MOODY'S
INVESTORS SERVICE

SPECIAL COMMENT

Moody's Revised Senior Ratings Algorithm

Analyst Contacts:

NEW YORK   +1.212.553.1653

Kumar Kanthan   +1.212.553.1428
Senior Vice President - Manager
kumar.kanthan@moodys.com

Sharon Ou   +1.212.553.4403
Vice President - Senior Credit Officer/Manager
sharon.ou@moodys.com

Varun Agarwal   +1.212.553.4899
Vice President - Senior Analyst
varun.agarwal@moodys.com

Sumair Irfan   +1.212.553.1035
Associate Analyst
sumair.irfan@moodys.com

Description of New Senior Ratings Algorithm and New Default Treatment

The default and ratings performance statistics that Moody's publishes—for example, in the Annual Default Study and Monthly Default Reports—are based on entity-level senior rating histories produced by the Senior Ratings Algorithm (SRA)[1]. The SRA takes a Moody's-rated entity's actual senior unsecured rating (or senior rating) history when one exists and estimates such when the entity does not have any rated senior unsecured debt in all or part of its rating history. These estimated ratings allow Moody's to meaningfully compare credit quality across entities, regardless of their capital structures. In October 2017, Moody's updated the senior ratings algorithm underlying the DRD and modified the rule that determines when an issuer can return to a cohort post default. This paper details the changes made to the algorithm.

---

[1] Throughout this appendix, we take entity and entity-level to refer to obligor and obligor-level.

The process of estimating an entity's senior rating has three broad steps. In the first step, notching rules are created based on the average notch difference in ratings between each class of debt and the senior unsecured debt of an entity. In the second step, the entity's reference credit—the debt class rating that has the highest priority—is selected. This is accomplished by ranking each class of rating on the basis of its ability to predict the senior rating; this ranking is referred to as the priority of the notching rule. In the third step, the reference credit's rating is adjusted by the number of notches based on its corresponding notching rule to estimate the entity's senior rating.[2]

We have redesigned the SRA so that notching rules are determined dynamically and are consistent with Moody's current rating practices.[3],[4]The redesigned algorithm allows dynamic changes in notching rules and their priority, whereas in its previous iteration, the algorithm used static notching rules that were updated intermittently. We have also expanded our universe of issuers to include banks that only have deposit ratings as well as obligors of industrial revenue bonds. As a result, we now include deposit defaults into our default statistics as opposed to only bond and loan defaults in prior years' studies. Finally, we have modified the rules by which a defaulted entity can reenter a cohort for the purposes of the default and ratings performance statistics.[5] In Senior Ratings Algorithm Update - A Brief Impact Study, we show the impact of each of these changes on rating performance statistics, specifically cumulative default rates, rating distribution and rating transition matrices.

These updates to our approach have the following impact:[6]

» With the switch from the old notching rules to the new notching rules, we see a decrease in the Caa-C cumulative default rates due to a number of nondefaulting issuers rated B in the old SRA now being rated in the Caa-C range in the new SRA.

» When deposit-only and IRB-only issuers are added to the sample, cumulative default rates decrease by varying degrees for the vast majority of rating categories and horizons.

» Moving from old cohort reentry rules to new cohort reentry rules has very little effect.

» Overall, when we look at the cumulative impact of these three changes, we see a drop in cumulative default rates for the vast majority of rating categories and horizons, as well as a general increase in rating counts. The drop in cumulative default rates is primarily due to the addition of deposit-only and IRB-only issuers; however, at the Caa-C rating category, cumulative default rates are driven down primarily due to the switch to dynamic notching.

Our new approach, while slightly more complex, has a few distinct advantages over its predecessor. First and foremost, the redesigned SRA estimates senior ratings assigned by Moody's analysts more accurately than before.[7] Second, because the redesigned model is dynamic, it reflects evolving notching trends in real time, rather than ex post. The chart below shows that barring a couple of instances (for example the period between 2003 and 2005), the redesigned SRA more accurately estimates senior ratings compared to its previous iteration. In addition, this new approach expands the coverage of entities and default events,

---

[2]   By entity-level rating, we mean ratings assigned to entities as a whole, as opposed to ratings assigned to specific debt instruments.

[3]   We adopted the new algorithm starting with Moody's September Default Report (October 2015).

[4]   We described the previous iteration of the SRA in Moody's Senior Ratings Algorithm & Estimated Senior Ratings (February 2009). An updated publication reflecting the redesigned SRA is forthcoming.

[5]   We relax the conditions under which defaulted entities whose resolution dates are unknown are reintroduced back into our study sample. Previously, we waited until an entity's estimated senior rating was upgraded to B3 or higher. In some cases, this treatment had the unintended consequence of keeping low-rated defaulted entities out of the sample for prolonged periods of time. Our new rule incorporates a time element in addition to the B3 rating threshold; now, even if its rating has not been upgraded to B3 or higher, a defaulted entity will be reinstated into the study sample after one week for distressed exchange events, one year for missed interest or principal payment events and five years for bankruptcy events.

[6]   We have recalculated the historical measures presented in this study, incorporating all the changes mentioned above. Entity ratings prior to April 26, 1982 are calculated using the previous SRA. Hence, historical measures prior to 1982 have not changed since last year's study.

[7]   In this context, rating accuracy refers to the ability of the model to correctly estimate a Moody's assigned senior rating when using non-senior ratings as inputs.

resulting in more robust default and ratings performance measurements. Finally, these gains do not come at the expense of introducing artificial rating volatility into the estimated entity-level rating histories.

Rating Accuracy: Redesigned SRA versus Previous SRA
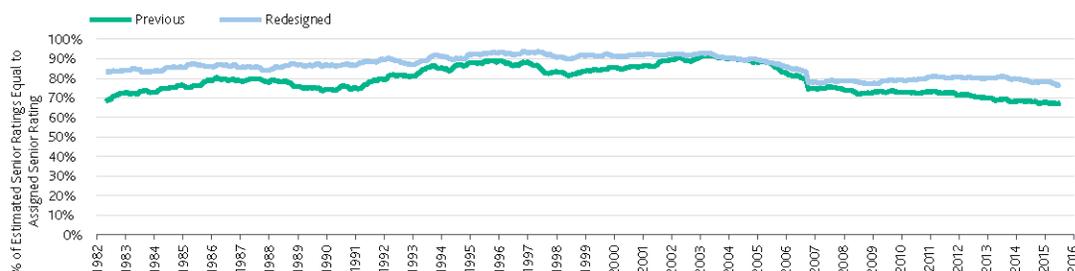
Source: Moody's

Note: The percentage of estimated senior ratings equal to the assigned senior rating is calculated on the same set of obligors for both models, i.e., on a matched-sample

Below, we describe in greater detail the various steps of the redesigned SRA, and where applicable, we highlight the major differences vis-à-vis our previous model.

Procedurally, the SRA performs the following six steps:

1. Filter out ineligible credits

2. Compute aggregated credit group histories

3. Infer notching rules

4. Select the reference credit group

5. Smooth artificial changes in the estimated senior rating

6. Remove entities without debt ratings

1. *Filter out ineligible credits*

We form a universe of credits from all of Moody's public, monitored, global scale long-term ratings, with the exceptions of structured finance ratings, short-term ratings, modeled ratings, defeased ratings and externally-backed ratings.[8] From this universe, we infer notching rules and select reference credits, as described below.

2. *Compute aggregated credit group histories*

Each credit from among this broad universe is characterized along the following dimensions:

» Class of debt or entity-level rating (e.g., regular bond, bank loan, first mortgage bond, Issuer Rating, Corporate Family Rating)[9]

» Seniority (e.g., senior unsecured, senior secured, subordinated)

» Backing status (not backed, internally backed, externally backed)

» Currency type (e.g., local currency, foreign currency)

---

[8]   Our previous SRA excluded certain types of debts that are now included in the redesigned SRA, such as industrial revenue bonds.

[9]   Moody's Rating Symbols and Definitions provides detailed definitions for Issuer Ratings and Corporate Family Ratings.

The SRA aims to estimate the hypothetical senior unsecured, non-backed, local currency, regular bond rating—in other words, the benchmark rating—for each entity. For entities that already have a benchmark rating, no estimation is required.

The four dimensions listed above are the salient factors affecting a particular credit's rating in relation to other credits in an entity's capital structure. We expect that for a given entity, credits that match along these four dimensions (referred to as credit groups) are homogenous and share the same rating at a fixed moment in time. In cases where ratings from the same credit group differ for a given entity, we calculate the median rating at each point in time.[10] In this way, we construct sanitized credit rating histories for each entity and refer to them as aggregated credit group histories.

3. *Infer notching rules*

In the next step of the SRA, we infer notching rules from each credit group to the benchmark rating. A notching rule is an abstraction for the prevailing notch difference that exists between a given credit group rating and the benchmark rating of the same entity as a function of time, credit group rating level, region and sector.[11] For each credit group and among the set of entities that have both the credit group rating and the benchmark rating, we compute the most frequently observed notch difference as a function of time, the credit group's rating and the entity's region and sector. If there is not sufficient consensus for a particular rule, no rule can be formed.[12] Rather than relying on static notching rules as the previous SRA did, the redesigned SRA allows historical ratings to drive the formation of notching rules, which can evolve over time.

4. *Select the reference credit group*

Having inferred notching rules, we then select the reference credit group for each entity at all points in time. The reference credit group is the one whose notching rule most reliably predicts the benchmark rating. In other words, it is the credit group that has the highest priority. A notching rule's priority is broadly based on two factors:

» How consistent is the credit group's notching from the benchmark rating?

» How targeted is the pool of entities from which the notching rule was formed?

The more consistent a credit group's notching is, the higher priority it will be assigned. For two notching rules that are equally consistent, the rule that is formed from a more targeted pool of entities (with respect to the entities for which we are selecting the reference credit group) will be assigned a higher priority.[13]

We have revised how we choose the reference credit group for entities that selectively default on subordinated debt, but continue to pay on senior debt obligations. The previous SRA chose the defaulted subordinated debt as the reference credit group when the gap between the senior- and subordinated debt ratings becomes wider than historical standards. This resulted in an artificially lowered rating, and was intended to balance two competing considerations: (1) estimating entity-level ratings, assuming that default risk is shared evenly across the entity's capital structure, and (2) reflecting Moody's ratings' true

---

[10] If there are an even number of credits in the credit group, we select the worse rating among the two middlemost ratings. We refer to this as the Median-Worst algorithm.

[11] Even though we refer to "notching rules", in no way are we suggesting that Moody's rating analysts rigidly follow these rules in practice. Our algorithm only seeks to determine the "average" notching observed within a particular region and sector.

[12] In order for a rule to be formed, we require two conditions be satisfied: (1) at least 50% of all entities must have the same notching, and (2) there must be at least 10 entities that have the same notching.

[13] For ease of exposition, this discussion of priority has been simplified. In our forthcoming publication on the redesigned SRA, we will expand on this topic in more detail.

discriminatory power by referencing the subordinated debt rating. In the redesigned SRA, we make no such adjustment for selective defaults.[14],[15]

Once we have determined the reference credit group for a particular entity, we apply its notching rule to the reference credit group's rating to derive the estimated senior rating. In this way, we construct entity-level estimated senior rating histories at all points in time.

5.   *Smooth artificial changes in the estimated senior rating*

It is possible that an entity's estimated senior rating history created in the previous step contains artificial rating changes—that is, rating changes that are unsupported by the entity's underlying aggregated credit group histories.[16] Artificial rating changes can be introduced due to changes in the reference credit group or changes in the notching rule. To remove these artificial rating changes, we apply a remedial smoothing procedure, by which we mean the process of shifting the entity's estimated senior rating history either prior to or after an artificial rating change by the same magnitude as the intended artificial change. This has the effect of eliminating the artificial rating change at the cost of distorting the entity's rating level.

The redesigned SRA allows artificial changes in an entity's estimated senior rating history to be smoothed either back in time or into the future. If the priority of the current notching rule is higher than that of the previous notching rule (with respect to a particular artificial rating change), the entity's estimated senior rating is smoothed back in time, meaning the previous rating is replaced with the current rating. Conversely, if the priority of the current notching rule is lower than that of the previous notching rule, the entity's estimated senior rating is smoothed into the future, meaning the current rating is replaced with the previous rating.[17]

6.   *Remove entities without debt ratings*

After smoothing is completed, the final step in the redesigned SRA is to remove entities from the data sample for the periods of time when they do not have rated debt obligations—namely, bonds, loans or bank deposits. Gaps in an entity's estimated senior rating history that are due to the entity not having debt ratings are treated as rating withdrawals. For this study, we only include entities that have debt ratings in our data sample because only for these entities do we track default events with a high degree of confidence. As a result, our default statistics remain unbiased and accurately reflect the true credit risk observed in the corporate universe.[18]

---

[14] In the future, we may choose to publish our default studies at the debt-class level. For example, we may choose to study subordinated debt ratings for financial institutions and consider only defaults on subordinated debts. This approach would avoid the issue highlighted here because both ratings and defaults would be measured on the same class of debt.

[15] The previous approach led to a more correct rating accuracy measurement at the expense of introducing inaccurate ratings while the new approach has the opposite effect. We plan to address this issue in the future by doing studies at the instrument level or by censoring non senior unsecured defaults when doing senior   unsecured entity-level studies.

[16] Aggregated credit group histories, as defined previously, are the rating histories calculated as the Median-Worst rating among all like credits of a particular entity.

[17] The concept of smoothing is vast and complex, and cannot be covered adequately in this appendix. In our forthcoming publication on the redesigned SRA, we will discuss smoothing in greater detail.

[18] Suppose we included entities that only were assigned entity-level ratings in our data sample. Our default statistics would then understate the true default risk because we would be including entities that do not even have the possibility of defaulting.

Report Number: 197341

Moody's
INVESTORS SERVICE