

Chapter 1

Introductions

On April 2, 2007, New Century Financial Corporation, the second-biggest subprime mortgage lender in the United States, and its related entities filed voluntary petitions for reorganization under the bankruptcy laws in the United States. New Century Financial Corporation listed liabilities of more than \$100 million and announced that the employment of about 3,200 people, more than half the workforce, will be terminated. During the week of July 16, 2007, the Bear Stearns Company, one of the largest global investment banks and securities trading firms in the world, disclosed the two subprime hedge funds which had lost nearly all of their value amid a rapid decline in the market for subprime mortgages.

These just announced the beginning of the Subprime mortgage crisis. This crisis was stemmed from several reasons: First, the rising of the floating subprime rate, which made the debtors insolvent and the bursting of the US housing bubble; Second, the subprime mortgage were rolled into Mortgage Backed Securities (known as MBSs) by banks and were sold to brokerage firms. These securities were re-splited and packaged as CDOs, it caused such kinds of the structure of credit derivatives were too complicated to be aware of the risk; Third, the most important reason for the reaserch in this article, because of these derivatives lacking of historical rating records, the mathematical pricing models became the only basis for rating; Finally the investors, such as investment banks, retirement funds, hedge funds, municipal funds and administrative funds, bought these credit derivatives according to the rate given by rating agencies. During 2006, about \$100 billion subprime mortgages were packaged in nearly \$ 375 billion CDOs and then were sold on the U.S. market. Many banks, mortgage lenders, real estate investment trusts (REITs), and hedge funds suffered significant losses as a result of mortgage payment defaults or mortgage asset devaluation. As of April 30, 2008 financial institutions had recognized subprime-related losses or write-downs exceeding U.S. \$280 billion.

In this article, we hope to find a model more precise than one factor double normal inverse Gaussian (NIG) copula model to estimate the fair prices for CDOs. We first provide one extension for the one factor model with closed skew normal (CSN) distribution under LHP assumption. Different from normal distribuiton, the CSN distribution includes more parameters to control the location, scale and shape of the distribution function and with more flexibility. Simultaneously, it also retains the

closure property just the same as the normal distribution. However, we still do not get satisfied results for the one factor double CSN copula model. It just brings a little improvement for pricing senior tranches, but it seriously overprices the junior and mezzanine tranches. On the other hand, the one factor double NIG copula model provides an excellent fitting price in the junior tranche. Therefore, we mix these two distributions and then replace the Gaussian distribution with it. we compare the numerical results of the one factor double mixture distribution copula model with those of the Gaussian and NIG factor copula models, the fair price for each tranche is more precise.

This article is organized as follows: In Chapter 1 we introduced some expositions for CDOs, such as asset securitization, credit default swap and CDS index. We then make some brief introductions for several CDOs pricing models from early research in Chapter 2. Kalemanova, Schmid and Werner (2007) originated the one factor double NIG copula model. In order to proceed with our article, we make a brief review of the one factor double NIG copula model and the properties of the NIG distribution in Chapter 3. In Chapter 4 we present two extensions for one factor double Gaussian copula model by replacing the normal distribution with closed skew normal distribution and mixture distribution of NIG and CSN distributions. Finally, in the last chapter we compare numerical results of pricing synthetic CDO tranches of the iTraxx with four different models (Gaussian, NIG, CSN and mixture distribution).

1.1. What Does Asset Securitization Means?

Asset securitization means enterprises or financial institutions collect and package assets with cash flows, then issue securities to the investors. Therefore, enterprises or financial institutions can raise funds form this process. Asset securitization helps to shape the future of traditional commercial banking. By using the securities markets to fund portions of the loan portfolio, banks can allocate capital more efficiently, access diverse and cost-effective funding sources, and better manage business risks.

Collateralized debt obligations (CDOs) are kinds of well known credit derivatives for asset securitization. We can see the classification illustration as follow.

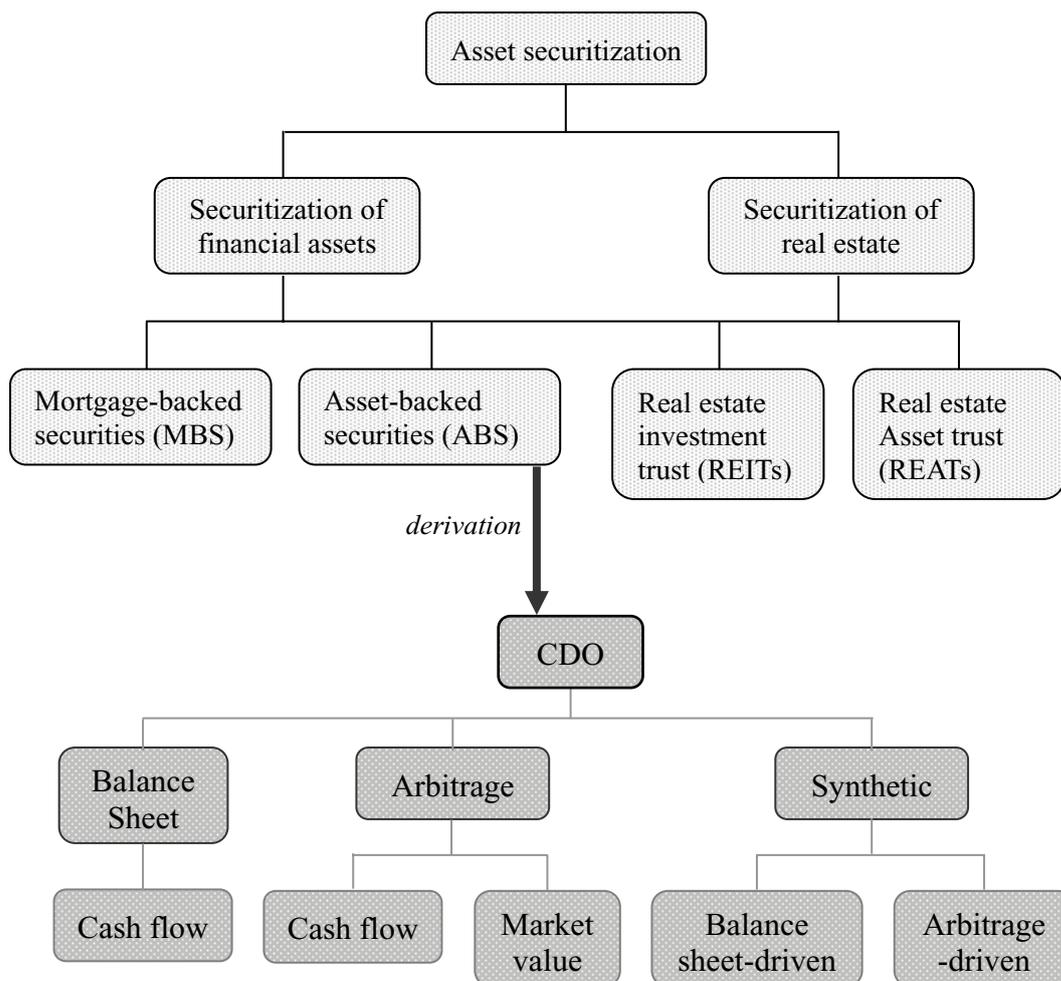


Figure 1: The classification chart of asset securitization. CDOs are the derivatives of asset-backed securities.

1.2. Collateralized Debt Obligations

Collateralized debt obligations (CDOs) are derived from Asset-backed securities. Such a credit derivation is a security backed by a diversified pool of one or more kinds of debt obligations, such as bonds, loans, credit default swaps, mortgage-backed securities, asset-backed securities, and even other CDOs.

A CDO is a way for creating securities with widely different risk characteristics from a portfolio of debt instruments. CDOs are constructed from a portfolio of fixed-income assets. These assets are divided into different tranches: senior tranches (rated AAA), mezzanine and junior tranches (AA to BB), and equity tranches (unrated). Losses are applied in reverse order of seniority, thus junior tranches offer higher coupons (interest rates) to compensate for the added default risk. CDOs serve as an important funding vehicle for fixed-income assets. The payoff of premium and

principal are first received by the investors of the senior tranche, then the mezzanine tranche, junior tranche, and finally the equity tranche.

The issuer of the CDO normally retains the equity tranche and sells other tranches to the market. A CDO provides a way of creating high quality debts from average quality (or even low quality) debts.

CDOs are initiated by an originator (or a sponsor). Then the originator sells the asset pool to a special purpose vehicle (SPV). Then the SPV re-splits and packages the reference portfolio and issues debt obligations (tranches/credit-linked notes) to investors. The structure of CDO is presented below:

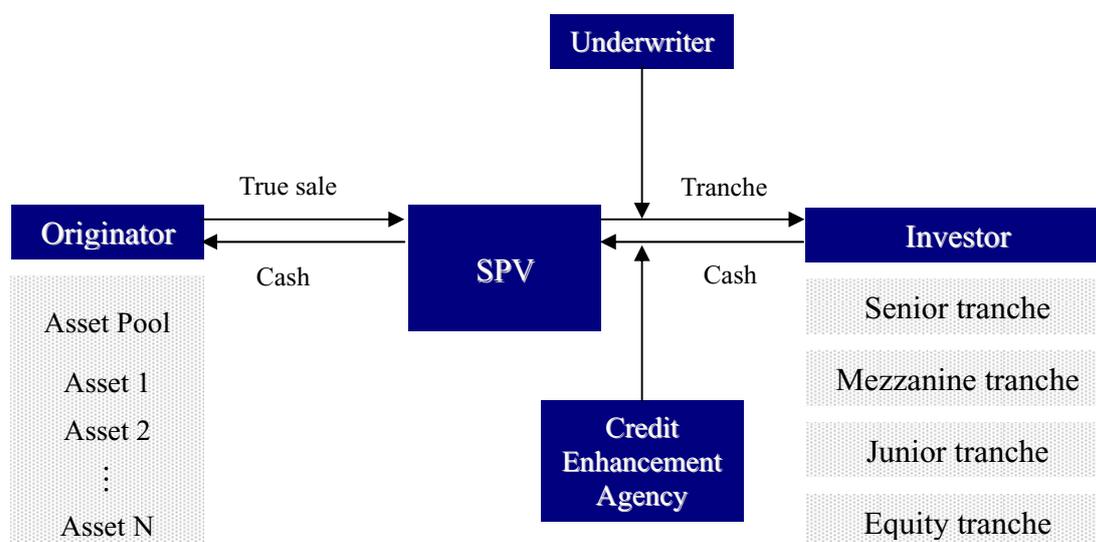


Figure 2: The structure of CDOs.

1.2.1. Synthetic CDOs

The CDO introduced above is referred to as a cash CDO. An alternative popular structure is a synthetic CDO. The originator of a synthetic CDO sells a portfolio of credit default swaps to third parties, then passes the default risk to the synthetic CDOs' tranche holders. But tranche holders do not truly have the reference obligations. This is the main difference between cash CDOs and synthetic CDOs. Because SPVs receive a large of cash at beginning, and they needn't pay oringnators initially. Then SPVs invest other stable products as a collateral pool (ex. government bonds etc.), hence they can afford the compensation if the credit event occurs. We can see the structure of synthetic CDOs from the following chart:

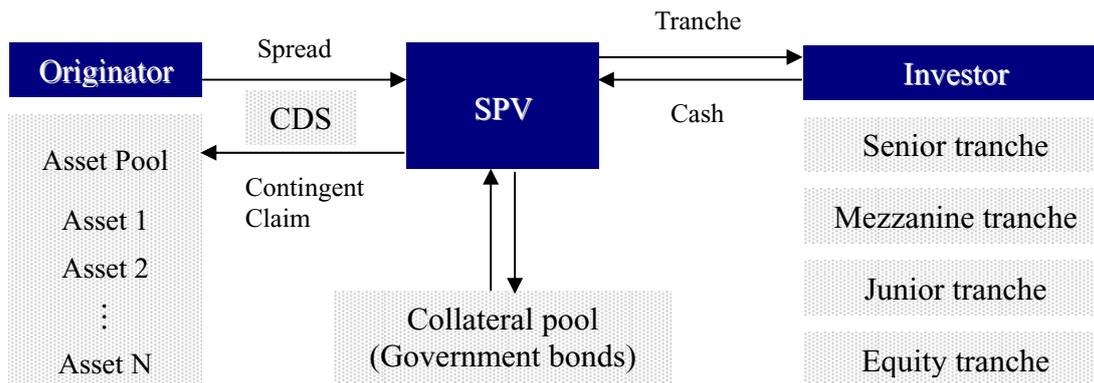


Figure 3: The structure of synthetic CDOs.

1.3. Credit Default Swaps

The Credit default swap (CDS) is one of the most popular credit derivatives. This is a contract that provides insurance against the risk of a default by a particular company (reference entity). The buyer of the insurance obtains the right to sell bonds issued by the company for their face value and the seller of the insurance agrees to buy the bonds for their face value when a credit event occurs.

The buyer of the CDS makes periodic payments to the seller until the end of the life of the CDS or until a credit event occurs. These payments are typically made in arrears every quarter, every half year, or every year. The settlement in the event of a default involves either physical delivery of the bonds or a cash payment.

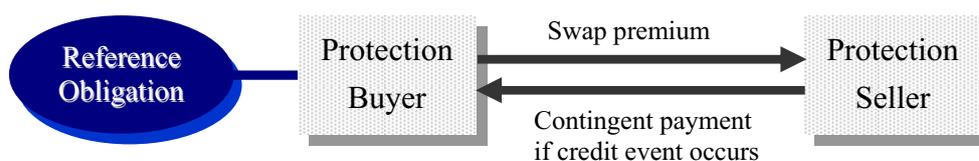


Figure 4: The flow chart of credit default swaps

1.3.1. Credit Default Swaps Index

Participants in credit derivatives markets have developed indices to track credit default swap spreads. The credit default swap index (denoted by CDX) is made up of reference credits which are judged by a poll of dealers to be the most liquid entities in the single name credit default swap market, and each name is equally weighted in the

reference portfolio. A credit default swap index contract provides protection against the credit risk of a standardized basket of reference entities. The mechanics of a CDX are slightly different from that of a single-name CDS. If a credit event occurs, the swap premium payment ceases in the case of a single-name CDS. In contrast with it, for a CDX the swap premium payment continues to be made by the protection buyer but based on a reduced notional amount since less reference entities are being protected. The index premium payments are standardized quarterly in arrears on the 20th of March, June, September, and December of each calendar year. Besides, it can be cheaper to hedge a portfolio of credit default swaps with a CDS index than it would be to buy many CDS to achieve a similar effect.

The composition of reference entities included in a CDX is renewed every six months based on the vote of participating dealers. The start date of a new version index is referred to as the roll date. The roll date is March 20 and September 20 of a calendar year or the following business days if these days are not business days. A new version index will be “on-the-run” for the next six months. The composition of each version of a CDX remains static in its lifetime if no default occurs to the underlying reference entities, and the defaulted reference entities are eliminated from the index.

The CDXs have many attractive properties for investors. Compared with the single-name swaps, the CDXs have the advantages of diversification and efficiency. In comparison with basket default swaps and collateralized debt obligations, the CDXs have the advantages of standardization and transparency. The CDXs with low bid-ask spreads are traded more actively than the single-name CDSs.

There are currently two main families of CDS indices: CDX and iTraxx. CDX indices contain North American and Emerging Market companies and are administered by CDS Index Company (CDSIndexCo), and iTraxx contain companies from the rest of the world and are managed by the International Index Company (IIC). The main credit default indices in derivatives markets are presented in Table 1:

Besides directly investing the CDXs via CDSs on the index or on a subindex, it is also possible to invest in standardized tranches of the CDXs via the credit default index tranches, and this is also a kind of synthetic CDO on a static portfolio. In next chapter, we make the literature review of some models for pricing CDOs.

Index	region	sector	Number of names/assets
Dow Jones CDX NA IG	North America	Investment grade ¹	125
Dow Jones CDX NA HY	North America	high yield ²	100
Dow Jones CDX NA IG HVOL	North America	investment grade (volatile names)	30
Dow Jones CDX NA XO	North America	high yield/ Investment grade	35
iTraxx Europe	Europe	investment grade	125
iTraxx Europe HiVol	Europe	investment grade (volatile names)	30
iTraxx Europe Crossover	Europe	high yield/ Investment grade	45
iTraxx CJ	Japan	investment grade	50
iTraxx Asia ex-Japan	Asia	mainly investment grade	50
iTraxx Australia	Australia	investment grade	25

Table 1: The main credit default indices in derivatives markets.

Resource: Credit flux

Overall index spread	iTraxx Europe Series 5 (5 years)		CDX.NA.IG Series 6 (5 years)	
	34.8 bps		45.8 bps	
	Spread	Correlation	Spread	Correlation
0%-3%	26%	9.9%	35%	9.4%
3%-6%	87 bp	19.6%	126 bp	22.9%
6%-9%	24 bp	26.9%	29 bp	30.8%
9%-12%	11 bp	33.0%	14 bp	41.3%
12%-22%	5 bp	49.4%	5 bp	65.4%

Table 2: CDS index tranche spread and base correlation quoted in market – June 23, 2006

Resource: Nomura Fixed Income Research <http://www.nomura.com/research/s16>

¹ It is also known as high grade, a credit rating of Baa3 (Moody's), or BBB- (Standard and Poor's or Fitch Ratings) and above. Many investors are prohibited from investing in debt without an investment grade rating. The boundary between investment grade and high yield (sub-investment grade) is therefore an important technical factor that can affect the level of credit spread.

² Also known as subinvestment grade or junk, a credit rating of below Baa3 (Moody's) or BBB- (Standard and Poor's or Fitch Ratings).