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Modeling the Effect of Macroeconomic Factors on Corporate Default and Credit Rating Transitions

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Abstract

In the reduced-form approach to credit modeling, default frequency has been found to depend on several firm-specific factors, most notably credit rating. But aggregate default rates also vary substantially over time, presumably reflecting changes in general economic conditions. In this paper, we fit Cox intensity models for major credit events, including defaults as well as major upgrades and downgrades in credit rating. The sample covers all corporate issuers in Moody's corporate bond Default Research Database over the period 1981 - 2002. The models incorporate both firm-specific factors related to a firm's credit rating history and a broad range of macroeconomic variables. Our results show that intensities of occurrence of credit events are significantly influenced by macro factors.

I. Introduction

Models of corporate default fall into two broad categories, structural models and reduced form models. Structural models consider the evolution of the value of the firm, with bankruptcy, and default, assumed to occur if firm value should fall below some insolvency threshold. Structural models have the practical advantage of making use of the firm's current stock price. Stock returns are very sensitive to all kinds of information about a firm's financial condition, and they are available daily. But structural models also have serious drawbacks, including the need to take proper account of the firm's capital structure, which may be quite complex, and difficulty in modeling important non-default credit events, such as a ratings downgrade.

Reduced form models, which will be the focus of our research, treat default as a random event like a lightning strike, that has a positive probability of occurrence for any firm at any time. In the simplest reduced form model, a credit event corresponds to the first jump time of a Poisson process with a constant hazard rate. An "event" can be defined flexibly, to be default, downgrade or upgrade from one bond rating category to another, or any other well-defined change of state. The resulting model yields a Markov chain for the occurrence of credit events. The reduced form approach is widely used for credit risk analysis in both academic and real world research, e.g., Jarrow, Lando and Turnbull (1995) and (1997), Lando and Skodeberg (2002), Duffie et al (2005), and Koopman et al (2005).

The constant hazard rate formulation treats all bonds in a given credit class, often defined in terms of bond rating, as homogeneous with respect to their future prospects. But there is empirical evidence of non-Markovian behavior, such as positive serial correlation in ratings changes, known as ratings drift. There also appears to be both time variation and cross-sectional variation in default probabilities across issuers within a given rating. For example, Altman and Kao (1992) indicated the existence of ratings drift for firms that recently had a change in rating, and more recently Hamilton and Cantor (2004) showed that the transition probabilities out of a rating class vary, depending on whether the bond entered its current rating by an upgrade or a downgrade. Christensen, et al (2004) modeled downward drift by introducing a hidden Markov chain. Other kinds of non-Markovian behavior were described by Lando and Skodeberg (2002) who found that the probability of a rating change diminishes the longer the bond stays in the same rating, and by Frydman and Schuermann **(**2006**)** who showed that a mixture of Markov chains statistically dominates a single Markov chain model.

Results reported by Hamilton, et al (2003), Hamilton and Cantor (2004) and Fledelius, et al **(**2004) indicate that within-class hazard rates for default and for ratings transitions vary considerably over time. Such time variation suggests that macroeconomic factors may play a role in determining default intensities. In particular, Bangia et al (2002) and Nickel, et al (2000) showed that upgrade, downgrade and default intensities differ over different economic regimes. Other studies that indicate sensitivity of default probability to macroeconomic factors include Kavvathas (2001), Carling et al (2002), Couderc and

Renault (2004) and Duffie (2005). Huang and Kong (2003) demonstrated a connection between macroeconomic factors and credit risk by analyzing the impact of macroeconomic announcements on credit spreads. These properties of credit risk exposure suggest that it depends on macroeconomic factors.

In this paper, we formulate and estimate models for the occurrence of credit events, allowing the hazard rate for a given issuer to be a function of both firm-specific factors and macroeconomic conditions. Firm-specific factors here are all related to a firm's credit rating history. Keeping to the spirit of the reduced-form specification, we do not attempt to include factors tied to a firm's capital structure or stock returns, such as KMV's "distance to default," even though they have been shown to have considerable explanatory power in structural default models.

Default is the most important change in credit quality, but hardly the only one that matters to investors. Indeed, the market will react to any change in perceived creditworthiness and yield spreads for the affected bonds will adjust to the new information. Moody's publishes tables of historical transition frequencies among the ratings categories and previous research on credit risk has attempted to estimate the full transition matrix for ratings changes.[1] We prefer to concentrate on the most important transitions rather than attempting to model the fine structure of the credit market.[2] We therefore focus on a few especially important types of credit events: transition from solvency into default, transition from investment grade (Moody's Baa and above) down to speculative grade (Ba or below), the reverse (upgrade from speculative to investment grade), and upgrade from near-insolvency (Moody's rating Caa, Ca, or C) into a B or higher rating category.

To estimate the hazard functions, we use the Cox regression model, a well-known and powerful technique in survival analysis. This semi-parametric model accommodates both time-fixed and time-varying explanatory variables, called "covariates" in survival analysis. The focus on incorporating macroeconomic factors into hazard functions for credit events is a key distinguishing feature of our work. Use of such "macro" factors in the Cox hazard model has not been extensively explored before. Duffie and Wang (2004) and Duffie, Saita, and Wang (2005) model the term structure of credit risk as depending on a small number of such factors (US personal income growth and sector earnings performance in the former; the trailing one-year return on the S&P 500 index and the 3-month Treasury bill rate in the latter). Their focus, however, is on building a forecasting model for credit risk that incorporates the time-series properties of the macro factors. By contrast, we are interested in establishing "stylized facts" about which macro

[1] See Hamilton, et al (2006), for an example of a historical ratings transition matrix. Nickell, Perraudin and Varotto (2000) explore the impact of overall "business cycle" conditions, along with the issuer's industry and country of domicile, on the set of transition probabilities among ratings classes.

[2] Jarrow, Lando and Turnbull (1997) model the ratings transition matrix, but faced the problem that many of the cells involving transitions from a high rating to default or, in general, to a much different rating have no entries, yet one does not want to accept that such transitions are impossible. Jarrow, Lando and Turnbull propose a kind of "tweak" to deal with this problem; Kijima and Komoribayashi (1998) offer a more elegant solution. We minimize the problem by using broad ratings categories and eliminating transitions with too few occurrences from consideration.

covariates are most important, and the nature of their impact on credit risk, including allowance for lagged effects. We do not attempt to predict the future values of those factors, which would require building forecasting models for them.

One defining property of a macro factor is that it has a broad impact on the economy. Another is that one may expect most or all bonds' credit rating changes to be affected by it. Classes of macro factors we explore include general economic indicators, as well as more targeted measures of the overall level of economic activity and its direction, and credit market conditions. These are described and discussed in detail in Section V.

We also consider firm-specific factors, which include the firm's initial rating class, whether it entered its current rating class by upgrade or by downgrade, and the length of time since the firm was first rated.

II. The Cox Hazards Model

Ratings migrations can be treated like survival data if we consider the time an issuer spends in a rating class as a survival time. Our analysis, however, goes further and explores how the risk of a "credit event," such as being upgraded or downgraded from a current rating class, depends on external (macroeconomic) and internal (firm-specific) factors, using the Cox hazard regression model (Cox (1972)) as a statistical tool. This model has been very popular in the analysis of survival data in medicine and has also been occasionally applied in finance. See, for example, Buehler (2005), Henebry (1997), or Lane, et al (1986). In this section, we present a brief overview of the Cox model in the competing risks framework, which is a natural framework for our data. For a more extensive discussion see, e.g., Kalbfleisch and Prentice (2002) or Cox and Oakes (1984).

Let T be the time of exit of an issuer from its current rating class, measured from when it entered that class. This exit constitutes an event. In our study, a "rating class" may refer to a single credit rating like Baa, but more frequently it will be an aggregated set of individual ratings, such as "all speculative grades." Exit from a rating class may occur due to any number of causes. For example, if the current rating is C, the cause of the exit could be upgrade, default or any non-credit reason for leaving the sample. We differentiate between exits due to credit events and to non-credit events.

To study how the risk of different types of credit events depends on covariates, we estimate the cause-specific hazard function for each type. For a type j event at time t, this is the limiting conditional probability of occurrence given that there has been no event of any type prior to time t, and given a P-vector of time-dependent covariates Z(t):

$$\lambda_j(t;Z(t)) = \lim_{h\to 0} h^{-1} P(t \le T < t+h, J = j \mid t \le T, Z(t)), \quad j \in J \qquad (1)$$

To put it differently $\lambda_j(t;Z(t))$ represents the instantaneous hazard rate of a type j credit event occurring at time t given Z(t).

The Cox hazards regression model specifies $\lambda_j(t;Z(t))$ to be of the form:

$$\lambda_j(t;Z(t)) = \lambda_{0j}(t)\exp[\,\beta_j'Z(t)\,], \quad j \in J \tag{2}$$

where β_j is a $P \times 1$ vector of regression coefficients, and $\lambda_{0j}(t)$ is an unspecified "baseline" function for spells of duration t. The Cox model is semiparametric: it consists of a nonparametric part, namely the baseline function $\lambda_{0j}(t)$, and the parametric part, $\exp[\beta_j'Z(t)]$. We note that each cause-specific hazard function has its own baseline function and its own vector of regression coefficients.

An important aspect of the Cox model is that, at any time t, the ratio of the hazard rates of a type j credit event for two different issuers does not involve the baseline hazard function. Consequently, if the covariates are all time-independent, the ratio of hazard rates stays constant over time. For this reason, the Cox regression model is often referred to as the proportional hazards model. However, our covariates are time-dependent, so the ratio of hazard rates does change over time.

The parameter $\exp(\beta_j^p)$, $1 \le p \le P$, represents a relative change in the hazard rate resulting from a one unit increase in the value of the p'th covariate, holding all other covariates constant:

$$\exp(\beta_j^p) = \frac{\exp[\,\beta_j^p(Z^p+1)\,]}{\exp[\,\beta_j^p Z^p\,]} \tag{3}$$

We now discuss estimation of the parameters β_j, $j \in J$ in model (2). It can be shown that each cause-specific hazard function can be estimated separately using the so-called partial likelihood approach.

It is important, in our context, to keep in mind that the time index t in $\lambda_j(t; Z(t))$ refers to the length of time since entering the current state, not calendar time. The fundamental object of analysis is a "spell," which is a time period that a given issuer remains continuously in a particular rating class.

The data used to estimate the parameters in $\lambda_j(t;Z(t))$ consist of all spells in a given rating class. Suppose that $T_1 < T_2 < \ldots < T_N$ are distinct lengths of spells that ended with a type j credit event, and let R_n denote the risk set at time T_n, that is, the set of issuers that were at risk for a credit event j just before T_n, $1 \le n \le N$. The information needed to estimate $\lambda_j(t;Z(t))$ consists of $\{Z_i(T_n), i \in R_n), 1 \le n \le N\}$.

A spell in a given rating may end due to the occurrence of a credit event or a non-credit event, or because the end of the sample period is reached. In estimating $\lambda_j(t;Z(t))$, spells

that end for any reason other than a type j credit event are treated as right-censored. A spell that is censored at time t will contribute to the risk set R_n if $T_n \leq t$, and will be excluded if $t < T_n$.

The partial likelihood function for estimation of parameter β_j is

$$L(\beta_j) = \prod_{n=1}^{N} \frac{\exp[\beta_j' Z_n(T_n)]}{\sum_{i \in R_n} \exp[\beta_j' Z_i(T_n)]} \tag{4}$$

where n is the label of the issuer who experiences a type j event at time T_n. Issuers who do not experience a type j event contribute to the likelihood function through their presence in the risk sets R_n.

The n'th factor in the partial likelihood function

$$\frac{\exp[\beta_j' Z_n(T_n)]}{\sum_{i \in R_n} \exp[\beta_j' Z_i(T_n)]} \tag{5}$$

is the conditional probability that an issuer with covariates $Z_n(T_n)$ experiences a type j event at time T_n given all issuers in R_n and that exactly one issuer experiences the event at T_n.

Although in theory no more than one event can occur at a single point in time, reporting of credit events in the real world is on a daily basis, which leads to cases of ties, in which several firms experience an event with the same value of T_n. In that case, the algorithm needs to be modified.[3]

Suppose there are $d_n \geq 1$ events observed at time T_n and let D_n be the set of firms that experience an event. Let q denote any subset of d_n firms drawn from the risk set R_n and Q_n be the collection of all of these subsets. The generalized version of the likelihood function (4) that incorporates ties can be written as (4')

$$L(\beta_j) = \prod_{n=1}^{N} \frac{\exp[\beta_j' \sum_{k \in D_n} Z_k(T_n)]}{\sum_{q \in Q_n} \exp[\beta_j' \sum_{k \in q} Z_k(T_n)]} \tag{4'}$$

The maximum likelihood estimator, $\hat{\beta}_j$ of β_j is given by the value that maximizes $L(\beta_j)$. Under usual conditions $\hat{\beta}_j$ is asymptotically normally distributed with a covariance

[3] For more details on the handling of ties, see SAS Online Doc 9.1.2, or Gail, et al (1981)

matrix that can be consistently estimated using the usual matrix of second derivatives of log $L(\beta_j)$. Inferences about inclusion or exclusion of the covariates can be based on standard likelihood ratio tests.

The essential feature of the partial likelihood method, first proposed by Cox(1972), is that it allows estimation of parameter β_j in the hazard function without knowledge of the baseline function. If it is needed, the baseline hazard function can be estimated subsequently in a nonparametric fashion. Since the focus of our analysis is on the estimation of relative risk faced by the issuers we have used partial likelihood estimation for β_j. For discussion of estimation methods for $\lambda_{0j}(t)$ we refer the reader to the aforementioned references.

III. Credit Ratings Data

Data on the history of credit events is drawn from Moody's Default Research Database, which contains information on over 11,000 issuers and more than 350,000 individual securities. The earliest data in the database come from the 1920s, but in view of the broad changes that have transformed the financial markets over the last 50 years, as well as the need to match credit data with other kinds of data with shorter available history, we limited our initial explorations to the period 1970 - 2002. The sample period we finally chose to investigate in depth is from 1981 - 2002. Table 1 provides short definitions for Moody's ratings. The rating classes Aaa, Aa, A and Baa are considered "investment grade" and the lower ratings are known as "speculative" or "junk" bond ratings. In 1992, Moody's added further subdivisions to the scale to indicate bonds that are relatively stronger or weaker than the average for their rating class (e.g., Baa1, Baa3), and subsequently, also a "Watchlist" covering bonds that Moody's believes may be close to a rating change, but one is not warranted yet. Although these finer gradations do contain information, we have not tried to make use of them in this study.[4] One reason is that that would substantially restrict the length of the historical sample we could cover.

Table 1 indicates that some firms rated in the C-categories have already defaulted. In case of a default, we use the date of default as recorded in Moody's database as marking a transition from the previous ratings class into the default state. Thus, we only treat firms that have not defaulted as being members of ratings classes C, Ca, and Caa.

Moreover, when a firm's credit quality is degenerating, it is not uncommon for it to be downgraded in quick steps through more than one rating class. For example, a firm might be downgraded from B to Ca and then fall into default a few days later. We feel that in such a case it is more appropriate to consider this as a transition from B to default, ignoring the very short period it was in the C category.

[4] See Hamilton and Cantor (2004).

Therefore, any rating prior to default that lasted less than two weeks (14 days) has been eliminated and the duration of the spell in the previous rating extended to include the very short time spent in the transitional rating.

An issuer's rating history may consist of spells in different credit classes. A spell may be complete or it may be right-censored. For example, in modeling the hazard rate of default from class C, spells in the C class that end in default are complete and all other C-spells are considered to be right-censored for the purpose of estimating the default hazard rate. There are thus three ways in which a C spell may be right-censored: if the issuer is still in the C class at the end of the sample period, if the C-spell ends because the issuer's rating has been withdrawn (hereafter referred to as a transition into the WR category), or if it ends with an upgrade to some other credit class (which is treated as right-censored in the partial likelihood approach, as described in Section II). The WR contingency may happen for several reasons, including a merger or extinction of all of a firm's rated debt through full repayment or defeasance. Completed C-spells contribute both to the numerator and denominator of the partial likelihood function in (4), while right-censored C-spells contribute only to the denominator.

Firms present at the start of the sample period begin with their current spells already under way. Such spells are called left-truncated. But since we know when left truncated spells entered their current rating class, we can include them in the estimation, which leads to the increase in estimation efficiency.

Table 2 summarizes the transitions we examine. Rather than attempting to model the fine structure of transitions among ratings classes and sub-classes, we consider only major transitions between solvency and default, between investment grade and speculative grade, and from a near-insolvency Caa, Ca, or C rating to B or higher.

Of 3422 spells for investment grade firms (Moody's Aaa, Aa, A, and Baa ratings), 1684 ended with no transition out of investment grade and 944 ended with WR. A downgrade from the investment class to a speculative rating occurred in 788 spells, of which nearly all were to a rating of Ba or B. In 5 cases, the transition was from an investment grade to a Caa, Ca, or C rating, and 6 investment grade firms ended in a direct transition into default. We do not attempt to model these latter two rare events.

Most important are the transitions into default, which overwhelmingly occurred from a speculative grade rating. There were 4327 spells in a speculative grade, of which 645 ended with an upgrade to investment grade, 1125 remained in a speculative grade at the end of the sample (912 in Ba or B and 213 in one of the C ratings), 1655 ended in WR, and 902 ended in default.

Defaults occurred in substantial numbers from both B and C classes, so we investigate those transitions separately. The last two lines in Table 2 show the numbers of transitions from those two classes. Notice that because of the different definitions of what constitutes a spell, the total number of transitions from the B and C categories exceeds the total from Any speculative grade. For example, a transition from Caa to B is counted

as a completed spell in line 4, but not in line 2, since both ratings are in the speculative category.

Upgrades to investment grade were almost exclusively from the Ba and B ratings. Therefore, to measure significant improvements in credit quality, we consider the 641 ratings upgrades from Ba and B to investment grade, and 102 upgrades from a rating in a C category to Ba or B.

IV Firm-Specific Covariates

The list of potential factors that may have explanatory power for credit events is very long. In this study we consider two broad categories of explanatory factors: factors derived from a firm's rating history and macroeconomic factors. We start with a discussion of ratings-related firm-specific covariates.

The four types of firm-specific variables that we consider are:

Initial rating class. It is well known that "fallen angels" (firms that began as investment grade and were subsequently downgraded into junk status) tend to behave differently from those that were initially rated as speculative grade.[5] We use two dummy variables to explore this effect, "Initial rating: Investment grade" and "Initial rating: C, Ca, Caa," with the former set to 1 for a firm that was initially investment grade, and the latter set to 1 for a firm that was initially rated in one of the C categories.

Current rating class A firm's current bond rating is the single most widely used measure of its credit quality. We form dummy variables and name them in the obvious way. For example, "Current rating: Ba" is set to 1 if the firm is currently rated Ba, and 0 otherwise.

Recent upgrade or downgrade Changes in credit quality show positive serial correlation, with a bond that has been recently downgraded being more likely to experience a further downgrade than one whose rating has not recently changed.[6] To capture this phenomenon, we constructed dummy variables for recent upgrades and downgrades. Some exploration with different specifications showed that the sizes and signs of the estimated coefficients on these dummies were quite variable and they were rarely significant for events more than 2 years old. In the specifications we report on here, we use 0,1 dummies to indicate an up- or downgrade within the last 2 years.

Years since first rated It has been observed that newly rated firms are less likely to change ratings class within a given year than are more seasoned firms in the same ratings class.[7] For instance, it would be quite unlikely for a firm to default on a bond prior to its first scheduled coupon payment. To capture this, we use the length of time the firm has been rated as a firm-specific covariate. We do not necessarily expect the effect to be

[5] See Mann, et al (2003).
[6] See Christensen, et al (2004).
[7] See Altman (1998), for example.

directly proportional to the number of years the firm has been rated, so this variable is entered in log form.

V. Macroeconomic Covariates

We now describe the macroeconomic covariates used in this study.[8]

General Macroeconomic Factors

Casual reflection, with or without casual empiricism for support, suggests that a variety of broad economic conditions might influence corporate credit risk. We therefore tested several key economic indicators. Table 3 lists the variables used in the models and provides statistics on their means and standard deviations, as well as the sources.

Interest rates Other things equal, one might expect that high interest rates would also correspond to general tightness in the economy and increased difficulty in raising cash to make debt service payments.[9] As a measure of the overall level of interest rates at a relevant maturity, we use the US Treasury Constant Maturity 10-year Rate.

Unemployment The unemployment rate is one of the most visible indicators of overall health of the macroeconomy. We use both the level and the change in the monthly Civilian Unemployment Rate, seasonally adjusted, constructed by the US Bureau of Labor Statistics.

Inflation Inflation is widely understood to be an important economic variable. In this case, however, it is unclear exactly what its effect on default rates should be. The common perception that inflation is bad for the economy might suggest that high inflation would increase default risk. But, from the perspective of a firm whose outstanding debt is in nominal dollars, inflation reduces the real value of its required payments for debt service, which might make it less likely to default. We therefore include the monthly percentage change in the seasonally adjusted Consumer Price Index, with no prior expectation of the sign of its coefficient.

Stock Market returns The performance of the stock market is an indicator of the general health of the macroeconomy. Moreover, in a structural default risk model, the behavior of a firm's equity is a direct measure of default risk exposure. We include the monthly return on the Standard and Poor's 500 stock index as a covariate.

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[8] In addition to the macroeconomic variables described below, we investigated measures of the availability of cash to the corporate sector (e.g., the growth rate of corporate profits). However, the available proxy variables were not that closely connected to the factor we actually wanted (how easy or hard it was for a firm facing insolvency to raise new capital rather than being forced into bankruptcy), and they turned out to have very little explanatory power, so they were dropped from the analysis.

[9] Duffie, et al (2005), found that higher short term interest rates corresponded to lower overall credit quality.

Index of Aggregate Economic Activity The large number of available series relating to the macroeconomy makes it very difficult to select the most important ones. To try to capture overall economic conditions in a single variable, the Chicago Federal Reserve publishes the Chicago Fed National Activity Index (CFNAI) , a composite series that summarizes the behavior of 85 series in four broad categories: production and income; employment, unemployment and hours; personal consumption and housing; and sales, orders and inventories. The CFNAI is reported monthly in the form of a 3-month moving average.[10]

The Direction of the Economy

Credit research often looks at economic strength in terms of the change in GDP or some similar measure of economic activity. This seems quite sensible: if the economy is growing rapidly, it is clearly in better health than if it is stagnant or shrinking. Yet, the time when the economy is able to grow the fastest is when there is a lot of slack. An economy with idle resources that can quickly be put back into production is capable of growing much faster than one at full employment. In other words, the most rapid GDP growth will tend to occur not when the economy is really strong, but when it is at the bottom of a recession and just beginning to turn around. From this perspective, it is less obvious that rapid growth in GDP should necessarily be associated with reduced default risk. We explore this issue with several measures of economic growth.

Real GDP growth The GDP figures were obtained from the St. Louis Fed, as mentioned above. Like many macro series, Real GDP is only available quarterly. As with all of the quarterly data, we constructed monthly series of Real GDP growth rates simply by repeating the quarterly value for each month in the quarter. Note that the variable that enters the estimation is constructed from the monthly series as an 18-month distributed lag, as will be described in more detail below. This effectively eliminates what would otherwise be an undesirable pattern, in which the month to month changes in these constructed monthly series would be 0 for two months out of three and then show a large jump to the next quarterly level.

Growth in Industrial Production Real GDP comprises all economic activity, much of which may be unrelated to credit conditions in the corporate sector. We therefore include the growth rate of industrial production as a possibly better targeted measure.

Change in Unemployment This is the first difference in the monthly unemployment rate.

[10] Full detail on the components and construction of the CFNAI index is available online at URL: http://www.chicagofed.org/economic_research_and_data/cfnai.cfm.

Measures of Economic Slack

Weakness in overall business conditions can be expected to translate into heightened risk of insolvency, but the measures of economic activity described in the previous category are all "changes" rather than "levels." They do not capture the actual state of the economy, just which direction it is moving. We therefore considered a third set of macro factors that attempt to measure economic weakness by the existence of slack in the economy, that is, by how the economy is currently performing relative to its potential.

Deviation from potential real GDP The St. Louis Federal Reserve produces a series that estimates the potential real gross domestic product for the US. Real GDP was obtained from the U.S. Department of Commerce: Bureau of Economic Analysis. The variable used in the estimation is defined as actual minus potential real GDP, so that it is negative on average, but an (algebraically) higher value corresponds to stronger economic conditions.

Capacity utilization One measure of demand conditions facing the corporate sector is how close current production is to maximum capacity. The Federal Reserve Statistical Release G17 shows monthly capacity utilization rates in percent, with 100 being maximum capacity.[11]

Industrial Production Deviation from Trend Another way to estimate the current strength or weakness of the overall economy is to compare current economic output to its long-term trend. We therefore constructed a deviation from trend variable based on industrial production. The industrial production figures were downloaded from the same Federal Reserve website as capacity utilization. For each date t, we fitted a simple exponential growth equation to the series, ending 18 months before t and beginning 20 years earlier than that. The 18-month lag was chosen to be consistent with the way we handle lags in our specifications, as will be described in detail below. The choice of a 20-year moving window was arbitrary. The fitted equation was used to project industrial production forward to date t, and the variable used in the model is actual date t industrial production minus the trend value. Again, with this definition, a higher value corresponds to a stronger economy.

Overall Credit Conditions

We would like to measure how easy or difficult it is for firms to raise capital, especially firms that have non-negligible exposure to default risk. One possibility would be the credit spread on speculative grade corporate debt relative to default-free Treasuries. Another is the recent overall default rate in the economy.

Corporate Credit Spreads Ideally, we would like to use the corporate credit spread on high-yield bonds. However, due to the very thin markets for such bonds prior to the late 1980s, data series do not go back far enough to be useful in this exercise. We therefore

[11] The data were downloaded from the Federal Reserve website (URL: http://www.federalreserve.gov/releases/g17/).

have included the closest available match, which is the spread between corporate Baa yields and constant maturity 10 year Treasuries.[12]

Overall Default Rate for Corporate Bonds This series is constructed by Moody's. It measures the percent of all US corporations defaulting in the previous 12-month period.

Lags

Empirical default studies often introduce macroeconomic factors into models simply as contemporaneous variables. But to the extent that the macro factors are measuring aspects of the overall financial health of the corporate sector, it is not plausible that they would have an instantaneous effect on defaults. Rather, one expects that things like high interest rates or slow growth in the economy would lead, cumulatively, to a gradual increase in credit risk. We considered it quite important to allow lagged values of our macro covariates to enter the specification. But with a large number of individual series, adding lagged values into the specification without constraints would have led to far too many coefficients to fit. Instead, we impose a very basic lag structure on the data, such that each variable is a weighted average over a fixed window, with exponentially declining weights.

Let $\{x_t ; t = 1,...,T\}$ be the raw monthly data series for a given variable. X_t represents the value used in the model for the x series in month t. X_t is given by

$$X_t = \frac{\sum_{k=1}^{K} \delta^{k-1} x_{t-k}}{\sum_{k=1}^{K} \delta^{k-1}} \qquad (6)$$

where K is the length of the lag window and δ is the decay factor. This specification uses data up to the previous month. There is no a priori best choice for these parameters. We chose K = 18 months and $\delta = 0.88$, which amounts to a fairly rapid rate of decay in a medium-sized window. The weight on the current month's data is about 9 times as large as on the oldest data point in the average and the mean lag is 8.33 months. To gauge the effect of our assumptions, we explored lag windows of 12 and 24 months, and decay factors from 0.8 to 1.0 (no decay). The results were not especially sensitive to these choices, over a wide range of values. We settled on 18 months and 0.88 because they were in the middle of the range of values that we considered most plausible, and they seemed to produce reasonably good results in terms of statistical fit and robustness to small changes in the estimation sample. With an infinite lag length ($K = \infty$), at this decay rate, observations in the most recent 18 months would receive 90% of the total weight.

[12] The corporate series was Moody's Baa Corporate Bond Yield series, as reported by the Federal Reserve in its H.15 Release, and downloaded from the St. Louis Fed website.

VI. Transitions into Default

The most important credit-related transition is from solvency into default. Table 2 shows that substantial numbers of defaults occur across all speculative ratings classes, with about 500 occurring from the lowest Caa, Ca, and C categories and about 400 from Ba and B ratings. There were only a handful of defaults directly from an investment grade rating in the previous month. This section will focus on the effects of firm-specific and macroeconomic factors on transitions from a speculative grade into default.

Individual Macro Factors

We first consider each macro factor individually, by estimating its impact on the hazard rate as a single covariate in a Cox specification, and also its marginal effect when added to a specification that includes the firm-specific factors. This will give some indication of each macro variable's potential importance and the direction of its effect. One reason to look at such simple and incomplete specifications is that they will indicate what other researchers are likely to find when they examine how default is influenced by any one of these variables. The estimation results for the firm-specific factors themselves are shown in Table 5 and will be discussed below.

The left side of Table 4 shows the univariate estimation results for all speculative ratings classes together and broken down by defaults from B grades and from C grades. The right side of the table reports coefficient estimates and p-values for each individual variable when it is included in a specification with a full set of firm-specific ratings factors.

In the univariate estimations for all speculative ratings, all five general macro factors are estimated with negative coefficients, meaning an increase is associated with a reduction in the hazard rate. Higher interest rates by themselves appear to reduce default intensity for a typical speculative grade issuer, but when the issuers are separated into B- and C-ratings classes, the sign becomes positive in both cases. The marginal effect of long-term bond yields in a specification that adjusts for ratings-related factors is significantly positive in all cases: higher interest rates are associated with higher default rates.

The coefficient on unemployment has an anomalous negative sign (higher unemployment appears to reduce default intensity) in the univariate estimations for both speculative grades overall and for transitions from C grades, though it is not significant for the latter. The marginal contribution when combined with firm-specific variables becomes significantly positive for overall defaults, while remaining negative but even less significant for defaults by C-rated issuers.

The coefficient on inflation in the equation for defaults from all speculative ratings classes is very small and insignificant in the univariate equations, but it becomes significantly positive as a marginal effect and in the breakdown of the univariate

estimation by ratings subcategories. The estimated effect of a strong stock market is erratic here. When considered on its own, a rising stock market is associated with a reduced hazard rate overall and for the weaker C-rated credits, and an insignificant effect on stronger speculative grades. But its estimated marginal contribution when firm-specific factors are included is to increase default intensity significantly.

The single variable measuring general macroeconomic conditions that performs the best is the CFNAI index. The estimated coefficient is large, negative, and highly significant: a stronger economy as measured by this aggregate index is associated with significantly lower default probabilities.

We consider three variables designed to measure whether economic conditions are improving or worsening. Growth in real GDP is an obvious choice, and we find that rapid GDP growth is associated with a reduction in the default rate that is highly significant in nearly all of the cases. The percentage change in industrial production performs equally well. The change in the unemployment rate also shows a very large effect, with high unemployment increasing default risk, except for the very insignificant negative coefficient for C-grades when combined with firm-specific variables. This highlights a result we will see throughout this analysis, that transitions both downward and upward from the C-rated classes seem to be more idiosyncratic and less related to macroeconomic conditions than are the other transitions we consider.

The next set of macro variables are all related to economic slack, i.e., underutilized resources, in the economy. This looks at economic conditions from the perspective of how far the current level of the economy is below (or above) its potential. The first variable is real GDP minus potential real GDP; the second is capacity utilization, as a percent of full capacity; and the third measures how far current industrial production is above or below the trend rate of growth over the last 20 years. In all cases, we expect the coefficient to be negative, since an (algebraically) higher value for the variable corresponds to a stronger economy, but the estimation results for these univariate equations are all over the board. Signs are mixed, there are significant negative values and significant positive ones, and no apparent regularities.

Finally, we look at two measures of credit conditions, the yield on Baa-rated corporates less 10-year Treasury yields as a measure of the bond market's perception of credit risk, and the aggregate default rate on corporate bonds over the last 3 months, to capture "contagion" in defaults, as well as the overall effect of other broad economic factors that we have not included specifically in the models. The issue of whether there is contagion in defaults is complicated and we do not try to settle it here. However, if significant contagion does exist in the credit markets, a necessary condition would seem to be that, holding other things constant, an increase in the rate of default occurrence in the economy would raise the probability of default for a given firm. That would show up here as a significantly positive coefficient on this variable.

By itself, a wider yield spread is associated with a significant increase in the default rate, but this does not carry through to the estimations with firm-specific dummies for all

speculative grades together, where the sign is reversed. A higher corporate bond default rate overall is strongly associated with increased hazard rates, except for an insignificant coefficient for its marginal impact on default from the C-grades.

Comprehensive Specifications for Default Intensity

The univariate results in Table 4 are useful because they give a first indication of the overall impact of each of the variables. However, many of our macro variables are quite highly correlated with one another, and the line of causation between any single one and corporate default is somewhat blurry. Rather, as we have described, we think of many of them simply as available measures of broad economic conditions. In Table 5 we combine them in more comprehensive specifications, instead of treating each as the sole macroeconomic explanatory covariate. Estimates for All speculative grades together are shown in Panel A, and then panels B and C split out the results for B and C grades separately.

To set the baseline, in the first two columns of Table 5 we present estimation results with only firm-specific ratings-related covariates. (The right side of Table 4 showed the estimated coefficient and p-value for each individual macro covariate when it was added as a single extra variable to this "Firm specific only" specification.)

There is some evidence that having started with an investment grade rating gives a firm a lower risk of default, because the estimated coefficient is negative in all three panels. Such "fallen angels" may have lower default rates than do firms that began with a speculative rating of Ba or B., but the estimated effect is significant at the 5% level only for firms currently in a C-rating class. Beginning with a rating in a C grade is strongly associated with a lower default risk, other things equal, in panels A and C (p-value=0.000), but not in panel B.

The next four dummy variables in Panel A relate to the issuer's current rating class. The baseline in each Panel is the lowest relevant rating category, i.e., C for "All speculative grades" and "C grades," and B for "B grades." In every case, the bond rating performs correctly, with all of the coefficients negative and significant, and with a higher rating always corresponding to a lower estimated hazard rate.

The next two variables deal with whether the issuer has been recently upgraded or downgraded. A firm that is weakening in credit quality may pass through a succession of lower ratings before eventually defaulting, so a recent downgrade presages possible further deterioration.[13] By contrast, an issuer that has recently been upgraded is unlikely to have an immediate reversal of fortune into default. The significant coefficients on the recent downgrade and upgrade variables strongly support this reasoning. The one exception is the coefficient on recent upgrades in the C category. The log(years since first rated) variable measures the length of time that the firm has been rated by Moody's, the idea being that a firm is relatively less likely to collapse into default shortly after

[13] Recall that we have eliminated transitions through ratings that last less than 14 days.

receiving its initial rating than is a more seasoned firm. The positive and significant coefficients (near-significant in Panel B) on the variable bear this out.

Now let us consider the effects of each of the macro variables when it is included in a comprehensive specification with all of the others. The second set of columns in Table 5, labeled "All variables," shows estimation results when all of the macro and ratings-related variables are included together.

One of the first things to note is that the estimated coefficients and the p-values for the Firm specific variables change very little when all of the macro variables are added. This indicates that the relevant information contained in the macro factors is incremental to, and largely independent of, that which is captured by the ratings-related covariates alone. We will see that this result holds generally across all of the specifications and all of the credit transitions we consider in the paper.

In contrast to the univariate results from Table 4, long-term interest rates are now estimated with a positive coefficient that is highly significant overall, though not for the sub-category transitions in Panels B and C. Similarly, the unemployment rate now has a positive coefficient overall. Like the Table 4 results on its marginal contribution in combination with firm-specific factors, higher unemployment increases default risk overall and from a B-rating, but in the comprehensive model its contribution to the default hazard rate from a C-rating class is not significant.

Higher inflation appears to decrease default risk overall, though again, it is not significant in Panels B and C. Anomalously, a stronger stock market is associated with higher default hazard rates. The CFNAI index gets a negative coefficient in Panels A and B--a stronger economy reduces default risk--but the coefficient is only significant at the 5% level for Ba and B-rated issuers, and it is insignificant with the wrong sign in Panel C.

Although the "Direction of the Economy" variables were significant with the "correct" signs in Table 4, when combined with the other macro variables, performance becomes erratic. None of them is significant overall and two of the three have the wrong sign (an increase in industrial production or a drop in unemployment is estimated to raise default risk).

One possible explanation for anomalous coefficient estimates when all of our variables are run together is multicollinearity. Since we think of the three variables in this group more as proxy measures of general economic expansion than as factors with a direct causal connection to defaults, we explored whether the effects of multicollinearity could be mitigated by using principal components to combine the three variables into a single factor. We did the same with the "Economic Slack" and "Credit Market Conditions" measures, but the results were not noticeably better than what we have found with the disaggregated specifications, while we lost the ability to consider each of the variables separately. We therefore do not report results using principal components here.

The "Economic Slack" variables are highly significant overall, and for defaults of B-rated, but not C-rated, firms. But the bad news is that both deviation from potential real GDP and capacity utilization have the wrong signs. A stronger economy by these measures is associated with a greater default intensity.

Finally, the two "Credit Market Conditions" variables are estimated to have the right signs--wider credit spreads and recent defaults are associated with higher current hazard rates--although the relationship is significant only for the corporate bond default rate in the equations for "All speculative grades" and "B grades."

One of the major issues of concern with regard to credit risk is whether there is contagion in the credit market, such that default by one firm tends to precipitate defaults by others. Das, Duffie, Kapadia, and Saita (2005) present evidence that defaults do tend to cluster more than would be predicted by credit risk models, but that the effect may be more environmental in origin than due to contagion. They hypothesize that defaults cluster because unfavorable macroeconomic conditions affect many firms at the same time, rather than because bankruptcy by one firm infects other vulnerable firms and leads them to default. As mentioned above, we will not attempt to examine this important issue closely here. But because our models allow us to take account of a broad range of macroeconomic factors, the highly significant coefficients on the Corporate bond default rate in Panels A and B of Table 5 are, at least, consistent with the existence of contagion in the credit market.

The last four lines in each panel of Table 5 provide measures of overall goodness of fit for these equations. The Akaike Information Criterion (AIC) is defined as

$$\text{AIC} = -2 \times \text{log likelihood} + 2 \times \text{number of estimated coefficients}$$

The idea is that the log likelihood measures the goodness of fit of the relationship, but this necessarily increases as more explanatory variables are added. The second term penalizes the specification for complexity. It is suggested that the model with the lowest AIC should be selected, to optimize the tradeoff between increased explanatory power and overfitting.

The second of these lines gives $-2 \times$ log likelihood. The difference between these values for a constrained model and an unconstrained model that nests the first one is distributed as chi-squared with degrees of freedom equal to the number of constraints. For example, considering "All Speculative grades to default" in Panel A, -2 x log likelihood for the model with only firm specific variables is 11129.81, but it drops to 10936.90 when the full set of macro variables is added. The addition of 13 macro variables (i.e., 13 coefficients not constrained to equal 0) improves the log likelihood by 192.91, which is highly significant for a chi-squared distribution with 13 degrees of freedom (the p-value is on the order of 10^{-34}).

Backward Selection to Eliminate Insignificant Variables

The "All variables" specification includes a number of variables that end up quite insignificant or significant but with the "wrong" signs. To eliminate variables that did not significantly improve explanatory power, we employed an automatic "backward selection" procedure. Starting with all variables included, the one variable with the least significant p-value was eliminated from the specification and the model was refitted. This process was repeated until all remaining coefficients were significant at the 5% level or better.

This was done in two ways. In the "Constrained" version, the firm-specific variables and the General macro factors were not included among the candidates for exclusion. We felt it was important to keep the former, because our primary focus is on gauging the marginal contribution of macro factors when added along with firm-specific covariates. We kept the General macro factors because we feel the coefficient estimates for them are of interest in their own right, whether they are significant or not. We also fitted unconstrained specifications, labeled "Full Selection," in which all variables were eligible for elimination. The rightmost columns of Table 5 show the results.

In Panel A, all of the firm specific and general macro variables survived the backward selection, with the coefficients and p-values virtually unchanged from their estimates with all of the covariates. This did not hold for Panels B and C. For defaults from a B-rating class, default intensity was not significantly affected by the initial rating or the number of years the firm had been rated, when these covariates were allowed to be eliminated in the Full Selection run. In Panel C, those variables did enter significantly, but the dummies for recent upgrades and downgrades were eliminated. Among the macro variables, the level of long term interest rates and inflation dropped out in Panel B, while inflation and the CFNAI index dropped out in Panel C.

For All speculative grades and for B-grades alone, all of the "Direction of the Economy" variables were knocked out. For the lowest rated bonds, in Panel C, the change in industrial production is estimated to have a large and significant effect with the right sign: faster industrial production growth reduces default risk for these firms. However, the change in the unemployment rate also has a large and significant coefficient, but with the wrong sign (rising unemployment makes default less likely). The "Economic slack" variables get highly significant coefficients in Panels A and B, but Deviation from potential real GDP and Capacity utilization have the wrong signs. None of the variables in this category survived backward selection for the C grade firms.

Finally, of the Credit Market variables, the Corporate bond default rate ends up with a highly significant positive coefficient in Panels A and B, although it does not survive as a significant factor for the lowest rated firms in the C categories. The magnitude of the coefficient is also very similar to its value in the comprehensive specification with all of the variables. If this result is due to contagion in the credit market, it is a consistent effect.

The goodness of fit statistics at the bottom of Table 5 allow us to test formally how much explanatory power is lost when variables are eliminated in the backward selection process. The resulting model is highly significantly better than the version with firm specific variables only, and statistically as good as the All variables model. Panels B and C tell the same story, except that it is not possible to compare the Full selection model to the Firm specific only model because they are no longer nested.

Gauging the Effective Relative Impact of the Macro Factors

The coefficient estimates in Table 5 give the impact of a one unit change in each covariate, but these magnitudes do not measure the relative importance of the different macro factors, because how likely a change of a given size is differs for the different variables. To get a better gauge of the effective relative importance of these variables on the hazard of default, Table 6 compares the raw coefficient estimates with standardized values obtained by multiplying the raw coefficient by the variable's standard deviation from Table 3. The standardized coefficient gives the effect on the hazard of default when the variable increases by one standard deviation. This allows us to better compare the effects of changes in the different factors that have roughly similar probability of occurrence.

For example, in Panel A of Table 6 the raw coefficient on the long-term interest rate is 0.132 and the coefficient on the S&P 500 return is slightly larger, 0.142. But the interest rate variable is considerably more volatile than the stock return variable, so that a typical move is considerably bigger for the interest rate than the S&P return. Taking that into account, the standardized coefficients are 0.339 and 0.176, respectively. The changes in the level of the long term interest rate actually have about twice as much influence on the hazard rate as variations in the return on the S&P 500. (Rescaling the coefficient obviously does not change its statistical significance.**)**

Among the General macro factors, the standardized coefficient on the long term interest rate is about 2 1/2 larger than the raw estimate. The coefficient on unemployment rises by about 50% and the coefficient on inflation doubles. On the other hand, the coefficient on the S&P 500 return rises, but only a little, and the CFNAI index coefficient falls by about a quarter.

All three Direction of the Economy variables fall substantially, especially the change in the unemployment rate. This last variable is not well-behaved in the different estimations in the paper, but its fitted coefficient tends to be quite large because the change in the unemployment rate itself is small. Standardizing the coefficients reveals that its effective importance is much less than its large coefficient estimate would suggest. By contrast, the measures of Economic Slack increase in importance substantially. The deviation of industrial production from its long term trend is seen to be nearly nine times as important as its raw coefficient might suggest. Capacity utilization also increases in importance, but unfortunately, it has the wrong sign. For the two Credit Market Conditions variables, the yield spread coefficient decreases substantially, but the variable is not in either

backward selection model in any of the Panels. The corporate bond default rate is highly significant in Panels A and B, and its standardized coefficient is hardly different from the raw value.

Looking at the (identical) backward selection models in Panel A of Table 6, we see that with standardized coefficients, long-term interest rates, unemployment, inflation and the deviation of industrial production from its long-term trend are all relatively more important variables than first appeared to be the case. The S&P 500 returns, the CFNAI index, and the corporate bond default rate all lost value or stayed about the same, meaning their relative importance in the default hazard rate is lower than first appeared to be the case.

Comparing the three Panels in Table 6, the behavior of the hazard rate for defaults from a B or Ba category is quite like that for All speculative grades, but unemployment is more important in Panel B while the long-term interest rate is less important. Panel C shows that the macro factors do not seem to affect the hazard of default for the lowest rated firms very much. Only a few of the variables are statistically significant, and both unemployment variables, as well as the S&P return, have the wrong sign.

VII. Downgrades from Investment to Speculative Grade

After default, probably the most important ratings transition is from "investment grade" (ratings Aaa, Aa, A, and Baa) down to "speculative grade" (Ba and below). A major reason for this is that many institutional investors will only hold investment grade bonds, either by covenant or by choice. A downgrade out of investment grade, as happened to General Motors and Ford in the spring of 2005, can cause considerable disruption in the market for that issuer's debt, as major investors are obliged to divest the bonds from their portfolios.

In this section we estimate the effects of macroeconomic factors on this transition. An important difference from the previous section is that in modeling default, we are looking at events that are largely exogenous, whereas all of the other transitions we will examine represent decisions made by a credit rating agency. It is certainly possible that a given macroeconomic or firm specific factor may have a different impact on the actual probability that a particular firm will default than on the creditworthiness of that firm as perceived by a rating agency. Moreover, Moody's states explicitly that they do not try to make their ratings correspond one for one with absolute default probabilities as these fluctuate over time. Rather, they consider a bond's rating as a measure of its relative risk compared to other bonds in that ratings class.[14] That is, in bad economic times, expected default rates for all bonds may rise, but only bonds that change substantially more or less than the average bond with the same rating will be reclassified.

[14] See Cantor and Mann (2003).

Analysis of Individual Macro Factors

Like Table 4, Table 7 presents the results from univariate models with each of the macro variables as the single covariate, in the left two columns, and the marginal contribution of that variable in a specification with the full set of firm specific variables in the right-hand columns.

Among the general macro factors, each of the variables is statistically significant at better than the 1% level, except for the unemployment rate in the univariate model (p=0.093) and there are no obviously anomalous signs. Higher long-term interest rates, higher unemployment, and more rapid inflation all are associated with increased risk of a downgrade from investment to speculative grade. Stronger aggregate returns in the stock market and a higher CFNAI index both indicate a lower hazard rate for a downgrade. Thus analysis of these general macro factors one at a time produces significant coefficient estimates with no obviously anomalous signs. It is also worth observing that the coefficient estimates are quite similar in size in the two different specifications.

The "Direction of the Economy" variables also are highly significant, with the "right" signs, and with very similar coefficients in the two specifications. Specifically, positive real GDP growth and an increase in industrial production are both associated with lower downgrade hazard rates, while increasing unemployment increases the risk of downgrade.

The measures of "Economic Slack" also have the right, negative, signs and are highly significant in both specifications. Similarly, the coefficients on the covariates measuring overall credit market conditions all are estimated to be positive and highly significant in both specifications. A stronger economy with less slack, leads to lower probabilities of downgrade from investment to speculative grade, while a tighter credit market with a wider credit spread between Baa corporates and 10-year Treasuries and/or a higher overall default rate among corporate bonds is associated with an increased hazard rate for downgrades.

These results are interesting and quite consistent with our expectations, but because the macro variables are fairly highly correlated with one another, coefficient estimates may change substantially when all macro variables are combined in a single model. Before discussing these results, we first analyze the model with only firm-specific factors.

Model with Firm Specific Factors Only

In Table 8, we see that if the issuer was originally rated investment grade, the hazard of being downgraded into a speculative rating category is significantly less than for a firm that started in a speculative grade.

The dummy variable "Current rating: Baa" is strong and highly significant. There is a much greater chance of being downgraded from the lowest investment grade into "junk

bond" status, than from a higher investment grade. This would be expected if Moody's were reluctant to downgrade a firm more than one (letter) rating at a time. For example, if the normal path for a Aa-rated firm that weakens substantially is to be downgraded first to A, then to Baa, and then eventually to a speculative grade rating, there will be many more downgrades to junk status from Baa than directly from higher grades. This will also lead to a kind of momentum or "ratings drift," such that a firm that has recently been downgraded into the Baa category is more likely to be downgraded again, than is a firm that has been Baa for several years. This reasoning is supported by the strong positive coefficient on "Downgraded within last 2 years," and the reverse logic for recent upgrades is also supported by the strong negative coefficient on "Upgraded within last 2 years." The last firm-specific covariate "log(years since first rated) is not statistically significant.

Before moving on to look at the specifications with macro covariates, notice that, as in the previous tables, the coefficient point estimates and significance levels on these firm-specific variables are very similar across the different specifications, suggesting that to the extent that the macro factors are able to add explanatory power to these models, it is incremental and largely orthogonal to the contribution of the firm-specific factors.

Models with All Macro Factors Included

The next pair of columns give the results for a comprehensive specification with all of the macro factors together and the rightmost columns report the two models resulting from backward selection.

Consider first the General macroeconomic factors. Although all are estimated to be significant at better than the 5% level, the results are quite different from the ones in Table 7. The coefficient on the long-term interest rate is now nearly 5 times larger: the marginal effect of higher overall interest rates in conjunction with the full set of other macro variables is to increase the downgrade hazard rate substantially. The unemployment rate, however, has now reversed sign, so that holding everything else equal, higher unemployment appears to reduce the risk of downgrade. Inflation has also changed sign--downgrade risk now seems to be reduced with higher inflation. Since the theoretical connection between inflation and credit risk is ambiguous, this result is less problematical than the sign reversal for unemployment.

A stronger stock market is still associated with reduced downgrade hazard. But the CFNAI index of aggregate economic activity has changed to a positive sign and is highly significant. This is probably the most anomalous result in this set of macro variables. As with the firm-specific factors, the estimated signs on all five coefficients are the same across the different specifications and their magnitudes are quite similar.

Among the "Direction of the Economy" variables, the coefficient on the growth in real GDP is now much larger and still significantly negative. But growth in industrial

production now is fitted with an anomalous positive sign. The change in the unemployment rate still has a positive coefficient, but it is no longer significant.

For the Economic Slack variables, we expect negative coefficients, consistent with less slack leading to lower downgrade probabilities, but Deviation from potential real GDP now enters with the wrong sign. The other two variables are still negative, but Capacity utilization is far from significant. The deviation of industrial production from its long-term trend is now about 5 times larger than in Table 7 and still highly significant.

Finally, in this comprehensive specification, the variables measuring credit market conditions both fail. The yield spread still has a positive coefficient, but it is no longer significant, and the corporate bond default rate has reversed sign: more defaults appear to reduce the downgrade hazard rate. The p-value is only near-significant, at 0.066.

Although some of the "nice" results from the univariate and single-macro variable specifications disappear when all of the variables enter the specification together, the improvement in goodness of fit is highly significant. Adding the macro variables improves (-2 times) the log-likelihood value from 9546.00 with just firm-specific factors to 9251.40, a drop of 294.60 at a cost of 13 degrees of freedom. The 0.001 critical value of a chi-squared distribution with 13 degrees of freedom is 34.6.

The Constrained and Full backward selection models are both statistically equivalent to the All variables model, and they both substantially dominate the model with only firm specific variables in terms of explanatory power. But they also keep significant variables with “wrong” signs.

VIII. Upgrades

The last two sections examined deterioration in credit quality. We now consider ratings upgrades. Again we do not attempt to model all upward transitions in credit rating, only the most important ones, which we take to be transitions from a speculative grade rating to investment class, and from a (non-default) rating of Caa or Ca to a speculative grade in the B or Ba categories. There were only 4 cases in our sample of a firm with a rating in any of the C classes jumping directly to investment grade, and no cases of a firm rated C jumping to a B rating or above, so these transitions are not considered.

Analysis of Individual Macro Factors

Table 9 shows the univariate estimation results for our macro factors. The first four columns show transitions from speculative to investment grade, and the four rightmost columns show transitions from a Caa or Ca category up to a B or Ba rating. Variables related to a stronger economic environment are expected to have positive coefficients.

Among the general macro factors, when considered alone higher interest rates are estimated to increase the hazard rates for both kinds of upgrades significantly, but when firm-specific factors are added, the influence of higher interest rates becomes insignificant. Higher unemployment should reduce the probability of an upgrade, but three out of four of the coefficients in the univariate runs are positive and significant. The sign is negative only for transitions up to investment grade when ratings-related factors are included, and not significant at 5%. The influence of inflation on these transitions, either by itself or in combination with firm-specific variables is inconsistent in sign and not significant. This is true also for the return on the S&P index and the CFNAI aggregate economic index, although some of the coefficients are close to significant, at about the 10% level.

For transitions to investment grade, all three of the variables measuring the direction of the economy have the wrong signs when run alone (more rapid growth in GDP and industrial production and lower unemployment reduce the hazard rate for an upgrade). The only improvement when firm-specific variables are added to the specification for upgrades to investment class is that the coefficient on industrial production goes to 0. For transitions to a B-level rating out of a C class, the signs are all right in the specification with firm-specific factors, but none of them are statistically significant.

Measures of economic slack all have the wrong signs when run alone, but in combination with the firm-specific factors, they all turn positive for upgrades to investment class. For transitions up from a C class, however, two of the three variables remain negative and one of them is statistically significant. The signs on the two credit market variables are both negative in these estimations, which is the correct sign, but only the corporate bond default rate in the transitions to investment grade is significant at 5%.

Model with Firm Specific Factors Only

Panel A of Table 10 presents estimation results for upgrades to investment class with all of the macro factors together. As before, we find that the coefficient point estimates and their significance levels for the firm specific covariates are very similar for runs with and without the macro covariates. For "fallen angels" that were initially rated as investment grade but are currently rated Ba or B, the probability of being upgraded back to investment grade is significantly greater than for an issuer that was originally rated as in the speculative grade B category. As expected, being in the higher of the two ratings classes, Ba, makes a very large difference to the hazard rate for an upgrade into investment grade.

Being downgraded within the last two years may reduce the chance of an upgrade, but again the effect is not significant. A recent upgrade, however, has a strong positive and significant effect. The length of time the firm has been rated is also a positive and significant influence. This is consistent with the idea that Moody's credit analysts want to see a consistent record of good performance before concluding that a recently rated firm has changed its creditworthiness enough to justify an upgrade in its rating.

For upgrades out of a C-category, the ratings-related covariates have the right signs, but statistical significance is mostly lower. The effect of an issuer's initial rating is stronger here than for upgrade to investment class. Fallen angels that were initially investment grade are much more likely to recover from a Caa or Ca rating than is a firm that was initially in ratings class Ba or B. Similarly, being initially rated in a C grade is a significant detriment to the probability of an upgrade. The impact of the issuer's current rating is again as expected: a Caa-rated issuer is much more likely to be upgraded than is one in the Ca class. These were the only two classes from which upward transitions to B or Ba occurred in our sample, so C-rated firms are not treated as being "at risk" for this type of transition, and we had to eliminate the "Current rating: Ca" dummy from the specification, making Ca the base case for this transition.

Coefficients on recent downgrades and upgrades both are estimated with the expected signs but, curiously, none of them is significant. The number of years since the initial rating has a negative coefficient, but again is insignificant. None of these three variables survives the full backward selection process. The lower significance levels for these firm-specific variables than in the earlier tables mirrors what we see for the macro covariates. Seemingly, transitions for the firms in these highly speculative ratings classes are determined more by idiosyncratic factors than are those for the more creditworthy firms.

Models with All Macro Factors Included

Adding in all of our macro covariates produces several interesting results in Panel A. Consider first the general macroeconomic variables. The coefficient on long-term interest rates is still positive, but it is much larger than in Table 9 and is now highly significant. Higher bond yields are consistent with a greater probability of an upgrade to investment class. Unemployment has an anomalous and significant positive sign, while inflation has now become a significant factor and its influence is negative: the marginal effect of higher inflation is to lower the hazard rate for an upgrade to investment class. Stock market returns are still estimated with an anomalous negative coefficient, and it has now become highly significant. However, reversing the results from the previous table, an increase in the CFNAI index in conjunction with other macro covariates is now found to have a strongly significant positive impact on transitions to investment grade. All of these variables survive the backward selection process.

The "Direction of the Economy" variables continue to behave poorly. GDP growth and the unemployment rate have the wrong signs, while the change in industrial production has the right sign, but is not significant. Only real GDP growth is significant and it appears, with the wrong sign, in the backward selection specifications.

By contrast, the variables measuring economic slack look better than in the previous table. Deviation from potential real GDP and industrial production relative to trend have

much larger positive and significant coefficients, although capacity utilization has now gone negative and significant.[15] Finally, the credit market variables are now both negative and significant and their coefficients have increased in magnitude.

The specification with all of the macro variables increases (2 times) the log-likelihood by a very highly significant 147.77 over the model with only firm-specific covariates. Constrained backward selection specification eliminates only two of those variables, reducing log-likelihood by an insignificant 1.04. Full backward selection knocks out two more, leaving a specification that is insignificantly less good than was achieved with all of the covariates.

Panel B of Table 10 presents models of the last transition we consider, from a highly speculative (but not yet in default) grade of Caa or Ca up to a rating of B or Ba. None of the general macroeconomic factors comes close to statistical significance in any of these models, except for unemployment in the constrained backward selection model, where it has the wrong sign. Similarly, the covariates related to the direction of the economy are all very far from significance and none of them survives the backward selection process.

The economic slack variables also add nothing. Deviation from potential real GDP is estimated to have a strongly negative effect (an upgrade is less likely when there is little slack in the economy); the other two variables have the right sign but only capacity utilization is significant (contrasting with what we saw for this variable in Panel A). Strangely, none of these variables survives constrained backward selection. Yet when all covariates are eligible for exclusion, two of these are among the four that remain in the final model, but only one has the right sign. Finally, both credit market covariates are almost significant, but with the wrong sign, and both are eliminated by backward selection.

Comparing across models in terms of goodness of fit, we see that adding all of the macro factors does increase (2 times) log-likelihood by 23.43, but in contrast to all of the other transitions, this is only barely statistically significant at the 5% level. The Constrained model is significantly better than the model with only firm-specific factors and it is not significantly worse than the specification with all of the macro factors, even though 8 of them have been eliminated, and the final model under full backward selection has only four covariates, but is not significantly worse than the model with all variables, and it is the best model in terms of the Akaike Information Criterion.

IX. Robustness of Results over Different Sample Periods

We have seen a large number of estimation results for different credit transitions, some of which appeared fairly robust over different specifications, while others did not. But all of

[15] It was hoped that replacing these three covariates in these regressions with their first principal component would remove the effect of multicollinearity. But, as was typical in our explorations with principal components in this exercise, the coefficient on the first principal component came out positive but not statistically significant.

the estimations covered the same sample period, 1981 - 2002, so an important question arises as to how robust the results would be to a change in the data sample. We have already alluded to the fact that we considered including the 1970s in the sample and decided against it because we felt that the economic environment was too different from what came afterwards. One example of this is that the 1970s was a period of sharply rising inflation, fueled by the first OPEC oil price shock and accommodative monetary policy from the Federal Reserve, whereas inflation began falling rapidly in 1981 and has been fairly low and stable since then. Also, it was only starting in the 1980s that a bond could be brought to the market with a speculative grade rating at issue, so the composition of the population of firms in the lower ratings classes changed substantially after the 1970s.

In order to evaluate the influence of macro factors properly, it is important for the data sample to cover a range of economic environments, so we would lose a lot of statistical power if we simply split the sample in two, for example fitting the models over, say 1981-1991 and 1991-2002. Instead, to get an idea of how robust or fragile our estimates may be to the specific sample period we have chosen, we examined two shorter periods: 1981-1997, which eliminates the economic expansion, Internet "bubble," and subsequent credit events; and 1986-2002, which covers the most recent period but knocks out the beginning of the sample, with its sharp recession that moderated the inflation and its relative scarcity of junk bonds.

Table 11 compares estimation results from those three time periods. We do not replicate all of the earlier estimations, just the most important ones: default from any speculative grade, downgrade from an investment to a speculative rating, and upgrade from speculative to investment grade. We show coefficients and standard errors (rather than p-values) to give better perspective on how different the coefficients are quantitatively across periods. Only results with all variables and constrained backward selection are reported.

Speculative Grades to Default

Panel A covers transitions into default. Looking first at the results for the firm specific factors, there are no clear disparities across sample periods, although a few coefficients vary quite a bit. Overall, we see that the latter period, 1986-2002 is very similar to the full sample, while estimates from the period ending in 1997 tend to have both larger coefficients on the ratings-related covariates and considerably larger standard errors. This suggests that inclusion of the most recent data has added considerable information about how bond ratings correlate with default.

The general macro variables show similar behavior, in that the standard errors tend to be higher during the early sample, the coefficient point estimates are different, but the results from the full period are more consistent with those from the later sample. Interestingly, the one variable that does not match this pattern is inflation, which shows a stronger effect in the samples that include the early 1980s than in the later sample, though the estimates are not all significant at 5%.

The Direction of the Economy variables show considerable variation across samples, but none of them is ever close to statistically significant and they all drop out in the backward selection. The Economic slack variables do not perform very well in any of the periods, with two of the three being estimated with anomalous negative signs. Two of them survive backward selection in the subperiods. The Credit conditions variables have "correct" positive signs, but the yield spread is eliminated by backward selection in all three periods. The overall corporate bond default rate is significantly positive in the full period and the earlier subperiod, but it is insignificant in the later period and drops out in the backward selection.

Overall, the estimation results appear to be relatively robust across these three periods, but there are some clear differences. One is that including the period after 1997 leads to considerably smaller standard errors on most of the coefficients. The other is that estimates of the quantitative impact of the ratings-related dummies were distinctly larger in the earlier subperiod than when data after 1997 is included.

Downgrade from Investment to Speculative Grade

The firm specific factors showed similar coefficient point estimates across the three sample periods, and while standard errors were somewhat larger in the 1981-1997 period than the others, the same variables came out statistically significant. The general macro factors behaved differently, however. Unemployment ended up with an anomalous negative coefficient in five out of six cases, although with all variables it was insignificant in the early period, and it turned significantly positive under backward selection. Inflation, on the other hand was statistically insignificant in the earlier period, while the S&P 500 index return got a negative coefficient that was significant except in the later period. The CFNAI index was fitted with a positive sign (a stronger economy increases the risk of downgrade), but it becomes insignificant in the later period.

The Direction of the Economy variables show very noisy performance here, with large coefficients that change sign across the subperiods. In only a few cases does one of these variables survive backward selection, and one out of three has the wrong sign. The Economic slack measures behave fairly similarly across the subperiods, but fewer than half of them survive backward selection, and two out of four have the wrong sign. The Credit market conditions variables are insignificant when all variables are included and only the yield spread remains after backward selection for the full sample. Thus, for this transition we find that the weak performance of these sets of covariates is consistent across subperiods.

Finally, Panel C looks at upgrades from a speculative rating in the Ba or B category to investment grade. Most of the firm specific factors show very similar point estimates and standard errors across the subperiods, with the exceptions being the dummies for initial rating in a C- category, and the dummy for whether the firm had been downgraded

recently. These coefficients change sign in the different runs, but none of them is statistically significant.

Among the general macro factors, the coefficients on long term interest rates are positive overall and in the earlier subperiod, but they weaken in the later subperiod. Unemployment has anomalous positive coefficients in all cases, but none is significant. Inflation is like long term bond yields, in that it is significantly negative in the full sample and in the first subsample, but when the first portion of the period is removed, the coefficient becomes significantly positive when all variables are included and negative but insignificant in the backward selection. The S&P return has an anomalous negative coefficient, but it also goes from significant to insignificant in the later subperiod. The CFNAI index has mostly the right sign, but statistical significance disappears in the subperiods.

The Direction of the Economy covariates again show very erratic and mostly insignificant performance across subperiods. The same is basically true for the Economic slack measures, but statistical significance appears somewhat higher, both for covariates with correct and anomalous signs. The results for Credit market conditions do look robust, with the correct negative signs even though they survive backward selection in only one of four cases for the subperiods.

The general conclusion from the results shown in Table 11 is that the specific time period covered by the data sample does have a fairly large effect on the coefficient point estimates and standard errors, but the overall conclusions regarding which variables are important in explaining credit events and the signs of their effects appear to be quite robust, at least to fairly small changes in the sample period.

X. Conclusions

This is the first study to add such a broad range of macroeconomic factors to a Cox model specification for credit risk. In this framework, we have been able to increase the number of observations in our sample by working with individual firm data, rather than, say, aggregated default frequencies by ratings class as in earlier studies. We also have been able to access Moody's comprehensive database covering credit events in the full population of rated firms over a long time period. Finally, we limited the credit events under consideration to default and a small number of major changes of ratings class, which allowed larger numbers of firms in the "at risk" population for each type of transition. All of these features of our research design increased our ability to obtain precise coefficient estimates for a large number of firm-specific and macroeconomic factors.

From this first broad look at the problem, several conclusions seem warranted.

1. Incorporating macroeconomic factors along with ratings-related variables in reduced form models of default intensity leads to a highly significant increase in explanatory power.

2. Our estimates of the effects of firm-specific factors confirm results found in other studies, notably:

- Credit ratings reflected probability differences correctly in every case. Higher rated firms were less likely to default or to be downgraded than lower rated firms and were more likely to be upgraded.

- There is a "ratings drift" or "momentum" effect, by which a firm that has been downgraded (upgraded) in the recent past has a higher intensity of being downgraded (upgraded) again than a firm in the same rating category that has not experienced a recent downgrade (upgrade).

- There is an "aging" effect, in that the intensity of occurrence for a credit event depends on how long the firm has been in its current rating. In particular, a recently rated firm is less likely to default than a seasoned firm in its ratings class. Similarly, a recently-rated speculative grade firm in the B-category is less likely to be upgraded to the investment class.

- There are regular differences in intensity of occurrence of credit events for firms that began as investment grade and were subsequently downgraded into a speculative ratings class ("fallen angels"), and for firms that started as speculative and have been upgraded ("rising stars") than for the average firms in their ratings classes.

- Coefficients on firm-specific factors, and their significance levels, are largely unaffected by addition of macroeconomic factors to the specification. However, the coefficients on the macro variables themselves are much less stable under different specifications, indicating that there is considerable correlation among them and overlap in the relevant information they contain relating to credit risk.

3. In models of the transition into default with macro covariates

- Coefficients on macro covariates in transitions from the lowest C grades tend to be less significant and more idiosyncratic than for B grades or for B and C grades combined.

- High interest rates are associated with higher default rates; so is higher unemployment. Strong economic conditions as measured by the CFNAI index are associated with lower default hazard rates from a B-ratings class and from all speculative ratings classes combined, but not from C-classes considered separately. Inflation and strength in the aggregate stock market have small, insignificant, and/or anomalous effects on default intensity.

- Proxy measures of the direction of the economy, economic slack, and overall credit market conditions show mixed results, with some variables significant, but not necessarily with the "right" signs

- We see some evidence consistent with "contagion" in the credit markets, as the overall default rate among corporate borrowers enters as a significant covariate associated with an increase in the risk of default for an individual firm.

- "Standardizing" the coefficient estimates by multiplying them by the standard deviations of the variables in the sample reveals that long term interest rates, unemployment, inflation, and the measures of economic slack are effectively more influential than their raw coefficient values would suggest, while the change in the unemployment rate has a very much smaller effect than its, typically large, estimated coefficient indicates.

4. In models of the transition from an investment grade rating downwards to speculative grade

- The ratings-related variables perform well, with highly significant correct signs. The exception was the log(years since first rated) variable, that was not significant.

- Among the macro factors, high long term interest rates, low inflation, and wide (Baa - 10 year Treasury) yield spreads were associated with increased risk of a downgrade, as was a weak stock market, although the coefficient on the latter was small.

- The other general macro variables had anomalous signs (e.g., risk of downgrade was increased by low unemployment and a strong CFNAI index), or signs were mixed for a set of similar variables (e.g., two of three economic slack variables had negative coefficients and one was highly significant).

5. In models of transitions to a higher ratings class

- Transitions upwards from a C-grade seemed to be little affected by the macroeconomic environment. The coefficients on the macro variables were nearly all either quite insignificant, or significant but with incorrect signs.

- The erratic performance of the general macro variables seen in the models for downgrades from the investment class is also found in the transitions from a speculative B-rating to investment grade. High long term rates and a strong CFNAI index were associated with a significant increase in the chance of upgrade and high inflation reduced it. But high unemployment and a weak stock market also were estimated to make upgrades more likely, as was weak real GDP growth, and the economic slack variables were all significant, but had mixed signs.

- The best-performing macro variables here (in addition to the CFNAI index) were the two Credit market conditions variables: a wide credit spread and a high recent corporate bond default rate both significantly reduced the intensity of an upgrade to the investment class.

6. The coefficient point estimates and standard errors are affected by the specific time period covered by the sample.

- For the transition to default, incorporating the most recent data from 1997-2002, into a sample beginning in 1981 tended to reduce the coefficients on the ratings-related variables, but to reduce their estimated standard errors even more.

- For the other transitions, the differences were less pronounced, although some individual variables changed from statistically significant to insignificant or the reverse.

- Overall, while there were clear differences in the results over different sample periods, few of the conclusions about which variables were important and the signs of their influence would have been altered by a moderate change in the sample period.

In summary, we consider that our results represent a broad first cut at incorporating a wide range of measures of the macroeconomic environment into reduced-form Cox models for the hazard rates of several important credit events. Further research along these lines is surely warranted and can be expected to refine our understanding of this important area.

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Table 1

Moody's Long-Term Rating Definitions

Aaa	Obligations rated Aaa are judged to be of the highest quality, with minimal credit risk.
Aa	Obligations rated Aa are judged to be of high quality and are subject to very low credit risk.
A	Obligations rated A are considered upper-medium grade and are subject to low credit risk.
Baa	Obligations rated Baa are subject to moderate credit risk. They are considered medium-grade and as such may possess certain speculative characteristics.
Ba	Obligations rated Ba are judged to have speculative elements and are subject to substantial credit risk.
B	Obligations rated B are considered speculative and are subject to high credit risk.
Caa	Obligations rated Caa are judged to be of poor standing and are subject to very high credit risk.
Ca	Obligations rated Ca are highly speculative and are likely in, or very near, default, with some prospect of recovery of principal and interest.
C	Obligations rated C are the lowest rated class of bonds and are typically in default, with little prospect for recovery of principal or interest.

Source: Moody's KMV

Table 2
Numbers of transitions

From \ To	Total	Investment grade	Any speculative grade	Ba and B	Caa, Ca, and C	Default	Withdrawn
Investment grade	3422	1684	788	783	5	6	944
Any speculative grade	4327	645	1125	912	213	902	1655
Ba and B	4196	641	1624	912	746	448	1486
Caa, Ca, and C	942	4	315	102	213	454	169

Notes:

Spells shorter than 14 days are eliminated from the sample, and the spell in the previous rating class is extended to include the short period.

Moody's ratings classes Caa, Ca, and C contain some firms that have already defaulted. In our sample, we exclude firms that have defaulted from those classes.

Transitions into the category "Withdrawn" occur when a firm no longer has rated bonds outstanding, because they have matured, or due to a non-default reason, such as a merger.

Spells ending with the rating "Withdrawn" or with no rating change at the end of the sample period are treated as right-censored.

TABLE 3
Statistics on Model Covariates

Variable	Mean	Standard deviation	Variable in Model	Source
General Macroeconomic Factors				
Long-term interest rate (10-year Treasury)	8.208	2.578	18-month distributed lag	Federal Reserve Bank of St. Louis
Unemployment rate	6.295	1.500	18-month distributed lag	US Bureau of Labor Statistics*
Inflation	3.706	2.021	18-month distributed lag	US Bureau of Labor Statistics*
S&P 500 return	0.904	1.240	18-month distributed lag	Wharton Research Data Service
CFNAI index (3-month moving avg)	-0.131	0.768	3-month moving average	Federal Reserve Bank of Chicago
Direction of the Economy				
Real GDP growth	0.763	0.449	18-month distributed lag	US Bureau of Economic Analysis
Change in industrial production	0.220	0.288	18-month distributed lag	Federal Reserve Board of Governors
Change in unemployment rate	-0.0053	0.0747	18-month distributed lag	US Bureau of Labor Statistics*
Economic Slack				
Deviation from potential real GDP	-1.576	2.424	18-month distributed lag	Bureau of Economic Analysis and Congressional Budget Office
Capacity utilization	80.77	2.74	18-month distributed lag	Federal Reserve Board of Governors
Industrial prod'n dev from trend (last 20 yrs)	0.237	8.625	18-month distributed lag	Federal Reserve Board of Governors
Credit Market Conditions	0.000	1.153		
Yield spread (Baa - 10 Year Treasury)	2.101	0.438	18-month distributed lag	Federal Reserve Bank of St. Louis
Corporate bond default rate (3-month moving avg)	1.473	1.069	3-month moving average	Moody's KMV
Firm Specific Factors				
Initial rating: Investment grade			(0,1) dummy	
Initial rating: C, Ca, Caa			(0,1) dummy	
Current rating: Ba			(0,1) dummy	
Current rating: B			(0,1) dummy	
Current rating: Caa			(0,1) dummy	
Current rating: Ca			(0,1) dummy	
Downgraded within last 2 years			(0,1) dummy	
Upgraded within last 2 years			(0,1) dummy	
log(years since first rated)			contemporaneous value	

* Data series downloaded from the St. Louis Federal Reserve (URL: http://research.stlouisfed.org/fred2/).

Table 4
TRANSITIONS INTO DEFAULT
Analysis of Individual Macro Factors

	Univariate results						Marginal contribution with firm specific variables					
	Speculative to default		B grades to default		C grades to default		Speculative to default		B grades to default		C grades to default	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
General Macroeconomic Factors												
Long-term interest rate (10-year Treasury)	-0.064	0.000	0.094	0.000	0.038	0.223	0.122	0.000	0.156	0.000	0.049	0.099
Unemployment rate	-0.181	0.000	0.066	0.059	-0.117	0.020	0.079	0.004	0.153	0.000	-0.097	0.055
Inflation	-0.002	0.938	0.125	0.000	0.113	0.001	0.146	0.000	0.197	0.000	0.076	0.045
S&P 500 return	-0.122	0.000	-0.013	0.719	-0.076	0.011	0.058	0.016	0.040	0.271	0.048	0.129
CFNAI index (3-month moving avg)	-0.500	0.000	-0.464	0.000	-0.417	0.000	-0.296	0.000	-0.413	0.000	-0.163	0.030
Direction of the Economy												
Real GDP growth	-0.713	0.000	-0.701	0.000	-0.580	0.000	-0.409	0.000	-0.631	0.000	-0.143	0.238
Change in industrial production	-1.193	0.000	-1.088	0.000	-0.911	0.000	-0.596	0.000	-0.922	0.000	-0.280	0.073
Change in unemployment rate	4.306	0.000	3.659	0.000	3.156	0.000	1.585	0.003	3.029	0.000	-0.166	0.831
Economic Slack												
Deviation from potential Real GDP	0.095	0.000	-0.027	0.217	0.044	0.109	-0.026	0.119	-0.074	0.000	0.063	0.020
Capacity utilization	-0.030	0.024	-0.014	0.454	-0.039	0.032	0.019	0.165	-0.011	0.566	0.042	0.029
Industrial prod'n dev from trend (last 20 yrs)	0.012	0.008	-0.026	0.000	-0.005	0.486	-0.019	0.000	-0.040	0.000	0.012	0.097
Credit Market Conditions												
Yield spread (Baa - 10 Year Treasury)	0.474	0.000	0.033	0.766	0.412	0.000	-0.140	0.061	-0.144	0.198	-0.045	0.647
Corporate bond default rate (3-month moving avg)	0.353	0.000	0.343	0.000	0.206	0.000	0.124	0.000	0.264	0.000	-0.006	0.893

Notes

Sample period: Jan. 1981 - Nov. 2002.

As described in the text, spells of less than 14 days are reclassified, and most covariates enter as with exponentially weighted 18-month moving averages with a decay factor of 0.88.

The right panel reports the estimation results for each single variable when added to a model with the following firm specific variables

- Initial rating: Investment grade
- Initial rating: C, Ca, Caa
- Current rating: Ba
- Current rating: B
- Current rating: Caa
- Current rating: Ca
- Downgraded within last 2 years
- Upgraded within last 2 years
- log(years since first rated)

Table 5
TRANSITIONS INTO DEFAULT

Panel A: All Speculative grades to default

					Backward Selection Models			
	Firm specific only		All variables		Constrained		Full Selection	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
Firm Specific Factors								
Initial rating: Investment grade	-0.237	0.062	-0.428	0.001	-0.528	0.000	-0.528	0.000
Initial rating: C, Ca, Caa	-1.282	0.000	-1.235	0.000	-1.170	0.000	-1.170	0.000
Current rating: Ba	-5.305	0.000	-5.765	0.000	-6.089	0.000	-6.089	0.000
Current rating: B	-3.505	0.000	-3.862	0.000	-4.075	0.000	-4.075	0.000
Current rating: Caa	-1.630	0.000	-1.793	0.000	-1.950	0.000	-1.950	0.000
Current rating: Ca	-1.019	0.000	-1.155	0.000	-1.319	0.000	-1.319	0.000
Downgraded within last 2 years	0.446	0.000	0.436	0.000	0.971	0.000	0.971	0.000
Upgraded within last 2 years	-1.465	0.000	-1.228	0.000	-0.723	0.026	-0.723	0.026
log(years since first rated)	0.141	0.013	0.144	0.013	0.155	0.005	0.155	0.005
General Macroeconomic Factors								
Long-term interest rate (10-year Treasury)			0.132	0.008	0.119	0.012	0.119	0.012
Unemployment rate			0.366	0.024	0.332	0.024	0.332	0.024
Inflation			-0.126	0.019	-0.141	0.003	-0.141	0.003
S&P 500 return			0.142	0.000	0.144	0.000	0.144	0.000
CFNAI index (3-month moving avg)			-0.254	0.101	-0.319	0.000	-0.319	0.000
Direction of the Economy								
Real GDP growth			-0.352	0.192				
Change in industrial production			0.072	0.873				
Change in unemployment rate			-1.141	0.432				
Economic Slack								
Deviation from potential Real GDP			0.423	0.000	0.438	0.000	0.438	0.000
Capacity utilization			0.140	0.039	0.152	0.000	0.152	0.000
Industrial prod'n dev from trend (last 20 yrs)			-0.084	0.001	-0.109	0.000	-0.109	0.000
Credit Market Conditions								
Yield spread (Baa - 10 Year Treasury)			0.185	0.498				
Corporate bond default rate (3-month moving avg)			0.273	0.000	0.265	0.000	0.265	0.000
Akaike Information Criterion	11147.81		10980.90		10976.35		10976.35	
-2 x log(likelihood)	11129.81		10936.90		10940.35		10940.35	
Likelihood ratio test: model vs Firm specific only			192.91	0.000	189.46	0.000	189.46	0.000
Likelihood ratio test: Final model vs All variables					3.45	0.486	3.45	0.486

Notes

Sample period: Jan. 1981 - Nov. 2002.

As described in the text, spells of less than 14 days are reclassified, and most covariates enter as exponentially weighted 18-month moving averages with a decay factor of 0.88.

Table 5 continued
TRANSITIONS INTO DEFAULT

Panel B: B grades to default

					Backward Selection Models			
	Firm specific only		All variables		Constrained		Full Selection	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
Firm Specific Factors								
Initial rating: Investment grade	-0.169	0.319	-0.341	0.048	-0.332	0.054		
Initial rating: C, Ca, Caa	-0.022	0.969	0.028	0.962	0.036	0.951		
Current rating: Ba	-1.810	0.000	-1.952	0.000	-1.946	0.000	-1.958	0.000
Current rating: B								
Current rating: Caa								
Current rating: Ca								
Downgraded within last 2 years	0.329	0.001	0.398	0.000	0.391	0.000	0.376	0.000
Upgraded within last 2 years	-1.743	0.000	-1.390	0.001	-1.403	0.001	-1.401	0.001
log(years since first rated)	0.140	0.067	0.120	0.123	0.118	0.130		
General Macroeconomic Factors								
Long-term interest rate (10-year Treasury)			0.088	0.155	0.047	0.404		
Unemployment rate			0.624	0.005	0.714	0.000	0.758	0.000
Inflation			-0.106	0.119	-0.037	0.534		
S&P 500 return			0.127	0.019	0.109	0.031	0.117	0.015
CFNAI index (3-month moving avg)			-0.459	0.021	-0.292	0.003	-0.301	0.001
Direction of the Economy								
Real GDP growth			-0.309	0.393				
Change in industrial production			1.263	0.040				
Change in unemployment rate			1.440	0.468				
Economic Slack								
Deviation from potential Real GDP			0.640	0.000	0.575	0.000	0.598	0.000
Capacity utilization			0.185	0.027	0.136	0.001	0.128	0.000
Industrial prod'n dev from trend (last 20 yrs)			-0.142	0.000	-0.103	0.001	-0.106	0.000
Credit Market Conditions								
Yield spread (Baa - 10 Year Treasury)			0.326	0.330				
Corporate bond default rate (3-month moving avg)			0.372	0.000	0.407	0.000	0.390	0.000
Akaike Information Criterion	5959.67		5784.52		5781.31		5776.07	
-2 x log(likelihood)	5947.67		5746.52		5751.31		5756.07	
Likelihood ratio test: model vs Firm specific only			201.16	0.000	196.37	0.000	191.60	
Likelihood ratio test: Final model vs All variables					4.79	0.310	9.55	0.388

Notes

See Notes for Panel A

Table 5 continued
TRANSITIONS INTO DEFAULT

Panel C: C grades to default

					Backward Selection Models			
	Firm specific only		All variables		Constrained		Full Selection	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
Firm Specific Factors								
Initial rating: Investment grade	-0.376	0.021	-0.396	0.021	-0.370	0.031	-0.391	0.022
Initial rating: C, Ca, Caa	-1.301	0.000	-1.325	0.000	-1.319	0.000	-1.432	0.000
Current rating: Ba								
Current rating: B								
Current rating: Caa	-2.070	0.000	-2.136	0.000	-2.114	0.000	-2.231	0.000
Current rating: Ca	-1.336	0.000	-1.335	0.000	-1.324	0.000	-1.414	0.000
Downgraded within last 2 years	0.316	0.058	0.231	0.175	0.255	0.130		
Upgraded within last 2 years	-0.392	0.459	-0.357	0.499	-0.384	0.466		
log(years since first rated)	0.146	0.017	0.154	0.015	0.156	0.014	0.164	0.009
General Macroeconomic Factors								
Long-term interest rate (10-year Treasury)			0.136	0.135	0.137	0.073	0.105	0.027
Unemployment rate			-0.172	0.543	-0.230	0.007	-0.201	0.004
Inflation			-0.103	0.231	-0.029	0.687		
S&P 500 return			0.170	0.009	0.148	0.004	0.153	0.002
CFNAI index (3-month moving avg)			0.087	0.733	0.115	0.560		
Direction of the Economy								
Real GDP growth			-0.281	0.532				
Change in industrial production			-1.064	0.145	-1.759	0.001	-1.581	0.000
Change in unemployment rate			-2.957	0.218	-4.179	0.010	-4.238	0.009
Economic Slack								
Deviation from potential Real GDP			0.128	0.530				
Capacity utilization			0.137	0.264				
Industrial prod'n dev from trend (last 20 yrs)			-0.052	0.237				
Credit Market Conditions								
Yield spread (Baa - 10 Year Treasury)			0.539	0.280				
Corporate bond default rate (3-month moving avg)			0.006	0.962				
Akaike Information Criterion	5072.15		5055.84		5047.00		5043.04	
-2 x log(likelihood)	5058.15		5015.84		5019.00		5023.04	
Likelihood ratio test: model vs Firm specific only			42.31	0.000	39.15	0.000	35.11	
Likelihood ratio test: Final model vs All variables					3.16	0.788	7.19	0.707

Notes
See Notes for Panel A

Table 6
STANDARDIZED COEFFICIENT ESTIMATES FOR TRANSITIONS INTO DEFAULT

Panel A: All Speculative grades to default

	All variables			Constrained Backward Selection			Full Backward Selection		
	raw coefficient	standardized coefficient	p-value	raw coefficient	standardized coefficient	p-value	raw coefficient	standardized coefficient	p-value
General Macroeconomic Factors									
Long-term interest rate (10-year Treasury)	0.132	0.339	0.008	0.119	0.306	0.012	0.119	0.306	0.012
Unemployment rate	0.366	0.549	0.024	0.332	0.498	0.024	0.332	0.498	0.024
Inflation	-0.126	-0.254	0.019	-0.141	-0.285	0.003	-0.141	-0.285	0.003
S&P 500 return	0.142	0.176	0.000	0.144	0.179	0.000	0.144	0.179	0.000
CFNAI index (3-month moving avg)	-0.254	-0.195	0.101	-0.319	-0.245	0.000	-0.319	-0.245	0.000
Direction of the Economy									
Real GDP growth	-0.352	-0.158	0.192						
Change in industrial production	0.072	0.021	0.873						
Change in unemployment rate	-1.141	-0.085	0.432						
Economic Slack									
Deviation from potential Real GDP	0.423	1.025	0.000	0.438	1.062	0.000	0.438	1.062	0.000
Capacity utilization	0.140	0.384	0.039	0.152	0.417	0.000	0.152	0.417	0.000
Industrial prod'n dev from trend (last 20 yrs)	-0.084	-0.724	0.001	-0.109	-0.939	0.000	-0.109	-0.939	0.000
Credit Market Conditions									
Yield spread (Baa - 10 Year Treasury)	0.185	0.081	0.498						
Corporate bond default rate (3-month moving avg)	0.273	0.292	0.000	0.265	0.265	0.000	0.265	0.283	0.000

Notes:

The coefficients from Table 5 are rescaled to give more meaningful comparisons of their relative importance in determining the hazard rates. Table 6 coefficients show the impact of a one standard deviation increase in the covariate's value.

Table 6, continued
STANDARDIZED COEFFICIENT ESTIMATES FOR TRANSITIONS INTO DEFAULT

Panel B B grades to default

	raw coefficient	standardized coefficient	p-value	raw coefficient	standardized coefficient	p-value	raw coefficient	standardized coefficient	p-value
General Macroeconomic Factors									
Long-term interest rate (10-year Treasury)	0.088	0.227	0.155	0.047	0.121	0.404			
Unemployment rate	0.624	0.936	0.005	0.714	1.137	0.000	0.758	1.137	0.000
Inflation	-0.106	-0.215	0.119	-0.037	0.000	0.000			
S&P 500 return	0.127	0.157	0.019	0.109	0.145	0.015	0.117	0.145	0.015
CFNAI index (3-month moving avg)	-0.459	-0.352	0.021	-0.292	-0.231	0.001	-0.301	-0.231	0.001
Direction of the Economy									
Real GDP growth	-0.309	-0.139	0.393						
Change in industrial production	1.263	0.364	0.040						
Change in unemployment rate	1.440	0.108	0.468						
Economic Slack									
Deviation from potential Real GDP	0.640	1.550	0.000	0.575	1.394	0.000	0.598	1.450	0.000
Capacity utilization	0.185	0.506	0.027	0.136	0.372	0.001	0.128	0.351	0.000
Industrial prod'n dev from trend (last 20 yrs)	-0.142	-1.221	0.000	-0.103	-0.884	0.001	-0.106	-0.916	0.000
Credit Market Conditions									
Yield spread (Baa - 10 Year Treasury)	0.326	0.143	0.330						
Corporate bond default rate (3-month moving avg)	0.372	0.398	0.000	0.407	0.435	0.000	0.390	0.417	0.000

Notes:
See the Notes to Panel A

Table 6 continued
STANDARDIZED COEFFICIENT ESTIMATES FOR TRANSITIONS INTO DEFAULT

Panel C: C grades to default

	All variables			Constrained Backward Selection			Full Backward Selection		
	raw coefficient	standardized coefficient	p-value	raw coefficient	standardized coefficient	p-value	raw coefficient	standardized coefficient	p-value
General Macroeconomic Factors									
Long-term interest rate (10-year Treasury)	0.136	0.350	0.135	0.137	0.354	0.073	0.105	0.270	0.027
Unemployment rate	-0.172	-0.258	0.543	-0.230	-0.345	0.007	-0.201	-0.302	0.004
Inflation	-0.103	-0.207	0.231	-0.029	-0.058	0.687			
S&P 500 return	0.170	0.211	0.009	0.148	0.184	0.004	0.153	0.190	0.002
CFNAI index (3-month moving avg)	0.087	0.067	0.733	0.115	0.088	0.560			
Direction of the Economy									
Real GDP growth	-0.281	-0.126	0.532						
Change in industrial production	-1.064	-0.307	0.145	-1.759	-0.507	0.001	-1.581	-0.456	0.000
Change in unemployment rate	-2.957	-0.221	0.218	-4.179	-0.312	0.010	-4.238	-0.316	0.009
Economic Slack									
Deviation from potential Real GDP	0.128	0.310	0.530						
Capacity utilization	0.137	0.375	0.264						
Industrial prod'n dev from trend (last 20 yrs)	-0.052	-0.447	0.237						
Credit Market Conditions									
Yield spread (Baa - 10 Year Treasury)	0.539	0.236	0.280						
Corporate bond default rate (3-month moving avg)	0.006	0.006	0.962						

Notes:
See the Notes to Panel A

Table 7
DOWNGRADE FROM INVESTMENT TO SPECULATIVE GRADE
Analysis of Individual Macro Factors

	Univariate results		Marginal contribution with firm specific variables	
	coefficient	p-value	coefficient	p-value
General Macroeconomic Factors				
Long-term interest rate (10-year Treasury)	0.072	0.000	0.094	0.000
Unemployment rate	0.042	0.084	0.077	0.001
Inflation	0.049	0.006	0.061	0.000
S&P 500 return	-0.247	0.000	-0.186	0.000
CFNAI index (3-month moving avg)	-0.381	0.000	-0.341	0.000
Direction of the Economy				
Real GDP growth	-0.822	0.000	-0.768	0.000
Change in industrial production	-1.291	0.000	-1.138	0.000
Change in unemployment rate	4.708	0.000	4.153	0.000
Economic Slack				
Deviation from potential Real GDP	-0.044	0.003	-0.061	0.000
Capacity utilization	-0.108	0.000	-0.092	0.000
Industrial prod'n dev from trend (last 20 yrs)	-0.026	0.000	-0.029	0.000
Credit Market Conditions				
Yield spread (Baa - 10 Year Treasury)	0.837	0.000	0.636	0.000
Corporate bond default rate (3-month moving avg)	0.206	0.000	0.127	0.000

Notes

See the Notes to Table 4.

Table 8
DOWNGRADE FROM INVESTMENT TO SPECULATIVE GRADE

					Backward Selection Models			
	Firm specific only		All variables		Constrained		Full Selection	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
Firm Specific Factors								
Initial rating: Investment grade	-0.357	0.000	-0.323	0.002	-0.328	0.001	-0.295	0.002
Current rating: Baa	2.734	0.000	2.723	0.000	2.729	0.000	2.737	0.000
Downgraded within last 2 years	0.820	0.000	0.788	0.000	0.769	0.000	0.760	0.000
Upgraded within last 2 years	-0.823	0.000	-0.735	0.000	-0.745	0.000	-0.780	0.000
log(years since first rated)	-0.050	0.258	-0.042	0.347	-0.045	0.314		
General Macroeconomic Factors								
Long-term interest rate (10-year Treasury)			0.355	0.000	0.386	0.000	0.387	0.000
Unemployment rate			-0.390	0.031	-0.407	0.016	-0.409	0.016
Inflation			-0.255	0.000	-0.261	0.000	-0.261	0.000
S&P 500 return			-0.093	0.019	-0.084	0.031	-0.084	0.031
CFNAI index (3-month moving avg)			0.562	0.000	0.512	0.000	0.510	0.000
Direction of the Economy								
Real GDP growth			-1.585	0.000	-1.633	0.000	-1.632	0.000
Change in industrial production			1.003	0.015	0.940	0.016	0.944	0.016
Change in unemployment rate			1.878	0.203				
Economic slack								
Deviation from potential Real GDP			0.495	0.000	0.395	0.000	0.395	0.000
Capacity utilization			-0.043	0.483				
Industrial prod'n dev from trend (last 20 yrs)			-0.134	0.000	-0.117	0.000	-0.116	0.000
Credit Market Conditions								
Yield spread (Baa - 10 Year Treasury)			0.261	0.294	0.437	0.001	0.443	0.001
Corporate bond default rate (3-month moving avg)			-0.116	0.067				
AIC (model)	9556.00		9287.40		9286.58		9285.60	
-2 x log(likelihood)	9546.00		9251.40		9256.58		9257.60	
Likelihood ratio test: model vs Firm specific only			294.60	0.000	289.42	0.000	288.40	
Likelihood ratio test: Final model vs All variables					5.17	0.160	6.20	0.013

Notes
See Notes to Table 5.

Table 9
UPGRADE TO HIGHER RATINGS CLASS
Analysis of Individual Macro Factors

	FROM B AND Ba RATINGS TO INVESTMENT GRADE				FROM C, Ca, Caa TO B RATING OR HIGHER			
	Univariate results		Marginal contribution with firm specific variables		Univariate results		Marginal contribution with firm specific variables	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
General Macroeconomic Factors								
Long-term interest rate (10-year Treasury)	0.077	0.000	0.004	0.802	0.146	0.006	0.075	0.193
Unemployment rate	0.076	0.009	-0.053	0.080	0.335	0.000	0.257	0.003
Inflation	0.019	0.433	-0.043	0.086	0.019	0.837	-0.033	0.699
S&P 500 return	-0.006	0.841	-0.025	0.423	0.113	0.085	0.127	0.065
CFNAI index (3-month moving avg)	-0.109	0.081	-0.114	0.055	0.243	0.160	0.277	0.112
Direction of the Economy								
Real GDP growth	-0.319	0.001	-0.279	0.003	0.023	0.930	0.158	0.568
Change in industrial production	-0.040	0.788	0.000	0.998	0.366	0.288	0.481	0.181
Change in unemployment rate	1.187	0.054	1.136	0.052	-1.372	0.430	-2.021	0.248
Economic Slack								
Deviation from potential Real GDP	-0.049	0.007	0.028	0.143	-0.186	0.000	-0.141	0.005
Capacity utilization	-0.004	0.801	0.028	0.096	0.000	0.990	0.019	0.643
Industrial prod'n dev from trend (last 20 yrs)	-0.006	0.257	0.016	0.002	-0.037	0.005	-0.024	0.100
Credit Market Conditions								
Yield spread (Baa - 10 Year Treasury)	-0.145	0.127	-0.139	0.153	-0.330	0.101	-0.356	0.094
Corporate bond default rate (3-month moving avg)	-0.264	0.000	-0.187	0.000	-0.187	0.038	-0.177	0.065

Notes
See Notes to Table 4.

Table 10
RATINGS CLASS UPGRADES

Panel A: FROM Ba and B TO INVESTMENT GRADE

					Backward Selection Models			
	Firm specific only		All variables		Constrained		Full Selection	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
Firm Specific Factors								
Initial rating: Investment grade	0.363	0.001	0.433	0.000	0.432	0.000	0.428	0.000
Initial rating: C, Ca, Caa								
Current rating: Ba	1.796	0.000	1.821	0.000	1.823	0.000	1.829	0.000
Current rating: Caa								
Current rating: Ca								
Downgraded within last 2 years	-0.076	0.518	-0.044	0.711	-0.045	0.708		
Upgraded within last 2 years	0.371	0.000	0.317	0.003	0.316	0.003	0.323	0.002
log(years since first rated)	0.333	0.000	0.321	0.000	0.321	0.000	0.317	0.000
General Macroeconomic Factors								
Long-term interest rate (10-year Treasury)			0.220	0.000	0.216	0.000	0.216	0.000
Unemployment rate			0.416	0.028	0.434	0.020	0.434	0.020
Inflation			-0.117	0.029	-0.098	0.046	-0.099	0.043
S&P 500 return			-0.162	0.000	-0.173	0.000	-0.173	0.000
CFNAI index (3-month moving avg)			0.374	0.034	0.488	0.000	0.488	0.000
Direction of the Economy								
Real GDP growth			-1.789	0.000	-1.747	0.000	-1.749	0.000
Change in industrial production			0.509	0.312				
Change in unemployment rate			0.336	0.844				
Economic slack								
Deviation from potential Real GDP			0.308	0.007	0.291	0.008	0.292	0.008
Capacity utilization			-0.190	0.009	-0.201	0.003	-0.201	0.003
Industrial prod'n dev from trend (last 20 yrs)			0.097	0.002	0.109	0.000	0.108	0.000
Credit Market Conditions								
Yield spread (Baa - 10 Year Treasury)			-0.593	0.043	-0.708	0.008	-0.709	0.008
Corporate bond default rate (3-month moving avg)			-0.296	0.000	-0.305	0.000	-0.307	0.000
AIC (model)	8479.44		8357.67		8354.71		8352.85	
-2 x log(likelihood)	8469.44		8321.67		8322.71		8322.85	
Likelihood ratio test: model vs Firm specific only			147.77	0.000	146.73	0.000	146.59	
Likelihood ratio test: Final model vs All variables					1.04	0.595	1.18	0.758

Notes

See Notes to Table 5.

Table 10 continued
RATINGS CLASS UPGRADES

Panel B: FROM Ca and Caa TO B GRADE OR ABOVE

					Backward Selection Models			
	Firm specific only		All variables		Constrained		Full Selection	
	coefficient	p-value	coefficient	p-value	coefficient	p-value	coefficient	p-value
Firm Specific Factors								
Initial rating: Investment grade	1.082	0.000	0.664	0.048	0.727	0.028		
Initial rating: C, Ca, Caa	-0.837	0.005	-0.834	0.008	-0.759	0.014	-0.496	0.024
Current rating: Ba								
Current rating: Caa	0.572	0.128	0.844	0.028	0.776	0.042	0.943	0.011
Current rating: Ca								
Downgraded within last 2 years	-0.488	0.085	-0.298	0.321	-0.301	0.304		
Upgraded within last 2 years	0.458	0.257	0.525	0.206	0.457	0.265		
log(years since first rated)	-0.282	0.066	-0.233	0.130	-0.238	0.117		
General Macroeconomic Factors								
Long-term interest rate (10-year Treasury)			0.026	0.867	-0.100	0.465		
Unemployment rate			-0.231	0.626	0.349	0.016		
Inflation			-0.119	0.537	-0.022	0.870		
S&P 500 return			0.019	0.883	0.131	0.160		
CFNAI index (3-month moving avg)			-0.154	0.761	-0.003	0.988		
Direction of the Economy								
Real GDP growth			0.449	0.639				
Change in industrial production			0.760	0.642				
Change in unemployment rate			-1.836	0.701				
Economic slack								
Deviation from potential Real GDP			-1.072	0.010			-0.627	0.000
Capacity utilization			0.529	0.019				
Industrial prod'n dev from trend (last 20 yrs)			0.112	0.243			0.134	0.001
Credit Market Conditions								
Yield spread (Baa - 10 Year Treasury)			1.803	0.050				
Corporate bond default rate (3-month moving avg)			0.454	0.054				
AIC (model)	1140.15		1142.71		1137.60		1129.56	
-2 x log(likelihood)	1128.15		1104.71		1115.60		1121.56	
Likelihood ratio test: model vs Firm specific only			23.43	0.037	12.55	0.028	6.58	
Likelihood ratio test: Final model vs All variables					10.89	0.208	16.85	0.328

Notes

See Notes to Table 5.

Table 11
Sensitivity of Estimation Results to Sample Period
Panel A: All Speculative grades to default

	All Variables						Constrained Backward Selection					
	1981-2002		1981-1997		1986-2002		1981-2002		1981-1997		1986-2002	
	coefficient	std error	coefficient	std error	coefficient	std error	coefficient	std error	coefficient	std error	coefficient	std error
Firm Specific Factors												
Initial rating: Investment grade	-0.428	0.132	-0.437	0.167	-0.407	0.139	-0.422	0.132	-0.428	0.167	-0.402	0.139
Initial rating: C, Ca, Caa	-1.235	0.153	-1.790	0.376	-1.260	0.154	-1.233	0.153	-1.776	0.374	-1.256	0.154
Current rating: Ba	-5.765	0.253	-6.630	0.524	-5.818	0.260	-5.755	0.252	-6.598	0.515	-5.799	0.259
Current rating: B	-3.862	0.211	-4.686	0.498	-3.941	0.213	-3.855	0.211	-4.658	0.489	-3.923	0.213
Current rating: Caa	-1.793	0.197	-2.923	0.489	-1.837	0.197	-1.791	0.197	-2.896	0.481	-1.824	0.197
Current rating: Ca	-1.155	0.215	-2.773	0.510	-1.166	0.216	-1.157	0.215	-2.762	0.502	-1.154	0.215
Downgraded within last 2 years	0.436	0.084	0.751	0.109	0.381	0.087	0.440	0.084	0.745	0.109	0.379	0.087
Upgraded within last 2 years	-1.228	0.340	-1.585	0.584	-1.311	0.360	-1.236	0.340	-1.595	0.584	-1.321	0.360
log(years since first rated)	0.144	0.058	0.037	0.084	0.137	0.060	0.141	0.058	0.036	0.084	0.134	0.060
General Macroeconomic Factors												
Long-term interest rate (10-year Treasury)	0.132	0.050	0.058	0.070	0.121	0.086	0.110	0.047	0.028	0.060	0.187	0.068
Unemployment rate	0.366	0.162	0.028	0.417	0.405	0.172	0.375	0.147	0.001	0.344	0.301	0.151
Inflation	-0.126	0.054	-0.145	0.079	-0.044	0.077	-0.111	0.047	-0.107	0.070	0.003	0.051
S&P 500 return	0.142	0.041	0.093	0.069	0.142	0.046	0.133	0.039	0.041	0.058	0.136	0.043
CFNAI index (3-month moving avg)	-0.254	0.155	-0.524	0.185	-0.194	0.188	-0.333	0.076	-0.331	0.094	-0.397	0.083
Direction of the Economy												
Real GDP growth	-0.352	0.270	-0.216	0.376	-0.421	0.324						
Change in industrial production	0.072	0.454	0.920	0.658	0.128	0.503						
Change in unemployment rate	-1.141	1.454	-0.438	2.084	1.719	2.023						
Economic Slack												
Deviation from potential Real GDP	0.423	0.104	0.527	0.135	0.471	0.135	0.429	0.076	0.503	0.094	0.360	0.087
Capacity utilization	0.140	0.068	0.072	0.114	0.139	0.093	0.114	0.030				
Industrial prod'n dev from trend (last 20 yrs)	-0.084	0.026	-0.179	0.073	-0.085	0.041	-0.085	0.022	-0.154	0.060	-0.050	0.024
Credit Market Conditions												
Yield spread (Baa - 10 Year Treasury)	0.185	0.272	0.203	0.323	0.319	0.326						
Corporate bond default rate (3-month moving avg	0.273	0.065	0.202	0.089	0.121	0.105	0.273	0.053	0.172	0.078		

Notes:

The model is estimated on three different sample periods: The full sample, Jan. 1981 - Nov. 2002; a subsample that excludes the last 5 years; and a subsample that excludes the first 5 years..
As described in the text, spells of less than 14 days are reclassified, and most covariates enter as exponentially weighted 18-month moving averages with a decay factor of 0.88.

Table 11, continued
Sensitivity of Estimation Results to Sample Period
Panel B: Downgrade from Investment to Speculative grade

	All Variables						Constrained Backward Selection					
	1981-2002		1981-1997		1986-2002		1981-2002		1981-1997		1986-2002	
	coefficient	std error	coefficient	std error	coefficient	std error	coefficient	std error	coefficient	std error	coefficient	std error
Firm Specific Factors												
Initial rating: Investment grade	-0.323	0.102	-0.027	0.147	-0.362	0.111	-0.328	0.102	-0.033	0.147	-0.364	0.111
Downgraded within last 2 years	0.788	0.079	0.593	0.102	0.853	0.088	0.769	0.078	0.614	0.101	0.862	0.087
Upgraded within last 2 years	-0.735	0.154	-0.981	0.213	-0.636	0.165	-0.745	0.154	-0.980	0.213	-0.648	0.165
log(years since first rated)	-0.042	0.045	-0.077	0.058	-0.023	0.049	-0.045	0.045	-0.075	0.058	-0.020	0.049
General Macroeconomic Factors												
Long-term interest rate (10-year Treasury)	0.355	0.045	0.409	0.064	0.319	0.083	0.386	0.042	0.436	0.042	0.445	0.057
Unemployment rate	-0.390	0.181	-0.017	0.429	-0.352	0.186	-0.407	0.169	0.630	0.168	-0.495	0.078
Inflation	-0.255	0.041	-0.205	0.064	-0.062	0.082	-0.261	0.038	-0.148	0.034	-0.060	0.060
S&P 500 return	-0.093	0.040	-0.123	0.059	-0.022	0.049	-0.084	0.039	-0.122	0.047	-0.045	0.042
CFNAI index (3-month moving avg)	0.562	0.144	0.825	0.159	0.095	0.217	0.512	0.142	0.951	0.124	0.089	0.087
Direction of the Economy												
Real GDP growth	-1.585	0.233	-2.277	0.325	0.204	0.363	-1.633	0.193	-2.290	0.199		
Change in industrial production	1.003	0.414	-0.257	0.597	-0.187	0.599	0.940	0.392				
Change in unemployment rate	1.878	1.475	-3.561	2.295	1.103	2.367						
Economic Slack												
Deviation from potential Real GDP	0.495	0.095	0.570	0.125	0.138	0.149	0.395	0.079	0.730	0.098		
Capacity utilization	-0.043	0.061	-0.027	0.112	-0.102	0.089					-0.236	0.032
Industrial prod'n dev from trend (last 20 yrs)	-0.134	0.025	-0.080	0.070	-0.049	0.046	-0.117	0.021				
Credit Market Conditions												
Yield spread (Baa - 10 Year Treasury)	0.261	0.249	0.063	0.290	0.384	0.332	0.437	0.134				
Corporate bond default rate (3-month moving avg	-0.116	0.063	-0.012	0.085	-0.012	0.120						

Notes:
See the Notes to Panel A.

Table 11, continued
Sensitivity of Estimation Results to Sample Period
Panel C: Upgrade from Ba and B to Investment grade

	All Variables						Constrained Backward Selection					
	1981-2002		1981-1997		1986-2002		1981-2002		1981-1997		1986-2002	
	coefficient	std error	coefficient	std error	coefficient	std error	coefficient	std error	coefficient	std error	coefficient	std error
Firm Specific Factors												
Initial rating: Investment grade	0.433	0.114	0.467	0.138	0.484	0.127	0.432	0.114	0.463	0.138	0.480	0.126
Current rating: Ba	1.821	0.128	1.890	0.171	1.762	0.131	1.823	0.128	1.884	0.171	1.759	0.131
Downgraded within last 2 years	-0.044	0.119	0.123	0.146	-0.068	0.130	-0.045	0.119	0.123	0.146	-0.069	0.129
Upgraded within last 2 years	0.317	0.105	0.361	0.132	0.250	0.111	0.316	0.105	0.374	0.131	0.262	0.110
log(years since first rated)	0.321	0.053	0.348	0.064	0.280	0.059	0.321	0.053	0.354	0.064	0.281	0.059
General Macroeconomic Factors												
Long-term interest rate (10-year Treasury)	0.220	0.046	0.210	0.063	0.142	0.094	0.216	0.045	0.226	0.047	-0.028	0.070
Unemployment rate	0.416	0.190	0.220	0.398	0.297	0.193	0.434	0.187	0.252	0.205	0.423	0.140
Inflation	-0.117	0.053	-0.233	0.074	0.199	0.094	-0.098	0.049	-0.288	0.053	-0.012	0.068
S&P 500 return	-0.162	0.043	-0.221	0.064	-0.063	0.052	-0.173	0.041	-0.173	0.056	-0.026	0.050
CFNAI index (3-month moving avg)	0.374	0.176	0.389	0.195	0.037	0.252	0.488	0.133	0.226	0.174	-0.127	0.109
Direction of the Economy												
Real GDP growth	-1.789	0.278	-1.703	0.335	-0.103	0.411	-1.747	0.243	-1.438	0.295		
Change in industrial production	0.509	0.504	1.384	0.637	-1.078	0.655			2.127	0.551		
Change in unemployment rate	0.336	1.705	4.404	2.162	-3.447	2.572			6.563	1.819		
Economic Slack												
Deviation from potential Real GDP	0.308	0.114	0.399	0.132	-0.286	0.174	0.291	0.110	0.340	0.128		
Capacity utilization	-0.190	0.073	-0.205	0.108	-0.326	0.101	-0.201	0.068				
Industrial prod'n dev from trend (last 20 yrs)	0.097	0.031	0.022	0.068	0.227	0.056	0.109	0.027			0.097	0.025
Credit Market Conditions												
Yield spread (Baa - 10 Year Treasury)	-0.593	0.293	-0.824	0.347	-0.556	0.373	-0.708	0.266				
Corporate bond default rate (3-month moving avg	-0.296	0.074	-0.366	0.092	-0.175	0.131	-0.305	0.072	-0.337	0.067		

Notes:

See the Notes to Panel A.