GROUP WORK PROJECT # _1__
GROUP NUMBER: _____4801_____

MScFE 600: FINANCIAL DATA

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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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Use the box below to explain any attempts to reach out to a non-contributing member. Type (N/A) if all members contributed.   **Note:** You may be required to provide proof of your outreach to non-contributing members upon request.
N/A

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Step 1: Collateral Realted Risk

	Financing Challenges	Collateral Challenges
Money at a fixed rate for an unsecured purchase	-> **Credit Risk**. Risk of default by borrowers. Creditworthiness assessing difficulty. Unsecured loans are riskier, make repayment difficult, and can lead to significant financial stress leading to higher interest rates. -> **Interest rate risk** as fixed rate can become less competitive and also less profitable when market changes. -> **Reinvestment risk**. If the interest rate goes down, the repayment will not be able to be reinvested in a similar rate. -> **Inflation risk**. If the inflation is high, the money from repayment may worth less in the end. -> **Economy risk**. When the economy gets bad, income decreases, leading to more consumer loans, increasing credit risk and affecting personal credit scores.	X
Money at a floating rate for a secured purchase	-> **Credit Risk**. Risk of borrowers default. Difficulty assessing the creditworthiness of the borrowers to pay in a floating rate environment. -> **Market Value of Collateral**. If the loan is non-recourse, a drop in property value (due to a market crash or inappropriate management) may lead to a default even if the borrower has the ability to repay. -> **Interest rate risk** as floating rates can fluctuate, when interest rate goes down the amount of total repayment would decrease. When interest rate increase, the borrow might not able to repay the loan. -> **Inflation risk**. -> **Reinvestment risk**.	X

Money at a fixed rate for a business for a construction loan	-> **Credit Risk**. Assessing business viability and profitability. -> I**nterest Rate Risk**. Changes in interest rate so fixed rates can become less competitive here also. If interest rate goes higher, the lended amount is locked and cannot benefit from the rate increase. -> **Economy risk**. Economic downturn can affect construction business cycle. -> **Project and market risk**. Prolonged construction projects can cause the project to overspend (costs of labor, raw materials, and interest rates change).	X
Publicly traded Equity	X	-> **Counterparty Risk**. Borrower failing to return borrowed equity i.e counterparty risk. -> **Market Risk** such as economic downturn, financial crisis, geopolitical tension etc. -> **Collateral Revaluation**. When the equity price increases, the challenge of monitoring the value collateral to remain sufficient to cover the borrowed equity.
Publicly traded bond	X	-> **Counterparty Risk.** Borrowers failing to pay the coupon amount. -> **Market volatility risk** due to market conditions affecting bond prices. -> **Valuation Challenge**. The valuation of the bond and collateral is challenging, especially when the trading volume is relatively smaller.
An illiquid security	X	-> **Counterparty Risk.** -> **Liquidity Risk**, larger than expected price decline while selling impacting the collateral value of security. -> **Market volatility risk.** -> **Valuation Challenge**. The price

		of illiquid is commonly not transparent and the bid-ask spread is wide, making valuation of the security challenging. -> **Operational challenges**. Managing illiquid securities can be complex and time-consuming. This can add to the lender's operational costs and make it more difficult to manage their portfolio.

Step 2: Statistical Related Challenges

	Volatility Challenges	**Correlation Challenges**
Money at a fixed rate for an unsecured purchase	-> **Volatility in interest** rate affecting lenders profitability and become less competitive and make pricing fixed-rate loans more difficult. -> **Economic volatility** affects in borrowers income and their ability to pay back and affects consumer purchasing behaviour.	-> Correlation between interest rate and repayment ability. The income of the borrower may be correlated with economic cycles which is also correlated with the borrower's income. -> Correlation between interest rate and creditworthiness of borrower. -> Correlation between macrorconomic factor and purchasing power of borrowers.
Money at a floating rate for a secured purchase	-> **Volatility in interest** rate impacting monthly payments on floating rate environment increasing default risks. -> **Volatility in market** can affect the value of colletratal used for loan. -> **Volatility in income** can affecting ability to payback.	-> Correlation between interest rate and secured purchase value. Usually when interest rate increase, the property market will drop. -> Correlation between macroeconomic factor and repayment ability.
Money at a fixed rate for a business for a construction loan	-> **Volatility in interest** rate affecting cost of financing. -> **Market volatility** can affect the availability of construction funds. -> **Volatility in construction cost** can affect projects feasibility.	-> Correlation between interest rates and construction business performance. -> Correlation between economic conditions and construction projects.
Publicly traded Equity	-> **Volatility in markets** can affect equity valuation, and market affects company earnings which will affect equity price as well. -> **Volatility in market turnover**. If the equity is illiquid, volatility may affect the lender in recovering capital in the event of default.	-> Correlation between market performance and company performance and equity prices. -> Correlation between economic cycles and stock price.

Publicly traded bond	-> **Interest rate volatility** can impact bond prices. -> **Market volatility** can affect the perception of bonds.	-> Correlation between interest rates and bond prices. -> Correlation between an issuer credit worthiness and bond prices. -> Correlation between economic and sector performance and bond prices.
An illiquid security	-> **Volatility in market depth and liquidity** can increase the valuation challenges in already illiquid security. -> Price Volatility can impact in lending decision for illiquid stocks.	-> Correlation between market conditions and illiquid security prices. -> Correlation between economic events and illiquid security prices.

Step 3: Identifying Data

● **Money at a fixed rate for an unsecured purchase (e.g. credit card) for an individual.**
1. **Data Type:** loan amount, credit score, income and employment status, other debts, utilization rates, interest rates
2. **Data Preprocessing:** modeling credit risk, scoring models or borrower, default probability analysis
3. **Data Frequency:** Monthly, Quarterly, Annually and all history
4. **Data Class:** Credit
5. **Data Source:** credit bureaus, banks, customer submission, interest rate indexes
6. **Data Variety:** Actual Data, Modeled Data, Adjusted Data, Relative Data

● **Money at a floating rate for a secured purchase (e.g. home or automobile) for an individual.**
1. **Data Type:** property value, loan amount, credit score, income and employment status, other debts, utilization rates, interest rates, market trends
2. **Data Preprocessing:** modeling credit risk, scoring models or borrower, default probability analysis, market modeling, collateral valuation, interest rate prediction
3. **Data Frequency:** Monthly, Quarterly, Annually
4. **Data Class:** Credit, real estate
5. **Data Source:** credit bureaus, banks, customer submission, interest rate indexes, property dealers
6. **Data Variety:** Trade Data, Actual Data, Observed and Modeled Data, Adjusted Data, Relative and Absolute data.

● **Money at a fixed rate for a business for a construction loan.**
1. **Data Type:** Loan value, collateral value, current debt amount, interest expense, economic indicators affecting construction industry (e.g., GDP, housing starts), Credit ratings of borrowers, interest rates, regulatory changes.
2. **Data Processing:** Loan performance metrics, Volatility of interest rates and construction market indicators
3. **Data Frequency:** Weekly, Quarterly, Annually
4. **Data Class:** Credit, fixed income, real estate
5. **Data Source:** Financial Statements, Industry Data, Company Data, Economic Indicators
6. **Data Variety:** Actual Data, Observed Data, Estimated Data, Modeled Data, Real-time data

● **Publicly traded Equity (e.g. common stock) – that is, securities lending of a Stock.**
   1. **Data Type: OHLC prices, Volume, Dividend yields, EPS, P/E Ratio, Market Cap**
   2. **Data Processing: Adjustments for stock splits and dividends, Financial ratio Calculation, Stock price volume analysis.**
   3. **Data Frequency: Daily, Quarterly,weekly, Anually**
   4. **Data Class: Equity**
   5. **Data Source: Exchanges, Financial Reports, Financial statements**
   6. **Data Variety: Quote data, Trade Data**

● **Publicly traded bond (e.g. treasury bond, corporate bond) – that is, securities lending of a bond.**
   1. **Data Type: Ratings Data, Yield to maturity, Credit Spreads, Coupon Rates**
   2. **Data Processing: Levels, Price to Yield, issuer credit worthiness**
   3. **Data Frequency: Varying frequency**
   4. **Data Class: Credit data**
   5. **Data Source: Exchanges, Brokers, Credit rating agencies**
   6. **Data Variety: Modeled data, Trade data**

● **An illiquid security – Small-cap stocks.**
   1. **Data Type: market capitalization, shares outstanding, financial statements**
   2. **Data Processing: stock prices, dividend yields, financial ratio,**
   3. **Data Frequency: Daily, Quarterly, Weekly, Anually**
   4. **Data Class: Equity, Market Indices**
   5. **Data Source: Exchanges, Financial Reports, Financial statements**
   6. **Data Variety: Quote data, Modeled data, Trade data**

Step 6: Describe how the data can help to meet the challenge

1. Money at a fixed rate for an unsecured purchase

We use the German Credit Risk dataset found on Kaggle which contains 1000 entries with the following attributes: Age (numeric), Sex (Categorical), Job (Categorical), Housing (Categorical), Saving accounts Amount(Categorical), Checking account Amount (Categorical), Credit Amount (numeric), Duration (numeric), Purpose (Categorical), and a Risk label (Categorical).

The dataset contains the key attributes of a unsecured purchase borrower and could be used to aid whether a lending decision should be made.

First, we plot the attributes distribution density for people in different risk groups.
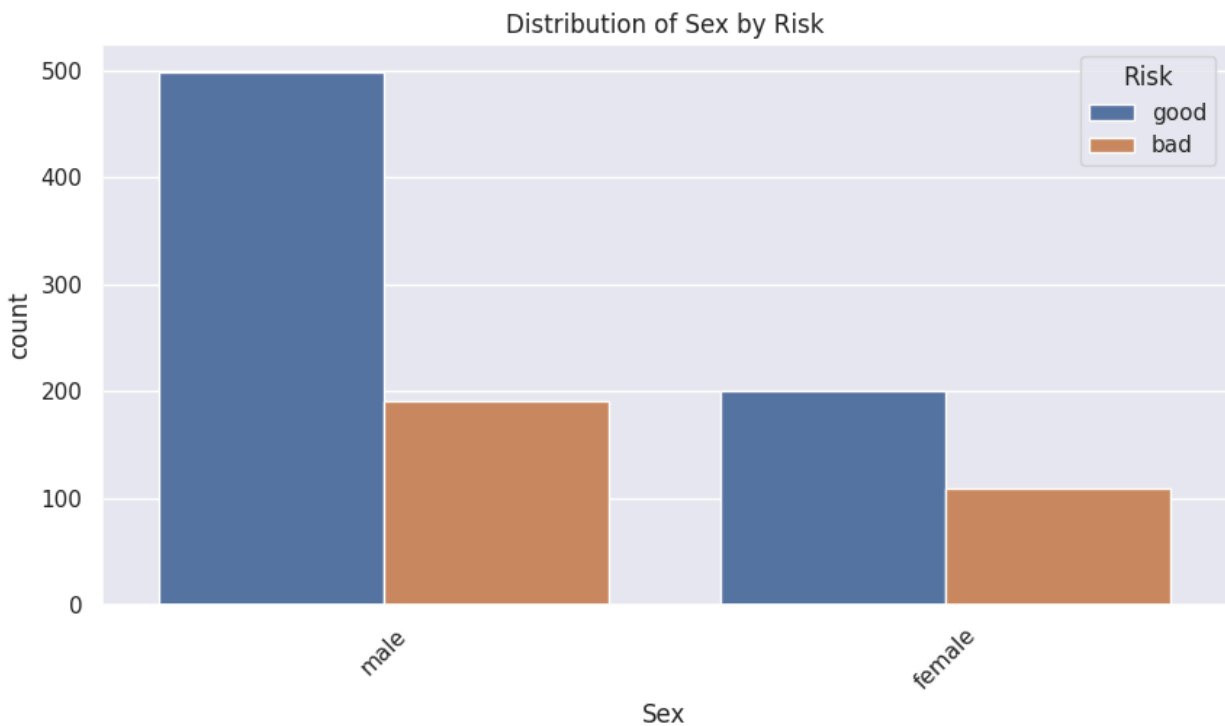

Distribution of Age by Risk

Distribution of Job by Risk
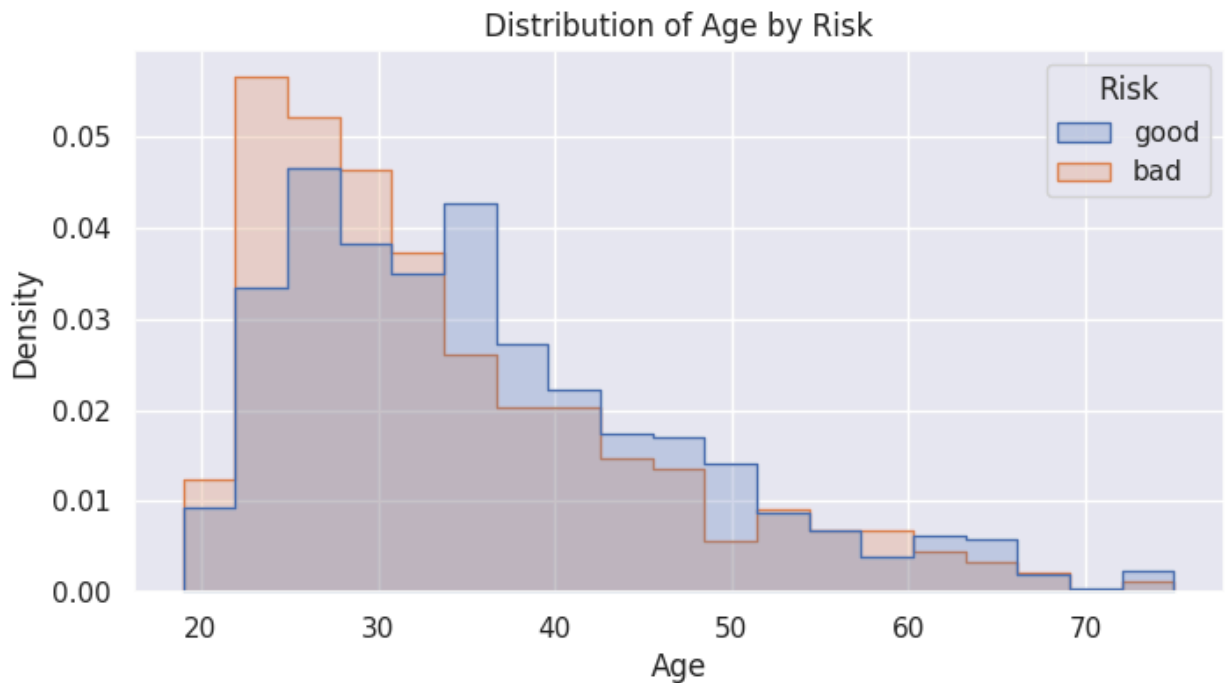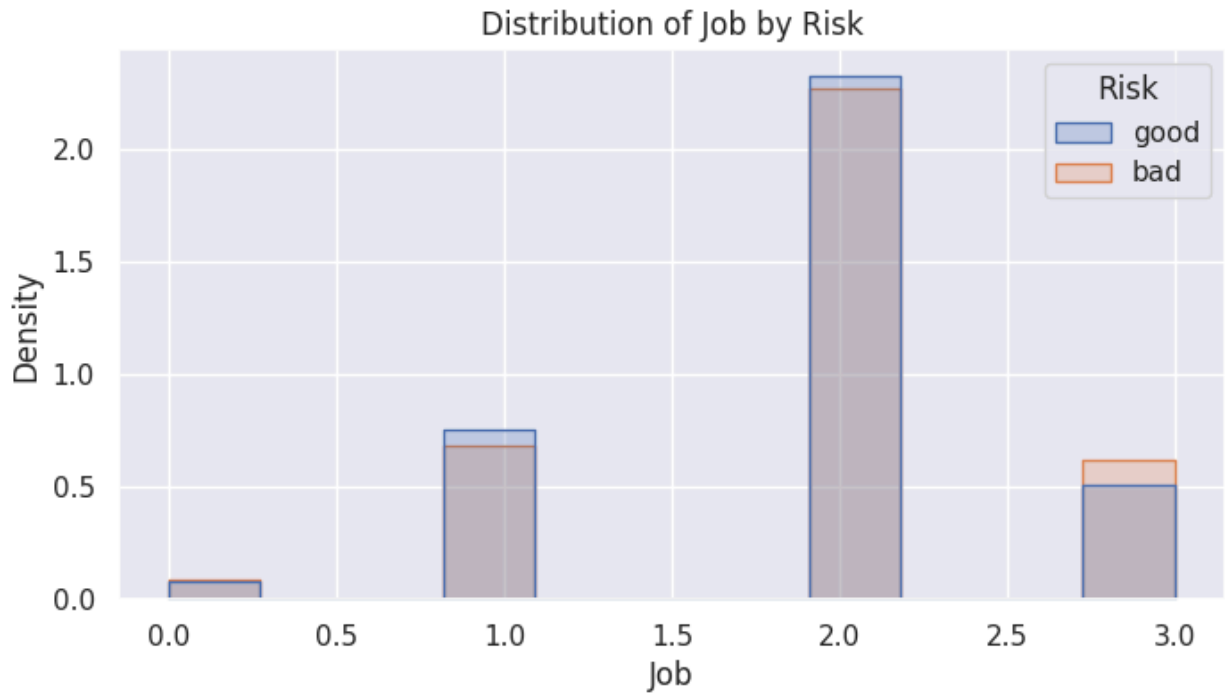
For age and job (in a scale of 0-3 points measurement of skillfullness, higher is more skilled), we see the distribution of good and bad risks are almost equal in different groups, implying no significant impact of age and job in risk profile.

Distribution of Credit amount by Risk
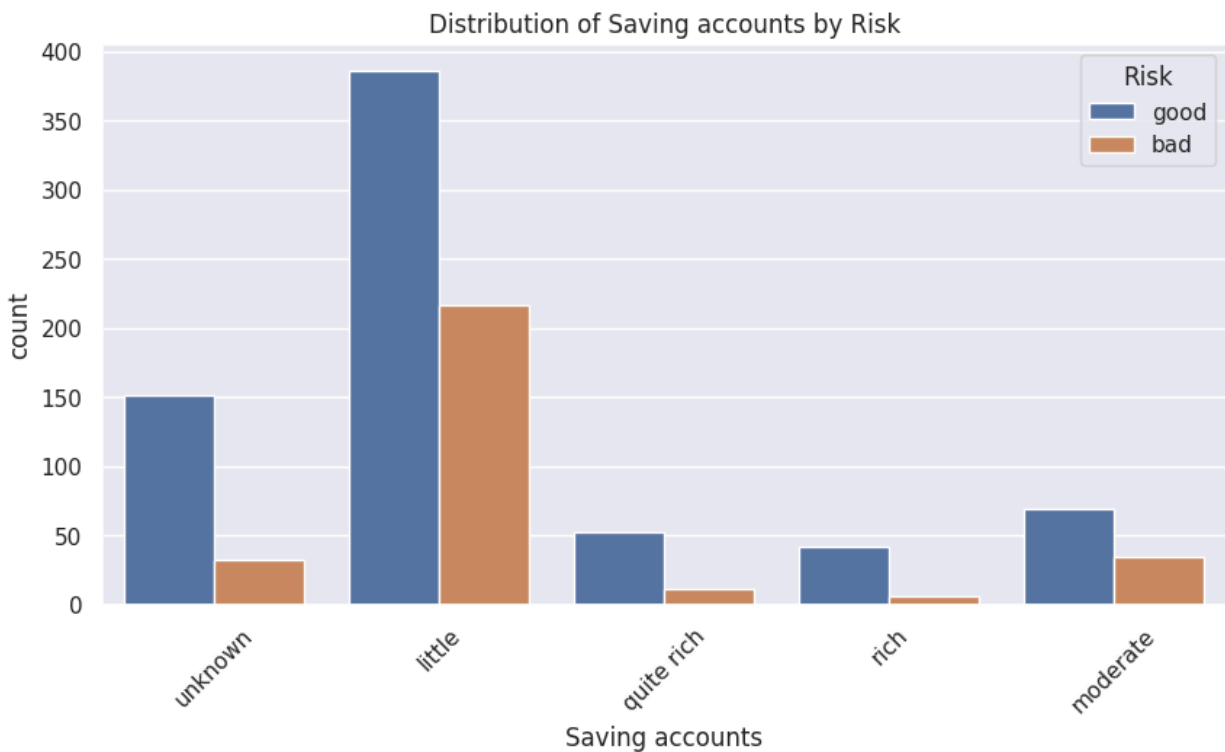
Distribution of Duration by Risk
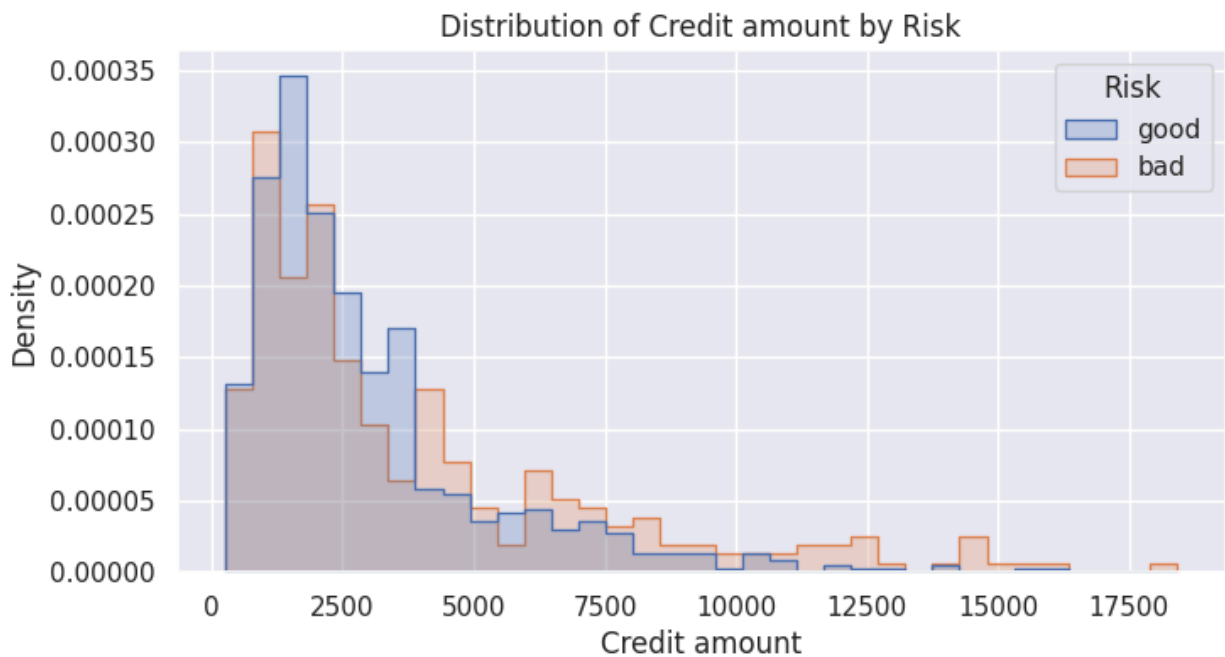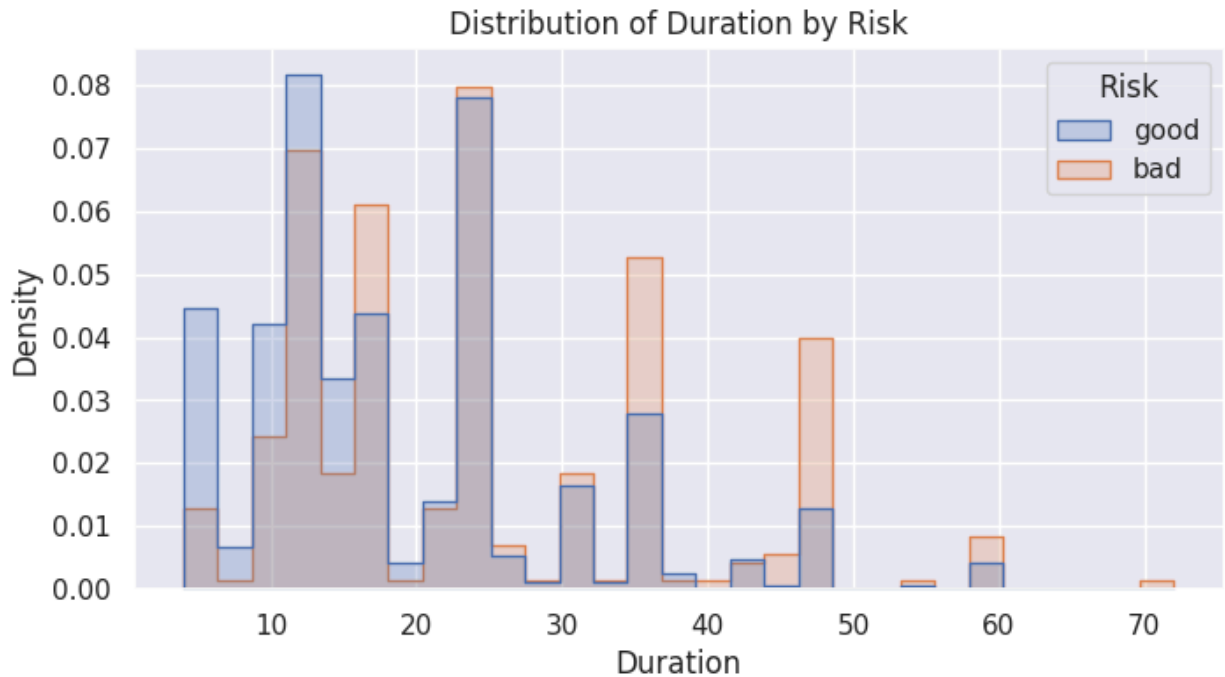
From the 2 figures above showing the relationship between risk and credit amount and duration, we could observe two clear correlations such that if the credit amount is higher and the duration is longer, the risk is also higher.

Distribution of Sex by Risk

From the distribution of sex by risk plot, we see a slightly higher risk of female comparing to males.

Distribution of Housing by Risk
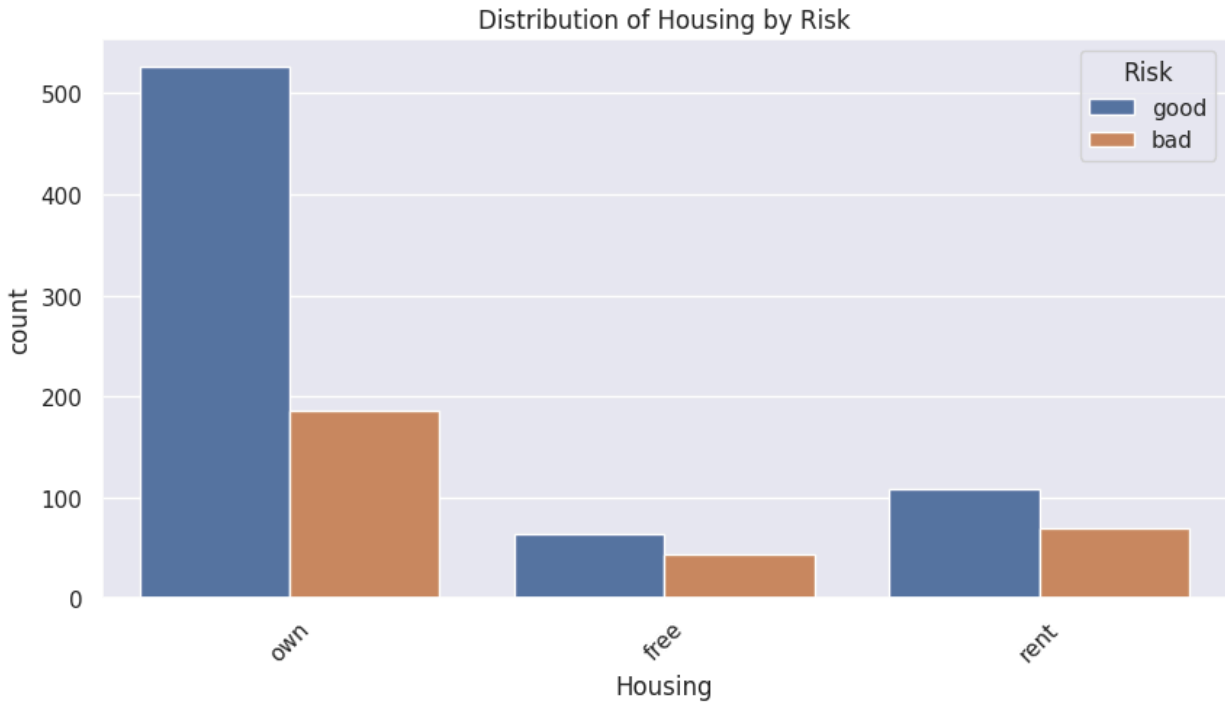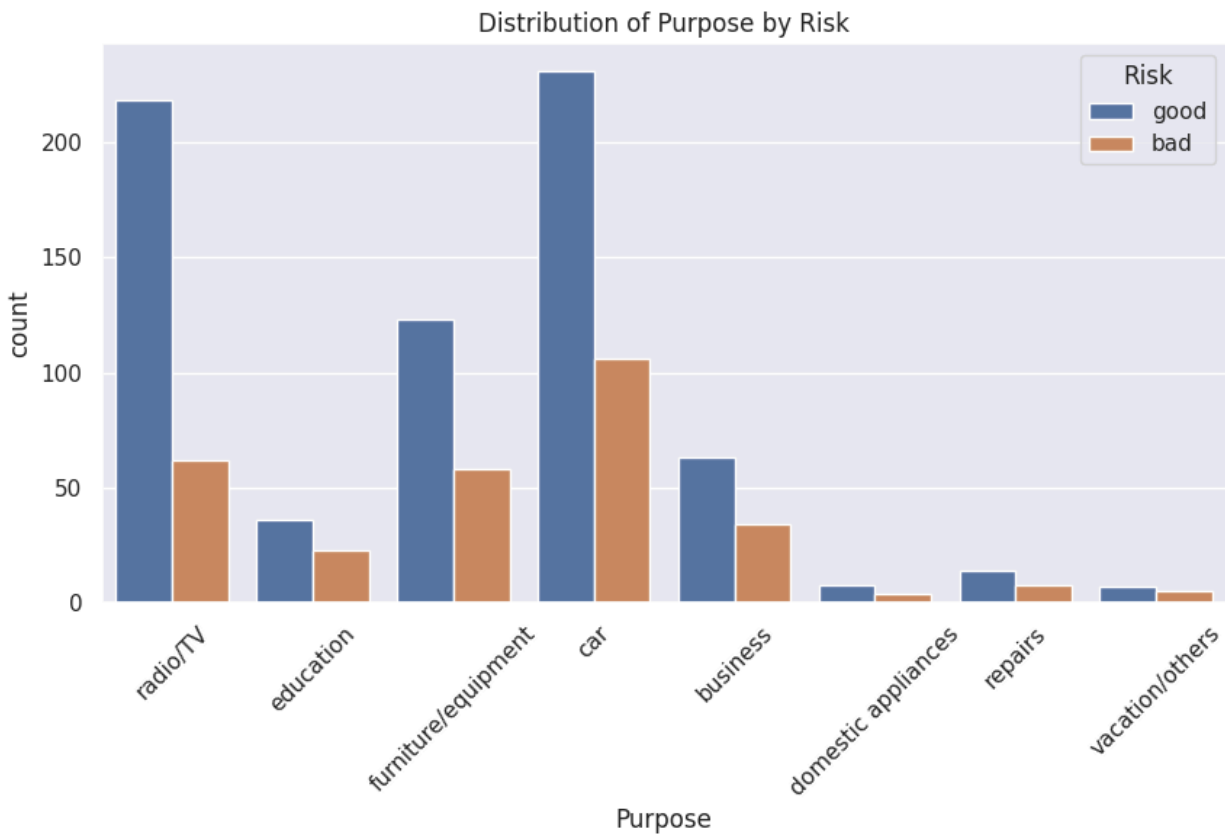

From the figure of housing status, we see people owning their home have a lower risk.

Distribution of Saving accounts by Risk

Distribution of Checking account by Risk

From the two figures above, we see people have more money in their account generally have a lower risk than people have little in their account.

Distribution of Purpose by Risk

Another interesting observation from the above figure of distribution of purpose by risk, we could see people borrowing for education, vacation or business have slightly higher risk than people buying a car or TV.

Beyond the qualitative analysis above, we could also train a predictive model for the risk and understand how different features affect the prediction outcome. We use a random forest classifier and get a prediction accuracy of 0.74 and macro F1 of 0.65. The prediction is not good enough since we only have 1000 data entries, but we believe when applied with the real-world data, the performance would be better.

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Feature ranking:
1. feature Credit amount (0.2429102833603888)
2. feature Age (0.18828154657398738)
3. feature Duration (0.1528232232069147)
4. feature Checking account (0.12797838806562198)
5. feature Purpose (0.08835438016216911)
6. feature Saving accounts (0.066855975686658981)
7. feature Job (0.05937968765275512)
8. feature Housing (0.043698702816807614)
9. feature Sex (0.02971781247476549)
```

From the feature importance rank, we could see the random forest classifier use credit amount, age, duration, checking account amount and purpose and the most important features. This aligns with our qualitative analysis except for age. This could due to either the classifier is not accurate enough or there are some correlation between features e.g. correlation between age and purpose.

This finding could help a credit card company to address the challenge of the estimating the chance of borrower default.

2. Money at a floating rate for a secured purchase
When lending with collaterals (e.g. mortgage), the market volatility of the collateral (the property price) is also very import since it affects the loss and chance of the borrower default. In this scenarios, we use the Singapore HDB flat resale price index from 1990 to 2023 quarterly, which is adjusted for location, flat size, floor level and etc, which reflects the accurate overall market trends of the HDB flats in Singapore.

First, we plot the trends as time series.

We could see a general upward trend with occasionally downward movements.

Next, we calculate the return and analyze the return and estimate the market volatility by calculating the standard deviation. We assume the return is normally distributed for simplicity now.


We see from the return graph that in some scenarios the change is very huge, up to about 30% while normally the change is small. We could calculate the mean change is 1.58% positive, and the standard deviation of change is 4.34%.

Since the mortgage in Singapore is usually 30 years, we want to understand how could the property market move in the 30 years period. We calculate the lower and upper bond of the total change given the normally distributed assumption and 95% confidence interval, which is 96.8% to 283.3%. So we could say in 30 years, the property value is likely to increase by 96.8% to 283.3% with 95% chance.

With these property market data analysis, we could be more confident in estimating the market related risk when lending money with collaterals.

3. Money at a fixed rate for a business for a construction loan

We assess Welltower's (REITs) fixed-rate construction project business loans using US market economic and construction industry data. I selected industry indicators for it, including total construction spending, which assesses the amount spent on construction over time, all employees, which represents the number of workers in the sector, and average hourly wages of all producing employees, which indicates the amount of spending. An overview of the construction and real estate markets can be obtained by looking at salaries for industry workers, price indexes for building materials, interest rates, including the Federal Reserve interest rate, and loans secured by real estate. Thus, if interest rates rise to a level comparable to 2023 and other industry indicators raise the risk level of the construction industry and their impact, the economy and industry's current level of risk will be demonstrated. The stock price reflects the above figure, which is associated with the company's performance.
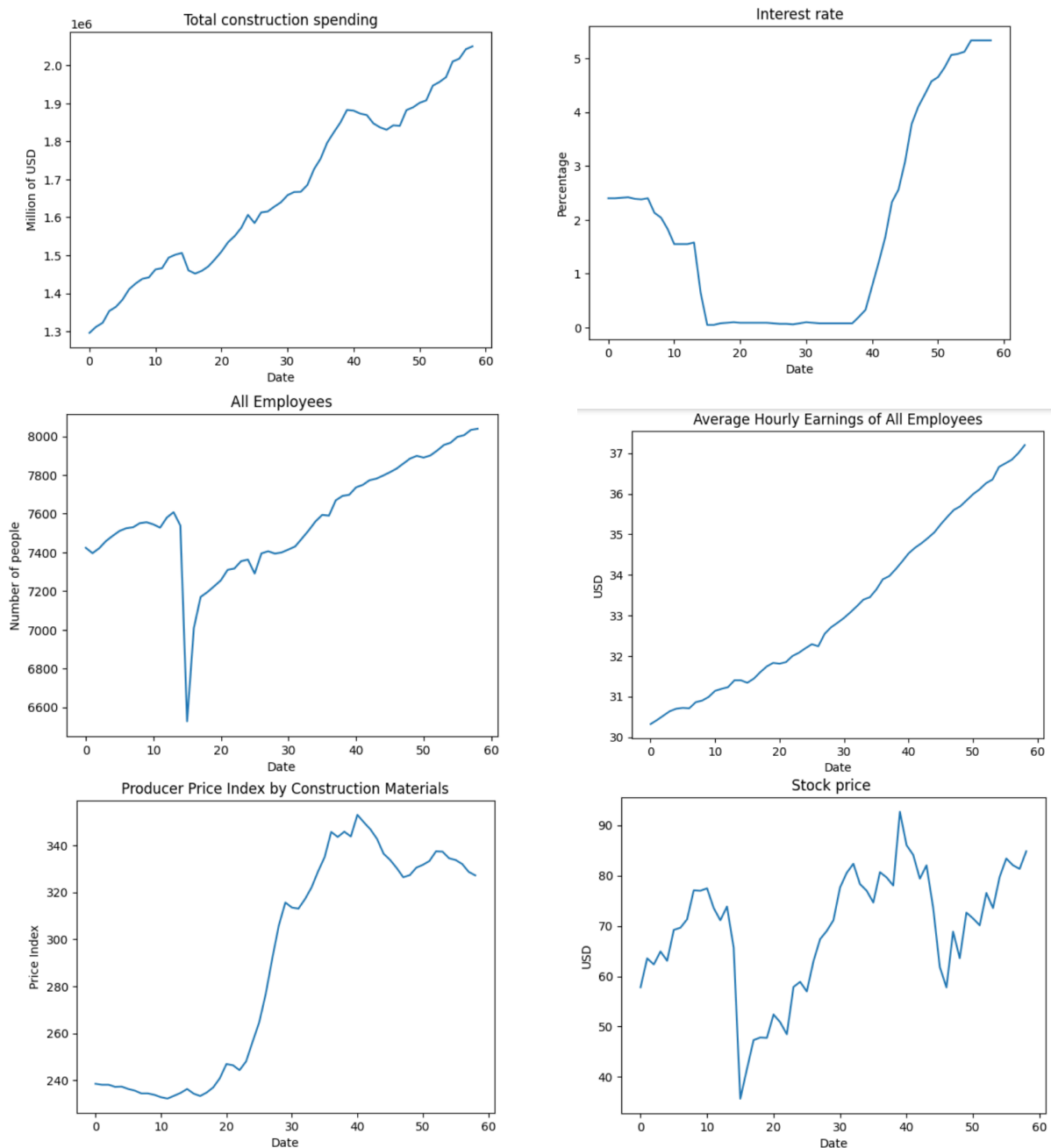
Both Welltower's fixed interest rate lending and the lending bank's fixed interest rate are impacted by changes in the aforementioned indices. Industry indicators like employment, spending, and raw material costs all have a negative impact on the industry's future when there is severe market volatility. This raises the risk of lending and the cost of borrowing money with interest. fixed rate and the opposite.

	Total Construction Spending	All Employees	Average Hourly Earnings of All Employees	Producer Price Index by Construction Materials	Interest rate	Loans Secured by Real Estate	Stock price
Total Construction Spending	1.000000	0.764239	0.981062	0.915350	0.509093	0.934618	0.562920
All Employees	0.764239	1.000000	0.783897	0.681477	0.764367	0.654550	0.719459
Average Hourly Earnings of All Employees	0.981062	0.783897	1.000000	0.879501	0.627082	0.985315	0.489235
Producer Price Index by Construction Materials	0.915350	0.681477	0.879501	1.000000	0.323758	0.826115	0.628616
Interest rate	0.509093	0.764367	0.627082	0.323758	1.000000	0.599052	0.304177
Loans Secured by Real Estate	0.934618	0.654550	0.985315	0.826115	0.599052	1.000000	0.301036
Stock price	0.562920	0.719459	0.489235	0.628616	0.304177	0.301036	1.000000

4. Publicly traded Equity (e.g. common stock) – that is, securities lending of a Stock.

For Publicly traded Equity we have used 5 years of data of NVIDIA, which is a leading American multinational technology company, renowned for its graphics processing units (GPUs) and AI-driven computing solutions. Specializing in GPU design for gaming, professional markets, and data centers, Nvidia has played a pivotal role in advancing visual computing and artificial intelligence technologies.

We are considering Avg Daily Trading Volume vs. Bid-Ask Spread vs. VIX Index as our factors to understand whether these would solve our problem or not Let's first understand why we have chosen these factors.

How these Graphs Address the Financial Challenge:

Our primary task is to assess if this asset is worthy of lending money or not, thus together these graphs allow us to present a thorough picture of the liquidity and market dynamics around the equity that is publicly traded. The financing team can spot periods of possible illiquidity by keeping an eye on the bid-ask spread and average trading volume. Furthermore, the association with the VIX index aids in predicting elevated market strain. When loan rates are determined and the risk of lending securities is evaluated during periods of heightened volatility and possible illiquidity, the financing team needs this information to make well-informed judgments.

Avg Daily Trading Volume vs. Bid-Ask Spread vs. VIX Index:

We can learn more about the liquidity of publicly traded shares by comparing these parameters. While a larger bid-ask gap may suggest reduced liquidity, a higher trading volume often denotes increased liquidity in the share. We can see the relationship between volatility and liquidity by superimposing the VIX index, a measure of market volatility, over it. Increased bid-ask spreads may be correlated with higher VIX readings, suggesting possible difficulties in carrying out deals and elevated market uncertainty.

Now let's see our analyzed reports of 5 years of data of NVDIA:
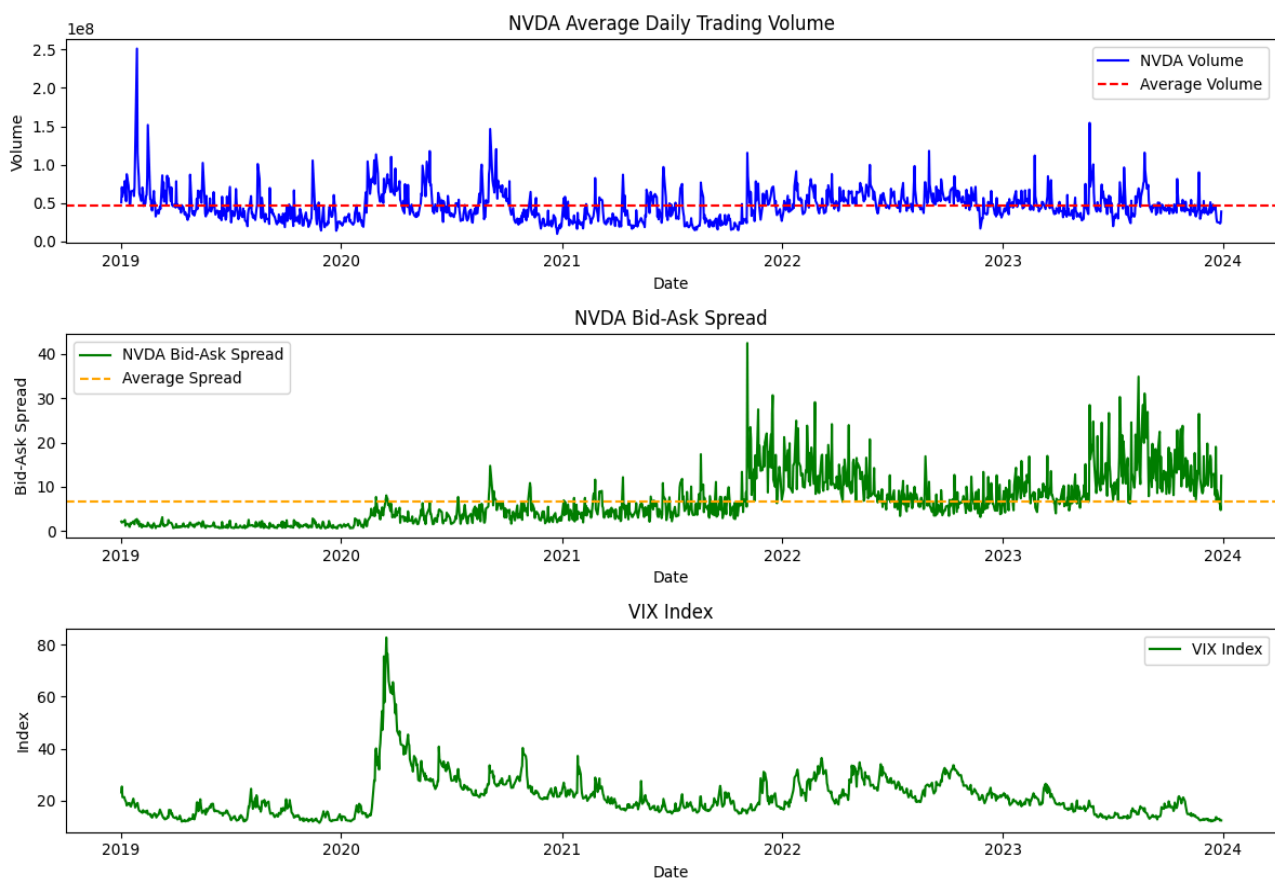
Here you can see during 2020 there is a huge increase in VIX which means the volatility is at it's peak but during the same period we can see there is not any significatinct increase in bid-ask spread which suggests that even in highly volatility scenario NVDIA have remained liquid and also we can observe that Volume during the same period is above average which means there is enough liquidity in this market so, we can conclude that this asset have ability to perform in times of increased volatility and and there is very less changes of potential illiquidity.

5. Publicly traded bond (e.g. treasury bond, corporate bond) – that is, securities lending of a bond.

For Publicly Traded Bond we have used 5 years of data of US govt 30 years treasury bond , which is a long-term fixed-income security issued by the United States Department of the Treasury, representing a reliable and low-risk investment option for investors seeking stable, long-term returns on their capital and we have also used 5 year Federal funds effective rate for comparison purposes.

We are considering Comparison of Bond Bid-Ask Spread to Federal Fund Rates as our factors to understand whether these would solve our problem or not Let's first understand why we have chosen these factors.

How these Graphs Address the Financial Challenge:

The financing team can use these data to help them decide on the best lending rates for bonds that are listed on a public exchange. Keeping an eye on the bid-ask spread in relation to federal fund rates facilitates the identification of any liquidity issues. Setting competitive lending rates and controlling the risk involved in lending bonds in various interest rate situations require the use of this information.

Comparison of Bond Bid-Ask Spread to Federal Fund Rates:

By comparing the bond's bid-ask spread to federal fund rates, the finance team may evaluate how changes in interest rates affect the bond's liquidity. Increased illiquidity may be indicated by a widening bid-ask spread, particularly in reaction to shifts in federal fund rates. This comparison facilitates comprehension of how changes in interest rates impact how simple it is to trade bonds on the market.

Let's analyze our comparison plot:
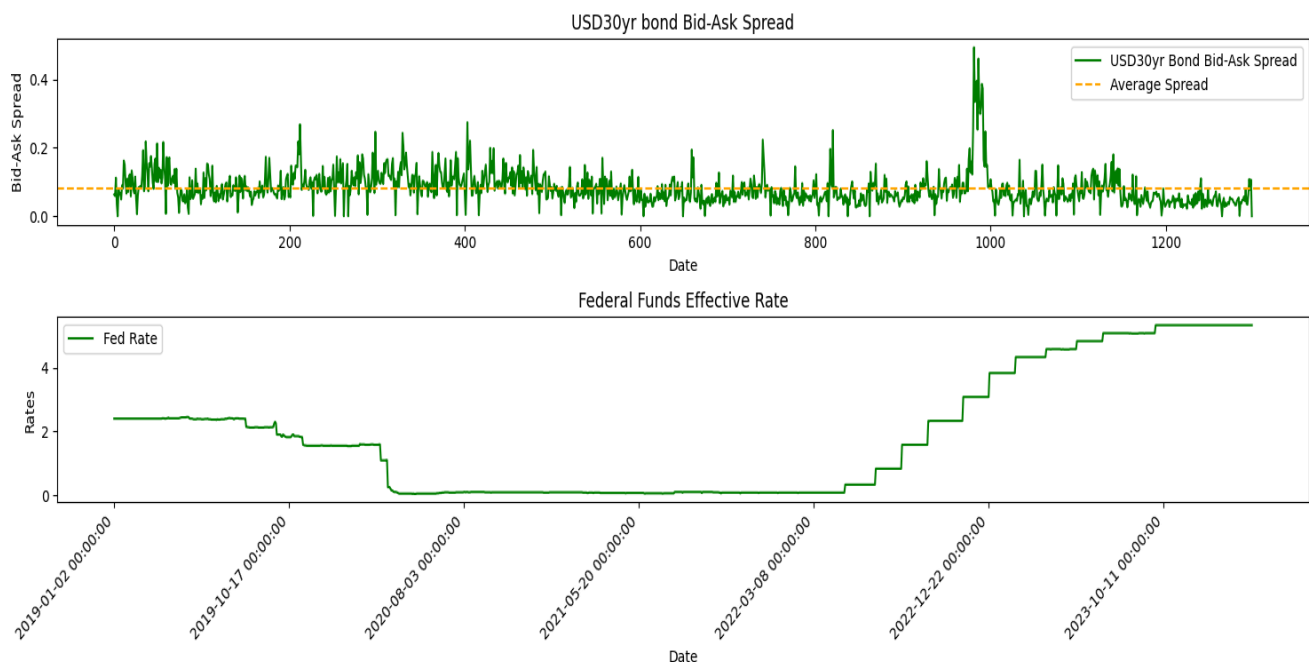
Here we can see between in the 4th quarter of 2022 when the fed started increasing the rate we can see there is an increase in bid-ask spread which signifies illiquidity and as we know interest rate and price are ngeatively correlated which means when the rate increase prices of bond drops and vice-versa so here we can analyze that when the interest rate increase the prices decrease as the bond is no longer attractive for buyers and because of that the bid-ask spread widen up leading to an illiquid market. We can conclude that when the rates are high there are high chances of illiquidity in the market and when the rates are low market is liquid and trading is easy in the asset.

6. An illiquid security – Small-cap stocks

Investors tend to become more risk averse as the VIX rises. Small-cap stocks may become less in demand as a result, increasing their illiquidity. Furthermore, market makers may find it more challenging to supply liquidity for small-cap stocks as the VIX rises. Higher trading expenses and broader bid-ask spreads may also result from this.
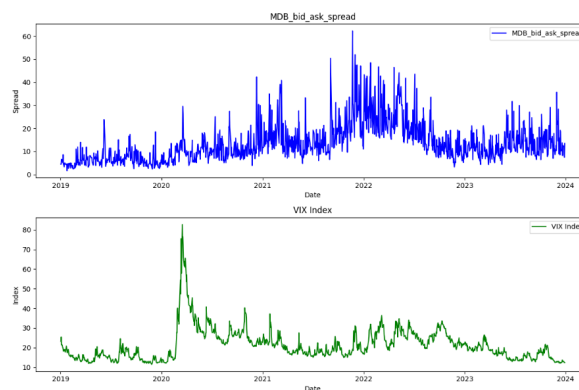
You can reduce the risk of illiquidity by averaging the VIX or creating a VIX index where you sell small-cap stocks when the VIX rises above the safe level. This is due to the fact that a higher VIX denotes a more volatile market, which can make it more challenging to buy and sell small-cap stocks. On the other hand, repurchasing small-cap stocks when the VIX declines is done so because a lower VIX denotes less market volatility, which can facilitate the purchase and sale of small-cap stocks.

Because companies with higher market capitalization are typically thought to be less liquid because they have more shares to trade and are more likely to be followed by institutional investors, market capitalization and the number of outstanding shares are important indicators to evaluate a stock's liquidity. Furthermore, financial statements offer a summary of a business's financial situation and can be used to pinpoint firms that are most likely to lack liquidity. Shares of companies with poor financials may be less liquid because they are less likely to draw in investors.

Project Google Colab Link :- 🔗 Group 4801_Group Work Project_1.ipynb