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Corporate bond default risk: A 150-year perspective ☆

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ABSTRACT

We study corporate bond default rates using an extensive new data set spanning the 1866–2008 period. We find that the corporate bond market has repeatedly suffered clustered default events much worse than those experienced during the Great Depression. For example, during the railroad crisis of 1873–1875, total defaults amounted to 36% of the par value of the entire corporate bond market. Using a regime-switching model, we examine the extent to which default rates can be forecast by financial and macroeconomic variables. We find that stock returns, stock return volatility, and changes in GDP are strong predictors of default rates. Surprisingly, however, credit spreads are not. Over the long term, credit spreads are roughly twice as large as default losses, resulting in an average credit risk premium of about 80 basis points. We also find that credit spreads do not adjust in response to realized default rates.

1. Introduction

This paper studies the properties of corporate bond default rates using an extensive new data set covering the 1866–2008 period. This data set is composed of both hand-collected data extracted from historical financial records such as the *Commercial and Financial Chronicle* as well as tabulated data from a variety of sources including the National Bureau of Economic Research (NBER), the Federal Reserve Board, Standard and Poor's, and Moody's Investors Service. In this study, we focus on the value-weighted default rates for U.S. nonfinancial bond issues. Thus, our focus is on "Main Street" rather than "Wall Street." Note that while nonfinancials have historically represented the majority of the bond market, they have generally received less attention in the literature, particularly during the earlier part of the study period.[1]

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[1] For example, there is an extensive literature documenting the failures of banks, securities firms, real estate trusts, and other financials during the Great Depression. These include Goldschmidt (1933), Galbraith (1955), Friedman and Schwartz (1963), Bernanke (1981, 1983), Kindleberger and Aliber (2005), Easley and O'Hara (1979), and many others. In contrast, there are relatively few sources describing failures of nonfinancial firms during this period. We observe, however,

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To provide overall perspective on corporate default rates, we begin with a simple descriptive analysis of the data. The U.S. experienced many severe clustered default events during the study period. The worst event occurred in the 1870s when the railroad boom of the 1860s was followed by a disastrous decade of defaults. During the three-year period from 1873–1875, the annual default rates total to 35.90% of the total par value of the corporate bond market. Several other three-year periods in the study period experience comparable default rates. Surprisingly, the worst three-year period during the Great Depression with default rates totaling to 12.88% barely makes it into the top five credit events for nonfinancials.[2] On average, the annual corporate default rate during the sample period is about 1.50%. Corporate defaults, however, cluster significantly in time and the default rate is very persistent.

A key aspect of this data is that it allows us to examine how default rates are related to financial and macroeconomic variables over a large number of business cycles. In doing this, we use a regime-switching framework since it is clear that the corporate debt markets and incentives of firms to default have undergone major structural changes over the course of 150 years. We find that stock market returns and changes in stock market volatility have significant predictive power for default rates. These results are very consistent with the implications of current financial theory. We also find that changes in gross domestic product (GDP) forecast default rates in the direction expected. On the other hand, other macroeconomic variables such as inflation and the growth rates of consumption and industrial production do not forecast future default rates. Surprisingly, credit spreads do not appear to have much predictive power for subsequent default rates.

We then explore the issue of how the market prices default risk. Applying a 50% loss rate to the average default rate of about 1.50% gives a back-of-the-envelope estimate of average annual credit losses of roughly 75 basis points. We find, however, that credit spreads average about 153 basis points during the sample period. Thus, credit spreads have been approximately twice as large as expected default losses, on average, implying an average premium of about 80 basis points for bearing default risk during the study period. We also use a regression approach to examine whether increases in default rates map into high credit spreads. We find no evidence that credit spreads respond to current default rates. Furthermore, changes in credit spreads are not related to a number of key macroeconomic variables. These counterintuitive results support the view that corporate credit spreads are driven significantly by financial market factors such as illiquidity and risk premia, rather than by fundamentals, consistent with Collin-Dufresne, Goldstein, and Martin (2001), Elton, Gruber, Agrawal, and Mann (2001), Longstaff, Mithal, and Neis (2005), and others.

In summary, this study provides three important results. First, we show that the historical default experience in the United States includes periods much worse than those during the Great Depression. Second, we find that default risk is forecastable on the basis of a number of financial and macroeconomic variables, but not by credit spreads. Third, we show that over the long-run, credit spreads appear to provide investors with a modest premium for bearing credit risk, but do not adjust to current default rates or macroeconomic conditions. These results have many important implications for credit markets.

This paper contributes to the extensive literature on corporate credit risk and bond valuation. Key theoretical work in this area includes Black and Scholes (1973), Merton (1973, 1974), Black and Cox (1976), Leland (1994), Longstaff and Schwartz (1995), Jarrow and Turnbull (1995), Jarrow, Lando, and Turnbull (1997), Duffie and Singleton (1997, 1999), Collin-Dufresne and Goldstein (2001), Goldstein, Ju, and Leland (2001), Duffie and Lando (2001), and others. Important studies focusing on default risk in corporate bonds include Altman (1968, 1989), Shumway (2001), Chava and Jarrow (2004), Duffie, Saita, and Wang (2007), Almeida and Philippon (2007), and Campbell, Hilscher, and Szilagyi (2008). Research addressing the default premium and the properties of corporate credit spreads includes Fons (1987), Sarig and Warga (1989), Kim, Ramaswamy, and Sundaresan (1993), Pedrosa and Roll (1998), Duffee (1999), Collin-Dufresne, Goldstein, and Martin (2001), Elton, Gruber, Agrawal, and Mann (2001), Huang and Huang (2003), Eom, Helwege, and Huang (2004), Longstaff, Mithal, and Neis (2005), Driessen (2005), Berndt, Douglas, Duffie, Ferguson, and Schranz (2005), Jarrow, Lando, and Yu (2005), Davydenko and Strebulaev (2007), Schaefer and Strebulaev (2008), Bharath and Shumway (2008), and many others. This paper contributes to the literature by examining default risk and its relation to credit spreads over a time period significantly longer than in any previous study.

The remainder of this paper is organized as follows. Section 2 describes the data set used and explains how it is constructed. Section 3 explores the properties of the historical corporate default rates. Section 4 studies the determinants of corporate default risk. Section 5 examines how the market prices corporate bond default risk. Section 6 makes concluding remarks. The Appendix provides a detailed description of the data collection process as well as the development of bankruptcy regulation.

2. Data

Our objective is to study the default rates that investors in the U.S. corporate bond markets have experienced historically. Specifically, our focus is on the bonds issued by U.S. firms in the nonfinancial sector. We limit our attention to U.S. corporate bonds since this allows us to

(*footnote continued*)
that most recent corporate and credit risk empirical studies exclude financial and utility industries (for example, see Eom, Helwege, and Huang, 2004).

[2] This is consistent with the evidence given in Friedman and Schwartz (1963) that the actual financial losses incurred by debtholders during the 1930–1933 period were relatively modest as a percentage of total market capitalization. Friedman and Schwartz also observe that "The impairment in the market values of assets held by banks… was the most important source of impairment in capital leading to bank suspensions, rather than the default of specific loans or of specific bond issues." See Friedman and Schwartz, pp. 351–355.

study the relation between default rates and a number of key financial and macroeconomic variables that are only available for the U.S. markets over such a long period. As discussed above, we focus on the nonfinancial sector. The nonfinancial sector has historically represented a much larger fraction of the market for long-term corporate debt than the financial sector. For example, financial issuers represented zero percent of all corporate bond issuers listed in the *Commercial and Financial Chronicle* (CFC) in 1870, 1.2% of all issuers listed in 1900, 6.9% of all issuers listed in 1930, and 1.8% of all issuers listed in 1969. Thus, the tendency of financial firms to raise capital through the bond markets is a relatively recent one from a historical perspective.[3]

In measuring default rates, we focus on the fraction of the total par value of the corporate bond market (the default rate) that enters into financial distress during each year in the sample period. Thus, our approach differs somewhat from that of other surveys such as Moody's (2009) *Corporate Defaults and Recovery Rates, 1920–2008* publication that are based on the fraction of issuers that enter into financial distress each year.[4] By studying the proportion of the total par value of bonds entering into financial distress, our results more closely reflect default rates from the perspective of a representative investor holding the value-weighted portfolio of all corporate bonds. For brevity, we will refer to the nonfinancial value-weighted default rate simply as the default rate throughout the remainder of this paper.[5]

Our sample period begins with 1866 since this is the first full year that the CFC was published. The CFC was the first national business newspaper in the United States. It published extensive lists of the corporate bonds available in the financial markets, including bonds traded on the NYSE, the NYSE Curb Exchange, the Amex, all of the regional exchanges, as well as leading unlisted and inactive bonds.[6] The year 1866, however, is a logical starting point for a number of other reasons. First, 1866 is the first full year following the conclusion of the Civil War, thereby representing something of a regime shift in U.S. history. Second, the 1866–2008 sample period closely parallels the 1857–2008 period covered by the NBER business-cycle-dating committee. Third, by beginning with 1866, we are essentially matching the starting date of the classic study of monetary history in the United States by Friedman and Schwartz (1963) which begins with 1867 (but also provides some discussion of events in earlier periods).

We also collected data from an extensive list of tabulated sources including the three volumes of the Hickman (1953, 1958, 1960) NBER study of corporate bond markets. This study was sponsored by the Works Project Administration and the Federal Deposit Insurance Corporation during the 1940s and 1950s and involved at least several dozen researchers over a number of years. We also obtained data from the NBER-sponsored study by Atkinson (1967), which extended the scope of the Hickman project by several decades. These studies were based on original data obtained from industry sources but were cross-checked with data from sources such as the Securities and Exchange Commission, the Interstate Commerce Commission, and the National Industrial Conference Board.[7] For the latter part of the study period (1970–2008), we also used data provided to us by courtesy of Moody's Default Risk Services and extracted from their extensive data set of corporate market issuers.

In addition, we also use data from the Federal Reserve Board Flow of Funds Accounts of the United States, Standard and Poor's Corporation, the Securities Industry and Financial Markets Association (SIFMA, formerly the Bond Market Association), Macaulay (1938), Homer and Sylla (1991), Carty (1997, 2000), and others.

It is important to emphasize that both the focus of our study and the nature of the data set used differ significantly from those in the well-known surveys of historical corporate default experience published by industry sources such as Moody's Investors Service Inc. and Standard and Poor's Corporation. In particular, we focus on value-weighted default rates [a similar approach is used by Altman (1989)]. In contrast, Moody's (2009) focuses on the percentage of issuers that default. This distinction is an important one, however, since smaller firms tend to default more frequently. Thus, issuer-weighted default rates can be numerically large while not economically large during some periods (including some years during the 1930s). Furthermore, the default rates in this Moody's publication include defaults by global issuers. In particular, as described by Carty and Lieberman (1997), Moody's default rates were elevated by global events such as the German Transfer Moratorium in 1933 introduced by the newly installed Nazi government which restricted 62 German firms from making foreign debt payments. These firms represent a large fraction of the total number of defaulting firms during 1933 in the Moody's sample. Carty and Lieberman also report that similar defaults occurred through payment moratoriums in Austria, Czechoslovakia, Rhodesia, Chile, and Uruguay. In addition, default rates published by industry sources are typically based on rated bonds. In contrast, our default statistics for the 1866–1969 period are based on the broader universe of all reported bonds (rated or unrated). Also, some of the earlier years in the Moody's sample may have less comprehensive coverage, perhaps because relatively few bond issues were rated. For example, Moody's publication implies that there were about 1,240 issuers in their sample in 1939.[8] In contrast, there were 2,486 bond issuers listed in the CFC at the beginning of 1939. Finally, the earliest data on default rates available from Moody's begin

[3] Financial firms, of course, raise outside financing from other sources such as deposits, commercial paper, or the money markets. For a description of growth in the financial sector, see Philippon (2008) and Gandhi and Lustig (2009).

[4] Moody's (2009) publishes some limited data on value-weighted default rates beginning with 1994. See Table 45 in Moody's.

[5] When the data allow, we also calculate equally weighted issue and issuer default rates and use these for a number of robustness checks.

[6] For a description of the history of the CFC and its founder, see Steeples (2002).

[7] Sadly, the original data collected by Hickman and Atkinson seem to have been lost.

[8] This follows from the number of defaults reported in Table 15 and the default percentage reported in Table 36 of the Moody's publication.

with 1920. Thus, our data set extends 54 years further into the past, covering an additional 14 business cycles.

The specific data used in calculating the default rate consist of two time series. The first is the total par value of a snapshot of all nonfinancial corporate bonds included in the historical source at the beginning of each year. The second is the total par amount of the subset of bonds in the annual snapshot entering into financial distress each year. The default rate is simply the ratio of the latter to the former. Note that for a default to be included in the numerator of this ratio, the bond needs to also be included in the denominator. This ensures that the estimated default rate is economically meaningful and bounded between zero and one.

Although we use a variety of data sources, the basic definition of financial distress remains fairly uniform throughout the study. In particular, financial distress includes events such as a firm defaulting on a coupon or principal payment, an initial account of a bondholder committee meeting, entering into receivership, bankruptcy, reorganization, etc. The Appendix provides details about the data sources, and the data collection protocols. In addition, the Appendix describes the definitions of financial distress used in constructing these time series and provides a brief history of bankruptcy law during the study period.[9]

Finally, we note that the liquidity of the corporate bond market during the early part of the study period appears to have been surprisingly good. In particular, the massive capital investments in steam and street railroads, canals, and later utilities in the 19th century were financed mainly by private means. Existing evidence suggests that capital was raised using securities with features that are very similar to modern financial instruments: common and preferred equity, and secured (and later unsecured) coupon-bearing debt. This gave rise to a liquid and active secondary market for railroad and other securities, with corporate bonds actively traded on the NYSE and other exchanges.

The NYSE by the 1860s already resembled its 20th century counterpart in many important respects and was also quick to implement technological novelties. For example, as early as September 1882 the NYSE introduced stock tickers (electric tickers based on Edison's invention). The telephone was installed in 1879 and the electric annunciator board in 1881. These innovations led to a substantial increase in trading volume and liquidity.

Investors, and particularly bond investors, had access to a wide range of reputable sources of information such as the CFC. In addition to the weekly newspaper, subscribers received a monthly bulletin of all the recorded prices on major exchanges and quarterly or semi-annual supplements which listed all the major companies and gave detailed information on securities issued by them. Henry Poor's annual railroad manuals (which included industrial firms as well) contained detailed information about all large companies, including balance sheets, income statements, details on collateral for most bond issues, as well as carefully drawn railroad maps. A sizable industry of financial analysts providing second-hand assessment of the development of financial markets and investment advice developed quickly and was not dissimilar to what we observe today.

3. Corporate default rates

As a first step in the analysis, we begin by providing a long-term historical perspective on corporate default experience in the United States. Table 1 reports summary statistics for the annual default rates for the 1866–2008 period. Fig. 1 plots the time series of these annual default rates.

As shown, the U.S. has experienced many severe default events during the study period. The most dramatic of these was the catastrophic railroad crisis of the 1870s that followed the enormous boom in railroad construction of the 1860s.[10] This railroad crisis lasted an entire decade, and two years during this period had default rates of roughly 15%. In fact, default rates during the three-year 1873–1875 period totaled 35.90%. In contrast, default rates for the worst three-year period during the Great Depression only totaled 12.88% and only rank fourth among the worst three-year default periods during the study period.

From Table 1, the long-run average default rate is 1.517%. Fig. 1, however, shows that the distribution of defaults is far from uniform. Rather, the historical experience is characterized by long periods with relatively few defaults following by episodes of significant clustering of defaults. This is also evident from the variation in summary statistics across the three subperiods, 1866–1899, 1900–1945, and 1946–2008. The result is a distribution of default rates that is highly skewed towards large values. As a result, the median default rate of 0.545% is significantly less than the mean default rate of 1.517%. The standard deviation of default rates is 2.414%. Fig. 2 plots the histogram of annual default rates.

The time series of default rates shows that there is wide variation in the historical experience. The first half of the study period is characterized by a series of severe and prolonged credit episodes. In contrast, the second half of the study period experienced far fewer major credit events. This pattern parallels the well-known evidence that, from 1857 (when the NBER data begin) to today, business cycles have generally become more infrequent and less severe.

These similarities between default events and business cycles motivate examining and contrasting their properties in more depth. Table 2 reports summary statistics for the major default cycles during the study period, where a

[9] There are many excellent financial and economic histories of the United States for the period covered by this study. Examples include Macaulay (1938), Friedman and Schwartz (1963), Snowden (1990), Homer and Sylla (1991), Markham (2001, 2002), and Hughes and Cain (2007). Also see Benmelech (2009) and Benmelech and Moskowitz (2010).

[10] See Benmelech (2009) for an in-depth analysis of the debt maturity of railroads and the marketability of railroad assets during this period.

Table 1
Summary statistics for annual corporate bond default rates from 1866 to 2008.
This table reports the indicated summary statistics for the annual percentage default rates of U.S. nonfinancial corporate bonds for the 1866–2008 period and the indicated subperiods.

Summary statistics	1866–1899	1900–1945	1946–2008	1866–2008
Mean	3.998	1.345	0.304	1.517
Standard deviation	3.571	1.383	0.530	2.414
Skewness	2.012	1.853	3.233	3.307
Kurtosis	4.725	4.127	12.783	14.686
Minimum	0.000	0.107	0.000	0.000
25th Percentile	1.978	0.347	0.009	0.131
Median	3.022	0.903	0.098	0.545
75th Percentile	5.195	1.957	0.380	2.096
Maximum	16.255	6.725	3.071	16.255
Serial correlation	0.388	0.450	0.680	0.628
Number of observations	34	46	63	143

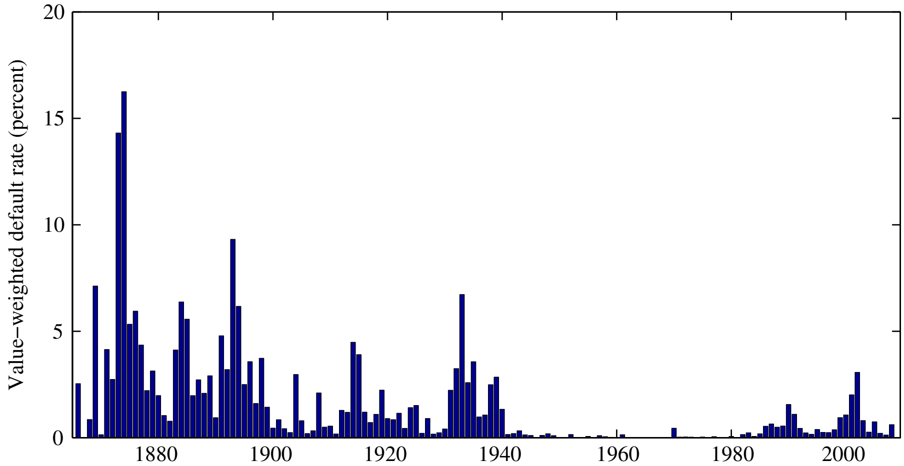

Fig. 1. Historical default rates. This graph plots the annual value-weighted percentage default rates for bonds issued by U.S. domestic nonfinancial firms for the 1866–2008 period.

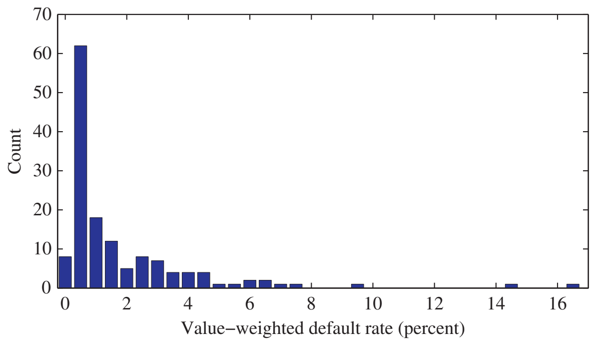

Fig. 2. Histogram of historical default rates. This figure shows the histogram of annual value-weighted percentage default rates for bonds issued by U.S. domestic nonfinancial firms for the 1866–2008 period.

default cycle is defined as a single year or a contiguous period of more than one year during which the default rate each year exceeds the mean rate of 1.517%. Table 2 shows that there were 13 of these default cycles during the study period. In contrast, the NBER identifies 31 distinct recessions during the same period.[11] Thus, while there are only about 40% as many default cycles as recessions, the fact that the economy spends about the same amount of time in both states illustrates the more persistent nature of default cycles. The NBER data imply that the average duration of a recession during the sample period is about 1.5 years. In comparison, the default cycles identified in Table 2 have an average duration of about 3.2 years, which is more than double that for the NBER recessions.

To explore this latter point further, we define an annual dummy variable that takes a value of one if any part of the year includes a recession, and zero otherwise. Similarly, we define an annual dummy variable that takes a value of one if the year is included in a default cycle as identified in Table 2, and zero otherwise. The first-order

[11] While the definition of a default cycle is somewhat arbitrary, it has the consequence that the total number of years identified as belonging to a default cycle (42) is almost precisely equal to the number of recession years (42.4) identified by the NBER during the same period. The results are virtually unchanged if we define default cycles with respect to the mean rate of corresponding subperiods.

Table 2
Default cycles.
This table lists the dates for the default cycles during the 1866–2008 sample period where a default cycle is defined as a contiguous period during which annual default rates exceed the unconditional mean default rate of 1.517%. The annual default rates are the annual percentage default rates of U.S. nonfinancial corporate bonds for the 1866–2008 period. The length of the default cycle is measured in years. Default rates are expressed as percentages.

Date of cycle	Length of cycle	Average default rate	Maximum default rate	Historical background
1866–1866	1	2.54	2.54	Post Civil War adjustment
1869–1869	1	7.13	7.13	Linking of coasts by railroad
1871–1880	10	6.04	16.25	Railroad boom and crash
1883–1889	7	3.68	6.37	Major bank panic of 1884
1891–1898	8	4.36	9.32	Major bank panic of 1893
1904–1904	1	2.97	2.97	Roosevelt, Panama Canal
1908–1908	1	2.10	2.10	Stock market panic
1914–1915	2	4.19	4.48	First World War
1919–1919	1	2.23	2.23	Post First World War adjustment
1931–1935	5	3.67	6.73	Great depression
1938–1939	2	2.67	2.84	Great Depression
1990–1990	1	1.56	1.56	Junk bond defaults
2001–2002	2	2.54	3.07	Dot-com crisis

Table 3
The most-severe three-year default periods.
This table lists the dates for the 12 top three-year default periods during the 1866–2008 sample period. Total default is the sum of the annual default rates during each three-year period, where the annual default rates are the annual percentage default rates of U.S. nonfinancial corporate bonds for the 1866–2008 period. Stock return is the sum of the annual stock market returns for each three-year period. NBER fraction is the proportion of time during each three-year period that the economy was in an NBER-designated business downturn. Default rates are expressed as percentages.

Rank	Period	Total default	Maximum default	Stock return	NBER fraction
1	1873–1875	35.90	16.25	1.50	0.72
2	1892–1894	18.69	9.32	−5.46	0.47
3	1883–1885	16.06	6.38	5.36	0.81
4	1933–1935	12.88	6.73	35.54	0.08
5	1876–1878	12.51	5.94	−1.29	1.00
6	1869–1871	11.41	4.14	10.06	0.50
7	1914–1916	9.59	4.48	15.98	0.33
8	1896–1898	8.91	3.73	18.74	0.50
9	1887–1889	7.71	2.91	5.17	0.36
10	1938–1940	6.67	2.84	7.61	0.17
11	1879–1881	6.16	3.14	26.14	0.08
12	2000–2002	6.15	3.07	−14.40	0.22

serial correlations for these two time series are 0.267 and 0.574, respectively. Thus, while default cycles are less common than business-cycle downturns, they tend to be significantly more persistent.

It is also interesting to observe from Fig. 1 that there are some long-term similarities between changes in bankruptcy law and the average level of defaults. The Appendix discusses that previous to 1898, there was virtually no Federal bankruptcy law. The passage of the U.S. bankruptcy law in 1898 (the Nelson Act) was viewed as very pro-debtor in nature and applied mostly to small establishments. In the absence of bankruptcy law applicable to large corporations, dealing with defaults of corporate bonds during this period gave rise to the concept of equity receivership, which is relatively pro-debtor and similar to contemporary Chapter 11. The Chandler Act of 1938 transferred power in bankruptcy away from managers and towards independent trustees, paving the way for a pro-creditor bankruptcy regime. As a result, managers had fewer incentives to file for bankruptcy under the Chandler Act. The passage of the Bankruptcy Reform Act of 1978 resulted in the pendulum swinging back with the creation of pro-debtor Chapter 11, the reintroduction of debtor-in-possession procedures, etc. Although clearly not a formal test, the long-run patterns of default shown in Fig. 1 are at least broadly consistent with the level of debtor protections provided during the various legal epochs. In particular, low-default rates during 1940–1979 follow substantial penalties imposed on debtors and managers in the Chandler Act, while the so-called junk bond revolution of the 1980s follows the 1978 Act.

As an alternative way of looking at major default events, we tabulate total credit losses over all three-year periods throughout the sample period. Table 3 provides summary statistics for the most significant three-year non-overlapping default events ranked by their severity.[12] As described above, the worst three-year period is the 1873–1875 period in which the default rates total to 35.90%. The 1892–1894 and 1883–1885 periods resulted in total default rates of 18.69% and 16.06%, respectively. The 1933–1935 period during the Great Depression ranks a distant fourth with a total default rate of 12.88%. Thus, while the Great Depression may have been the most severe economic event during the sample period, it is far from being the worst credit event experienced in the corporate bond market. The fifth and sixth worst three-year periods have total default rates very similar to that of the 1933–1935 period. Observe that the 2000–2002 period is the *only* post-World-War-II period in the top 12 three-year periods listed in Table 3.

Table 3 also reports the average stock market return for each of these three-year periods. The annual stock market return time series is given by combining the monthly data for 1802–1929 provided by Schwert (1990) with Center for

[12] The sum over three years can include a few issuers that default more than once. These issuers, however, represent a very small fraction of the total.

Research in Security Prices (CRSP) value-weighted data for the subsequent period (data provided by Ken French). Of the 12 high-default periods, eight have average stock market returns that are below the overall average of 10.33%. The average return over the 12 periods is 8.66%. Given the volatility of stock returns, however, we cannot reject the hypothesis that the average return for the 12 periods is not significantly less than the overall average of 10.33%.

Table 3 also reports the average fraction for each three-year period that the economy is in a downturn based on its NBER business-cycle identification. As shown, the average fractions range from 0.08 to 1.00. Averaging over all 12 periods, the overall average is 0.43. This is slightly higher than the unconditional average over the entire sample period of 0.32. Thus, business cycles and credit cycles are only moderately correlated. For example, the simple correlation between the annual dummy variables for business cycles and default cycles described above is only 0.263.

4. Forecasting default rates

Having nearly 150 years of default rate history for the U.S. corporate markets provides us with a unique opportunity to study the determinants of corporate default risk over a much longer horizon than previously possible. In this section, we examine the extent to which default rates can be forecast using financial and macroeconomic variables.[13] In doing this, we first describe the empirical approach used in the analysis. We then describe the variables used to forecast default rates. Finally, we report the results and discuss their implications.

4.1. The regime-switching model

Although the long time series of default rates provides us with unique insights, it also presents us with a number of challenges. In particular, there have been many changes during the study period in the corporate bond markets and their legal, macroeconomic, regulatory, and capital-markets environments. As examples, consider the major changes that have occurred during the study period in terms of bankruptcy laws and the introduction of structures such as pre-packaged bankruptcies, distressed exchanges, debt-for-equity swaps, and debtor in possession (DIP) financing. In addition, the basic structure of the debt market has evolved to provide firms facing financial distress many more "outside options" via high-yield markets, distress-fund investing, securitizations, etc. In addition, the risk tolerance of the marginal provider of capital in the corporate bond markets may have evolved over time and it is likely that the corporate bond market is now a more credible alternative to accessing debt capital than it was in the 19th century. All of these innovations may have changed the incentives and propensity of firms to default on their debt (since defaults are endogenous outcomes).[14] Thus, it is clear that we cannot simply proceed under the usual economic assumption that "all other things are held fixed" and estimate the usual type of regression specification.

Motivated by these considerations, our approach will be to use a regime-switching framework in studying the determinants of corporate default risk. In particular, we use a three-state Markov-chain regime-switching model in which we examine the marginal effects of a vector of financial and macroeconomic variables in explaining variation in realized default rates. This approach allows us to control for changes in the overall legal/economic/historic environment in three ways. First, by allowing for multiple regimes, the model captures the possibility that the "background" rate of defaults may vary over time. This type of time variation is consistent with the spirit of the above discussion that suggests that changes in the environment may affect the incentives of firms to default and, therefore, that different "background" rates of default could be observed over the course of 150 years. Second, when a major structural change occurs, such as a change in the bankruptcy law or the alternatives available to distressed firms, the change is likely to have effects for years or even decades. Thus, major "tectonic" shifts in the nature of default risk could introduce patterns of persistence in observed default rates. To control for these types of persistent effects, we include the lagged value of the default rate as one of the explanatory variables in the regime-switching model. Finally, major structural changes in the nature of corporate default risk are also likely to be in response to broader changes in the macroeconomic environment. Given this, the analysis will include a number of key macroeconomic variables as controls for the underlying economic forces that may act as catalysts for structural changes in the corporate bond markets. Let D_t denote the default rate for year t. Following Hamilton (2005), the econometric specification of the model is given by

$$D_t = a_t + \sum_{k=1}^{N} b_k X_{k,t-1} + \varepsilon_t, \tag{1}$$

where X_{t-1} is a k-vector of ex ante explanatory variables and the b_k terms are the corresponding slope coefficients. The volatility of the residuals ε_t is denoted by σ. The intercept term a_t follows a three-state Markov chain (taking values a_1, a_2, and a_3) with the transitional probability π_{ij} of moving from state i to state j given by the matrix

$$\begin{bmatrix} \pi_{11} & \pi_{21} & \pi_{31} \\ \pi_{12} & \pi_{22} & \pi_{32} \\ \pi_{13} & \pi_{23} & \pi_{33} \end{bmatrix}. \tag{2}$$

In addition, let ξ_{it} denote the probability (conditional on the data) of being in state i at time t.

[13] A number of academic and practitioner papers have focused on the topic of forecasting default rates. Examples include Fons (1991), Jonsson and Fridson (1996), and Helwege and Kleinman (1997). These papers, however, cover much shorter study periods than that used in this paper.

[14] We are extremely grateful to the referee for raising this issue and discussing many of the ways in which the environment has changed for corporate issuers. Our discussion draws heavily on the referee's insights and comments. We are also grateful to the referee for suggesting the regime-switching approach and the use of macroeconomic variables in providing controls for structural changes in the corporate bond markets during our study period.

Table 4
Summary statistics for the explanatory variables.

This table reports summary statistics for the indicated variables used in the regime-switching model for forecasting realized default rates. The sample consists of 143 annual observations from 1866 to 2008 for the explanatory variables (except for variables with data beginning later than 1866 which have fewer than 143 observations as indicated). Stock return is the annual return on the stock market. Stock return volatility is the annualized volatility of monthly stock market returns. Riskless rate is the average annual government short-term bond rate (either Treasury bonds or high-grade New England municipal bonds). Credit spread is the average annual credit spread for high credit quality bonds. Consumption growth is the annual growth rate in per capita consumption. IP growth is the annual growth rate in industrial production. Inflation rate is the annual percentage change in the price level. GDP growth is the annual percentage change in gross domestic product (gross national product prior to 1929).

Variable	Mean	Standard deviation	Minimum	Median	Maximum	Serial correlation	*N*
Stock return	0.1033	0.1895	−0.4435	0.1066	0.5750	0.0192	143
Stock return volatility	0.1485	0.0802	0.0397	0.1361	0.6276	0.5934	143
Riskless rate	0.0469	0.0209	0.0195	0.0406	0.1288	0.9629	143
Credit spread	0.0060	0.0053	−0.0031	0.0047	0.0211	0.8826	143
Consumption growth	0.0211	0.0357	−0.0946	0.0226	0.1105	−0.0849	117
IP growth	0.0425	0.0954	−0.2694	0.0416	0.4483	0.0441	143
Inflation rate	0.0227	0.0614	−0.1564	0.0229	0.2069	0.3299	137
GDP growth	0.0577	0.0690	−0.2327	0.0602	0.2778	0.3845	117

As discussed in Hamilton (2005), this model can be estimated recursively via maximum likelihood in the following way. First, we specify initial (time zero) values for state probabilities ξ_{i0}. Next, given being in state j at time t, the conditional likelihood function η_{jt} is given by

$$\eta_{jt} = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(\frac{-(D_t - a_{jt} - \sum_{k=1}^{N} b_k X_{k,t-1})^2}{2\sigma^2}\right). \tag{3}$$

Summing over all i and j gives the likelihood function f_t,

$$f_t = \sum_{i=1}^{3}\sum_{j=1}^{3} \pi_{ij}\xi_{i,t-1}\eta_{jt}. \tag{4}$$

The state probabilities are then updated by the recursive expressions

$$\xi_{jt} = \frac{\sum_{i=1}^{3} \pi_{ij}\xi_{i,t-1}\eta_{jt}}{f_t}. \tag{5}$$

Making the usual independent and identically distributed (iid) assumption for the residuals ε_t allows us to define the log likelihood function for the data by summing the log likelihoods for each date. The model can then be estimated using standard maximum likelihood techniques.

4.2. The explanatory variables

Identifying explanatory variables that are available throughout most of the 1866–2008 study period is a challenging task given the lack of data during the early years of the sample. Despite this, we were able to extract a number of financial and macroeconomic time series from the historical record that may be relevant for forecasting default rates. Summary statistics for these variables are given in Table 4.

First, as described above, we include the lagged default rate D_{t-1} as a way of controlling for any unmodeled sources of persistence in default rates. In doing this, the coefficients on the other explanatory variables have a straightforward interpretation as measure of the marginal effect of these variables on the expected default rate.

Second, we include a number of financial market variables in the model. Specifically, we include as explanatory variables the annual stock market return, the annualized stock market return volatility, the yield on riskless government bonds, and the spread between the yield of a high-quality long-term corporate bond index and the yield of riskless government bonds with similar maturities.[15]

The annual stock market returns are obtained from the sources described in Section 3. The annualized stock market return volatility is estimated by computing the volatility of the 12 monthly stock market returns for each year. Yields on government bonds are obtained from data provided by Homer and Sylla (1991) for 1866–1989, and from the Federal Reserve Board's Selected Interest Rates H.15 statistical release for the annual 10-year constant maturity Treasury rate for the 1990–2008 period. Homer and Sylla argue that because government bonds were distorted by gold premiums and liquidity issues, "market yields on governments must be disregarded altogether from 1863 until 1918 as a guide to American long-term interest rates." Accordingly, we use the yields on high-grade New England municipal bonds from 1866–1914, and the yield for the high-grade Bond Buyer municipal bond index from 1915–1918 as proxies for the riskless government yield during these periods.[16] For the 1919–1989 period, we use the average of long-term government bonds provided by Homer and Sylla (which is taken from the Federal Reserve, see the sources listed in Homer and Sylla, Table 50). The data are taken from Homer and Sylla Tables 42, 43, 45, 48, and 51. As a measure of the yield on high-quality corporate bonds for the 1866–1899 period,

[15] Ideally, we would like to include a measure of aggregate corporate leverage in the analysis. Unfortunately, leverage measures for the 19th century are not available. Some very preliminary evidence we collected for one year (1889) suggests that book leverage ratios were actually higher than observed today (on the order of 40–50%) and that there was a substantial cross-sectional variation with some firms having only common equity and many others exhibiting very high leverage ratios.

[16] Shiller (1989) adopts the same approach in identifying historical interest rates. Note that there is no personal tax advantage to municipal bonds at this time because personal income tax was not introduced until 1909.

we use the annual yields on high-grade railroad bonds given in Tables 42 and 43 of Homer and Sylla. For the 1900–1989 period, we use the year-end yields for prime corporate bonds given in Tables 45, 47, and 50 of Homer and Sylla. For the 1990–2008 period, we use the annual Moody's Aaa index as reported by the Federal Reserve Board's H.15 statistical release. A key advantage of using the high-grade railroad and prime corporate bond indexes reported by Homer and Sylla is that they allow us to measure corporate yields annually over more than a century while essentially holding the definition of the index composition fixed.[17]

Third, we include an additional four variables in the model that reflect changes in macroeconomic conditions in the U.S. and are continuously available as far back as the 19th century. Specifically, we include the annual percentage growth rate in per capita real personal consumption, the annual percentage growth rate in industrial production, the annual inflation rate, and the annual percentage growth rate in GDP (Gross National Product (GNP) prior to 1929).

The data for per capita personal consumption and price levels are obtained from Chapter 26 of Shiller (1989).[18] The consumption data are available beginning in 1889. The price level data are available beginning in 1871.[19] The industrial production data are obtained from three sources. Industrial production data for the 1865–1915 period are given in Davis (2004). For the 1916–1920 period, we use the total physical production data provided by the NBER as macroeconomic series a01008a. Data for the 1921–2008 period are obtained from the Federal Reserve Board, Series G17. Kuznets (1961) reports annual gross national product data for the 1885–1929 period. Data on gross domestic product for 1929–2008 are obtained from the Bureau of Economic Analysis National Income and Product Accounts (NIPA) series.[20]

Table 5
Results from the maximum likelihood estimation of the regime-switching model.

This table reports the parameter estimates and their asymptotic *t*-statistics from the maximum likelihood estimation of the regime-switching model used to model realized default rates. The regime-switching model is estimated using the annual percentage default rates of U.S. nonfinancial corporate bonds along with the explanatory variables described in Table 4 for the 1866–2008 period.

Parameter	MLE estimate	*t*-Statistic
a_1	0.00741	6.08
a_2	0.04261	17.25
a_3	0.11137	22.43
π_{11}	0.89526	31.73
π_{12}	0.08865	3.73
π_{13}	0.01609	1.43
π_{21}	0.84799	8.44
π_{22}	0.15201	1.51
π_{23}	0.00000	0.00
π_{31}	0.69561	1.43
π_{32}	0.00001	0.00
π_{33}	0.30438	1.00
Default rate	0.35466	11.54
Stock return	−0.01174	−2.94
Change in volatility	0.02801	2.79
Change in riskless rate	−0.38053	−1.28
Change in credit spread	−0.16387	−1.32
Consumption growth	0.00441	0.54
IP growth	0.01888	1.42
Inflation rate	0.01048	0.39
GDP growth	−0.04582	−3.09
σ	0.00751	16.01
Log likelihood		−436.4811

4.3. Empirical results

Given these explanatory variables, we can now estimate the regime-switching model via maximum likelihood and examine the extent to which these ex ante variables are able to forecast realized default rates. This is done in the following way. First, we specify initial values for the conditional probability function ζ_{1i}, $i=1,2,3$. In particular, we assume that the three states are equally likely. In actuality, however, the results are very insensitive to the choice of initial conditions. Next, we use a genetic search algorithm to maximize the recursively defined log likelihood function, where the maximization is performed over the parameters $\{a_1,a_2,a_3,\pi_{11},\pi_{12},\pi_{13}, \pi_{21},\pi_{22},\pi_{23},\pi_{31},\pi_{32},\pi_{33}, b_1,b_2,\ldots, b_9, \sigma\}$.[21] Given the high dimensionality of the optimization problem, it is important to insure that the algorithm attains the global maximum. To do this, we generate a random vector of starting values for the parameters and then maximize the log likelihood function given these starting values. This process is done repeatedly to provide a robustness check that the algorithm has identified the global maximum.[22]

[17] One referee raised the interesting question of whether the maturity and seasoning of the bond market affected default rates. To address this, we examined the relation between the amount of debt issued during the prior year (as measured by the percentage increase in the notional amount included in the annual snapshot) and the subsequent year's default rates. Intuitively, large increases in the amount of debt outstanding should reflect bond issuance, which, in turn, may proxy for changes in the average age or seasoning of debt. As it turns out, the correlation between the two variables is only 0.0088 and is not significant. Similarly, the correlation between the amount of debt issued during a year and the default rate is only 0.105 and is not significant.

[18] These time series are updated annually and available from http://www.econ.yale.edu/~shiller/data.htm. Olney (1999) argues that credit concerns played a central role in the large decline in personal consumption during the 1930s.

[19] Since there are missing observations for some of the macroeconomic variables during the first part of the sample period, we follow the standard practice of replacing missing observations by their mean in the empirical analysis.

[20] We also examined the relation between corporate default rates and personal bankruptcy rates. Specifically, we obtained the data on personal bankruptcy rates in the U.S. for the 1900–2005 period reported in Garrett (2006, 2007) (data provided courtesy of Thomas Garrett) and updated it through 2008 with data from the Administrator of U.S. Courts. The correlation between default rates and personal bankruptcy rates is only 0.0412 and is not statistically significant. We are grateful to the referee for suggesting this variable.

[21] Note that three of the probabilities are identified by the adding-up constraint since $\pi_{i1}+\pi_{i2}+\pi_{i3}=1$ for $i=1,2,3$.

[22] Since default rates range from zero to one, we also conducted a number of robustness checks verifying that the normality assumption for the residuals is reasonable. In addition, we also checked to make sure

The empirical results are reported in Table 5. As shown, the regime-switching model identifies three distinct regimes for default rates. The first regime is characterized by an annual "background" default rate of 0.741%; the second, an annual default rate of 4.261%; and the third, an annual default rate of 11.137%. All three of the regime parameters a_1, a_2, and a_3 are statistically significant. For convenience, we designate these three regimes as the low-default, mid-default, and high-default regimes. These three regimes are clearly consistent with the historical properties of the default rate illustrated in Fig. 1. These results are also broadly consistent with the default regimes inferred from the market prices of collateralized debt obligation (CDO) tranches in Longstaff and Rajan (2008).

The estimated Markov transition probabilities indicate that the first regime is very persistent. Specifically, for a one-year horizon, the probability of remaining in a low-default regime is 89.526%, while the probability of migrating to the mid-default and high-default regimes are 8.865% and 1.609%, respectively. In contrast, the other two regimes are much less persistent. In particular, the probability of remaining in a mid-default regime is 15.201%, and the probability of remaining in a high-default regime is 30.438%.

To illustrate the long-run implications of the model for the percentage of time spent in each regime, we compute the time series of the conditional probability functions ξ_{it} and report their averages in Table 6. As reported, the average conditional probabilities of being in the low-default, mid-default, and high-default regimes are 88.81%, 9.08%, and 2.11%, respectively. Thus, these results imply that being in the mid-default regime is an event that occurs roughly every decade, on average, while being in the high-default regime occurs about every 50 years, on average. Table 6 also reports the proportion of years in which the most likely regime is identified as the low-default, mid-default, and high-default regimes as 88.73%, 9.16%, and 2.11%, respectively. Similar results are obtained by iterating the Markov transition probability matrix.

Turning to the explanatory variables, Table 5 shows that even after allowing for regime-switching, the default rate is forecastable by its lagged values. Specifically, the coefficient on the lagged default rate is 0.355 with a t-statistic of 11.54. Thus, there is a significant degree of persistence in default rates. As discussed earlier, this persistence may be a result of structural changes in the corporate bond market and its environment; including the lagged default rate as an explanatory variable may control for unmodeled structural changes over the course of the study period.

Table 5 shows that the stock market return has significant forecast power for subsequent default rates. In particular, the coefficient for the lagged stock return is −0.012, indicating that if the stock market return was, say, 50%, then the next year's default rate would be 0.589% lower the subsequent year. The t-statistic for the lagged stock market return is −2.94. Similarly, changes in stock market return volatility are also significant. The coefficient for the change in volatility is 0.028 and has a t-statistic of 2.79. This coefficient implies that an increase in the level of stock market volatility from, say, 10–20%, would map into an increase of 0.28% in the subsequent year's default rate.

Finding that stock market returns and stock market return volatility have significant forecast power for subsequent realized default rates is consistent with current financial theory. For example, consider the extensive literature on structural credit models. This class of models was introduced by the important early series of papers on option pricing theory and its applications including Black and Scholes (1973) and Merton (1973, 1974). Significant extensions of the basic structural credit framework include Black and Cox (1976), Geske (1977), Leland (1994, 2004), Longstaff and Schwartz (1995), Goldstein, Ju, and Leland (2001), Collin-Dufresne and Goldstein (2001), and many others. In this class of models, corporate bonds represent contingent claims on the underlying assets of a firm. By modeling the asset-value dynamics and the events triggering default, contingent-claims valuation technology can be applied to the debt claims of a firm. A common aspect of these types of models is that changes in stock prices and stock return volatility affect corporate default probabilities. Reduced-form models such as those presented in Jarrow and Turnbull (1995), Duffie and Singleton (1997, 1999), Chava and Jarrow (2004), and Duffie, Saita, and Wang (2007) can have similar implications.[23]

The other variable with significant forecast power for realized default rate is the growth rate in the GDP measure. The coefficient estimate of −0.046 implies that a 10% increase in GDP translates into a decline of about 0.46% in the subsequent year's default rate. The t-statistic for this variable is −3.09. This result is consistent with the literature

Table 6
Summary statistics for the estimated regime-switching probabilities.

This table reports the average probability of being in each of the indicated regimes as implied by the maximum likelihood estimation of the regime-switching model. The regime-switching model is estimated using the annual percentage default rates of U.S. nonfinancial corporate bonds along with the explanatory variables described in Table 4 for the 1866–2008 period. Regimes 1, 2, and 3 consist of the years in which the estimated constant of the regime-switching model takes values a_1, a_2, and a_3, respectively, where these parameters are as given in Table 5. The table also reports the estimated fraction of years in which the indicated regime is the most likely state of the economy.

Regime	Average probability	Fraction of years spent in regime
Regime 1	0.8881	0.8873
Regime 2	0.0908	0.0916
Regime 3	0.0211	0.0211

(*footnote continued*)
that the expected fitted values of the regime-switching model are positive. There are only several observations where the expected fitted value is negative, and then only by a few basis points. Thus, using a more complex specification for default rates (such as taking the log transformation) would have little effect on the results. These robustness checks provide support for the specification of the regime-switching model.

[23] One referee raised the issue of whether it might be possible to nest the Merton structural credit framework within our regime-switching model. It is clear that by including stock returns, changes in volatility, and changes in the riskless rate in our specification, we are including the key variables that might appear in a structural model of the overall corporate debt market. Thus, finding that these variables are significant can be viewed as providing support for the general implications of structural credit models such as Merton.

linking credit risk to the broader macroeconomic environment. For example, Fama and French (1993), Dichev (1998), Chava and Jarrow (2004), Vassalou and Xing (2004), Campbell, Hilscher, and Szilagyi (2008), and others consider the extent to which credit risk represents a systematic risk in the macroeconomic environment that is priced in financial markets (see, for example, Bhamra, Kühn, and Strebulaev, 2010a, 2010b). Accounting-based examples include Beaver (1966), Altman (1968), Ohlson (1980), Beaver, McNichols, and Rhie (2005), and others that focus on earnings and accounting ratios (which reflect the sales, expenses, growth, liquidity, etc. of the firm, which in turn derive from the economic and business environment the firm faces) and their ability to forecast defaults.

One particularly striking result is that changes in corporate credit spreads have no forecast power for realized default rates. Specifically, the *t*-statistic for the lagged change in the corporate credit spread is only -1.32. This result parallels and complements the findings in Collin-Dufresne, Goldstein, and Martin (2001) who show that a considerable part of the time variation in credit spreads does not appear to be closely related to the economic fundamentals driving default risk. Our findings suggest that the converse proposition holds: that credit spreads have little explanatory power for default risk. One possible interpretation of these results is that time variation in credit spreads is driven primarily by changes in credit and liquidity risk premia, and only marginally by changes in the actual probability of default.

Finally, we also examined the goodness of fit of the regime-switching model. Specifically, we compute the correlation of the expected fitted value of the model with the realized default rates. The correlation between the two time series is 0.954. In addition, the variance of the residuals σ^2 is only 9.68% as large as the variance of the realized default rates, implying that the model captures 90.32% of the variation in the data. Thus, the regime-switching model is very successful in capturing the variation in realized default rates.

5. How does the market value default risk?

Given these empirical results, a logical next step is to examine whether corporate bonds are priced in a way that is consistent with the properties of realized default rates. In this section, we first study the long-run historical relation between credit spreads and default rates. We then examine how credit spreads are related to changes in current default rates, financial variables, and macroeconomic conditions.

5.1. Default losses and credit spreads

To study the long-run relation between default risk and credit spreads, we use the straightforward approach of simply comparing the long-run average loss rate on corporate bonds with the average credit spread over the same period. Recall that over the entire sample period, the average default rate is about 1.50%. Making the broad-brush assumption that corporate defaults result in a 50% loss on average, a simple back-of-the-envelope computation suggests that average historical default losses during the study period are on the order of 75 basis points per year.[24] This estimate is surprisingly similar to the average credit loss rate of 91.3 basis points for the 1982–2008 period reported in Table 29 of Moody's (2009).[25]

Ideally, we would like to compare the average default loss with the average yield spreads for the bonds in the sample. Note that the credit spread for high-quality bonds used in the regressions in the previous section, although providing a consistent measure of the historical variation in credit spreads, may understate the average spread for all bonds in the annual snapshot (since not all bonds are high-quality). Although we do not have yield data for the individual bonds in the annual snapshot, we approximate the average yield in the following way. For the 1866–1899 period, Macaulay (1938) reports yield data for a sample of long-term high-quality railroad bonds. Since his sample is tilted towards bonds with lower yields (although there is considerable variation in the yields reported), we use the maximum yield for the set of bonds included in his sample each year as the proxy for the value-weighted average yield for all bonds. For the 1900–1918 period, we use the quadrennial information in Table 49 of Hickman (1960) to calculate the weighted-average yield for all the bonds in the market.[26] For the 1919–2008 period, we use the simple average of Moody's Aaa and Baa bond indexes (implicitly assuming that the average bond has a spread midway between these two indexes). As a robustness check for methodology used in obtaining the 1866–1899 estimates, we apply the methodology to Macaulay's data for 1900 and contrast it with that given by using the Hickman data. The resulting estimates for 1900 are very similar, giving average yields of 4.19% and 4.28%, respectively. Similarly, as a robustness check for the use of the average of the Moody's indexes, we contrast this average with the average yield implied by the Hickman data for 1920, 1924, and 1928. The average values of the yields given by the two methodologies over this period are nearly identical. We define the yield spread as the

[24] Hickman's (1960) Table 152 implies that the average recovery rate of defaulted issues during the 1900–1944 period is about 62.5% of par value. Table 26 of Moody's (2009) implies an average recovery rate of 41.4% for the 1982–2008 period. Thus, an assumed 50% recovery rate is broadly consistent with the historical experience.

[25] It is important to acknowledge that assuming a constant loss rate of 50% may not fully capture the economics of credit losses. One reason for this is that loss rates may vary over time as bankruptcy laws change, as the industry composition of the cross-section of issuers evolves, and as the degree of collateralization associated with bond issues varies. In addition, Altman, Brady, Resti, and Sironi (2005) have suggested that default rates are negatively correlated with recovery rates and, therefore, calculating expected loss from the mean values of these two variables could lead to an underestimation. Nevertheless, this assumption should provide a reasonable first approximation.

[26] Because of the quadrennial nature of the data, we cannot use it for purposes of estimating the model in the previous section; the high-quality corporate bond index used in the previous section is much more appropriate for estimating the regime-switching model because of its consistent composition over time. For the purposes of estimating the average value-weighted yield in the market, however, the Hickman data should be more representative of the market.

difference between our measure of corporate yields and the riskless rate proxy.

This time series results in an average corporate yield spread over the 1866–2008 period of 153.3 basis points. Thus, the average yield spread is about 78 basis points higher than our back-of-the-envelope estimate of the historical default losses. This implies that the market appears to incorporate a risk premium of roughly 80 basis points into corporate bond prices. The difference between the mean yield spread of 153.3 and an expected loss rate of 75 basis points is highly statistically significant.

Alternatively, we can estimate the ratio of the expected risk–neutral credit losses to actual credit losses (the ratio of Q- and P-measure expected losses) by dividing the average yield spread of 153.3 basis points by the estimated average credit loss of 75 basis points, giving a value of 2.04. This ratio is often used in the empirical credit literature as a measure of the size of the credit premium (including both the premium for the event of default or jump risk and the premium for changes in the probability that default occurs). For example, Driessen (2005) estimates the ratio of the risk–neutral and actual intensities for a sample of 104 U.S. firms for the 1991–2000 period. He finds that the ratio for AA-rated, A-rated, and BBB-rated firms are 1.83, 2.61, and 2.37, respectively. Similarly, Berndt, Douglas, Duffie, Ferguson, and Schranz (2005) estimate the ratio for a sample of 94 U.S. firms using credit default swap (CDS) spreads and Moody's KMV expected default frequencies for the 2000–2004 period. The mean of their estimated ratios is 2.8; the median of their estimated ratios is 2.0. Thus, our estimated ratio of 2.04 for the 1866–2008 period closely parallels the results in the literature based on much shorter time periods.[27]

It is important to provide a number of caveats in interpreting these results. First, we cannot assert that the corporate credit spreads implied by the data described above match precisely the credit spreads for the specific snapshot of bonds on which our estimates of defaults are based. Second, as discussed previously, the historical government bond yield data in Homer and Sylla (1991) does include data for State rather than Federal bond issues for some periods during the late 19th and early 20th centuries. To the extent that these State issues carry more credit risk than Federal issues, then the estimated credit spreads could slightly underestimate the actual credit spread. Third, we acknowledge that our analysis is done an a pre-tax basis since we look only at pre-tax cash flows. Clearly, the ratio could be different if the numerator and denominator were computed using after-tax cash flows. Despite these caveats, however, these results provide intriguing evidence that the pricing of credit risk by financial markets is remarkably consistent over time. To investigate these results further, there is an urgent need for reliable long-run data on corporate credit pricing.

[27] These results are also consistent with Almeida and Philippon (2007).

Table 7
Results from the regression of credit spread changes on financial and macroeconomic variables.

This table reports the parameter estimates and their Newey-West t-statistics from the regression of annual credit spread changes on contemporaneous values in the indicated variables. Change in default rate represents the change in the annual percentage default rate of U.S. nonfinancial corporate bonds for the 1866–2008 period, and the variables represent the corresponding changes in the explanatory variables described in Table 4.

Variable	Coefficient	t-Statistic
Intercept	0.00008	0.27
Change in default rate	−0.00161	−0.17
Stock return	−0.00292	−2.22
Change in volatility	0.00723	2.04
Change in riskless rate	−0.14680	−2.32
Consumption growth	−0.00189	−0.17
IP growth	0.00078	0.37
Inflation rate	−0.00002	−0.01
GDP growth	0.00483	0.83
Adj. R^2		0.1386

5.2. What drives credit spreads?

The results in Table 5 indicating that changes in credit spreads do not forecast subsequent default rates are very puzzling. Indeed, these results raise the fundamental question that if credit spreads do not contain information about future default rates, then what exactly are they measuring and what drives their values?

To explore this, we examine the relation between changes in credit spreads and contemporaneous changes in default rates and the financial and macroeconomic variables used in the previous section. Specifically, we regress the annual change in the credit spread on the contemporaneous change in the realized default rate, stock market returns, changes in volatility and the riskless rate, and the macroeconomic variables. The regression results are reported in Table 7.

Perhaps the most striking result in Table 7 is that credit spreads are not significantly related to changes in the default rate. This is particularly perplexing since we would expect that increases in the current default rate would imply higher default credit losses in the future given the persistence of default rates. Certainly, an important caveat in interpreting these results is that changes in credit spreads should reflect changes in the expected default rates over the average life of the bonds in the corresponding portfolio. Even ignoring other factors that influence credit spreads, using realized default rates increases the noise of the regression.

In contrast, the financial variables in the regression are all significantly related to credit spreads. The regression coefficient for the stock return is negative in sign, implying the intuitive result that spreads narrow as the stock market rallies. The Newey-West t-statistic for the coefficient is −2.22. The regression coefficient for changes in volatility is positive, indicating that spreads widen in periods of increased stock market uncertainty. This result is consistent with a risk premium interpretation. Changes in the riskless rate are negatively related to changes in credit spreads with a t-statistic of -2.32. This negative relation is consistent with the results in Longstaff and Schwartz (1995) who demonstrate the inverse relation between spreads and the riskless rate in a structural credit framework.

Finally, Table 7 indicates that none of the macroeconomic measures are significantly related to changes in credit spreads. This result is also puzzling unless it is the case that the macroeconomic information relevant for pricing corporate bonds is already impounded into the financial variables included in the regression.

6. Conclusion

We study the nature of corporate bond default risk using an extensive new data set covering the 1866–2008 period. This data set extends by nearly a century the horizon over which corporate bond default risk can be studied (relative to previous academic research in the literature).

A number of important findings emerge from this analysis. We find that the corporate bond markets have suffered many clustered default cycles, and that some of these have been much more severe than those experienced during the Great Depression. Default cycles tend to be less frequent but more persistent than NBER economic downturns. This is perhaps one reason why the correlation between the two types of cycles appears relatively weak.

Second, we explore the determinants of default risk by examining whether a number of key financial and macroeconomic variables are able to forecast default rates. Using a regime-switching framework, we find that stock market returns and stock market return volatility have significant forecast power for default rates. In addition, changes in GDP are strongly related to subsequent default rates. In contrast, inflation and growth rates in consumption and industrial production do not forecast subsequent default rates. These results raise intriguing issues about the relation between the macroeconomy and credit markets that we hope to explore in future research. Surprisingly, changes in credit spreads do not appear to be related to subsequent default rates.

Finally, we consider how the market values credit risk over the long-term. We find that average credit spreads are roughly twice the estimated average default losses on corporate bonds. Thus, the ratio of risk–neutral to actual default losses is roughly two, consistent with a number of recent studies based on shorter sample periods. Furthermore, we find that credit spreads are unrelated to recent default experience in the corporate bond market. This evidence is consistent with recent work by Collin-Dufresne, Goldstein, and Martin (2001) showing that credit spreads are driven by factors difficult to explain by standard credit models.

Appendix A

In measuring the default rate, we focus on the set of corporate bonds that satisfy the following criteria. First, we include only bonds issued by U.S. corporations in the sample. This criterion excludes bonds issued by firms domiciled in other countries. Second, we include only bonds of nonfinancial corporations in the sample. Specifically, bonds for corporations in the banking, securities, real estate, insurance, mortgage, etc. industries are not included in the sample. This criterion also excludes the mortgage bonds that were widely used during the first part of the 20th century to finance major hotels, office buildings, etc. Third, we include only bonds issued by private for-profit corporations; bonds issued by eleemosynary entities such as religious organizations and universities are excluded as are bonds issued by public sector entities such as sovereigns, states, and municipalities. Note, however, that bonds issued by utilities and street railroads are included since these issuers are in the private sector. As described below, a few additional criteria are imposed on the set of corporate bonds included in the sample during several of the subperiods. In each of these cases, however, the same criteria are applied to both the numerator and denominator of the default rate calculation. Thus, these additional restrictions likely have little effect on the estimated default rates.

A.1. Primary data sources

The data for the 1866–1899 period are extracted from the CFC. This weekly newspaper was founded in 1865 and was the first national business newspaper in the United States. During the 1866–1899 period, the CFC published extensive lists of the corporate bonds that were available in the financial markets, including bonds traded on the NYSE, all of the regional exchanges, as well as leading unlisted and inactive bonds. Thus, the listing of bonds in the CFC is far more extensive than simply the bonds actively traded at the major exchanges. In addition to providing listings of issuers and their bonds, the CFC also reported on key news items relating to these issuers and bonds such as missed coupons, defaults, bondholder committees, receiverships, reorganizations, bankruptcies, etc. As far as we can determine, the coverage of these news items appears to have been relatively comprehensive. In particular, the CFC reported news about financial distress not only for the issuers included in the annual snapshot, but also for many much smaller firms as well. Poor's manuals were used to cross-check some of the data obtained from the CFC.

The data for the 1900–1965 period are taken directly from two NBER sources. The first is a three-volume report on an extensive NBER research project during the 1940s and 1950s sponsored by the Works Project Administration and the Federal Deposit Insurance Corporation. This massive project was headed by W. Braddock Hickman and involved the efforts of more than two dozen researchers and research assistants. The stated objectives of the project were, first, to provide basic statistical time series data on corporate bond financing that might be useful to researchers and, second, to analyze and interpret the data. As part of this research, extensive data were collected on both the par amounts of outstanding bonds and bonds entering into default each year. The scope, methodology, and results of this research project are thoroughly documented in Hickman (1953, 1958, 1960). The second source is based on a subsequent NBER project in which

Hickman's study was extended to cover the 1944–1965 period using essentially the same methodology. This research project is extensively documented in Atkinson (1967). The CFC was used to cross-check data for some years in this subperiod.

The data for the 1966–2008 period come from three different sources. The first is data on the par amount of all domestic nonfinancial bonds and is tabulated by the Federal Reserve. These data are based on industry sources and are computed by tabulating the total amount of new corporate bond issuance and extinguishments each year. The second source for this period is again the CFC which is used in identifying firms entering into default during the 1966–1969 period. The third source is a data set provided to us by Moody's covering the 1970–2008 period and is extracted from the data underlying Moody's (2009). Specifically, we extract default amounts for U.S. nonfinancial firms from the larger Moody's data set of bonds for all issuers (including global and financial issuers). The data and methodology used by Moody's in determining these numbers are also described in this publication.

A.2. The annual time series

The annual default rate is computed as the ratio of the annual default amount to the par value of all bonds in the annual snapshot. Recall that the annual snapshot consists of all bonds listed in the historical data source at the beginning of the year. The annual default amount is the total par amount of the subset of bonds that are included in the annual snapshot and whose issuers enter into financial distress during the year.

For the 1866–1877 period, the annual snapshot consists of all bonds included in the first weekly Bond List published by the CFC each year. For several years, this source is missing. In these cases, we use the prior year's snapshot as that year's snapshot. The annual default amounts are obtained by totaling the par amounts of bonds for issuers entering financial distress, where these issuers are identified by reports provided in the CFC.

For the 1878–1899 period, a comprehensive listing of corporate bonds appears in the January supplement to the CFC. The listing of corporate issuers in this supplement is titled *General Quotations of Bonds and Stocks*. The CFC describes this listing as providing quotations for "all securities listed on any Stock Exchange in the United States, and for all leading unlisted and inactive securities for which we are able to obtain reliable prices." In general, the number of issuers in this listing is typically several times as large as the number of issuers with bonds that are actively traded on the NYSE.

Although comprehensive, this listing of bonds does not provide par amounts for the bonds for the 1878–1899 period. Thus, we use the following algorithm in estimating the default rates for this period. First, we count the number of bond issues listed in the supplement at the beginning of each year during this period. An analysis using data for 1876 indicates that there is a very high correlation between the par amount of debt of a corporate issuer and the number of bond issues for that issuer. This high correlation holds since the vast majority of bond issuers during this period are in the railroad industry. Second, for each year, we count the number of bonds included in that year's snapshot that enter into financial distress. To calculate the default rate for these years, we then divide the total number of defaulted bond issues by the total number of bond issues in the supplement. As a robustness check for this methodology, we apply it to several of the years during the 1866–1878 period. We find that this methodology results in estimates of the default rates for these years that are very close to those obtained based on par values.

For the 1900–1943 period, the total par amount of the bonds in the annual snapshot comes from the total par amounts for U.S. nonfinancial firms that appear in Table A-6 of Hickman (1953). As described in Hickman, the scope of his study does not include a 100% tabulation of all corporate bonds. Rather, Hickman tabulates par values for all bond issues with aggregate par amount of $5 million or more (the large issues sample), and then tabulates additional par values for a 10% random sample of the remainder of bonds for which data are available. The par value of the bonds included in the large issues sample, however, represents the overwhelming majority of the estimated total par value of all corporate bonds. Thus, there is little loss of generality from limiting our attention to the large issues sample of bonds that is exhaustively tabulated by Hickman (as opposed to the small issues sample that is only statistically sampled). The total par value of bonds that default each year (and are included in the total value of all bonds at the beginning of the year) is given as the all-industries total in the large issues section of Table 136 of Hickman (1960).

We observe that the Hickman study focuses on straight bonds (single-maturity obligations), and excludes several other categories of bonds such as equipment trust bonds, income bonds, convertible bonds, and serial bonds. As discussed by Hickman, however, these other categories of bonds represent only a small fraction of total par value of bonds in his sample. Since both the total par value of bonds in the snapshot and the par value of defaulted bonds are based on the same categories of bonds, there should be little impact on the estimated default rate as a result of Hickman's focus on straight bonds.

For the 1944–1965 period, the total par value of corporate bonds at the beginning of each year and the total par value of corporate bonds defaulting during the year are provided in Table 21 of Atkinson (1967). As is described in Atkinson, his study closely follows the methodology used in Hickman (1953, 1958, 1960). The key difference between the two studies is that Atkinson broadens his focus to include most categories of corporate bonds (rather than just straight bonds).

As robustness checks for both the Hickman (1953, 1960) and Atkinson (1967) data, we tabulated the total number of bond issuers at the beginning of each year during this period as well as the number of bond issuers entering into financial distress each year using the CFC and a methodology similar to that described above for the 1866–1899 period. The default rates based on issuers were very similar to those obtained using the Hickman and Atkinson data. In addition, we compared the default rates implied by the Hickman and Atkinson data with those reported in Moody's (2009). Even though Moody's results include both foreign issuers and financial issuers, there was generally close agreement between their results and those implied by the Hickman and Atkinson data sets. See Carty and Lieberman (1997) for a discussion of how differences between Hickman's results and those of Moody's can be reconciled. Appendix C of Hickman (1953) also conducts an in-depth comparison of their data with a number of other contemporary sources including the CFC, the *Journal of Commerce*, and estimates provided by the Securities and Exchange Commission, the Interstate Commerce Commission, and the National Industrial Conference Board.

For the 1966–2008 period, the total par value of corporate bonds at the beginning of each year is given from line 7 of Table L.2 Credit Market Debt Owed by Nonfinancial Sectors of the Federal Reserve Board's Flow of Funds Accounts of the United States Z.1 statistical release (see historical statistical releases for earlier data) for the end of the preceding year. As a robustness check, we compared the Federal Reserve data with that of Atkinson for the mid-1960s and found that the two estimates of the total par value of the corporate bonds were very similar. Furthermore, we compared the Federal Reserve estimates with those reported by the Securities Industry and Financial Markets Association (SIFMA) for the 1995–2008 period and found close agreement between the two sources.

In determining the total par value of defaulted bonds for the 1966–2008 period, we used two different sources. For the 1966–1969 period, we again examined the CFC for news reports about firms entering into financial distress. For the 1970–2008 period, we used the data set described above that was provided to us by Moody's and extracted the par amounts of defaulted bonds for domestic nonfinancial issuers.

During the middle to latter part of the 19th century, the corporate bond market consisted primarily of railroad and canal bonds. During this period, however, there were also a number of industrial and financial bond issues in the market. For example, the 1866 CFC lists 138 railroad bond issuers, 14 canal bond issuers, and six industrial bond issuers. The set of industrial bond issuers includes Western Union, three coal and mining firms, and two bridges. Near the end of the 19th century, the corporate bonds included in the sample consisted of railroad bonds, street railroad bonds, gas and other utility bonds, and numerous miscellaneous industrial bonds. After World War I, the corporate bonds were recategorized simply as railroad, utility, and industrial bonds. For detailed descriptions of the composition of the corporate bond market by industry, see Hickman (1953), Atkinson (1967), and Moody's (2009) classifications of corporate bonds.

A.3. The definition of financial distress

To identify the bonds included in the snapshot that enter into financial distress each year, we use the following procedure. For each year from 1866 to 1899, we examined each weekly issue of the CFC. Whenever a news item is reported relating to the financial distress of an issuer, we check whether bonds of that issuer are included in the sample for that year. As is standard in the literature on estimating default rates, a parent firm is assumed to enter financial distress when any of its subsidiaries enter financial distress. Typical reports include such events as missed coupon payments, defaults, bondholder committee meetings, entering into receivership, bankruptcy, reorganization, etc. If the issuer is represented in the sample, then we determine whether the report represents the initial indication of financial distress for that issuer. For example, imagine that an issuer is first reported in 1873 as defaulting on a bond issue. Then subsequent reports of entering into receivership in 1874, of the scheduling of a bondholders committee meeting in 1875, and a bankruptcy or reorganization in 1876 would not be included as initial events of financial distress.

To provide a uniform standard for identifying initial events of financial distress for the 1866–1899 period, we use the following algorithm. If there have been no previous reports of financial distress for the issuer, then the report is viewed as an initial event. If more than five years have elapsed since a previous report for the issuer appeared, then the new report is identified as an initial event, unless the previous report clearly indicates that the firm has exited financial distress (bankruptcy, reorganization, or reaching an accord with the bondholders). For each year, we total the par value of bonds (or the number of bond issues) of distinct issuers entering into financial distress based on this algorithm and use this number as the numerator in determining the percentage of defaults for that year. We follow the same procedure for the 1966–1969 period.

The definition of financial distress used by Hickman is described in Chapter 5 of Hickman (1953). Atkinson (1967) uses a similar definition of financial distress in his extension of Hickman's study. Moody's definition of financial distress is documented in the Appendix to Moody's (2009).

A.4. Bankruptcy law

There are many in-depth reviews of the history of bankruptcy law in the United States including Warren (1935), Tabb (1995), Skeel (2001), and Franks and Sussman (2005). Tabb (1995) explains that U.S. bankruptcy law dates back to the Constitutional Convention of 1787 which empowered Congress to "pass uniform laws on the subject of bankruptcy." Quoting from Tabb: "For over a century after the Constitution, however, the Bankruptcy Clause remained largely unexercised by Congress. During those periods, many states stepped into the void and passed their own bankruptcy legislation. A Federal bankruptcy law was in existence only from 1800 to 1803, from 1841 to 1843, and from 1867 to 1878. Permanent Federal bankruptcy legislation did not go into effect until 1898."

The passage of the Act of 1898 (the Nelson Act) represented the beginning of permanent Federal bankruptcy law. The Act was viewed as ushering in a regime characterized by liberal debtor treatment, although there were many restrictions placed on the ability of corporations to enter voluntary bankruptcy. From 1898 to the passage of the Act of 1938 (the Chandler Act), there were many amendments made to the 1898 Act, typically in an effort to mitigate its extreme pro-debtor nature. It is important to observe, however, that the early part of the 1930s saw the passage of a number of pro-debtor amendments and laws by Congress that favored rehabilitation rather than liquidation of defaulting firms. A number of these amendments were struck down by the Supreme Court, but then reworked and reenacted by Congress in a way that survived judicial review. The Chandler Act represented a major overhaul of the 1898 Act and formalized many of the corporate reorganization mechanisms that had been passed by Congress during the earlier part of the 1930s (such as the railroad reorganization laws of 1933 and 1935).

The Chandler Act effectively transferred power in bankruptcy away from managers and towards independent trustees. As a result, as Skeel (2001) suggests, the 1938 Act discouraged managers of large firms from filing for bankruptcy (under Chapter 10 designed originally for large corporations) if there was any way to avoid it. In later decades, managers used all manner of tricks to file under Chapter 11 (designed originally for small businesses) which left the management intact.

Bankruptcy law in its current form was ushered in through the Bankruptcy Reform Act of 1978. This Act introduced many major changes to the bankruptcy process, combined several of the earlier types of reorganization into a Chapter 11 process, and reintroduced debtor-in-possession procedures and trustees, etc. The most recent major revision to bankruptcy law was the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 which made sweeping changes to the ability of consumers and businesses to file for voluntary bankruptcy.

A.5. Equity receivership

The lack of a Federal bankruptcy law during most of the latter part of the 19th century proved to be a challenge for corporate bondholders since most of the defaults during this period were for railroads, almost all of which (especially the large ones) were interstate. As Tabb (1995) says, “Given the interstate nature of virtually all of the railroads, state remedies were entirely inadequate. The creative solution achieved was to invoke the power of the Federal courts to supervise the restructuring of the railroad. Court-supervised receiverships remained the predominant means of corporate reorganization for about a half century, until Federal reorganization laws were enacted during the Depression. A receivership was commenced when a creditor petitioned the Federal court to exercise its equity jurisdiction to appoint a receiver to take control of the corporate debtor’s assets. The receiver then would be able to continue to run the railroad, while looking for a buyer for the assets. Eventually the assets would be sold in a foreclosure sale, and the creditors would be paid out of the proceeds of the sale. Since the business could be sold as a going concern, a higher price could be realized.”

It is important to stress that various bankruptcy acts sporadically introduced in the 19th century (including the more permanent 1898 Act) were meant mainly for small businesses rather than large corporations. For example, the 1867 Bankruptcy Act assumed that bankrupt corporations would simply be shut down and their assets liquidated. Such an approach did not make sense for railroads, since everyone agreed that it was important to keep the railroads running. By the final decades of the 19th century, the courts had developed a judicial reorganization technique known as equity receivership, which became the basis for modern corporate reorganization. As explained in detail in Skeel (2001), equity receivership was effectively cobbled together by various claimholders and courts from two powers that did have an established common-law pedigree: courts’ equitable authority to appoint receivers and the right of a mortgage holder to foreclose on a mortgaged property if the debtor defaults.

As Skeel further explains, by analogy to current bankruptcy law, appointing a receiver served the same purpose as the automatic stay does now. Several important cases further modified the equity receivership procedure. In one such case, the court approved a “receiver’s certificate” by allowing priority to be given to investors who contributed new funds (because railroads needed financing to cover operating costs). This is similar to the current practice of debtor-in-possession financing in Chapter 11. In the 1884 Wabash receivership, equityholders (led by Jay Gould, a robber baron) filed for receivership themselves before defaulting and were appointed the receivers. Indeed, in a study of 150 receiverships between 1870 and 1898, Swaine (1898) found that insiders were appointed as receivers in 138 of the cases. To give yet another example, in the 1913 case of Northern Pacific v. Boyd, the Supreme Court announced the “fixed principle” that outlined the rights of unsecured creditors and eventually would become bankruptcy’s absolute priority rule.

Importantly, certain industries (such as railroads) were treated differently under the 1938 Chandler Act. In particular, the Act had new railroad provisions (Section 77), which provided for a binding two-thirds vote by classes of creditors and for nationwide jurisdiction but still left the reorganization process itself entirely to the parties themselves.

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