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THE GLOBAL FINANCIAL CRISES

Abstract

The paper considers the purpose and use of MBS, what role they played in the financial crisis and problems caused by them. It also considers the impact of default correlations on losses caused on different tranches of MBS. This paper also looks at how the misuse of Gaussian Copula and repackaging of junior tranches into new ABS exacerbated the 2008 Financial crisis. Finally, a short numerical example of European Call & Put Option valuation using Black Scholes Model and Binomial Model is analyzed.

Keywords: Mortgage Backed Securities, 2008 Financial Crisis, Default Correlations, Black-Scholes Model, Binomial Model, European Call & Put Options.

Introduction

Mortgage-backed security (MBS) is an investment that is made up of a bundle of home loans bought from the banks that issued them. Investors in MBS receive periodic payment. **A mortgage-backed security (MBS) is formed by pooling mortgages. Investors who buy mortgage-backed securities are essentially lending money to homebuyers. MBS can be bought and sold through brokers.**

Benefits of MBS

A mortgage-backed security makes the bank an intermediary between homebuyers and the investment community. Banks can offer mortgages to their customers and sell them at discounted prices for inclusion in MBS. Banks put the sale on the balance sheet positively, and if the homebuyer defaults at some point, they lose nothing. Banks adhere to reasonable mortgage origination standards. Homeowners will continue to make payments on time and rating agencies reviewing MBS will conduct due diligence.

CAUSES OF THE GLOBAL FINANCIAL CRISIS

These causes are broadly summarized into faulty ratings, risky mortgage lending, and lack of accountability and transparency. Customarily, getting a mortgage was difficult

for anyone with lousy creditworthiness or an unstable job; however, things changed in the 2000s. Investors in the U.S looking for a low-risk, high-return investment started funding the U.S. housing market with the hopes of getting a better return on interest rates. The craving for profit gave rise to mortgage- backed securities, which large financial institutions can invest in, rather than dealing with individuals on a one-on-one basis. (O'Donnell)

Mortgage-backed securities are created when financial institutions buy thousands of individual mortgages, bundle them together, and sell shares of that pool to investors. Investors gobbled these securities, considering the rate of return was higher when compared to other financial instruments like bonds, treasury bills. These securities also looked safe. For one, home prices were climbing, and the lenders thought, worst-case scenario, a borrower defaults in his loan, we can sell the house for more money. Also, credit-rating agencies kept assuring investors about the safety of mortgagebacked securities. Many of these mortgage-backed securities received AAA ratings from them, meaning they were most outstanding, assuming that mortgages were for only borrowers with good credit.

Since investors were desperate to buy more of these securities, the lenders did their best to create more of them. Therefore, more mortgages were required to sort out the high demand in the credit market. As a result, lenders relaxed their standards and lent to people with low incomes and low creditworthiness. These were known as subprime mortgages.

Over time, several institutions even started to employ abusive credit traditions to create mortgages. They borrowed without ascertaining income and offered absurd modifiable-rate mortgages with initial costs that people could afford but eventually outgrow their means. These home loans were relatively new, so analysts could still refer to historical data to suggest home debt was a safe bet. The reality was that it was becoming less safe, but investors invested money relying on the reviews. Traders began selling riskier products called collateralized debt obligations (CDOs), which credit agencies highly rated. (Turk)

Role that MBS played in the 2008 Financial Crisis

Mortgage-backed securities played a central role in the financial crisis that began in **2007, wiping** out trillions of dollars **of wealth. Price to enter the market. This kicked off** subprime **MBS, degrading** the quality of all mortgage-backed securities and **rendering** their ratings meaningless.

Subprime borrowers **defaulted, leading to a prolonged** housing market collapse.

Things got worse as more people gave up their mortgages because their homes were worth less than their mortgages. Losses increased as institutional investors and banks tried unsuccessfully to dump their nefarious investments in MBS. Credit tightened and many banks and financial institutions failed. This disrupted lending so much that it threatened to collapse the entire economy.

Option Pricing during the 2008 Financial Crisis ^{2,3}

David X. Li was a Chinese actuary and quant who pioneered the use of Gaussian copula to value MBS & CDOs. Earlier, it was very difficult to value the default probabilities for a book of loans and mortgages, since it was impossible to determine the exact correlations between different risks.

However, David Li decided to assume that markets are efficient and they correctly price default risk. He simply used market prices to model default probabilities rather than characteristics of underlying loans. This simplistic model was adopted by numerous market participants and when teaser rates on variable interest rate loans stopped, defaults & correlations increased and hence the model proved unreliable.

Merits & Demerits of Different Tranches of MBS

- a) The main advantage of senior tranche is that investors are protected from ordinary default losses that are caused when few of the high risk mortgages default on their home loans. But the disadvantage is that they receive lower interest income on their MBS assets. Another disadvantage is that if correlations tend to one as they tend to during crisis times then senior tranche can suffer large losses.
- b) The advantage of junior tranche is that it earns higher interest income as compared to senior tranche. But it faces a higher probability of default than senior tranche. The junior tranche has another disadvantage that it is very difficult to find investors for this tranche. A detailed explanation of this is provided later.
- c) Equity tranche faces the highest default probability. But it also earns the highest interest income. This tranche is usually retained by the originator of mortgages.⁵ This is because they want to earn higher / residual profits from their portfolio of mortgages. They also retain the majority of losses that are likely to occur. This gives other MBS holders higher confidence regarding the payment that they will receive on their MBS assets. So the advantage of equity tranche is that it can be used by mortgage originator to accept main losses and keep other MBS holders secure. The disadvantage of Equity tranche is that it has very low credit rating & high default probability so not suitable for the majority of investors.

Impact of Default Correlations on Different Tranches⁴

Consider 5 different types of tranches: A, B, C, D & E. A is least risky and defaults only if all underlying mortgages fail. E is riskiest and defaults if anyone of mortgage defaults.

The default probability matrix for 5 tranches assuming each defaults are perfectly correlated (correlation = 1) and perfectly independent (correlation = 0) is given below. We have assumed that the default probability is 5% fixed for each tranche. The table also gives the risk multiple for each between independent and correlated tranches.

MBS Type	Perfectly independent default probability	Perfectly correlated default probability	Risk Multiple
A	0.00003%	5%	160000
B	0.0030%	5%	1684
C	0.11281%	5%	44
D	2.14344%	5%	2
E	20.3627%	5%	0.2

The Independent scenario will be possible when markets are healthy and stable. Correlated scenario is similar to the 2008 crisis situation. It demonstrated the fact that when a crisis happens all tranches default together contrary to the expectation that these tranches are independent.

Tranche A which is considered to be least risky when correlations are 0 is 160000 times riskier if we assume that defaults are perfectly correlated. Tranche E which is considered to be riskiest when correlations are 0 is $\frac{1}{5}$ times riskier if we assume that defaults are perfectly correlated.

Thus we can conclude that:

1. When correlations are low, senior tranche is a relatively safe investment & equity

tranche is a relatively high-risk investment

2. When correlations are high, senior tranche is a relatively high-risk investment & equity tranche is a relatively low-risk investment.

Repackaging of the junior tranche⁵

As mentioned previously, there were few buyers for junior tranche. So the originators had to use creative methods to sell them. A commonly employed technique was to combine multiple different junior tranches from different MBS and create a new ABS (Asset Backed Security). This new ABS was further divided into senior tranche, junior tranche & equity tranche. Credit rating agencies also gave favorable ratings for tranches of this new ABS.

For this new ABS, the terms of senior tranche, junior tranche and equity tranche were very deceptive. All these were effectively junior tranches of underlying mortgages. The below table gives an example of the losses that may be faced on the junior tranche of both original MBS & new ABS.

Loss on underlying assets	Loss on junior tranche of original MBS	Loss on junior tranche of new ABS
10%	33.33%	93.33%
13%	53.33%	100%
17%	80%	100%
20%	100%	100%

Hence, we can see that even a 3% increase in loss of underlying assets can give 100% loss in junior tranche of new ABS. This was not understood by many institutions before the crisis and later led to significant losses when housing defaults increased.

ROLE PLAYERS IN THE HOUSING MARKET

There were many key players in this crisis:

HOMEBUILDERS: The home builders were responsible for building more houses on land available, which large companies had purchased a share of the land from the Government. Utilizing a contract, these owners entered into profitable deals as it was

a housing boom. When the collapse happened, more houses were up in the market, almost eliminating the need to build new ones. These activities fell the profits of these home builders consistently from 2006, rendering many jobless.

MORTGAGE LENDERS: A mortgage lender is an entity that offers and underwrites home loans. These lenders offered up sub-prime mortgages to those who did not meet the creditworthiness criteria.

MORTGAGE-BACKED SECURITIES: These securities were only as sound as the fundamental mortgage. So once mortgages failed, these also failed.

REALTORS: Most of these entities lost much money as they were brokers selling houses to consumers. They also did not care to check the financial credibility of the occupants. However, during the peak season, they were ready to sell off houses to the highest bidder. As more houses were on sale, the supply was high as people started giving up their houses. Soon, they were almost out of business as many refused to purchase a house.

REAL ESTATE APPRAISERS: The real estate appraisers were to ensure that market participants willing to get a house went through necessary checks, which meant that they ascertain the house's correct market value, the replacement value, and the income of the possessor. If anyone does not match each other, they should raise the alarm. However, their appraisals were faulty, as evident in sub-prime mortgages' appearance and the hike in interest rates.

The stakeholders in this game who stood to gain more if the market prices skyrocketed were mortgage lenders, banks, realtors, insurance companies like AIG.

Townships that collect local real estate taxes: They are a local governing body that collects property tax. They will use the assessed taxes to fund and improve other community projects and provide law enforcement, fire protection, education, road and highway construction, libraries, and other services that benefit the community.

Homeowners using a mortgage: Homeowners using mortgages are individuals or groups of people that own a real estate property through mortgage financing

RISKS ASSOCIATED WITH THE CRISIS

The **biggest** risk facing stakeholders is credit risk. This is the **potential** for default due to **the** failure of **the borrower** to make required payments. **Lenders bear key risks such as loss of** principal and interest, **disruption of cash flows**, and increased collection costs. **Loss may** be total or partial.

Systemic risk is the possibility of a complete system failure rather than just individual elements failing. It denotes the danger of a financial sector cascading failure induced by financial system linkages, resulting in a severe economic slump in a financial setting. The systemic risks involved in the housing market include market risk, interest rate risk, purchasing power risk.

Market Risk is the chance that an individual or other entity will suffer losses due to factors affecting the overall performance of financial market investments.

Interest Rate Risk is the possibility that a change in overall interest rates may cause the fixed-rate investment to lose value. Loans with fixed-interest decline as interest rates rise, and vice versa.

Purchasing Power Risk is the risk that inflation will depreciate the actual worth of an investment's cash flows.

REGULATIONS ARISING FROM THE CRISIS.

The global financial crisis of 2007-2008 led to the clamor for legislative and regulatory changes in the United States and around the world. The banks were primarily responsible for the majority of governmental responses to the crisis. In order to stabilize the economy, significant policies and regulations were introduced, each with its intended impact. These regulations are; The stimulus package proposed by Fiscus, Troubled Asset Relief Program (TARF), Dodd-Frank Reform Act. In this work, our emphasis shall be on the Dodd-Frank Reform Act. (Acharya)

INTENDED AND UNINTENDED REGULATORY EFFECTS

The crises hit the market really hard with a lot of selling and little buys. Regulatory acts

were intended to assist with the issues but there were some unaccounted behaviours that the regulations could not necessarily fix immediately. For example: Liquidity became a serious issue as regulation had an effect on short-selling.

THE DODD-FRANK REFORM ACT

The Dodd-Frank Wall Street Reform and Consumer Protection Act was passed in 2010 by President Barack Obama. To maintain financial stability and avoid another financial crisis from wreaking havoc on the economy. The statute was the most substantial overhaul of financial regulation in the United States since the 1930s. The financial sector was safer after the crisis as a result of this regulation and many other measures. It is critical to evaluate how this law has improved financial stability. (Jickling)

Financial Stability: Under the law, the Financial Stability Oversight Board and the Department of Orderly Liquidations are tasked with overseeing the financial stability of large financial companies ("too big to fail"). The law also provides for liquidation through an orderly liquidation fund. The fund was established to help liquidate financial companies placed in trustees and to prevent taxpayers' money from being used to support such companies and causing systemic risk. rice field. it may also force us to increase our reserve requirements. Similarly, the new Federal Insurance Administration is tasked with identifying and overseeing insurers deemed "too big to fail." (Berwick)

The Consumer Financial Protection Bureau(CFPB): The CFPB was created with the mandate to prevent predatory lending (subprime mortgages) and make it easier for consumers to understand the terms of a mortgage before taking it out. This prevents mortgage brokers from getting higher fees by completing loans with higher fees and higher interest rates. The CFPB also oversees other types of consumer credit, such as credit and debit cards, and handles consumer complaints. Lenders, other than car lenders, must disclose information in a way that consumers can easily understand. Applying for a credit card is one of them. (Conley)

Securities and Exchange Commission (SEC) Office of Credit Ratings: This office within SEC was created and tasked with ensuring that agencies provide meaningful and reliable credit ratings of the businesses, municipalities, and other entities they assess. This was aimed at preventing credit rating agencies from giving false ratings that contributed to the crises. (TARP)

Whistleblower Program: This law was also superseded by the Sarbanes-Oxley Act

(SOX) to promote and expand the existing whistleblowing program established after the Enron crisis. Specifically, it enacted a compulsory bonus program in which the whistleblower could receive 10% to 30% of his litigation cost earnings, and broadened the scope of eligible employees to the company's subsidiaries and affiliates. Expanded to include employees and broadened the limit judgment. This allows a whistleblower to file a claim against his employer within 90 days to her 180 days after discovering the violation. (schedule)

UNINTENDED CONSEQUENCES OF THE DODD-FRANK ACT(DFRA)

Some government programs or laws always have drawbacks, such as the overregulation of the banking industry following the financial crisis, which drove individuals and corporations alike to seek out less regulated financial services (AFS). Low-income households and young wage earners are the most affected. The CFPB's more excellent protection and stringent standards make credit more difficult to obtain. People are becoming acclimated to AFS, which causes banks to lose business. (Claessens) While the DFRA has provided significant benefits, it has also resulted in specific unforeseen effects. Because of the high cost of regulatory compliance, the DFRA focused on significant banks. However, the restrictions ended up having an outsized influence on community banks. In addition, the following are some of the negative consequences of the Act: (Rodrigo)

Financing from a private seller: - This is when a private seller transfers title to a property and, rather than receiving the full transaction price in cash, opts for a mortgage for a significant portion of the sale price. Historically, private sellers financing has benefited sellers, buyers, and their respective states. The Dodd-Frank Wall Street Reform and Consumer Protection Act shifted the private market to financial institutions, benefiting banks at the expense of private sellers. Unfortunately, this was the polar opposite of what the Act was designed to achieve. (Chaudary)

Reduced Market Liquidity:

The DFRA ensures the protection of financial institutions while also causing the market to remain illiquid. Because not all securities are mark-to-market, the bond markets are hampered, and most bonds do not have a consistent supply of buyers and sellers, resulting in a liquidity shortage. As a result, there are few prospects for individuals at all levels of the investment chain. (Dullien)

NOTABLE CAUSES OF THE CRISIS

Greed: The desire to get rich quickly contributed to the crisis as many key players were motivated. Homeowners desired to become rich quickly by flipping real estate. Mortgage originators went to the extent of giving loans to unworthy clients in order to increase loan volumes. Home appraisers were giving flawed, but favorable ratings to mortgages owners.

Bankers were paid vast amounts of money to securitize precarious subprime mortgages. Regulators were motivated to get a bigger paycheck offered by the private sector. In an attempt to please their people, politicians compel banks to lend money to their un- creditworthy constituents. (Tang)

Fraud: Much fraud led to the crisis. Fraud was evident from the rating agencies that gave false ratings to the mortgage originators that gave toxic mortgages to unworthy clients.

Faulty assumptions: With the bubbling of the house mortgage market, key players assumed that the demand would continue to rise, leading to a continual increase in house prices. Nevertheless, this assumption was wrong as the housing bubble eventually burst. (Buckley)

Negligence: Some regulatory agencies absconded from their responsibilities in overseeing the entire process.

Carelessness: Most key players were not receptive to the change in the demands over time as they were carried away by the returns on investment.

Ignorance: Some prospective homeowners entered into contracts without sufficient information and lacked understanding of the contract terms, which led to many defaults. (Haldane)

MORTGAGE-BACKED SECURITY (MBS)

Mortgage-backed securities (MBS) are examples of Asset-backed securities that is backed by a mortgage. It is akin to financial instruments such as stocks, bonds, and the likes. The value of the MBS lies in the underlying asset.

MODALITIES OF MORTGAGE-BACKED SECURITIES

Creating an MBS begins when a bank or mortgage company **takes out a mortgage**. **These originators (lenders) transact this** loan to investment **banks**. **Proceeds** from the sale to investment **banks will be** used to **issue** new loans. **Lenders begin** the process of **creating** new **mortgages** for new **customers, while** investment **banks** take the original loan and **match** it to a **bunch** of mortgages with similar interest rates. **Investment banks then form bundles** of similar **mortgages** and place the **bundles** in special **companies** called Special Purpose Vehicles (SPVs) or Special Investment Vehicles (SIVs) designed to create MBS. **This** separates the mortgage-backed securities from **the** bank's other services. **SPVs sell** these mortgage-backed securities to investors. **An investor buys his MBS the same way he buys a bond**. **Investors pay to keep her MBS and receive** income while holding the **bond**. **This is assuming** the customer pays off **the mortgage** and the MBS investor **gets** some **profit** in return.

TYPES OF MORTGAGE-BACKED SECURITIES

There are two basic types of mortgage-backed **securities**: mortgage-backed **securities** and **mortgage-backed securities (CMOs)**.

Pass-through MBS

The pass-through mortgage-backed security is structured in the form of trust such that principal and interests payments are passed through to the investors. It is designed to have a specific maturity date, though; the average life may be less than the stated maturity age. Under the grantor trust rules, the trust that sells pass-through MBS is taxed, which dictates that the holders of the pass-through certificates should be taxed as the direct owners of the trust apportioned to the certificate.

Collateralized Mortgage Obligation (CMO)

Collateralized mortgage obligations are divided into tranches which comprise multiple pools of securities. Each tranche is associated with different maturities and priorities in the receipt of the principal and the interest. The tranches are also given separate credit ratings. Investors prefer riskier tranches because there come with higher interest rates. Also, the least risky tranches offer the lowest interest rates.

Numerical Example of Option Pricing using Black-Scholes Model & Binomial Model

We have attached the Excel sheet showing the calculation of European Call & Put Options on Microsoft during the 2008 crisis. We have used both the standard Black-Scholes Model and 6 step recombining binomial tree.

Parameters for the Black-Scholes Model:

1. $S = \$35.22$. The current stock price is taken as the stock price of Microsoft on 2 January 2008.
2. $K = 35$. The strike price is \$35.
3. $T = 0.5$. The time to maturity is 0.5 years.
4. $\sigma = 22.71\%$. The annual volatility is calculated as: Volatility of daily continuously compounded returns $\times \sqrt{252}$
5. $r = 1\%$. The continuously compounded annual risk free interest rate is 1%

Parameters for the Binomial Model:

In addition to the above parameters, the binomial model has below parameters:

1. Monthly $r = 0.08\%$. It is the monthly continuously compounded risk free interest rate. It is calculated as annual risk free rate / 12
2. Monthly $\sigma = 6.54\%$. It is the monthly volatility. It is calculated as annual volatility $\times \sqrt{(1/12)}$
3. $u = 1.0676$. It is the up movement factor and calculated as $\exp(\text{Monthly } \sigma)$
4. $d = 0.9367$. It is the down factor and calculated as $1/u$.
5. $p_u = 0.49$. It is the probability of up movement and calculated as $(\exp(\text{monthly } r) d)/(u-d)$
6. $p_d = 1 - p_u$. It is the probability of down movement and calculated as $1 - p_u$.
7. The number of time steps in Binomial Model is 6.

Calculation Methodology for Black Scholes Model:

In the Black-Scholes Model, the Call & Put Option Price is calculated using the standard formulae:

$$d1 = [\log(S/K) + (r + \sigma^2/2)*T] / \sigma\sqrt{T} \quad \text{and} \quad d2 = d1 - \sigma\sqrt{T}$$

$$\text{Call Price} = S * N(d1) - K * \exp(-r*T) * N(d2) \quad \& \quad \text{Put Price} = K * \exp(-r*T) * N(-d2) - S *$$

N(-d1) Calculation Methodology for Binomial Model:

For the Binomial Model we have constructed a six step recombining Binomial Tree as

below:

Month 0	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
						52.15525
					48.85173	
				45.75745		45.75745
			42.85917		42.85917	
		40.14446		40.14446		40.14446
	37.6017		37.6017		37.6017	
35.22		35.22		35.22		35.22
	32.98916		32.98916		32.98916	
		30.89962		30.89962		30.89962
			28.94243		28.94243	
				27.10921		27.10921
					25.39211	
						23.78377

1. For each of possible share prices the call & put payoff is calculated.
2. The probability for each path is ${}^6C_n \cdot p^{6-n} \cdot d^n$ where $n = 0, 1, 2, 3, 4, 5, 6$. So the probabilities for each path from highest path to lowest path are 1.38%, 8.64%, 22.49%, 31.21%, 24.36%, 10.14% & 1.76%.
3. The discount factor is $\exp(-\text{annual risk free rate} \cdot \text{term of option in years})$
4. The expected discounted payoff for call & put options is calculated as $\text{payoff} \cdot \text{probability} \cdot \text{discount factor}$.
5. The fair value of options is calculated as the sum of expected discounted payoff.

Summary of Results:

European Option	Black-Scholes Price	Binomial Model Price	Percentage Difference
Call	\$2.44	\$2.38	2.58%
Put	\$2.05	\$1.99	3.07%

The percentage difference between the prices under Black-Scholes Model and Binomial Model is less than 5% for both Call & Put Options. If time steps are increased to 50, then the prices will be approximately equal.

Conclusion

MBS had an influential role in freeing up capital and increasing credit in the economy before the 2008 crisis. However, they were misused and resulted in significant losses in the economy. Now regulations like Dodd-Frank and Volcker Rule have prevented such excesses from happening again. However, the crisis still holds a lot of lessons for investors. Specifically, that any financial instrument must be used with great care and only after understanding all associated risks with it. Investors must also not take decisions based on greed and quick profits but think about long term consequences of their decisions.

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