Securitization:

In Module 4, we defined a derivative as a financial instrument whose value depends on the value of some underlying asset(s). Now, we refine this definition to say that a derivative has a finite lifetime and that its value is known precisely at either inception (e.g., swap) or expiration (e.g., option). Thus, while a weather derivative does not have an underlying asset or security (often called "the underlying"), it still satisfies the price condition at one of the boundaries. We also introduced the concept of a mortgage-backed security (MBS) as a type of derivative security that is backed, or secured, by a bundle of home loans. If you need a refresher on mortgages, refer to Module 4, Lesson 3 as needed.

*In this lesson, we track a mortgage from **origination** to **securitization**. Origination is the creation of the mortgage loan itself: a bank originates a mortgage simply by entering a mortgage contract and lending money. Securitization was defined in Module 4 as the creation of new securities that are collateralized by assets such as mortgages. We will also discuss credit risk and how to analyze it conceptually. Then, we discuss in more detail the transformation of mortgages into MBSs via the securitization process.*

Specific to the United States, there is also a class of mortgages known as **jumbo loans** or **mortgages**. A jumbo loan is a mortgage used to finance properties that are too expensive for a conventional mortgage. Loan limits are set by the **Federal Housing Finance Agency** (FHFA) and assigned to two government-sponsored enterprises in terms of the maximum amount the FHFA agrees to cover: the Federal National Mortgage Association (FNMA, colloquially known as *Fannie Mae*) and the Federal Home Loan Mortgage Corporation (FHLMC, commonly known as *Freddie Mac*). Note that these are government sponsored enterprises (GSE) and not government agencies. These two GSEs are responsible for buying the bulk of U.S. residential mortgages from lenders, and they set the limit on the maximum value of any individual mortgage that they will purchase from lenders. This amount is important because lenders rely on these purchases to free up liquidity and provide new loans. As of this writing (2024), the limit is $766,550 in most counties, but it changes every year. Jumbo mortgages may have high credit quality, but they are in amounts above conventional conforming loan limits. In areas of the U.S. where the prices of real estate are very high, most mortgages could be jumbo loans. Traditionally, the interest rates on jumbo mortgages are higher than for conforming mortgages, but not in every case. However, jumbo loans have been associated with some of the craziest excesses during the housing bubble (2004-2007). During that period, over $3 trillion worth of jumbo loans were originated and offered at terms that were too easy and which ultimately precipitated the collapse that ensued, as most of us know by now.

Once one understands that mortgages are complex creatures and that there are risks behind mortgages, one should also realize why lenders put borrowers through what is usually a rigorous vetting process. We could say that if this process had been equally rigorous during the housing bubble, perhaps we would not have experienced what we did, but that is a story for another time. We will look at how banks and lenders in general vet prospective borrowers more in detail in the next section.

Credit risk and 5 Cs:

In the U.S., the borrower applies for a mortgage from a retail bank, or possibly from a mortgage bank that specializes in residential mortgages. (Note that some banks may specialize in commercial mortgages.) Borrowing is a type of credit, and banks are traditionally in the business of providing credit (loans), so it's no surprise that loans have credit risk. What is credit risk? As you recall from Module 1, credit risk is the risk that the lender does not receive the money that is owed to them in full and on time. In other words, credit risk is the risk of loss due to non-payment. In the case of a mortgage, it is the risk that the borrower does not pay back all of the money borrowed to buy a home.

To manage credit risk, a bank requires a significant amount of credit information from its clients. For instance, the borrower must complete a lengthy application for a mortgage. This application requires various types of information. You can probably already guess at least some of the types of information that a bank would want to know about a borrower before deciding to originate a loan.

Before moving on, take a minute or two to write down what information you would want to know about a borrower before loaning them money.

Then, check out the *Open Risk Manual* from the required reading. Does what you wrote down match one or more of the 5 Cs of credit analysis?

Next, we'll take a closer look at the 5 Cs:

- Capacity;
- Capital;
- Character;
- Collateral; and
- Conditions.

A single mortgage is considered illiquid because most investors and other financial players do not want a single mortgage.

The bank can now hold on to this mortgage loan asset and wait for Jacob to make monthly payments of principal and interest until he has fully paid back the loan. However, there are at least two reasons that this may be undesirable from the bank's perspective:

1. The mortgage term is likely 30 years, which is a long time for the bank to have its capital tied up in a single transaction. If the bank needs money during that time (say if depositors in the bank want to withdraw money), it could be hard for this bank to sell a single mortgage. A single mortgage is considered illiquid because most investors and other financial players do not want a single mortgage; there isn't a market for single mortgages. If the bank desperately needed to sell the mortgage loan because it needed money to pay its liabilities (e.g., the depositors want to withdraw their money), another bank might buy the mortgage but for less than it is worth. The risk of not being able to sell an asset at all or having to sell an asset at a steep discount is called **liquidity risk**.
2. This retail bank may not have much capital, and $400,000 may be a sizable portion of their assets. Let's consider an extreme example and say that the bank only has $4 million in capital. That means the bank loaned Jacob 10% of their capital. If Jacob is the only borrower who defaults (doesn't make the monthly mortgage payments) on the loan, the bank's capital decreases to $3.6 million, which may be unacceptable to investors in the bank as well as the bank's senior management. Too much of their capital, and too much risk, is concentrated in a single borrower. This is known as **concentration risk**. We saw from Module 3 that this is the opposite of a diversified portfolio. Just as we might be interested in having diversification in a stock portfolio and not having too much concentration in a single stock, the bank would also want diversification in the form of mortgage loans to a variety of borrowers.

If the bank does not want to keep the mortgage because of these risks, it can sell Jacob's loan to an investment bank. What is an investment bank? Why does an investment bank want these mortgages and their concentration and liquidity risks? What will the investment bank do with the mortgages it buys? We'll answer these questions in the next section.

4. The Investment Bank

Investment banks have a major role in the securitization of mortgages and other assets. But what is an investment bank? An investment bank is different from a commercial or retail bank in that its clients are usually larger institutions, though some of the services provided overlap across bank types.

	Investment Bank	Commercial or Corporate Bank	Retail Bank
Typical clients	Corporations and other institutions	Businesses, governments, and other institutions	Individuals, small businesses
Typical services	• Bond and equity underwritings • Initial Public Offerings (IPOs) • Mergers and acquisitions (M&A) advice and support • Brokerage (trade facilitation) • Dealing in swaps and other OTC derivatives • Issuance of MBSs and ABSs (via trust vehicle)	• Secured and unsecured lending • Cash management • Payment processing • Treasury services • Foreign exchange • Facilitate wires • Automated Clearing House (ACH) services	• Deposits (checking and savings accounts) • Loans (including mortgages and personal line of credit) • Access to cash (e.g., ATMs) • Safe deposit boxes • Facilitate wires

The following motto summarizes the strategy of investment banks active in mortgage securitization: "We are in the moving business, not the storage business."

Watch the "Mortgage-backed Securities Overview" video from the list of required readings and see if you can explain what this motto means in terms of what an investment bank does with mortgages.

Does the investment bank in the video store (hold onto) the mortgages that it buys from the retail bank? Or does the investment bank move (sell) the mortgage into a special purpose entity (SPE)?

Since the investment bank moves these mortgages into an SPE, the investment bank doesn't keep the liquidity or concentration risks.

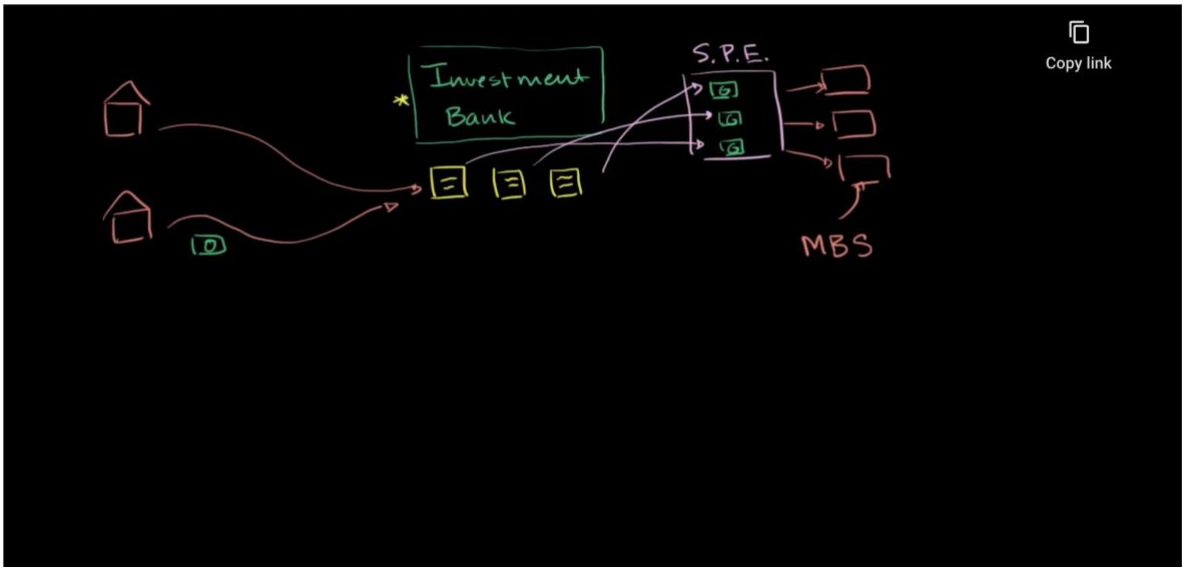
Investment bank can buy some mortgages (becomes the lender of the homeowners). Investment bank owns the shares of the SPE and can sell those shares to investors.

SPE is a corporation, and it sticks all of the mortgages inside. (SPE becomes the owner of the mortgages). SPE pay interest to the owner of the MBS.

These shares are called MBS (mortgage backed securities).

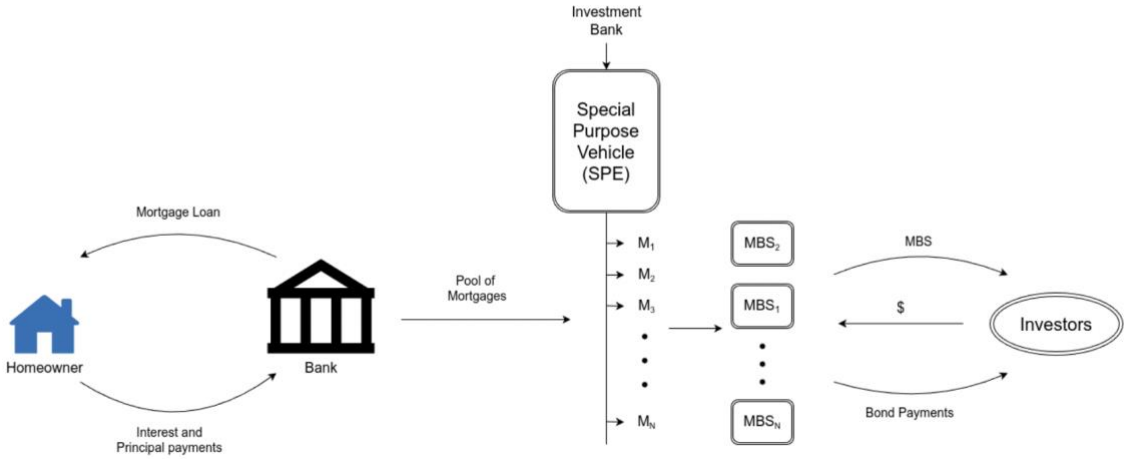
Mortgage-backed security overview

Google Classroom Microsoft Teams



Watch the "Mortgage-backed Securities III" video from the list of required readings and pay close attention to what ultimately happens to all the monthly mortgage payments from borrowers. Where does that money end up?

Figure 1: Process of Mortgage Securitization and MBS Issuance



5. The Securitization Transformation

As you can see, a single mortgage-backed security is backed or collateralized by many thousands of individual mortgages. If an investor buys $1 million worth of MBSs, a single mortgage will only comprise a fraction of a percent of that investment. The concentration risk we discussed above has been diversified away. The MBS has diversified underlying assets (mortgages) in the sense that there is no concentration in a single mortgage borrower. However, the MBS is still completely concentrated in the larger mortgage market. As such, this concentration in the mortgage asset class cannot be diversified away from MBSs.

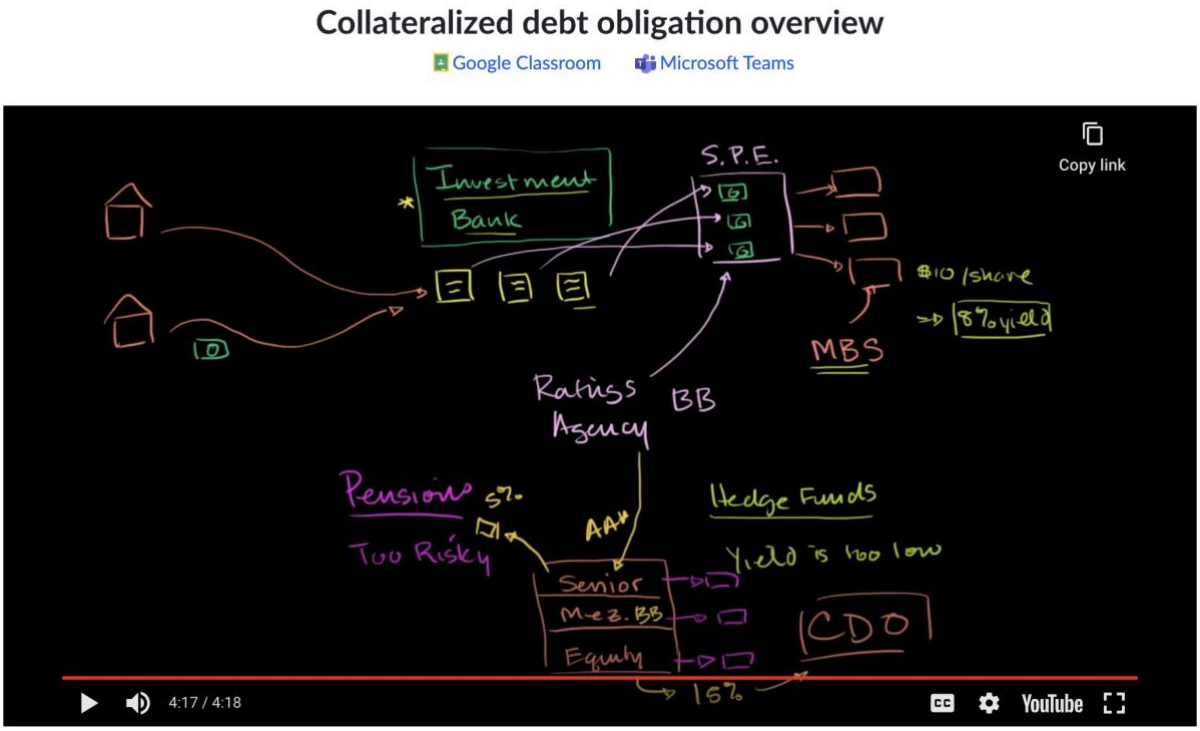
Because this concentration risk has been at least partly eliminated, more investors want to buy MBSs; that is, there is an active market for MBSs. As long as there is an active market for buying and selling a security, it is considered liquid. The illiquid, concentrated single mortgage has been transformed into a relatively liquid security with diverse underlying mortgages. We will discuss definitions and calculations related to liquidity in Lesson 4.

We know about the securitization process that results in MBSs. We also discussed the credit concepts used to decide whether to make a personal loan (like to Nushi in our earlier example) or a mortgage loan or when buying a bond. Next, let's apply these concepts to two MBS investments. Take a look at the summary statistics for the mortgages underlying these two securities.

Please consider and try to answer the following questions about MBS collateral from the perspective of the 5 Cs of credit:

- LTV stands for "loan to value." The loan-to-value ratio is 80% for a $400,000 loan on a $500,000 house. This implies that the borrower supplied a down payment of $100,000.
- DTI stands for "debt to income." The debt-to-income ratio is 33% if the borrower has $330 of monthly debt expenses (such as the mortgage payment) and makes $1,000 per month.
- FICO originally stood for "Fair Isaac Corporation," the company that developed the credit scoring model. FICO is a third-party **credit scoring service**. A high FICO score indicates a creditworthy borrower who is likely to repay their debts.

CDO (collateralized debt obligations): is a derivative security from the mortgages.



6. Tranches and the Payment Waterfall

One of the simplest examples of securitization would involve the sale of only one class of bonds. But this would not necessarily be the best way to repackage the mortgages or any asset-backed security in general. Investors have different desires for returns and different appetites for risk.

For these reasons, the structure of securitization is often more complicated and involves several classes of bonds. In the introductory video, "Collateralized Debt Obligation Overview" and in the "Collateralized Debt Obligation (CDO)" video that follows it (both from the required readings), pay special attention to the differences between senior, mezzanine, and equity tranches of the collateralized debt obligation (CDO), especially in terms of risk and priority of cash flows.

From those readings, it should emerge that securitization involves forms of credit enhancement via what the industry calls **subordination** or **credit tranching**, which is realized by creating different bond classes. These bond classes differ in the way they share losses deriving from the defaults of the borrowers whose loans are included in the collateral.

The **senior bond class** is the least risky bond class, and it can comprise several sub-classes (tranche A, tranche B, etc.), each with a certain level of subordination to the previous sub-class. It is not unusual to refer to the non-senior classes as **subordinated classes** or **junior bond classes**. The risk goes up as we consider each subsequent class. And the risk goes up even more as we consider the **meazzanine** and the **equity classes**.

The process of subordination works in that the more subordinated classes protect the credit for the more senior bond classes: when losses occur, they are absorbed (i.e., attributed to) by the subordinated classes before any loss is incurred by the senior bond classes. These classes may satisfy the investors. Obviously, to compensate the holder of junior or subordinated bond classes for the additional risk, they will receive a higher return.

Example. *Consider the case in which an investment bank has created an SPE with a total par value of $300 million of mortgages. In the SPE, the credit tranching consists of 3 classes of bonds: tranche A (senior class) with a par value of $200 million, tranche B (a subordinated mezzanine class) with a par value of $70 million, and tranche C (an equity class) with a par value of $30 million. Losses will be absorbed in this order: tranche C, tranche B, and tranche A. Then:*

- *If defaults do not exceed $30 million, then they will all be absorbed by tranche C.*
- *If defaults are, say, $50 million, then $30 million will be absorbed by tranche C and $20 million by tranche B. Nothing happens to tranche A, which would be fully repaid.*
- *However, if the SPE were to experience a massive default, say $140 million, then tranche C and tranche B would be completely wiped out, and tranche A will also suffer a $40 million loss as the subordinated tranches could only shield it from a loss of up to $100 million.*

While defaults are certainly feared as they could wipe out investments, there is another type of risk that is important to consider: **prepayment risk**. What is prepayment risk? In general, prepayment risk refers to the risk that the principal amount (or at least a portion of the principal amount) outstanding on a loan is prematurely paid back. Why should we worry about prepayment, since we get our money back earlier instead of later? Well, we should think of why someone who owes us money is willing to pay us back earlier than agreed.

Suppose you had a mortgage on which you pay an interest rate of 6%. Now, overall interest levels are going down, and you are offered the opportunity to **refinance** your mortgage with a different bank for just 4.5%. What would you do? Unless there are restrictive clauses in your mortgage agreement or large penalties to pay, you would refinance your mortgage, right? The bank that originally provided your mortgage loan receives its money back ahead of time and can use that money to originate new mortgages. However, and this is where the problem lies, the new mortgage will be for around 4.5% instead of 6%. This is bad news for the bank, and it is usually not good news for the MBS investors either since investors receive their principal back ahead of time and need to reinvest it at what are likely lower rates of return. So, yes, there is less credit risk, but now they face reinvestment risk. To alleviate the issue of the uncertainty of cash flows that occurs with prepayment risk, investment banks can create an SPE whose MBSs consist of bond classes that possess different expected maturities. This type of tranching is called **time tranching**. This works like credit tranching essentially, but the difference is that prepayments are first absorbed by the subordinated classes and then, only after the buffering of the subordinated classes is completely used up, the more senior classes. It is quite unusual for MBSs to shield investors from prepayments as it would be too costly for the investment bank that issues the MBSs. However, time tranching addresses these issues. Of course, again, junior tranches would be compensated with a higher return for assuming more reinvestment risk.

You may wonder: why do we need a special legal entity, the SPE, in securitization? There are several reasons. The SPE will get a rating, as you learned from the required readings/videos. And this rating may be different from that of the company that issues the bonds associated with the securitization process. Using an SPE, the bonds can be backed by specific collateral instead of a generic collateral, which is very relevant in the unfortunate case of bankruptcy. We won't elaborate on this topic, but the creation of SPEs to issue MBSs is very relevant for legal reasons. While the process can vary based on different jurisdictions, in the case of securitization, courts have no discretion to change seniority for the very simple reason that the bankruptcy of an issuer does not extend to the SPE.

Now that you have seen how assets can be securitized to create new securities, read the relevant pages of the Romero-Torres primer on securitization structure in India[2]. The concepts are the same, but this reading goes into a little more detail. You'll read more about cash flows and other relationships between the participants, from the borrowers to the investors, as well as some additional market players that have special roles to play, such as the servicer, the rating agency, and the credit enhancement provider.

1. The 5 Cs Return

The required reading "Understanding the Securitization of Subprime Mortgage Credit" lists five credit characteristics of the subprime mortgagor, numbered below for easy reference (Ashcraft & Schuermann 14-16):

1. Two or more 30-day delinquencies in the last 12 months, or one or more 60-day delinquencies in the last 24 months;
2. Judgment, foreclosure, repossession, or charge-off in the prior 24 months;
3. Bankruptcy in the last 5 years;
4. Relatively high default probability as evidenced by, for example, a credit bureau risk score (FICO) of 660[1] or below (depending on the product/collateral), or other bureau or proprietary scores with an equivalent default probability likelihood; and/or,
5. Debt service-to-income ratio of 50 percent or greater; or, otherwise limited ability to cover family living expenses after deducting total debt-service requirements from monthly income.

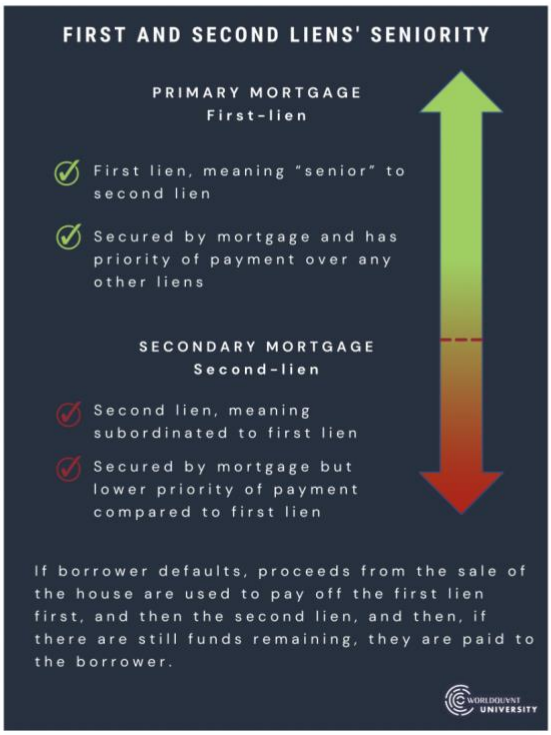
Recall the 5 Cs of credit analysis and consider how you might use them to evaluate these characteristics.

The first four all suggest a deficiency in the borrower's *character* or *capacity*. Multiple delinquencies (late payments) in the past year or two most likely means the borrower was unwilling or unable to pay on time. Same with bankruptcy and "judgment, foreclosure, repossession, or charge-off," which are actions taken when a borrower never repaid their debt, as opposed to just repaying late. As discussed in the last lesson, a bad (low) credit score is also interpreted as a *character* issue. Lastly, we recognize the "debt service-to-income ratio" as the DTI ratio we discussed in the last lesson, which is another measure of *capacity*.

In "the motivating example" of the same section, the mortgage pool underlying a particular MBS offering is summarized by, among other data, the following (Ashcraft & Schuermann 14-15):

- 98.7% of the mortgage loans are first-lien. The rest are second-lien home equity loans.
- 43.3% are purchase loans, meaning that the mortgagor's stated purpose for the loan was to purchase a property. The remaining loans' stated purpose are cash-out refinances of existing mortgage loans.
- 90.7% of the mortgagors claim to occupy the property as their primary residence. The remaining mortgagors claim to be investors or purchasing second homes.
- The **combined loan-to-value ratio (CLTV)** is the sum of the original principal balance of all loans secured by the property to its appraised value. The average mortgage loan in the pool has a CLTV of 80.34%, which implies an average downpayment of 20%. However, given that this is an average number, the astute credit risk analyst should pay attention to the proportion of borrowers with more than 80% CLTV.

A first-lien loan has priority over a second-lien loan. (From the perspective of the five Cs, the implications of this difference might be captured under "Collateral"; alternatively, they might be classified under "Conditions" because whether the loan has a first- or second-lien is a "contractual term of the loan.") If a borrower has a second-lien loan and the borrower defaults, then the lender of the first-lien loan is repaid from the proceeds of the liquidated collateral first. The lender of the second-lien loan only benefits if the value of the collateral (a house in this case) exceeds the amount of the first-lien loan. As such, for the MBS investor reviewing the mortgage pool referenced above, the fact that almost all of the loans are first-lien is good: this *collateral* is better than a similar pool with a higher proportion of second-lien loans.



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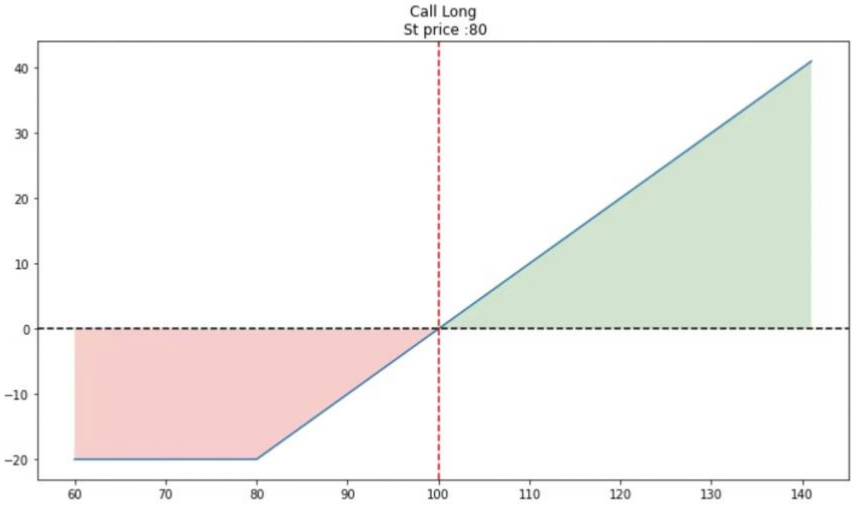
Say, for example, a bank provides an $80,000 loan to a borrower to buy a $100,000 house (the borrower made a $20,000 down payment): This is analogous to the bank having a short put with an $80,000 strike. A few months later, the local real estate market deteriorates, and the house is now worth $80,000. In this situation, most borrowers will continue to make their mortgage payments and avoid default. Though the house price decreased significantly, the bank has not lost any money--yet.

Figure 3: Long Call Payoff Diagram

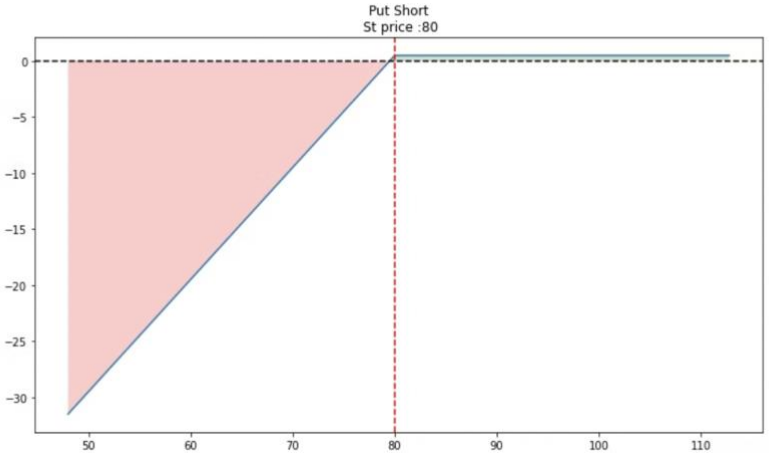


Now, say the real estate market sinks even more, and the house is only worth $50,000. (Such a loan is called "under water" because the home value is worth less than the outstanding loan amount.) At this point, many mortgage borrowers will decide to walk away, as described above. If the borrower does default, the bank suddenly has a loss of at least $30,000 (check the graph): the bank's P/L has moved down the diagonal into a loss. This broken line demonstrates the non-linearity of risk to the bank.

By this same logic, the borrower has a long call position on her house. If her house price increases substantially, she can sell her house, pay back the mortgage loan, and make a profit. Her P/L profile is shown in the graph below: she has all of the upside (potential profit from house price appreciation) and hardly any of the downside (risk of loss).

Figure 4: Short Put Payoff Diagram

Figure 4: Short Put Payoff Diagram



2. NINJAs, Liars, and Information Asymmetry

As discussed in the readings, more aggressive, or risky, underwriting allows for more relaxed documentation standards. These loans are also called "no doc" or "low doc" loans, referring to the level of documentation. And here, documentation simply refers to the credit applicant providing proof (documents) of such things as the borrower's income and assets. The borrower may answer the lender's questions about income and assets but doesn't have to document or prove their answers. For example, the borrower for a **SIVA** mortgage has merely **stated** their **income** but **verified** their **assets**. A **SISA** mortgage borrower has merely **stated** their **income** and **stated** their **assets**. These types of loans had been called "liar loans" because of the ease and frequency with which borrowers could exaggerate their *capacity* and/or *capital* in a mortgage application. Lenders of such loans would rely heavily on the borrower's credit score as an indicator of *character* and overall creditworthiness.

For SIVA, SISA, and **NINA** (**no income** and **no assets** information is provided by the borrower) loans, the lender might still at least check that the borrower is in fact employed where they say they are employed. Enter the **NINJA** loan: **No income** and **no job** or **assets** information is provided by the borrower to the lender. The NINJA borrower is silent on these *capacity* and *capital* characteristics.

3. Information and Moral Hazard

"Informational friction" or "asymmetric information" describes a situation where one party to a transaction or agreement has more or better information than the other. The information is not symmetric across the two parties. For example, the borrower under a "no doc" or "low doc" loan knows how much they have in assets and how much they make in income, but the lender does not have any certainty about these figures.

Asymmetric information easily leads to moral hazard: the party with better information may be tempted to act in bad faith because the consequences are not consequential enough. Recall that the low-doc or no-doc mortgages were called "liar loans." Moral hazard also describes a situation where one party takes excessive risk for their own benefit because they will not bear the full cost of those risks.

The classic example of moral hazard comes from the insurance industry: once a party or person is insured, they may take more risks than before they were insured. If someone has fire insurance, they may not be as careful to put out the fire in their fireplace at night. If someone has insurance against auto theft, they may be more likely to leave their keys in the car or leave their car parked in a bad neighborhood. And similarly, if there is little or no downside to overstating one's income and assets so that person can get a mortgage loan, they will be tempted to do so. After all, if they default on the mortgage because they can't afford to make the payments, the mortgage is non-recourse, so they can just walk away. A person might also choose to walk away if real estate prices decline significantly: why should someone keep making mortgage payments on a principal amount of $400,000 if the house is now only worth $300,000? This is a moral hazard and only one of the several moral hazards that beset the financial industry in general and the mortgage and MBS markets in particular.

The reading "Understanding the Securitization of Subprime Mortgage Credit" (Ashcraft and Schuermann) discusses several **informational frictions** and moral hazards in the mortgage and MBS markets and how these created the conditions for the credit crisis in the United States. Pay close attention to how these dynamics played out. Given the profit motive of most financial players, it pays to become very familiar with how incentives affect the behavior of other participants in whichever market you are active.

Exposure at default (EAD):

5. Model Risk: "All models are wrong but some are useful."

This aphorism attributed to the British Statistician George Box (1919-2013) may oversimplify things, but it makes the point that no one model is correct in every way. Nevertheless, if we make judicious use of models, considering carefully what they purport to tell us and being careful about the inputs and assumptions, then they are indeed useful.

When there is a possibility of default, it is rare to lose everything, and the amount one can lose also depends on whether the loan/investment is collateralized or not. To understand the necessary concepts, we start by introducing some terminology.

Probability of Default (PD) is a term used to measure the likelihood that a borrower will default on their debt obligations within a specific time frame. It is a critical component in credit risk assessment and is crucial in credit risk modeling and more. PD is typically estimated using statistical models and historical data. Among the models, the most typical are logistic regression and credit scoring models.

Loss given default (LGD) is the estimated amount of money a bank or other financial institution loses when a borrower defaults on a loan, and it is given as a percentage of total exposure at the time of default or, equivalently, as the amount that we could lose for every single dollar value of investment. A financial institution is very likely to have more than one investment, and therefore, its **total LGD** is calculated after a review of all outstanding loans using cumulative losses and exposure. It is a basic ingredient of most risk models, such as the Basel II model.

LGD is used in the calculation of economic capital, expected loss, and regulatory capital. The expected loss is calculated as a loan's LGD multiplied by both its **probability of default** (PD) and the financial institution's **exposure at default** (EAD).

EAD is the total value of a loan that a bank is exposed to when a borrower defaults. If a borrower takes out a loan for $1,000,000 and two years later the amount left on the loan is $700,000, and the borrower defaults, the exposure at default is $700,000 not $1,000,000.

The **default recovery rate** (RR) can be described as the percentage of each dollar invested that is going to be recovered in case of a default. As we wrote earlier, it is rare to lose everything. Thus, if we have invested $1,000,000 in bonds with a given rating, we may know from historical data that in case of default the recovery rate is 40%. This means that for every $1 invested, we will be able to recover $0.40. It seems plausible that the better the rating of the bond, the higher the RR will be.

Expected loss

This leads us to finally begin to describe LGD via at least two formulae:

$$\text{LGD (dollar amount)} = \text{EAD} \times (1 - \text{RR}).$$

and

$$\text{LGD (as percentage)} = 1 - \frac{\text{Potential Sale Proceeds}}{\text{Outstanding Debt}}.$$

The second formula is useful when there are forms of collateral. Note that the RR has to be estimated, so the LGD estimated with the first formula could seem more technical; however, it might actually sell a formula as more mathematical than it is in reality.

Example. *A bank has loaned $400,000 to a firm. The firm receiving the loan has agreed to put up certain nonproducing assets for a value of $200,000 as collateral. After 2 years, the amount still to be repaid is $320,000. The bank estimates that for this type of loan, the probability of default is 6%, the recovery rate can be estimated at 50%, and the bank's analysts estimate that the collateral could be sold quickly for $190,000. What is the LGD for the bank on this particular loan*? What is the expected loss?

Answer. If we ignore the collateral, then we could use the first formula, i.e.,

$$\text{LGD (dollar amount)} = 320,000 \times (1 - 50\%) = 160,000.$$

Considering the presence of collateral, instead we would find

$$\text{LGD (as percentage} = 1 - \frac{190,000}{320,000} = 40.63\%.$$

The expected loss has to employ the probability of default, that is:

$$\text{expected loss (dollar amount)} = \text{PD} \times LGD = 6\% \times 160,000 = 9,600.$$

Considering collateral, the expected loss can be computed as

$$\text{expected loss (dollar amount)} = 320,000 \times 6\% \times 40.63\% = 7,801.$$

It is often interesting and important to model the relationships between the variables just introduced. These may be highly nonlinear and may change over economic cycles. Hence, you should appreciate George Box's aphorism at this point.

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$$\text{expected loss (dollar amount)} = 320,000 \times 6\% \times 40.63\% = 7,801.$$

It is often interesting and important to model the relationships between the variables just introduced. These may be highly nonlinear and may change over economic cycles. Hence, you should appreciate George Box's aphorism at this point.

Some investors may question the indication from rating agencies that are supposed to utilize very sophisticated models as the agencies could very well have a conflict of interest: if they give low ratings, the companies using their services may no longer do that, and therefore, exaggerating the ratings would be in the agencies' own interests.

As an investor in MBSs, one way to avoid the rating agencies' conflicts of interest would be to perform your own credit analysis (or have such analysis performed in house, i.e., within your own trustworthy firm). Another benefit of an independent analysis (if done well) could be the minimization of both model risk and the risk of financial loss due to bad decision making as a result of a bad model. Indeed, the main culprit in the subprime mortgage crisis, according to the readings, was the *failure of rating agencies' models to incorporate appropriate assumptions and valid inputs*. This is called model failure, and the risk of such failure is called "model risk." Since rating agencies' models were considered proprietary, investors could not verify their appropriateness and validity. A firm might be tempted to not get rated if they expect to receive a poor rating. However, smart investors see through this and quickly learn to assume that companies or securities with no rating have very low credit quality.

Certainly, constructing a good credit risk model for a huge pool of mortgages with widely varying characteristics (LTV and DTI ratios, borrower credit scores, loan purposes, etc.) is not simple. With that in mind, read the article "Determination of Default Probability by Loss Given Default" by Mišanková et al. to understand how the most important variables, such as loss given default (LGD) and probability of default (PD), are related. Also, consider carefully which of the inputs to these models can be known exactly and which ones need to be calculated, which may also require a model and thus implies model risk. Remember, no single model provides a complete or perfect interpretation of the world. Models cannot replace judgment that comes with true understanding. When a single investor relies blindly on a model, they will probably incur significant losses; when many investors make this mistake, the problem may become much larger, even systemic.

The math presented should not be difficult. Don't concern yourself too much with the technical discussion of the many variants of the fundamental formulae, though you should expect to learn about most of the regression approaches mentioned in later coursework. We will return to these formulae when we build out our own valuation model for a hypothetical MBS in the next course: Financial Data.

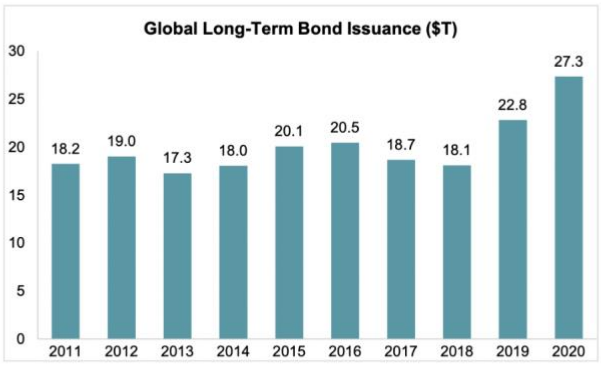
Liquidity and credit market:

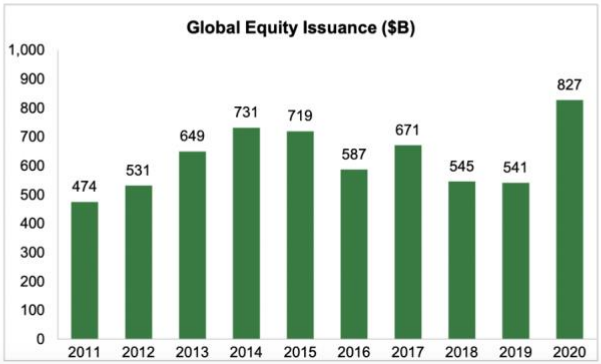
1. The Credit Market and Its Components

The credit market includes securities that involve some sort of borrowing or debt. For this reason, the "debt market" is synonymous with the "credit market." Since the debt market comprises mostly bonds, the credit or debt market may also be known as the bond market.

The bond market is vast, even compared to the global equity market. Compare the annual issuance of debt and equity in the following two graphs and be sure to note the units ($T for bonds vs. $B for equity). How many times larger was bond issuance in 2020 compared to equity issuance?

Figure 1: Bond and Equity Issuance





Compare bond issuance in 2020 to 2018. What is this ratio? It appears to be exactly 1.5x. This suggests that the bond market was very healthy in 2020, despite the beginning of the global COVID-19 pandemic. Interestingly, the equity market also appears to have been rather healthy in terms of global issuance. (How the bond and equity markets *performed* in terms of the profit earned by investors in those markets is a completely separate question, which we do not address in this lesson.)

The following tables provide a different but related view: the value of the total outstanding bonds. Which countries had the five largest values of bonds outstanding in 2020? Let's consider the European Union (EU), a single country for this purpose.

Figure 2: Outstanding Bond Value

$ Billions

	Australia	Canada	China	EU27	Hong Kong	Japan	Singapore	United Kingdom	United States	Other Developed Markets	Emerging Markets	Total
2006	957.3	1,327.4	1,198.3	15,894.2	99.1	9,090.3	140.3	3,989.8	23,881.7	527.1	633.9	57,739.6
2007	1,251.4	1,542.9	1,704.5	19,312.8	104.3	9,852.1	166.3	4,706.8	26,145.9	602.2	808.9	66,198.1
2008	1,141.9	1,369.7	2,228.0	20,256.7	102.7	12,329.9	167.6	4,099.6	28,033.8	604.0	749.0	71,082.9
2009	1,523.7	1,671.6	2,577.9	24,101.1	151.3	12,268.5	185.0	5,280.9	29,132.6	775.9	840.7	78,509.2
2010	1,742.9	1,866.6	3,065.3	23,324.9	184.0	14,604.1	219.0	5,210.2	30,208.7	833.7	991.9	82,251.4
2011	1,872.6	1,963.4	3,528.4	23,463.5	211.7	15,809.1	240.9	5,587.2	31,021.5	839.0	1,001.7	85,539.1
2012	2,037.5	2,173.5	4,294.1	24,307.6	250.5	14,254.1	294.8	5,928.8	32,300.4	950.8	1,140.0	87,932.0
2013	1,879.5	2,241.9	4,960.8	24,999.2	303.9	11,909.2	331.4	5,851.0	33,284.5	960.2	1,100.9	87,822.5
2014	1,916.9	2,206.1	5,835.4	22,074.9	343.5	10,558.0	349.3	6,169.5	34,302.9	888.8	1,150.4	85,795.7
2015	1,819.1	2,767.5	7,752.5	19,871.1	372.4	10,638.7	322.3	5,891.5	35,317.4	859.9	1,199.2	86,811.7
2016	1,823.2	2,943.5	9,408.8	19,379.9	404.9	11,248.5	326.4	5,439.2	36,716.1	935.1	1,272.1	89,897.5
2017	2,003.9	3,267.4	11,757.1	22,129.5	473.7	11,932.1	412.2	6,078.4	37,903.4	1,033.3	1,497.8	98,488.7
2018	1,899.9	3,149.3	12,906.9	21,437.8	511.7	12,477.0	441.1	5,792.2	39,456.1	1,003.6	1,501.9	100,577.5
2019	1,957.4	3,369.5	14,725.9	21,788.2	531.9	12,828.8	492.9	6,325.2	41,226.0	1,117.9	1,601.4	105,964.9
2020	2,498.4	3,910.3	18,555.6	25,226.0	556.1	14,678.3	542.8	7,172.4	47,237.0	1,334.8	1,757.0	123,468.6
Average	1,755.0	2,384.7	6,966.6	21,837.8	306.8	12,298.6	308.8	5,568.2	33,744.5	884.4	1,149.8	87,205.3
Y/Y % Change	27.6%	16.1%	26.0%	15.8%	4.6%	14.4%	10.1%	13.4%	14.6%	19.4%	9.7%	16.5%
5-Year CAGR	6.6%	7.2%	19.1%	4.9%	8.3%	6.6%	11.0%	4.0%	6.0%	9.2%	7.9%	7.3%
10-Year CAGR	3.7%	7.7%	19.7%	0.8%	11.7%	0.1%	9.5%	3.2%	4.6%	4.8%	5.9%	4.1%

Source: Kolchin, Katie et al._ 2021 Capital Markets Fact Book._ SIFMA, July 2021, p. 44. https://www.sifma.org/wp-content/uploads/2021/07/CM-Fact-Book-2021-SIFMA.pdf.

At $47 trillion (about 38% of the $123 trillion global total), the United States' outstanding bond value is almost twice as much as the EU's (about 20% of the global total). These two are followed by China (15%), Japan (12%), and the United Kingdom (6%). The rest of the bond markets by country are rather small compared to these five large ones.

The required reading "Bonds" defines liquidity risk as "the risk that investors won't find a market for the bond, potentially preventing them from buying or selling when they want" (U.S. Securities and Exchange Commission). (We discuss liquidity in more detail later in this lesson.) If you were an investor looking for a bond market with low liquidity risk, you would probably start looking at one of the five large bond markets. You still need to take into account the liquidity of the specific bond within these markets, but you are more likely to find a liquid bond in these markets than in some of the other much smaller bond markets. If you had to base a decision on where to invest to minimize liquidity risk based only on the information in these two charts, would you start looking for a bond investment in Hong Kong or in Australia?

On the other hand, you may be willing to take on some liquidity risk, as long as you are appropriately compensated for that risk. Depending on your preferences as an investor, there is probably *some* level of bond yield that would induce you to invest in a less liquid bond or bond market. So the smaller bond markets are not necessarily less attractive, so long as you are compensated for the risk you take. Risk and return generally go hand in hand. This is one meaning of the economic adage, "There is no such thing as a free lunch." So if you "had appetite for" (meaning you could tolerate and were seeking) liquidity risk, expecting of course to be compensated for the risk you were taking on, would you start your search in Canada or Singapore?

Based just on the information in the chart, you would probably look in Australia's more liquid bond market in the first scenario but in Singapore's less liquid bond market in the second scenario.

Given the top five bond markets in terms of outstanding market value discussed above, the following chart of annual issuances shouldn't come as too much of a surprise: the same top five countries dominate. Take note of the year-over-year percentage change (Y/Y % Change beneath the main part of the table): which countries' bond markets are growing at the fastest rates? A high rate of issuance growth is another broad indicator of the health of the overall credit market, though of course one still needs to evaluate bonds on an individual basis before investing. By this measure, what bond markets seem to have been struggling over this 15-year period?

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Figure 3: Global Bond Issuance

Global Long-Term Bond Issuance

$ Billions

	Australia	Canada	China	EU27	Hong Kong	Japan	Singapore	United Kingdom	United States	Other Developed Markets	Emerging Markets	Total
2006	185.5	266.9	179.6	3,259.5	14.2	2,417.3	12.3	927.0	5,286.0	458.8	1,305.7	14,312.9
2007	165.1	316.1	788.0	3,409.2	13.2	2,592.0	28.5	1,047.7	5,449.4	415.8	1,462.4	15,687.4
2008	175.7	382.0	524.7	3,432.3	10.7	2,430.4	21.0	1,119.1	4,501.1	384.0	872.7	13,853.6
2009	274.7	439.8	524.5	4,352.1	25.1	3,232.2	26.9	1,181.4	6,185.5	450.6	1,233.7	17,906.6
2010	320.0	472.9	704.5	3,667.3	30.2	3,594.0	37.6	674.4	6,727.2	470.4	1,753.5	18,452.1
2011	335.6	554.5	900.8	3,698.3	32.4	4,045.9	33.2	731.4	5,657.9	523.5	1,725.1	18,238.6
2012	346.7	516.9	791.5	3,727.3	45.9	4,285.9	40.9	734.7	6,067.8	541.7	1,911.9	19,011.2
2013	311.6	576.2	975.9	3,602.9	38.3	3,747.3	43.6	645.2	5,055.4	536.0	1,732.9	17,265.1
2014	314.0	547.0	1,603.3	3,668.4	53.6	3,469.1	39.5	642.5	5,272.5	560.9	1,868.5	18,039.2
2015	240.8	502.4	2,436.2	2,947.0	44.9	3,219.0	31.9	486.7	7,803.2	559.8	1,778.5	20,050.4
2016	294.0	499.8	3,650.6	2,908.3	63.0	3,425.4	51.8	489.1	6,330.0	544.7	2,197.0	20,453.6
2017	299.3	589.7	2,790.8	2,969.5	64.2	3,230.5	36.0	474.1	5,641.4	547.3	2,024.7	18,667.3
2018	258.8	524.9	2,908.9	2,797.7	45.8	3,033.4	51.9	550.4	5,502.4	545.3	1,871.7	18,091.2
2019	219.1	538.8	3,782.1	2,960.1	88.8	3,125.0	50.2	416.3	8,616.0	574.1	2,437.4	22,807.8
2020	419.7	742.5	5,088.4	3,756.3	81.9	3,364.5	37.4	752.6	9,401.9	690.7	3,000.5	27,336.5
Average	277.4	498.0	1,843.3	3,410.4	43.5	3,280.8	36.2	724.8	6,231.8	520.2	1,811.7	18,678.2
Y/Y % Change	91.6%	37.8%	34.5%	26.9%	-7.7%	7.7%	-25.5%	80.8%	9.1%	20.3%	23.1%	19.9%
5-Year CAGR	11.7%	8.1%	15.9%	5.0%	12.8%	0.9%	3.2%	9.1%	3.8%	4.3%	11.0%	6.4%
10-Year CAGR	2.7%	4.6%	21.9%	0.2%	10.5%	-0.7%	-0.1%	1.1%	3.4%	3.9%	5.5%	4.0%

Sources: Bloomberg, Refinitiv
Note: Long-term is defined as a security with maturity of 13 months or longer at issuance; includes corporate, municipal and sovereign issuance.

Source: Kolchin, Katie et al. *2021 Capital Markets Fact Book*. SIFMA, July 2021, p. 37. https://www.sifma.org/wp-content/uploads/2021/07/CM-Fact-Book-2021-SIFMA.pdf.

At 92% and 81% year-over-year growth, the bond markets in Australia and the UK were healthy over the period in question according to this metric. By the same token, Singapore's -26% "growth" suggests some problems in that market that require further investigation.

Credit spreads:

2. Credit Spreads and Credit Default Swaps

Again, the above assessments of the overall health of credit markets are much too broad to justify an actual specific investment. A more thorough analysis might start with the credit spread. A spread is just a difference in levels; a **credit spread** is the difference in yield between a particular bond and the risk-free rate for the same maturity. Stated differently, the credit spread is the *yield premium* for a fixed maturity. A risky bond needs to yield more to attract investors. If a risk-free bond and a risky bond had the same yield, investors would only invest in risk-free bonds. Consequently, risky bonds need to yield more.

The riskier the bond, the higher the yield must be in order to attract investors. The difference in yield between a risky bond and a risk-free bond (the credit spread) is therefore a good indicator of the riskiness of the bond. In fact, the credit spread can be used to calculate a probability of default (PD)[1] as discussed in the "CDS and CDS Spreads" reading and video.

As you watch the "Credit Default Swaps" video found in the same reading, pay special attention to the calculation of PD. (You may also find the transcript of the video below the embedding to be helpful.) Remember that the "recovery rate" is how much value the creditor expects to *recover* if the bond issuer (the borrower) defaults.

We have already considered the notion of recovery rate in the previous lesson, but it does not hurt to repeat it here as a further application. Recall the 4,000 Naira loan to Nushi, collateralized by her nice watch. Let's say we estimate the watch to be worth 4,500 Naira. It would be irrational for Nushi to intentionally not repay her loan since the watch is worth more. But if she did default on (not repay) her loan, we have her watch, which we can sell to get some of our lost loan amount back. It may be the case that we aren't able to find a buyer for the watch at the 4,500 Naira price. (Watches are not that *liquid*, as we will discuss more later in this lesson.) We may only be able to sell it quickly for 3,000 Naira, in which case we only recover 3,000 Naira out of our 4,000 Naira loan so that the recovery rate on this loan is 75%.

Once you are familiar with the PD calculation that uses credit spread (CS) and recovery rate (RR) as inputs from the video, you can calculate the probability of Nushi's default with just a few assumptions. Let's say you'll have a one-month loan term and the risk-free interest rate (RFR) is 1% per month. You decide to make Nushi the loan at the rate of 5% (so the bond yield is 5%): she should pay you back 4,200 Naira (4,000 Naira principal plus 200 Naira interest) in one month. Based on the definition of credit spread above, CS = BY − RFR = 5% - 1% = 4%. We already calculated our recovery rate, RR = 75%.

PD = CS / (1 − RR) = .04/(1-.75) = .16 = 16%.

The probability of default implied by these assumptions is 16%. What if you actually believe Nushi's PD is 25%? Then the 4% CS is not enough to compensate you for the risk. You can easily rearrange the equation above to find the cre spread that corresponds to the PD you assign to Nushi:

Credit spread = probability of default * (1 – recovery rate)

The probability of default implied by these assumptions is 16%. What if you actually believe Nushi's PD is 25%? Then, the 4% CS is not enough to compensate you for the risk. You can easily rearrange the equation above to find the credit spread that corresponds to the PD you assign to Nushi:

CS = PD (1- RR)

Now you would require a credit spread of

CS = PD (1- RR) = .25 * (1-.75) = .0625 = 6.25%

So you would require a higher interest rate of RFR + CS = 1% + 6.25% = 7.25%, or 290 Naira.

Would the CS go up or down if you believed that Nushi's PD was lower, say, only 10%?

CS = PD (1- RR) = .10 * (1-.75) = .025 = 2.5%, which is lower than the original CS = 6.25%.

Go ahead and manipulate the inputs in the following estimation formula and see whether the impact of the changes are linear or nonlinear.
What did you find? Discuss with your classmates in the forum.

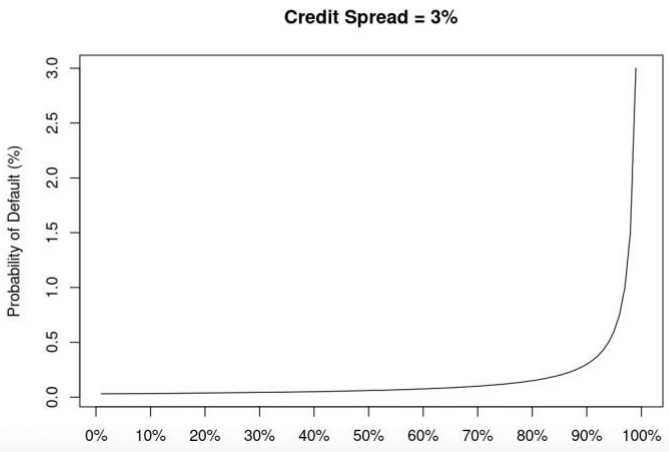
Probability of Default, Credit Risk, Credit Spread

Interest rate (%):

5

Risk-Free Rate (%):

2



IMPORTANT REMARK about the PD formula. Say that $RF = 2\%$, the interest rate on the bond is 5%, so that $CS = 3\%$. Assume now that $RR = 90\%$. If we use the formula $PD = CS/(1 - RR)$, we find

$$PD = \frac{3\%}{1 - 90\%} = 0.30$$

which seems to be a very reasonable conclusion. However, if in the same setting, we change RR from 0.90 to 0.99, we find

$$PD = \frac{3\%}{1 - 99\%} = 3.$$

This clearly does not work since a probability cannot be larger than 1. So what is going on? It is very simple: the formula for PD only works locally. When we assume that CS was 3% with a RR of 90%, that could have been correct, but it is very unlikely that CS =3% when RR = 99%. In fact, one could even argue whether we need to have a credit spread/premium when, in case of default, we are able to recover nearly the entire investment.

Hence, the gist of things here is that we CANNOT toy with the formula because if we move in a neighborhood of $RR = 0$ or $RR = 1$, it does not work. Said differently, the CS and RR inputs are not independent. Using the terminology of Module 3, CS and RR are correlated. Indeed, in credit risk, one has correlated variables, so attention has to be given to ranges, assumptions, etc. As such, it's important to use the formula with care. Do not conclude that $PD = 3!$, which shows the utmost disregard for or ignorance of the notion of probability: a horrible trait to exhibit for someone who wants to be a quantitative analyst.

As discussed in "7.1 CDS and CDS Spreads," a CDS is very similar to traditional insurance in that the CDS buyer pays a premium to insure against the risk of a bond's default, much like an insurance customer buys (pays a regular premium for) insurance against the risk of, for example, a catastrophe damaging a home.

An important difference between a CDS and traditional insurance, however, is that you don't need to own any bonds to buy a CDS. You can buy protection on something you don't even own. In other words, you can use a CDS to *speculate* on a bond instead of just *hedging* the risk on the bond. Likewise, you can use a CDS to sell protection on something.

This is very different from the traditional insurance market. If someone else could buy fire insurance on your house, they could make a lot of money if your house burned down. They could make so much money that they might even set your house on fire. This would be an example of moral hazard ("where one party takes excessive risk for their own benefit because they will not bear the full cost of those risks"), which we discussed in the last lesson.

CS and RR are correlated.

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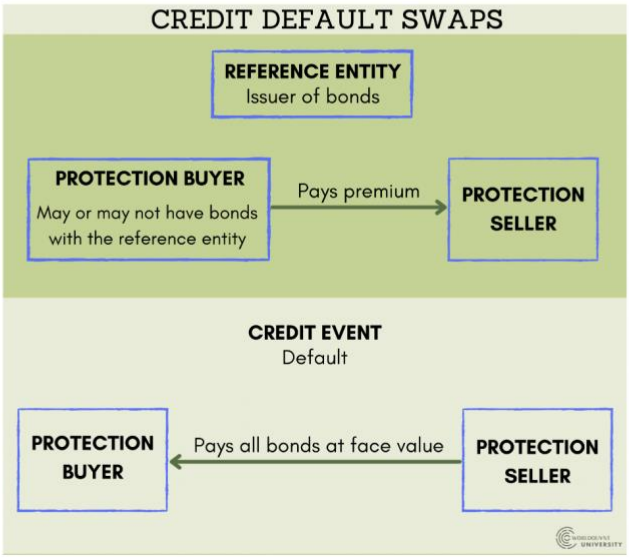
When you own a bond and buy CDS protection on that bond, you have the same interest rate risk from the bond that you had before, but you've offloaded the credit risk to some other market participant. If you don't have the bond but you believe that the bond is headed for default, you can buy protection (on the bond that you do *not* have) and make money on the default.

This aspect of CDSs is analogous to buying a put option on an equity security (stock): you don't need to own the stock in order to buy a put or sell a call on that stock.

Figure 4: Credit Default Swap: Protection Buyer, Protection Seller, and Reference Entity



We say that CDSs "commodify" credit risk: CDSs allow us to buy and sell credit risk as if it were a mere commodity. In other words, CDSs nicely package, price, and transfer credit risk from one party to another, turning it into a commodity.

3. Ratings and Credit Spread

As we saw in the calculation examples above, higher PD implies a higher credit spread. Ratings are a function of the PD, or probability of bankruptcy as used in the table: the highest rating (AAA) is for bonds that have almost no risk of default, meaning PD at or very near zero.

Note that "investment grade" refers to bonds rated BBB or better, and bonds rated below BBB are called "junk." There is nothing disparaging about the latter term; it is just credit market jargon. Another term for these sub-BBB bonds is "high yield."

Figure 5: Ratings and Probabilities of Default

Credit rating	Probability of bankruptcy, %
AAA	0.07
AA	0.51
A+	0.6
A	0.66
A–	2.5
BBB	7.54
BB	16.63
B+	25.0
B	36.8
B–	45.0
CCC	59.01
CC	70.0
C	80.0
D	100.0

Source: Pirogova, Oksana et al. "The Algorithms for the Environmental Finance Based on Adjusted Present Value Models." *E3S Web of Conferences*, 2019, vol. 91, p. 9. https://www.e3s-conferences.org/articles/e3sconf/abs/2019/17/e3sconf_tpacee2019_08021/e3sconf_tpacee2019_08021.html.

The credit ratings on different bonds are based on the PDs that the rating agencies calculate. (Again PDs, not a single PD: rating agencies will make their own assumptions, resulting in different models and different PD results, though the various PDs are likely rather similar.) A *low* PD is associated with a *high* rating and vice versa.

4. Liquidity and Liquidity Risk

Default risk is just one of the risks that should concern us. As discussed above, bonds also have liquidity risk, which generally refers to "the risk that investors won't find a market for the bond, potentially preventing them from buying or selling when they want." We can calculate default risk (PD) in a rather straightforward way, so how do we measure or calculate liquidity risk?

First, let's define liquidity. The real value of an asset is CHF 100, but right now, you can sell it for only 90 CHF. The difference, 10 CHF here, indicates how liquid the asset is. The more liquid an asset is, the closer the market value and selling price are. If you want to sell a FAANG stock (that is, one of the big U.S. tech companies--Facebook (now Meta), Amazon, Apple, Netflix, and Google (now Alphabet)) during trading hours on the NYSE (New York Stock Exchange), you can get a price (bid price) close to the market value (average of bid and ask price). But if you want to sell an unknown stock in the after-hours market, you will get a bid price that is far from the ask price (high bid-ask spread) because it is not a highly traded stock. It is off hours, and it's very likely that there are only a few market makers around.

The authors of "Market Liquidity Risk: An Overview" (Stange and Kaserer) summarize several approaches to calculating, or modeling, liquidity risk. We will work with some of these models in the next course. For the purposes of this lesson, you should read about the models to understand why certain factors or inputs are used the way they are.

Stange and Kaserer also provide a helpful discussion of the important aspects of liquidity. For example, liquidity risk is not merely an absent-or-present phenomenon but rather a complex and messy risk that changes over time (even with time of day) in nonlinear ways. Liquidity is relative, not binary; it isn't that a bond or other security is either liquid or not (discrete). Some bonds are more liquid than others, and that liquidity can increase or decrease over time depending on market circumstances. Also, liquidity is often a function of your position size (the amount of a security you have). Liquidity also depends on how much time you have to liquidate, meaning your liquidation horizon.

One of the inputs used in many liquidity models is the bid-ask spread, or the difference between current offer prices (to sell) and bid prices (to buy) for a particular security. When these prices match, the transaction takes place, and the new bid-ask spread is the difference between the next highest offer price and the next lowest bid price. The more liquid the security, the lower this bid-ask spread should be.

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Let's test whether the bid-ask spread makes sense as a liquidity measure in some other contexts:

1. Let's say you want to sell your house. You believe it's worth $250,000, and you're happy to sell it at that price. A potential buyer inspects your house and is willing to pay $200,000 for it. That's a $50,000 bid-ask spread, or 22.5% of the average between the bid and offer prices. That is a lot of money, but it is consistent with the fact that houses are known to be relatively illiquid. If you are willing to wait, then eventually, another buyer might come along and offer a higher value, closer to (or even above) the market value. If you do not have the luxury of waiting, then you may be forced to sell at the highest bid price.
2. Let's say you buy 100 shares of Apple Inc. stock at $160 per share. In a normal market, you should be able to sell those same 100 shares later that day at very close to the price at which you bought them, say $159 per share, only a .6% difference from when you bought it. This is consistent with the fact that the stock market for blue-chip (high-quality) stocks is generally very liquid.
3. When you tried to sell Nushi's watch after she defaulted, you would have been happy to sell it for 4,000 Naira, but the highest price you could find was 3,000 Naira, meaning the bid-ask was 1,000 Naira, or almost 30% of the average between the bid and offer prices. This confirms what we said before: watches are not that liquid, especially used watches.

In the reading "Liquidity, Credit Risk and Pricing of Corporate Bond," traded volume appears frequently in the discussion of liquidity, where lower volumes imply less liquidity. Volume is especially central to the calculation of the Amihud illiquidity factor. Using the same three examples, we can test whether volume might function as an indicator of liquidity:

1. You buy and sell your house infrequently, quite rarely in fact.
2. On the other hand, the volume of Apple shares traded every day is measured in the tens of millions.
3. You will only need to sell Nushi's nice watch once.

Another important factor in liquidity is **fungibility**—-how easily a good or asset can be interchanged with another thing or asset of the same type. Let's review the three examples again with this in mind:

1. You chose your house because it has the right number of rooms and the right size; because it is located in the neighborhood you want to live in; because it has the style or architecture that you like; etc. Although it may look exactly the same as the house next door, it has different amounts of sunlight, a different location, and different views. Although there are many other houses that are the same size with the same number of rooms, even in the same neighborhood, they will not be even close to the same house. Houses are not easily interchanged for other houses. Houses are not considered fungible because no two houses can be identical. Even if everything else is almost exactly the same, they certainly have different GPS coordinates.
2. You could buy one share of Apple stock, then sell it later to your friend who already has one share of Apple stock. The next day, you can change your mind again and buy a share of Apple stock from the same friend. You wouldn't notice whether your friend sold you the share that she bought from you or the share that she has owned for longer. And you would not care because stock shares are fungible.
3. On the other hand, you would be very hesitant if someone wanted to trade (used) watches with you, even if they are the same make and model. You cannot easily tell, for example, if the other watch works as well as yours; it might take hours to ascertain whether the watch runs fast or slow. Perhaps the battery is about to run out. The watch might have some kind of damage that is not immediately apparent. Luckily, people don't often ask to trade watches because watches aren't fungible.

Note in this reading the reference to "yield spread over the benchmark curve (SP)" and the definition they provide in footnote 3. Does this spread sound like any other spread we have discussed in this lesson? It's not that similar to the bid-ask spread. In fact, this is the same as our definition of credit spread and should be interpreted as such.

1. Correlation, House Prices, and the Stock Market

We have discussed the strong relationships between many factors or variables, for example, between probability of default and credit spread: when one increases, we expect the other to increase. We can measure the strength of this relationship in many ways, but one of the most basic is correlation: the strength (and direction) of a "linear" relationship. There is a linear relationship between two variables when the graph of the two variables more or less fits on a straight line. Note: We use Pearson correlation in this lesson, which is considered parametric, meaning it assumes the data have particular distributions. Spearman and Kendall correlations do not make assumptions about the distribution of the data, but these alternative correlations still measure the association between two variables, i.e., the degree to which two variables move in the same direction or opposite directions.

With your fresh and thorough understanding of the concept of correlation, read the introduction and literature review of the required reading paper, "The Relationship between Stock and Real Estate Prices in Turkey: Evidence around the Global Financial Crisis." Yuksel discusses two ways that we might understand the relationship between the stock and real estate markets: the wealth effect and the credit-price effect. In both views, there is a positive correlation between prices in the two markets. There also appears to be a positive linear relationship between these markets and the economy (both globally and in Turkey) as measured by GDP, as you might expect.

According to economists, changes in a consumer's wealth cause changes in the amounts and distribution of one's consumption. People typically spend more overall when one of two things is true:

- People actually get richer when they get a job that pays a higher salary; or
- People perceive themselves to be richer: for example, the assessed value of their home increases, or a stock they own goes up in price.

Note the distinction between actual and perceived additional wealth. There is often a psychological component about feeling rich. We may have bought a house for, say, $500,000 and now we see that we can sell it for $600,000, so we feel richer. However, one could counter that if they sell the house, their only house, they would likely need to buy a new one which would also very likely have gone up in price, so the additional $100,000 is not exactly free purchasing power. However, many consumers cannot see this, and they feel rich. On the other hand, someone may own several homes: one to live in and others as investments. In this case, the investor is experiencing an actual wealth effect.

Housing wealth effects are widely believed to have played an important role in the boom of the early 2000s and the recession that followed. As a matter of fact, the 2000s saw a large run-up and subsequent decline in aggregate house prices that led housing to play an unusually large role in driving the business cycle over that period.

According to the "wealth effect" mechanism, in a rising stock market, would you prefer to buy or to sell a house? It's a good time to sell your house because the increased demand for real estate means you can get a better price. It's a bad time to buy because prices are increasing.

According to the credit-price effect, rising real estate prices should help the stock market by allowing companies to borrow more (to invest in their own operations) and at cheaper rates. Say you wanted to invest during a time of rising interest rates in only one of two very similar companies in the same industry: "Big Prop Inc." (BPI), which has significant real estate holdings, or "NoMaD Inc." (NMDI) with no real estate assets. The credit-price effect suggests that BPI can borrow more or at cheaper rates than NMDI because BPI has more collateral to secure its loans. (Recall that collateral is one of the 5 Cs of credit analysis.) You would certainly want to take into account that BPI may have lower financing costs than NMDI when you analyze the two companies in more detail. On the other hand, say real estate prices have just started to decrease after years of rising. Now, you might be concerned about whether BPI is prepared for the resulting decrease in the property values that collateralize their loans, while NMDI's financing costs may not change as drastically because it didn't have as much debt in the first place.