
Andreas Krause
Collaterised debt obligations
NEW YORK STOCK EXCHANGE
LIVERMORE

- We now consider the valuation of another credit derivative that was widely used until the Great Financial crisis of 2007/8, the Collaterised Debt Obligation.
- These CDOs were not developed as a tool to hedge credit risk directly, but allowed banks to sell risky loans to investors not seeking a large exposure to credit risk.
- To do this, only some part of the loan was sold, the remainder retained by the bank. The derivative was constructed such that those parts sold off were supposed to be nearly free of credit risk and most credit risk retained by the bank.

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Tranching losses

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- Fixed income assets can include mortgages

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→ We will not oitline the principles on which such CDOs can be valued.

- In principle, CDOs are bonds and they bear a coupon payment, similar to ordinary bonds.
- The repayment of the bond is uncertain, however, as it will depend on the losses from defaults of the original loas that have accumulated.

- It is this coupon payment, which if the CDO is sold at face value determines the yield that constitutes the 'price' of the CDO, it represents the yield of the bond (CDO).
- The pricing principle is that the expected repayment of the CDOs, consisting of the coupon payments and the final repayment of the bond, has to be the same as that of a risk-free bond with the same maturity.
- While making such a calculation is not trivial, it can be conducted using numerical methods, and we obtain a yield of the CDO, which will consist of the risk-free rate and a spread to account for the risk of the CDO.

→ Conducting this pricing itself is more difficult in practice as the following considerations show.

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Pricing collaterised debt obligations

- Collaterised debt obligations are structured like ordinary bonds with a coupon payment

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→ We will not oitline the principles on which such CDOs can be valued.

- In principle, CDOs are bonds and they bear a coupon payment, similar to ordinary bonds.
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- First each of the loans that is included into the CDO will have a different probability of default, which should be considered in the derivation of the spread.
- As a simplification, it is assumed that all default rates are identical, such as the average default rate.

- We also need to consider the correlation of defaults across the different loans as they will have an impact on the distribution of the number of defaults we have in a CDO.
- Correlations will be different between loans, but we make the simplification that all correlations are identical, using the average correlation.

- We have to consider not only the case that a tranche is not repaid fully with a fixed recovery rate as in the case of CDSs,
- or it being repaid in full,
- But a tranche might be partially repaid if the losses accumulated have exceeded the amount of more junior tranches, but there are not sufficient defaults to eliminate the tranche considered fully.
- We will therefore have to consider the number of defaults in a tranche; this is where the correlation of defaults becomes relevant.

- Such pricing is complex to model and the spread of a CDO will in general be determined using computer simulations, also called Monte-Carlo simulations. What we effectively do is we use the probabilities of default and correlations across the assets and then through the use of random losses from the resulting distribution generate the payments an investor in the CDO would get and set the spread such that the average payment matches that from a risk-free bond.

→ We will not look at the details of this technique to determine the CDO spread, but will instead look

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Additional considerations in pricing CDOs

- The pricing is conducted similarly to credit default swaps, but additional factors have to be taken into account
- The fixed income instruments have different default rates, but it is commonly assumed default rates are identical
- The defaults of the fixed income instruments will be correlated, it is commonly assumed correlations are identical
- A tranche may be not repaid at all, fully repaid, or partially repaid, depending on the number of defaults of the entities included
- Using Monte-Carlo simulations, the spread of CDOs can be determined

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Additional considerations in pricing CDOs

→ The pricing of CDOs is much more complex than for CDSs as the payments ro investors are affected by a number of other concerns.

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  - However, there are a number of factors that complicate the derivation of the spread.
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Key drivers of CDO spreads

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Key drivers of CDO spreads

→ We will not look at the way such Mone-Carlo simulations can be conducted, but instead will immediately focus on the key results that emerge out of such an analysis of the spread.

- It is not surprising that a higher default rate will increase the spread incerasing. This is due to the higher risk of an investor making losses from such more frequent defaults. This applies to tranches of all seniority.
- We find that the effect of the correlation of defaults on the spread of CDOs depends on the seniority of the tranche we consider.
- We observe that the spread of the most senior tranches are increasing in the correlation of defaults.
- We observe that the spread of very junior and equity tranches are decreasing in the correlation of defaults.
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  - The spread of intermediate tranches are initially decreasing in the correlation of defaults,
  - but then once the correlation of defaults is sufficiently high, increase again.

→ We can now illustrate the size of the spread graphically.

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Key drivers of CDO spreads

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Key drivers of CDO spreads

- Higher default rates increase the spread due to the increased risk
- Higher correlations have an ambiguous effect on the spread

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Key drivers of CDO spreads

- Higher default rates increase the spread due to the increased risk
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- For senior tranches the spread is increasing in the correlation

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- Mezzanine tranches have an initial decrease

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Spread of collaterised debt obligations

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Spread of collaterised debt obligations

→ We consider here the spread of a CDO as an example to illustrate the results introduced before.

- The consider the spread of the CDO as determined by different correlations of defaults (we only consider positive correlations) and the seniority of tranches, where 0 denotes the equity tranche and 1 the most senior tranche.
- We see here that the spread reduces for junior tranches as the correlation increases, while the spread increases for senior tranches. Of course, the spread os more senior tranches is lower than for more junior tranches as the junior tranches bear any losses from default first.

→ We will now seek to provide a rational for this result.

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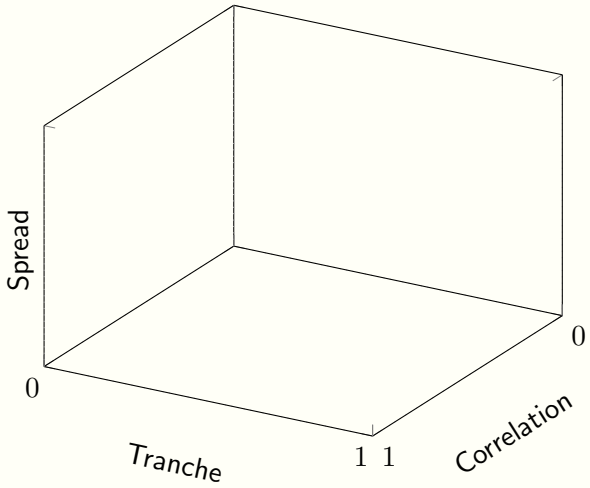
Spread of collaterised debt obligations



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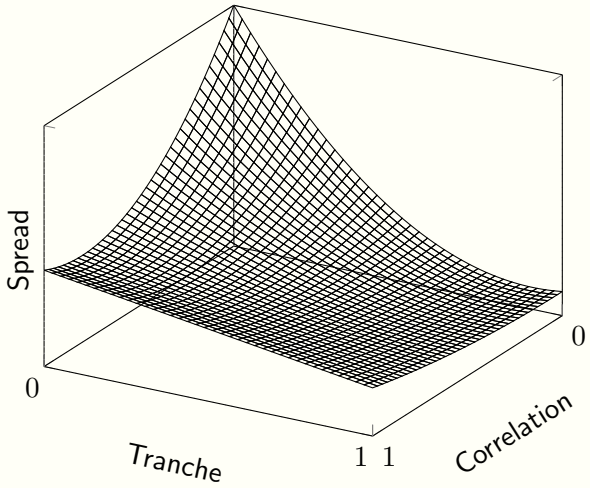

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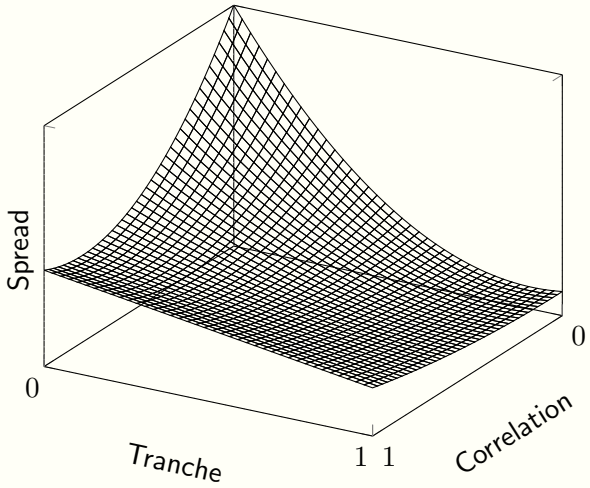

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Defaults and correlation

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Defaults and correlation

→ We will now look at the impact different correlations have on the spread of different CDO tranches.

▶
- If the correlation increases, then the likelihood of having no default at all is increasing. Suppose the correlation is 1; in this case either all loans default or all loans do not default, there will be no case of some loans defaulting. This now means that there is a reasonable chance of the equity tranche not suffering any losses; this change is the probability of the loans not defaulting. If ont he other hand, the correlation is lower, there will most likely be some losses as we can have situations where a small number of loans default while other do not default; it is very unlikely that no loan will default if the correlation is low. It is therefore very likely that the equity tranche will face a loss.
- Thus a lower correlation implies a higher loss to the equity tranche and this will result in a higher spread as the correlation increases.

▶
- The same mechanism works in the opposite direction for senior tranches. With a correlation of 1, the loans will either all be repaid or none is repaid.
- This is a situation of either all loans default or no loan defaults.
- With lower correlations, the chances of all loans defaulting is very low, less than with a correlation of 1. This implies that the spread with a high correlation should be higher as the losses are higher.

▶
- For intermediate tranches, mezzanine tranches, both effects are relevant and we see that the initially the effect reducing the spread is stronger. An increase in the correlation makes it less likely that they are affected by losses to their tranches.
- Once the correlation is sufficiently high, the effect increasing the spread dominates.

→ We can now illustrate the effect the correlation of defaults has on the fraction of defaults and hence the spread of the CDO tranches.

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Defaults and correlation

- As the correlation increases, the likelihood of no losses at all increases

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Defaults and correlation

- As the correlation increases, the likelihood of no losses at all increases, reducing the spread of the equity tranche

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Defaults and correlation

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Defaults and correlation

- As the correlation increases, the likelihood of no losses at all increases, reducing the spread of the equity tranche
- At the same time the probability of high losses increases ("all-or-nothing")

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Defaults and correlation

- As the correlation increases, the likelihood of no losses at all increases, reducing the spread of the equity tranche
- At the same time the probability of high losses increases ("all-or-nothing"), causing the spread of senior tranches to increase

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- At the same time the probability of high losses increases ("all-or-nothing"), causing the spread of senior tranches to increase
- For intermediate correlations, these two effects combine and as the correlation increases, the spread initially decreases

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- For intermediate tranches, mezzanine tranches, both effects are relevant and we see that the initially the effect reducing the spread is stronger. An increase in the correlation makes it less likely that they are affected by losses to their tranches.
- Once the correlation is sufficiently high, the effect increasing the spread dominates.

→ We can now illustrate the effect the correlation of defaults has on the fraction of defaults and hence the spread of the CDO tranches.

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Defaults and correlation

- As the correlation increases, the likelihood of no losses at all increases, reducing the spread of the equity tranche
- At the same time the probability of high losses increases ("all-or-nothing"), causing the spread of senior tranches to increase
- For intermediate correlations, these two effects combine and as the correlation increases, the spread initially decreases and then increases again

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Defaults and correlation

→ We will now look at the impact different correlations have on the spread of different CDO tranches.

▶
- If the correlation increases, then the likelihood of having no default at all is increasing. Suppose the correlation is 1; in this case either all loans default or all loans do not default, there will be no case of some loans defaulting. This now means that there is a reasonable chance of the equity tranche not suffering any losses; this change is the probability of the loans not defaulting. If ont he other hand, the correlation is lower, there will most likely be some losses as we can have situations where a small number of loans default while other do not default; it is very unlikely that no loan will default if the correlation is low. It is therefore very likely that the equity tranche will face a loss.
- Thus a lower correlation implies a higher loss to the equity tranche and this will result in a higher spread as the correlation increases.

▶
- The same mechanism works in the opposite direction for senior tranches. With a correlation of 1, the loans will either all be repaid or none is repaid.
- This is a situation of either all loans default or no loan defaults.
- With lower correlations, the chances of all loans defaulting is very low, less than with a correlation of 1. This implies that the spread with a high correlation should be higher as the losses are higher.

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- For intermediate tranches, mezzanine tranches, both effects are relevant and we see that the initially the effect reducing the spread is stronger. An increase in the correlation makes it less likely that they are affected by losses to their tranches.
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→ Let us now consider the fraction of defaulting loans in a CDO for a low and a high correlation.

- We look at the distribution of the fraction of defaults (density).
- Let us first consider the case of a low correlation. The underlying variable has Bernoulli distribution in that it is either default or not default. If these defaults are independent of each other, thus have a correlation of zero, combining a large number of such loans will result in a binomial distribution with a mean at the probability of default, which we had assumed to be identical for all loans.
- If we increase the correlation, the outcomes (default and no default, respectively), become more and more alike. With a high correlation it will be the case that either most loans are not defaulting or most loans are defaulting, it will be quite unlikely to be that some loan default, while others do not default; this gives rise to the shape of the distribution is indicated here.

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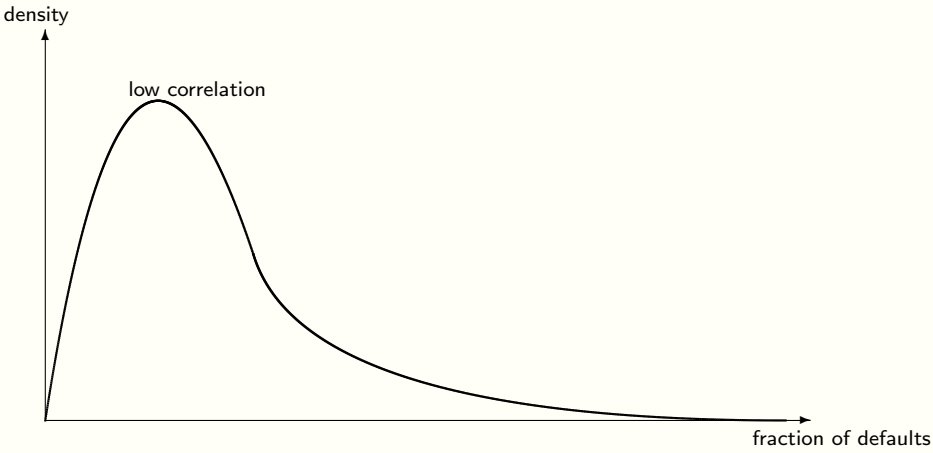

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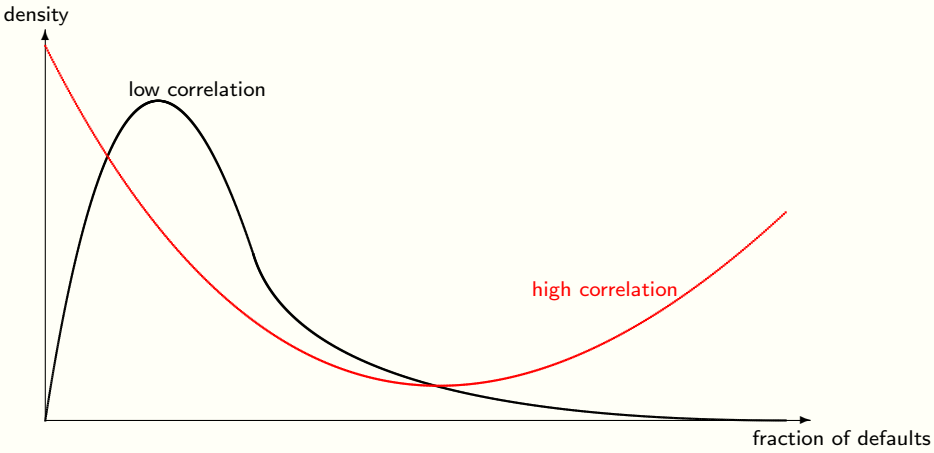

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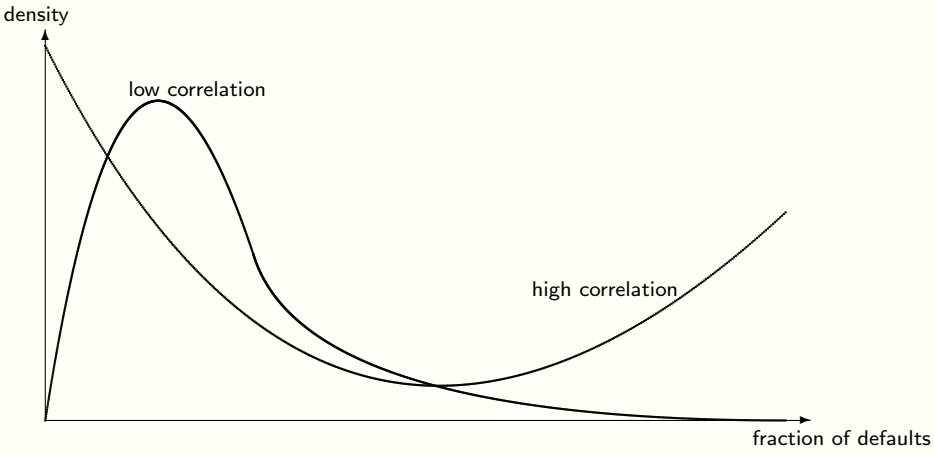

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- Overall, the risks to the value of a CDO are complex and not easy to determine as the effects also depend on the seniority of the tranches, as well as the interaction between default probabilities and the correlation of default.

→ The absence of analytical solutions to the value of CDOs makes it difficult for investors to evaluate risks and the complexity of the interactions between default rates and correlations, makes a proper risk assessment difficult. With both parameters changing and often in the same direction, it the magnitude of the effect any changes have are difficult to predict and hedging against adverse movements become difficult.

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- It is intuitu=ive clear that a higher default rate will increase the spread; or for a given spread, an increase in the default rate will reduce the value of all tranches.
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- What the impact is depends on the seniority of the tranche, a more senior tranche is likely to require a higher spread if the correlation increases, while a junior trance is likely to require a lower spread. Thus if the correlation increases, for a given spread, the value of a senior CDO tranche reduces while that of a junior tranche increases.
- Overall, the risks to the value of a CDO are complex and not easy to determine as the effects also depend on the seniority of the tranches, as well as the interaction between default probabilities and the correlation of default.

→ The absence of analytical solutions to the value of CDOs makes it difficult for investors to evaluate risks and the complexity of the interactions between default rates and correlations, makes a proper risk assessment difficult. With both parameters changing and often in the same direction, it the magnitude of the effect any changes have are difficult to predict and hedging against adverse movements become difficult.

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