Disagreement between Rating Agencies and Bond Opacity: A Theoretical Perspective[*]

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January 22, 2014

Abstract

In this paper, we explicitly model a bond rating process under varying degrees of bond opacity and derive conditions under which disagreements between rating agencies (rating splits) can serve as a useful proxy for opacity in empirical analyses.

JEL classification: G20, G24, G30

Keywords: Opaque assets; ratings; rating agencies; rating splits.

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1 Introduction

The term opacity refers to a situation in which risks are hard to observe for an outsider (see, e.g., Morgan, 2002). Opacity is a highly relevant and topical issue in economics. The opacity of financial products has been blamed for amplifying the recent turmoil on financial markets (see, e.g., Borio, 2008; Crouhy, Jarrow and Turnbull, 2008; Zingales, 2008; Hellwig, 2009; Dymski, 2010). Also, it is conventional wisdom that opacity of firms is a major obstacle for obtaining outside funding. Following Morgan (2002), numerous empirical studies have employed rating splits, i.e. disagreement between rating agencies on ratings, as a proxy for opacity.[1] This is usually motivated by an empirically observed positive correlation between rating splits and other commonly applied opacity measures (see, e.g., Morgan, 2002; Bonaccorsi di Patti and Dell'Ariccia, 2004 and Livingston, Naranjo and Zhou, 2007). Nevertheless, empirical results on opacity derived from rating splits have repeatedly been inconsistent with the results obtained from other measures of opacity.[2] Beyond this, we still lack a robust theory explaining the relationship between rating splits and opacity.

This paper fills this gap by explicitly modeling the bond rating process under varying degrees of bond opacity. Following Morgan (2002), opacity in our model means that a potential buyer and/or a rating agency finds it hard to estimate the true default probability of a bond. This will be particularly true if information about the bond issuing firm

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[1] See, e.g., Bonaccorsi di Patti and Dell'Ariccia (2004) and Hyytinen and Pajarinen (2008) who investigate the opacity of young and old firms or Iannotta (2006) who studies the opacity of the financial and the non-financial sector. In more recent studies, rating splits serve as a proxy for the opacity of banks (see Bannier, Behr and Güttler, 2010; Balasubramnian and Cyree, 2011 and Jones, Lee and Yeager, 2012), industries (see Beck, Demirguc-Kunt, Laeven and Levine, 2008), insurance companies (see Pottier and Sommer, 2006), corporate bonds (see Güntay and Hackbarth, 2010 and Livingston and Zhou, 2010) and loans (see Drucker and Puri, 2009).

[2] For example, Morgan (2002) concludes from rating splits that the banking sector is inherently more opaque than other sectors while Flannery, Kwan and Nimalendran (2004), using market microstructure data to measure opacity, do not find an unusually high degree of opacity of banks. With respect to insurance companies, there is a similar debate (see Morgan, 2002 and Ianotta, 2006).

is scarce. Then, buyers have to rely on, e.g., the industry-wide distribution of default probabilities which tends to be easier to assess. The larger is the range of this distribution, the larger is the extent of a bond's opacity. In the model, there are two rating agencies that can reduce the opacity of bonds by applying a screening technology. The technology provides information about the bonds' default characteristics. It allows the agencies to update those expectations purely based on industry-wide information. The extent of opacity reduction increases in the quality of the screening technology. Consequently, the model captures two determinants of (post-screening) opacity of a bond: the range of possible default probabilities in an industry prior to screening and the quality of the rating agencies' screening technology. In addition to rating splits and opacity, the model also addresses the relationship between rating splits and the uncertainty about final returns of bonds.

We concentrate on a scenario in which one agency rates more conservatively than the other in the sense that it has stricter requirements for giving a favorable rating. This is strongly corroborated by empirical evidence (see, e.g., Pottier and Sommer, 1999; Morgan, 2002; Güttler, 2005; van Roy 2005; Livingston, Wei and Zhou, 2010). For this scenario, we show that generally it is not useful to proxy opacity or uncertainty about final returns by rating splits because split ratings may be systematically observed even if opacity or uncertainty is completely absent. Moreover, we show that this can be avoided by controlling for specific variables and derive conditions under which rating splits can actually serve as a proxy for opacity or uncertainty.

2   The Model

Consider two rating agencies and a large number of bonds. At a later date, each bond will either yield a return normalized to one or default and repay nothing. Half of the bonds are 'good'. They default with low probability ρ_l. The other half is 'bad' and has a high default probability $\rho_h \geq \rho_l$. A potential buyer cannot tell whether a bond is actually good or bad. Without further information he expects a default with probability $\bar{\rho} = \frac{1}{2}\rho_l + \frac{1}{2}\rho_h$. This lack of information creates a useful role for the rating agencies. They have access to a screening technology providing a noisy signal s about a bond's true default probability.[3] The signal can be either s_l or s_h and satisfies

$$\Pr[s_l \mid \rho_l] = \Pr[s_h \mid \rho_h] = \frac{1+q}{2},$$

$$\Pr[s_h \mid \rho_l] = \Pr[s_l \mid \rho_h] = \frac{1-q}{2},$$

where $\Pr[s_i \mid \rho_j]$ with $i = l, h$ and $j = l, h$ denotes the conditional probability of s_i for a given ρ_j and $q \in [0; 1]$ reflects the quality of the screening technology.

The agencies use the signal to update their pre-screening expectations $\bar{\rho}$ according to Bayes' rule. After having obtained a 'good' signal s_l, post-screening expectations satisfy

$$E[\rho \mid s_l] = (1 - q)\bar{\rho} + q\rho_l \leq \bar{\rho}. \tag{1}$$

The interpretation of (1) is straightforward. If the signal is useless, $q = 0$, the agencies will not update their expectations, $E[\rho \mid s_l] = \bar{\rho}$. If $q > 0$, the signal s_l will be informative implying an expected default probability (after screening) below $\bar{\rho}$. Moreover, since

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[3]   The assumption that the two rating agencies have access to the same screening technology and obtain the same signal is purely made for the sake of expositional brevity. If we allowed for different screening technologies or signals, the qualitative results would remain unchanged.

$\frac{\partial E[\rho|s_l]}{\partial q} < 0$, the probability will be lower, the higher is the quality of the signal. If $q = 1$, the signal will be perfectly informative. Then, the expected and the true default probability will coincide, $E[\rho \mid s_l] = \rho_l$. The implications of a 'bad' signal s_h are analogous. Bayes' rule then implies

$$E[\rho \mid s_h] = (1 - q)\,\bar{\rho} + q\rho_h \geq \bar{\rho}, \tag{2}$$

so that $E[\rho \mid s_h]$ is increasing in q, equal to $\bar{\rho}$ for $q = 0$ and equal to ρ_h for $q = 1$.

A risk-neutral rating agency $r = 1, 2$ transforms the updated expected default probability $E[\rho \mid s_i]$ into a letter rating A or B. The agency aims at minimizing its expected costs $E[C_r^{mis}]$ of misrating. As in Morgan (2002), we use this term in an ex-post sense by distinguishing between two forms of misrating. First, ex-post *over*rating refers to a bond that defaults after having obtained an A. In this case, the rater incurs a cost $C_r^o > 0$. Consequently, for a given signal s_i, the expected costs of an A-rating are $E[C_r^{mis} \mid A] = E[\rho \mid s_i]C_r^o$. Second, ex-post *under*rating refers to a B-rated bond that does not default. Then, the cost to agency r is $C_r^u > 0$ so that the expected costs of a B-rating are $E[C_r^{mis} \mid B] = (1 - E[\rho \mid s_i])\,C_r^u$. The bond thus will obtain an A-rating from agency r only if $E[C_r^{mis} \mid A] \leq E[C_r^{mis} \mid B]$. This condition translates to

$$E\left[\rho \mid s_i\right] \leq \frac{C_r^u}{C_r^o + C_r^u} =: \hat{\rho}_r, \tag{3}$$

where $\hat{\rho}_r$ denotes the cutoff probability for converting the updated expected default probability into a letter rating. If the agency expects the bond to default with a small probability, $E\left[\rho \mid s_i\right] \leq \hat{\rho}_r$, the bond will receive an A. Otherwise, it will be rated B.

The threshold $\hat{\rho}_r$ is determined by the under- and overrating costs. Henceforth, let us assume as in Morgan (2002) that these costs, and therefore also the threshold $\hat{\rho}_r$, differ across the two agencies. To clarify our main point, it is sufficient to analyze the case $C_1^o > C_1^u$ and $C_2^u > C_2^o$, which implies $\hat{\rho}_1 < 1/2 < \hat{\rho}_2$. That is, consistent with the literature cited in the introduction, the first agency is more conservative than the second. It has stricter requirements for an A-rating as its overrating costs exceed its costs of underrating while the second agency finds overrating less costly than underrating.

A rating split will occur if one agency gives an A-rating while the other assigns a B to the bond. Using the decision rule (3) and expectations as given by (1) or (2) we obtain:

Lemma 1: *Define $\Delta := \rho_h - \rho_l$. There will be a post-screening rating split only if*

$$(a) \quad \bar{\rho} \in (\hat{\rho}_1, \hat{\rho}_2] \quad \text{and either} \quad s = s_l, \quad \tfrac{1}{2}q\Delta < \bar{\rho} - \hat{\rho}_1$$

$$or \qquad\qquad s = s_h, \quad \tfrac{1}{2}q\Delta \leq \hat{\rho}_2 - \bar{\rho},$$

$$(b) \quad \bar{\rho} \notin (\hat{\rho}_1, \hat{\rho}_2] \quad \text{and either} \quad s = s_l, \quad \tfrac{1}{2}q\Delta \in [\bar{\rho} - \hat{\rho}_2, \bar{\rho} - \hat{\rho}_1)$$

$$or \qquad\qquad s = s_h, \quad \tfrac{1}{2}q\Delta \in (\hat{\rho}_1 - \bar{\rho}, \hat{\rho}_2 - \bar{\rho}].$$

Depending on pre-screening expectations $\bar{\rho}$, there are two scenarios. In scenario (a), characterized by $\bar{\rho} \in (\hat{\rho}_1, \hat{\rho}_2]$, a rating split occurs prior to screening. The more conservative first agency gives a B-rating while the less conservative second agency gives an A. The split will persist after screening if the signal has too little impact on the post-screening assessment of the bond's default probability to change ratings. This will be the case if the quality q of the signal is poor and/or if the bonds are rather homogenous with respect to their default probability, i.e. if the range Δ is small. In scenario (b) with $\bar{\rho} \notin (\hat{\rho}_1, \hat{\rho}_2]$, the pre-screening ratings of the two agencies will coincide. In this scenario, a post-screening rating split will emerge if the signal has a medium impact on the post-screening assess-

ment of the bond's default probability. The impact must be large enough so that one agency alters its rating. However, it may not be too large so that the other agency leaves its rating unchanged.

3   Opacity and Rating Splits

Opacity means that it is hard to estimate the true default probability of a bond. In our model, $\rho \in \{\rho_l, \rho_h\}$ is the true default probability. Therefore, we can use the post-screening variance

$$\sigma^2_\rho(s_i) := E\left[(\rho - E[\rho \mid s_i])^2 \mid s_i\right] = \frac{1}{4}\left(1 - q^2\right)\Delta^2 \tag{4}$$

of the bond's default probability as an opacity measure. According to (4), opacity will reach a minimum if screening provides a perfect signal ($q = 1$), allowing to perfectly discriminate between good and bad bonds, or if there is no need for discrimination ($\Delta = 0$), as the true default probabilities do not differ across bonds. In either case, agencies can perfectly estimate the true default probability of a bond. Also, we can infer from (4) that the level of opacity is higher, the lower is the precision of the signal or the more heterogeneous bonds are with respect to their probability of default. Finally, opacity reaches a maximum if $q = 0$ and $\Delta = 1$.

Rating splits can serve as a proxy for opacity as long as they occur only if the level of opacity is above a certain threshold. Unfortunately, this requirement will not always be fulfilled. To see this, recall from scenario (a) in Lemma 1 that for intermediate pre-screening expectations $\bar{\rho} \in (\hat{\rho}_1, \hat{\rho}_2]$, there will be a persistent rating split if $q = 0$ and $\Delta = 0$. While $q = 0$ can be associated with fully opaque bonds as the screening technology

is useless, $\Delta = 0$ will be associated with homogeneous and thus fully transparent bonds. Consequently, we may observe rating splits at any possible level of opacity. Furthermore, considering scenario (b) in Lemma 1, an increase in q, which is associated with a decrease in opacity, may actually lead to a post-screening rating split. By combining Lemma 1 with (4), we can conclude

Proposition 1: *Assume there is a requirement that for any given signal, a rating split should occur only if σ_ρ^2 is above a certain threshold. This requirement will only be met if $\bar{\rho}$ and Δ are given with $\bar{\rho} \in (\hat{\rho}_1, \hat{\rho}_2]$ and $\Delta > 2 \max \{\bar{\rho} - \hat{\rho}_1, \hat{\rho}_2 - \bar{\rho}\}$.*

The proposition reveals that rating splits can serve as a opacity measure if opacity is driven by signal quality only. This can be achieved by controlling for both, pre-screening expectations $\bar{\rho}$ and the heterogeneity Δ of bonds. The former must be at an intermediate level, which gives rise to a pre-screening rating split that will persist if the opacity level is high due to a bad quality of the signal. The latter must be sufficiently large. This ensures that a high quality signal, which indicates little opacity, leads to a rather large change in the assessment of the bond's default probability, so that the post-screening ratings of the agencies are aligned.

4 Uncertainty and Rating Splits

At the individual level, the final return $\pi \in \{0, 1\}$ of a bond will be uncertain unless its true probability of default $\rho \in \{\rho_l, \rho_h\}$ is equal to either zero or one. Taking this true default probability ρ (which the agencies will typically not know for sure even after

screening) as given, we can measure the true uncertainty of the return at the individual bond level by the variance

$$\sigma_\pi^2(\rho) := E\left[(\pi - E[\pi \mid \rho])^2 \mid \rho\right] = \rho\,(1 - \rho)\,.$$

Moreover, at an aggregate level, the shares of good and bad bonds as well as their respective true default probabilities ρ_l and ρ_h are known. Therefore, the average variance

$$\overline{\sigma}_\pi^2 := \frac{1}{2}\sigma_\pi^2(\rho_l) + \frac{1}{2}\sigma_\pi^2(\rho_h) = (1 - \bar{\rho})\,\bar{\rho} - \frac{1}{4}\Delta^2 \tag{5}$$

of bond returns can serve as a measure of the aggregate uncertainty of all bonds. The variance as defined in (5) shows that bond returns are perfectly certain, $\sigma_\pi^2 = 0$, if either all bonds default ($\bar{\rho} = 1$, $\Delta = 0$) or no bond defaults ($\bar{\rho} = 0$, $\Delta = 0$) or only all bad bonds default ($\bar{\rho} = 1/2$, $\Delta = 1$). Uncertainty will be higher, the closer are the pre-screening expectations to $1/2$ and the smaller is Δ, implying that the individual default probabilities of good and bad bonds are further away from their boundaries. Finally, the maximum degree of uncertainty is reached if $\bar{\rho} = 1/2$ and $\Delta = 0$.

From the special case $\bar{\rho} = 1/2$ and $q = 0$, which is associated with a persistent rating split irrespective of the actual uncertainty level σ_π^2, we can already conclude that rating splits are not always a good proxy for uncertainty. Beyond this, we can infer from Lemma 1 and (5)

Proposition 2: *Assume there is a requirement that for any given signal, a rating split should occur only if σ_π^2 is above a certain threshold. This requirement will only be met if $\bar{\rho}$ and q are given with $\bar{\rho} \in (\hat{\rho}_1, \hat{\rho}_2]$ and $q > \frac{\max\{\bar{\rho} - \hat{\rho}_1, \hat{\rho}_2 - \bar{\rho}\}}{\min\{\bar{\rho}, 1 - \bar{\rho}\}}.$*

To ensure that rating splits are a meaningful proxy for bond uncertainty, we need to control for the quality q of the screening technology as well as for pre-screening expectations $\bar{\rho}$. Controlling for these variables implies that changes in bond uncertainty reflect changes in the heterogeneity Δ of the bonds' default probability. The signal quality q must be large enough. Otherwise, changes in Δ (and thus changes in the level of uncertainty) would not affect post-screening expectations of the agencies (and thus ratings). Pre-screening expectations $\bar{\rho}$ must be at an intermediate level so that a pre-screening rating split will persist only if the bonds are relatively homogeneous, which will indicate a high level of uncertainty.

5 Conclusion

In empirical analyses, rating splits have been used as a proxy for opacity. However, the results of these analyses are frequently inconsistent with results of studies applying other measures of opacity (see introduction). By explicitly modeling a bond rating process, we have shown that it is not useful to proxy opacity or uncertainty about final returns by rating splits unless specific conditions are met. As for opacity, it must be possible to control for the average default probability over the bonds and for the heterogeneity of the bonds with respect to their default probabilities. As for the described uncertainty, it must be possible to control for the average default probability and, in addition, for the quality of the rating agencies' screening technology.

Appendix - Proof of Propositions 1 and 2

Recall from Lemma 1 that there will be a rating split only if

$$q\Delta \in [\phi_2, \phi_1) \qquad \text{for} \quad s = s_l,$$
$$q\Delta \in (-\phi_1, -\phi_2] \quad \text{for} \quad s = s_h, \tag{6}$$

where $\phi_i := 2(\bar{\rho} - \hat{\rho}_i)$ for $i = 1, 2$.

Proof of Proposition 1 From (4), we can infer that the requirement in Proposition 1

- will be met for some given $\bar{\rho}$ and Δ if rating splits occur only if $q \in [0, 1]$ (and thus $q\Delta \in [0, \Delta]$) is small; in conjunction with (6), this requires (see the proposition)

$$\phi_2 \leq 0 < \phi_1 < \Delta \qquad \text{for} \quad s = s_l,$$
$$\phi_1 > 0 \geq \phi_2 > -\Delta \quad \text{for} \quad s = s_h,$$

- will be met for some given $\bar{\rho}$ and q if rating splits occur only if $\Delta \in [0, 2\min\{\bar{\rho}, 1 - \bar{\rho}\}]$ (and thus $q\Delta \in [0, 2q\min\{\bar{\rho}, 1 - \bar{\rho}\}]$) is large; in conjunction with (6), this requires (which is infeasible)

$$0 < \phi_2 \leq 2q\min\{\bar{\rho}, 1 - \bar{\rho}\} \leq \phi_1 \qquad \text{for} \quad s = s_l,$$
$$0 \geq \phi_1 > -2q\min\{\bar{\rho}, 1 - \bar{\rho}\} \geq \phi_2 \quad \text{for} \quad s = s_h,$$

- cannot be met for some given Δ and q, that fully fixes σ_ρ^2.

Proof of Proposition 2 From (5), we can infer that the requirement in Proposition 2

- cannot be met for some given $\bar{\rho}$ and Δ, that fully fixes σ_π^2,

- will be met for some given $\bar{\rho}$ and q if rating splits occur only if $\Delta \in [0, 2\min\{\bar{\rho}, 1 - \bar{\rho}\}]$ (and thus $q\Delta \in [0, 2q\min\{\bar{\rho}, 1 - \bar{\rho}\}]$) is small; in conjunction with (6), this requires (see the proposition)

$$\phi_2 \leq 0 < \phi_1 < 2q\min\{\bar{\rho}, 1 - \bar{\rho}\} \quad \text{for} \quad s = s_l,$$

$$\phi_1 > 0 \geq \phi_2 > -2q\min\{\bar{\rho}, 1 - \bar{\rho}\} \quad \text{for} \quad s = s_h,$$

- will be met for some given Δ and q if there exists some x such that rating splits occur only if $\bar{\rho} \in \left[\frac{1}{2} - x, \frac{1}{2} + x\right]$, which is in conflict with (6).

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