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MEASURING CHANGES IN CORPORATE CREDIT QUALITY

SUMMARY

This study analyzes major trends in corporate credit ratings, using both a rating database spanning 70 years from May 1923 through June 1993, and a corporate bond default database covering 23 years from 1970 through 1992. The direction of rating changes, stability of ratings, lengths of time that ratings are held, and default experience of rated issuers are examined.

The results reveal:

- The credit quality of the universe of long-term rated issuers remained relatively constant over the period from 1950 through 1979. However, it has deteriorated in each year since then. A marked deterioration in the credit quality of short-term issuers also began at the end of the 1970s but has recently reversed.
- A sharp increase in rating activity (the average number of ratings changed or assigned per issuer per year) accompanied the deterioration of credit quality cited above. The data show that average long-term rating activity levels for 1980 - 1992 were 2.5 times as great as for the period from 1950 to 1979. The short-term rating data exhibit a doubling of average rating activity for the 1980 - 1992 period over 1973 - 1979 levels.
- The likelihood of a downgrade within one year is comparable across rating categories. The probability of an upgrade within one year, however, is greater for Baa-and-lower ratings than for ratings above Baa. For time horizons greater than one year, issuers rated Baa have a greater chance of being upgraded than downgraded.
- Ninety-eight percent of letter rating changes are within two categories and 94% of short-term rating changes are within one category of the original rating.
- A strong positive correlation between long-term credit quality and the average length of time that a letter rating is held. The expected lifetime of a Aaa rating is 10 years while that for a B rating is 4 years. Similarly, the expected life of a P-1 rating is 9 years and that of an NP rating is 2 years.
- The likelihood that a rating will change increases with time for Aaa and Aa ratings; it is approximately constant through time for A, Baa, and Ba ratings; and it decreases with time for B and Caa ratings.
- Issuers upgraded to a given rating, except the B level, are no more likely to be subsequently upgraded within one year than are issuers downgraded to that same rating. Conversely, issuers downgraded to a given rating, are more likely to be subsequently downgraded within one year than are issuers upgraded to that same rating.

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Introduction

Moody's credit opinions provide investors with an assessment of an issuer's ability to meet its debt obligations in a timely manner. Ratings are designed to look into the future. However, for many reasons, ranging from the unpredictability of the business cycle to event risk, the future of a rated issuer is not deterministic. As a result, ratings may change.

Changes in credit quality are of obvious interest to investors. In the case of default, investors might lose a substantial portion of their investments. The ability of a structured transaction to meet its contractual payments may be dependent on the credit quality of an underlying pool of corporate issues. Loan indentures may offer a rated entity the opportunity to repay a loan before maturity in the event of an upgrade. In each of the above cases, there is a value to investors in knowing what to expect in terms of the future evolution of issuer credit.

While the credit paths of rated firms are not predetermined, historically they have exhibited patterns. In this study we have compiled a number of statistics that show various aspects of rating changes for some or all of the last 70 years. These statistics should be helpful in analyzing the expected future "credit paths" of rated issuers.

Methodology

The results of this study are drawn from Moody's proprietary database of approximately 4,700 long-term public debt issuers and 2,400 short-term debt issuers. The long-term rating data span the 70-year period from May 1, 1923, through June 22, 1993, while the short term data extends from August 20, 1971, through June 22, 1993.

As with Moody's special reports on long-term public debt defaults, the unit of study is the issuer. In order to keep the focus on changes in corporate credit quality, we have omitted municipal and sovereign issuers. In addition, we have omitted firms whose rated debt consists solely of issues backed by entities which are not members of the issuer's corporate family, since the ratings of such debt would reflect that backing and not the underlying credit risk of the issuing firm.

Because not all members of a corporate family hold the same rating or have their ratings changed at the same time, we count each legal entity separately. To facilitate this, we track an issuer's actual or "implied" senior long-term rating. If the issuer has senior unsecured rated debt, we use that rating as the measure of the issuer's credit quality for as long as such obligations are outstanding. In cases where an issuer does not have senior unsecured debt, we infer what this debt would most probably be rated if it did exist. We derive this "implied" senior rating from actual ratings assigned to an issuer's other rated debt. Fifty-five percent of our observations use actual senior unsecured ratings. Thirty percent are derived from actual subordinated debt ratings by assuming a rating of one letter grade above the subordinated rating (or, following the introduction of numerical modifiers in 1982, one numerical notch above for investment grade and usually two numerical notches for speculative grade). The remaining 15% of observations are derived from actual senior secured debt ratings by reducing those ratings one letter-grade (or, following the introduction of numerical modifiers, one numerical notch).

We have also included data from our long and short-term default studies. In doing so, we replaced downgrades associated with a default (usually to the Ca or C rating) with a "Default" category. Since this effectively eliminates the Ca and C categories, we leave these out completely.

Trends in long-term letter rating changes

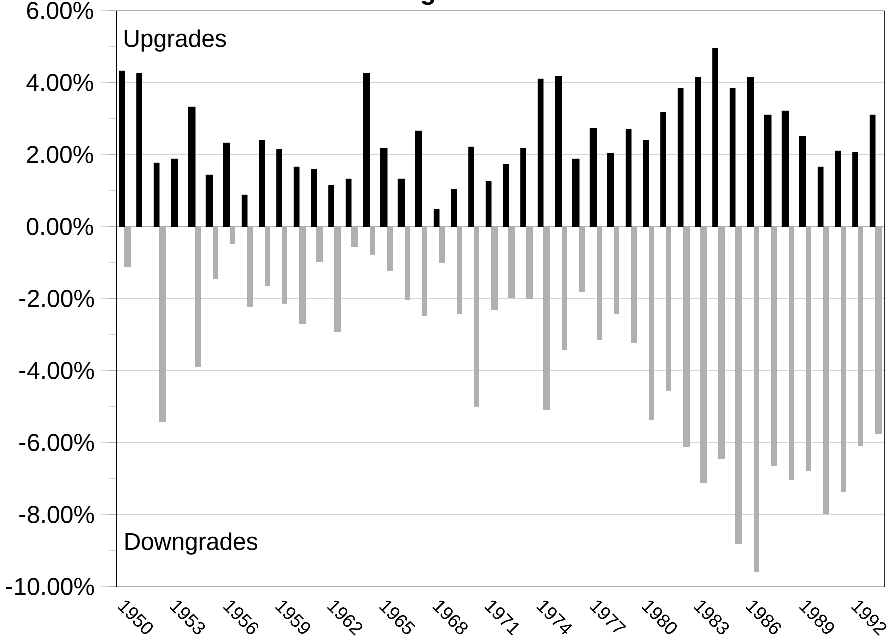
An important indicator of overall trends in corporate credit quality is the percentage of issuers affected by upgrades or downgrades. To calculate the annual percentage of issuers upgraded or downgraded one or more letter rating categories, we use the number of issuers in our database at the beginning of a given year as the denominator. Our numerator is the number of issuers upgraded or downgraded in the course of the year, not counting multiple rating changes for a single issuer. The results are listed in table 1 and graphically displayed in figure 1.

This particular indicator illustrates the prolonged deterioration in overall corporate credit quality that started around 1980. For the thirty-year period covering 1950 to 1979, the average yearly percentage of upgraded companies (2.26%) slightly exceeded the percentage of downgraded companies (2.18%). By contrast, the period from 1980 through 1993 saw the average yearly percentage of issuers upgraded increase to 3.18% while the percentage of issuers downgraded more than tripled to 6.82%[1]. The signifi-

1 1982's figures are straight-line interpolations from 1981 and 1983. We use this interpolation because our algorithm for implying senior ratings artificially inflated the numbers of upgrades and downgrades during our 1982 adoption of numerically modified ratings. For example, an issuer with subordinated debt rated Ba prior to 1982 has a senior implied rating of Baa. If, upon adoption of the modified rating system, this issue comes in at the lower end of the Ba scale, say Ba3, then its senior implied rating is now Ba1. This corresponds to the letter rating Ba. Hence our algorithm has artificially created a downgrade from Baa to Ba even though there has been no rating revision. The actual numbers occurred in nearly the same ratio as those presented here. 1993's figures are annualized from the data available as of 6/22/93.

Figure 1

Annual Percentage of Issuers Affected by Letter-Rating Changes 1950 - 1993[2]



cant increase in the percentage of issuers downgraded during this period is due to a slew of special events and the overall trend towards corporate leveraging. For example, the recession of 1982 proved to be the most severe of the post-W.W. II era. In 1986, sharply lower oil prices prompted large numbers of industrial and financial company downgrades. Finally, concerns about problem loans in the banking system led to numerous downgrades in 1989, just one year before the onset of another recession.

In addition to a deterioration in credit quality during the 1980s, there appears to have been an increase in the level of rating activity. We summarize annual rating activity in this report by computing the sum of all upward and downward letter rating changes and dividing by the number of issuers outstanding at the beginning of the given year.[3] This measurement captures both the effects of multiple rating changes for a single issuer within a given year and the relative size of rating changes. In effect, it shows the pace at which ratings change, based on units of letter ratings changed per issuer. In order to measure the increase or decrease in aggregate credit quality, we propose rating drift. Rating drift is calculated by aggregating the number of upward letter rating changes, less the total number of downward letter rating changes, and dividing this difference by the number of issuers outstanding at the beginning of a given year. Hence, rating drift summarizes the overall increase or decrease in credit quality of the rated universe as a percentage of one letter grade.

Figure 2 portrays the activity and drift data which is also shown in table 1. Consistent with measurements of overall upgrades and downgrades, rating activity and drift held nearly stationary until the early 1980s. Between 1950 and 1980, yearly activity levels averaged 4.77% and drift averaged -0.07%. During this period the aggregate credit quality of Moody's-rated companies remained unchanged as drift was a meager -0.07%, even though one out of twenty issuers (4.77%) saw their ratings change each year, on average. Starting in 1980, however, average yearly activity levels almost tripled to 12.43% while average yearly drift turned decidedly negative to -4.97%. Activity and drift peaked in 1986, at which point Moody's overall rating activity amounted to roughly one-sixth of a letter grade (18.14%) per rated issuer and aggregate credit quality of Moody's-rated companies slipped by nearly one-tenth of a letter grade (-9.11%).

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2 See footnote 1.
3 For example, one issuer rating change from Baa to A represents one letter rating change. One issuer rating change from Baa to Aa represents two letter rating changes.

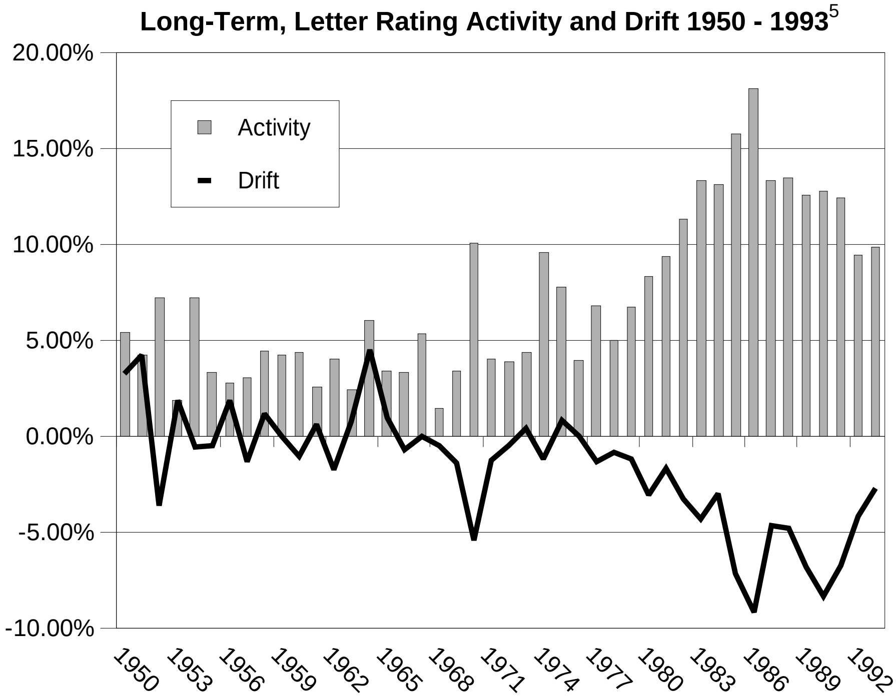
Table 1

Long-Term, Letter Rating Changes by Year 1950 - 1993[4]

	Downgraded Issuers		Upgraded Issuers		Rating	Direction
	Number	Percentage	Number	Percentage	Activity	of Drift
1950	1	1.09%	4	4.35%	5.43%	3.26%
1951	0	0.00%	4	4.26%	4.26%	4.26%
1952	6	5.41%	2	1.80%	7.21%	-3.60%
1953	0	0.00%	3	1.89%	1.89%	1.89%
1954	7	3.89%	6	3.33%	7.22%	-0.56%
1955	3	1.45%	3	1.45%	3.38%	-0.48%
1956	1	0.47%	5	2.35%	2.82%	1.88%
1957	5	2.20%	2	0.88%	3.08%	-1.32%
1958	4	1.61%	6	2.42%	4.44%	1.21%
1959	6	2.14%	6	2.14%	4.29%	0.00%
1960	8	2.69%	5	1.68%	4.38%	-1.01%
1961	3	0.97%	5	1.61%	2.58%	0.65%
1962	10	2.91%	4	1.16%	4.07%	-1.74%
1963	2	0.54%	5	1.36%	2.45%	0.82%
1964	3	0.76%	17	4.28%	6.05%	4.53%
1965	5	1.22%	9	2.20%	3.41%	0.98%
1966	9	2.03%	6	1.35%	3.38%	-0.68%
1967	12	2.48%	13	2.69%	5.37%	0.00%
1968	6	1.01%	3	0.50%	1.51%	-0.50%
1969	16	2.40%	7	1.05%	3.45%	-1.35%
1970	36	4.98%	16	2.21%	10.10%	-5.39%
1971	18	2.27%	10	1.26%	4.04%	-1.26%
1972	17	1.97%	15	1.73%	3.93%	-0.46%
1973	18	1.98%	20	2.20%	4.40%	0.44%
1974	47	5.08%	38	4.10%	9.61%	-1.19%
1975	33	3.39%	41	4.21%	7.80%	0.82%
1976	19	1.81%	20	1.90%	4.00%	0.00%
1977	34	3.12%	30	2.75%	6.80%	-1.29%
1978	27	2.39%	23	2.03%	5.04%	-0.80%
1979	38	3.22%	32	2.71%	6.78%	-1.19%
1980	67	5.37%	30	2.41%	8.34%	-3.05%
1981	61	4.54%	43	3.20%	9.38%	-1.64%
1982	87	6.11%	55	3.86%	11.36%	-3.23%
1983	113	7.11%	66	4.15%	13.34%	-4.28%
1984	110	6.44%	85	4.97%	13.17%	-2.98%
1985	173	8.80%	76	3.87%	15.77%	-7.12%
1986	219	9.60%	95	4.16%	18.14%	-9.11%
1987	178	6.62%	84	3.13%	13.32%	-4.61%
1988	215	7.03%	99	3.24%	13.51%	-4.81%
1989	231	6.78%	86	2.53%	12.57%	-6.81%
1990	297	7.95%	63	1.69%	12.77%	-8.32%
1991	291	7.37%	84	2.13%	12.45%	-6.73%
1992	256	6.08%	87	2.07%	9.45%	-4.18%
1993	258	5.73%	140	3.11%	9.91%	-2.71%

4 See footnote 1.

Figure 2



Trends in long-term modified rating changes

Moody's added numerical modifiers to its letter rating system in 1982. Table 2 lists the number and percentage of issuer upgrades and downgrades (without counting multiple upgrades or downgrades for the same issuer), for each year from 1983 through 1992. It also includes estimates of these numbers for 1993, based on data available as of June 30. We calculate activity and drift measurements just as we did for the letter-rating changes, except that we use changes in numerical notches rather than letter ratings. These figures are also presented in table 2 and graphically displayed in figure 3.

Consistent with the results for broad rating categories, rating drift remained negative throughout this period. The averages for yearly rating activity and drift since 1983 are: 35.5% and -13.3% respectively. These numbers are nearly three times as large as what we report for the letter rating changes for the same period. To understand this difference, two items must be kept in mind. First, the addition of numerical modifiers to the letter rating system increased the number of possible long-term ratings from nine to 19 while leaving the high (Aaa) and low (Caa, Ca, C) ends of the credit scale unchanged. In this way, the middle five letter-rating categories were divided into three times as many numerically modified categories. This finer scale for measuring credit risk necessarily induced a greater number of rating changes per issuer.[6]

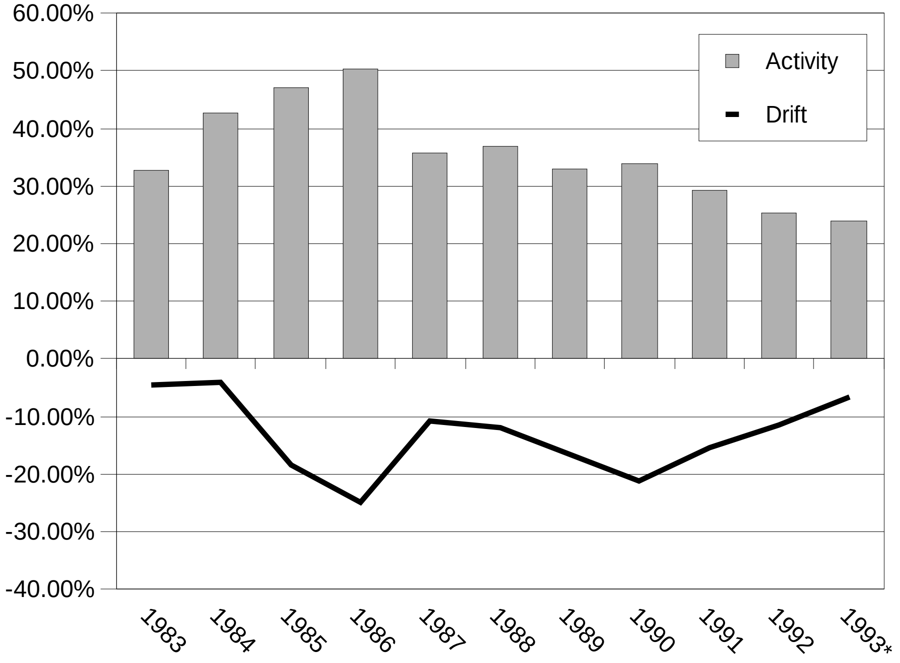
Second, the 1983 - 1993 average yearly activity of 35.5% indicates that the average issuer experienced rating changes amounting to 35.5% of one numerical notch each year. As there are three numerical notches per letter rating (excluding the Aaa and Caa-and-below categories), this measurement is roughly three times that for letter rating activity (13.1%) over the same period.

5 See footnote 1.

6 For example, in the letter rating system, a gradual decline in an hypothetical issuer's credit quality from Aa to A might have been represented by a rating change from Aa to A. If this same scenario were to take place under the modified rating system, the same decline in credit quality might have been signaled through a steady decline from Aa2 to Aa3 to A1 resulting in two modified rating changes in place of 1 letter rating change.

Figure 3

Long-Term, Modified Rating Activity and Drift by Year 1983 - 1993



*1993's numbers are annualized from the data available from 1/1/93 through 6/22/93.

Table 2

Long-Term, Modified Rating Changes by Year 1983 - 1993

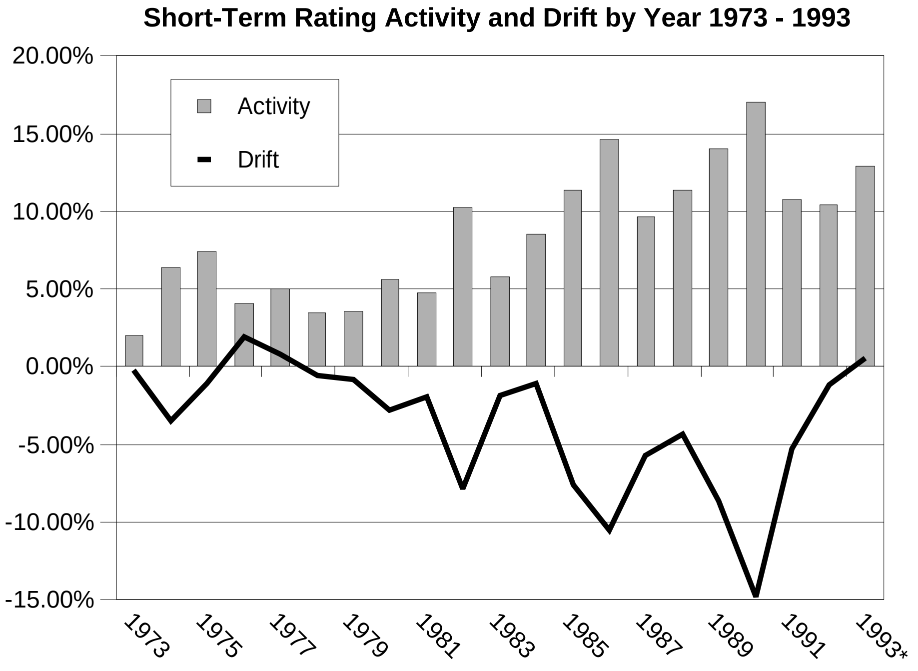
	Upgraded Issuers Number	Upgraded Issuers Percentage	Downgraded Issuers Number	Downgraded Issuers Percentage	Rating Activity	Drift
1983	122	8.91%	148	10.81%	32.65%	-4.60%
1984	191	12.46%	173	11.29%	42.60%	-3.98%
1985	169	9.37%	237	13.14%	47.17%	-18.46%
1986	171	8.02%	345	16.19%	50.40%	-24.96%
1987	159	6.22%	274	10.72%	35.67%	-10.79%
1988	176	6.00%	324	11.04%	36.97%	-11.82%
1989	168	5.12%	337	10.27%	32.97%	-16.51%
1990	138	3.82%	489	13.52%	33.88%	-21.21%
1991	153	3.99%	485	12.65%	29.26%	-15.38%
1992	178	4.33%	451	10.98%	25.27%	-11.54%
1993*	238	5.40%	450	10.21%	23.86%	-6.53%

*1993's numbers are annualized from the data available from 1/1/93 through 6/22/93.

Trends in short-term rating changes

Moody's short-term debt ratings (P-1, P-2, P-3, and NP) are opinions of the ability of issuers to repay punctually senior debt obligations that have an original maturity not exceeding one year. Prime-1 through Prime-3 are investment grade ratings, while Not Prime indicates a below-investment grade opinion. Short-term debt is typically a senior unsecured obligation of a firm. Hence, the implied senior rating adjustment that is sometimes necessary for the long-term calculations is not necessary for short-term rating histories. Table 3 shows the number and percentage of all upgrades and downgrades for issuers with short-term ratings, as well as the activity and drift measurements defined in previous sections. The numerators of the activity and drift ratios are the number of short-term ratings changed in a given year.

Figure 4



*1993's numbers are annualized from the data available from 1/1/93 through 6/22/93.

Table 3

Short-Term Rating Changes by Year 1973 - 1993

	Downgrades		Upgrades		Rating	
	Number	Percentage	Number	Percentage	Activity	Drift
1973	5	1.13%	4	0.90%	2.03%	-0.23%
1974	24	4.92%	7	1.43%	6.35%	-3.48%
1975	18	3.81%	15	3.18%	7.42%	-1.06%
1976	5	1.06%	14	2.98%	4.04%	1.91%
1977	11	2.10%	15	2.87%	4.97%	0.76%
1978	10	1.83%	8	1.47%	3.49%	-0.55%
1979	13	2.19%	8	1.35%	3.54%	-0.84%
1980	29	4.10%	9	1.27%	5.65%	-2.82%
1981	26	3.32%	10	1.28%	4.72%	-1.91%
1982	66	7.98%	10	1.21%	10.28%	-7.86%
1983	30	3.48%	17	1.97%	5.79%	-1.85%
1984	40	4.69%	32	3.76%	8.57%	-1.06%
1985	60	7.04%	16	1.88%	11.38%	-7.63%
1986	93	9.56%	19	1.95%	14.59%	-10.48%
1987	52	5.40%	19	1.97%	9.66%	-5.71%
1988	62	6.42%	32	3.31%	11.39%	-4.35%
1989	85	8.17%	24	2.31%	14.02%	-8.65%
1990	124	11.55%	12	1.12%	17.04%	-14.80%
1991	74	6.96%	26	2.45%	10.72%	-5.27%
1992	59	5.36%	47	4.27%	10.45%	-1.18%
1993*	33	5.68%	35	6.02%	12.91%	0.52%

*1993's numbers are extrapolated from the data available from 1/1/93 through 6/22/93.

It is noteworthy that the drift of the short-term ratings is highly pro-cyclical. Figure 4 shows the downward acceleration in short-term credit quality drift that occurred during the 1973-75 recession, at the slump in the first half of 1980, throughout the 1982 recession, during the slowdown of 1985 and again at the recession of 1990. Accompanying each of these troughs in drift is a spike in activity. The correlation of yearly short-term rating drift with the current year's percentage change in GDP is 42%.

While a firm's long-term health largely determines its ability to pay, liquidity crises can mitigate this ability in the near term. Crises of this type are more prevalent in a slack or contractionary economy. Because liquidity crises have the potential to affect the timely payment of short-term debt, our short-term ratings are especially sensitive to them. The high correlation of short-term rating drift with the growth in GNP reflects this sensitivity.

The pattern of pre-1980 stationarity and post-1980 acceleration of activity, accompanied by an overall deterioration in credit quality, that characterizes the long-term rating data also applies to the short-term rating data. Between 1973 and 1979, rating activity averaged 4.55% of one short-term rating level per rated issuer while rating drift averaged -0.50% of one short-term rating level per rated issuer. After 1979, mean yearly rating activity more than doubled to 10.51% while rating drift turned, on average, to more than ten times its pre-1980 average: -5.22%. Over the entire period, rating activity averaged 8.52% per year and rating drift averaged -3.65% per year.

Magnitude and dispersion of rating changes

Figure 5

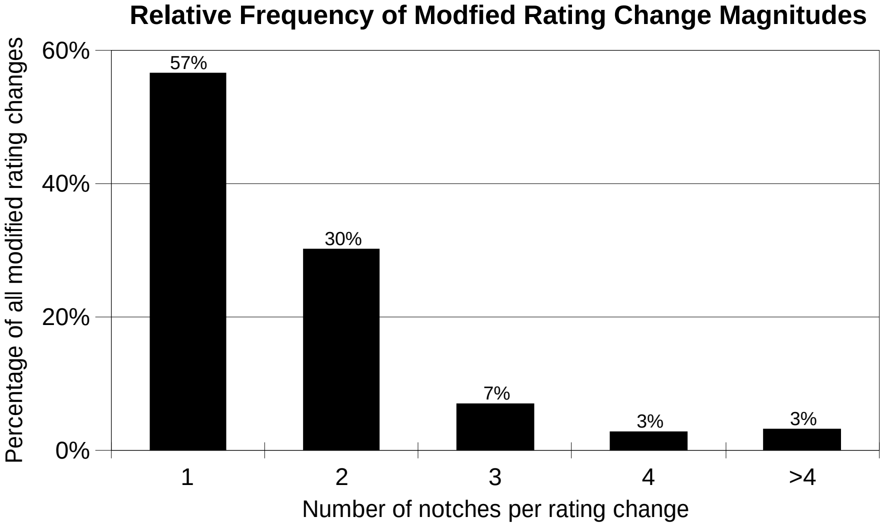
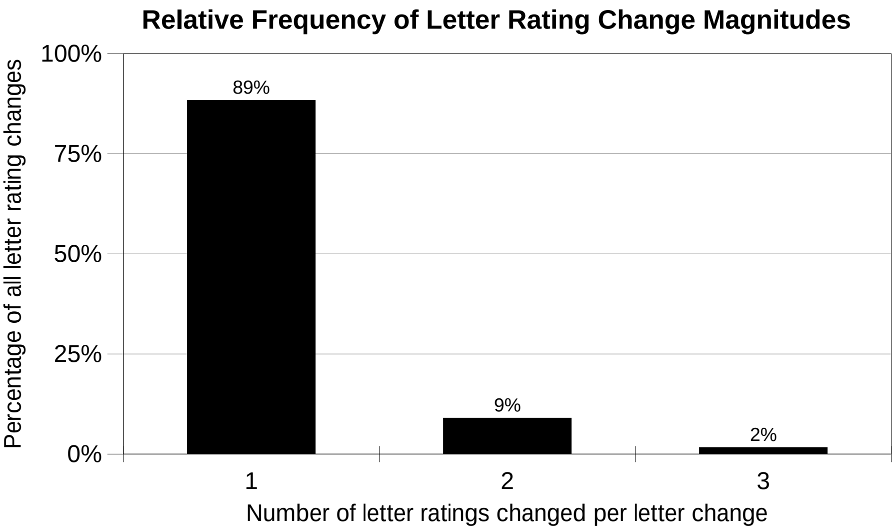
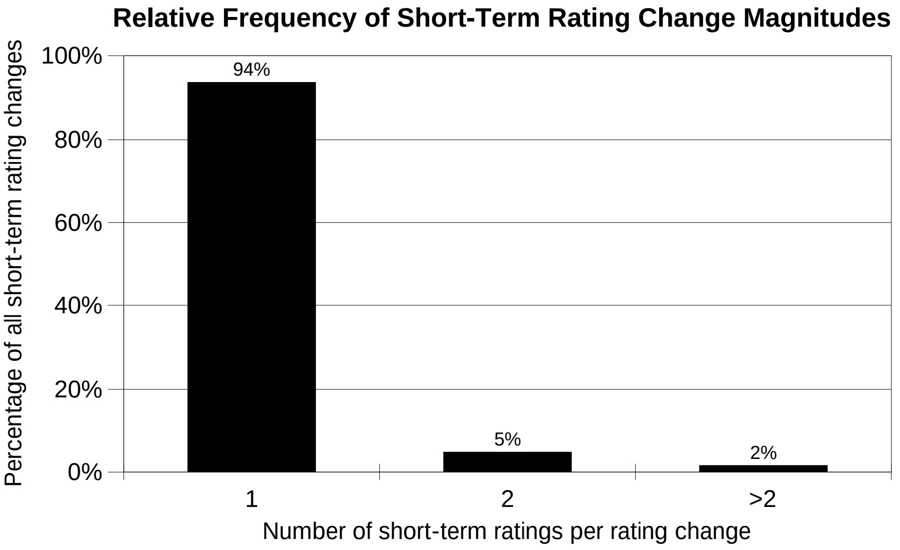


Figure 6



We define the magnitude of a rating change as the number of rating categories that a rating change spans. For example, an upgrade from Ba to Baa spans one letter rating category. A downgrade from Ba

Figure 7



to Caa spans two categories. This same concept applies, in the obvious manner, to both our numerically modified ratings and our short-term ratings. The accompanying charts display the frequency of rating revisions by the magnitude of change for the entire period spanned by our database. As expected, they show that changes of smaller magnitude are relatively more frequent than large rating revisions. Frequent rating changes of several steps or more would indicate that "surprises" in firms' credit developments are relatively common. In fact the charts show just the opposite: Moody's ratings generally anticipate the frequency and severity of unforeseen credit developments by keeping large magnitude rating changes to a minimum. Ninety-four percent of short-term rating changes are of one rating. Ninety-eight percent of long-term letter rating changes are within two ratings and 94% of changes in the more finely sliced modified ratings are within three notches.

These figures illustrate the frequency of rating changes of varying magnitudes in our data base but they do not show how different rating categories change through time. A concise representation of the state of this evolution at a specific point in time is a rating transition matrix. Figures 8 - 11 below depict letter rating transition matrices for one-year, two-year, five-year and 10-year horizons. The rows indicate the rating at the beginning of the specified period. Each column corresponds to a rating, default or withdrawn status as of the end of the period. Each cell entry, excluding the "Default" column, is the weighted average percentage of issuers who held the row rating at the beginning of the time period and the column status at the end of the time period. For example, 2.5% of all A-rated companies, on average, enjoyed a net improvement of one letter rating (to Aa) by the end of any one year period.[7]

Care must be taken when interpreting the percentages under the "Default" heading. Because of the distinct methodology of this study, not all defaulted firms included in Moody's study of long-term bond defaults are included in this effort.[8] Hence, both the numerators and denominators of Moody's default rates have changed for this study. For this reason, these numbers are not directly comparable to those published in our long-term default studies. Also, by their nature, transition matrices estimate the probability of an issuer experiencing a net change from the row rating to the column status at the end of a specified time period. They are calculated by comparing beginning-of-period ratings to end-of-period status. By focusing on just two points in time, they ignore the intervening credit history. Clearly, if the history includes a default where interest and/or principal may be lost, it should be flagged. For this reason, the percentages in the "Default" columns are *cumulative* default rates and are not necessarily based on the actual status of defaulted issuers at the end of the specified periods.[9] That is, for the transition matrix of a specified time period, the figure reported in the "Default" column for a given rating is an es-

7 The increase in credit quality is net since each rating transition matrix is a snapshot of the evolution of the rating profile at a specific point in time. Therefore, they do not address the dynamics of how the hypothetical A-rated issuer arrived at the Aa rating one year later. It may well have been upgraded to Aaa and then downgraded to Aa between the beginning and end of the one-year period.
8 More specifically, as mentioned in the "Methodology" section, we have excluded from this study those "firms whose rated debt consists solely of issues backed by entities who are not members of the issuer's corporate family." Hence, defaulters who fall into this category are excluded from the database as are a number of other issuers.
9 We treat the event of default as a terminal state. For example, a Chapter 11 firm may emerge and so not be in default at the end of the specified time period. We treat the emerged firm as a new entity and keep the original firm in default.

timate of the probability of default *within* the specified time period and not a statement as to the probability of an issuer being in default at the end of the specified time period.

Finally, the "WR" column reports the weighted average percentage of issuers that held the row rating at the beginning of the period and that had their ratings withdrawn at the end of the period. A senior implied rating might be withdrawn for any number of reasons, from retirement of all rated debt to completion of an exchange offer for all rated debt.

To calculate these probabilities, we tracked the senior implied rating and default status of each issuer in our database as of January 1 of each year beginning with 1970. These matrices ignore all pre-1970 rating data in order to incorporate Moody's Default Data which extends back only to 1970.

Figure 8

One-Year Rating Transition Matrix

			Rating To:							
		Aaa	**Aa**	**A**	**Baa**	**Ba**	**B**	**Caa**	**Default**	**WR**
	Aaa	89.6%	7.2%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%
Rating	**Aa**	1.1%	88.8%	6.9%	0.3%	0.2%	0.0%	0.0%	0.0%	2.8%
From:	**A**	0.1%	2.5%	89.0%	5.2%	0.6%	0.2%	0.0%	0.0%	2.5%
	Baa	0.0%	0.2%	5.2%	85.3%	5.3%	0.8%	0.1%	0.1%	3.0%
	Ba	0.0%	0.1%	0.4%	4.7%	80.1%	6.9%	0.4%	1.5%	5.8%
	B	0.0%	0.1%	0.1%	0.5%	5.5%	75.7%	2.0%	8.2%	7.8%
	Caa	0.0%	0.4%	0.4%	0.8%	2.3%	5.4%	62.1%	20.3%	8.4%

Figure 9

Two-Year Rating Transition Matrix

			Rating To:							
		Aaa	**Aa**	**A**	**Baa**	**Ba**	**B**	**Caa**	**Default**	**WR**
	Aaa	80.9%	12.6%	1.6%	0.1%	0.1%	0.0%	0.0%	0.0%	4.6%
Rating	**Aa**	2.2%	78.6%	12.1%	1.1%	0.6%	0.0%	0.0%	0.1%	5.4%
From:	**A**	0.1%	4.9%	79.6%	8.6%	1.5%	0.5%	0.1%	0.1%	4.6%
	Baa	0.1%	0.5%	9.8%	73.3%	8.6%	1.6%	0.2%	0.4%	5.6%
	Ba	0.1%	0.1%	0.8%	8.4%	64.4%	10.5%	0.7%	4.3%	10.7%
	B	0.0%	0.2%	0.2%	1.0%	8.2%	58.6%	2.4%	14.7%	14.6%
	Caa	0.0%	0.4%	0.4%	2.2%	3.1%	8.7%	44.5%	27.1%	13.5%

Figure 10

Five-Year Rating Transition Matrix

			Rating To:							
		Aaa	**Aa**	**A**	**Baa**	**Ba**	**B**	**Caa**	**Default**	**WR**
	Aaa	62.5%	21.8%	4.9%	0.5%	0.7%	0.2%	0.1%	0.2%	9.1%
Rating	**Aa**	5.5%	52.9%	22.3%	3.9%	1.8%	0.5%	0.0%	0.4%	12.7%
From:	**A**	0.3%	9.9%	59.6%	15.0%	3.9%	1.1%	0.2%	0.6%	9.3%
	Baa	0.2%	1.9%	18.8%	49.7%	12.6%	3.2%	0.3%	1.7%	11.6%
	Ba	0.2%	0.5%	3.6%	13.6%	37.4%	12.6%	0.8%	10.1%	21.2%
	B	0.1%	0.1%	0.7%	3.1%	10.3%	31.8%	1.7%	24.6%	27.4%
	Caa	0.0%	0.0%	0.6%	7.6%	5.8%	14.0%	19.9%	35.1%	17.0%

Figure 11

Ten-Year Rating Transition Matrix

		Rating To:								
		Aaa	**Aa**	**A**	**Baa**	**Ba**	**B**	**Caa**	**Default**	**WR**
	Aaa	47.1%	31.5%	8.8%	3.6%	1.7%	0.2%	0.1%	1.0%	6.0%
Rating	**Aa**	8.4%	33.6%	30.6%	9.6%	3.3%	0.8%	0.2%	1.3%	12.1%
From:	**A**	0.6%	14.8%	43.0%	17.9%	5.9%	2.5%	0.4%	1.1%	13.9%
	Baa	0.3%	4.7%	26.4%	29.9%	13.2%	4.2%	0.4%	4.0%	17.0%
	Ba	0.4%	1.7%	10.0%	18.6%	19.8%	10.4%	0.6%	13.9%	24.6%
	B	0.8%	0.0%	4.9%	6.1%	11.6%	16.5%	0.4%	30.2%	28.5%
	Caa	0.0%	0.7%	4.3%	14.5%	6.8%	8.5%	8.5%	48.7%	8.5%

Note that the values along the diagonals of these matrices are the probabilities of an issuer having the same rating at the end of the specified time period as it had at the beginning. As the time period spanned by the transition matrices expands, the higher quality ratings have a higher likelihood of remaining unchanged than their lower quality counterparts. This relative stability is discussed in the "Distributional Aspects of Rating Changes" section below. Considering any one of these matrices, one sees that for the Aa and A ratings, the frequency of net downgrades exceeds that of net upgrades. For any of the given time horizons, it is more likely for an issuer starting with one of these ratings to have a lower rating at the end of the period than a higher rating. For issuers rated Baa, however, this bias ends. Within a one-year horizon, Baa-rated issuers are about as likely to be rated above Baa as below. Moreover, as the time horizon expands, Baa-rated issuers are more likely to have a higher rating than lower until, after ten years, there is almost two times as great a chance of having a single-A rating (26.4%) as there is of having a Ba rating (13.3%). Continuing down the credit spectrum, there is a greater chance of a B-rated issuer enjoying a net upgrade than there is for a Ba-rated issuer. Caa-rated issuers, however, tend to be too weak to make the uphill climb and tend to fall into default.

Figures 12 - 14 are rating transition matrices for the modified rating categories and Figures 15 - 17 show the same for short-term ratings. The patterns in the modified rating transition matrix are roughly similar to those of the letter rating transition matrix. The salient characteristic of the short-term rating transition matrices is the lack of staying power for the P-3 and NP ratings. Within just two years, on average, 83% of P-3-rated issuers changed ratings and 40% were to the "Withdrawn Rating" status. For more on this topic see figure 22 and the accompanying discussion.

Figure 12

One-Year Rating Transition Matrix

		Rating To :																	
		Aaa	Aa1	Aa2	Aa3	A1	A2	A3	Baa1	Baa2	Baa3	Ba1	Ba2	Ba3	B1	B2	B3	Caa	D	WR
	Aaa	87.0%	5.7%	2.7%	0.2%	0.2%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.1%
	Aa1	0.9%	88.2%	3.1%	3.5%	0.9%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.8%
Rating	Aa2	1.0%	2.6%	73.9%	9.3%	6.2%	1.6%	0.9%	0.2%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	4.2%
From :	Aa3	0.1%	1.0%	2.3%	77.3%	9.3%	4.1%	1.1%	0.2%	0.2%	0.2%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	3.9%
	A1	0.1%	0.2%	0.9%	4.4%	76.8%	7.6%	2.8%	1.1%	0.3%	0.3%	0.4%	0.5%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	4.4%
	A2	0.0%	0.1%	0.2%	0.8%	5.0%	76.6%	7.3%	3.7%	1.2%	0.4%	0.3%	0.2%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	3.8%
	A3	0.0%	0.1%	0.1%	0.3%	1.4%	8.2%	71.0%	6.8%	4.2%	1.7%	0.6%	0.3%	0.4%	0.6%	0.1%	0.0%	0.0%	0.0%	4.4%
	Baa1	0.0%	0.1%	0.1%	0.1%	0.2%	2.9%	7.0%	68.4%	9.3%	3.7%	1.1%	0.6%	0.6%	1.0%	0.0%	0.0%	0.1%	0.1%	4.9%
	Baa2	0.0%	0.2%	0.2%	0.2%	0.2%	1.0%	3.6%	7.6%	67.3%	8.4%	2.6%	0.5%	1.0%	0.9%	0.3%	0.3%	0.2%	0.0%	5.7%
	Baa3	0.0%	0.0%	0.0%	0.0%	0.2%	0.5%	0.4%	4.9%	9.6%	61.5%	7.9%	3.1%	2.4%	1.2%	0.3%	0.1%	0.1%	0.5%	7.2%
	Ba1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.7%	3.0%	5.7%	67.4%	4.2%	4.3%	2.4%	0.3%	1.1%	0.2%	1.0%	8.7%
	Ba2	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.4%	1.9%	5.8%	66.7%	6.5%	5.3%	0.7%	1.4%	0.3%	0.9%	9.9%
	Ba3	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.3%	0.1%	0.8%	2.3%	3.0%	70.0%	6.8%	1.0%	3.3%	0.8%	3.0%	8.4%
	B1	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%	0.0%	0.1%	0.4%	0.2%	2.3%	4.1%	68.4%	1.1%	6.2%	0.9%	6.3%	9.5%
	B2	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.4%	0.0%	0.0%	0.4%	1.7%	3.0%	6.0%	62.5%	6.9%	5.6%	5.2%	7.8%
	B3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.3%	0.3%	1.5%	4.1%	1.3%	64.7%	3.9%	15.2%	8.5%
	Caa	0.0%	0.0%	0.0%	0.6%	0.6%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.6%	1.2%	1.2%	1.2%	1.9%	55.9%	21.1%	14.9%

Figure 13

Two-Year Rating Transition Matrix

		Rating To :																		
		Aaa	**Aa1**	**Aa2**	**Aa3**	**A1**	**A2**	**A3**	**Baa1**	**Baa2**	**Baa3**	**Ba1**	**Ba2**	**Ba3**	**B1**	**B2**	**B3**	**Caa**	**D**	**WR**
	Aaa	79.8%	8.1%	2.1%	0.8%	0.3%	0.6%	0.0%	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0%
	Aa1	2.1%	78.4%	4.7%	3.7%	2.6%	1.1%	0.3%	0.2%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%
Rating	**Aa2**	1.8%	6.1%	55.7%	12.8%	9.6%	4.6%	1.2%	0.8%	0.2%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	6.7%
From :	**Aa3**	0.3%	1.0%	4.3%	62.0%	12.9%	6.1%	2.4%	1.1%	0.3%	0.4%	0.3%	0.3%	0.5%	0.1%	0.0%	0.0%	0.0%	0.3%	7.6%
	A1	0.2%	0.4%	2.1%	8.9%	59.8%	10.9%	4.7%	1.4%	1.0%	0.6%	0.4%	0.8%	0.7%	0.8%	0.1%	0.1%	0.1%	0.1%	7.0%
	A2	0.1%	0.2%	0.2%	2.0%	8.3%	59.2%	10.4%	5.3%	2.5%	1.1%	0.9%	0.6%	0.6%	0.6%	0.3%	0.0%	0.1%	0.1%	7.4%
	A3	0.0%	0.2%	0.2%	0.9%	3.6%	12.8%	49.5%	9.8%	6.5%	3.9%	1.4%	0.2%	1.5%	0.6%	0.1%	0.2%	0.0%	0.3%	8.2%
	Baa1	0.0%	0.1%	0.3%	0.4%	0.8%	6.1%	9.1%	48.4%	12.0%	6.3%	2.5%	0.8%	2.0%	1.5%	0.1%	0.2%	0.1%	0.3%	8.9%
	Baa2	0.1%	0.5%	0.2%	0.6%	1.1%	2.4%	7.8%	9.1%	43.8%	10.3%	5.0%	1.1%	1.9%	1.8%	0.7%	0.9%	0.0%	0.3%	12.2%
	Baa3	0.0%	0.0%	0.1%	0.0%	0.1%	1.2%	2.1%	9.2%	14.3%	37.7%	8.0%	4.0%	2.6%	2.9%	1.1%	0.4%	0.4%	1.5%	14.3%
	Ba1	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	1.5%	1.2%	6.0%	7.8%	43.9%	5.8%	5.9%	3.4%	1.0%	2.0%	0.6%	3.2%	17.2%
	Ba2	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.5%	1.4%	3.0%	8.8%	43.3%	7.7%	9.2%	0.4%	2.3%	0.7%	4.6%	17.5%
	Ba3	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.7%	0.1%	0.8%	3.9%	4.2%	50.4%	9.1%	0.8%	5.6%	1.2%	7.9%	14.7%
	B1	0.0%	0.0%	0.1%	0.2%	0.2%	0.0%	0.1%	0.2%	0.1%	1.0%	0.5%	2.9%	4.2%	50.0%	1.7%	8.2%	1.3%	13.2%	16.3%
	B2	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.6%	0.0%	0.0%	0.6%	2.2%	7.2%	5.6%	38.9%	10.6%	6.1%	11.7%	16.1%
	B3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	1.0%	0.4%	2.8%	6.0%	1.8%	46.0%	4.6%	20.1%	17.1%
	Caa	0.0%	0.0%	0.0%	1.0%	1.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	2.1%	2.1%	1.0%	2.1%	35.1%	26.8%	27.8%

Figure 14

Five-Year Rating Transition Matrix

Rating From :	Rating To : Aaa	Aa1	Aa2	Aa3	A1	A2	A3	Baa1	Baa2	Baa3	Ba1	Ba2	Ba3	B1	B2	B3	Caa	D	WR
Aaa	51.9%	10.8%	6.1%	4.0%	1.9%	1.5%	0.2%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%	0.0%	0.4%	22.1%
Aa1	4.9%	44.8%	6.3%	8.3%	5.7%	3.8%	2.4%	2.5%	1.1%	0.2%	0.2%	0.5%	0.2%	0.0%	0.0%	0.0%	0.0%	0.3%	19.0%
Aa2	3.0%	6.3%	23.6%	14.5%	12.6%	8.5%	4.7%	3.3%	1.1%	1.7%	0.5%	0.6%	0.6%	0.0%	0.0%	0.0%	0.2%	0.6%	18.2%
Aa3	1.3%	1.7%	6.9%	30.8%	14.1%	11.4%	5.3%	2.8%	0.9%	0.9%	0.5%	0.5%	0.5%	0.9%	0.0%	0.0%	0.1%	0.9%	20.5%
A1	0.8%	0.6%	2.2%	13.3%	33.0%	13.2%	6.2%	4.5%	2.1%	1.9%	1.2%	0.0%	0.9%	1.2%	0.4%	0.2%	0.5%	1.8%	15.9%
A2	0.0%	0.2%	0.1%	2.9%	10.6%	31.9%	12.6%	7.4%	5.5%	3.4%	1.8%	1.1%	1.7%	1.0%	0.4%	0.1%	0.3%	1.0%	18.1%
A3	0.0%	0.2%	0.3%	2.7%	5.2%	14.1%	22.1%	9.1%	8.9%	6.0%	3.2%	1.8%	4.0%	1.8%	0.0%	0.1%	0.0%	1.0%	19.4%
Baa1	0.0%	0.2%	0.9%	1.1%	2.2%	6.9%	12.3%	22.7%	11.5%	5.5%	2.5%	1.5%	3.2%	2.6%	0.9%	0.6%	0.2%	2.0%	23.2%
Baa2	0.6%	1.0%	0.3%	0.8%	1.3%	5.0%	8.1%	9.1%	20.6%	9.1%	3.8%	1.6%	2.6%	2.6%	1.1%	0.8%	0.8%	1.6%	29.2%
Baa3	0.5%	0.0%	0.0%	0.2%	0.5%	3.1%	4.4%	10.1%	14.1%	12.6%	6.8%	4.6%	2.6%	3.5%	0.4%	0.7%	0.0%	5.7%	30.3%
Ba1	0.0%	0.0%	0.1%	0.0%	0.3%	1.2%	2.3%	3.6%	8.5%	7.9%	14.0%	3.5%	6.5%	5.3%	1.0%	2.3%	1.2%	7.4%	34.8%
Ba2	0.0%	0.0%	0.4%	0.0%	0.0%	0.6%	1.4%	0.4%	2.0%	2.9%	7.3%	14.9%	5.3%	8.3%	0.2%	4.1%	0.6%	11.6%	40.1%
Ba3	0.0%	0.2%	0.0%	0.0%	0.0%	0.1%	0.3%	0.4%	0.4%	1.5%	3.0%	4.7%	19.1%	6.4%	0.7%	6.7%	1.0%	19.3%	36.1%
B1	0.0%	0.0%	0.0%	0.1%	0.3%	0.1%	0.5%	0.3%	0.4%	1.1%	1.5%	3.0%	2.8%	20.3%	1.7%	6.4%	1.1%	27.1%	33.3%
B2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	1.0%	3.0%	4.0%	12.9%	12.9%	8.9%	4.0%	21.8%	30.7%
B3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.3%	0.3%	1.2%	0.0%	0.9%	3.6%	5.7%	0.9%	15.9%	3.9%	26.4%	40.2%
Caa	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.2%	6.5%	3.2%	0.0%	19.4%	25.8%	41.9%

Figure 15

One-Year Rating Transition Matrix

		Rating To: P-1	P-2	P-3	NP	Default	WR
Rating From:	**P-1**	89.9%	3.8%	0.2%	0.3%	0.0%	5.7%
	P-2	5.7%	80.0%	4.0%	1.2%	0.0%	9.1%
	P-3	0.5%	13.0%	49.5%	12.0%	0.2%	24.8%
	NP	0.9%	1.9%	6.3%	63.0%	0.0%	27.8%

Figure 16

Two-Year Rating Transition Matrix

		Rating To: P-1	P-2	P-3	NP	Default	WR
Rating From:	**P-1**	80.5%	6.4%	0.7%	0.7%	0.0%	11.8%
	P-2	10.0%	64.9%	4.6%	2.0%	0.0%	18.4%
	P-3	1.5%	21.6%	26.7%	9.9%	0.3%	39.9%
	NP	1.3%	4.7%	7.8%	39.2%	0.0%	47.0%

Figure 17

Five-Year Rating Transition Matrix[10]

		Rating To: P-1	P-2	P-3	NP	Default	WR
Rating From:	**P-1**	61.0%	10.1%	1.4%	0.9%	0.0%	26.6%
	P-2	17.3%	39.7%	4.0%	1.4%	0.0%	37.6%
	P-3	5.0%	23.9%	5.8%	2.7%	0.0%	62.5%
	NP	9.8%	7.8%	3.9%	13.7%	0.0%	64.7%

Distributional aspects of rating lives

The concept of the "average length of time" that an issuer holds a senior rating is difficult to approach. There is no fundamental law stating that an issuer's credit rating has to change over time, but experience shows that the *majority* of firms do experience a change sooner or later. So how does one measure the average length of time that a rating is held? One way to arrive at a lower bound is to calculate the average time a rating is held *given that it subsequently changes*. To calculate this, one could take the simple average across issuers of time spans that a particular rating was maintained before the impending change. This estimate is obviously biased downward since, by definition, it eliminates those issuers who did not undergo rating revisions and whose inclusion would therefore increase the "average." In order to address this bias, and examine rating lives more fully, we introduce a statistical model.[11] Appendix I covers the details of the estimation of this model.

By plotting the distributions of historical rating life spans, we found that a Weibull distribution most closely models the life span characteristics of bond ratings.[12] The Weibull distribution is a generalization of the exponential distribution and is commonly used for modeling "lifetime" data.[13] Maximum likelihood techniques are available to provide estimates of the distribution's parameters (listed in table 4) for each long- and short-term rating category. The estimated probability distributions are then used to estimate the mean lifetime of each rating category. For example, Figures 18, 19, and 20 show that higher ratings are relatively more stable as reflected by their longer average "lives."

10 The zero in the (P-3, Default) entry for this matrix is due to the fact that a five-year rating transition matrix can only use data generated before 1988 (in order to have 5 years of data to examine). This eliminated some short-term defaulters.
11 The bias is due to what is called Type I censoring.
12 A random variable, t, has the Weibull distribution if it has a probability density function of the form: $w(t;a,b) = \left(\frac{b}{a}\right)\left(\frac{t}{a}\right)^{b-1} e^{-\left(t/a\right)^b}$, where *a* is a scale parameter and *b* is a shape parameter.
13 They are equivalent if *b*=1.

Figure 18

Average Length of Letter Rating Lives

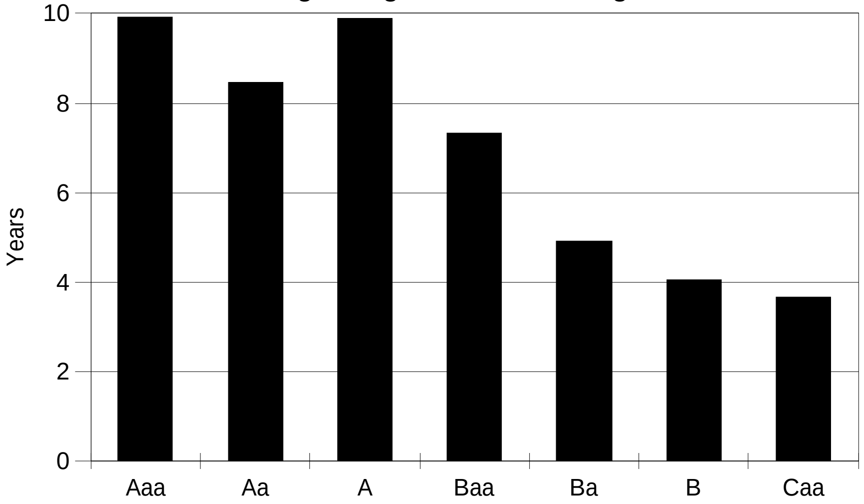


Figure 19

Average Length of Modified Rating Lives

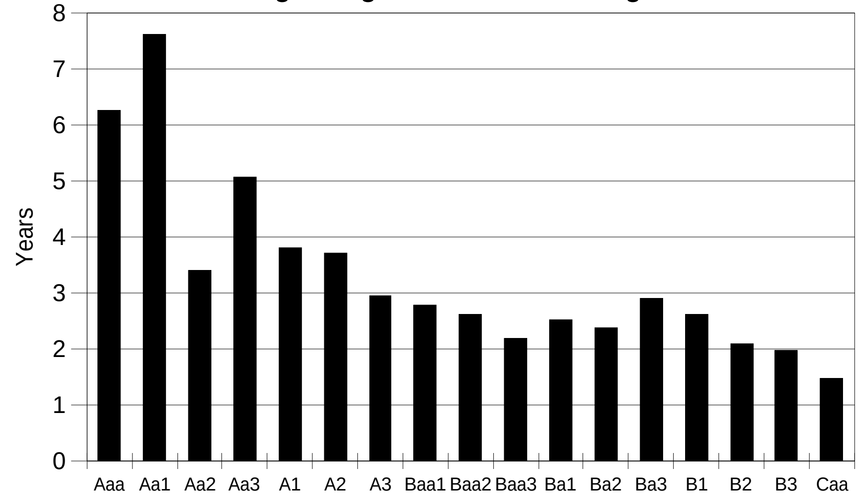


Figure 20

Average Length of Short-Term Rating Lives

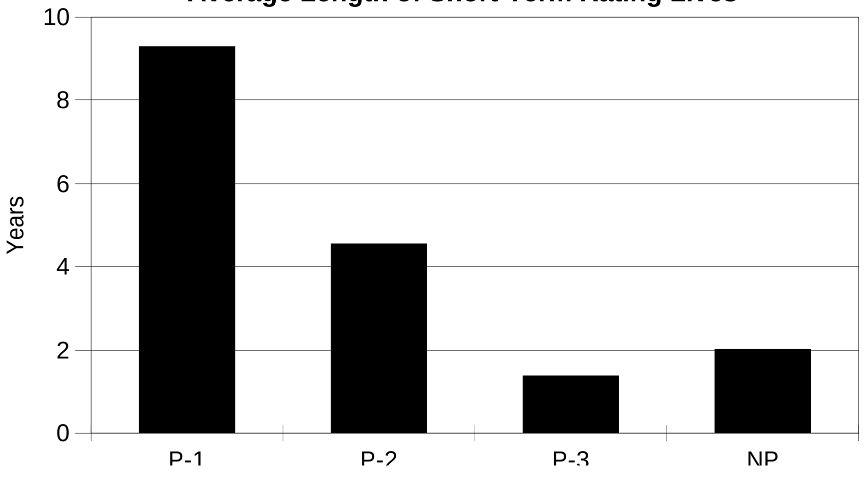


Table 4

Estimated Scale and Shape Parameters for the Weibull Distribution

Rating	Shape b	Scale a
Aaa	1.10	10.29
Aa	1.16	8.90
A	1.02	9.99
Baa	0.99	7.28
Ba	1.06	5.04
B	0.91	3.90
Caa	0.57	2.27
Aaa	1.38	6.85
Aa1	1.05	7.76
Aa2	1.25	3.66
Aa3	1.12	5.30
A1	1.16	4.02
A2	1.09	3.83
A3	1.09	3.04
Baa1	1.13	2.90
Baa2	1.05	2.66
Baa3	1.15	2.29
Ba1	1.10	2.62
Ba2	1.10	2.47
Ba3	1.20	3.08
B1	1.03	2.64
B2	1.06	2.14
B3	0.82	1.76
Caa	0.70	1.16
P-1	1.16	9.77
P-2	1.00	4.54
P-3	0.90	1.33
NP	0.85	1.86

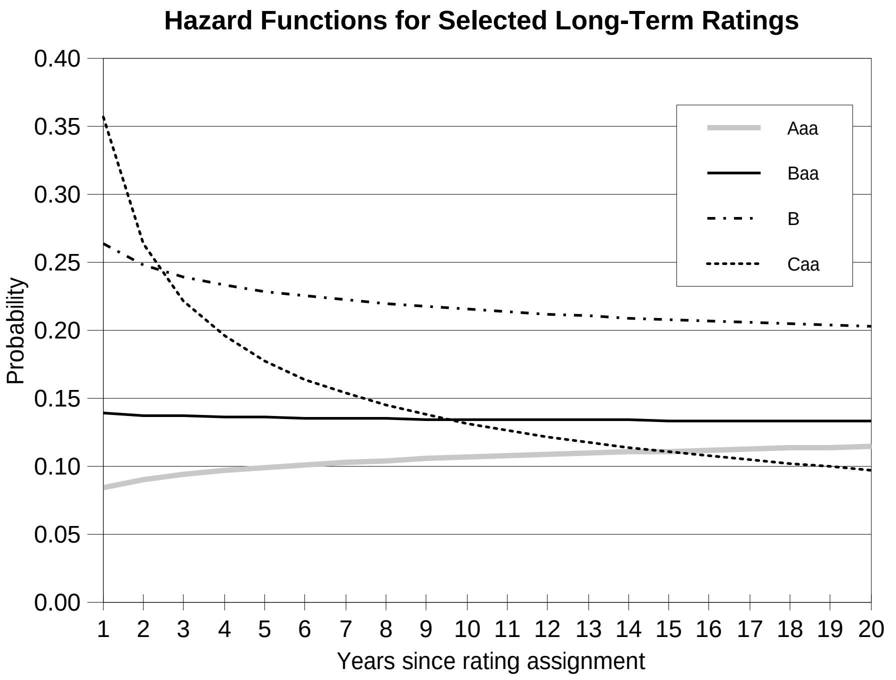
Such a complete description of the distribution of rating lives permits us to answer many interesting questions. For example, suppose an issuer's senior unsecured debt held a B rating for the previous 5 years. What is the probability that this rating will change in the current year? The hazard function $(h(t;a,b))$ is the probability of a rating change at time t, given that no previous change has occurred. It has been developed to answer these questions. Based on our parameter estimates the answer, given by $h(6;3.90,0.91)$, is 0.23, where 6 is the t^{th} year, 3.90 is the scale parameter, a, and 0.91 is the shape parameter, b, for the B rating category. In addition, it is interesting to note that this probability gets smaller with time. That is, the probability of a rating change for this issuer is smaller after 10 years of holding steady at the B level (0.22) than it is after holding B for just one year (0.26). For random variables that are Weibull-distributed, the hazard function has a simple form whose propensity to increase or decrease over time depends on whether the shape parameter is greater than or less than one.[14] Figure 21 shows the hazard functions associated with four long-term rating categories – two investment-grade and two speculative grade.

In general, the shape parameter falls from just above 1.0 to below 1.0 as credit quality decreases. As this happens, the hazard function changes from increasing with time to decreasing. The intuition behind this pattern is that for the highest-rated companies, there is nowhere to go but down. Hence, over longer periods of time the credit quality of these companies appears to slowly erode, thereby increasing the rate at which they are downgraded. For the lowest-rated companies, the probability of a rating change is initially high. But as time progresses, if credit quality hasn't improved or if the firm hasn't defaulted, credit worthiness appears to level off. Hence, over longer time horizons, the probability of a rating change decreases. Finally, for low-investment-grade issuers, the most populous ratings in our database, there is room to change in either quality direction. The odds of a rating change appear to develop at approximately constant rates as the time horizon expands.

The probability that a rating won't change before a specific date is also of interest. This probability differs from the hazard function in that it is not conditioned upon having no prior rating change.

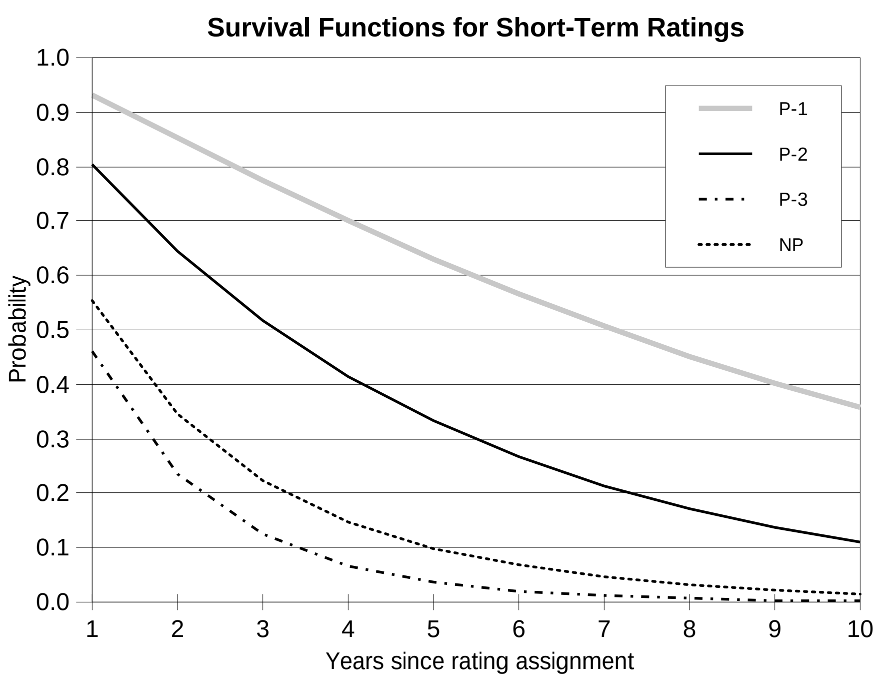
14 $h(t;a,b)$ = probability of a rating change $(w(t;a,b))$ given no previous rating change $(1-W(t;a,b))$, where $w(t;a,b)$ is the density function and $W(t;a,b)$ is the distribution function. Hence, $h(t;a,b) = w(t;a,b)/(1-W(t;a,b)) = (b/a)(t/a)^{b-1}$.

Figure 21



Conditioning requires knowledge (assumed or actual) of the rating experience up to the time in question (in order to assert that there was no rating change prior to time *t*). It answers the question: "If an issuer receives a senior rating of P-2 today, what is the probability that it will still be at P-2 (without any intervening changes) in 1, 2, 3 or more years?" The survival function, $(s(t;a,b))$, summarizes this probability and is a function of the same scale and shape parameters discussed above.[15] Figure 22 depicts the survival functions for the four short-term rating categories.

Figure 22



15 The probability of holding a rating for a given number of years is one minus the probability of the rating changing in the given number of years. Hence, $s(t;a,b) = 1 - W(t;a,b)$, where $W(t;a,b)$ is the distribution function.

The survival functions are all downward-sloping since the probability of a rating change increases with the amount of time allowed for the rating to change. Equivalently, the probability that a rating won't change decreases as the amount of time in which it may change increases. As expected, the probability that an issuer rated P-1 will keep its rating for periods up to 10 years is higher than for any other short-term rating category. The P-2 survival function lies under that for P-1 but above those for P-3 and NP. The survival functions for the lowest two rating categories are inverted and much lower than those of the higher quality ratings. The estimated probability of a P-3- or NP-rated issuer holding steady at the same rating for 10 years is very small *(s(10,1.33,0.90)* = 0.002 and *s(10,1.86,0.85)* = 0.016 respectively). These figures show that it is highly unlikely for a low-rated issuer to maintain its rating over a ten-year span. These ratings appear to be transitory states. In "Defaults and Orderly Exits of Commercial Paper Issuers" (Moody's Special Report, February 1993) Moody's reports that, as of September 30, 1992, P-3- and NP-rated CP constituted just 0.4% and 0.2% respectively of the total amount of CP outstanding. Given the relatively short estimated average "lives" of these ratings, the evidence seems to indicate that issuers can't maintain a low-quality short-term rating for long. Lower-quality short-term issuers must either improve to P-2 or P-1 or exit the market.

Rating momentum

The question of "rating momentum" arises frequently. Rating momentum presupposes that prior rating changes carry predictive power for the direction of future rating changes. For example, the existence of rating momentum would suggest that an issuer upgraded to A is more likely to be subsequently upgraded than downgraded within a one-year period. The first hypothesis to be tested (for each letter rating category) is that the probability of an upgrade, given that the previous rating change was an upgrade, is less than or equal to the probability of a downgrade given that the previous rating change was an upgrade. The hypothesis is that there is no upward rating momentum. The second hypothesis to be tested is that the probability of a downgrade, given that the previous rating change was a downgrade, is less than or equal to the probability of an upgrade given that the previous rating change was a downgrade. Here, the second hypothesis is that there is no downward rating momentum.

To test these hypotheses, we gathered rating histories for all those firms with at least one rating change in our database (this encompasses the rating experience from January 1938 through June 1993). These firms were grouped according to whether their momentum was upward or downward. We then modeled the probability of an upgrade, downgrade, or no change within one year of the prior rating change for each firm as a random variable, X, that assumed the values of *1*, *-1*, or *0* with probabilities p_u, p_d, and p_o respectively. Since our sample sizes are large, we assume that the sample mean is normally distributed.[16] "Large" positive values of Z* are evidence for rejecting the hypotheses. The results of these tests for the rating categories B through Aa and the probabilities of observing a Z* value at least as great as generated by these tests are given in table 5.

Table 3

Rating	Momentum	Estimated Prob(Up)	Estimated Prob(Down)	Upward Momentum Z*	Probability of observing Z > Z*	Reject Hypothesis @ 5% ?	Downward Momentum Z*	Probability of observing Z > Z*	Reject Hypothesis @ 5% ?
Aa	Up	1.32%	3.62%	-1.81	0.97	No			
Aa	Down	1.52%	5.56%				2.16	0.02	Yes
A	Up	1.08%	2.37%	-1.50	0.93	No			
A	Down	1.19%	6.96%				4.62	0.00	Yes
Baa	Up	2.87%	3.16%	-0.22	0.57	No			
Baa	Down	1.85%	11.47%				6.64	0.00	Yes
Ba	Up	7.66%	7.66%	0.00	0.50	No			
Ba	Down	4.20%	15.38%				6.25	0.00	Yes
B	Up	7.69%	0.00%	2.06	0.02	Yes			
B	Down	5.71%	23.82%				8.74	0.00	Yes

The test results show that, for the 5% level of confidence, upward momentum is nonexistent for all rating categories except B, for which the 7.69% estimated chance of an upgrade following another upgrade within one year is significantly greater than the 0% estimated chance of a downgrade following an upgrade within one year.

The results are very different for downward momentum. For each rating category, the probability of a downgrade following a downgrade within one year significantly exceeds (at the 5% level of confi-

16 $Z^* = \frac{1}{n}\sum_{i=1}^{n} X_i$ is asymptotically normal with mean $p_u - p_d$ and variance $p_u + p_d - (p_u - p_d)^2$.

dence) that of an upgrade following a downgrade.

The evidence supports the hypothesis that a downgraded issuer is more prone to a subsequent downgrade within one year than an upgrade. In light of the drastic deterioration in corporate credit quality associated with the 1980s, it is interesting that evidence for rating momentum is not solely a function of this period's data. An entirely analogous procedure to the above, except that pre-1980 data is examined, reveals that, at the 5% level of confidence, both the Aa and A ratings showed no sign of downward rating momentum while the Baa, Ba, and B categories showed significant downward momentum.

Appendix I

The data suffers from Type I data censoring. That is, we do not have complete data on all the rating lives in our sample. For example, an issuer may have held the Aaa rating since 1970. In this case, all that we know is that there is an Aaa-rated issuer that has held the rating for at least 23 years. In a sense, we have some information on this observation but not all (i.e. the exact lifetime of the rating). Maximum liklihood estimation takes advantage of the (incomplete) information we have.

Hence, if T_i is the rating lifetime and L_i is the censoring time for the i^{th} observation, our data consists of a series of observations (t_i, δ_i), where $t_i = min(T_i, L_i)$ and $\delta_i = 1$ if $T_i \leq L_i$ and $\delta_i = 0$ if $T_i > L_i$. δ_i is an indicator of whether the i^{th} data point is an observed lifetime or an observed censored lifetime. T_i is the actual observed length of time the rating is held, censored or not. The T_i are assumed to be independent and identically distributed.

If $w(t)$ is the probability density function of the T_i and $W(t)$ is the probability distribution function of each of the T_i observations, then the joint probability distribution function of (t_i, d_i) is

$$w(t_i)^{\delta_i}\left[1-W(L_i)\right]^{1-\delta_i} \quad .$$

The likelihood function of the data is then

$$\mathrm{L} = \prod_{i=1}^{n} w(t_i)^{\delta_i}\left[1-W(L_i)\right]^{1-\delta_i} \quad .$$

Each observed lifetime contributes $w(t_i)$ to the likelihood function while each censored time contributes $(1- W(t_i))$.

For the Weibull distribution

$$w(t;a,b) = \left(\tfrac{b}{a}\right)\left(\tfrac{t}{a}\right)^{b-1} e^{-\left(t/a\right)^{b}}$$

and

$$W(t;a,b) = 1 - e^{-\left(t/a\right)^{b}} \quad .$$

Using these functions and optimizing the likelihood with respect to the scale, a, and shape, b, parameters one obtains the equations that implicitly define the maximum likelihood estimators, $\hat{b}$, $\hat{a}$

$$\left[\sum_{i=1}^{n} t_i^{\hat{b}} \log t_i \bigg/ \sum_{i=1}^{n} t_i^{\hat{b}}\right] - \frac{1}{\hat{b}} - \frac{1}{r}\sum_{i\in D} \log t_i = 0$$

$$\hat{a} = \left(\frac{1}{r}\sum_{i-1}^{n} t_i^{\hat{b}}\right)^{1/\hat{b}}$$

where $r = \sum_{i\in D} \delta_i$ and D is the set of observations for which $\delta_i = 1$. The first equation can be used to obtain an estimate of b, which can, in turn, be used in the second equation to estimate a.