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Predicting Defaults of High Yield Bonds

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Introduction, Motivation, Goals

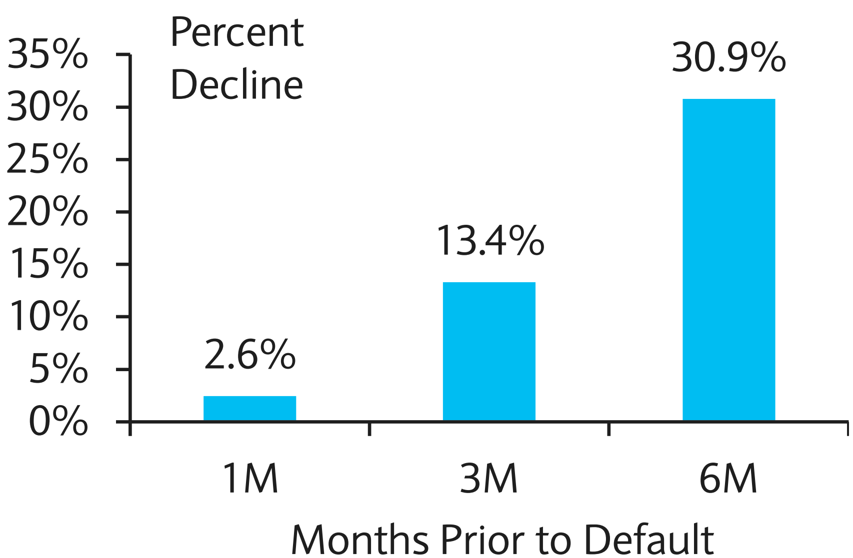
Introduction

- High Yield debt offers attractive returns but increased risk
- Much of this increased risk is the possibility that the issuer will default on its debt obligation
- Default risk is also a primary driver of bond prices and changes in bond prices
- We aim to quantify this risk by isolating some drivers of near-term default
- We chose to focus on a 6M default horizon
- Average 6M default probabilities for debt in US HY index is 2.5% (1998-2017)
- US HY index bond prices tend to decrease approximately 30% in the 6 months before default
- For US HY index issuers that also have traded equity, the average equity price decreases approximately 50% in the 6M prior to default.

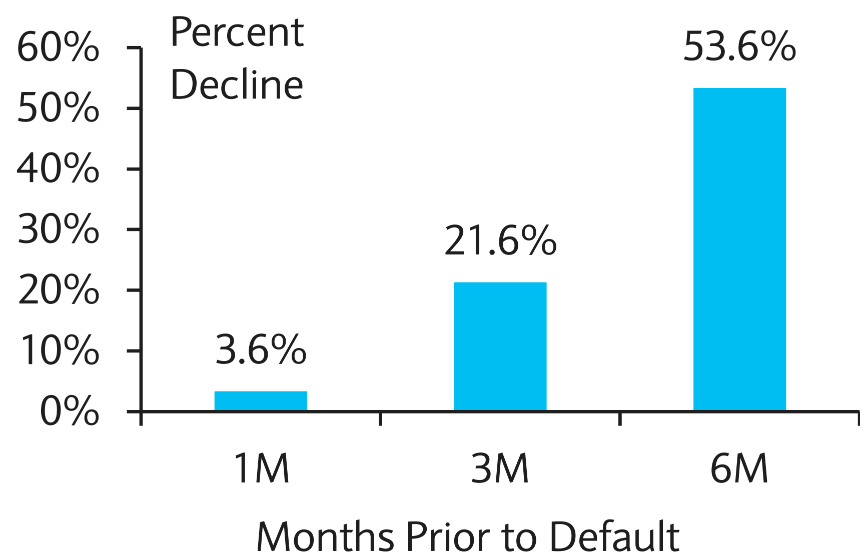
Motivation: Why Should We Care About Defaults?

- Detecting defaults is key in avoiding losses in the HY debt markets
  - Average bond price in US HY index declines 30.9% in the 6M prior to default
- Detecting defaults is useful in avoiding losses in equity markets as well
  - Average equity price of HY issuers declines 53.6% in the 6M prior to default

Average Decline in HY Bond Price Prior to Default



Average Decline in Equity Price Prior to Default

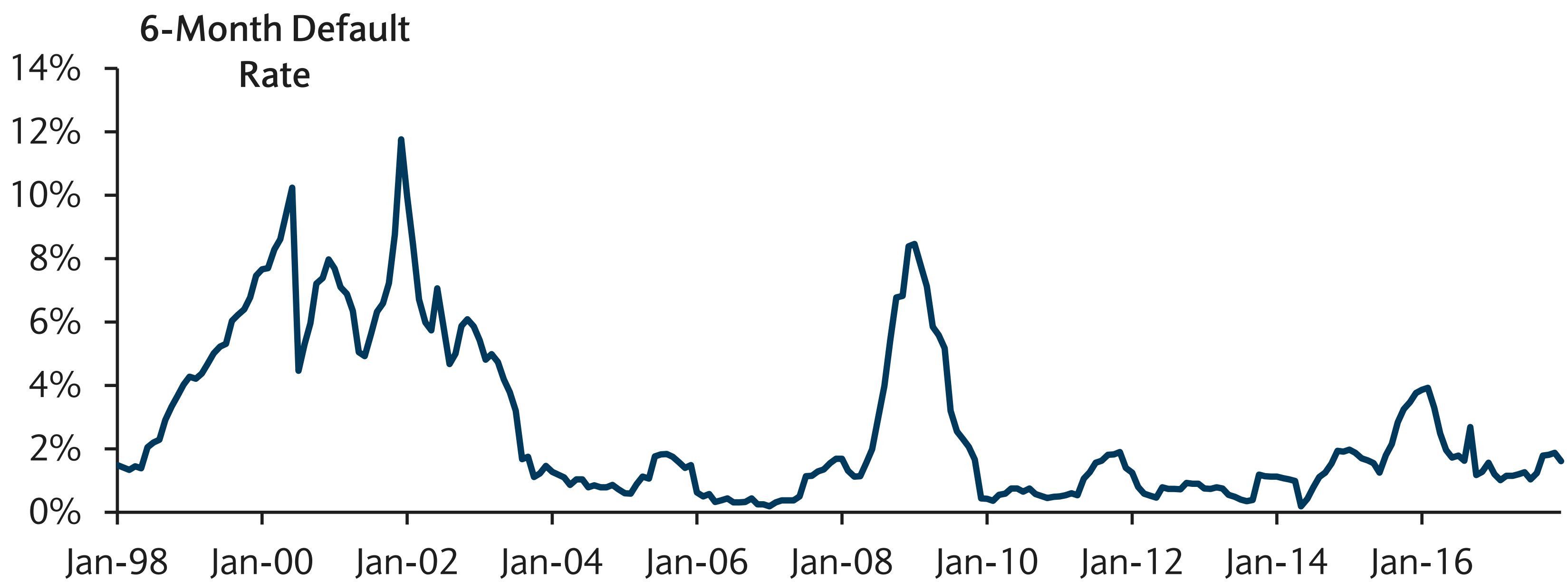


Source: Bloomberg Barclays Indices, Compustat, Barclays Research

Motivation: Are Defaults Rare Events?

- While defaults in Investment Grade markets may be rare, they are relatively common in non-investment grade markets
    - On average 2.5% of all HY issues in our sample default within 6M

Percentage of US HY Issuers Defaulting within 6 Months



Source: Bloomberg Barclays Indices, Barclays Research

Goals

- Our main goal is to understand the drivers of default in US HY credit markets and use this information to build a model that accurately predicts default over a six-month time horizon

- More precisely, we answer three main questions:

  - What are the main drivers of default for US HY credit?

  - How do we quantify the effect of these drivers of default?

  - How well does a default classification model using these drivers perform out-of-sample?

Data and Signal Generation

Sample Universe: Construction

- The sample universe used in our analysis are any records of bonds that:
    - Belonged to the US HY index
    - Traded anytime between January 1998 and June 2018
    - Were issued by a public company
    - Had not yet defaulted

- Only public debt is considered since the model uses issuer balance sheet and traded equity data to generate signals

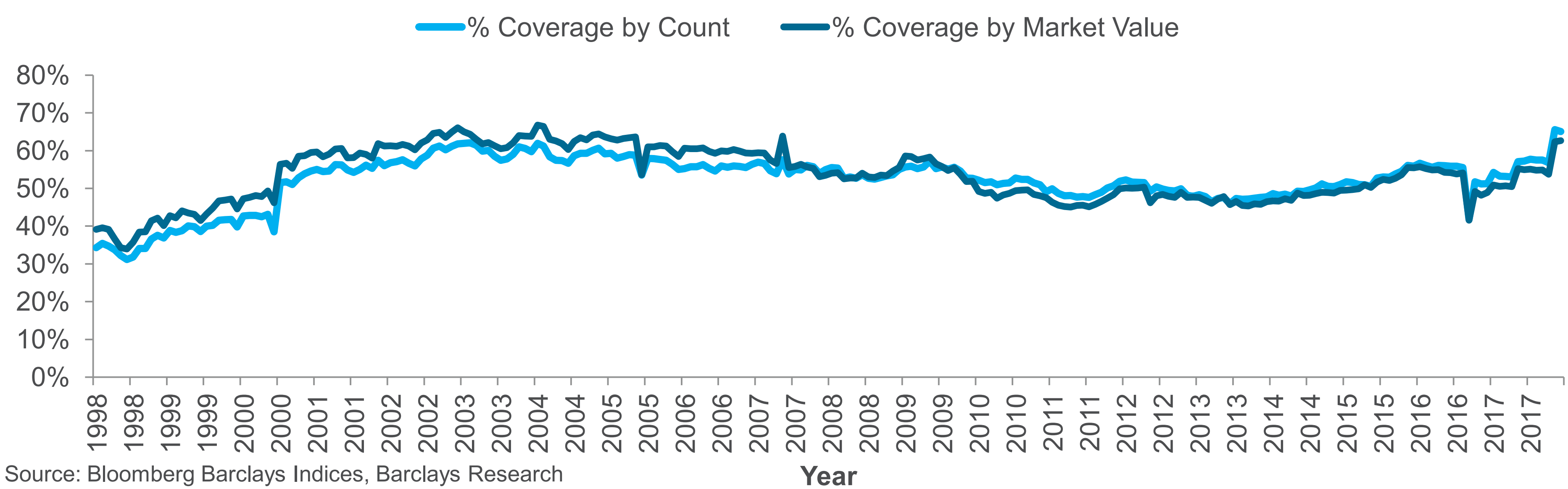
- Final coverage is approximately 52% US HY index

Sample Universe: Coverage

- Average HY Index Coverage of Final Dataset is:
  - 52.3% by count
  - 52.8 % by market value

	Coverage of US HY Index After Application of Each Data Source				
	Initial Coverage	After Including Bond-Equity Mapping	After Including Equity Data	After Including Balance Sheet Data	Final Coverage
By Count	100.0%	68.6%	52.7%	52.3%	52.3%
By Market Value	100.0%	71.4%	53.4%	52.8%	52.8%

Percentage of US HY Index Covered by Final Dataset



Source: Bloomberg Barclays Indices, Barclays Research

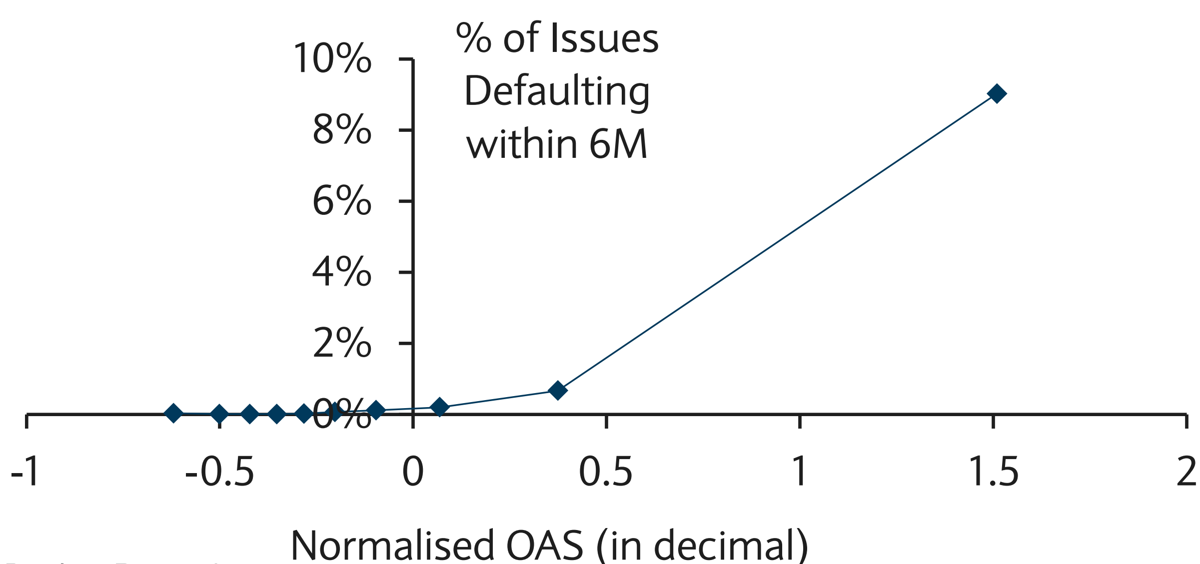
Predictors of Default: Normalised OAS

- Market spreads price in default risk as well as liquidity
- To focus on relative default risk, we normalise OAS relative to the average HY OAS
- We define the Normalised OAS of issuer j in month i as:

$$Normalised\ OAS_i^j = \frac{OAS_i^j - Avg\ OAS_i}{Avg\ OAS_i}$$

- We rank the HY universe by deciles of Normalised OAS and plot the default rates
- Increasing Normalised OAS leads to an increase in defaults in a nonlinear manner

6-Month Realised Default Rate as a Function of Normalised OAS



Source: Bloomberg Barclays Indices, Barclays Research

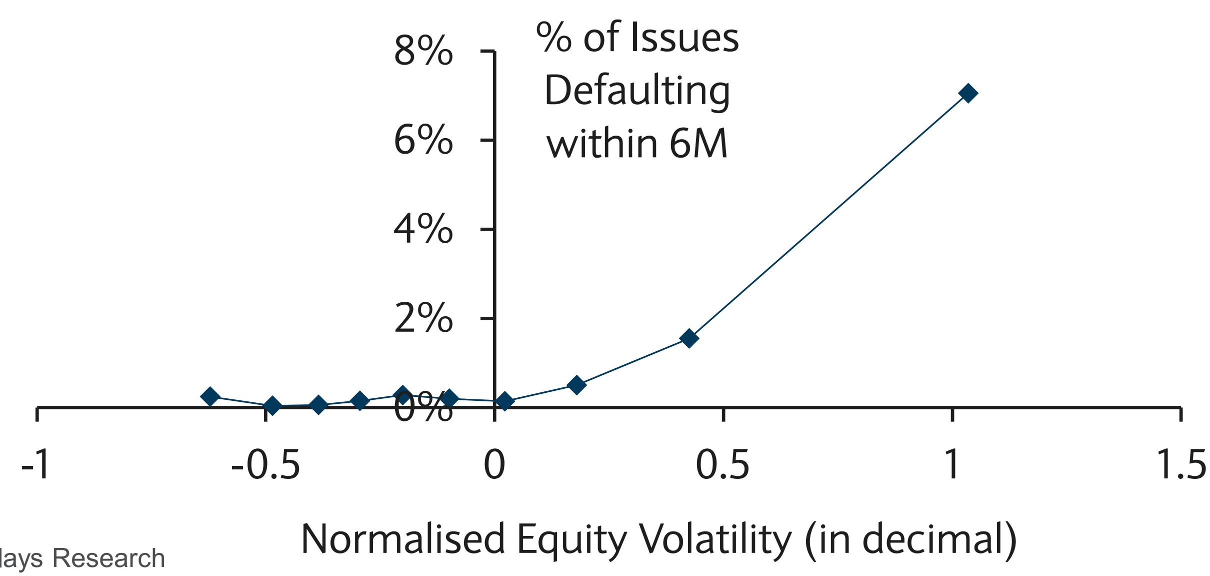
Predictors of Default: Normalised Equity Volatility

- Issuers with large volatility in equity prices have a higher uncertainty in future equity and asset values, and hence a higher risk of becoming insolvent
- We normalise equity volatility relative to the average volatility of stocks in our sample:

$$Normalised\ Equity\ Vol_i^j = \frac{Equity\ Vol_i^j - Avg\ Equity\ Vol_i}{Avg\ Equity\ Vol_i}$$

- A decile plot shows that an increase in Normalised Equity Volatility leads to a nonlinear increase in defaults

6-Month Realised Default Rate as a Function of Normalised Equity Volatility

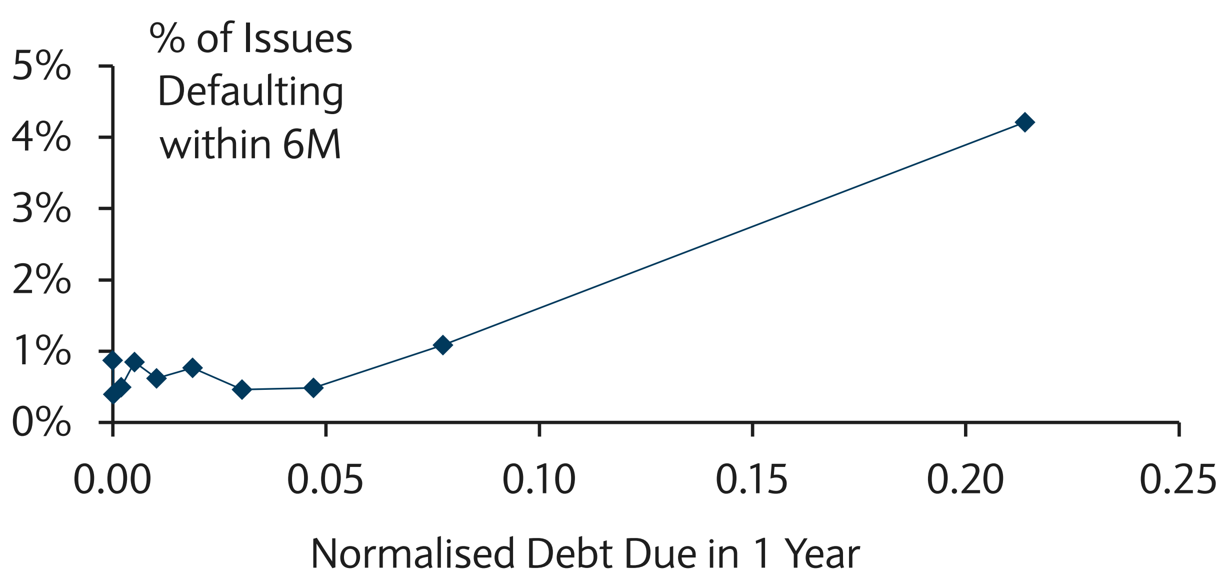


Source: Compustat, Barclays Research

Predictors of Default: Debt Due in 1Y / Assets

- Issuers with a large amount of debt due in the short term may have a hard time refinancing, especially during periods of elevated systemic risk
- To create an effective signal, we normalise the debt due in 1Y by dividing by the total assets of the issuer
- This relative measure of short-term debt gives a much stronger signal for default over a 6M time horizon than using the traditional total debt to equity ratio.

6-Month Realised Default Rate as a Function of Near-Term Liabilities



Source: Compustat, Barclays Research

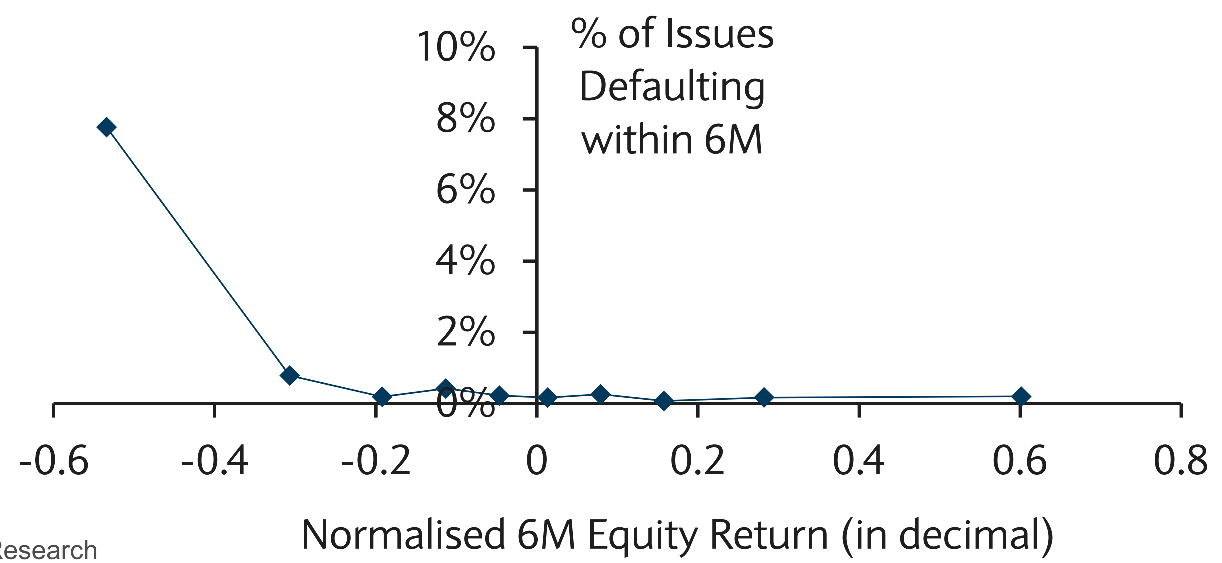
Predictors of Default: Normalised Equity Returns

- Equity momentum gives us information about the market's estimation of default probability
- We again consider only the idiosyncratic portion of the 6M equity momentum by subtracting the 6M SPX Return:

$$Normalised\ 6M\ Equity\ Return_i^j = Ret6M_i^j - Ret6M_i^{SPX}$$

- When Normalised 6M Equity Returns are substantially negative, the probability that the issuer will default increases.

6-Month Realised Default Rate as a Function of Past 6M Equity Return

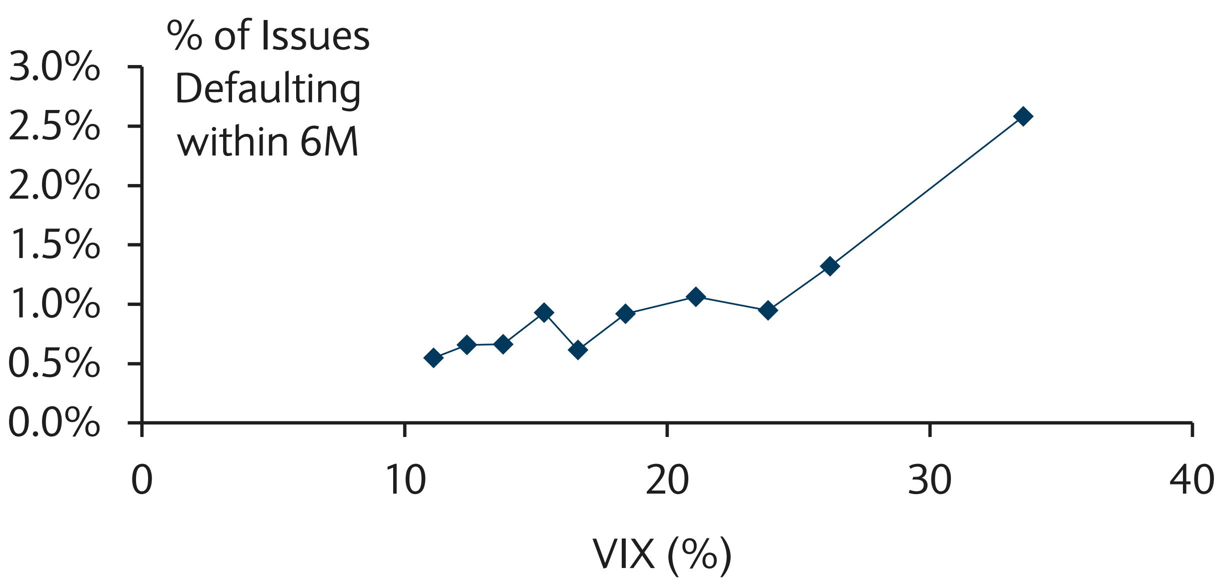


Source: Compustat, Barclays Research

Predictors of Default: VIX

- Since most our default signals are focused on idiosyncratic risk, we use VIX as a systemic signal that gives us information about the overall state of the market.
- An issue with relative signals such as Normalised OAS or Normalised Equity Volatility is that all issuers have a different probability of default depending on whether the overall market conditions are weak or strong
- All else equal, a HY issue has greater probability of defaulting when the VIX is high

6-Month Realised Default Rate as a Function of VIX Level



Source: Bloomberg, Barclays Research

Predictors of Default: Correlation Between Signals

- The table below shows correlations among the different signals used in our model, as well as between each signal and future defaults
- Order of default signal strength is: Normalised OAS > Normalised Equity Volatility > Short-Term Debt to Assets > Normalised Equity Return >VIX

	Default within 6M	OAS	Equity Volatility	Short Term Debt	6M Equity Return	VIX Level
Default within 6M	100.0%	38.5%	19.2%	15.6%	-12.3%	6.5%
OAS	38.5%	100.0%	30.8%	16.7%	-17.1%	4.0%
Equity Volatility	19.2%	30.8%	100.0%	6.9%	-5.0%	-0.3%
Short Term Debt	15.6%	16.7%	6.9%	100.0%	-6.3%	8.7%
6M Equity Return	-12.3%	-17.1%	-5.0%	-6.3%	100.0%	-5.2%
VIX Level	6.5%	4.0%	-0.3%	8.7%	-5.2%	100.0%

Source: Compustat, Bloomberg Barclays Indices, Barclays Research

Modelling Framework and Results

Modeling Framework: Default Classifier

- We use logistic regression to forecast the future default state at a specified future time horizon
- The logistic classifier is of the form $\ln\left(\frac{PD_i}{1-PD_i}\right) = \alpha + \sum_{i=1}^{N} \beta_i X_i + \varepsilon_i$
  - X_i are the signals (model inputs)
  - α is the intercept and β_i are the regression coefficients
  - ε_i are the residuals
  - PD_i are the estimated probabilities of default output by the model for each bond
- The model is trained based on our (perfect foresight) knowledge of what happened in the 6 months subsequent to each market snapshot
- The model then gives a value of 0 to a bond that is predicted to survive 6 months into future, and a value of 1 to a bond that is predicted to default within those 6 months

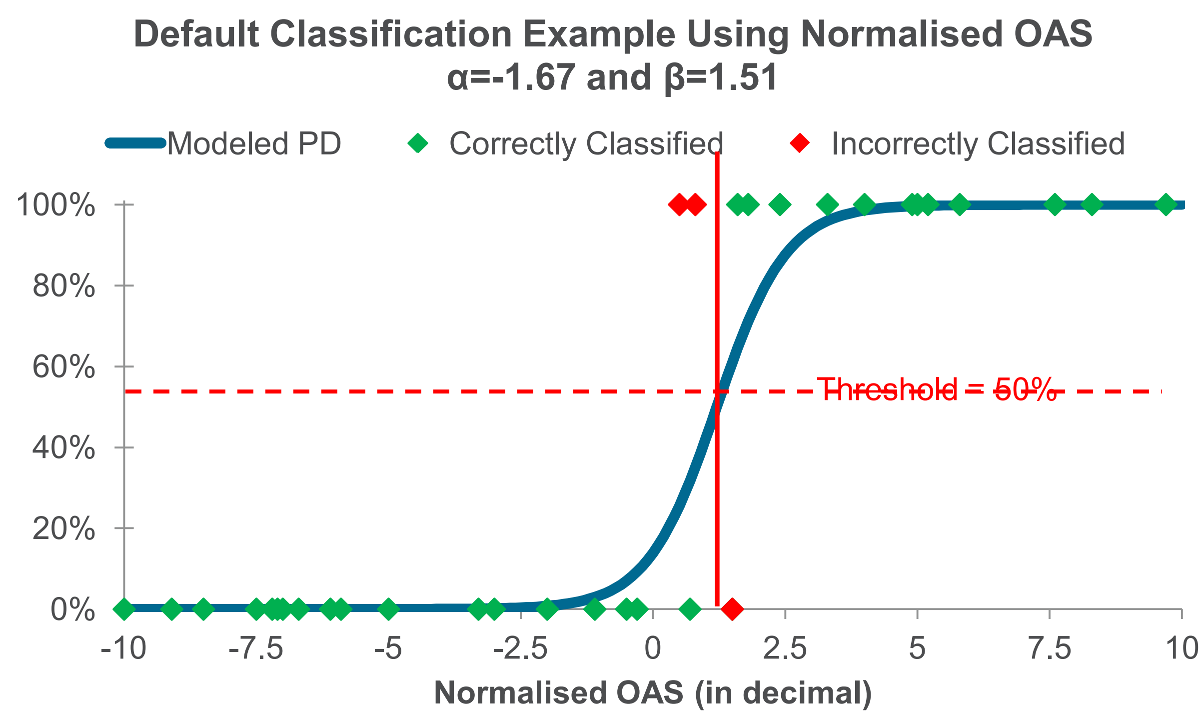
Modeling Framework: Outputs of the Model

- Main outputs of the modeling framework are:
  - Probability that a bond will default within 6M (other horizons can be considered)
  - Bond is forecast to survive (state=0) if PD<0.5
  - Bond is forecast to default (state=1) if PD>=0.5
  - Adjusting the PD threshold can change the trade-off between false positives (allowing bonds that will default into the portfolio) and false negatives (flagging bonds that end up recovering)

- The modeling framework also generates cross-validation metrics:
  - A confusion matrix stating hit ratio, false positives, false negatives etc
  - An ROC Curve (that shows the effect of changing the PD threshold)
  - Model statistics such as pseudo R^2

Default Classification: Normalised OAS Example

- As a simple example, consider a model where the only signal is Normalised OAS
- If we take the default threshold as 50% (i.e PD ≥ 50% means default and PD<50% means survival) then the model predicts default if Normalised OAS ≥ 1.11 and survival if Normalised OAS < 1.11
- This means if the OAS of a bond is 2.11 times greater than the average OAS of the HY index, the model predicts the bond will default in 6M



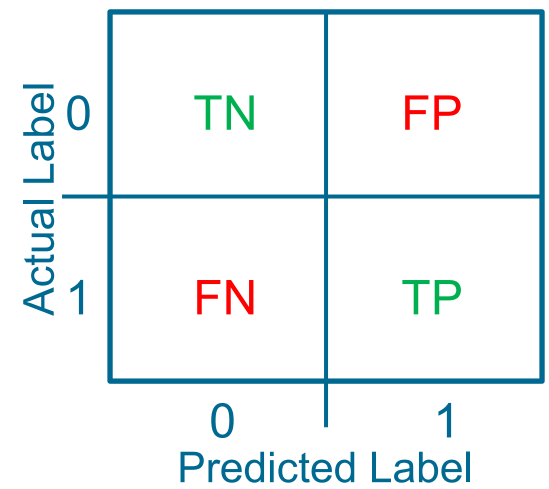
Source: Compustat, Bloomberg Barclays Indices, Barclays Research

Modeling Framework: Confusion Matrix Calculus

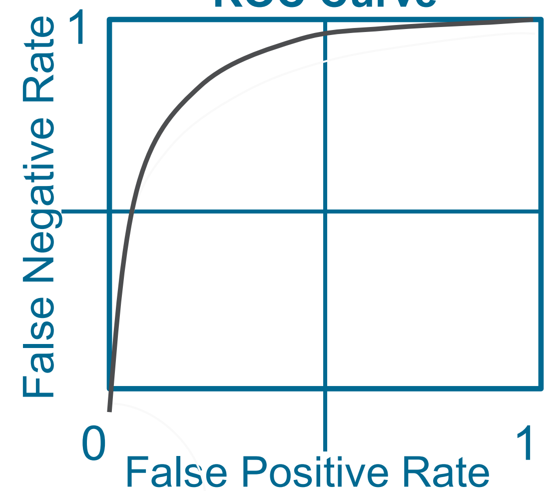
- Key Measure of Out-of-Sample Performance is given by Confusion Matrix
    - TP = True Positive (Hit)
    - TN = True Negative (Correct Rejection)
    - FP = False Positive (i.e., False Alarm or Type I error)
    - FN = False Negative (i.e., Miss or Type II error)

- Total Positives: $P = TP + FN$
- Total Negatives: $N = TN + FP$
- Total Observations: $Tot\ Obs = P + N = TP + FN + TN + FP$
- True Positive Rate: $TPR = \frac{TP}{P}$
- True Negative Rate: $TNR = \frac{TN}{N}$
- False Positive Rate: $FPR = \frac{FP}{N} = 1 - TNR$
- False Negative Rate: $FNR = \frac{FN}{P} = 1 - TPR$
- Accuracy Ratio: $AR = \frac{TP + TN}{P + N} = \frac{TP + TN}{TP + TN + FP + FN}$

Confusion Matrix



ROC Curve



- Accuracy Ratio is not the best measure of model performance

Choosing the Right Penalties for Different Error Types

- Classification problems having far fewer of one class than another require carefully choosing the penalties for False Positive and False Negatives

- As an extreme example, if there are 100 times more observation of one class (the primary class) than another, then predicting that all future observations will be of the primary class will lead to an overall Accuracy Ratio of 99%

- This leads to two main observations:

    - The accuracy ratio (AR) is not a good measure of performance for default classification, and instead we focus on minimizing FNR and FPR.

    - Assuming we wish to construct a long-only portfolio, it is important to have a weighted penalization scheme that penalises False Negatives more than False Positives since a False Negative (holding a bond that defaults) is more costly than a False Positive (avoiding a bond that survives)

- Penalties for different error types are chosen differently if the portfolio is short or long-short

Choosing the Right Penalties: Example

- Our framework allows us to penalise false positive and false negatives differently
- As an example, consider a model with just Normalised OAS as a signal

Penalizing FN and FP Equally

- α= -5.12, β=0.54
- Model predicts default only if OAS > 10.4 times avg HY OAS

Actual Label	Predicted Label 0	Predicted Label 1
0	87289	133
1	739	144

P	N	TPR	TNR	FPR	FNR	AR
883	87422	16.3%	99.8%	0.2%	84.7%	99.0%

Penalizing FN 1000 Times More Than FP

- α= 0.26, β=2.02
- Model predicts default only if OAS > 0.87 times avg. HY OAS

Actual Label	Predicted Label 0	Predicted Label 1
0	54588	32834
1	23	860

P	N	TPR	TNR	FPR	FNR	AR
883	87422	97.4%	62.4%	37.6%	2.6%	62.8%

Source: Compustat, Bloomberg Barclays Indices, Barclays Research

Choosing the Right Penalties: Balanced Weights

- The "balanced" penalization weights are inversely proportional to their relative observations:
  - False Positive Weight: $W_{FP} = 1/N$
  - False Negative Weight: $W_{FN} = 1/P$
- This tends to equalise or "balance" the False Positive and False Negative Rates
- Below is a model using Normalised OAS with 'balanced' penalization. The model predicts a bond will default if Normalised OAS > 2.11 times the average OAS of the HY index

FP weight = 0.01 , FN weight = 0.99

Actual Label \ Predicted Label	0	1
0	82508	4914
1	151	732

P	N	TPR	TNR	FPR	FNR	AR
883	87422	82.9%	94.4%	5.6%	17.1%	94.3%

Source: Compustat, Bloomberg Barclays Indices, Barclays Research

The Default Model: Coefficients and Performance

- By combining the individual signals discussed above and using the "balanced" penalization we arrive at our model for predicting defaults in US HY
- The combined model reduces the false negative rate from 17% to 8% without a substantial increase in the false positive rate

	Intercept	OAS	Short Term Debt	6M Equity Return	Equity Volatility	VIX
Coefficient	-3.76	0.97	2.64	-0.93	0.95	0.067
Significance	***	***	***	***	***	***

FP weight = 0.01 , FN weight = 0.99

Actual Label \ Predicted Label	0	1
0	82271	5151
1	70	813

P	N	TPR	TNR	FPR	FNR	AR
883	87422	92.1%	94.1%	5.9%	7.9%	94.1%

Source: Compustat, Bloomberg Barclays Indices, Barclays Research

The Default Model: General Comments

- By-and-large, Normalised OAS is a good predictor of default, suggesting that the market does a reasonable job of determining default for HY bonds
- However, our model outperforms the benchmark Normalised OAS by increasing the default hit-rate (TPR) without any real increase in false positives
- Given the same set of signals, the performance results depend on how we choose to penalise FP and FN
- Our goal was predicting defaults, and as such we used a balanced penalization scheme in estimating the model parameters
- The penalization scheme should be tailored to the particular application for the model

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