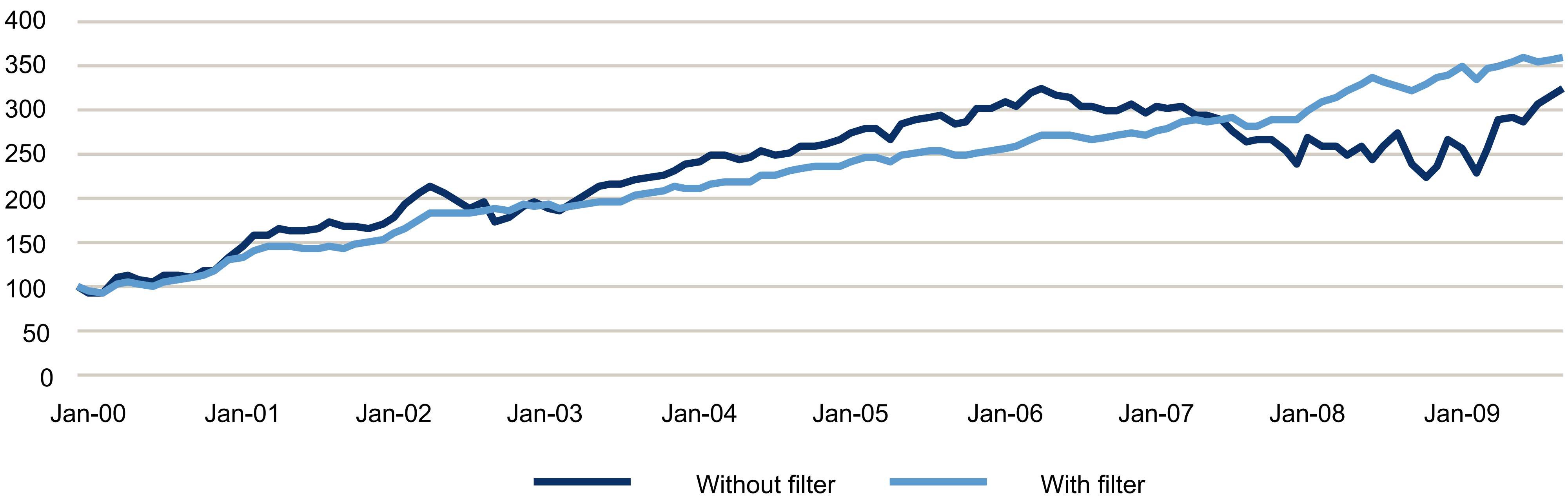
	Disparity Buckets			
	L	**M**	**H**	
	-1.4%	0.2%	**1.4%**	*Return*
2001–2008	5.2%	4.3%	3.2%	*St.Dev.*
	(107)	(107)	(107)	*N*
	0.3%	3.7%	**4.0%**	
2001–2004	5.1%	3.1%	2.8%	
	(79)	(79)	(79)	
	-4.1%	-3.3%	**-0.9%**	
2005–2008	5.6%	4.6%	2.7%	
	(135)	(135)	(135)	

Source: Barclays Capital.

BARCLAYS CAPITAL

Equity

- Construct simple strategy based on book-to-market ratio
- Long stocks with high book-to-market, short S&P futures
- Find “true” value by filtering out distressed stocks using default probability
- Strategy with default probability filter generates much more persistent and robust return



Source: Barclays Capital.

BARCLAYS CAPITAL

Conclusion

- Need for reliable measure of credit risk
  - Risk management (VaR, ES)
  - Portfolio construction, trading strategy, etc.
- Advantage and disadvantage of structural and reduced-form framework
- Benefits of the combined approach
- Incorporate macro views on aggregate default rate
- Applications
  - Risk management
  - Portfolio construction

References

- Asvanunt, A. and A. Staal. “The Corporate Default Probability model in the Barclays Capital POINT platform (POINT CDP)”. Portfolio Modeling, Barclays Capital, April 2009
- Asvanunt, A. and A. Staal. “The POINT Conditional Recovery Rate (CRR) Model”. Portfolio Modeling, Barclays Capital, August 2009
- Engelmann, B., E. Hayden and D. Tasche. “Testing Rating Accuracy”. Risk, 16, 82-86, January 2003
- Erlandsson U., and G. Rennison. “Projecting the Credit Cycle in 2009-10”. Quantitative Credit Strategy, Barclays Capital, December 2008

BARCLAYS CAPITAL

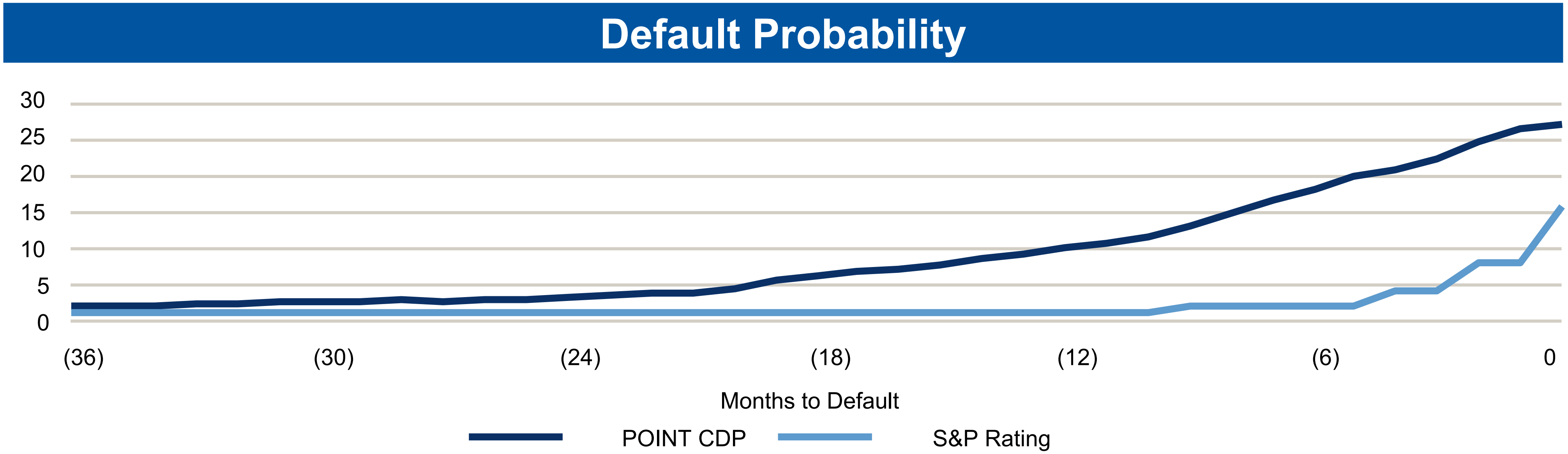
QUANTITATIVE PORTFOLIO
MANAGEMENT CONFERENCE

Appendix – Measure Model Performance

Performance Measurement

- Correlation to markets
  - Does it agree with the view observed in the credit market?
  - Rank correlation with CDS spreads
- Timely prediction
  - Does it provide early warning of the upcoming distress / default?
- Predictive power
  - How well does it differentiate between healthy and distressed firms?
  - How many issuers with high default probabilities actually default?
- Accuracy
  - How accurate is the level of the probability?
  - Is it unbiased?

Timely Prediction Test

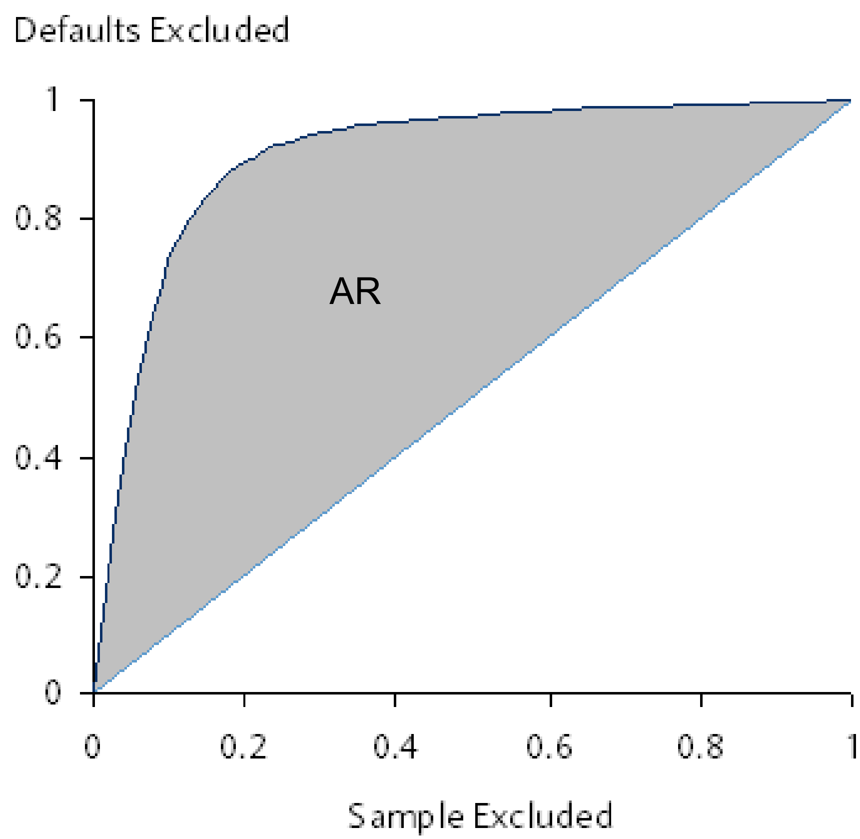


Source: Barclays Capital.

- How well does the default probability detect upcoming default?
- Create a sample of default firms and look at their model default probabilities up to 36 months prior to default
- Compare median probabilities with other credit risk measures
- In the above example, we compare with S&P rating (translated to appropriate scale)

Predictive Power Test

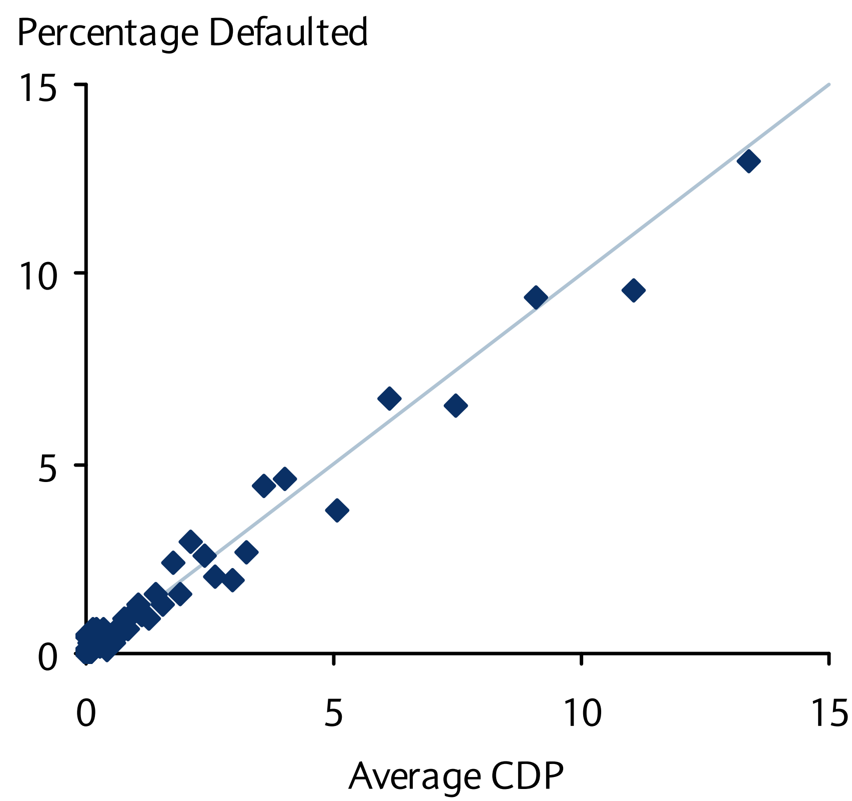
- Characterizes ability to distinguish healthy from distressed firms
- Cumulative accuracy profile (CAP) and accuracy ratio (AR)
- Rank firms by their model default probabilities from highest to lowest
- Remove firms one by one and, as we do so, compare the fraction of defaults removed and fraction of overall sample removed
- AR is the area between CAP curve and 45-degree line divided by the area under 45-degree line (0.5)
- High predictive power means CAP curve should steeply rise to 1, resulting in AR close to 1



Source: Barclays Capital.

Accuracy Test

- Determines accuracy of the probability levels
- Divide sample into groups with similar default probabilities
- Compare fraction of sample that defaults and average default probability within each group
- Accurate / unbiased estimates should generate a plot with data points close to the 45-degree line



Source: Barclays Capital

BARCLAYS CAPITAL

Analyst Certification and Important Disclaimers

Analyst Certification(s)

I, Attakrit Asvanunt, hereby certify (1) that the views expressed in this research report accurately reflect my personal views about any or all of the subject securities or issuers referred to in this research report and (2) no part of my compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed in this research report.

Important Disclosures

For current important disclosures regarding companies that are the subject of this research report, please send a written request to: Barclays Capital Research Compliance, 745 Seventh Avenue, 17th Floor, New York, NY 10019 or refer to https://ecommerce.barcap.com/research/cgi-bin/all/disclosuresSearch.pl or call 212-526-1072.

Barclays Capital does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that Barclays Capital may have a conflict of interest that could affect the objectivity of this report. Any reference to Barclays Capital includes its affiliates. Barclays Capital and/or an affiliate thereof (the “firm”) regularly trades, generally deals as principal and generally provides liquidity (as market maker or otherwise) in the debt securities that are the subject of this research report (and related derivatives thereof). The firm's proprietary trading accounts may have either a long and / or short position in such securities and / or derivative instruments, which may pose a conflict with the interests of investing customers. Where permitted and subject to appropriate information barrier restrictions, the firm's fixed income research analysts regularly interact with its trading desk personnel to determine current prices of fixed income securities. The firm's fixed income research analyst(s) receive compensation based on various factors including, but not limited to, the quality of their work, the overall performance of the firm (including the profitability of the investment banking department), the profitability and revenues of the Fixed Income Division and the outstanding principal amount and trading value of, the profitability of, and the potential interest of the firms investing clients in research with respect to, the asset class covered by the analyst. To the extent that any historical pricing information was obtained from Barclays Capital trading desks, the firm makes no representation that it is accurate or complete. All levels, prices and spreads are historical and do not represent current market levels, prices or spreads, some or all of which may have changed since the publication of this document.

Barclays Capital produces a variety of research products including, but not limited to, fundamental analysis, equity-linked analysis, quantitative analysis, and trade ideas. Recommendations contained in one type of research product may differ from recommendations contained in other types of research products, whether as a result of differing time horizons, methodologies, or otherwise.

Important Disclaimers *(cont'd)*

This publication has been prepared by Barclays Capital, the investment banking division of Barclays Bank PLC, and/or one or more of its affiliates as provided below. This publication is provided to you for information purposes only. Prices shown in this publication are indicative and Barclays Capital is not offering to buy or sell or soliciting offers to buy or sell any financial instrument. Other than disclosures relating to Barclays Capital, the information contained in this publication has been obtained from sources that Barclays Capital believes to be reliable, but Barclays Capital does not represent or warrant that it is accurate or complete. The views in this publication are those of Barclays Capital and are subject to change, and Barclays Capital has no obligation to update its opinions or the information in this publication. Barclays Capital and its affiliates and their respective officers, directors, partners and employees, including persons involved in the preparation or issuance of this document, may from time to time act as manager, co-manager or underwriter of a public offering or otherwise, in the capacity of principal or agent, deal in, hold or act as market-makers or advisors, brokers or commercial and/or investment bankers in relation to the securities or related derivatives which are the subject of this publication.

The analyst recommendations in this report reflect solely and exclusively those of the author(s), and such opinions were prepared independently of any other interests, including those of Barclays Capital and/or its affiliates.

Neither Barclays Capital, nor any affiliate, nor any of their respective officers, directors, partners, or employees accepts any liability whatsoever for any direct or consequential loss arising from any use of this publication or its contents. The securities discussed in this publication may not be suitable for all investors. Barclays Capital recommends that investors independently evaluate each issuer, security or instrument discussed in this publication and consult any independent advisors they believe necessary. The value of and income from any investment may fluctuate from day to day as a result of changes in relevant economic markets (including changes in market liquidity). The information in this publication is not intended to predict actual results, which may differ substantially from those reflected. Past performance is not necessarily indicative of future results.

This communication is being made available in the UK and Europe to persons who are investment professionals as that term is defined in Article 19 of the Financial Services and Markets Act 2000 (Financial Promotion Order) 2005. It is directed at, and therefore should only be relied upon by, persons who have professional experience in matters relating to investments. The investments to which it relates are available only to such persons and will be entered into only with such persons. Barclays Capital is authorized and regulated by the Financial Services Authority ('FSA') and member of the London Stock Exchange.

Barclays Capital Inc., US registered broker/dealer and member of FINRA (www.finra.org), is distributing this material in the United States and, in connection therewith accepts responsibility for its contents. Any U.S. person wishing to effect a transaction in any security discussed herein should do so only by contacting a representative of Barclays Capital Inc. in the U.S. at 745 Seventh Avenue, New York, New York 10019.

Subject to the conditions of this publication as set out above, Absa Capital, the Investment Banking Division of Absa Bank Limited, an authorised financial services provider (Registration No.: 1986/004794/06), is distributing this material in South Africa. Absa Bank Limited is regulated by the South African Reserve Bank. This publication is not, nor is it intended to be, advice as defined and/or contemplated in the (South African) Financial Advisory and Intermediary Services Act, 37 of 2002, or any other financial, investment, trading, tax, legal, accounting, retirement, actuarial or other professional advice or service whatsoever. Any South African person or entity wishing to effect a transaction in any security discussed herein should do so only by contacting a representative of Absa Capital in South Africa, 15 Alice Lane, Sandton, Johannesburg, Gauteng 2196. Absa Capital is an affiliate of Barclays Capital.

Non-U.S. persons should contact and execute transactions through a Barclays Bank PLC branch or affiliate in their home jurisdiction unless local regulations permit otherwise.

In Japan, foreign exchange research reports are prepared and distributed by Barclays Bank PLC Tokyo Branch. Other research reports are distributed to institutional investors in Japan by Barclays Capital Japan Limited. Barclays Capital Japan Limited is a joint-stock company incorporated in Japan with registered office of 2-2-2, Otemachi, Chiyoda-ku, Tokyo 100-0004, Japan. It is a subsidiary of Barclays Bank PLC and a registered financial instruments firm regulated by the Financial Services Agency of Japan. Registered Number: Kanto Zaimukyokucho (kinsho) No. 143.

Barclays Bank PLC Frankfurt Branch is distributing this material in Germany under the supervision of Bundesanstalt fuer Finanzdienstleistungsaufsicht (BaFin). This material is distributed in Malaysia by Barclays Capital Markets Malaysia Sdn Bhd.

IRS Circular 230 Prepared Materials Disclaimer: Barclays Capital and its affiliates do not provide tax advice and nothing contained herein should be construed to be tax advice. Please be advised that any discussion of U.S. tax matters contained herein (including any attachments) (i) is not intended or written to be used, and cannot be used, by you for the purpose of avoiding U.S. tax-related penalties; and (ii) was written to support the promotion or marketing of the transactions or other matters addressed herein. Accordingly, you should seek advice based on your particular circumstances from an independent tax advisor.

BARCLAYS CAPITAL