Collateralized Debt Obligation and its impact to the financial crisis

Susann Engelmann*

Abstract

Despite of the broad discussed advantages of securitization in literature, huge negative effects appear in terms of SF CDOs, especially in relation to structure and valuation (Rating) as happened in the current financial crisis. This paper investigates how CDOs could encourage the crisis in terms of liquidity and confidence. The results show that model risk, failures in parameter estimation and an insufficiently considered systematic risk implies huge downgrades in economic downturns, whereas in economic upturns these instruments encourage financial stability.

Keywords: collateralized debt obligations (CDOs), rating, liquidity crisis

*PhD-Candidate at the University of Kassel, Department of Economics , Germany; engelmann@wirtschaft.uni-kasel.de.
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1. Introduction

"Many people argue that derivatives reduce systemic problems, in that participants who can't bear certain risks are able to transfer them to stronger hands. These people believe that derivatives act to stabilize the economy, facilitate trade, and eliminate bumps for individual participants. And, on a micro level, what they say is often true. [...] however, [...] the macro picture is dangerous."

Warren Buffet (2003)

Since 2007 the probably most known word "toxic securities" appeared daily in headlines of newspapers for instance the Financial Times ("Rally in 'toxic' securities set to boost banks", 09/27/2009). Warren Buffet already labeled credit derivates in his shareholder letter of 2003 as "*financial weapons of mass destruction"*. At this time he and his associate Chareles Munger were aware of what is in the today's public controversies. They mentioned that a "witch's cauldron" comprising cheap credits, lax regulation and large yields of banks indicate a bubble which finally busted on the 15th July 2007 by downgrading 131 ABS products through Moody's, mainly backed by subprime mortgages. These highly complex structured finance products include Collateralized Debt Obligations, which have to be partly blamed for the current financial crisis in addition to rating agencies. Until-mid 2009 news concerning billions of write-offs referring to CDO tranches, which had massive losses in value, were announced on a daily basis. The most important investment banks, like Merrill Lynch incurred losses through CDOs and their hedging contracts (CDS) about $ 27 billion in 2007/2008 (Keoun & Harper 2008). Major Banks for instance Credit Suisse (totally $ 2.65 billion) resp. Société Générale ($ 1.4 billion in 4.Q/2010) suffered further billions of losses (FAZ 2008 / Alich 2010).

Consequently, the question arises how these products could contribute to instability of financial markets as studies for instance Jobst (2003), Krahnen (2005), Rudolph (2007) or Duffie (2008) attribute them strengthening financial stability. Münchau (2009) denotes CDOs as the most dangerous instruments traded. However, what sets these structured products so risky? Rudolph (2007) points out three advantages: perfection of capital markets in lowering transaction costs, increasing liquidity, restrictions of debtors and lenders; completion of capital markets int. al. market access for investors having different risk profiles; improvement of information efficiencies. It is revealed that SF products imply a risk diversification effect providing stability, which also triggers incentive issues, for instance lower mentoring by banks, based on their originate-to-distribute policy. Contagion effects emerge as insurers are less

regulated than banks and a shift of risk to the insurers which results in counterparty risk. Duffie (2008) confirms that CDOs disperses risk to various investors and also out of the banking system to institutional investors, hedge funds or equity investors which encourage financial stability. Brigo et al. (2010) supports the statement that special limits and threat of rating models are well known in literature however, systems which are fully implemented in libraries of banks are hard to change. Moreover they state that the following issues were ignored: originate-to-distribute system, possible supervisory oversight and regulatory errors.

The goal of the paper is to analyze the complex issues of Structured Finance CDOs caused by rating models. To demonstrate which mistakes are made the valuation methods of the big three rating agencies will be analyzed. It is carried out that model risk and errors in parameter estimates leads to underestimation of default risks and default times, which are the two core weaknesses of these models.

2. Characterization of CDOs

According to the common literature CDOs can be divided into ***conventional CDOs*** (true sale securitization) and ***synthetic CDOs*** (synthetic securitization). Employing a true sale or synthetic structure depends on which way the credit risk of an underlying portfolio is transferred to a Special Purpose Vehicle (SPV).[2] The former occurs if assets of the portfolio are fully transmitted, also called *off balance sheet transaction*. In the case of synthetic structures only the credit risk is transferred partially (Total Return Swaps) or fully (Credit Default Swaps, Credit Linked Notes). The underlying pool remains in the possession of the originator and will not be separated from its balance sheet (*on balance sheet transaction*) (Jortzik 2006, pp. 15-18). Depending on its underlying CDOs are further classified into ***Corporate CDOs*** (CBOs, CLOs) and ***SF CDOs*** (ABS CDOs, CDO-squared). Those transactions are arranged in accordance to the choice of risk transfer, purpose, credit structure, kind of management and assets chosen for the underlying pool (CGFS 2005, p. 5).

<u>Arbitrage vs. balance sheet</u>

Balance sheet transactions are characterized by selling a defined pool of assets from an issuer's balance sheet to third parties/CDO in order to manage risk, raise lending capacity, and reduce regulatory capital requirements and cost of funding (Cheng 2002, p. 2). Hence, balance sheet clean-up of banks become possible as they are bound to hold high regulatory capital for

[2] That implies a broader classification of CDOs into conventionally (true sale) and synthetic structure (Jortzik 2006, pp. 15-19.

risky assets. True sale balance sheet CDOs facilitate reducing regulatory capital requirements whereas synthetic balance sheet CDOs aim to allow an issuer the hedging of its credit risks by CDS. Within an ***arbitrage transaction*** Asset Manager resp. Investment banks buy parts of underlying pools for arbitrage purposes only, in order to exploit price differences between acquisitions cost of assets from the collateral pool in the secondary market and its sales value. Meaning, there are valuation differences between securitized assets and issued notes of CDO tranches. To obtain arbitrage based revenues active trading within market value structures or buy-and-hold investments in assets through different payment terms within a cash flow structure are required. Whereas in the first of these variants the asset manager focuses on expectations regarding appreciation and high yield, he compares incoming cash flows of securitized assets to payment liabilities in the second one (Jobst 2007, pp. 10-11). For instance Arbitrage CDOs benefit from differences between returns of high-yield assets and returns of issued triple-A senior tranches (Birmili 2007, p. 15).

Cash flow vs. market value

Market value transactions involve an asset pool rated market-to-market periodically and are actively managed by a portfolio manager to increase the underlings' cash flow in applying a buy-and-hold strategy. Its performance largely depends on the manager's ability to hold and improve the collateral. Hence, principal and interests can be served by generating cash through active and flexible trading, meaning targeted purchase and sale of underlying assets and generating interest by invested assets. As a mandatory part of market value CDOs Overcollateralization-test[3] (O/C ratio) are based on the market value of the underlying portfolio (Tavakoli 2008, p. 124). ***Cash flow transaction*** settles interest and principal of individual tranches by cash flows from the underlying assets without active trading by a manager who acts within a set of trading limitations (*passive buy-and-hold strategy*). Further limitations are made in the composition of the underlying portfolio by the rating agency that rates it (Fabozzi et al. 2007, p. 10 / Goodman et al. 2005, p. 674). The compliance with these requirements is reviewed through coverage- and quality-tests[4]. Cash Flows are distributed by the waterfall-principal after taxes and fees for int. al. trustees, servicers and registration (Appendix 1). In

[3] The O/C ratio for a tranche equals the principal balance of the collateral portfolio divided by the principal balance of that tranche and all tranches senior to it (Fabozzi et al. 2007, p. 13).

[4] Coverage tests protect investors of CDO tranches against losses of the underlying portfolio. There are two categories Overcollateralization test and Interest coverage tests (I/C ratio). The I/C ratio for a tranche is computed by dividing the scheduled interest due on underlying collateral portfolio by scheduled interest to that tranche and scheduled interest to all tranches senior to it (Fabozzi 2007, pp. 13-14).

the case of a shortfall in interest paid to senior tranches, capital yields have to be applied (Fabozzi et al. 2007, p. 11. / Goodman et al. 2005, p. 675).

Managed vs. Static

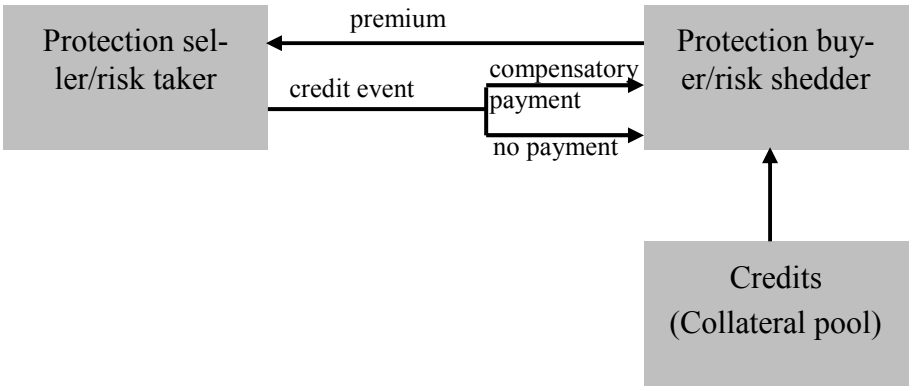
The majority of CDOs employ ***managed*** structures implying that assets for the collateral pool and substitution decisions are chosen by the collateral manager, who incorporates the following responsibilities: active trading within the reinvestment period due to the realization of capital gains, minimizing losses as well as administration and control of the portfolio within particular requirements. Therefore the manager has the possibility to use market opportunities and to anticipate or respond to credit events, meaning that he hold a significant key role regarding of a CDO transaction performance. ***Static CDOs*** typically employed for synthetic structures are a minority. By contrast to managed transactions there is no reinvestments of cash flows and asset exchanges (Cheng 2002, p. 11).

2.1. Synthetic CDOs

Synthetic CDOs (SCDO) are created to transfer credit risk from the originator (protection buyer) using credit derivate instruments (CDS, TRS, CLN) *directly* or *indirectly* via an SPV to the investor (protection seller). Arbitrage synthetic structures uses Total Return Swaps while balance sheet motivated synthetic CDOs apply to CDS and/or CLN. The assets itself remain in the originators balance sheet (Masek & Choudhry 2004, p. 580). SCDOs are further motivated by regulatory capital mitigation, meaning that assets protected by CDS will require lower regulatory capital under Basel II.

First, to fully understand a synthetic CDO a brief description of ***Credit Default Swaps (CDS)*** is required. The International Swaps and Derivates Association (ISDA) were responsible for CDS standardization by compiling market principles, industry-wide benchmarks and counterparty related requirements (Prince et al. 2005, p. 699). A CDS is a contract between a protection buyer (risk shedder) who pays a periodically premium to the protection seller (risk taker) who in return pays a compensatory payment in case of ex ante defined credit events (bankruptcy, failure to pay, restructuring of debts) (Rudolph et al. 2007, p. 68). The compensatory payment can be either *cash* or *physical settlement*. If the difference between the par value (initial price) of the reference portfolio and its market value after the event is paid from the risk taker to the risk shedder, cash settlement are employed whereas selling of securities in face value int. al. $ 10 million to the risk taker who in return pays $ 10 million to the risk shedder are known as physical settlement (Deutsche Bundesbank 2004b, p. 44).

Figure 1: Credit Default Swap



Source: Modified according to Rudolph et al. 2007, p. 69.

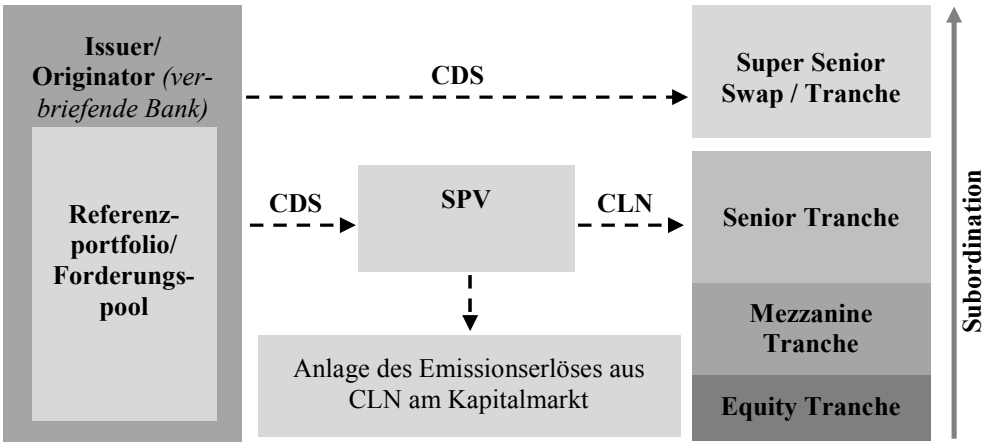
Synthetic CDO deals can be *unfunded, partially funded* or *fully funded*. ***Unfunded structures*** contain CDS contracts between the issuer (originator) and the SPV that in turn enters into a CDS contract with investors. No payment is made at the beginning of the transaction from protection seller to protection buyer, so that the risk taker depends on a SPVs ability to pay for losses during a SCDOs maturity. Instead, the protection buyer periodically makes premium payments to the SPV, which are transferred to investors according to tranching. In the event of defaults face values of the underlying portfolio are reduced and have to be remunerated by compensatory payments appropriate to tranches seniority (Prince et al. 2005, p. 701-702).

Fully funded synthetic CDOs incorporate a SPV to which the whole credit risk of the portfolio by means of CDS is transferred. The issuer enters into a CDS with the SPV whereas the SPV issues CLN that proceeds are invest in high quality securities, for instance risk-free government debt or triple-A ABS (Goodman 2002, p. 64-65). The Investor buys the CLN and therefore takes the credit risk. To ensure investor claims premium payments by the CDS and interest payments from the collateral pool have to be ensured. CLNs are usually issued in different tranches that are rated by rating agencies (Deutsche Bundesbank 2004a, p. 31). In the case of default events losses are covered by selling the proportional share of the collateral and current yield.

Partially funded SCDOs are the most common. Only up to 15% of the notional amount of the collateral pool is issued via CLN resp. funded by the SPV. The remaining unfunded amount called *super senior tranche* obtains a triple-A rating and is hedged by CDS (*Super Senior Swap*) (Goodman 2002, p. 67). A smaller amount app. 10% to 15% is invested in the Senior tranche (AA to AAA), Mezzanine tranche (BB to A) and Equity tranche (unrated). In those

structures the issuer enters into *two CDS contracts*. The first provide protection for losses regarding the portfolio amount issued by CLN and the second one for the super senior tranche that is increasingly done the last years by insurance companies like Monoliners (Prince et al. 2005, p. 702).

Figure 2: Partially funded SCDO



Source: Modified according to Deutsche Bundesbank 2004a, p. 31.

2.2. ABS CDOs

The first ABS CDO was issued in 1999 and backed by aircraft ABS, mutual fund fees, manufactured housing and franchise loan. Since 2003 these two-layer products are backed by SF securities of RMBS, CMBS, Home equity ABS and CDO tranches (Benmelech & Duglosz 2009, p. 13).

Table 1: Typical collateral composition of ABS CDOs (in %)

	High grade ABS-CDO	Mezzanine ABS-CDO
Subprime RMBS	50	77
Other RMBS	25	12
CDO	19	6
Other	6	5

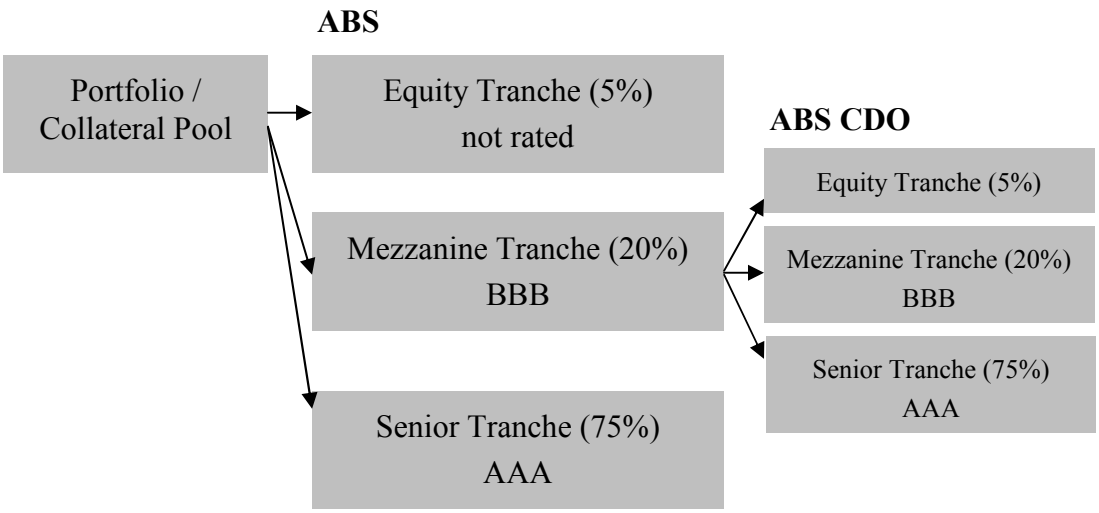
Source: BIS 2008, p. 37.

Depending on the quality of the collateral ABS CDOs are classified into two categories: ***High-Grade (HG)*** holding a collateral incorporating triple-A to A rated securities and ***Mezzanine (Mezz)*** holding BBB rated securities (BIS 2008, p. 49). The former imply a low credit spread, are highly leveraged and possess a larger deal size by $ 1 billion to $ 3 billion than

mezzanine structures with $ 300 million to $ 1.5 billion. The lower leverage of *Mezz ABS CDOs* is founded on a higher spread and low-rated collateral. This collateral primarily compromises mezzanine tranches of subprime RMBS and other structured products. These structures hold a below investment-grade limit of 5%. The ratings distribution of the collateral typically is 70% to 80% BBB and 20% to 30% A.

HG ABS CDOs are invested in highly-rated RMBS with a collateral pool of higher quality mortgages, for instance rather ALT-A than subprime and tranches of other CDOs (BIS 2008, p. 49). These collaterals obtain a WARF of 40% to 70%, to ensure a portfolio credit quality of AA – A. These CDOs often incorporates a Super Senior Tranche sized of 70% to 90% that is privately placed. Owing a investment-grade rating leads to the assumption that HG ABS CDOs will almost obtain a default likelihood of zero implying credit support for e.g. BBB notes below 1%. Nevertheless, that does not preclude minor faults for timing of cash flows and default risk (McManus et al. 2008, p. 208-210).

Figure 3: Typical Mezzanine ABS CDO Structure



Source: Modified according to Hull 2009, p. 658.

ABS-CDOs underlie various risk drivers. The Bank for International Settlement (2008) has classified ***three main risk groups***: asset-side risk, liability-side risk and effects of systematic and idiosyncratic risk. According to *asset side risk*, the study point out economic risk factors (nationwide house price appreciations) causes high portfolio losses due to simultaneous asset defaults. Meaning, that in the case of a well diversified portfolio with a large amount of small assets the idiosyncratic risk (underwriting standards of the mortgage originator, effectiveness of the mortgage pool servicer) will not occur but a higher correlation of pool looses to systematic risk. However, payouts of RMBS tranches are affected by both. But only returns of well

diversified portfolios are less volatile. Equally, asset quality can affect a portfolios return. Low-rated securities of Mezz ABS CDOs having a lower credit enhancement than high-rated securities of HG ABS CDOs and are more likely to suffer credit losses in times of economic insecurity. The Performance of CDO tranches also depends on *liability-side drivers*. That implies the CDO tranches attachment points and related credit enhancements determine investor claims on cash flows. Attachment points characterize a tranches position within the CDO capital structure which is directly connected to the volatility of collateral returns. The demand for protection to a CDO tranche for obtaining a certain target rating rises by an increasing volatility of the underlings return (BIS 2008, pp. 49-52). According to *systematic and idiosyncratic risk* BIS (2008) show that CDO tranches depends on a combination of systematic and idiosyncratic risk factors and perform well under most circumstances. However, the study reveals exemplary to Mezzanine RMBS that tranches sustain massive looses almost entirely in times of systematic stresses, which implies a positive correlation of collateral pools to systematic factors. The reason is that all RMBS within the collateral are subject to the same risk factors. Further it is proved that senior tranches are more sensitive to systematic shocks whereas idiosyncratic aspects have a lower influence (BIS 2008, pp. 53-55).

3. Analyses of valuation methods of the big three

Rating approaches of the "big three" rating agencies aim to value the risk and return of CDO transactions within a *two-stage process*[5] and underlie an ongoing review as well as continuously progression. As part of the financial crisis, main features of these highly controversial discussed *models of SF CDOs* will be explained in the next section which also points out the ex ante obviously mistakes (see 3.4). The three key input factors of CDO rating models are probability of default, expected loss and correlation.

3.1. Moody's Binomial-Expansion-Technique (BET) Approach

The most known quantitative approach to generate expected-losses within valuation of CDO structures was developed by Moody's in 1996, termed ***Binomial-Expansion-Technique (BET)***. This method aims to create a hypothetical portfolio of uncorrelated, homogenous assets that have identically face values as well as probabilities of default (PDs), to comprehend the behavior of the originally portfolio and to have corresponding expected losses (ELs) (Ci-

[5] This iterative CDO rating process differs to the traditional one in the following facts: pure emission-rating, analyses of payment obligations of issued tranches, ex ante valuation, analyses of CDOs is based on quantitative methods. The first involves modeling and analyzing the credit risk of an underlying portfolio. A structural analysis is made during the second step for instance CDO Managers performance or legal risks.

fuentes & O'Connor 1996, p. 2). Therefore, the losses of an *idealized* portfolio follow a binomial distribution (Garcia et al. 2005, p. 3). The number of identical assets (Diversity Score[6]) will be selected, that the variance of the default function is equal to that of the hypothetical one (Borgel et al. 2004, p. 151). Concluding, the DS level implies evidence regarding the diversification of credit defaults within a CDOs underlying pool. Further assets of the hypothetical portfolio are of a lower quantity than the actual portfolio in order to explain why assets of the actual portfolio are correlated whereas the idealized binomial assets are uncorrelated. Hence, the DS of the hypothetical portfolio is lower (Witt 2004, p. 2).

To determine ***asset correlations*** Moody's uses a framework tree that comprises different branches. These branches correspond to sectors and subsectors within the variety of SF as assets. The narrower the sector to which a credit belongs is defined, the higher the correlation. Further, the degree to which two credits have region, vintage or "key agent" characteristics in common influences their correlation. ***Recovery Rates*** are estimated depending on sector type, tranche thickness and rating of each asset. Based on the expected loss and assumed recovery rate the ***probability of default*** is calculated by

(1)

$$DP = EL/(1 - RR)$$

The EL is derived from Moody's idealized EL table based on credit rating and average life of a particular asset. Rating determination of individual tranches by means of the two parameters *weighted average rating factor (WARF[7])* and *diversity score (DS)* consists of three steps: 1) generating default scenarios 2) estimating loss per tranche and 3) transferring into rating (Lassalvy & Moguno 2009, pp. 5-8).

<u>BET Method - Step 1 to 3</u>

First, default scenarios hast to be computed assuming that n of N independent and therefore binomial distributed assets default with probability p as the average PD of the portfolio $P \sim Bi(N, n, p)$:

[6] The Diversity Score is a measure for the diversification of a portfolio and provides information about the distribution of the underlying assets. Regarding CDOs the DS constitutes a measurement for correlation to secured assets of the pool whereby the correlation refers to the default probabilities of these assets. For a detailed description see Gluck & Remeza (2000), Garcia et al. (2005) and Schmidtchen & Krämer-Eis (2002). The originally DS created for conventional CDOs was adjusted in 2000 to rate multi-sector CDOs with for a underlying pool of assets with correlated default risk. To estimate the alternative Diversity Score (ADS) the securized assets are assigned to different industry sectors. Moody's assumes for corporate credits 33 different industry sectors. The portfolio score can be computed by summing up all industry diversity scores. (Gluck & Remeza 200, p. 15).

[7] The WARF is determined in summing up the rating factors weighted by their share in the collateral pool. Rating factors estimate the default risks of an obligor in relation to an AAA credit with the same maturity.

(2)

$$P(n) = \binom{N}{n} \mathrm{p}^n (1 - \mathrm{p})^{N-n}$$

The calculated collateral risk is then matched with the credit enhancement of the structure to obtain an appropriate rating for all CDO tranches (Picone 2003, p. 26).

In the *next step* the effects of defaults to individual tranches are analyzed by a cash flow model. The payment waterfall of a specified CDO structure just as all factors affecting its distribution are incorporated and transferred into a rating(Lassalvy & Moguno 2009, p. 13).

Then, the expected loss for an individual tranche EL_{Tr} can be determined by the weighted average of losses of a particular tranche across all scenarios *0* to *D*,

(3)

$$\mathrm{EL_{Tr}} = \sum_{\mathrm{j=0}}^{\mathrm{D}} \mathrm{P_j L_{Tr,j}}$$

where $L_{Tr,j}$ denotes the loss of a tranche with *j* defaults weighted by P_j as its probability that scenario *j* will occur.

The Loss of a tranche for a specific scenario is defined by

(4)

$$\mathrm{L_{Tr,j}} = max\left(0, \frac{PV_{promised} - PV_j}{PV_{promised}}\right)$$

where $PV_{promised}$ is the present value of the promised cash flows and PV_j the present value to the tranche.[8]

The Expected loss for the tranche is then transferred into a tranche rating via Moody's idealized, cumulative expected loss rate (*step 3*). This implies an EL_{Tr} comparison by a range of benchmarks which represents the maximum of a certain rating level and the weighted average life (WAL) of a unique tranche (Lassalvy & Moguno 2009, p. 14).

Depending on the complexity of the CDO structure Moody's utilize different approaches to define the collaterals default distribution with a cash flow like the ***Correlated Binomial Expansion Technique (CBET)*** and the ***CDOROM approach***. In general Moody's uses CBET

[8] To compute present values the promised tranche coupon rate as discount rate are employed (Lassalvy & Moguno 2009, p. 13).

for *managed* cash flow and hybrid SF CDOs with a payment waterfall structure. The CDO-ROM model in conjunction with a cash flow model will be applied to *static* cash flow and hybrid SF CDOs. In the case of synthetic SF CDOs it depends on whether they have complex waterfalls or not, so that first a decision related to the level of complexity is needed before choosing the right model (Lassalvy & Moguno 2009, p. 9).

Reference portfolios that have a low diversification score and highly correlated assets[9] require an analysis of each asset and explicitly consideration of default correlations. Meaning that default probability stresses are not needed as it is the case of BET (Witt 2004, p. 6). Therefore Moody's developed the ***CBET***[10] that is mostly consulted for *managed* Cash SF CDOs having complex waterfalls in combination with a cash flow model (Fender & Kiff 2004, p. 6 / Hu 2007, p. 15). This approach enables to represent the actual portfolio by an idealized one which incorporates homogenous, correlated assets. The initially CBM was used with default correlation between pairs of assets assuming that conditional correlations are constant as defaults increase. However, moody's revisited it in 2005 and introduced the *asset correlation* in order to produce a broader range of fatter-tailed loss distribution, which is also implemented in the CDOROM model. Without the independence assumption it is possible to get higher probabilities of multiple defaults (tail events) for the idealized portfolio as it is the fact for the default distribution of the actual portfolio (Toutain et al. 2005, pp. 1-2 / Witt 2004, pp. 1-2). CBET employs a *set of four parameters*: default probability, recovery rate, number of representative assets and Moody's Asset Correlation (MAC). The second two are different to the originally BET (Xie & Witt 2005, p. 3). Being based on the asset correlations between actual assets of the underlying pool, MAC describes the average asset correlation within a defined amount of representative assets having the same ratings. That is in contrast to the older BET where the DS expresses the number of representative assets (Hu 2007, p. 16).

Static Cash SF CDOs require the ***CDOROM Model*** combined with a cash model that generates flows according to each tranche. This model is also applied to *synthetic* SF CDOs without any complexity according to payment priority like waterfall or over-collateralization tests. In this case premium resp. coupon payments are paid by the CDS counterparty. That's because of the special transaction structure of a synthetic CDOs were these payments are not directly linked to defaults of the collateral[11]. The model is based on a *Monte Carlo simulation (MCS)* applied to calculate the expected loss on tranches (Kothari 2006, p. 458). Moody's

[9] As an example ABS CDOs are highly concentrated in one asset type, for instance RMBS.
[10] For further information see Moody's Correlated Binomial Default Distribution 2004 and Moody's modeling approach to rating structured finance cash flow transactions 2005.
[11] For further information see Moody's CDOROMv2.6 User Guide.

introduces a *Gaussian copula* to simulate correlated defaults in applying asset correlations and to obtain random recovery values assuming that recoveries of defaulted assets are correlated with each other.[12] Among all scenarios both, simulated recoveries and defaults characterize the loss distribution for the collateral. In order to reproduce the capital structure within CDOROM the attachment point (credit enhancement of all tranches in percentage of the portfolio size) and the thickness[13] of a tranche (notional size in percentage) have to be incorporated. Additionally, annual spread paid on a tranche also needs to be integrated. As related to the Monte Carlo simulation approach for synthetic SF CDOs the probability of all simulated scenarios are equal. Consequently, the EL of a Tranche is calculated by

(5)

$$\mathrm{EL_{Tr}} = \frac{1}{N}\sum_{j=0}^{N} \mathrm{L_j}$$

with a loss per tranche

(6)

$$\mathrm{L_{Tr,j}} = max\left(0, \frac{Tr_{Notional} - PV_{CF}}{Tr_{Notional}}\right)$$

$Tr_{Notional}$ denotes a tranches notional value and PV_{CF} describes the present value of a tranches Cash flow (Lassalvy & Moguno 2009, pp. 6-14).[14]

Due to the financial crisis and related enormous downgrades especially of CDOs backed by RMBS Moody's *revisited* its rating models. In particular changes are made by the three main input factors. Based on a beta distribution Moody's introduces a simulation-based stochastic recover rate model. From this follows that recover rates are a function of rating level and a tranches thickness depending on the size of the collateral pool. Further the current asset rating is employed instead of its initial. In terms of PDs a resecuritization stress factor is utilized to consider the leveraged rating impact on SF. Changes related to correlations of SF CDOs imply higher values of asset correlations. For a detailed description see Hyder (2009).

[12] In terms of synthetic SF CDOs and CDO-squared Moody's uses Recovery Rates that have the same correlation of 10% between all pairs of defaulted assets (Lassalvy & Moguno 2009, pp. 6-14.).
[13] The thickness of a tranches describes the portfolio loss level at which the tranche is defaulted by 100% (Lassalvy & Moguno 2009, p. 13).
[14] The discount rate employed for calculating present values is the current swap rate plus the promised spread on the tranche based on its remaining maturity (Lassalvy & Moguno 2009, p. 13).

3.2. Standard & Poor's CDO Evaluator Approach

The ***Actuarial-Approach*** will be employed if no rating is available from S&P for a particular asset. Prospective default rates are derived from the originators historical default and recovery information of the corporate customer segment. Then, tranching is implemented by multiplying the predicted portfolio loss with specified stress scenarios that depending on the target rating of a particular tranche (Schmidtchen & Krämer-Eis 2003, p. 4).

If all secured assets possess an S&P rating resp. assigned an S&P rating through a mapping by the originator ***CDO EVALUATOR*** structural model is used. Tranching and valuation carried out by a two-step process: 1) estimating specified default rates based on calculated correlations and default probabilities between individual assets of a particular pool to determine the expected loss distribution, 2) cash flow analyses to determine a tranches thickness.

S&P estimates a 1-year transition matrix based on historical data and produces default rates by raising the matrix to higher powers in order to assign each asset of the portfolio **a *probability of default*** based on asset class, rating and maturity. Assumptions regarding ***default correlation*** between pair wise assets are based on empirical default observations (like joint default probability) and generated by the average intra-industry and inter-industry correlations (Gilkes et al. 2005, pp. 5-9).

The model focuses on the calculation of the loss distribution of a particular portfolio consisting of N assets in simulating the default times of every single asset by a single-step Monte Carlo simulation. In particular, this approach considerate correlation among assets of the underling pool explicitly, which makes it also available to low diversified portfolios (Schmidtchen & Krämer-Eis 2003, pp. 4-5; Gilkes et al. 2005, p. 3).

<u>CDO EVALUATOR – Step 1 to 2</u>

First, asset-specified defaults, recovery rates and correlations across assets of a particular portfolio have to be determined within the Gaussian-copula-method following Li (2000). Meaning that the survival probability of each asset *i* is obtained on the basis of their cumulative default probabilities. By use of the Gaussian-copula function the dependency across defaults of various assets can be introduced:

(6)

$$C(u_1, \dots, u_N) = \Phi_{\Sigma}(y_1, \dots, y_N)$$

$\Phi_{\sum}$ denotes the multivariate standard normal cumulative distribution function with correlation matrix $\sum$. Based on a Copula-function the standard normal variables y_i can be interlinked and a multivariate distribution of uniform random variables u_i is generated. Hence, the default times are calculated within the MCS in one simulation run as follow: 1) Simulation of a vector with N standard normal variables y_i for each asset[15], 2) application of correlation matrix $\sum$ on vector N applying Cholesky factorization $u_i = \Phi(y_i)$, 3) estimation of random variables u_i, and 4) computation of the default time for each asset $\tau_i = S^{-1}(u_i)$.

If an assets default time τ_i occurs before the final maturity T of a CDO transaction, then the asset is deemed to be defaulted. In that case the *expected loss* L_i is obtained by

(7)

$$\mathrm{L_i} = \mathrm{E_i}(1 - \delta_\mathrm{i})$$

E_i describes the exposure-at-default and δ_i denotes the asset-specified recovery rate. S&P uses fixed as well as stochastic (beta distributed) ***recovery rates*** in the CDO EVALUATOR Model.[16]

The expected loss of the portfolio is determined by

(8)

$$L(t) = \sum_{\mathrm{i}} E_i\ (1 - \delta_i)\ 1_{\{\tau_i \leq t\}}$$

$1_{\{\tau_i \leq t\}}$ denotes the default indicator for asset i (Gilkes et al. 2005, pp. 3-8). Therefore the CDO EVALUATOR generates a portfolio specified loss distribution comprising default rates of all underlying assets in order to estimate the enhancement levels, which adjust the PD of the individual tranches to the desired credit rating level. That is done by a set of *scenario default rates (SDR)* which can be derived from the portfolio loss distribution. The SDR is the level of portfolio defaults that a tranche have to resist in order to obtain a target rating. Tranching of the loss distribution function subsequently implemented in according to the Value-at-risk approach. The default function curve depends on diversification of the portfolio, which means the lower the diversification the right-skewed the curve. Thus, the likelihood of more extreme default events increases and lowers the senior tranche at the same time. This effect occurs at Moody's by reducing the Diversity Score (Schmidtchen & Krämer-Eis 2002, p. 5 / S&P 2008, p. 1).

[15] Usually within 500.000 simulations one vector of N assets is build (Kothari 2006, p. 45).
[16] For detailed description see Gilkes (2005).

Derived default rates will be transformed into loss rates (*scenario loss rate-SLR)* to determine the size of each tranche by a cash flow model (*second step*). The results are subject to a test within different scenarios, following the principle of no losses in these scenarios. If claims of payments could not fully be paid within a scenario, the thickness resp. target rating has to be adjusted or additional enhancements have to be integrated in the CDO transaction. This model involves structural properties (e.g. assumption to default times) as well as debt related properties (average collateralization ratio; time lag between credit event and realization of collateral) concerning derivation of loss dimension like Moody's BET Approach (Schmidtchen & Krämer-Eis 2002, p. 5).

3.3. Fitch's Vector Approach

The asset's probability of default is assessed in three stages within ***Fitch's Default Vector Model (VECTOR)*** through a multi step Monte Carlo simulation: 1) estimation of the three input factors; 2) default rates ascertainment; 3) cash flow modeling.

First, in the case of an existing rating from Fitch, an asset's ***probability of default*** is drawn from Fitch's default matrix[17] in accordance to maturity (with a maximum of 10 years) and rating. Additionally, redemption plans has to be included in terms of PDs estimation due to the fact that market values of assets often are below their face values effecting PDs. If no Fitch rating for an underlying asset is available, S&P or/and Moody's ratings are used modified by bond and CDS-prices (Zelter & Kendra 2007, p. 4). Should no public rating from an NRSRO be obtainable, Corporate-Rating Models or a mapping to the originators internal rating is consulted to assess an asset (Gill et al. 2004, p. 5).

Recovery Rates are driven by asset type, geographic location and the associated macroeconomic factors, therefore distinguishing between four country groups A, B, C, D (Appendix 2). Fitch supposes in the case of a default that a tranches thickness and its position within the CDO structure constitute the most suitable determinant for its recovery rate. The default of a SF tranche is affected by its current rating, sector, country and vintage. Fitch has revisited its RR assumptions to higher recoveries regarding larger tranches like super senior or senior, meaning that those require higher recoveries in the event of default (Neugebauer et al. 2008, pp. 12-13).

[17] The default matrix comprises Fitch's CDO default rates for various maturities (max. 10 years) and rating categories. It also forms the basis for estimating the RDR and RLR (Hrvatin 2004, p. 14).

Fitch employs ***asset correlations*** instead of default correlations by using a *statistical factor model*.[18] Assuming that the return amount of one's capital investment is determined through specified influencing variables F_{kt} *(k=1,...,n)* asset correlations can be expressed as:

(9)

$$R_{it} = a_{it} + \beta_{i1}F_{1t} + \beta_{i2}F_{2t} + \cdots + \beta_{ik}F_{kt} + \beta_{\varepsilon}\varepsilon_{it}$$

R_{it} denotes the return on asset i over period t, ε_{it} describes the idiosyncratic risk and β_{ik} the alteration of the return on asset i caused by alteration of k (factor loading) (Gill et al. 2004, p. 26). Thus, Fitch derived the factor loading for 6100 companies of 34 countries within the Dow Jones global range which were clustered in 25 industry and ten regions (Appendix 3). According to structured products classifications into 21 regions[19] and six main asset segments as well as further subsectors e.g. 45 for the U.S. were identified (Gill 2004, p. 10). Concluding, average factor loadings for each industry-region clustering and average idiosyncratic risk can be computed, which leads to the pair-wise return correlation co-efficient:

(10)

$$\rho_{12} = \frac{\operatorname{cov}(R_1 R_2)}{\sigma_1 \sigma_2}$$

(10.1)

$$\operatorname{cov}(R_1 R_2) = \sum_{i=1}^{N-1}\sum_{j=1}^{N-1} \overline{\beta}_{1,i}\,\overline{\beta}_{2,j} \operatorname{cov}(F_i, F_j) + \overline{\beta}_{1,N}\,\overline{\beta}_{2,N} \operatorname{cov}(\varepsilon_1, \varepsilon_2)$$

(10.2)

$$\sigma_x = \sqrt{\sum_{i=1}^{N-1} \overline{\beta}_{x,i}^2 \sigma_{F_i}^2 + \overline{\beta}_{x,N}^2 \sigma_{\varepsilon}^2}$$

In a *second step*, default rates are estimated in determining figures based on the input factors within a multistage Monte Carlo simulation (Gill et al. 2004, p. 26).

[18] Historical Information's about assets are unavailable, meaning that Fitch employs correlations of stock yields as substitutes of asset correlations.

[19] These are USA, Canada, Central America, South America, Germany, Austria, Switzerland, France, Belgium, Luxembourg, Netherlands, Italy, Greece, Spain, Portugal, Scandinavia, UK & Ireland, Eastern Europe, South Africa, Australia, New Zealand, Japan, China, Hong Kong, Asia Other (Gill 2004, p. 11).

These figures compute the performance of every single asset for each year of maturity:

- Recovery Default Rate (RDR) – share of the initial portfolio which defaults during a specific rating scenario,
- Rating Recovery Rate (RRR) – expected weighted average RR for the particular portfolio in the specific rating scenario,
- Portfolio Correlation Rate (PCR) – average correlation of the particular portfolio,
- Rating Loss Rate (RLR) – expected portfolio loss for a particular portfolio within a specific rating scenario,

whereby RDR, RRR and a default distribution function build the essential components for cash-flow modeling (Gill et al. 2004, pp. 11-12). Within the *third step*, the particular portfolio has to undergo various stress scenarios that further include currency changes as well as modeling of default times. In terms of default times a minimum of two different scenarios like frontloaded- and backload-stress-test are required. If an individual tranche passes the stress scenarios, the target rating is achieved (Borgel et al. 2004, p. 153).

Fitch also revisited its rating model regarding correlation, default probabilities and recover rates. Assumptions of RR for SF assets were reduced considerable and changes in correlations were made for instance that investors in tranches of portfolios concentrated in single sector and single vintage will be protected against the determined peak portfolio default rate. For further details see Neugebauer et al. (2008).

3.4. Taking a critical look at the valuation approaches

Moody's uses an ***EL*** approach so that investors can derive future losses within a CDOs maturity. *S&P* and *Fitch* employ a value-at-risk method that leads to a testimony of the ***PD*** in timely and fully interest and repayment of principal. Whereas cumulative default rates incorporated for each asset by S&P, Fitch includes conditional default probabilities on an annual basis.[20] In order to compute ***default distributions***, all of them apply to Monte Carlo simulation based models with highly complex assumption and parameter. Instead of a single period only Fitch runs multi step simulation for each year of the deal. ***Recovery Rates*** differs according to the models used. Moody's apply to RR between 5%-85% depending on asset type, S&P assume 5%-79% conditional on type and recovery whereas Fitch relate to 5%-95% with regard

[20] The conditional default probability in year n+1equal to the difference between the cumulative default rate for year n+1 and the cumulative default rate for year n divided by the cumulative default rate of year n. (Obrist 2007, p. 23).

to an assets initial industry and region (Lassalvy & Moguno 2009, p. 29 / S&P 2009, p. 25 / Neugebauer & Moore 2008, p. 13).

A weak point of Moody's BET model is an underestimation of senior tranches expected looses as a result of the significant undervaluation of portfolios tail probabilities (Bluhm et al. 2010, p. 335). Additionally, Fitch model considers the loss dimension within the simulation process and correlations based on the factor model. Nevertheless, accuracy of values regarding risk assessment will not increase by complexity of rating methods. In fact the challenges in parameter estimation induce uncertainties to correlations (see 3.4.2) that may result in higher risks concerning individual tranches. Another criticism states that the three rating agencies employ an iterative rating process that leads to discrepancy between the rating structure of a CDO and the credit quality of the underlying assets caused by the objective to reach the highest possible rating at minimum costs (Benmelech & Duglosz 2009b, p. 628).

3.4.1. Two main weaknesses

Hence, modeling default times and default correlations are ***main weaknesses*** of the rating methodology. Correlation coefficients determine the pair wise dependency of ***default times*** and apply a linear dependency across risk factors. Therefore correlations in economic downturns as well as boom periods are equal. But in reality, in economic downturns a high quantity of similar credit defaults occurs while in the other case defaults are nearly independent. Furthermore Monte Carlo simulations generate *multivariate normal distributions* that undervalue the likelihood of potential catastrophes like simultaneous defaults of originators in the so called downturns (Borgel et al. 2004, pp. 154-155).

Default correlations possess a significant effect on the risk and market value of CDO tranches and thus imply increasing volatilities of the pools cash flow. If defaults are independent within a large pool of homogenous assets, the default rate converges to the average expected default rage whereas entirely correlated defaults lead to a 0% or 100% default rate (Duffie 2008, p. 18). Accordingly, incorrect correlation estimations cause over- or undervaluations to the risk of the underlying or individual CDO tranches (Fender & Kiff 2004, p. 10).

Besides historical data, default correlations are described by copula functions, which are calibrated to prices of CDS-index tranches as it is the case for all three models explained above. Duffie (2008) shows that some models contain inconsistencies, for instance different correlation models pricing tranches of a particular CDO structure are applied. While it can be eliminated by Copula models with a large set of parameters, the added factors obtain no realistic

information. However, Duffie also states that models which are of a high flexibility also can match actual market prices without realistic data. It remains in question how these models then represent adequate pricing and rating of CDOs. *Rudimentary correlation* hypothesis builds another issue to rating methods, for instance implying that asset pairs within a same industry sector have identical correlations and also asset pairs without the same industry sector (Duffie 2008, pp. 18-19). It is questionable whether to which extend an appropriate amount for ***recovery rates*** can be determined by various stress scenarios accurately, so that in times of crisis losses are sufficiently covered (Morkötter & Westerfeld 2009, p. 3).

No clear evidence is found how *systematic risks* are involved in rating SF CDOs. However, considering the fact that these approaches incorporate factor models systemic risk are included.[21] That is further reflected by running a variety of stress scenarios within MSC that simulate different economic changes for instance currency changes or cyclical fluctuations which causes various defaults.

3.4.2. Model risk

Adelson (2003) states that a large number of downgrades referring to high-yield CDO tranches are mainly caused by under-modeling default and recovery rates, resulting in the today's well known ***model risk***. This term describes the risk, that a consulted model for rating a tranche may reproduces the true risk of this tranche insufficiently. There are *two components of model risk* in the context of rating SF CDOs. *First*, according to quantitative models potential deviations in terms of assumptions regarding the estimation of the credit risk of an underlying from actual values, implies unrealistic assumptions concerning recovery rates and default correlations. *Second*, deal-specific, structural model risk relates to an originator's individual structuring technique, especially to the redistribution of cash flows as provided in the contract. In the case of third parties, operational as well as legal risk occurs. Finally, the risk of unrealistic assumptions turns in to a false pricing of CDOs inter alia due to the influence of ratings to pricing and similar assumptions in CDO pricing models across market participants (CGFS 2005, p. 22). The model risks de facto depend on parameter assumptions (correlation, recovery rates, recovery value, default rates), and therefore are determined substantially by *rating accuracy* (Fender & Kiff 2004, p. 9).

[21] Factor models include both idiosyncratic and systematic risk and are used to describe the performance of a credit/asset *i*. $V_i = \sqrt{\rho_i}\,\mathrm{Y} + \sqrt{1-\rho_i}\,\varepsilon_i$. While Y denote the market-related-factor (systemic risk) and ε_i the idiosyncratic risk. Hence, the default behavior of an asset or credit can be demonstrated. In combination with the MCS these both factors are realized within different stress scenarios and the portfolio loss distribution is generated. Therefore it turns out for which stress scenario simultaneous defaults appear.

Coval et al. (2009) describe, that ***failures in parameter estimates*** lead to alterations of default risk and imply defaults of triple-A rated SF securities. In terms of increasing default correlations almost small uncertainties enlarges which causes default losses from equity piece to senior tranche. Especially CDO^2 with RMBS as their underlying assets incorporates significant errors in default correlations, default probabilities, and recovery rates. Furthermore, Benmelech and Dlugosz (2009b) point out uniformity in CDO structures and associated restrictions. They supply evidence that originators have access to rating software for CDO transactions which incorporates further potential for model risk.

Model risk constitutes the *main risk to investors* and therefore really has to be understood by them. Otherwise inappropriate risk-adjusted returns as well as important losses will arise (Fender & Mitchell 2005, pp. 86-87). If investors just place reliance on assessment of creditworthiness by rating agencies model risk is transmitted to the whole financial markets. In addition, rating agencies cannot revert to historical data regarding structured finance, especially CDOs compared to ratings of corporate bonds with historical statistical series as well as years of experience in valuating default risk. Furthermore, no appropriate compliance relating to the lack of experiences in the use of quantitative models, no regular adjustments to particular securitization properties as well as false model assumptions, int.al. increasing real estate prices concerning MBS, induced massive downgrades of SF CDOs (Crouhy et al. 2007, p. 85). Subsequently, false testimonies on dependencies of default and credit risk of the underlying occurs (Ashcraft & Schuermann 2008, pp. 43-45).

Krahnen & Wilde (2008) indicate that AAA tranches are highly sensitive to macro factors driven by a large diversification compared to corporate bonds with the same rating and PD. Equally it provides an explanation for the different behavior to macro factor deterioration. All of these mentioned failures are reasons for the massive downgrades since 2007.

4. Effects to the financial crisis

CDO structures are considered to be profitable in market phases ensuring high yields, whereas it causes disproportional defaults and falls extremely in its value in times of crisis. Advantages of these securitization constructs turn into disadvantages and incorporate a reinforcing effect related to liquidity issues of banks, hedge funds, pension funds and special purpose vehicle (SPV). Values of ABS-CDOs depreciated (see 4.1), SPVs managed by hedge funds or banks were subject to execution and partly sold its assets (Nagel & Benders 2007). ***Conduits*** belongs to the "Shadow Banking System", hold an investment-grade rating (Triple-A), invest

in CDOs, have no equity cushion and are refinanced by issuing *Commercial Papers* (Mortgaged Backed Commercial Paper; Asset Backed Commercial Paper). As the value in credit related claims of subprime debtors and CDOs started to depreciate investors retracted their follow-up financing. Missing information about the impact to other Conduits and how they were affected by depreciated subprime mortgages implied ***uncertainty*** to investors about risk distribution. Banks resp. financial institutions were required to convert the notional amount of liquidity facilities which additionally provoked uncertainties regarding quality and risk-taking capability. Refinancing of Conduits via money market became impossible (Rudolph 2009, p. 23). Consequently, a view banks like Citibank, HSBC Holdings resp. Société Générale were forced to record their SPVs on their balance sheets. For instance AIG had to consolidate the Nightingale SPV of its subsidiary AIG Financial Products after rapid decreasing asset prices and demand of senior tranches (Tavakoli 2008, p. 417).

CDS in combination with synthetic CDOs played a key role as CDO tranches could obtain the highest possible rating and mezzanine tranches were rated triple-A through resecuritization. Offered by credit insurers (Monoliners), insurance companies (AIG) as well as hedge funds CDS led to the *counterparty risk*. Protection buyer experienced problems of liquidity as they were invited to pay a compensatory payment (Cash or physical settlement) caused by decreasing pricing of CDOs (crisis of liquidity, see 4.2). Investor relied increasingly on risk assessment of rating agencies since multi structures of CDOs imply direct and complex debtor/creditor relationships. Due to the *lack of transparency* investors were no longer in a position to differentiate across securities used as collateral. In addition, in the course of a large number of downgrades the trust in rating agencies decreases similarly as the confidence across banks decreased since they were forced to provide its SPVs with liquidity. Financial Institutions were unable to assess liquidity demands of its competitors on a reliable basis, which resulted in a *crisis of confidence*, mainly founded on lack of transparency (Beresa et al. 2009, pp. 43-44 / IFD 2008, p. 98). In the absence of confidence on the interbank market increases in CDS Spreads were caused, as no financial institution had sound knowledge about the risk of the other party having in its bank balance sheet.

4.1. ABS CDO Performance

The market for CDOs backed by ABS was subject to a continuous demand until mid 2007, especially for mezzanine structures. These products present the largest share of downgraded CDO transactions by approximately 42% of the total write-downs of financial institutes globally, and therefore made a substantial contribution to its liquidity squeeze (see Table 2)

(Benmelech & Duglosz 2009, p. 2). Recent vintages mainly Mezz ABS CDOs were extremely invested in RMBS backed by subprime mortgages or worse.

Table 2: Crisis-related Write-Downs of ABS-CDOs ($ millions)

		Latest announcement	ABS-CDO	Total
Insurers / Asset Managers	ACA Capital	11/08/2007	1,700	1,700
	AIG	11/10/2008	**33,190**	66,943
	Ambac	11/05/2008	11,136	12,761
	MBIA	05/12/2008	3,500	6,900
North America Banks	Bank of America	01/16/2009	9,089	12,855
	Bear Stearns	01/29/2008	2,300	2,300
	Citigroup	10/16/2008	**34,106**	55,383
	JP Morgan Chase	09/16/2008	1,300	12,072
	Lehman Brothers	06/16/2008	200	9,000
	Merrill Lynch	10/16/2008	**26,100**	55,068
	Morgan Stanley	12/17/2008	7,800	17,383
European Banks	Credit Suisse	10/23/2008	3,427	9,357
	Deutsche Bank	10/30/2008	2,092	14,974
	Fortis Bank	08/04/2008	4,359	8,163
	ING	11/12/2008	565.0	8,617
	Royal Bank of Scotland	11/04/2008	3,609	12,146
	UBS	08/12/2008	**21,870**	37,805
Asian & EM Banks	Aozora Bank	05/15/2008	510.0	510.0
	Mitsubishi UFJ	08/13/2008	395.5	3,640
	Mizuho	11/13/2008	3,898	7,650
	National Australia Bank	10/21/2008	669.5	669.5
	Sumitomo Mitsui	11/19/2007	561.7	561.7

Source: Benmelech & Duglosz 2009, p. 38.

Tranches of M*ezzanine RMBS* were hard to sell compared to more senior tranches. Therefore it had to be resecured within a new collateral pool obtaining a share of 80% of the total. The remaining 20% were invested in CMBS resp. other CDO tranches. The underlying of a second layer structure (ABS CDO) incorporates tranches of former securitizations whereas the underlying of a one stage securitization (RMBS) posses only mortgages. Both have a totally different risk profile. However, the structure of the second layer product ABS CDO underlies the same securitization construction, implying that the senior tranche get a triple-A (Hamerle & Plank 2008, pp. 8-9).

Hamerle et al. (2008) / Hamerle & Plank (2008) analyse the default behavior of synthetic CDO/ABS CDOs and state that changes in macro economic factors and systemic risk in times of a strong economy will have no impact, demonstrated by no defaulted tranches. But they are highly sensitive to systemic risk in economic downturns and already a small alteration according to systemic risk factors causes huge deterioration of a tranches credit rating. Therefore ABS CDOs exhibit an "all or nothing" risk profile and heavily depend on systematic stresses (BIS 2008, p. 6). Evidence is presented, that ***stress-sensitivity*** as well as ***correlation*** increases by each securitization level. In particular, resecurized mezzanine RMBS are exposed to a high stress-sensitivity and higher risk regarding dead loss. This fact has been ignored before the financial crisis, resulting in ruinous misinterpretation. Hence, ABS CDOs had to default when house prices started to decline. Moreover, the results of these studies exhibit show that securities of the same transaction and rating but different in securitization level reveal differences in losses. Whereas an ABS CDO totally can default, the underlying triple RMBS will just suffer low losses (Appendix 4).

Benmelech & Duglosz (2009a) identify ***three major issues*** of ABS CDOs based on a systematically analyses of macroeconomic data: 1) lack of inter-sector diversification, 2) very high concentration on Home equity ABS, 3) low inter-vintage diversification. ***Rating-Shopping*** as another critical point may be evidenced according RMBS mostly having only a rating from one rating agency. In contrast CMBS and CDOs obtain two or three ratings from different agencies.

4.2. Impacts of CDO downgrades to Monoliners & Hedge funds

Hedge funds and insurance companies invest equally in mezzanine as well as equity tranches. Especially mezzanine investors depend on credit ratings that form the basis of investment guidelines and determine the regulatory capital. The poor performance of ***hedge funds*** is caused by its increased investment in equity pieces. One of the smallest investment bank *Bear Stearns* with an extended part of mortgages exposures was forced to liquidate its hedge funds „High-Grade Structured Credit Enhanced Leveraged Fund" and „High-Grade Structured Credit Fund" on 07/18/2007. These were only founded to invest in CDOs with subprime mortgaged exposures. Bear Stearns ran further into trouble as one of the creditors to Carlyle Capital Corp. (CCC) that had to be liquidated partially (Brunnermeier 2008, p. 88). Carlyle Capital Corp. as invested in triple-A agency bonds of *Fannie Mae* and *Freddie Mac*, served as a collateral for credits from various financial institutes with a volume of app. $20 billion. As the real estate prices dropped down and bonds had to be depreciated lenders of the debt capital for

financing CCC demanded an increase in its collateral. At that time, Bear Stearns was not able to follow this requirement (Spiegel Online 2008a). Finally, Bear Stearns takeover through JP Morgan Chase with 2 $ per share, was supported by $30 billion of the FED (Sorkin 2008). Hedge funds rely on loan funds from investment banks which act as prime broker. Within the beginning crisis of confidence they underlie funding difficulties, in particular increasing costs for new credits and no renewal of revolving credits.

A few years ago ***Monoliner*** (credit insurers) started insuring high complex structured finance products in addition to their traditional business, for instance insuring MBS, ABS as well as super senior tranches of CDOs/CLOs against potential defaults employing credit default swaps. Exemplary insurers are *Ambac, MBIA, FAS* resp. *FGIC* which guarantee is based on its triple-A ratings (Spiegel Online 2008b).

If CDO tranches diminish in value capital adequacy requirement to Monoliners has to increase in order to retain the AAA ratings. But these insurers cannot revert to an appropriate equity capital in times of enormous simultaneously defaulting obligors (Tavakoli 2008, p. 414). For such a scenario the equity position is insufficient. According to studies of Uwe Burkert an expert from Landesbank Baden-Württemberg (LBBW) $ 1 Mio. equity capital covers int.al. $ 147 Mio. of MBIAs written CDS (Ambac $ 143 Mio.) (Amann 2008). Credit insurers provided CDS contracts by almost $459 billion to super senior tranches and app. $ 125 billion to ABS-CDOs with subprime underlying. Therefore with beginning of decreasing house prices, legal enforcements and credit defaults Monoliners became solvency problems due to fast increasing default risk resulting in widening risk premiums. Rating agencies announced to downgrade the Monoliners which caused massive depreciations to insured bonds and complex CDO tranches. The guarantee for risk premiums in credit events became insecure as the ability of the insurer to act within a credit event became insecure. Downgrades of Monoliners implied *high liquidity problems* to banks, pension's funds and investors because the insurers lost their AAA rating. Hence, these investors had to increase the consign capital for ensured bonds as the bank need to deposit equity capital according to the creditworthiness of the insurer. The worse a bonds rating is, the more has a bank to deposit capital (Osman 2009). Additional depreciations on securities of CDO transactions caused losses of billions which in turn implied *fire sales* (Brunnermeier 2008, p. 78).

At the beginning of the downturn spiral was one of the smallest Monoliners ACA Capital, which resulted int.al. in depreciations of app. $ 3.1 billion for *Merrill Lynch*, due to the fact that the risky items had to be reintegrated in its balance sheet at lower market prices (Tavakoli

2008, p. 416). ACA was downgraded by S&P in December 2007 from A to CCC. In March 2008 Fitch Ratings downgraded FGIC from AA (Moody's A3) to BBB (Moody's Baa3) (Isaacs-Lowe & Dorer 2008, p. 1 / Aurora 2008, p. 1). ***Ambac*** and MBIA as the two largest Monoliners lost their triple-A on 06/05/2008 whereas the former was rated CC on 12/02/2009 by S&P (Moody's 07/29/2009: Caa2) and ***MBIA*** is rated BB+ since 09/28/2009 (Moody's 25.09.2009: Ba3) (Veno 2009, p. 2 / Venkatesan et al. 2009, p. 1). For instance, MBIA possess a multisector CDO Portfolio of $ 22.6 billion from what app. 75 % was originated between 2005 and 2007 and with a high share of collaterals including RMBS (Venkatesan et al. 2009, p. 4).

Especially, in the case of the *American International Group (AIG)* may be evidenced the ***counterparty risk***, which was highly undervalued. Rather than being a credit insurer, AIG originally operated within the traditional insurance business that implies a highly *interconnectedness* to other market participants. Therefore this American insurance group is deemed to be too interconnected to fail and systematically important to the insurance market. One of the main counterparties are Société Générale, Goldman Sachs and Deutsche Bank (Appendix 5) (ECB 2009, pp. 26-28.). A series of support measures were required during various simultaneous credit events, overall $ 182 billion government aid. The counterparties could maintain its CDS and AIG were able to pay the outstanding claims at nominal value (FTD 2010). *AIG Financial Products* was the primary net seller of CDS to protect triple-A CDO tranches from 2003 to 2005 and wrote CDS, Derivates as well as future contracts with a notional value of $ 2.7 trillion. The subsidiary was backed by investment-grade triple-A of the parent company (ECB 2009, p. 29). Since 09/15/2008 all three rating agencies had downgraded AIGs long-term debts by two (S&P) resp. three (Fitch, Moody's) notches, liquidity issues of AIG Financial Products rose, and a run on its securities lending operations were initiated. Therefore debtors started to return their borrowed securities and requisitioning their cash collateral. This was proved to be nearly impossible as AIG had invested their cash collateral in MBS which were hard to sell due to its depreciations (ECB 2009, pp. 29-30.).

Cont & Moussa (2009) points out, that ***contagion effects*** regarding financial markets are subject to the market network structure rather than on the size of market participant. For instance, high interconnectedness enhances correlations across spreads of various market participants as it happened in the case of Lehman Brothers. The *interconnectedness* raised mainly in terms of credit derivates, is additionally aggravated by synthetic structures which incorporate CDS. If a financial institution forms the reference entity for CDSs the Counterparty risk will be

enormous. Hence, failures of one institution can enhance CDS spreads of another and make it nearly impossible for investors to separate between obligors risk and CDS counterparty risk. In modeling the spreading of systemic risk across financial institutions as well as single-name CDS effects, Cont & Moussa (2009) show that CDS imply contagion effects related to credit events and therefore link the protection buyer to its counterparty. Thus CDS increases the impact of default events by large financial institutions, the probability that a default has effects on various institutions (Spillover Effect) and the systemic risk.

5. Conclusion

CDOs enable banks to outsource credit risk and encourage the capital market by liberating regulatory capital ensuing in almost unlimited lending activities. However, if these instruments are falsely rated huge serious consequences arise. Failures in parameter estimation and model uncertainty rise to high powers due to the unique structure of CDO transactions, particularly in CDO-squared. Model risk finally implies a false pricing or statement concerning rating and risk exposure of CDO notches, resulting in inappropriate credit enhancements. Additionally, credit enhancements induced a significant underestimation of default risks. Abstract mathematics and the blind faith in mathematic models have led to disregard exogenous shocks, as it was the case of falling real estate prices. It is important to note that some of the rating agencies were quite aware of how changes in parameter assumptions would cause a collapse of their models. This is demonstrated by an interview between the Associate of the CFA Robert Rodriguez (2007) from First Pacific Advisors and an analyst from Fitch Ratings. In response to the question what impacts will have a price decline of one to two percentage 1% to 2% over a long period, the analyst replied: *„The models would break down completely (Rodriguez 2007)“*.

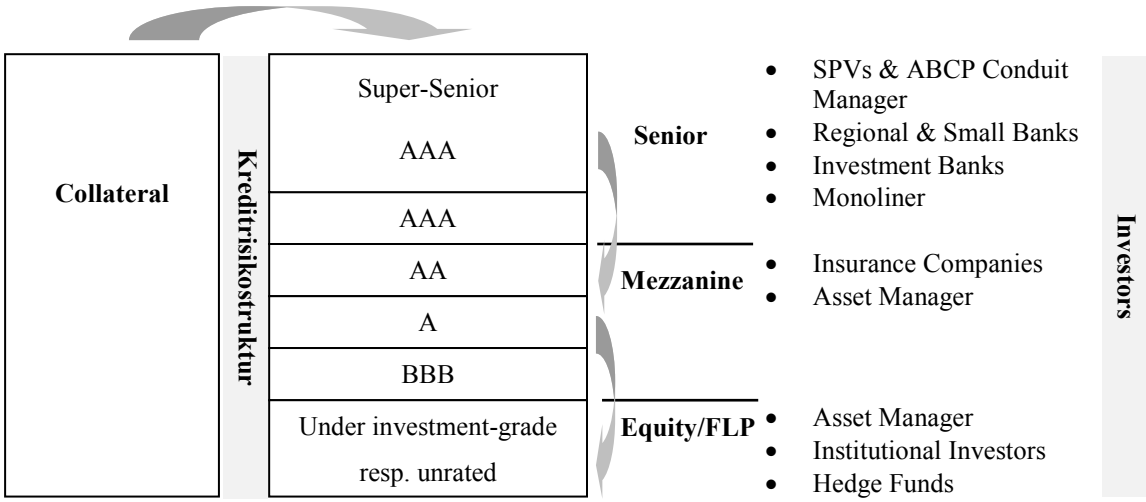
Benmeldech & Duglosz (2009a) found that most notches are rated by two or three agencies. For instance, CMBS or CDOs obtained two or three ratings whereas RMBS are mainly rated once. But an empirical analysis whether ratings of notches from various agencies are equal or not should be conducted. Because all models differ in some way and it is well known that rating outcomes of especially Moody’s and S&P are very similar. However, that is just a common assumption that should be proved empirically for SF CDOs.

Nevertheless, it turns out that not just the products itself and the models have to be blamed but rather the parties involved in the structuring process, for instance asset managers, trustees, servicers or arrangers. Success or failure of CDO transactions is determined by their perfor-

mance. The question is whether the parties have to be regulated due to significant incentive issues. But this is another concern that needs to be analyzed within the principal agent approach in future research.

Appendices

Appendix 1: Distribution of losses and credit risk structure



Source: Authors' design.

Appendix 2 – Fitch's Standard Recovery Rate Assumptions

Recovery Rate Assumptions

Seniority (%)	AAA	AA	A	BBB	BB	B
Group A						
Senior secured	56.000	59.500	66.500	70.000	70.000	70.000
Mezzanine, second lien, jr secured	20.000	21.250	23.750	25.000	25.000	25.000
Senior unsecured	32.000	34.000	38.000	40.000	40.000	40.000
Subordinate	20.000	21.250	23.750	25.000	25.000	25.000
Group B						
Senior secured	40.000	42.500	47.500	50.000	50.000	50.000
Mezzanine, second lien, jr secured	4.000	4.250	4.750	5.000	5.000	5.000
Senior unsecured	28.000	29.750	33.250	35.000	35.000	35.000
Subordinate	12.000	12.750	14.250	15.000	15.000	15.000
Group C						
Senior secured	32.000	34.000	38.000	40.000	40.000	40.000
Mezzanine, second lien, jr secured	4.000	4.250	4.7500	5.000	5.000	5.000
Senior unsecured	28.000	29.750	33.250	35.000	35.000	35.000
Subordinate	8.000	8.500	9.500	10.000	10.000	10.000
Group D						
Senior secured	24.000	25.500	28.500	30.000	30.000	30.000
Mezzanine, second lien, jr secured	4.000	4.250	4.750	5.000	5.000	5.000
Senior unsecured	20.000	21.250	23.750	25.000	25.000	25.000
Subordinate	8.000	8.500	9.500	10.000	10.000	10.000

Source: Fitch

Source: Neugebauer et al. 2008, p. 21.

Group A Countries

Australia, Austria, Bahamas, Bermuda, Canada, Cayman Islands, Denmark, Finland, Germany, Gibraltar, Hong Kong, Iceland, Ireland, Japan*, Jersey, Liechtenstein, Netherlands, New Zealand, Norway, Singapore, Sweden, Switzerland, UK, US. (*Fitch created distinct recovery rate assumptions for Japanese senior unsecured obligations. These are assumed to recover at 25%).

Group B Countries

Belgium, Chile, Cyprus, France, Italy, Luxembourg, Portugal, South Africa, South Korea, Spain, Taiwan.

Group C Countries

Bulgaria, Costa Rica, Croatia, Czech Republic, Estonia, Greece, Hungary, Israel, Latvia, Lithuania, Malaysia, Malta, Mauritius, Mexico, Morocco, Panama, Poland, Romania, Slovakia, Slovenia, Thailand, Tunisia, Uruguay.

Group D Countries

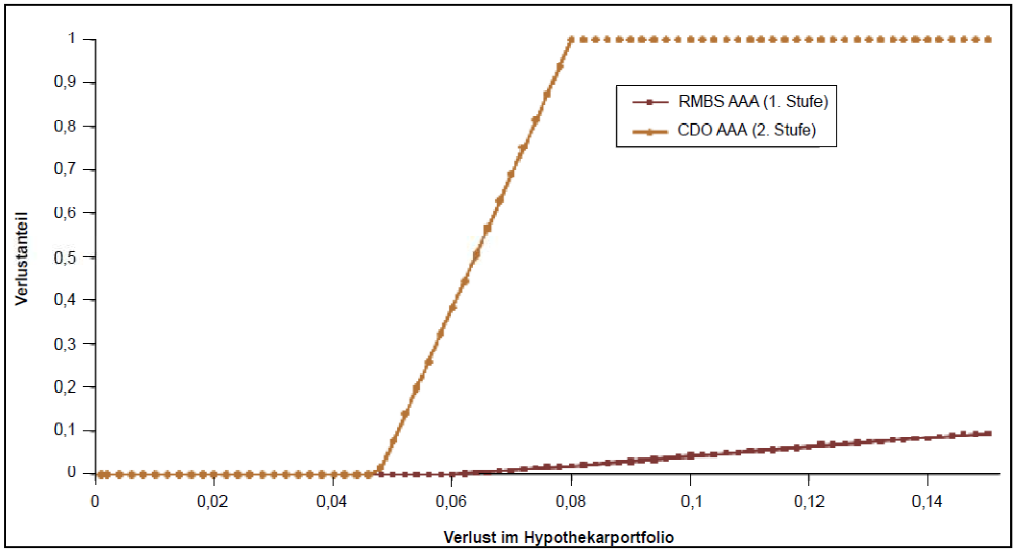
Albania, Argentina, Asia Others, Barbados, Bosnia and Herzegovina, Brazil, China, Colombia, Dominican Republic, Eastern Europe Others, Ecuador, Egypt, El Salvador, Guatemala, India, Indonesia, Iran, Jamaica, Kazakhstan, Liberia, Macedonia, Marshall Islands, Middle East and North Africa Others, Moldova, Other Central America, Other South America, Other Sub Saharan Africa, Pakistan, Peru, Philippines, Puerto Rico, Qatar, Russia, Saudi Arabia, Serbia and Montenegro, Turkey, Ukraine, Venezuela, Vietnam.

Appendix 3 – Fitch's Industry Classes for Correlation

Listing	Sector
1	Aerospace & Defence
2	Automobiles
3	Banking & Finance
4	Broadcasting/Media/Cable
5	Building & Materials
6	Business Services
7	Chemicals
8	Computers & Electronics
9	Consumer Products
10	Energy
11	Food, Beverage & Tobacco
12	Gaming, Leisure & Entertainment
13	Health Care & Pharmaceuticals
14	Industrial/Manufacturing
15	Lodging & Restaurants
16	Metals & Mining
17	Packaging & Containers
18	Paper & Forest Products
19	Real Estate
20	Retail (General)
21	Supermarkets & Drugstores
22	Telecommunications
23	Textiles & Furniture
24	Transportation
25	Utilities

Source: Gill et al 2004, p. 10.

Appendix 4: Average looses of AAA tranches from the first and second layer



Source: Hamerle & Plank 2008, p. 9.

Appendix 5: The Main Counterparties of AIG ($ billions)

Institution	Aggregate Notional Value	Negative Market to Market Value
Société Générale	16,4	8,4
Goldman Sachs	14,0	8,0
Deutsche Bank	8,5	3,6
Merrill Lynch	6,2	3,4
Calyon	4,3	2,4
UBS	3,8	2,0
Deutsche Zentralgenossenschaftsbank (Coral Purchasing)	1,8	1,0
Barclays (BGI cash Equivalent Fund II and Barclays)	1,4	0,6
Bank of Montreal	1,1	0,6

Source: ECB 2009, p. 28.

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