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| **Statement of integrity:** By typing the names of all group members in the text boxes below, you confirm that the assignment submitted is original work produced by the group (excluding any non-contributing members identified with an "X" above). | |
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| **Team member 1** | **Sandro Dong** |
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| Use the box below to explain any attempts to reach out to a non-contributing member. Type (N/A) if all members contributed.<br>**Note:** You may be required to provide proof of your outreach to non-contributing members upon request. |
|---|
| N/A |

**Step 1**

| | Financing challenges | Collateral challenges |
|---|---|---|
| Money at a fixed rate for an unsecured purchase | - High default risk due to missing collateral.<br>- With increased credit risk and higher interest rates, there is more pressure on borrowers.<br>- Difficulty of recovering losses after borrower's default | x |
| Money at a floating rate for a secured purchase | - Asset depreciation risk.<br>- Variable interest rates affect repayment amount.<br>- Borrower repayment ability in economic downturn | x |
| Money at a fixed rate for a business for a construction loan | - Prolonged loan repayment term due to setbacks (costs, market uncertainties, etc.)<br>- Project feasibility and viability risk affect loan repayment term. | x |
| Publicly traded equity | x | - Operational risks result in ownership disputes and delayed collateral access.<br>- Volatility Risk: depreciation in the actual collateral value compared to the loan value<br>- Selling equity at wrong market timing, which in turn leads to low public patronage. |
| Publicly traded bond | x | - Liquidity risks and the timely sale of bonds at the right price could be challenging<br>- Compliance risks: non-compliance may result in legal penalties.<br>- Foreign exchange risks: |

| | | |
|---|---|---|
| | | Depreciation in the valuation of bond purchase currency may affect debt service obligations. |
| An illiquid security | x | - Maintenance cost: cost of maintaining security before trading security impacts the overall value of the asset, which buyers/borrowers may not be willing to bear.<br>- Margin calls: Disposing of illiquid security at a large discount incurs significant losses. |

**Step 2**

| | Volatility challenges | Correlation challenges |
|---|---|---|
| Money at a fixed rate for an unsecured purchase | - Borrower's income instability/volatility affects repayment ability.<br>- Economic downturns increase default rates<br>- Inflation or unemployment rate increase affect repayment ability | - High inflation correlates to higher money lending: higher bills to manage. Increase in default rate.<br>- Unemployment rate correlates to default rate. Borrower might lose his stable income. |
| Money at a floating rate for a secured purchase | - Collateral price volatility affects debt-to-equity ratio.<br>- Interest rate volatility affects repayment ability.<br>- Economic downturns increase default rates | - Correlation between high interest rates and default rates.<br>- Housing price decrease correlate with default rates.<br>- Economic condition in the house region correlates with the house price |
| Money at a fixed rate for a business for a construction loan | - Unexpected/unplanned costs of construction materials affect borrowers, resulting in default.<br>- Changes in the project plan to simplify construction structure affect the valuation of collateral, which results in default. | - Negative correlation between high construction costs and loan refinancing.<br>- Negative correlation between loan-to-value ratios. |
| Publicly traded equity | - Market risk: equity prices fluctuate based on company performance, economic conditions, etc.<br>- Liquidity challenge: High volatility may cause liquid equity to become illiquid.<br>- Credit risk: market performance of public equity impacts the company's debt-to-equity | - Correlation of equity price and market conditions.<br>- Negative correlation between market volatility and equity liquidity.<br>- Correlation between the equity price and debt repayment capacity of the company.<br>- High correlation of equity prices within the |

| | | |
|---|---|---|
| | ratio.<br>- Industry-specific risks: Changes in the price of equity in one company may affect the equity prices in another company | same industry. |
| Publicly traded bond | - Credit risk: Changes in economic conditions may affect the value of the bond (and its intended purpose), which may in turn affect the dividend payments.<br>- Operational risk: Unexpected changes within company's management, dent in company's reputation may affect investors' trust and lead to changes in bond prices. | - Correlation between the bond value and dividend payments<br>- Correlation between bond performance and unexpected events.<br>- Correlation with market variables like interest rate can drive the value of a bond up or down. |
| An illiquid security | - Bid-ask spread risk: Wide bid ask spreads affect the volatility of the security.<br>- High price fluctuation due to low volume<br>- Large market move after large trades. Illiquid securities price will be significantly impacted in case of large trades<br>- Refurbishment risk: Restructuring illiquid securities for the sake of attracting investors may/may not improve liquidity and volatility | - Lack of diversification because of lack of clear correlation patterns with other asset classes.<br>- Correlation between bid-ask spread and the liquidity and volatility of the assets. High bid-ask spreads result in illiquidity and low volatility.<br>- Correlation between refurbishment costs and volatility. |

**Step 3**

**Money at a fixed rate for an unsecured purchase:**

1. Credit data, economic data
2. Raw default rates, raw default levels
3. Monthly or quarterly frequency
4. Data class: Credit data
5. Data provided by banks, credit scoring agencies (FICO), and financial services providers
6. Observed data, adjusted data, and actual data

**Money at a floating rate for a secured purchase:**

1. Credit data, economic data, and asset data
2. Raw prices, raw price volatility, raw default rates, and raw default levels
3. Monthly, quarterly or annually
4. Automobile loans, mortgage data, and real estate data
5. Real estate databases, financial institutions, automobile dealers
6. Actual data, adjusted data, and trade data

**Money at a fixed rate for a business for a construction loan:**

1. Credit data: historical credit score/ratings of construction firms, default rates, FICO scores.
2. Construction-related data: geographical location data, project timelines/schedule, potential delays, buffer costs, historical data of actual costs to initial project cost ratio, regulatory requirements/licensing lead time data, producer price index (PPI)
3. Monthly or quarterly payments.
4. Market Data : Stock performance indices on construction ETFs, material/construction costs data.
5. Data Sources: Analytics companies
6. Actual construction budget vs. estimated budget (which is the basis for acquired loan), loan repayment adjustment data.

**Publicly traded equity:**

1. Market data: Empirical stock prices/indices data; economic data: inflation rates, interest rates, bid-ask spreads; financial data
2. Historical and implied volatility data; empirical and forecasted earnings data; cash flows, income statements vs balance sheets, dividends, etc.
3. Data Frequency: Daily
4. Data class: Equity
5. Data Source: Exchanges, OTC, and Brokers
6. Data variety: observed data, Adjusted data, trade data

**Publicly traded bond:**

1. Credit data: credit ratings, spreads, and default rates, economic data: investor confidence indices, GDP, unemployment rates, and the CPI index; market data: raw bond prices/returns; financial data: debt-to-equity ratios; interest rate data, investors/analysts sentimental data.
2. Historical and implied volatility data; correlation data of bonds with other assets; yields, prices, cash flows, dividends, etc.
3. Data Frequency: Daily
4. Data class: Fixed Income securities.
5. Data Source: OTC and Brokers and Vendors,
6. Data variety: observed data, averaged data, adjusted data

**An illiquid security:**

1. Market data: empirical vs. current prices, bid-ask spreads, liquidity ratios, trading times; economic data: inflation data, latest policy data; financial data: historical trading earnings data, discount rates.
2. Historical and implied volatility data; raw prices and discount prices, etc.
3. Data frequency: daily, monthly, quarterly, or annually (frequency varying depending on data class)
4. Data class: rare metals, small cap, collectibles, real estate
5. Data sources: exchanges, brokers, 3rd party vendors
6. Variety: Observed vs adjusted, traded vs quote

**Step 4**

**Money at a fixed rate for an unsecured purchase**

In this scenario, we want to collect credit card default rates, credit card average interest rates and Consumer Spending data. Default rates and average interest rates can be sourced from official financial institutions like the Federal Reserve and Consumer Spending data here is sourced from data platforms like MacroTrends:

- Delinquency Rate on Credit Card Loans, All Commercial Banks (Board of Governors of the Federal Reserve System (US), 2024a)
- Commercial Bank Interest Rate on Credit Card Plans, All Accounts (Board of Governors of the Federal Reserve System (US), 2024b)
- U.S. Consumer Spending 1960-2024 (Macrotrends, 2024)

**Money at a floating rate for a secured purchase**

In this scenario, we would require data on default rates of residential mortgages, average home values in a specific geographical location. For the first one, we can source the data from official financial institutions like the Federal Reserve. For the latter, we can get data from real estate databases like Zillow's Zillow Home Value Index (ZHVI):

- Delinquency Rate on Single-Family Residential Mortgages, Booked in Domestic Offices, All Commercial Banks (Board of Governors of the Federal Reserve System (US), 2024c)
- ZHVI All Homes (SFR, Condo/Co-op) Time Series, Smoothed, Seasonally Adjusted($), City data (Zillow, 2024)
- 30-Year Fixed Rate Mortgage Average in the United States (Board of Governors of the Federal Reserve System (US), 2024d)

**Money at a fixed rate for a business for a construction loan**

In this scenario, we want to collect economic data - producer price index (PPI) and credit card default rates. PPI and average construction costs can be sourced from official financial institutions like the Federal Reserve, and credit analysts opinions can be sourced from platforms like Moody's Analytics:

- Delinquency Rate on Loans Secured by Real Estate, All Commercial Banks [DRSREACBS], retrieved from FRED, Federal Reserve Bank of St. Louis (Board of Governors of the Federal Reserve System (US), 2024d)
- Credit Opinion: For Corporate Construction and Homebuilding Firms (Moody's, 2024)
- U.S. Census Bureau, Total Construction Spending: Health Care in the United States [TLHLTHCONS], retrieved from FRED, Federal Reserve Bank of St. Louis; June 23, 2024. (U.S. Census Bureau, 2024)
- U.S. Bureau of Labour Statistics, Producer Price Index by Commodity: Construction (Partial): New Nonresidential Building Construction [WPU801], retrieved from FRED, Federal Reserve Bank of St. Louis; June 23, 2024: (U.S. Bureau of Labor Statistics, 2024a)
- U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Special Indexes: Construction Materials [WPUSI012011], retrieved from FRED, Federal Reserve Bank of St. Louis (U.S. Bureau of Labor Statistics, 2024b)

**Publicly traded equity**

In this scenario, we want to collect financial data - debt-to-equity ratio, balance sheet; market data - empirical returns, volatility, dividend, valuation, earning ratio, and most importantly closing stock price. These values can be sourced from exchanges or official financial institutions like Simply Wall St.:

- Data from exchanges or public domains like yahoo finance. Yahoo finance
    1. Daily price for equity: HDFC Bank Limited (HDFCBANK.NS)
    2. Daily price for Bank index : NIFTY BANK (^NSEBANK)
- U.S. Tech Dividend Stocks lists, retrieved from Simply Wall St.: US Tech Dividend Stocks.

**Publicly traded bond**

In this scenario, we want to collect bond credit ratings, financial data - debt-to-equity ratio, balance sheet; market data - empirical bond prices, yields, return, volatility, dividend, valuation, and earning ratio. Credit ratings can be sourced from the official Moody's analytics platform, while financial and market data can be sourced from financial news platforms like Yahoo Finance:

- US Treasury bonds data, retrieved from Yahoo Finance: US Treasury Bonds
    1. Daily 10Y bond yield data: 10 Year Bond yield (^TNX)
    2. Daily price of Treasury bond: iShares 20+ Year Treasury Bond ETF (TLT)
- Microsoft Corporation bond ratings, retrieved from Moody's Analytics: Microsoft bond ratings
- Apple Inc. bonds credit ratings insights (annual review), retrieved from S&P Global Ratings: Apple Annual Review

**An illiquid security**

In this scenario, we want to collect data for an illiquid commodity like rare metals(palladium), small cap stocks, painting prices or antiquated French wine. Data such as empirical vs. current prices, volumes, bid-ask spreads, trading times will be sourced on platforms like Bloomberg Terminal:

- Futures on rare commodities like palladium from Yahoo finance. Commodities Futures
    1. Daily volume and prices of Palladium Futures: Palladium (PA=F)
    2. Daily volume and price of S&P 500 index: SPDR S&P 500 ETF Trust (SPY)
- Precious and Industrial Metals data, retrieved on Bloomberg: Industrial Metals Commodity Price
- Energy Data, retrieved on Bloomberg: Energy Data
- penny/small cap stocks which are relatively illiquid from exchanges.

## Step 5

### Money at a fixed rate for an unsecured purchase

First, we have to do some exploratory analysis on the data gathered in step 4. From the head() of the 3 DataFrames loaded, the first thing noticed (except for incomprehensible column names) is the date format difference. Moreover, the interest rate DataFrame has a lot of invalid values ('.'), and the first 10 years of Consumer Spending data are 0. Once the data is cleaned up, we can plot the distribution over time.

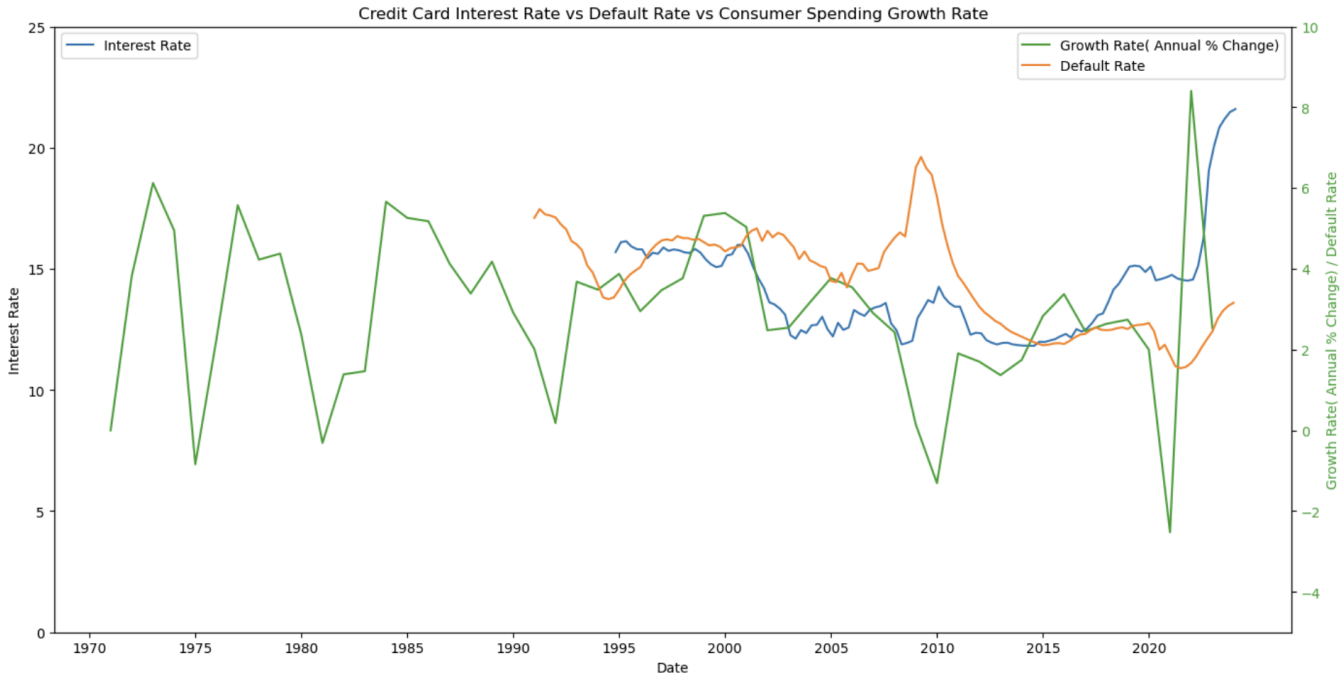


Figure 1: Credit card interest rate vs Credit card default rate

In Figure 1 we plot the credit card default rate vs credit card default rate in the US. We can clearly observe that the 2 distributions have quite a strong correlation: when default rates rise, so do interest rates and vice versa. In fact the correlation between the 2 distributions is as high as 0.88. From the chart the most noticeable spike in default rates is in the years between 2007 and 2009, with interest rates following the growth. This observation coincides with our natural perception, where during the 2007-2008 financial crisis more and more people were not able to meet their loan repayments. Another interesting aspect is the big spike in the credit card interest rates after around 2022. Even though there is an increase in default rates as well, default rates are at a relatively low level compared to its past, whereas the interest rates are at the dataset's historical high. The explanation on this might be due to the US Fed Funds Interest rates increasing since 2022 to try to get the inflation down. Finally, looking at the consumer spending data, there is a clear inverse relationship between consumer spending growth rate and default rate. During economic downturns borrowers have a higher chance of default.

**Money at a floating rate for a secured purchase**

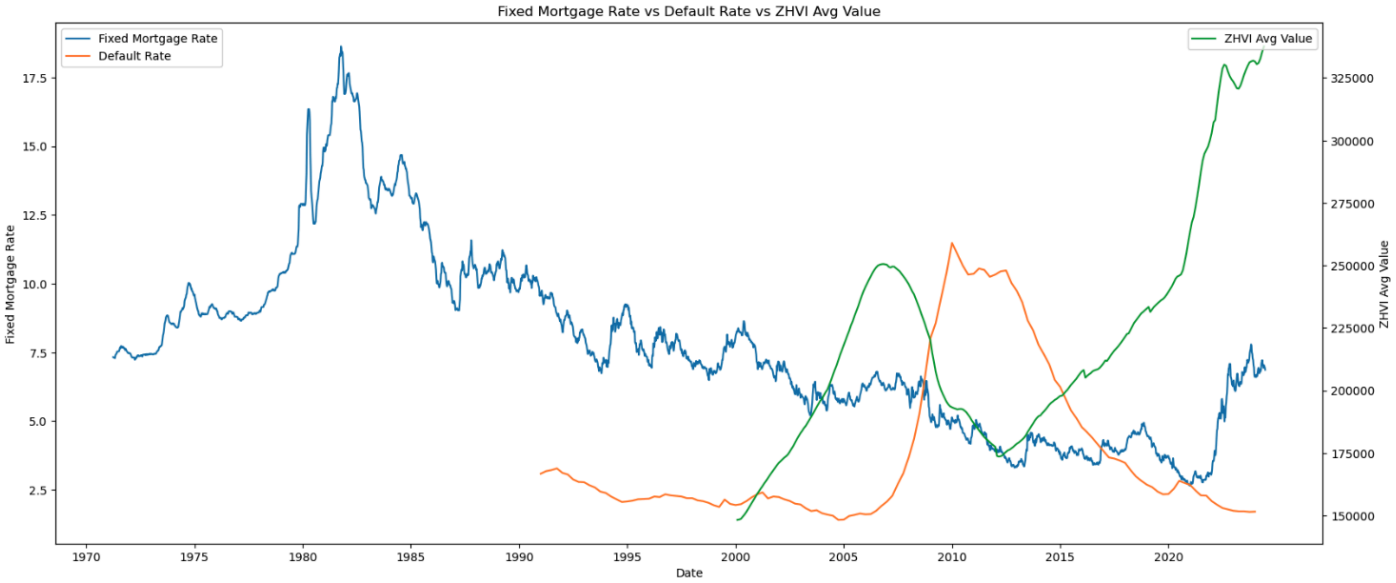


Figure 2: Fixed Mortgage Rate vs Mortgage Default Rate vs ZHVI Average Value

Due to data unavailability for home mortgages with floating interest rates, we are using the US 30-Year fixed rate mortgage average as a substitution which can indirectly inform us on the floating mortgage rates economic environment. For the Zillow Home Value Index, the dataset provides a large amount of monthly data for over 21000 cities across the US starting from the year 2000. For easier analysis we condense the value for each month as an average value of all the cities value. Plotting the data, the first most noticeable insight is the negative correlation between the mortgage default rate and the housing value index: when house value decreases, default rate increases and vice versa. This phenomenon is especially evident during the 2007-2008 financial crisis period, where the sudden drop of house values brought mortgages heavily underwater, leaving borrowers to default. The correlation between house values and mortgage rates are surprisingly not high, the change in mortgage rate does not predict house price trends.

**Money at a fixed rate for a business for a construction loan**

To implement the exploratory statistics for this scenario, we aim to pull out 10-year data for the Average Cost of building construction, Producer Price Index (PPI) for the erected buildings, which is indicative of their selling prices, as well as the Producer Price Index for the construction Materials - which is indicative of the cost of construction materials over this period.

The data sources used in this scenario cuts across various construction projects (ranging from Health to Residential and Non-residential buildings). This is representative of data trends within the industry and not specific to a particular kind of construction project.

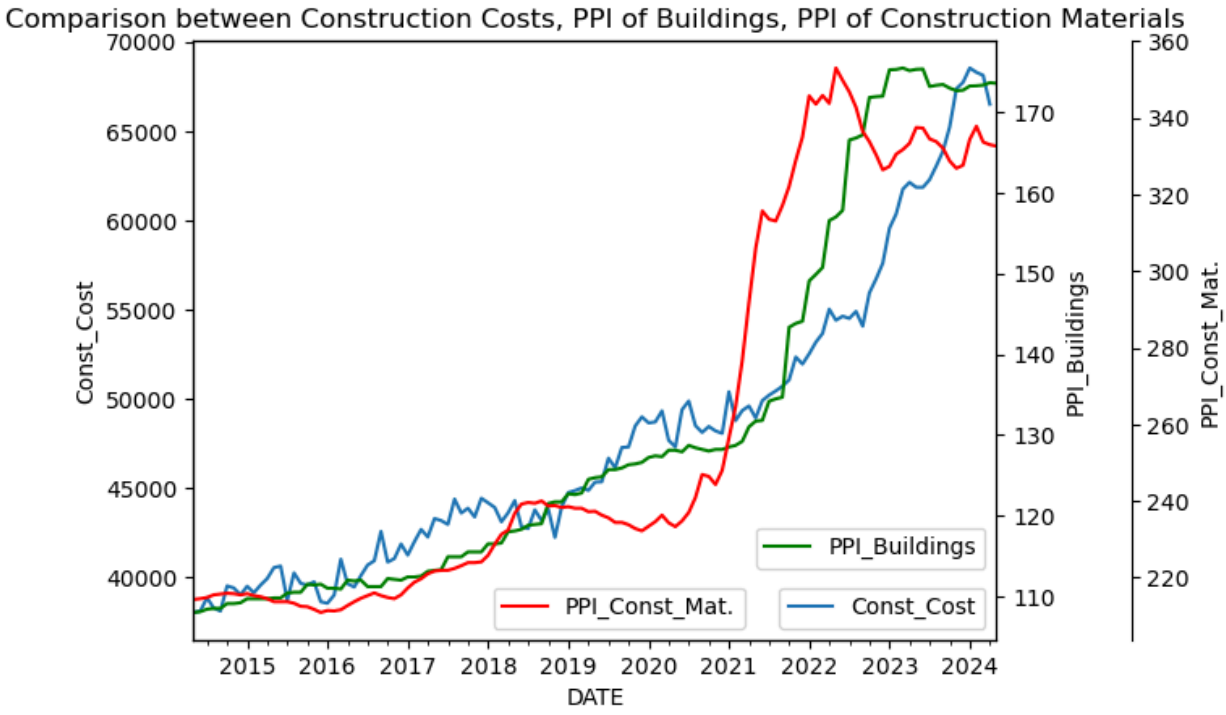


Figure 3: Construction Costs vs PPI of Buildings, vs PPI of Construction Materials.

Fig. 3. above depicts that PPI index for construction materials & complete building structures, as well as construction costs, spiked after 2020. While each of these factors is dependent on another, it is important to introduce a different factor, such as the default rate on Real Estate loans, into the picture.

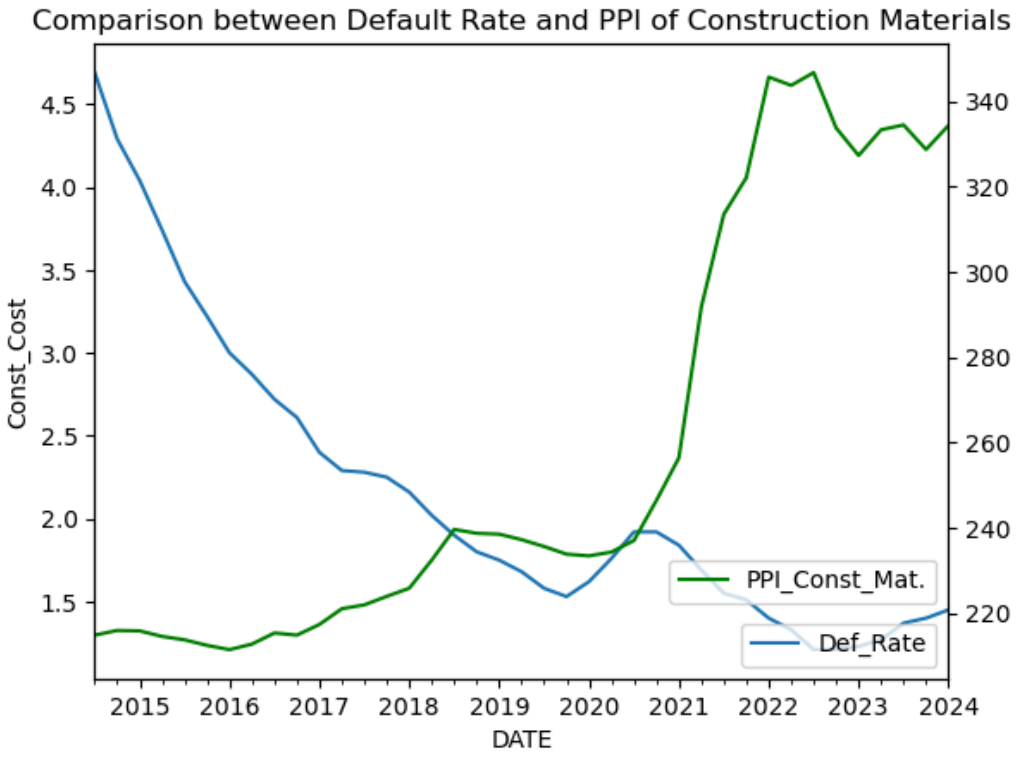


Figure 4: Default Rate on Real Estate Loans vs PPI of Construction Materials.

After the 2008 recession in the US, the default rate declined drastically for construction firms. Interestingly, after the small spike in 2020 (most likely because of the COVID lockdown), the interest rate reduced further while the selling price of construction materials skyrocketed because of the high inflation rate. In the years 2021 & 2022, there was a minor decline in the price of construction materials and a corresponding increase in the default rate.

This surge in the price of buildings within the aforementioned period is mainly a result of the prices of construction materials (Intelligence Lab, 2023) as well as the surge in insurance premiums for construction firms and homebuilders (NAIOP, 2023). The fact that The Intelligence Lab considers the construction industry in the UK market while NAIOP considers the construction industry in the US is an indication that the inflation rate has significantly impacted the industry across continents.

**Publicly traded equity**

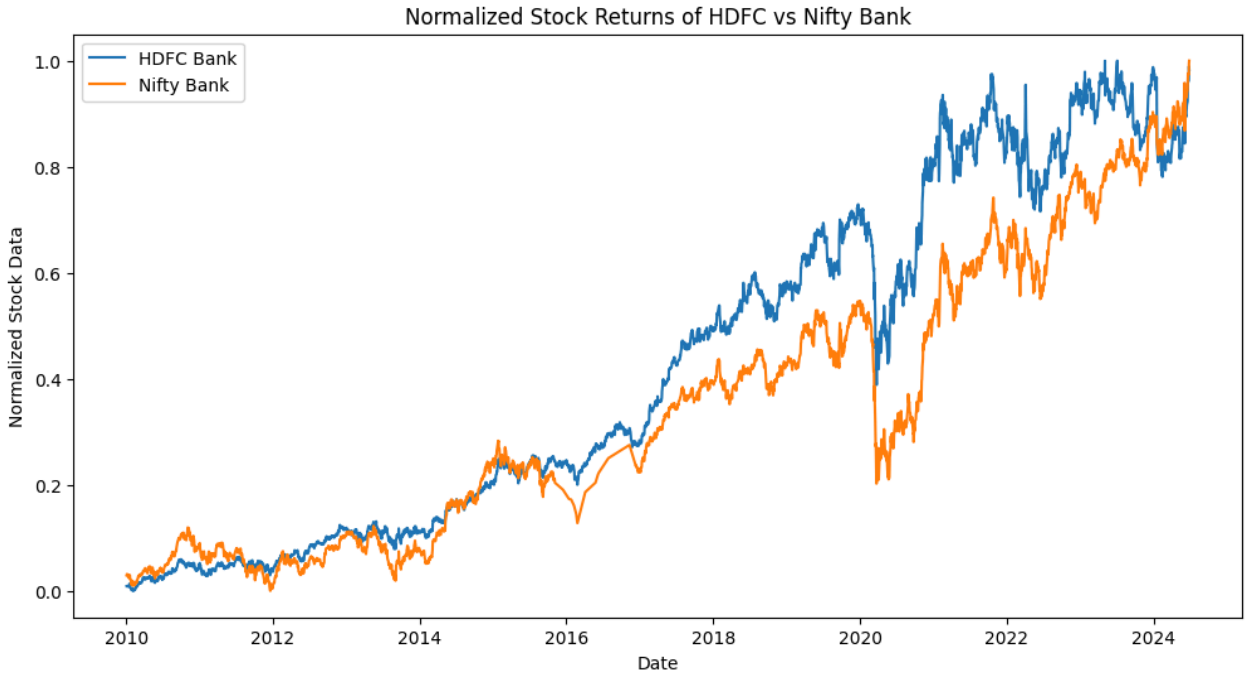


Figure 5: Normalized stock returns of HDFC Bank and Nifty Bank Index

Here, we are delving into the correlation risk associated with lending of publicly traded equity. We are taking HDFC Bank (HDFC Bank: A Private Bank in India) as the equity. If it is highly correlated with market indices, we face the risk of a downturn of the equity in the event of index downturns. The effect only amplifies if the party we lent has positions primarily in that particular sector. So we take the Nifty Bank Index (NSEBANK, a bank index which consists of major banks in India) and check the correlation.

We look at daily data from Yahoo Finance starting from 2010 until date. The levels are pretty different for the equity and the index. So, we normalize the data by taking incremental differences and dividing by the range of the series.

From the plots, we can see that HDFC Bank and Nifty bank look highly correlated. In fact, the correlation is 96.8%, which is very high. So this is in line with our narration that high correlations can be devastating.

**Publicly traded bond**

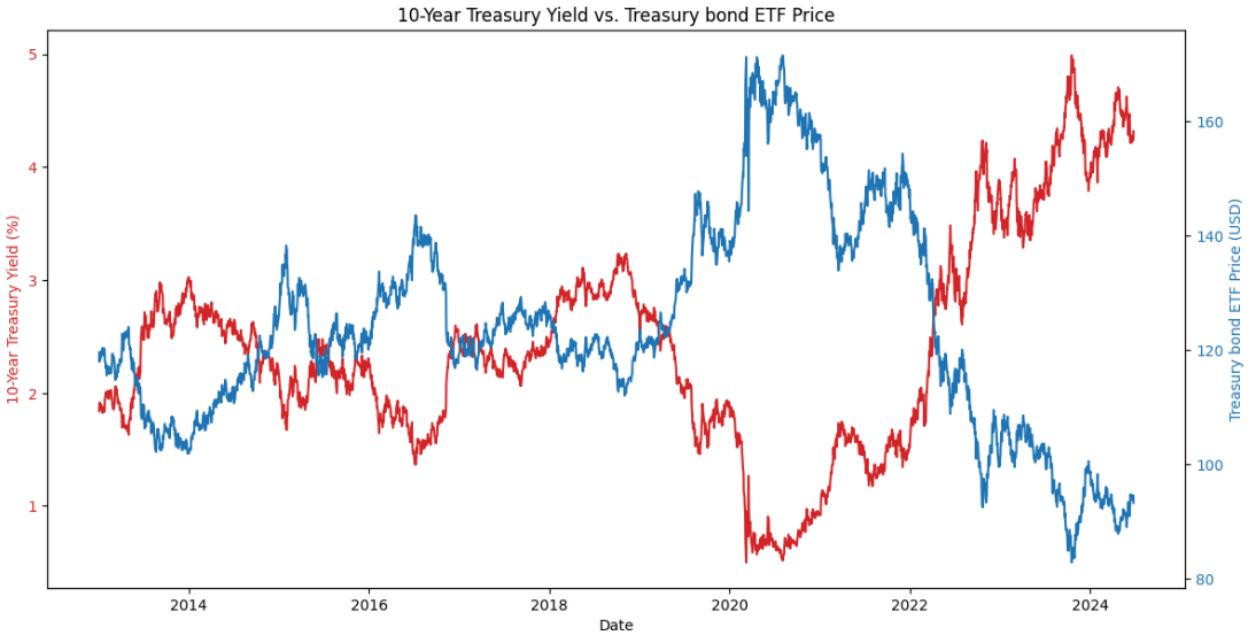


Figure 6: Yield of 10Y US Treasury Note vs Treasury bond ETF price

Here, we are looking at correlation risk and macroeconomic events associated with lending of publicly traded bonds.

We are taking Treasury bond ETF data (TLT) as an indicator of bond price. We have learnt from earlier classes that the bond prices are negatively correlated with interest rates. So we look at the 10Y treasury note yield data for the same period(yields and interest rates are directly correlated). And plot the bond price and yield against each other to observe a mirror image of trends, indicating negative correlation. The calculated correlation for above data is -93.7%

So, when interest rates are changed, yields follow a similar trend, and it drives the bond prices in opposite directions, so we are exposed to very high correlation risk. And from past we have observed that macroeconomic events play a major role in the change of interest rates

**An illiquid security**

For an illiquid security we take rarely traded precious metal palladium (PA-F palladium futures). And we will see how its volatility increases because of illiquidity and observe the price fluctuates rapidly.

We use SPY (a tracker of S&P 500 index) as a liquid security to benchmark against. We use daily data between 2022-23 for analysis. In that period, the average volumes per day are as follows

Average Volume of Illiquid Security (PA=F): 45.56 shares

Average Volume of Liquid Security (SPY): 94.76 million shares

We can clearly see PA=F is a lot more illiquid than SPY.

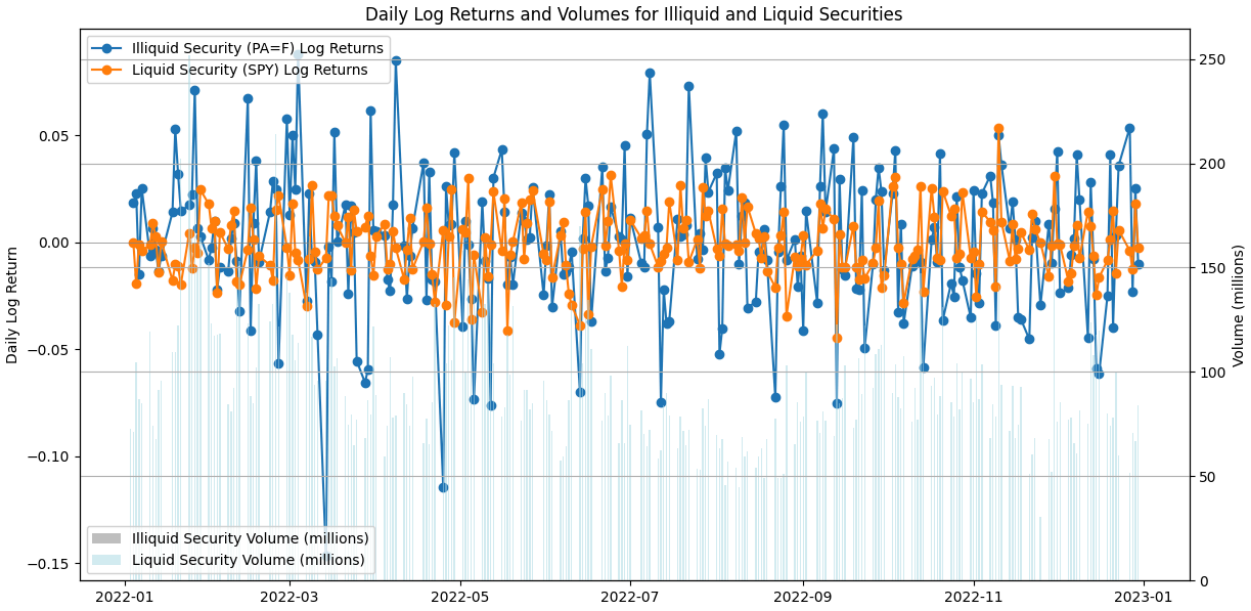


Figure 7: Log Returns and volumes of Illiquid and liquid securities. Illiquid security has bigger jumps and higher volatility

From the graph above we can observe that the jumps of the illiquid security are larger and frequent than the liquid stock. This is a visual indication of higher volatility. And indeed the calculations show that the volatilities of log returns are

Volatility of Illiquid Security PA=F: 3.32%

Volatility of Liquid Security (SPY): 1.53%

So this analysis is inline with our expectation of illiquid securities exhibiting large unpredictable price movements. And it is quite hard to hedge the volatility risk.

## Step 6

### Money at a fixed rate for an unsecured purchase

After some analysis on the previous steps, we can make some simple conclusions on how the data can help the financing challenges. The inverse correlation between consumer spending growth and default rates, can show how default rates might be during economic downturns, where consumer spending growth stalls. By understanding historical trends we can help lenders predict periods of high default risk, to be able to adjust lending criterias and rates accordingly. In addition the correlation between interest rates and default rates can enhance the financing team's predictive models to forecast default risks more accurately.

### Money at a floating rate for a secured purchase

In this scenario, analyzing historical house values can help borrowers evaluate the risk of collateral depreciation leaving the mortgage underwater during economic downturns, helping determine the loan lending criteria. Moreover, the historical value data will be helping predictive models spot the risk of default during an imminent house market crash, and adjust lending criterias.

### Money at a fixed rate for a business for a construction loan

The plot of the default rate on Real Estate loans vs. producer price index on construction materials is an indication that construction/real estate firms would most likely sell or auction building structures at the price that enables them break even and earn a yield on their investment within a short period of time without necessarily defaulting in the repayment of loans. This result of the visual data shows that building prices will continue to rise because of inflation in the cost of building materials, and the credit default rate will continue to decline as long as this continues.

Therefore, the financial team has no need to be wary of the credit default potential of the real estate firm, as these firms mitigate the risk of default by selling buildings at higher prices or selling significant amounts of investment shares to the public should the firm suspect the risk of illiquidity of the asset (because of the high prices). Either way, the loan will be repaid. Moreover, the negative correlation value of -0.688 obtained further supports this claim: as the prices of construction materials surge, selling price of buildings increase and consequently the default rate declines , This theory is corroborated by Moody's analysis of credit ratings for companies within the construction and building sector, which is a pretty stable range between A2 and B2. (Moody's: Construction & Homebuilding).

### Publicly traded equity

From the data analysis we did in step 5, We observe that the correlation of equity with indices and the market in general can spell disaster when the general market sentiment is bad. We can understand the risks we could potentially face and try to hedge them by diversifying within equities that are negatively correlated with the general trend, or we can additionally lend in fields that usually have no/negative correlation with equities, like gold. We can also ask for collateral (and ask for something that is not positively correlated with equity).

### Publicly traded bond

From the charts above, we draw a major conclusion of how IR rates can devalue or appreciate bonds. So interest rates are a good indicator (rising interest rates will decrease the bond price). With this information, we can be aware of the risk we are taking and evaluate the cases where the bond prices could be so low that the borrower might prefer defaulting than paying up. This also shows that political and macroeconomic events can severely affect bond prices. Few viable options to solve the challenge is

1. editing collateral requirements and terms based on anticipated interest rate changes and frequent valuation of bond prices
2. Hedging the interest rate risk by investing in derivatives like interest rate swaps.

**An illiquid security**

From the analysis from step %. We observe that illiquid securities trade far less in volumes and have high volatilities. And this makes the price prediction of the security highly unpredictable. This effect only intensifies in case of large trades in one direction, because of low volume, the price and in turn face feedback loop for that period.

So as a lender, we should be aware of the volatility risk associated with the illiquid security. This can be tackled as by doing one of the following

1. charge a premium for the volatility risk at the inception of trade lending
2. edit the haircuts or margin requirements to mitigate price fluctuations

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- (b) U.S. Bureau of Labor Statistics. "Producer Price Index by Commodity: Special Indexes: Construction Materials [WPUSI012011]." Retrieved from FRED, Federal Reserve Bank of St. Louis. June 25, 2024. https://fred.stlouisfed.org/series/WPUSI012011
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