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Probability of Default: An Undervalued Driver of Corporate Bond Prices

Authors

David W. Munves, CFA
+1.212.553.2844
david.munves@moodys.com

Yukyung Choi
+1.212.553.0906
yukyung.choi@moodys.com

Contact Us

Alternatively, you may contact our customer service team:

Americas	+1.212.553.1653 clientservices@moodys.com
Europe	+44.20.7772.5454 clientservices.emea@moodys.com
Asia-Pacific	+85.2.3551.3077 clientservices.asia@moodys.com
Japan	+81.3.5408.4100 clientservices.japan@moodys.com

Summary

Moody's Analytics' EDF™ (Expected Default Frequency) probability of default measures can help corporate bond investors receive appropriate compensation for the credit risk in their portfolios. This is perhaps a surprising claim to make: credit risk is one of corporate bonds' most prominent features, so it should be fully incorporated in security prices. However, analytical paradigms vary by institution, and in many cases don't include the systematic application of quantitative default risk measures. Public Firm EDFs can fill this gap, providing buyside users of the metric with a key informational advantage over their competitors.

One benefit of using EDFs in investment and portfolio maintenance processes is to aid fund managers in constructing portfolios with attractive trade-offs between credit risk and yields and returns. EDFs also find ready uses in portfolio surveillance, which is often a relatively labor-intensive, low value-added activity for fund managers. Institutions can streamline such processes by focusing analytical attention on high EDF names, with resulting cost savings.

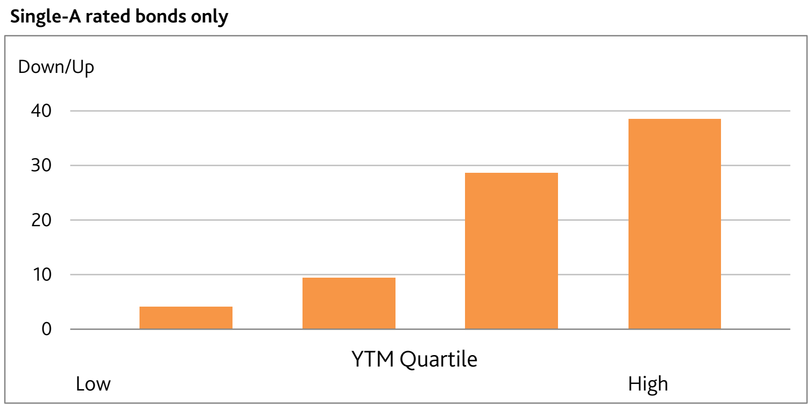
Getting paid for the risks you take

Corporate bond portfolios face a range of risks, ranging from price volatility to default. The key, of course, is to make sure that issue prices provide appropriate compensation for such risks. Or better yet, to find investments that are cheap for their risk levels. In the sections to follow we focus on credit risk, using downgrade rates as a proxy for this in investment grade, and default rates as the measure for high yield. We show how EDFs identify bonds that are trading cheaply for their credit risk levels. This means that in many cases investors can buy bonds with reduced credit risk, but that have yields and higher returns similar to those for issues with much more elevated risk levels.

Credit risk vs. yields and returns

The corporate bond market is very good at identifying credit risk. Amongst other things, lower yielding bonds have lower credit risk, something that is evidenced in investment grade by reduced downgrade rates (we address default risk in high yield later). The relationship between yield levels and downgrade rates holds even within a rating category (Figure 1, which covers the high downgrade periods of July 2007-February 2009 and March-November 2011). So measured this way, portfolio managers are being compensated for taking on credit risk. The problem is that reducing credit risk usually means accepting a lower portfolio yield.

Figure 1: Euro IG Corp. bond downgrade/upgrade rates ranked by bond yield quartiles (7/07-2/09, 3/11-11/11)



In this paper we show how Public Firm Expected Default Frequency (EDF) metrics[1] from Moody's Analytics can help bond portfolio managers break out of the seeming limitation imposed by the trade-off between yield levels and credit risk. Specifically, we demonstrate the use of EDFs to identify bonds with good levels in prevailing market conditions, but that carry below-average levels of credit risk.

We illustrate this starting with Figure 2. The data consists of euro investment grade bonds, and covers the high downgrade periods, as noted (Appendix I contains the same data for sterling bonds for this and other Figures). Let's start with the panel on the left. As a first step, we rank ordered the bonds by their yields, from low to high. We then divided the issues into four equally-sized groups. The 25% lowest yielding bonds are in the table's bottom row and the 25% highest yielding issues are in the top one. We then re-ranked each quartile by the issues' EDFs and again divided them into four groups. The bonds with the lowest EDF levels are on the left and the highest are on the right.[2] Each cell contains an average of 337 issues.

The numbers in the 16 cells are the ratios of Moody's downgrades to upgrades over a one-year horizon on a bond count basis. Thus, for the highest-yielding quartile (in the top row), the downgrade/upgrade ratio ranges from a high of 25.05:1 (in the far right cell) to a low of 5.60:1 (on the far left). We see the same association of lower EDFs with better downgrade/upgrade ratios in the other yield quartiles rows.

1 "EDF" is Moody's Analytics' brand name for "probability of default". They are derived from information about companies' capital structures and their share prices and price volatility. We publish EDFs at the entity and bond levels. EDFs are available for almost all the bonds in the major corporate indices sold by publicly traded issuers. The metrics incorporate market information, so they are forward-looking and up to date (they are produced on a daily basis). They are calibrated to reflect realized default rates. For example, if a portfolio has 100 firms, each with a one-year EDF of 1%, then experience shows that one of them will default over the next year. Since firms with high EDFs have elevated levels of credit risk, it is not surprising that rating agencies downgrade their issues at above average rates. For further details about EDFs, please see the Modeling Methodology paper Credit Risk Modeling of Public Firms: EDF 9 (Nazeran and Dwyer, June 2015). EDFs and related data, including their drivers, are available via the CreditEdge website, an Excel add-in, an XML feed, and a daily data file. Moody's Analytics also produces EDFs for privately held firms. The modeling approach for private firms differs substantially from that used for publicly held firms. Private firm EDFs are available via the RiskCalc platform. In this paper all references to "EDFs" are to public firm metrics.

2 We produce term structures of EDFs per entity. The studies in this paper use the average annualized EDF that matches the years to maturity for each bond issue.

Figure 2: Euro IG corp bond yields and EDF levels by quartiles (7/07-2/09, 3/11-11/11)

1yr downgrade/upgrade ratios

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	5.60	12.82	40.00	25.05
3	5.77	10.18	29.74	37.50
2	1.25	4.48	18.00	52.56
1 (Low)	1.35	4.49	9.85	26.88

Average yield to maturity

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4	7.08	7.29	7.66	8.31
3	5.61	5.59	5.63	5.62
2	4.96	4.94	4.86	4.83
1	4.12	4.17	4.20	4.11

Since one row contains a quarter of the bonds when ranked by yield, it is logical to expect some difference in yields among the four cells in it. This brings us to the real question: do EDFs help identify superior trade-offs between credit risk (evidenced by downgrades) and yields and returns? We answer this with the help of the right-hand panel, where the numbers in each cell represent the average yield to maturity of the bonds in it. For example, the average yield in the top-right cell is 8.31%, while that in the top-left cell is 7.08%. So during the high downgrade periods, for a 123 bp reduction in average yield, the downgrade/upgrade ratio is reduced by around a factor of four-and-a-half (25.05:1 to 5.60:1). One can debate if the give-up in yield between the two cells (a bad thing for investors) is worth the reduction in credit/downgrade risk (a benefit). But at least the trade-off exists, i.e., bonds with higher credit risk have higher yields and vice versa.

The next yield quartile row presents a different story entirely. The decline in the downgrade/upgrade ratio between the right-hand and left-hand cells is even more significant (it's by around a factor of 6.5), but it is achieved at the cost of only a 1 bp yield reduction (5.62% to 5.61%). The same pattern holds for the bottom two rows. Thus, aside from the highest-yielding quartile, *the bonds' incremental credit risk in the form of higher credit risk/higher EDFs (and the resulting elevated downgrade rates) is not incorporated into security prices*. This is the "key informational advantage" that we noted at the outset of the paper, one that is uncovered by analyzing the bonds' EDFs in conjunction with their yields.

Figure 3: Euro IG corp bond 1-year annualized total returns and Sharpe Ratios by YTM and EDF quartiles (7/07-2/09, 3/11-11/11)

Annualized Tot. Ret. (%)

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	4.89	2.74	0.76	4.28
3	8.29	7.21	6.43	4.40
2	8.90	8.22	6.72	6.29
1 (Low)	6.96	6.84	6.43	6.22

Sharpe Ratio

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4	0.34	0.08	-0.08	0.12
3	1.12	0.87	0.63	0.31
2	1.69	1.33	0.96	0.96
1	1.80	1.65	1.28	1.38

Figure 3 extends the analysis by showing the one-year average total returns and Sharpe Ratios for the same bonds used to create Figure 2, and for the same two periods. The top row on the left-hand panel of Figure 3 has a different pattern than that in the right-hand panel in Figure 2. For total returns, lower credit risk (as evidenced by lower downgrade rates) is associated with higher returns. That is, during times of credit stress, for the top-yielding bonds, selecting issues with low EDFs (and therefore lower expected downgrades) means a *gain* in total returns, in contrast with the give-ups in yield in Figure 2. Thus, the reduced credit risk associated with low EDFs results in better bond performance when measured across time. The counter-intuitive combination of lower risk bonds and higher returns repeats in the other three rows. Again, this evidence strongly suggests to us that credit risk (evidenced as downgrade rates) is not being fully baked into these securities' prices. Moreover, the right-hand panel in Figure 3 tells us that across the entire market, low EDF bonds have higher risk-adjusted returns.

Not surprisingly, the average ratings are lower for the cells in the upper row. And consistent with the higher yields, the average spreads on such issuers are elevated as well. However, the average durations amongst the groups are all in the same range (Figure 4).

Figure 4: Euro IG corp bond average ratings, durations, and spreads by EDF levels and quartiles (7/07-2/09, 3/11-11/11)

Average rating

YTM Quartile	1 (Low)	2	3	4 (High)
4 (High)	Baa1	A3	A2	A2
3	A3	A3	A2	A1
2	A2	A2	A2	A1
1 (Low)	A1	A2	A1	A1

EDF Quartile

Average duration

YTM Quartile	1 (Low)	2	3	4 (High)
4	5.64	5.74	5.80	5.83
3	5.52	5.57	5.52	5.46
2	4.76	4.81	4.71	4.96
1	3.43	3.58	3.72	4.00

EDF Quartile

Average spread

YTM Quartile	1 (Low)	2	3	4 (High)
4	415	474	546	562
3	229	249	273	270
2	153	162	176	180
1	102	117	124	126

EDF Quartile

We have carried out this analysis of rating change rates/EDF ranks vs. yields and total return ranks using data back to 2006 divided by different market states. In all cases, the patterns of data behavior and the trade-offs are the same. Please see Appendix II for details.

What have you done for me lately?

While the historical data provides evidence of the EDF model's power over different market states back in time, what's really relevant for investors is what can it do for them now and in the future. We provide an indication of this in Figure 5, which contains EDF and yield levels as of August 2015. Even in a relatively low credit risk environment, there is considerable variation amongst average EDF levels in the cells in the lefthand table. We'll only know the realized downgrade rates once a year has passed, of course. However, based on what we've learned from the other exercises, we can expect a meaningful difference in the downgrade rates per cell in the coming 12 months, with the bonds in the high EDF groups experiencing above-average rates of decline. This is not to mention the fact that in many cases bondholders are not getting paid for taking on the higher level of credit risk, as evidenced by the elevated EDF levels. That is, per the righthand panel, the differences in yields amongst the cells are minimal, again in keeping with the experience of the earlier periods. Thus, while this section has focused on mining a lot of historical data, there is every indication that the benefits of employing EDFs to select bonds with superior risk/return characteristics will persist in the years to come.

Figure 5: Euro IG corp average EDFs and yields to maturity, August 2015

Average EDF

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	0.17%	0.33%	0.74%	1.73%
3	0.16%	0.30%	0.72%	1.66%
2	0.11%	0.21%	0.53%	1.24%
1 (Low)	0.05%	0.11%	0.30%	0.84%

Average Yield to Maturity (%)

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4	2.25	2.26	2.21	2.46
3	1.46	1.45	1.43	1.46
2	0.94	0.96	0.95	0.96
1	0.43	0.52	0.49	0.54

The relationship between EDF levels and ratings changes

Figures 2-5 show the link between what Moody's ratings analysts do (change ratings) over various 12-month periods, and the EDFs prevailing at the beginning of the timeframes. So what, exactly, is the interplay between a quantitative model's output and the work of hundreds of analysts and untold thousands of rating committee meetings?

The ratings analysts are usually aware of issuers' EDFs, and often use then as a way to identify entities that might warrant early review, if only to see if the factors driving the changed EDFs are reflected in the relevant ratings. They do not change companies' ratings only because their default metrics have risen or fallen. Rather, what's happening is that developments in the issuers' credit quality are first showing up in shifts in their EDFs. The analysts are usually aware of the underlying drivers of changes in the firms' default metrics. But the rating process is inherently slower to react than a market-derived signal like EDFs. So while the elevated credit risk is frequently reflected in lower ratings, this usually occurs with a lag. Moody's Investors Service's emphasis on ratings stability adds to the dynamic.

The speculative grade conundrum: the yield is nice, but the default risk is not

We now turn our attention to the high yield sector. Given the euro market's relatively small size and short history, we do so using US data. Default risk is intensively analyzed by market participants, of course. But even with this, as with investment grade bonds, we find evidence that it is not fully incorporated into bond prices.

To substantiate this claim we again utilize the 4X4 framework, and data from high risk periods, in this case 2000-2002 and 2008-2009. The difference is that we're counting bond defaults, rather than downgrades and upgrades.

Figure 6: US HY corp bond annualized total returns and Sharpe ratios by EDF and YTM quartiles (2000-2002, 2008-2009)

1yr Default Rate

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	4.9%	7.5%	6.9%	13.6%
3	0.3%	0.2%	1.5%	1.2%
2	0.0%	0.1%	0.1%	0.6%
1 (Low)	0.0%	0.0%	0.0%	0.3%

Average yield to maturity

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4	16.38	16.59	17.85	22.69
3	10.33	10.64	10.71	10.75
2	8.76	8.73	8.78	8.80
1	7.42	7.48	7.60	7.66

Default rates are strongly associated with yield levels, as one would expect (Figure 6). That is, the numbers in the left panel are higher in the upper rows. As with Figure 2, within each row the EDF data is highly informative. For example, in the top row, the default rate in the far right-hand cell is three times that in the far left-hand cell. This is also to be expected, since entities with high EDFs default at elevated rates. Amongst the riskiest bonds, i.e., those in the top quartile, the yield give-up that comes with the lower EDFs/lower default rates is substantial: an investor would give up 6.31% in yield (22.69%-16.38%, in top row of the righthand panel of Figure 6) in order to cut his or her the default rate by 8.7 percentage points (13.6% to 4.9%). Thus as in investment grade, for these issues investors are paid, as they should be, to take on increase credit/default risk. But much like in Figure 2, in the other three rows EDFs identify issues with advantageous trade-offs between lower credit risk and yield reduction. For example, in the second row from the top, moving from the far right cell to the far left cell reduces the default rate by a factor of 4 times (from 1.2% to 0.3%), for only a 42 bp fall in average yield (10.75% to 10.33%).

As we did with the investment grade exercise, in Figure 7 we analyze annualized total returns and Sharpe Ratios for speculative grade bonds, ranked by yields and EDFs, again for periods of credit crisis. The left-hand panel shows that for the highest yielding issues, bondholders would suffer a very significant give-up in total return if they held lower EDF bonds than issues with high EDFs (23.36% vs. 42.64%). This is to be expected: the data covers two highly volatile periods with high default rates. The top right-hand bucket is packed full of cheap issues that, in the subsequent 12 months, either defaulted at somewhat lower prices or recovered strongly. In the market's parlance, for issuers of such bonds it was a case of "fly or die". And enough flew, so to speak, to allow the cohort to perform very well indeed.

Figure 7: US HY corp bond annualized total returns and Sharpe ratios by EDF and YTM quartiles (2000-2002, 2008-2009)

Annualized Tot. Ret. (%)

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	23.36	18.05	23.11	42.64
3	12.81	12.93	10.56	10.27
2	9.99	10.03	9.54	7.31
1 (Low)	9.37	9.18	8.82	6.55

Sharpe Ratio

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4	0.72	0.62	0.81	1.27
3	0.77	0.65	0.57	0.53
2	0.78	0.69	0.63	0.42
1	1.03	0.83	0.70	0.42

But a very different picture emerges when we move down the rows in the left-hand panel of Figure 7. Let's take the second row from the top as an example. Per Figure 6, the bonds in the left-hand bucket defaulted at a 0.3% rate, compared to a 1.2% rate for their counterparts on the far right. Yet in Figure 7 we see that the low EDF/low default bonds had an average one-year total return of 12.81%, compared to 10.27% for their high EDF/high default rate counterparts. As with the other 4X4 exercises, this shows that EDFs identify many bonds with superior returns per unit of credit risk.

In Figure 8 we provide additional statistics for the bonds in the high yield market study, also for 2000-2002 and 2008-2009. Predictably, the higher yielding bonds have lower ratings and increased spreads.

Figure 8: Average rating, duration, and spread for the US HY market by EDF and yield (2000-2002, 2008-2009)

Average rating

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	B2	B2	B2	B3
3	B1	B1	B1	B1
2	Ba3	Ba3	Ba3	Ba3
1 (Low)	Ba2	Ba3	Ba3	Ba3

Average duration

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4	4.87	4.80	4.32	3.95
3	5.80	5.48	5.41	5.11
2	5.81	5.43	5.53	5.33
1	4.79	5.54	5.20	5.22

Average spread

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4	1,153	1,194	1,373	1,798
3	591	638	673	704
2	452	467	475	521
1	328	342	344	372

Even in the current, relatively low default risk environment, as in the investment grade sector there are meaningful differences in EDFs per bucket, while the corresponding yields to maturity show little differentiation once we move away from the riskiest securities (Figure 9). We can therefore expect to see substantial differentials in the default rates per grouping in the future.

Figure 9: US HY Average EDFs and yields to maturity, ranked by EDFs and yields, August 2015

Average EDF

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	1.27%	3.54%	8.39%	25.39%
3	0.27%	0.61%	1.25%	3.17%
2	0.23%	0.43%	0.88%	2.14%
1 (Low)	0.13%	0.27%	0.53%	1.30%

Average Yield to Maturity (%)

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4	10.20	11.23	15.28	34.11
3	6.77	6.88	6.97	7.15
2	5.63	5.61	5.62	5.66
1	3.91	4.48	4.25	4.47

Appendix II shows the same data but for different points in time. As can be seen, the extreme yield and return behavior in the top rows of the relevant tables is more muted in non-crisis periods.

Conclusion

The main point of this paper is that in the majority of cases investors are not being adequately compensated for taking credit risk in the investment grade and high yield markets. One can posit a number of reasons why this is the case, but our view is that it's because quantitative probability of default measures are not systematically incorporated into fund managers' securities analysis and portfolio surveillance processes.[3] This is not to say that the prevailing fundamentally-based, bottom-up approaches are "broken": many funds outperform their benchmarks, and the corporate bond market continues to attract cash. Rather, our claim is that incorporating an additional quantitative signal (namely, EDFs) into existing processes can improve portfolio level trade-offs between risk and return. Also, as noted in the introduction, public firm EDFs can also be used to streamline surveillance routines, thus providing portfolio managers with gains in operating efficiency. We believe that these benefits mean that public firm EDFs will increasingly be employed to inform decisions around corporate bondholdings.

3 Credit pricing models have PDs as inputs, of course. While these are widely used to price illiquid securities and CDS contracts, as well as credit-based structured deals, the evidence suggests that their role is not as prominent amongst relative value and total return-oriented cash investors.

Appendix I: Sterling : downgrade/upgrade ratios vs. yields and returns

1yr downgrade/upgrade ratios

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	3.34	9.52	24.53	22.45
3	2.96	8.05	32.21	59.25
2	1.02	10.95	23.06	66.17
1 (Low)	3.11	12.33	10.07	7.22

Average yield to maturity

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	7.88	8.01	8.18	8.90
3	6.61	6.68	6.69	6.68
2	6.01	6.00	6.02	6.05
1 (Low)	5.11	5.27	5.27	5.27

Annualized Tot. Ret. (%)

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	5.67	4.86	2.76	-0.02
3	10.49	8.05	4.54	2.02
2	11.23	9.12	6.25	3.18
1 (Low)	7.61	6.19	4.22	3.03

Sharpe Ratio

YTM Quartile	EDF Quartile 1 (Low)	2	3	4 (High)
4 (High)	0.42	0.29	0.07	-0.12
3	1.40	0.86	0.32	0.01
2	1.55	1.15	0.60	0.16
1 (Low)	0.93	0.60	0.29	0.14

Appendix II: Euro IG: EDFs vs. yields and returns for different market states*

Bear markets

Average yield to maturity

YTM Quartile \ EDF Quartile	1 (Low)	2	3	4 (High)
4 (High)	7.23	7.44	7.78	8.64
3	5.63	5.69	5.71	5.74
2	4.91	4.93	4.94	4.94
1 (Low)	4.21	4.27	4.34	4.31

Annualized Tot. Ret. (%)

YTM Quartile \ EDF Quartile	1 (Low)	2	3	4 (High)
4 (High)	8.79	7.87	7.35	10.91
3	9.55	9.67	8.70	7.04
2	9.14	8.69	7.58	6.92
1 (Low)	7.38	6.95	6.83	6.50

1yr downgrade/upgrade ratios

YTM Quartile \ EDF Quartile	1 (Low)	2	3	4 (High)
4 (High)	5.55	15.02	27.19	20.20
3	3.44	6.05	13.57	19.40
2	0.99	2.96	10.10	27.83
1 (Low)	1.34	3.23	14.06	27.20

Bull markets

Average yield to maturity

YTM Quartile \ EDF Quartile	1 (Low)	2	3	4 (High)
4 (High)	5.45	5.70	6.11	6.96
3	3.75	3.79	3.81	3.84
2	2.92	2.93	2.94	2.93
1 (Low)	1.94	2.10	2.15	2.19

Annualized Tot. Ret. (%)

YTM Quartile \ EDF Quartile	1 (Low)	2	3	4 (High)
4 (High)	14.62	16.66	18.40	19.05
3	8.22	8.71	8.73	8.48
2	5.72	5.65	5.62	5.78
1 (Low)	3.24	3.42	3.50	3.64

1yr downgrade/upgrade ratios

YTM Quartile \ EDF Quartile	1 (Low)	2	3	4 (High)
4 (High)	5.79	26.16	23.20	56.89
3	2.01	4.90	12.17	6.07
2	0.81	2.83	7.67	8.49
1 (Low)	0.59	1.62	5.13	23.33

Stable markets

Average yield to maturity

YTM Quartile \ EDF Quartile	1 (Low)	2	3	4 (High)
4 (High)	5.12	5.21	5.41	5.59
3	4.11	4.12	4.12	4.15
2	3.57	3.59	3.62	3.61
1 (Low)	2.94	3.02	3.05	3.04

Annualized Tot. Ret. (%)

YTM Quartile \ EDF Quartile	1 (Low)	2	3	4 (High)
4 (High)	2.25	-0.93	-2.56	-2.20
3	4.33	3.08	1.54	1.25
2	4.82	4.12	2.46	2.27
1 (Low)	3.96	3.60	3.37	2.77

1yr downgrade/upgrade ratios

YTM Quartile \ EDF Quartile	1 (Low)	2	3	4 (High)
4 (High)	2.10	3.86	8.07	4.19
3	2.07	3.38	8.39	10.11
2	1.08	1.93	3.99	4.61
1 (Low)	0.54	6.03	2.22	2.08

* Bear markets 7/07-2/09, 6/11-12/11, 7/11-12/11. Bull markets 3/09-4/10, 1/12-12/14. Stable market 1/07-6/07, 5/10-6/11. Market states determined by the prevailing spread trends.