



# Exploratory Data Analysis in Hong Kong RML Market

Kyro 2024/01  
Financial Stability Surveillance Division



# Agenda

1, Introduction to RML

2, Methodology of carrying exploratory data analysis

3, Result and finding

4, Conclusion

# 1.1, Background

1, Introduction

3, Result

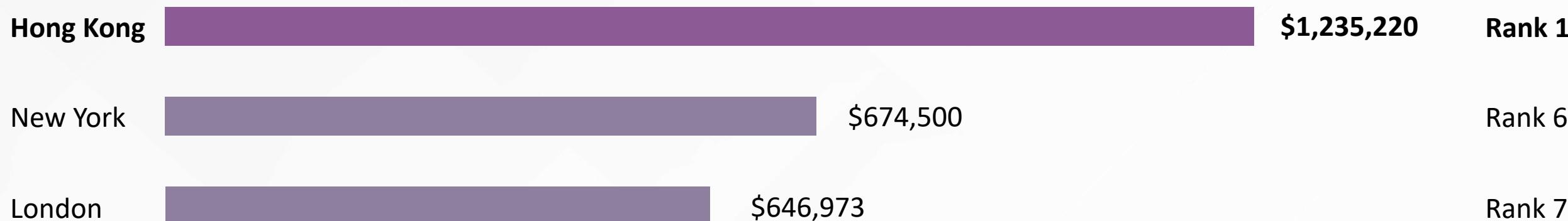
2, Methodology

4, Conclusion



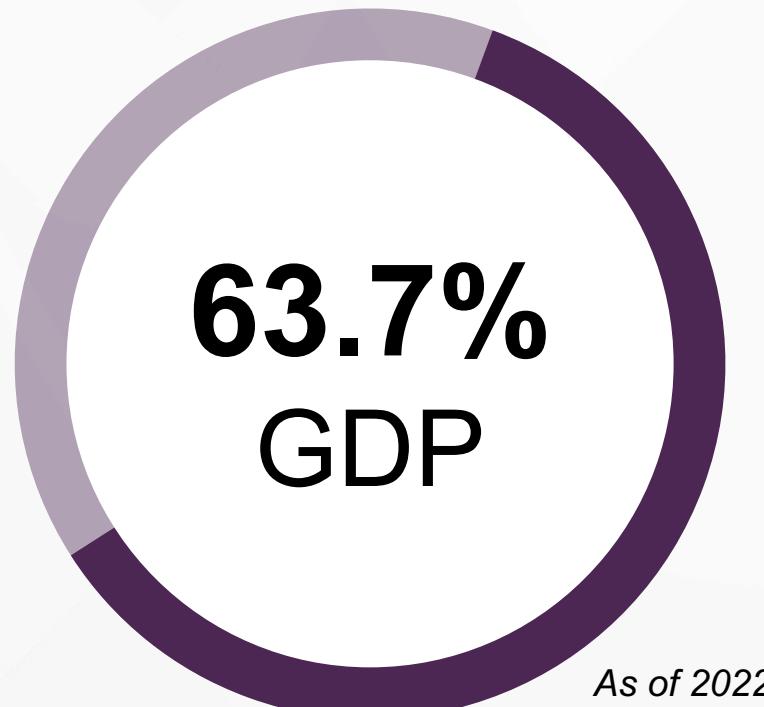
- Hong Kong has among the highest property prices in the world so most home buyers in Hong Kong rely on mortgages

Average property price (\$USD)

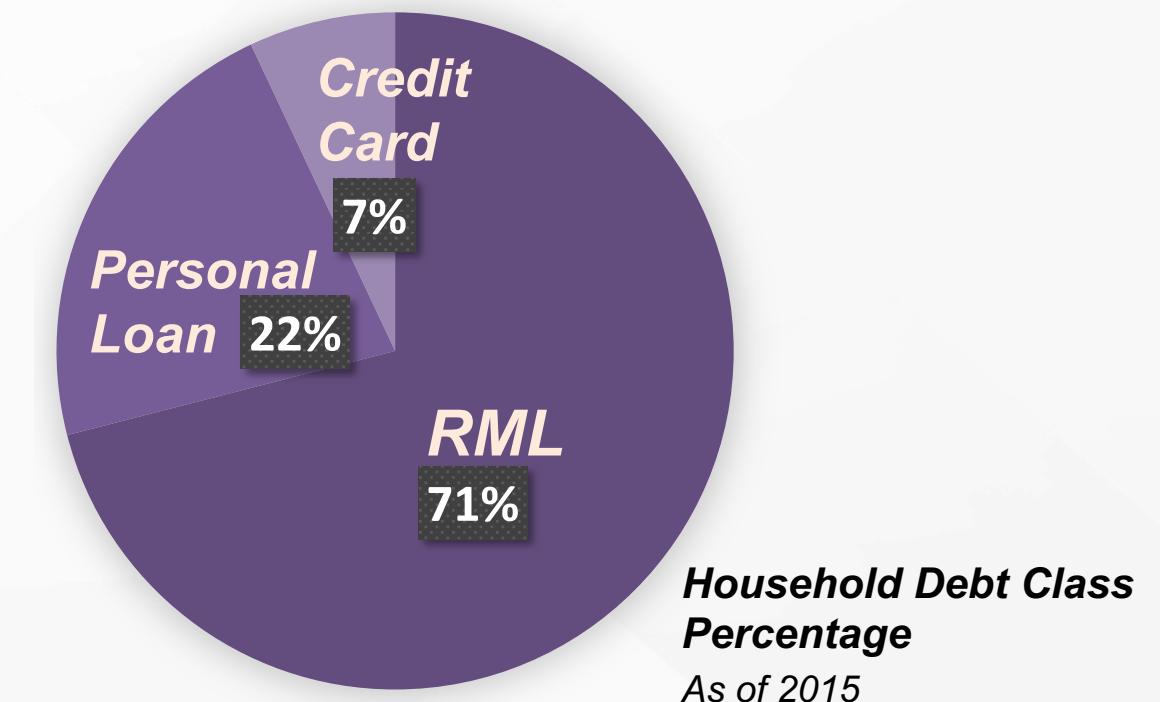


As of 2020

- Outstanding loans of RML market is in a huge size



- Residential Mortgage Loans (RML) is the majority of total household debt



# 1.2, Objective

1, Introduction

3, Result

2, Methodology

4, Conclusion



## Uncover trends and patterns on RML market

- Understand the nature of the RML market
- Identify changes in market dynamics



## Gain insights into borrower and lender behavior

- Extract the factors affecting borrower preferences
- Analyze lender strategies and risk management practice



## Verify policy hypothesis

- Assess the effects of policy changes to RML market, such as regulatory adjustments or interest rate fluctuation



## Support HKMA's functions

- Facilitate financial surveillance by identifying risks early
- Support policymaking by exploring the macro trends



## Data Processing Workflow



# 2.1, Data Collection

1, Introduction

3, Result

2, Methodology

4, Conclusion



- All data is collected from **reputable and open sources**, including the HKMA and the C&SD website.
- The collected data was **categorized into relevant sectors**: economic, banking, and interest rates. The collected data was categorized into relevant sectors: economic, banking, and interest rates.
- The most relevant datasets were **selected** for the EDA on the RML market, such as [Outstanding Loan], [RML in negative equity], [No. of new drawn RML] as RML area and [Unemployment Rate], [HIBOR] and other as factor area.

Name	Sector	From	Area
RML in negative equity	Banking	HKMA	RML
RML survey	Banking	HKMA	RML
No. of new drawn RML	Economic	HKMA	RML
HKD interbank transaction	Debt	HKMA	IBL
IBL	Debt	HKMA	IBL
Balance Sheet	Banking	HKMA	Factor
Capital adequacy	Banking	HKMA	Factor
Credit card lending survey	Banking	HKMA	Factor
Customer Deposits	Banking	HKMA	Factor
External liabilities and claims	Banking	HKMA	Factor
FPS (Address, Turnover in HKD&RMB)	Banking	HKMA	Factor
Liquidity	Banking	HKMA	Factor
Number of AI	Banking	HKMA	Factor
Consumer Price Index (CPI)	Economic	C&SD	Factor
GDP	Economic	C&SD	Factor
Purchasing Managers' Index (PPI)	Economic	C&SD	Factor
Unemployment rate	Economic	C&SD	Factor
Unemployment rate (By sector)	Economic	C&SD	Factor
Balence sheet	Exchange Fu	HKMA	Factor
Composite interest rate (Weighted Average of Deposit, NCD, IBL, Debt)	Exchange Ra	HKMA	Factor
HIBOR	Exchange Ra	HKMA	Factor
HKD interest rate (Time&Saving Deposit <100K)	Exchange Ra	HKMA	Factor
Loan to china	Banking	HKMA	CL
Loans by economic sector	Banking	HKMA	CL



Datasets List

# 2.2, Data Cleaning

1, Introduction

3, Result

2, Methodology

4, Conclusion



			New applications received 貸款申請		New loans drawn down 新取用按揭貸款			New loans approved <sup>3</sup> 新批出按揭貸款 <sup>3</sup>										
			Number 宗數	Value 貸款額	Number 宗數	Value 貸款額	Number 宗數	Number (M-o-M) (No.)	% change (按月變動)	(HK\$ Mn) (百萬港元)	% change (按月變動)	(M-o-M) (No.)	% change (按月變動)	(HK\$ Mn) (百萬港元)	% change (按月變動)	(M-o-M) (No.)	% change (按月變動)	
2016	December	十二月	10,505	-26.0%	29,556	11.7%	8,323	7.2%	32,470	-15.7%	8,961	-16.0%						
2017	January	一月	10,022	-4.6%	25,439	-13.9%	7,027	-15.6%	28,730	-11.5%	7,818							
	February	二月	10,013	-0.1%	21,675	-14.8%	6,204	-11.7%	28,114	-2.1%	7,554							
	March	三月	15,667	56.5%	25,344	16.9%	7,004	12.9%	37,650	33.9%	10,123							
	April	四月	13,095	-16.4%	21,631	-14.7%	5,996	-14.4%	32,526	-13.6%	8,343						-17.0%	
	May	五月	14,906	13.8%	29,355	35.7%	7,909	31.9%	42,354	30.2%	11,038	32.3%						
	June	六月	14,876	-0.2%	32,899	12.1%	8,850	11.9%	44,984	6.2%	11,737	6.3%						
	July	七月	9,191	-38.2%	33,137	0.7%	8,639	-2.4%	34,570	-23.2%	9,093	-22.5%						
	August	八月	11,036	20.1%	28,877	-12.9%	7,776	-10.0%	30,631	-11.4%	8,159	-10.3%						
	September	九月	11,484	4.1%	28,550	-1.1%	7,375	-5.2%	30,105	-1.7%	7,894	-3.2%						
	October	十月	11,382	-0.9%	22,087	-22.6%	6,076	-17.6%	29,575	-1.8%	7,970	1.0%						
	November	十一月	12,369	8.7%	26,797	21.3%	7,094	16.8%	36,394	23.1%	9,491	19.1%						
	December	十二月	10,655	-13.9%	23,657	-11.7%	6,434	-9.3%	28,382	-22.0%	7,268	-23.4%						
2018	January	一月	14,334	34.5%	27,996	18.3%	7,197	11.0%	38,957	37.3%	9,916	36.4%						



T3.7

T3.7 (old)

Merge the current and old time series data

Map the values to numerical format

Handle the missing values and records

Normalize the data structure

Rename columns to be more descriptive and standardized

## 2.2, Data Cleaning

1, Introduction

3, Result

2, Methodology

4, Conclusion



IDX	Year	Month	Quarter	Applications	Approved Nu	Approved Val
2	1996	06	2		9280	1462
3	1996	07	3		11873	1765
4	1996	08	3		9039	13397
5	1996	09	3		8220	11673
	1996	10	4		10578	15499
	1996	11	4		11180	16807
8	1996	12	4		12861	19544
9	1997	01	1		13014	20626
10	1997	02	1		10260	18799
11	1997	03	1		9659	16797
12	1997	04	2		12837	22713
13	1997	05	2		13662	26047
14	1997	06	2		13561	25529
15	1997	07	3		16716	32495
16	1997	08	3		11712	24917
17	1997	09	3		11928	25452
18	1997	10	4		9144	17865

Mapped the values  
to numerical format

Merged the current and  
old time series data

Handled the missing  
values and records

Normalized the  
data structure

Renamed columns to  
be more descriptive  
and standardized

# 2.3, Data Transformation

1, Introduction

3, Result

2, Methodology

4, Conclusion



Filtered the starting time

Joined different area datasets by year and month

Computed useful information by raw data

year_quarter	HIBOR 3-month	HKD Deposits	Deposits Rate 3-month	Unemployment Rate	Applications Number	Approved Number	Approved Percentage
2000_Q1	5.982534	1.760344e+06	4.580000	5.5	NaN	7287.333333	NaN
2000_Q2	6.700764	1.757144e+06	5.380000	5.0	NaN	7043.333333	NaN
2000_Q3	6.244596	1.810556e+06	5.026667	4.9	NaN	7322.666667	NaN
2000_Q4	6.060968	1.836674e+06	4.913333	4.4	NaN	6126.333333	NaN
2001_Q1	5.156541	1.856363e+06	4.060000	4.4	NaN	5175.666667	NaN

Grouped by year and quarter

Aggregated the mean value of each group

# 2.4 Data Analysis, Visualization

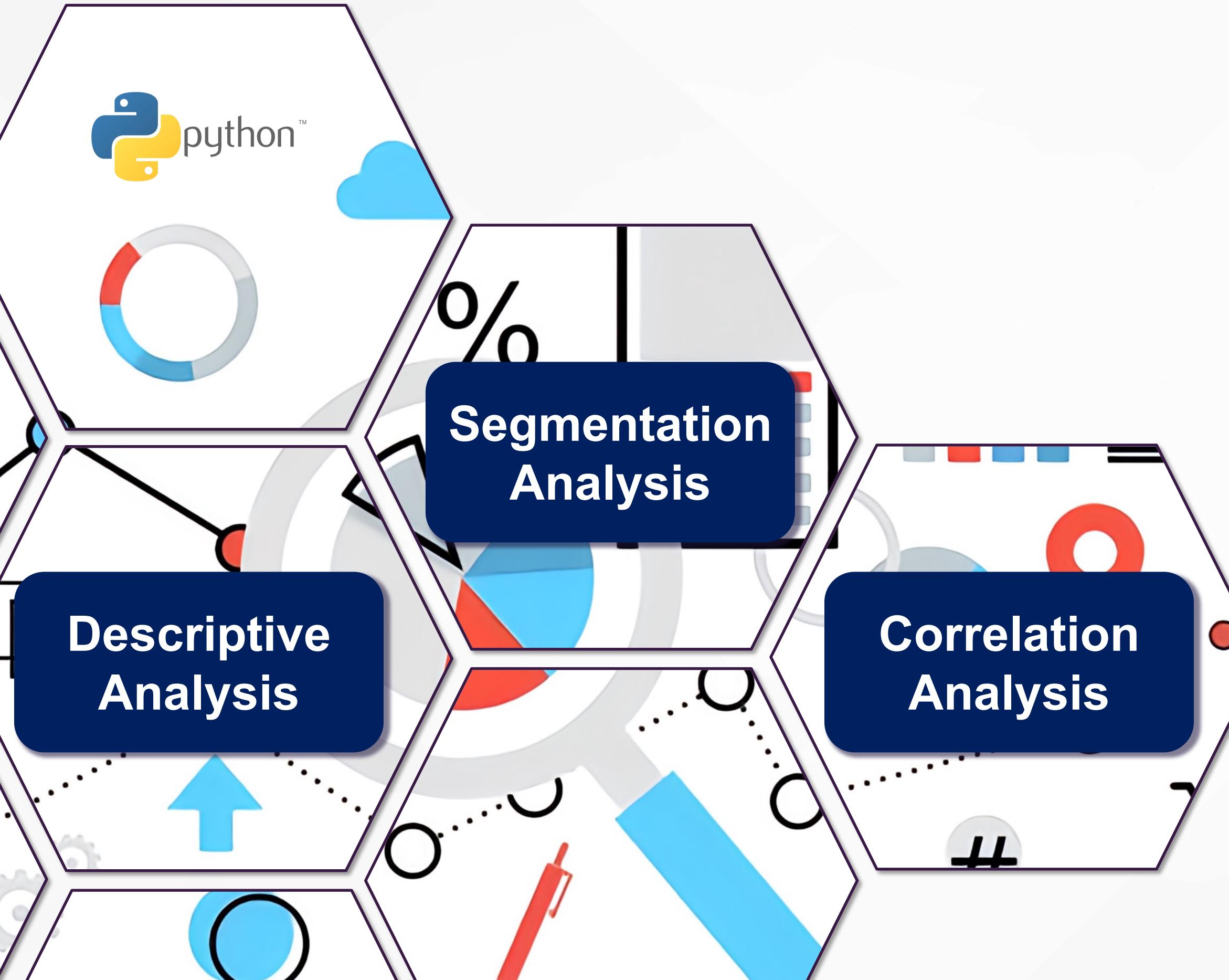
1, Introduction

2, Methodology



3, Result

4, Conclusion



## Analysis Tools

Python packages used

- Pandas
- Numpy
- Datetime
- Matplotlib
- Seaborn

## Visualization Methods

- Pie chart
- Bar chart
- Time Series plot
- Heatmap
- Regression plot

# 3.1 Outstanding Loans

[1, Introduction](#)

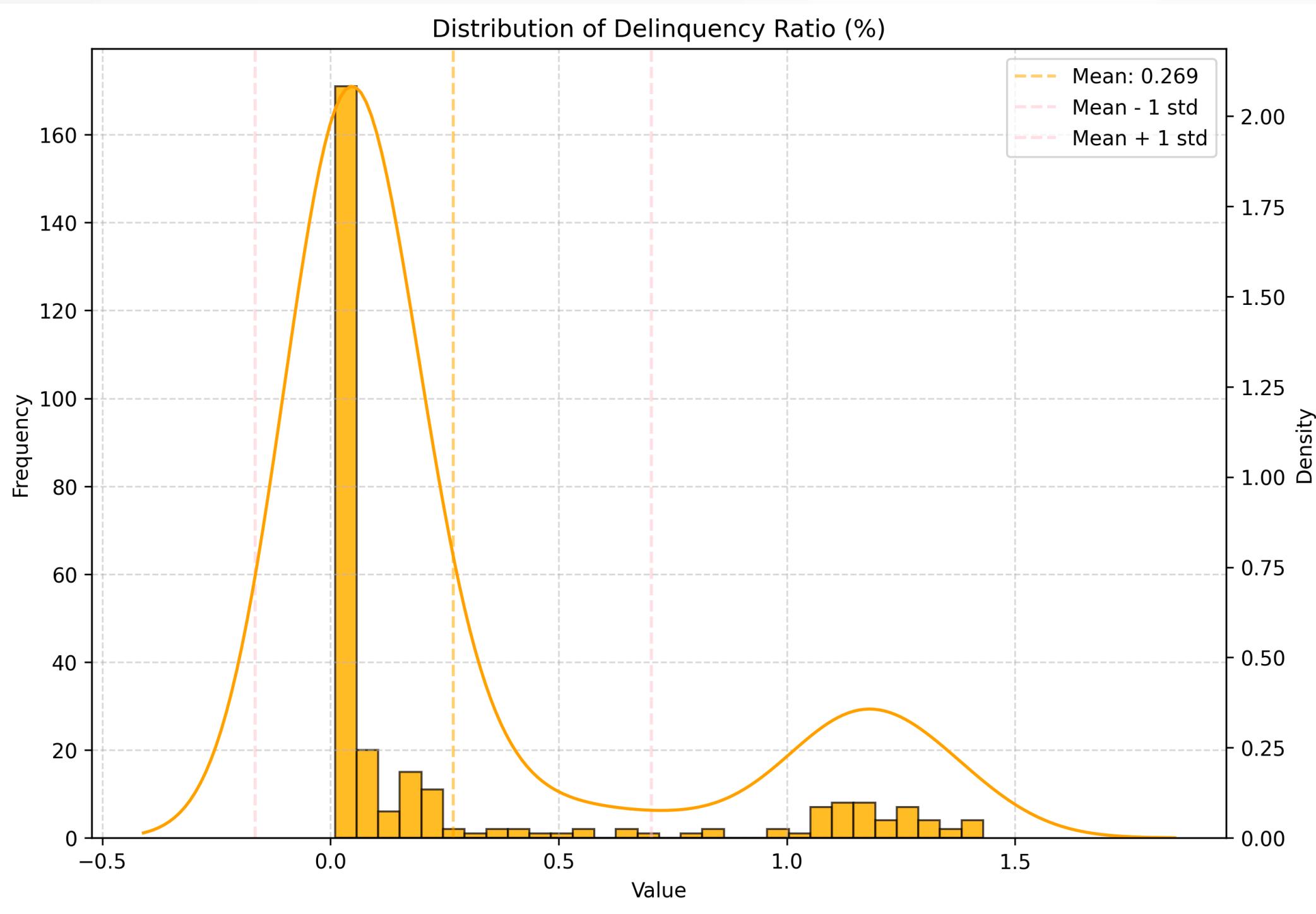
[3, Result](#)

[2, Methodology](#)

[4, Conclusion](#)



## Low delinquency and rescheduled ratio (3 month)



Metrics	Value
Count	287
Mean	0.27
Std.	0.43
Min.	0.01
Lower Quartile	0.02
Median	0.04
Upper Quartile	0.20
Maximum	1.43

The mean delinquency ratio is less than **0.3%**, among the 287 months (23years) data, indicating a low overall rate of delinquency.

# 3.1 Outstanding Loans

1, Introduction

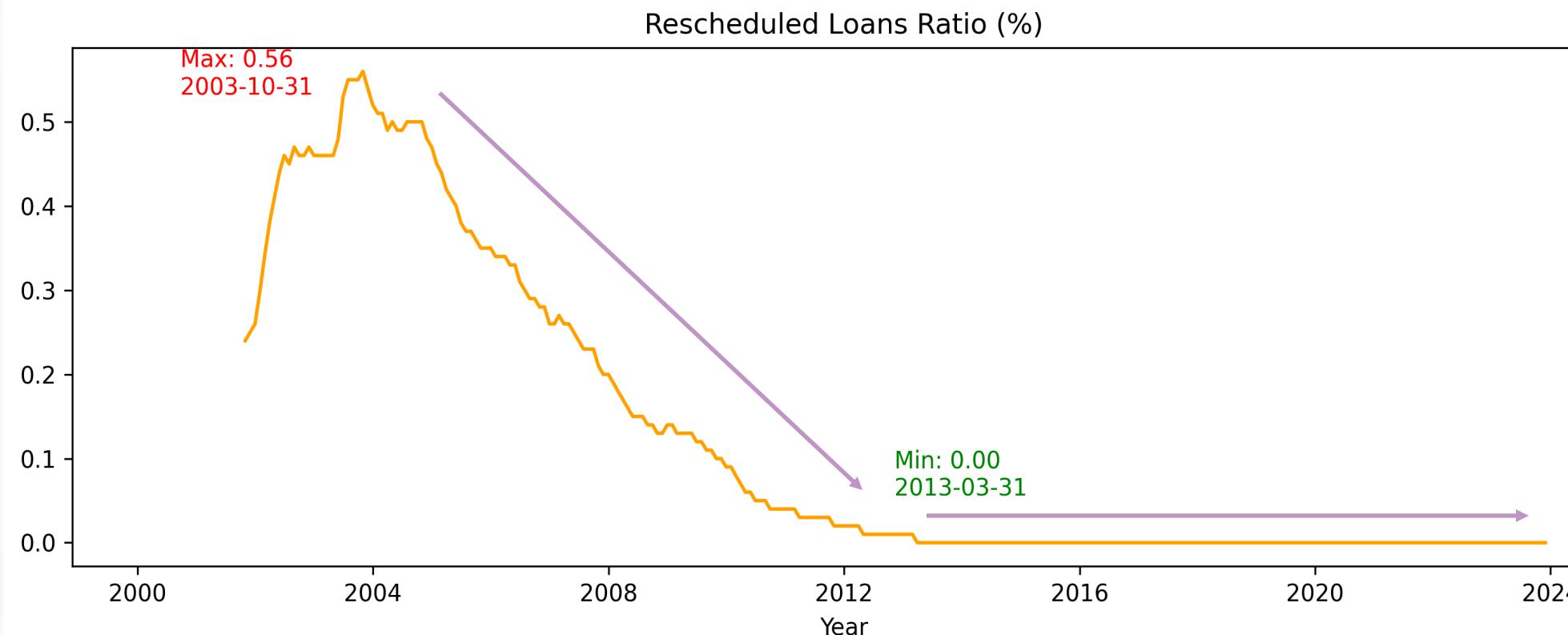
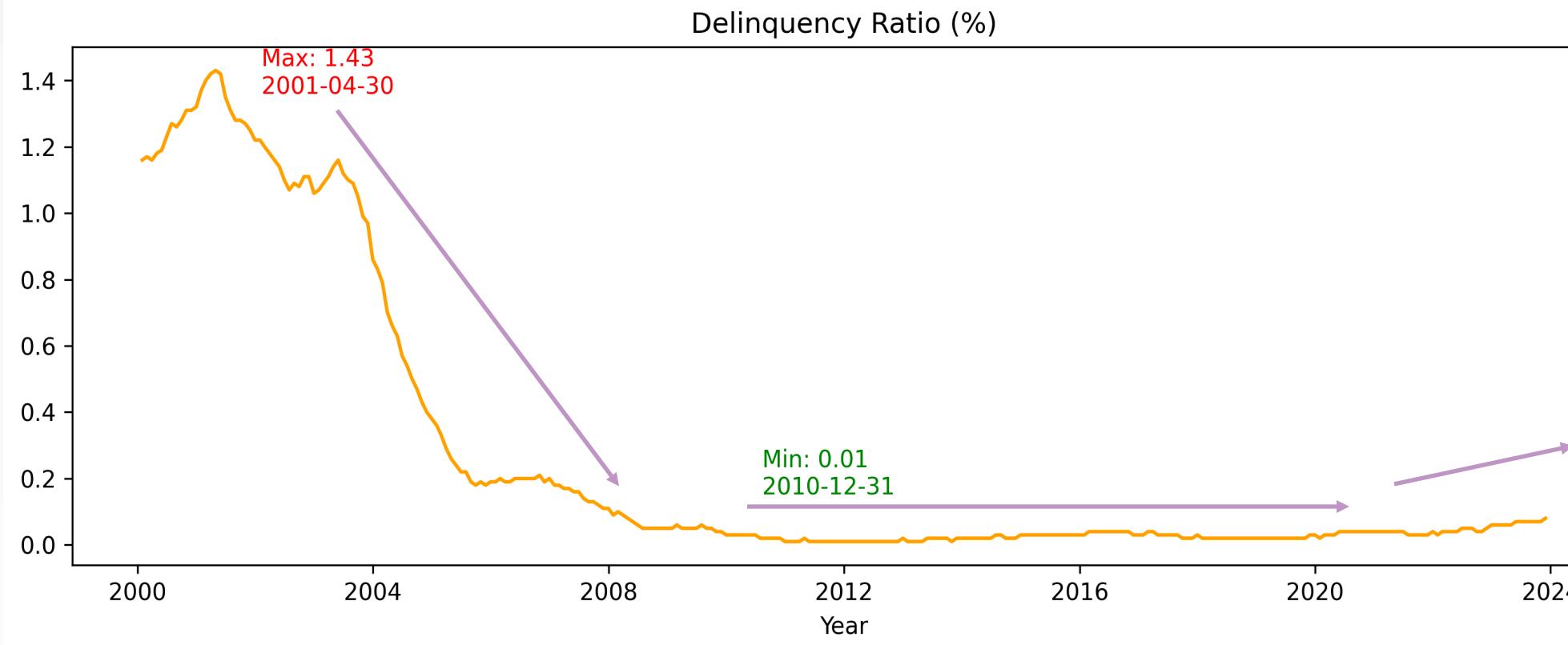
3, Result

2, Methodology

4, Conclusion



## Stable delinquency and rescheduled ratio (3 month)



- The delinquency ratio has consistently remained below **2%** over the 10-year period
- The rescheduled loan ratio has consistently remained below **0.01%** over the 10-year period
- However, the delinquency ratio has experienced a slight increase recently. It is consistently increasing from **0.03%** to **0.08%** start from year of 2022

# 3.1 Outstanding Loans

1, Introduction

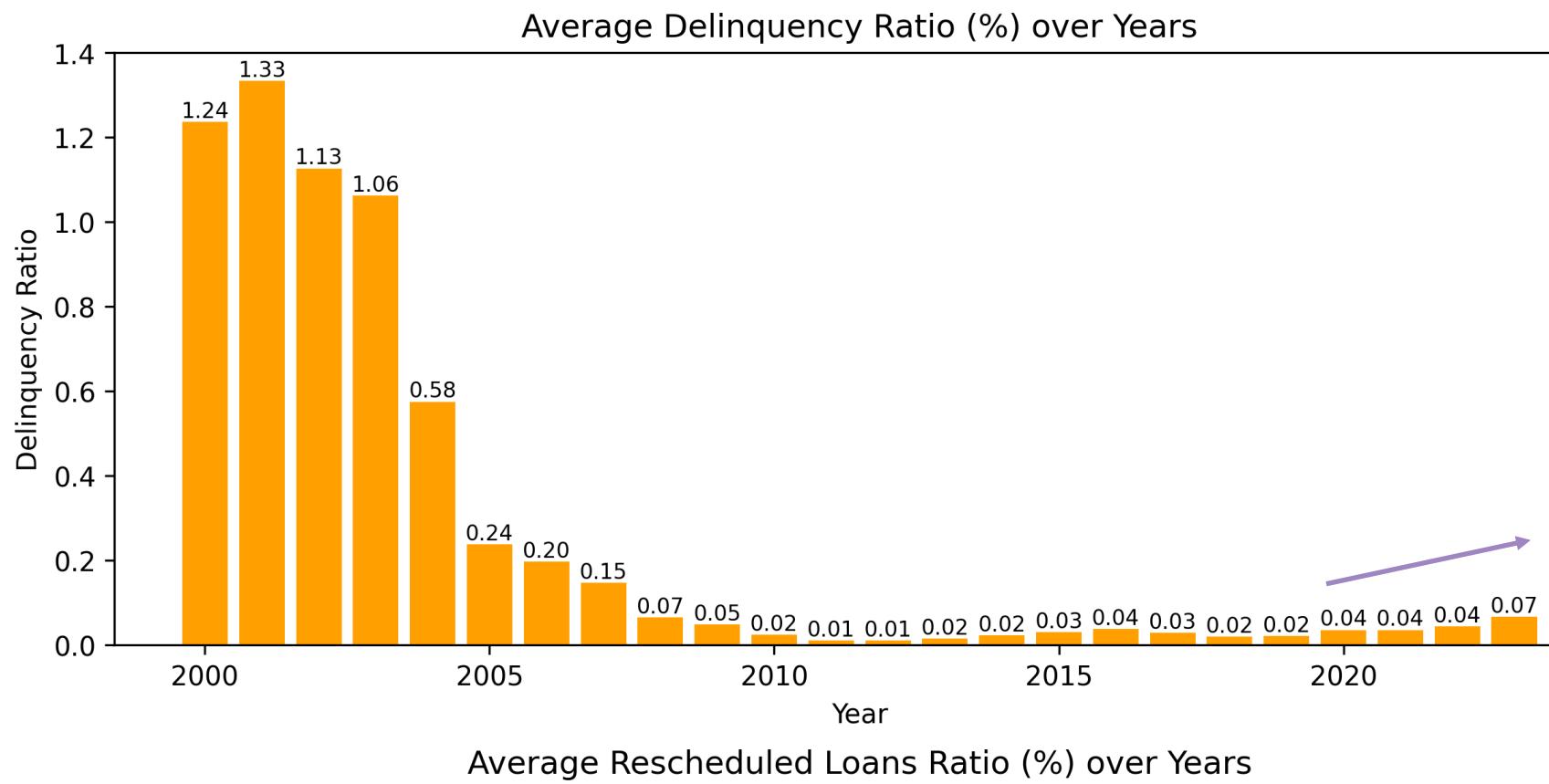
3, Result

2, Methodology

4, Conclusion



## Stable delinquency and rescheduled ratio (3 month)



**Strong financial health and stability among borrowers**

Borrowers are generally able to meet their debt obligations on time

**Efficient risk management by lenders**

Lenders are making efficient lending decisions and maintaining rigorous credit assessments

- Following cap LTV, DSR with stress testing
- Considering collateral, guarantor

# 3.1 Outstanding Loans

[1, Introduction](#)

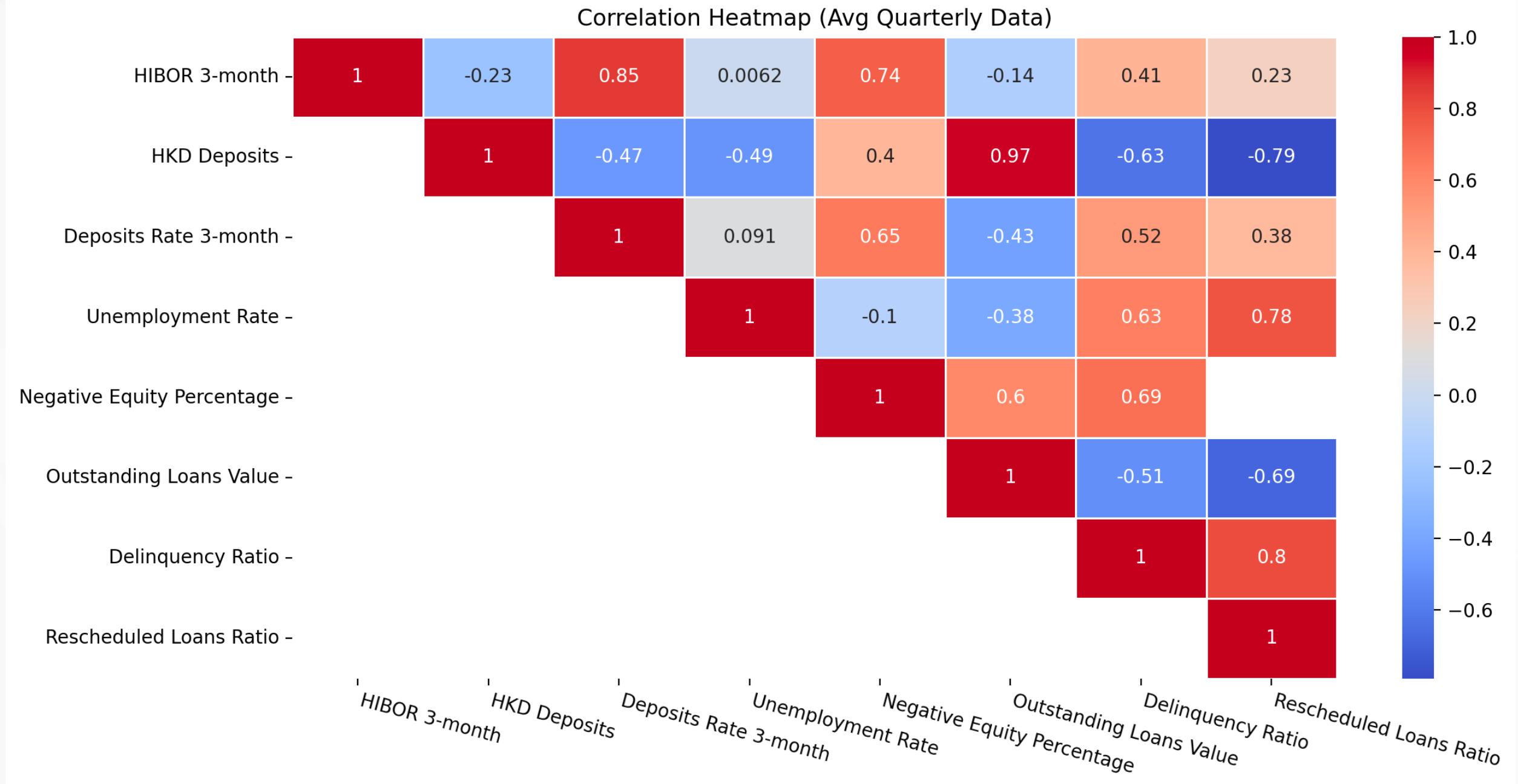
[3, Result](#)

[2, Methodology](#)

[4, Conclusion](#)



## Correlation Heatmap



# 3.1 Outstanding Loans

[1, Introduction](#)

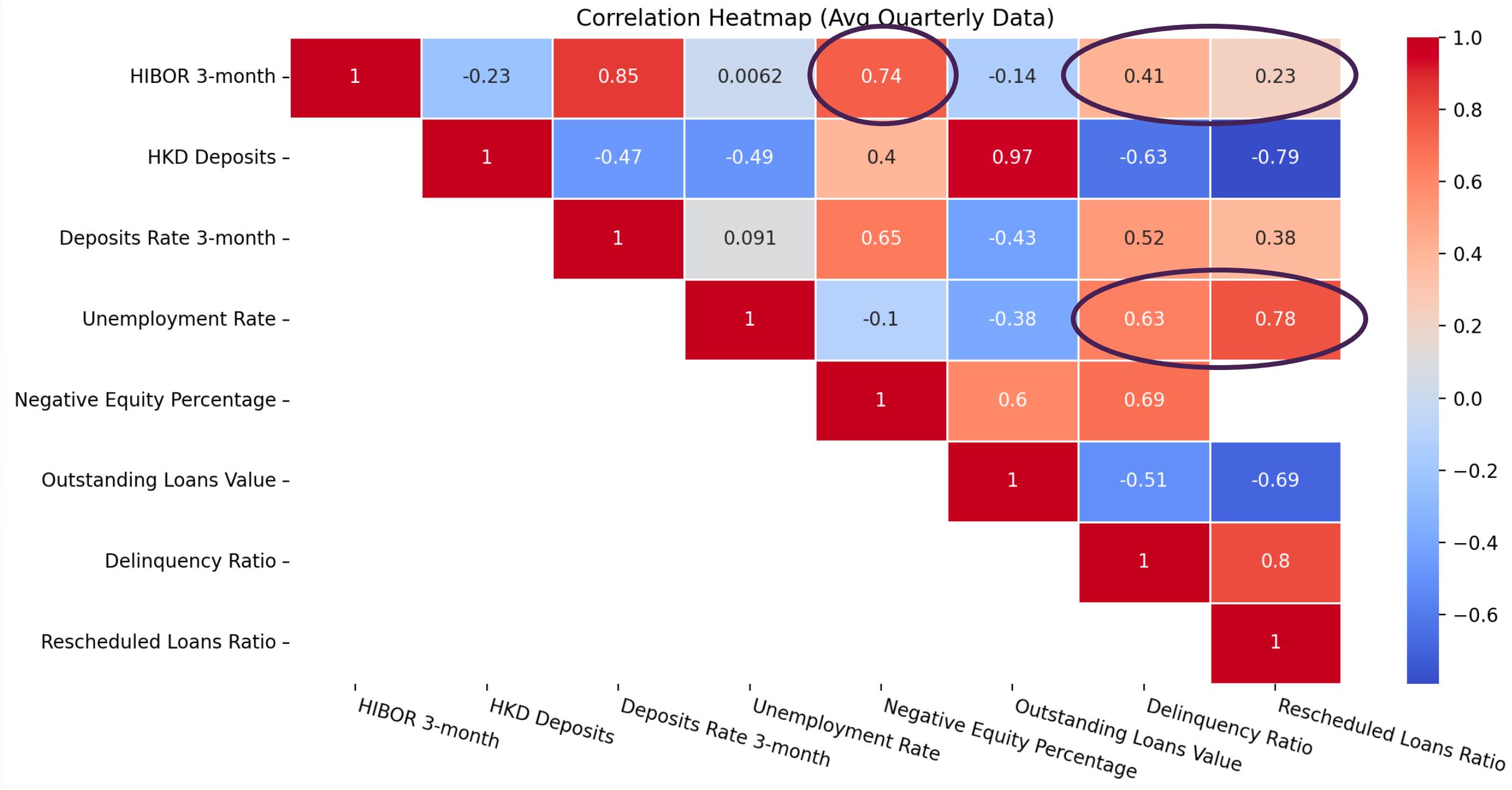
[3, Result](#)

[2, Methodology](#)

[4, Conclusion](#)



## Correlation Heatmap



# 3.1 Outstanding Loans

1, Introduction

3, Result

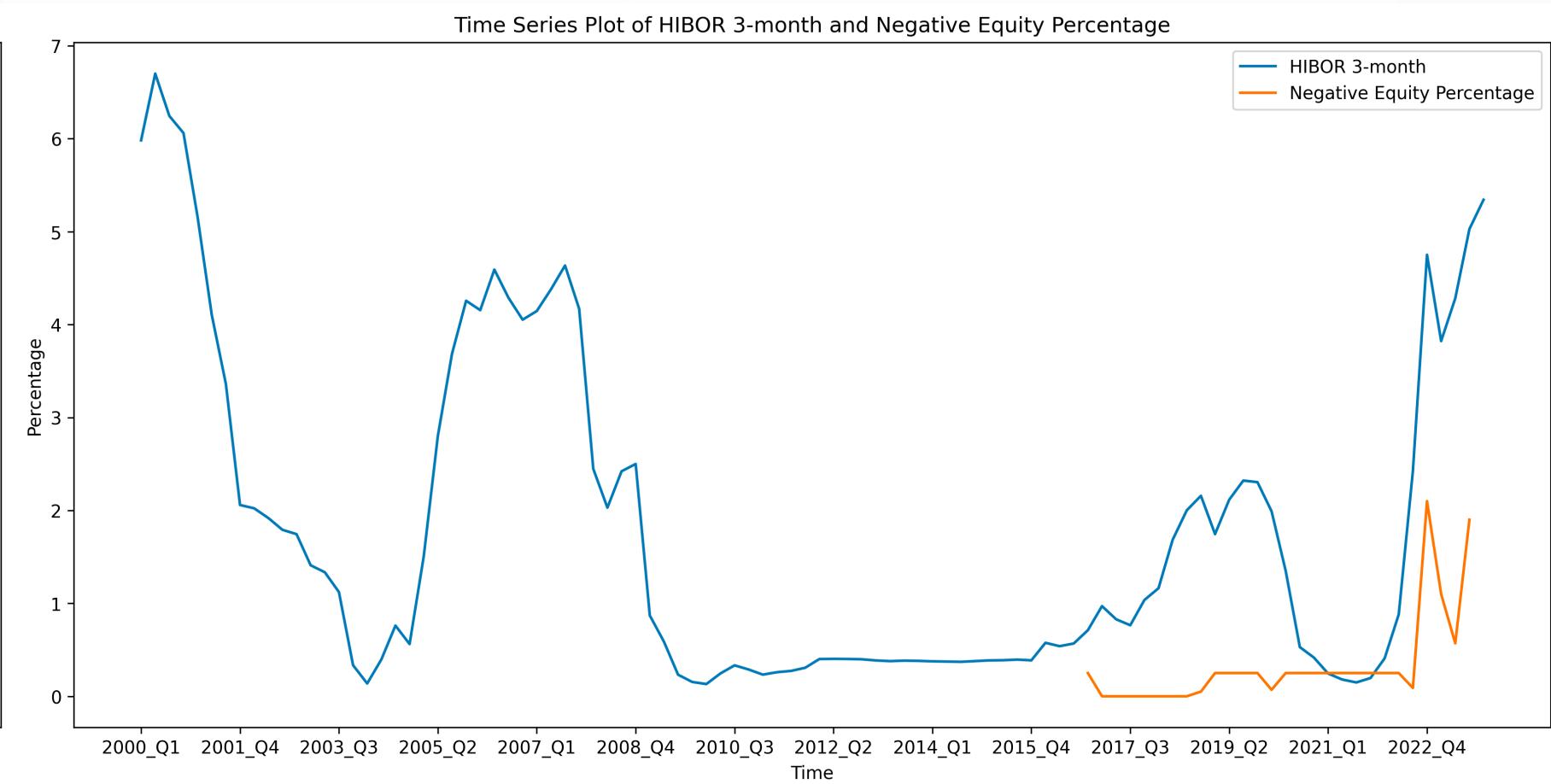
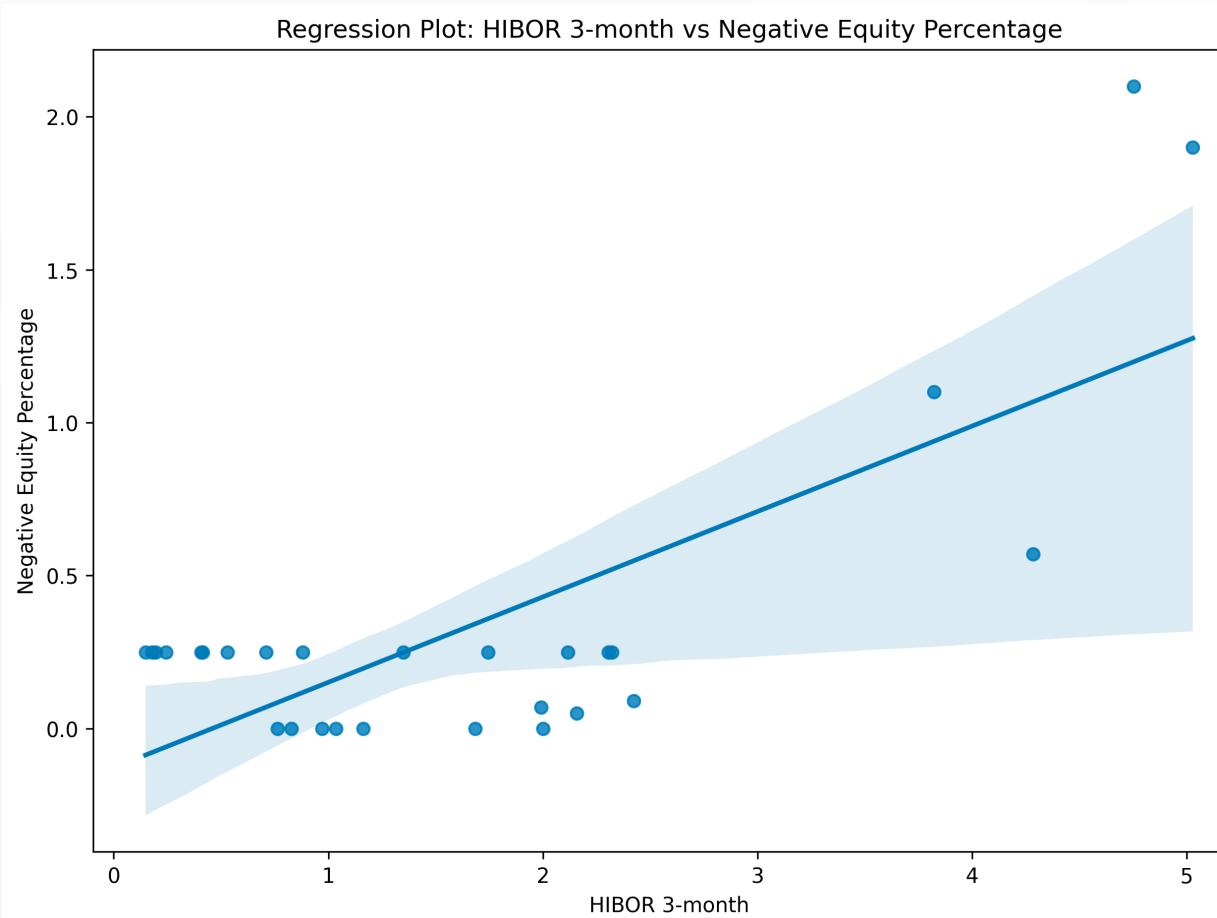
2, Methodology

4, Conclusion



## Negative Correlation between HIBOR and Negative Equity

- Correlation Coefficient: 0.74
- Floating mortgage rates link borrowers' repayment capacity to market rates
- Borrowers facing negative equity may have an incentive carry strategic default, leaving the lender with a **loss**
- **Lack of data samples**



# 3.1 Outstanding Loans

1, Introduction

3, Result

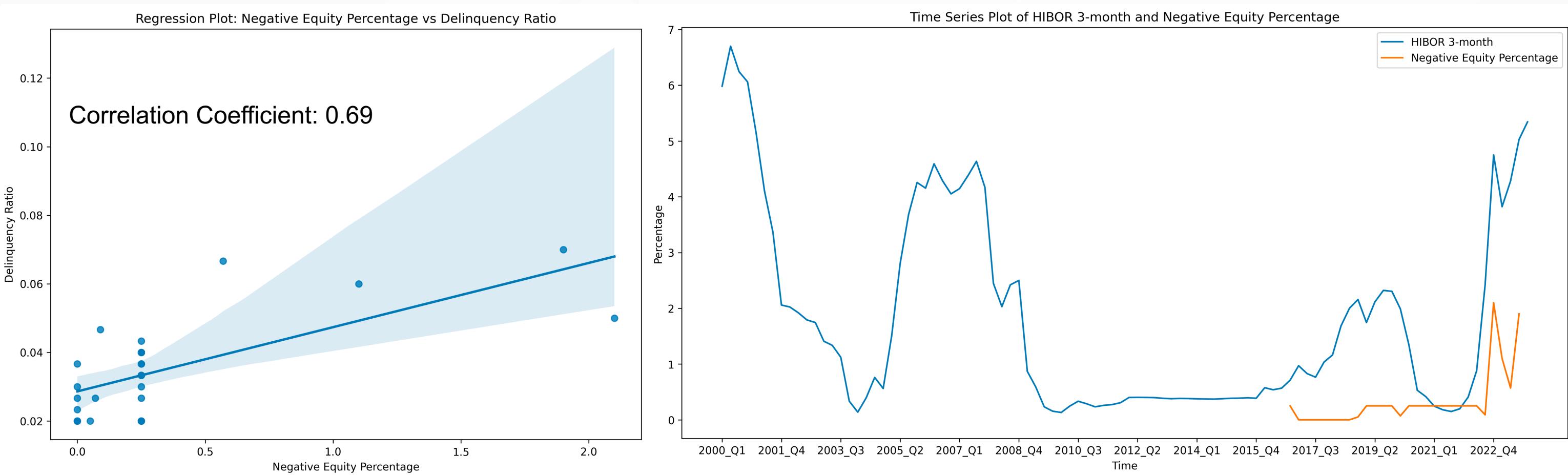
2, Methodology

4, Conclusion



## Negative Correlation between HIBOR and Negative Equity

- Correlation Coefficient: 0.74
- Floating mortgage rates link borrowers' repayment capacity to market rates
- Borrowers facing negative equity may have an incentive carry strategic default, leaving the lender with a **loss**
- **Lack of data samples**



# 3.1 Outstanding Loans

[1, Introduction](#)

[3, Result](#)

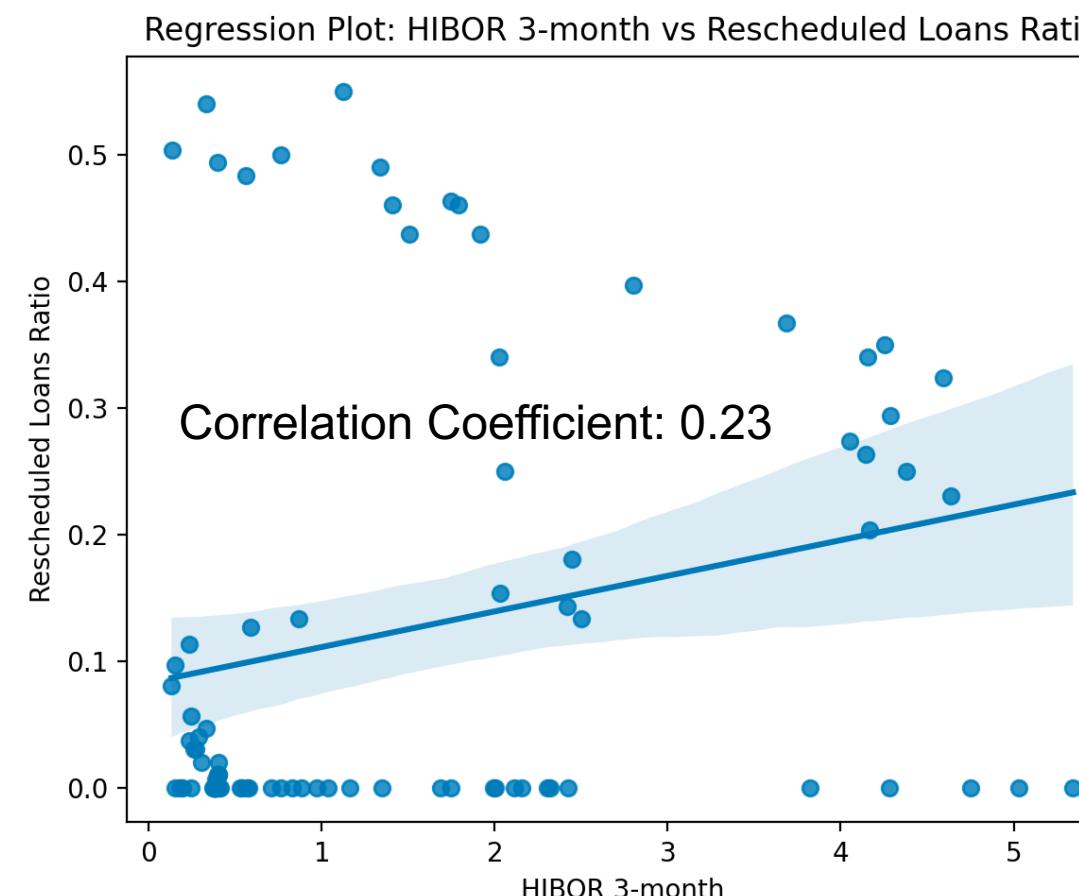
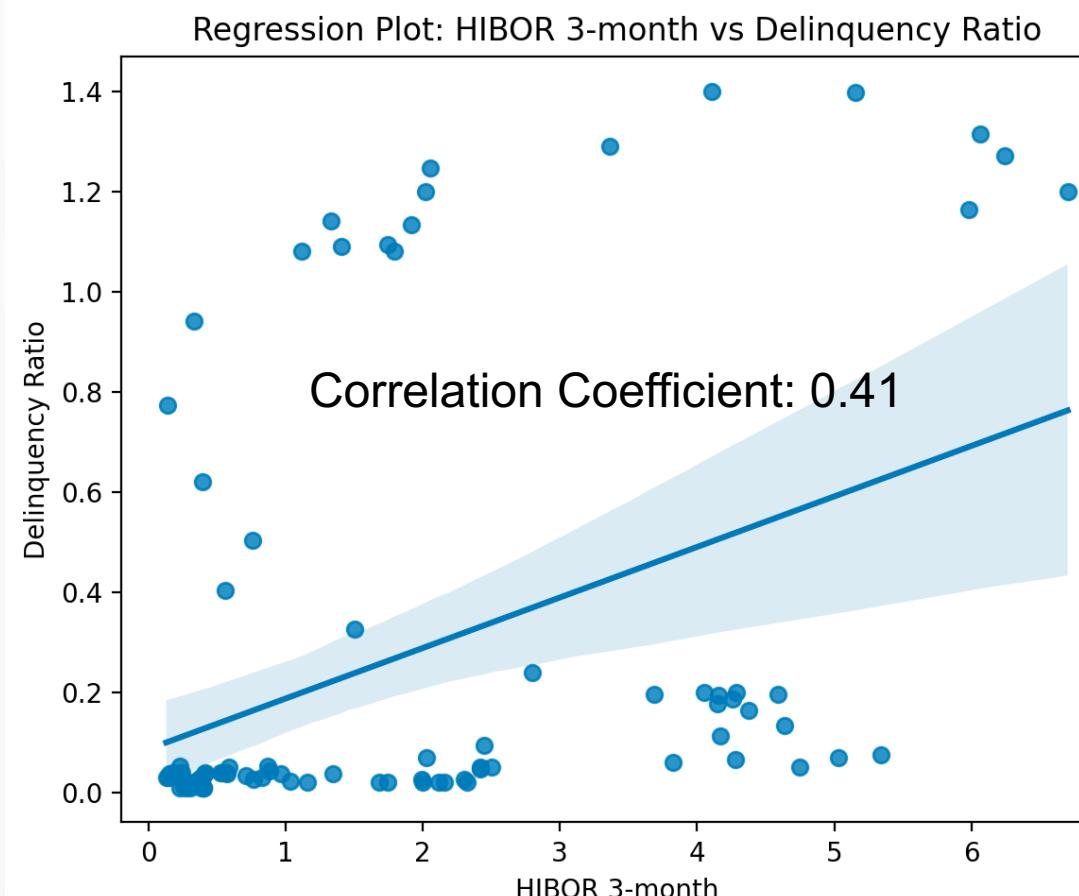
[2, Methodology](#)

[4, Conclusion](#)



## Positive Correlation between HIBOR and Delinquency & Rescheduled Loan Ratio

- When HIBOR rises suddenly, monthly loan payments for floating rate mortgages increase at the same time
- Borrowers may have budgeted their repayments based on stable or lower rates over time
- Those with loans close to their repayment capacity limits become vulnerable to rate rises, which pushing them into delinquency or need for rescheduling



# 3.1 Outstanding Loans

[1, Introduction](#)

[3, Result](#)

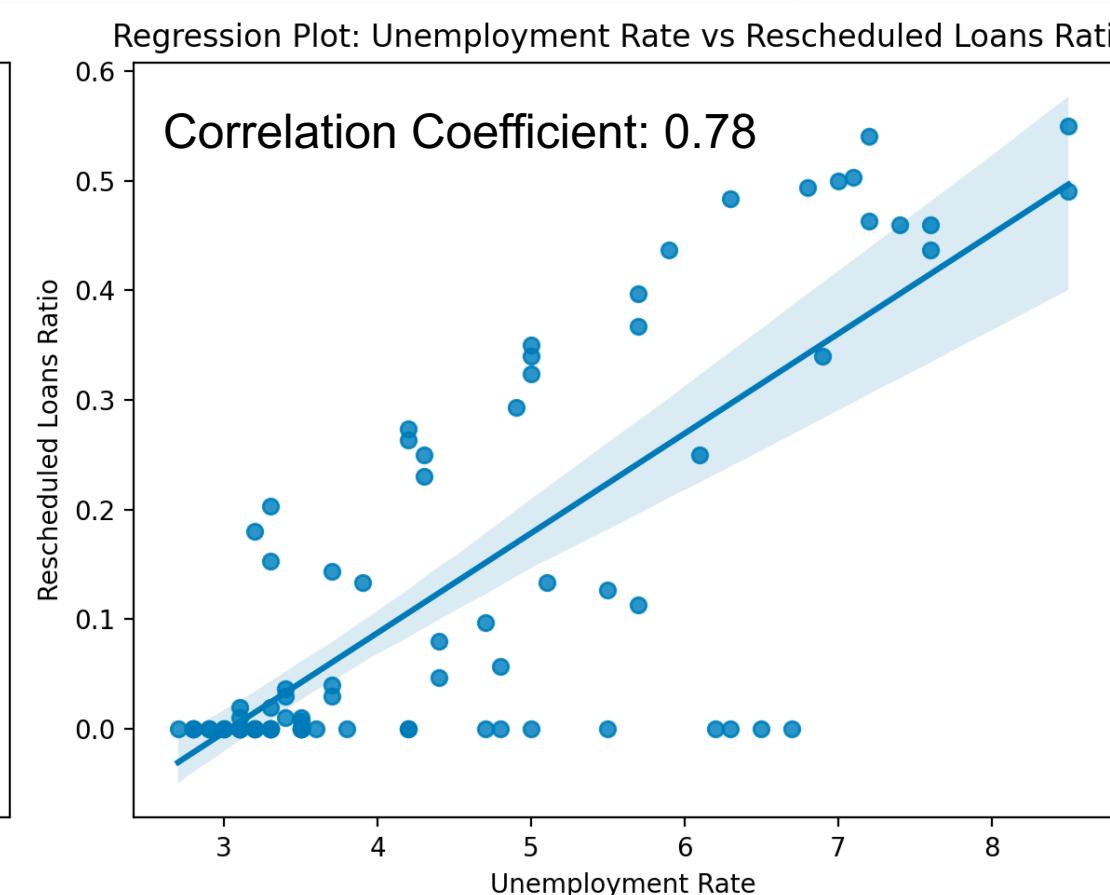
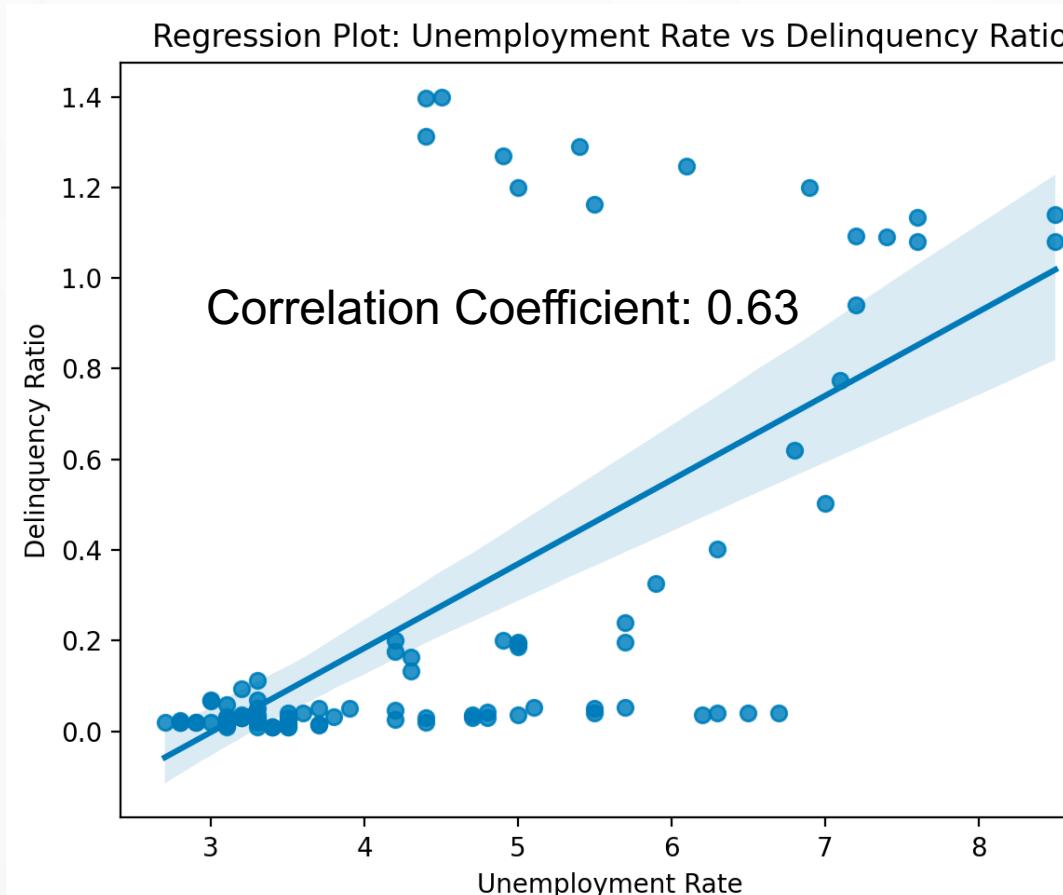
[2, Methodology](#)

[4, Conclusion](#)



## Positive Correlation between Unemployment Rate and Delinquency & Rescheduled Loan Ratio

- Job losses reduce household income and enlarge debt service ratio (DSR)
- Unemployed borrowers may exhaust savings quickly trying to service loans without income, which making it more challenging for borrowers to meet their coming debt obligations
- Unemployment Rate has no correlation between HIBOR



# 3.2 New Loans

1, Introduction

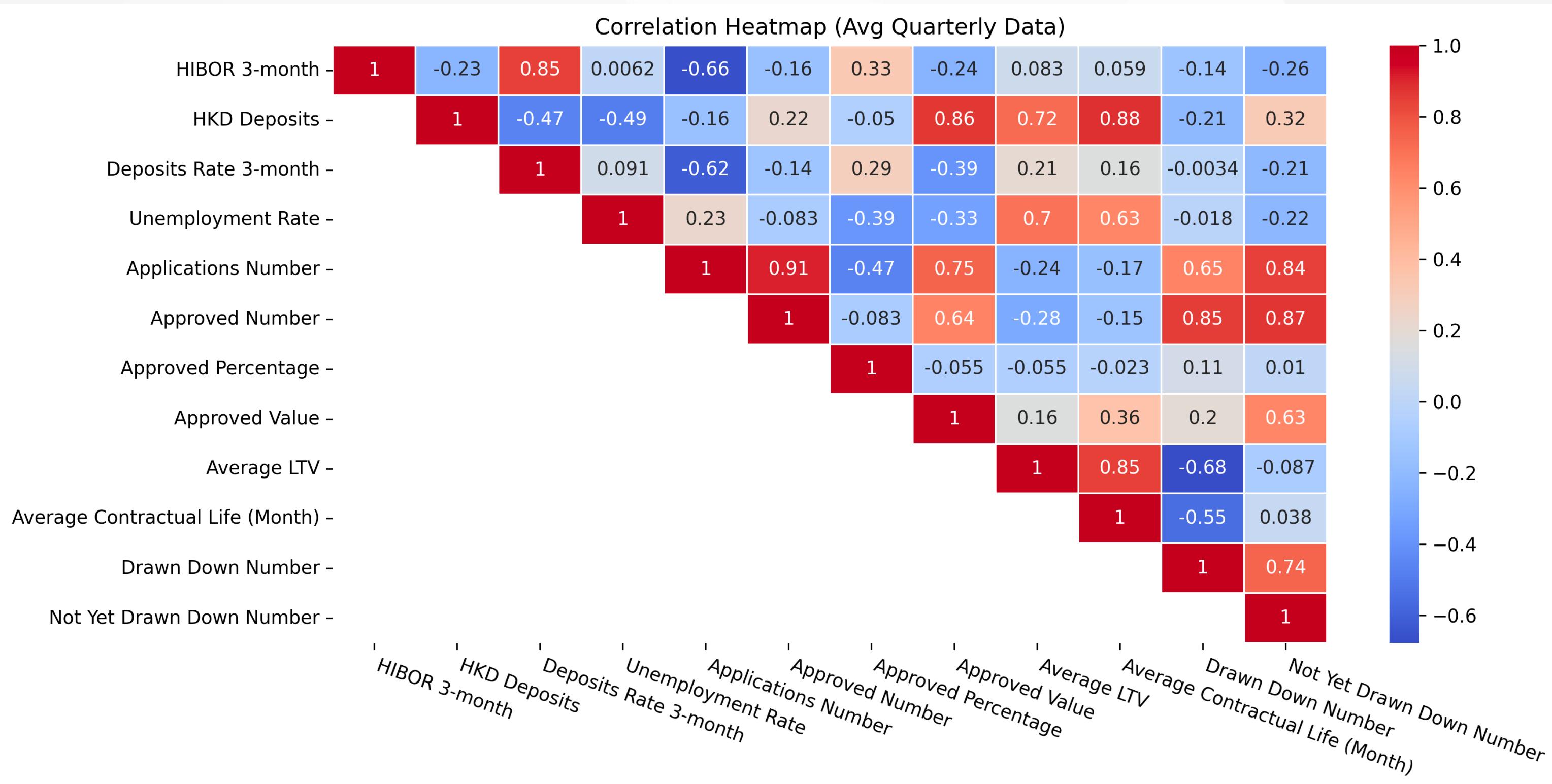
3, Result

2, Methodology

4, Conclusion



## Correlation Heatmap



# 3.2 New Loans

1, Introduction

3, Result

2, Methodology

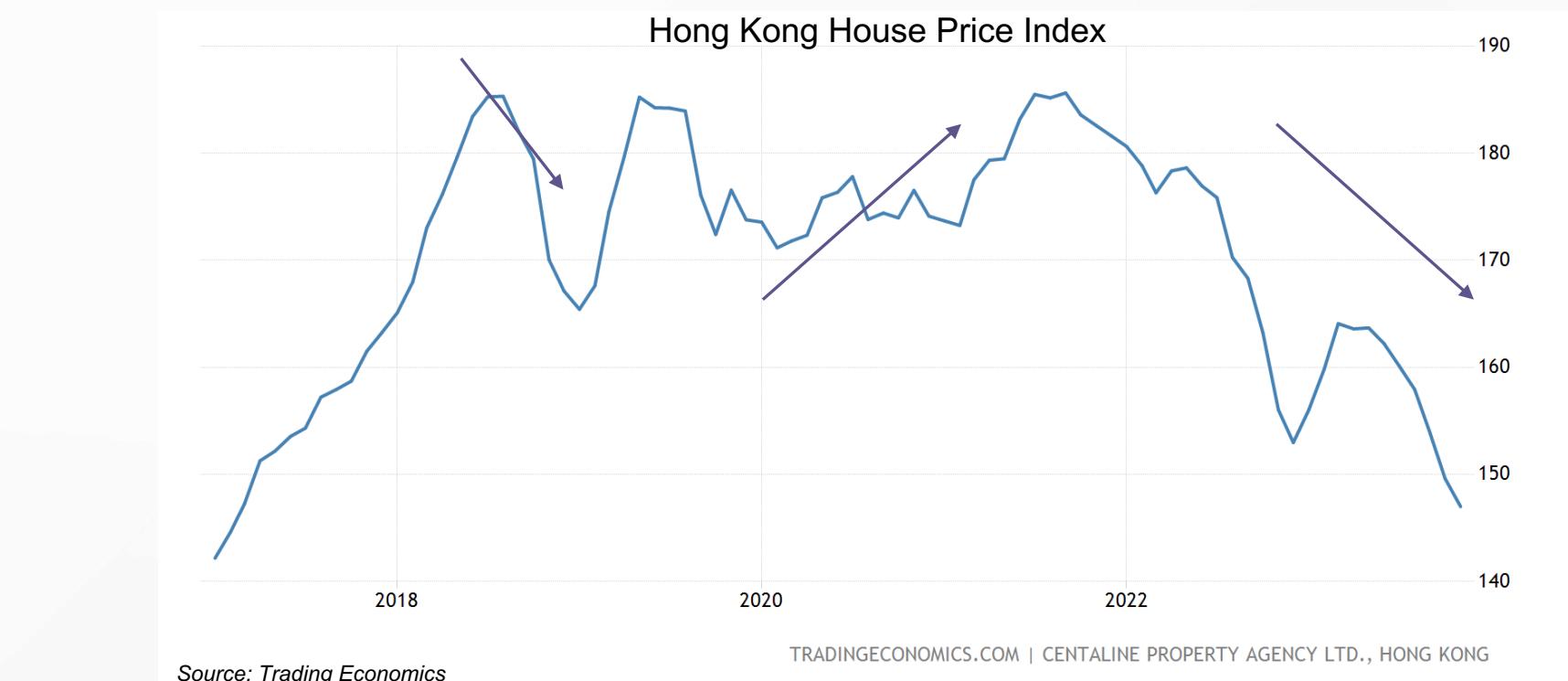
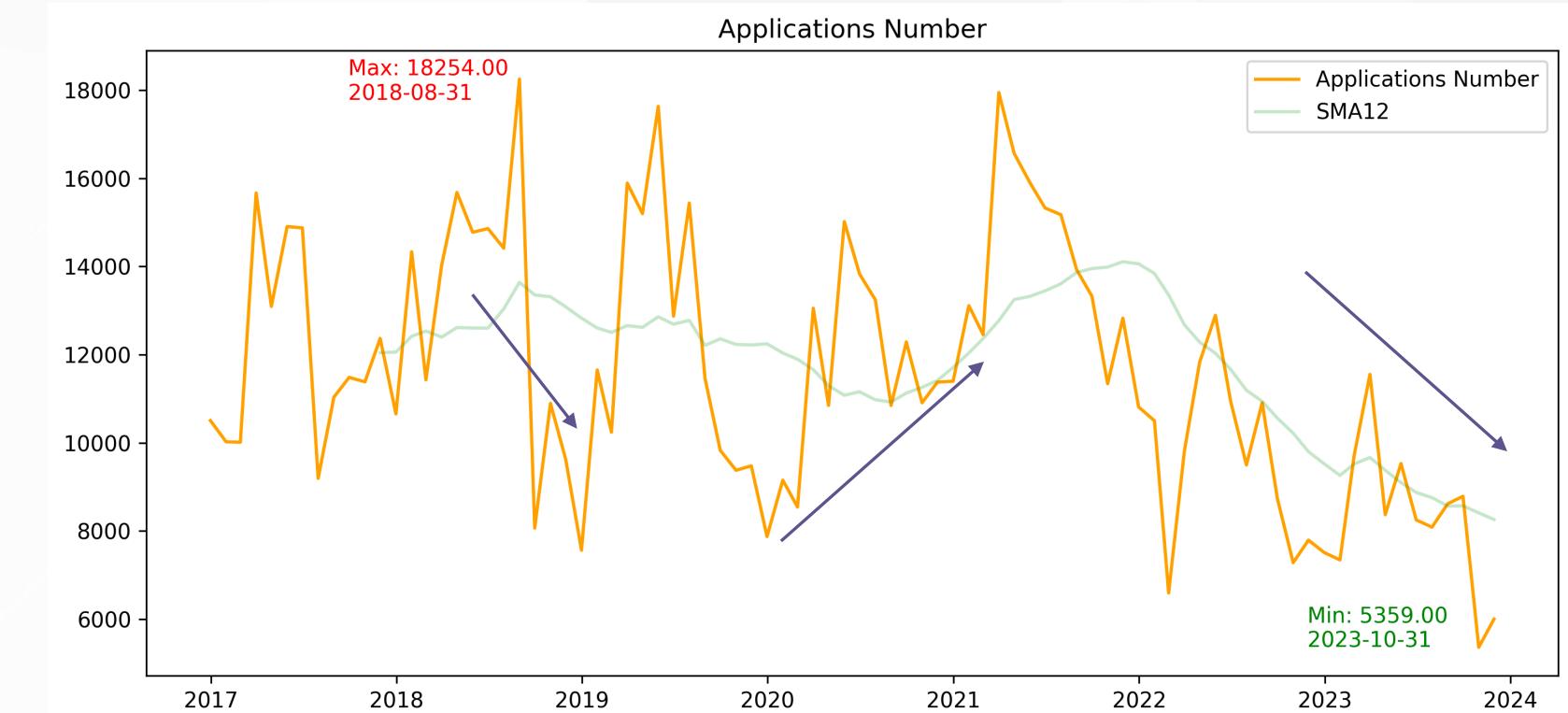
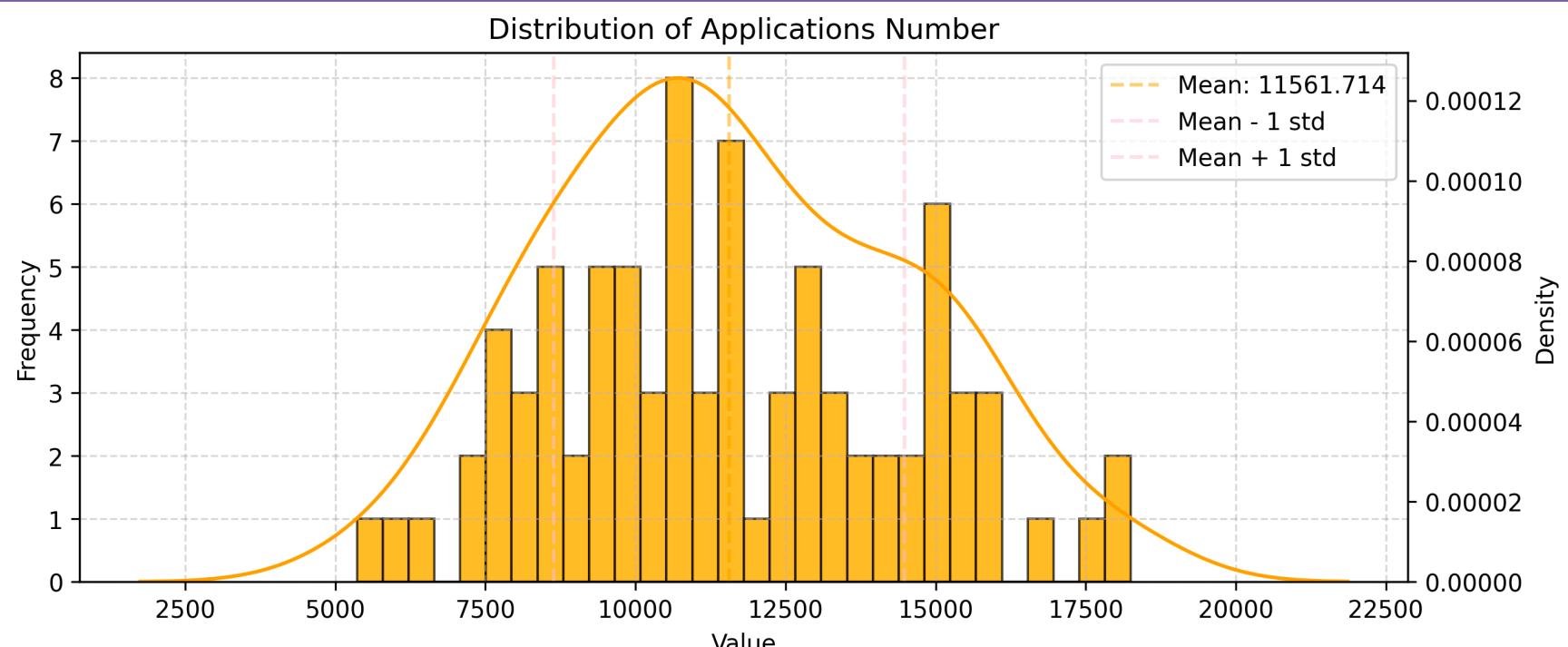
4, Conclusion



## Fluctuation of Application Number

- The mean application number is 11500 each month, and observed like **random** variable
- The RML application number is recently breaking a **new low**
- The RML application number is **positively correlated** to house price index, as higher demand leads to higher price

Count	Mean	Std.	Min.	Q1	Median	Q3	Max.
84	11562	2919	5259	9492	11357	13853	18254



## 3.2 New Loans

1, Introduction

3, Result

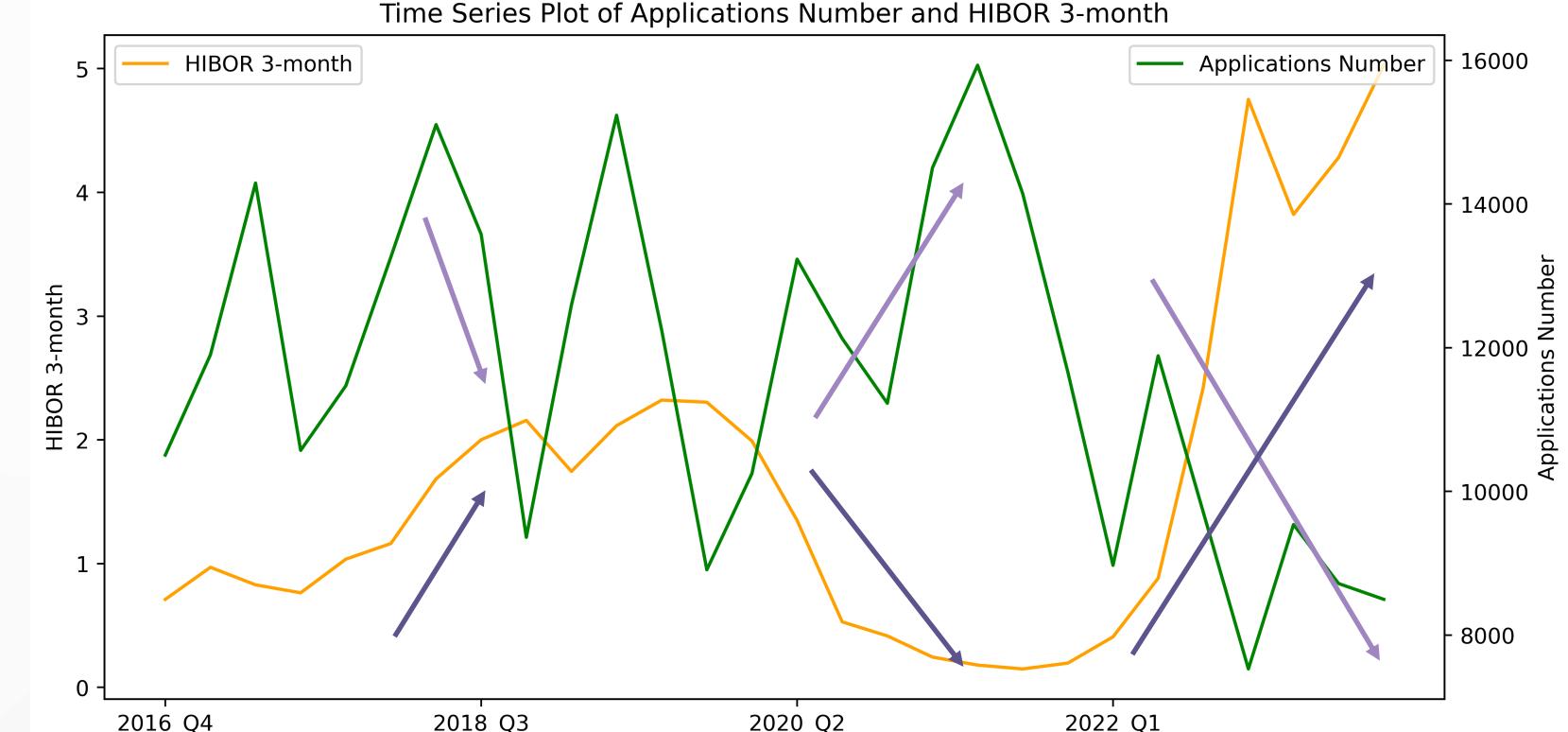
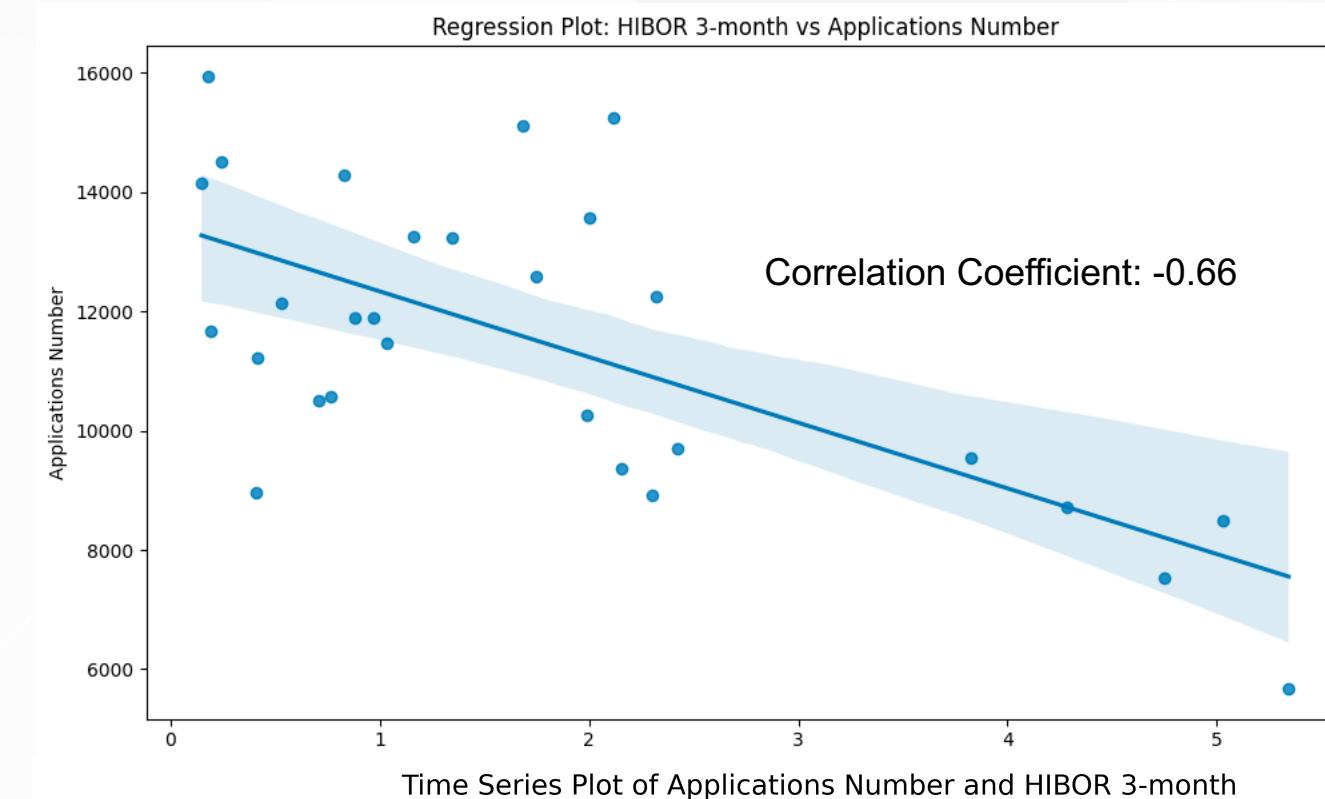
2, Methodology

4, Conclusion



### Negative Correlation between HIBOR and Application Number

- Many RML interest installment are floating rate linked to HIBOR
- When HIBOR rises, it causes mortgage interest rates and monthly repayments to also increase. **Higher borrowing costs** make it more expensive for new borrowers to apply for loans



# 3.2 New Loans

1, Introduction

3, Result

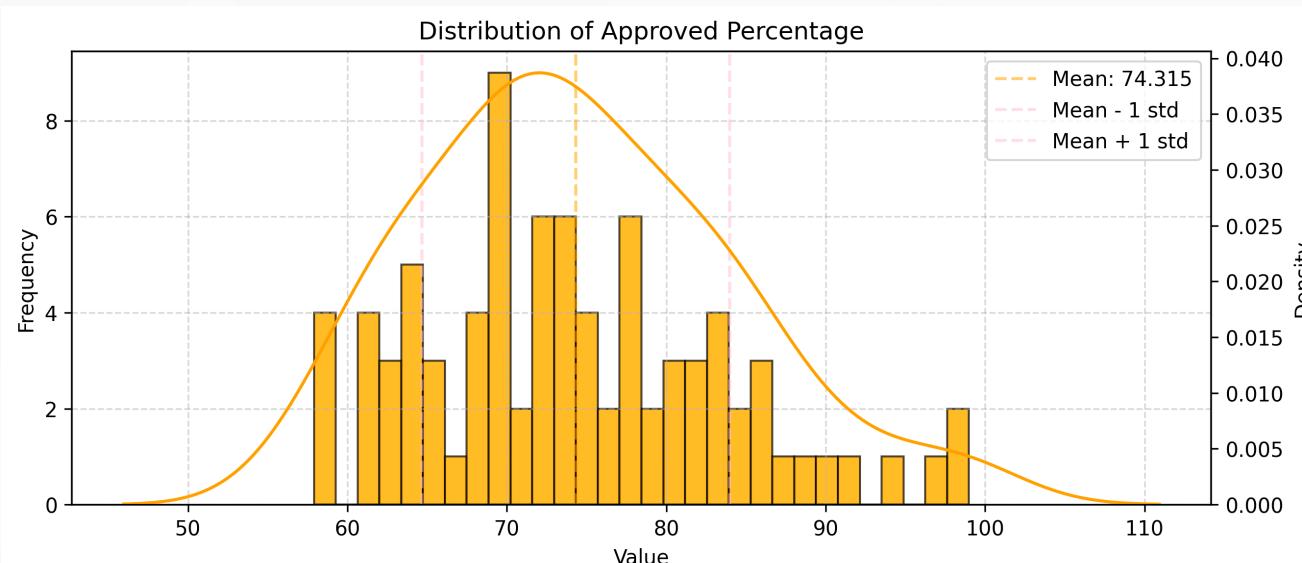
2, Methodology

4, Conclusion

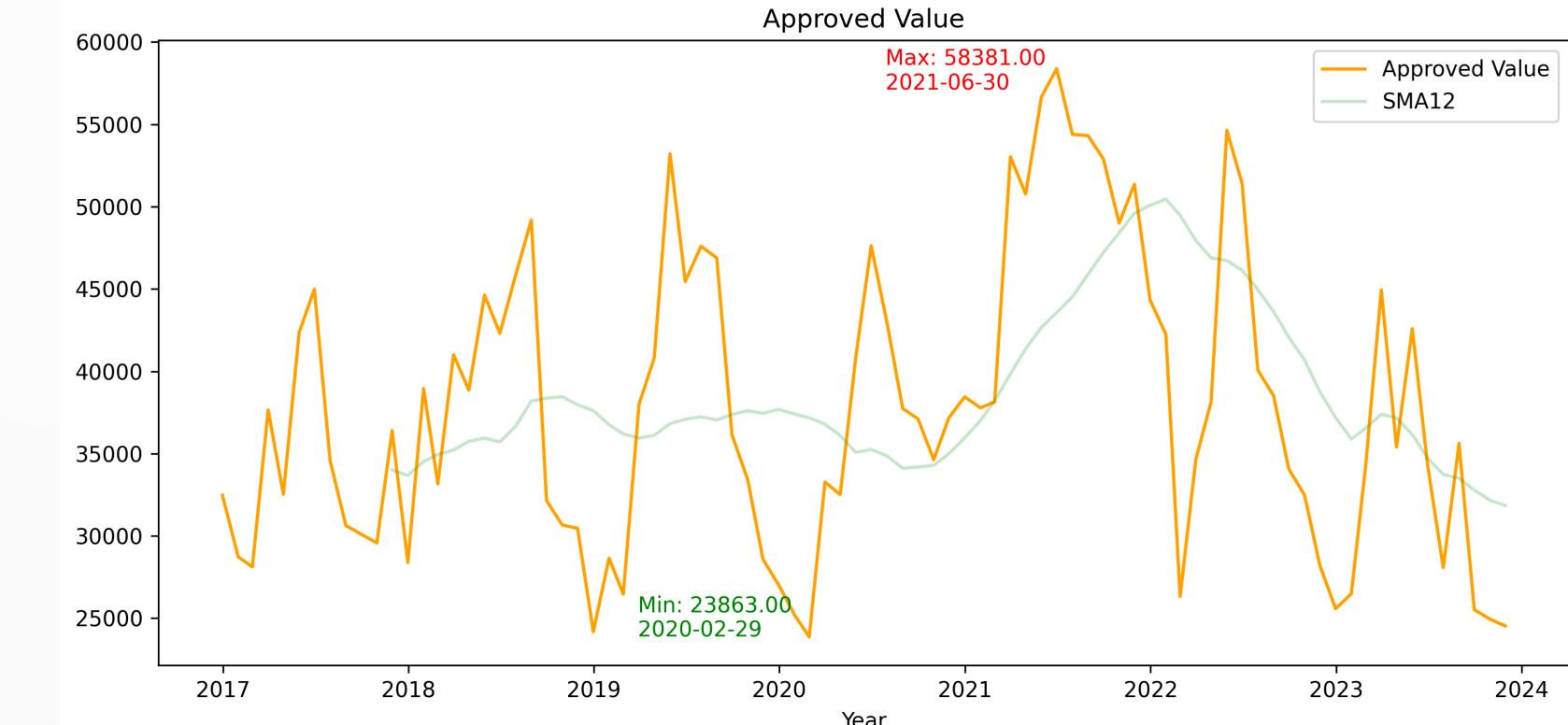
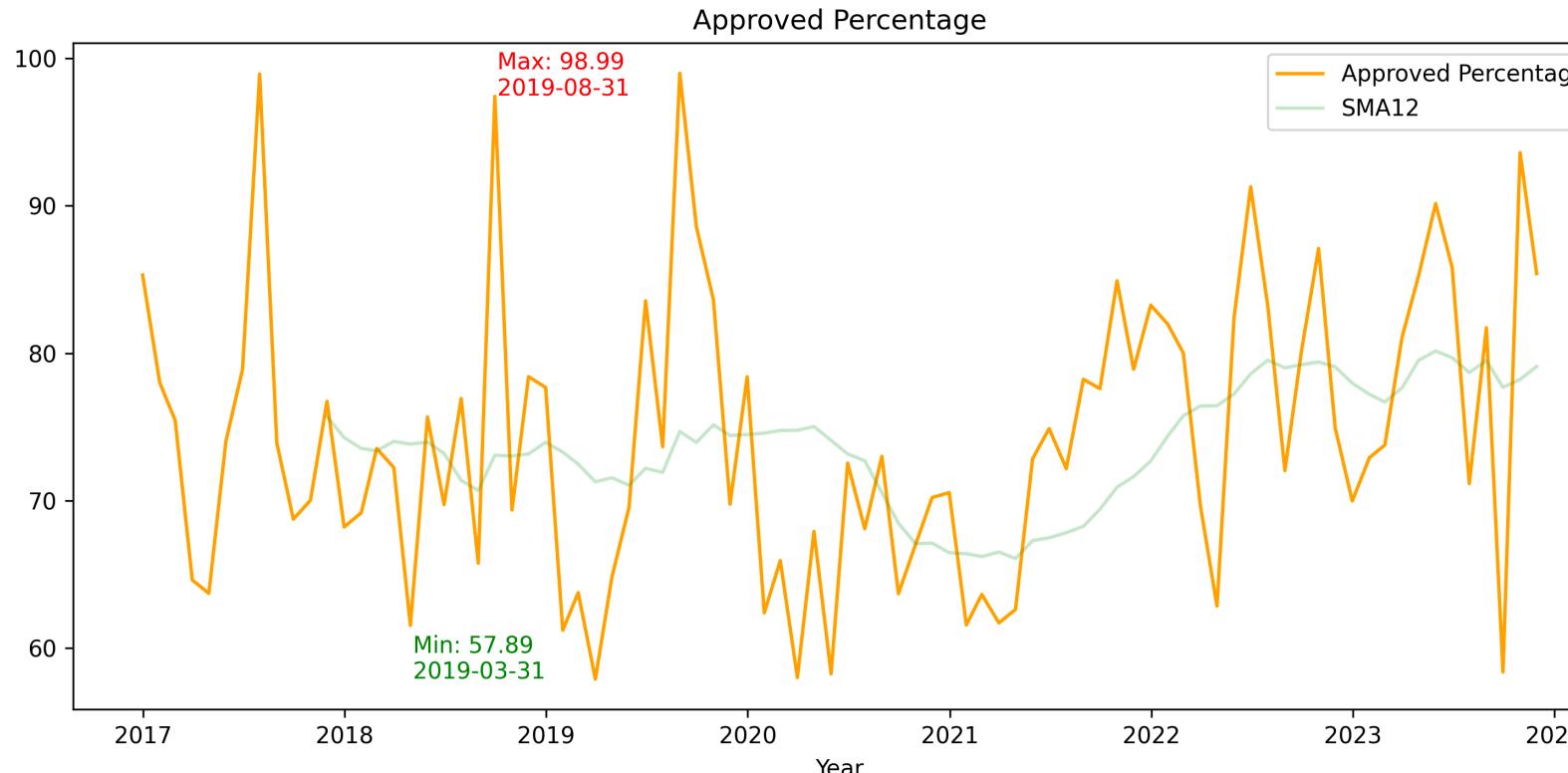
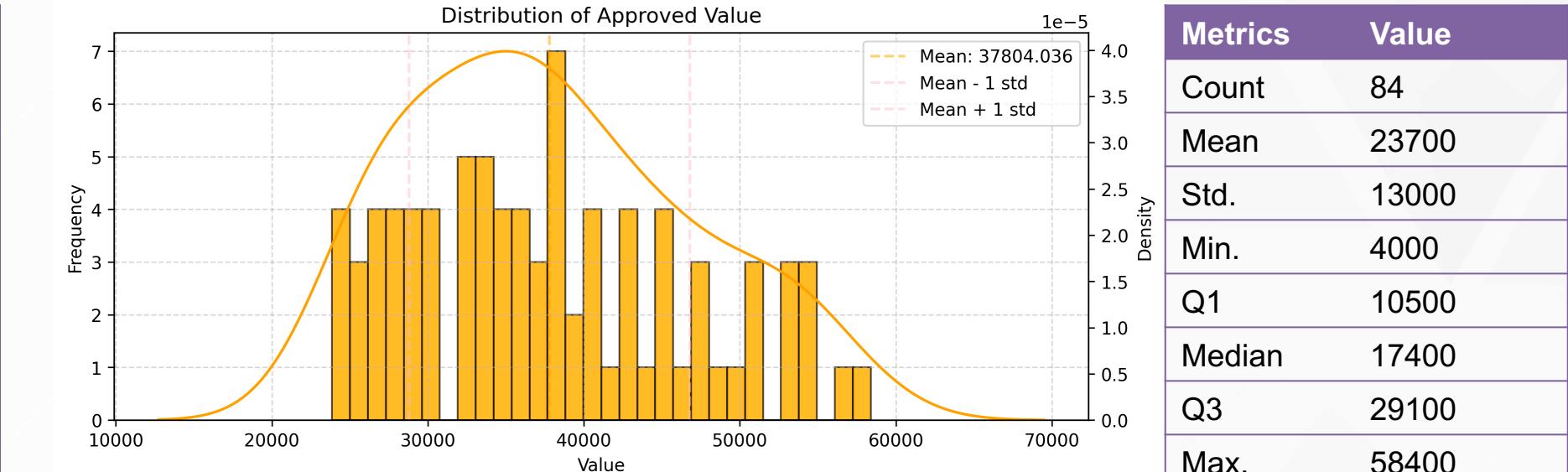


## Fluctuation of Approved Percentage

- The mean approved percentage is 74% each month, and observed like **random variable**



Metrics	Value
Count	84
Mean	74.3
Std.	9.7
Min.	57.9
Q1	68
Median	73.3
Q3	80.4
Max.	99



## 3.2 New Loans

1, Introduction

3, Result

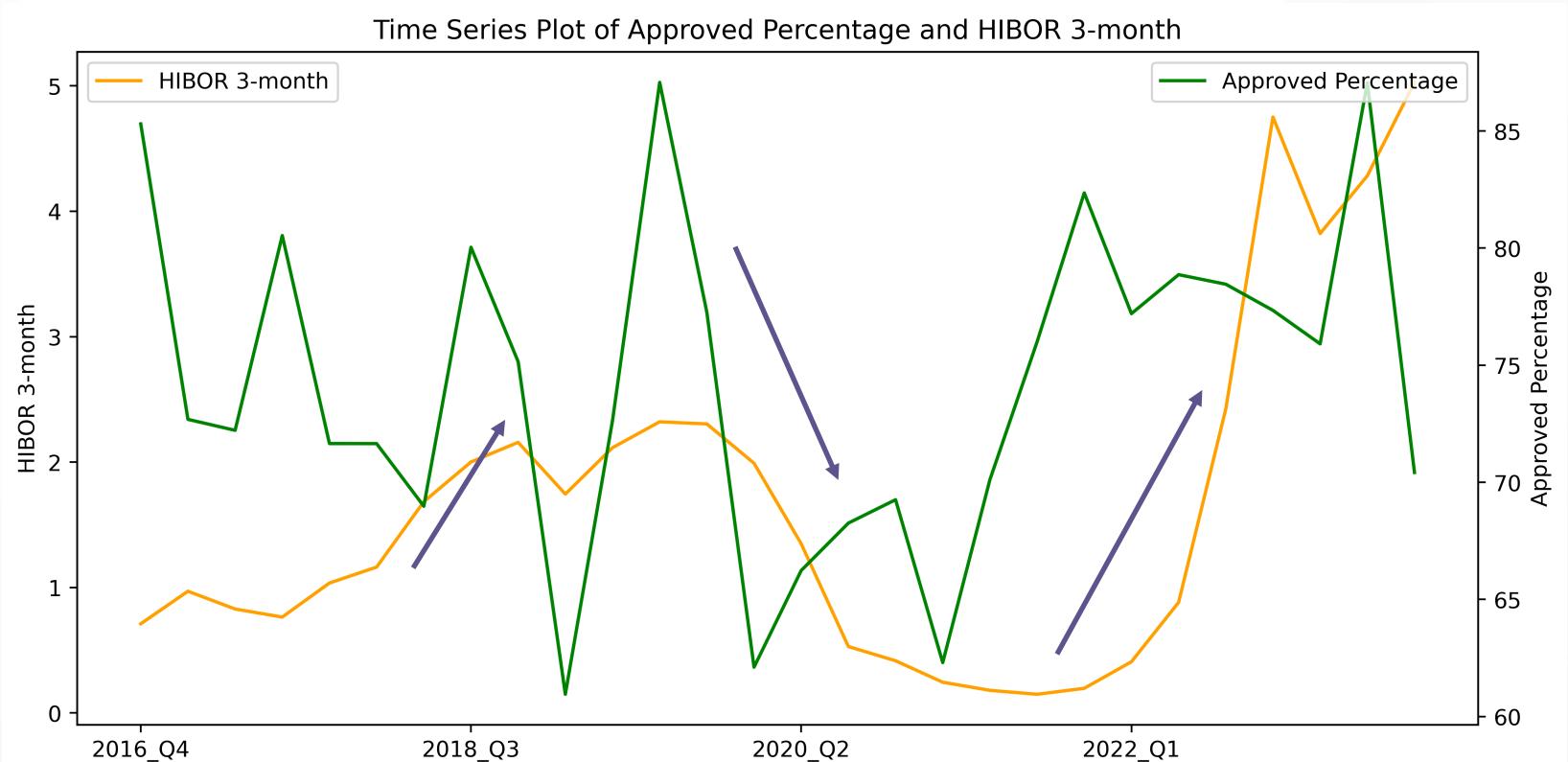
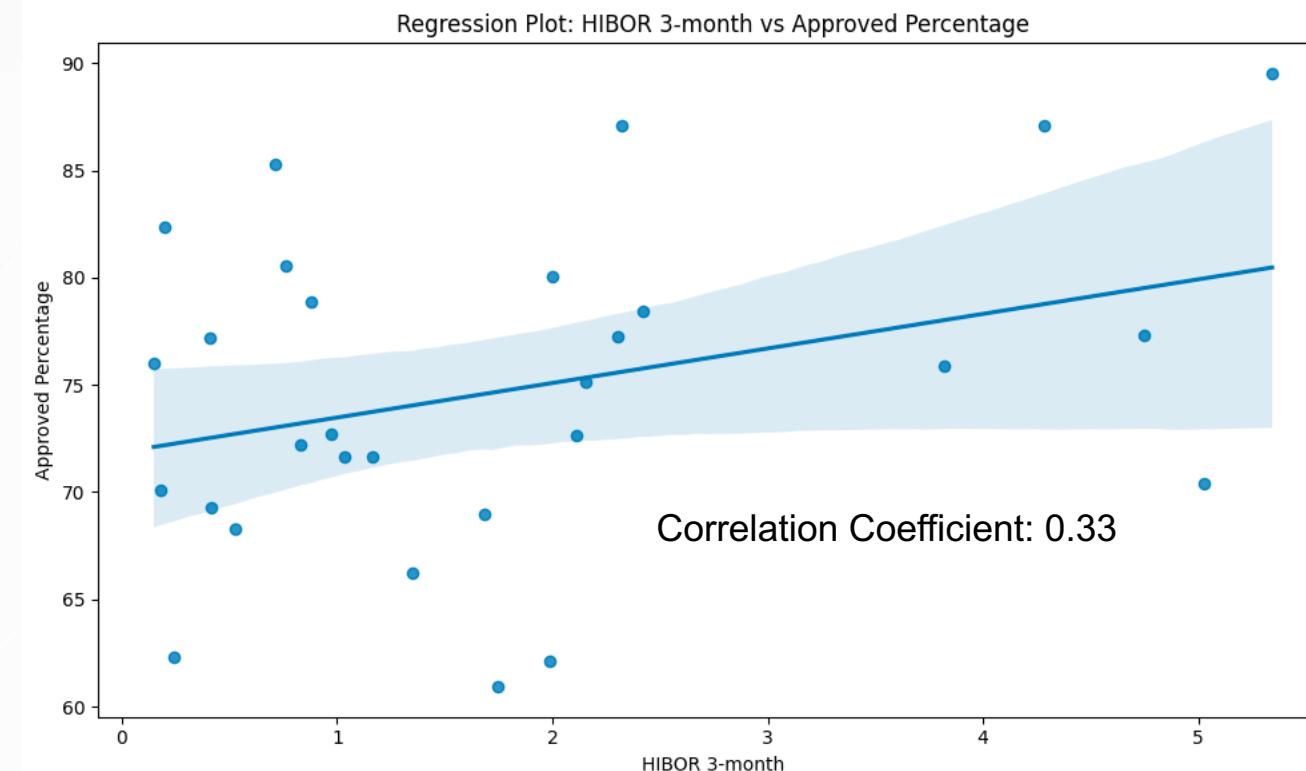
2, Methodology

4, Conclusion



### Slight Positive Correlation between HIBOR and Approved Percentage

- When HIBOR rises, interest rates on floating rate mortgages also increase. Borrowers need to pay higher interest on their loans
- Lenders are beneficial to higher interest rates as they **earn more interest income** over the life of each approved loan, leading them have a stronger financial incentive to approve



## 3.2 New Loans

1, Introduction

3, Result

2, Methodology

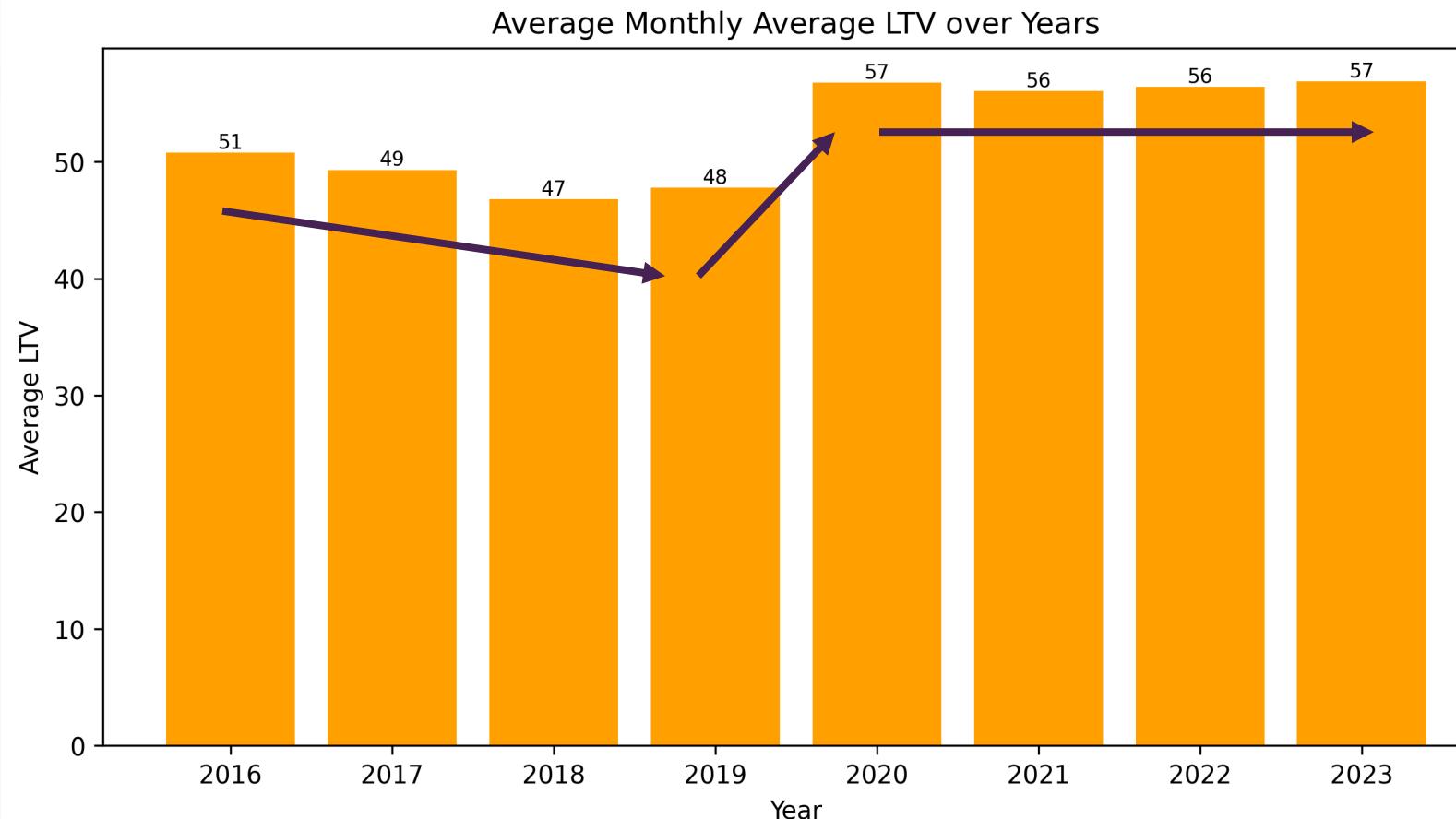
4, Conclusion



### Sharpe Increase of LTV start from 2020

- In 2020, there is a sharp rises from 47.8% to 56.78%, nearly **10%** increases year-on-year
- Earning of lenders increased ?
- Property Price dropped ?
- Policy changed by HKMA ?
- Uncertainty during COVID-19 ?

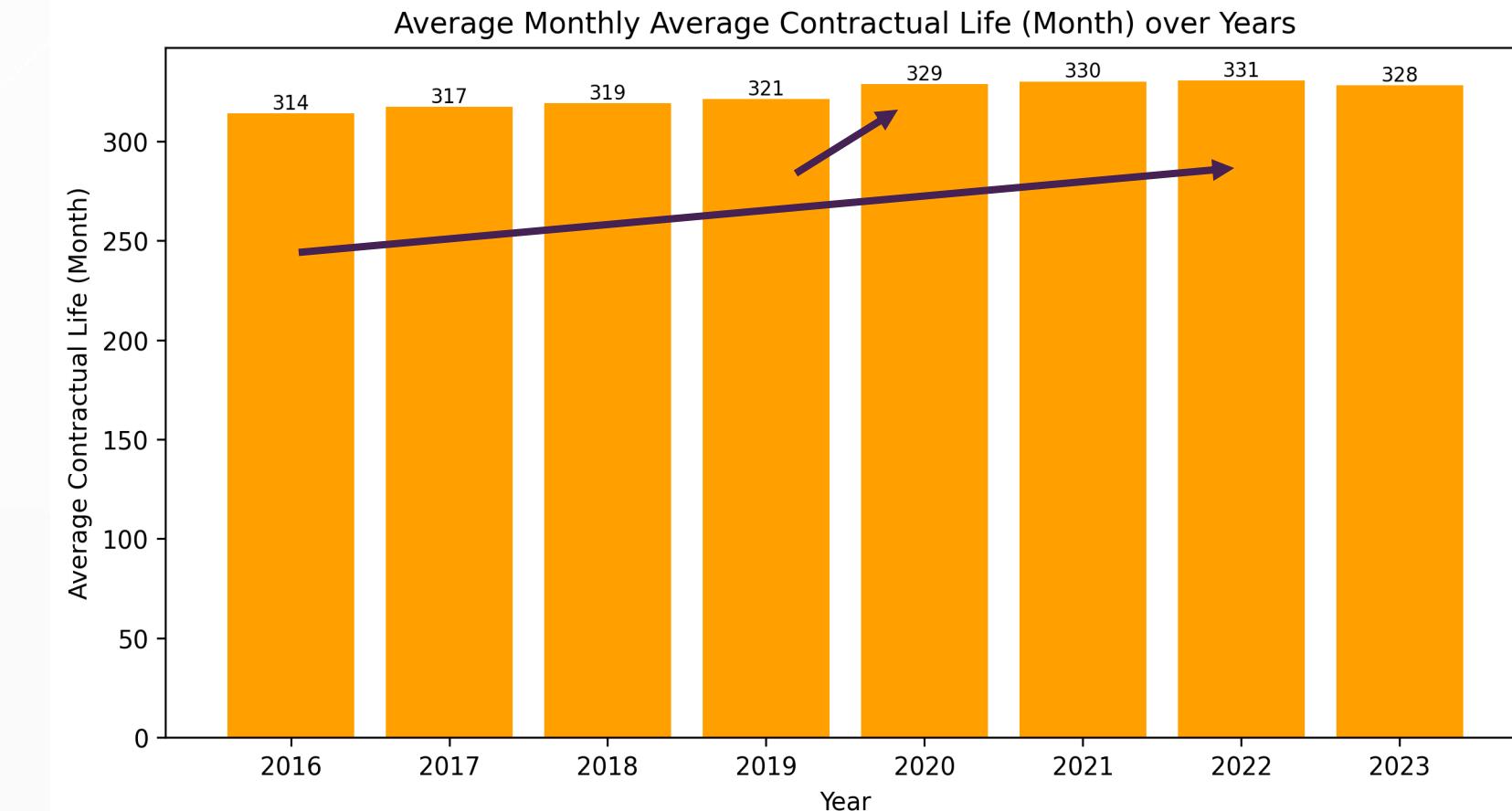
Count	Mean	Std.	Min.	Q1	Median	Q3	Max.
84	53	4.7	44.3	48.2	54.4	57	60.1



### Slightly Increasing Trend of Tenors

- The tenor show a general slight uptrend from 2016 to 2023
- It is positively correlated with LTV
  - Both tenors and LTVs saw a significant increase from 2019 to 2020
  - Average tenors have remained at relatively high in recent years

Count	Mean	Std.	Min.	Q1	Median	Q3	Max.
84	325	5.9	312	320	326	330	336



# 3.2 New Loans

1, Introduction

3, Result

2, Methodology

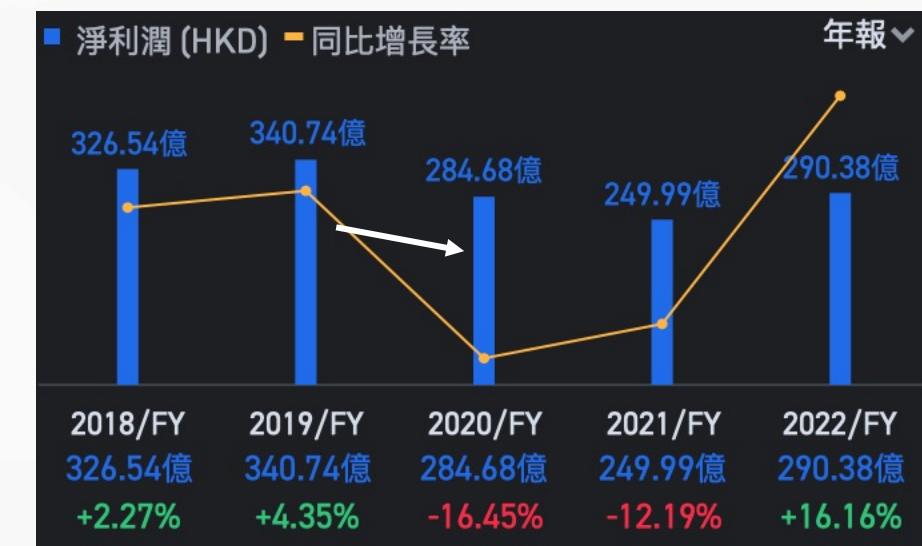
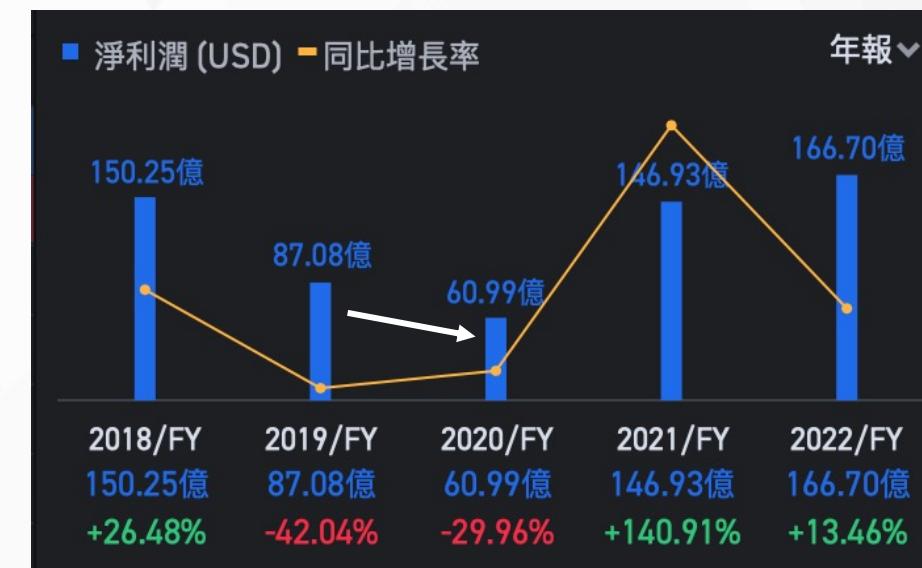
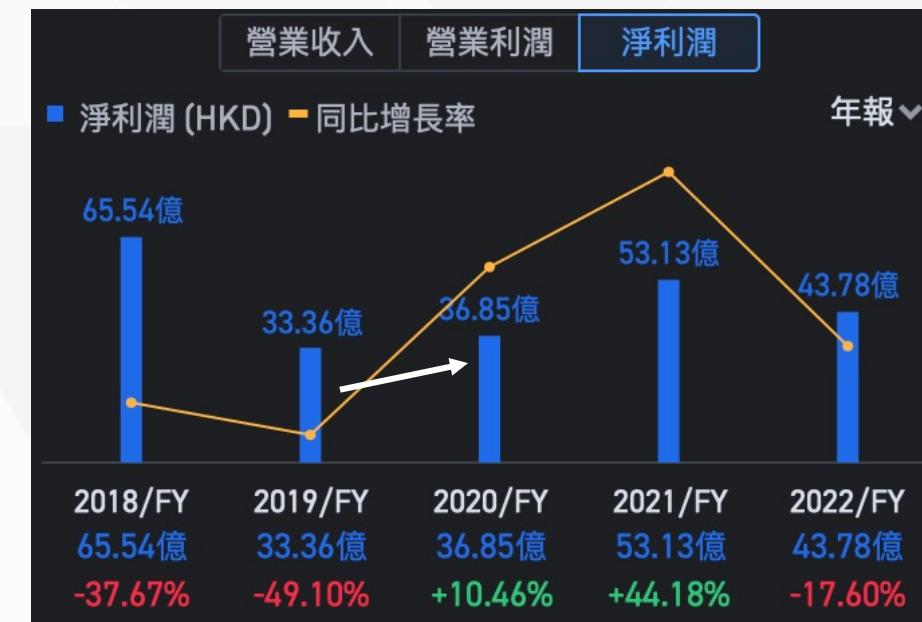
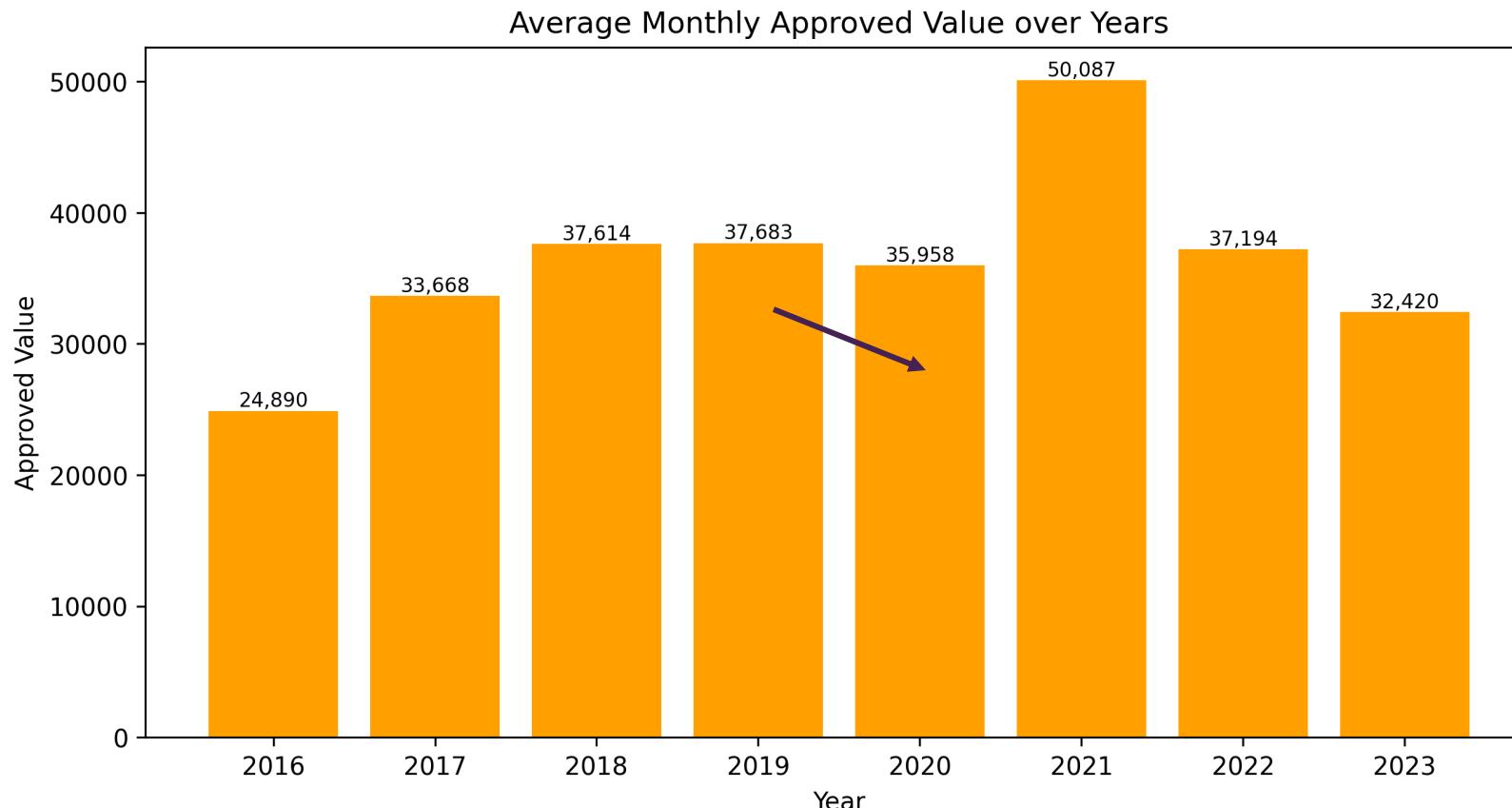
4, Conclusion



## Sharpe Increase of LTV start from 2020

LTV = Loan Value / Market Value

- The lender earnings **did not** show an increase between 2019 and 2020 among banks industry
- The approved value of loans during the same period **decreased**
- There is **no evidence** to show a sharp increases of earning among AIs, which contribute to higher capital reserves and capability of taking additional risk



## 3.2 New Loans

1, Introduction

3, Result

2, Methodology

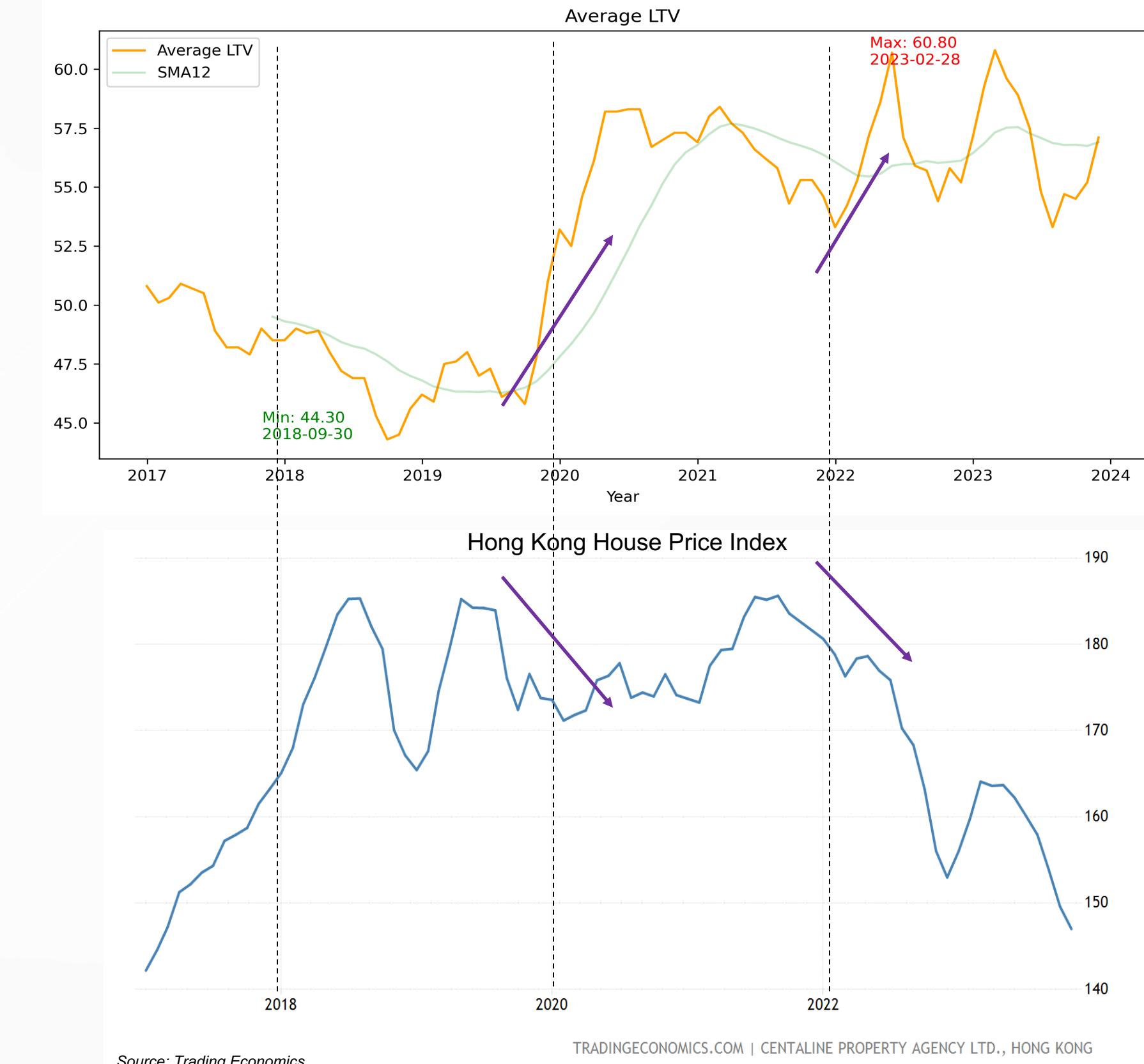
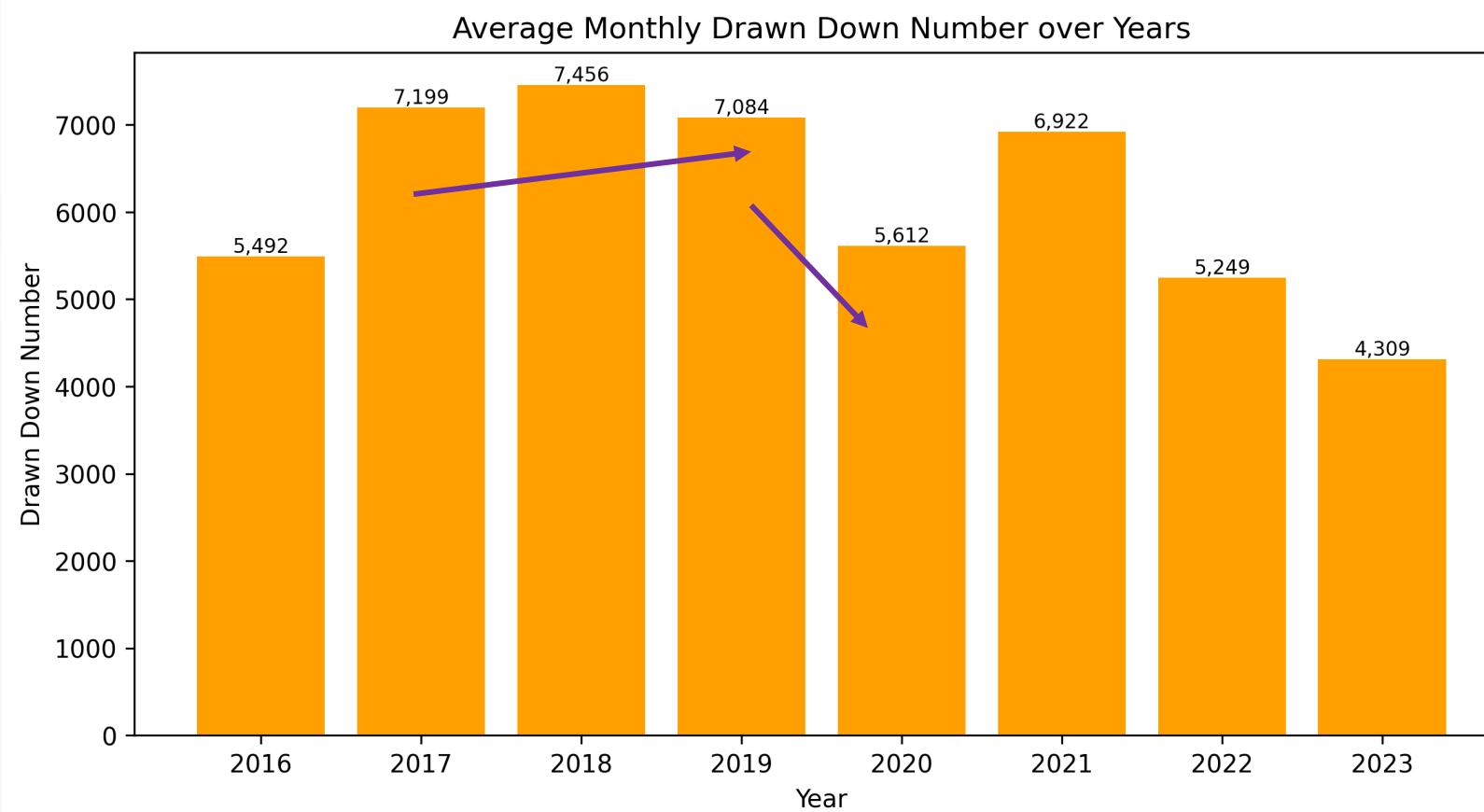
4, Conclusion



### Sharpe Increase of LTV start from 2020

LTV = Loan Value / Market Value

- When the property values decreased in the market, the outstanding loan amounts remained unchanged as they were already approved and drawn and trigger the risk of LTV



## 3.2 New Loans

1, Introduction

3, Result

2, Methodology

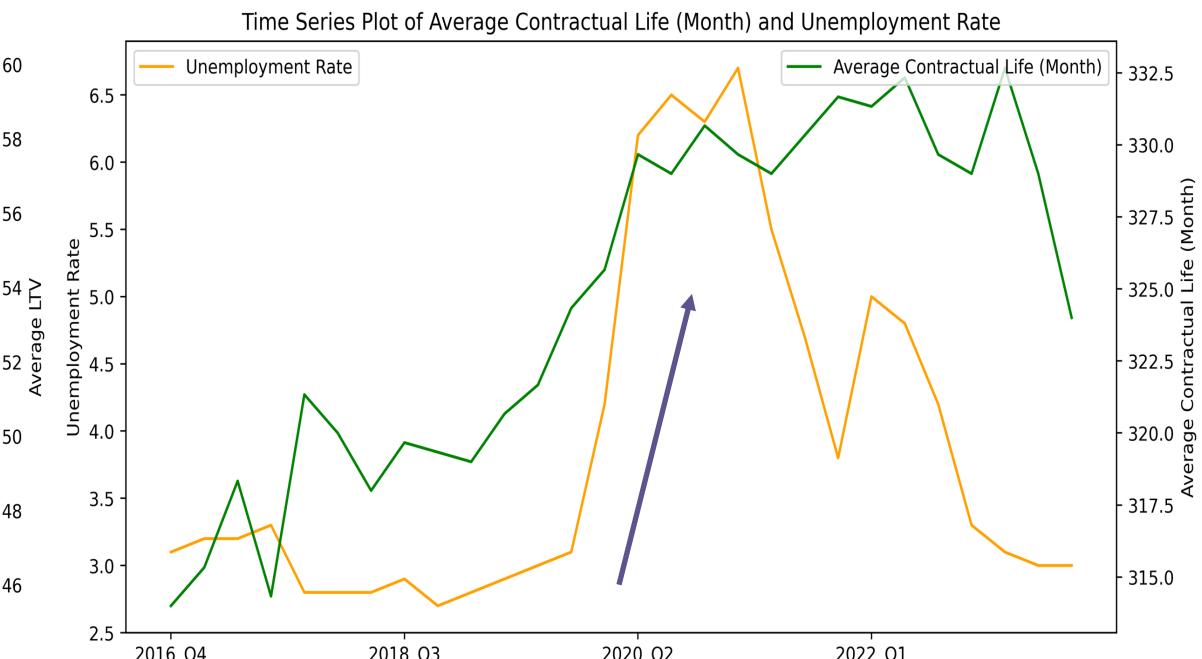
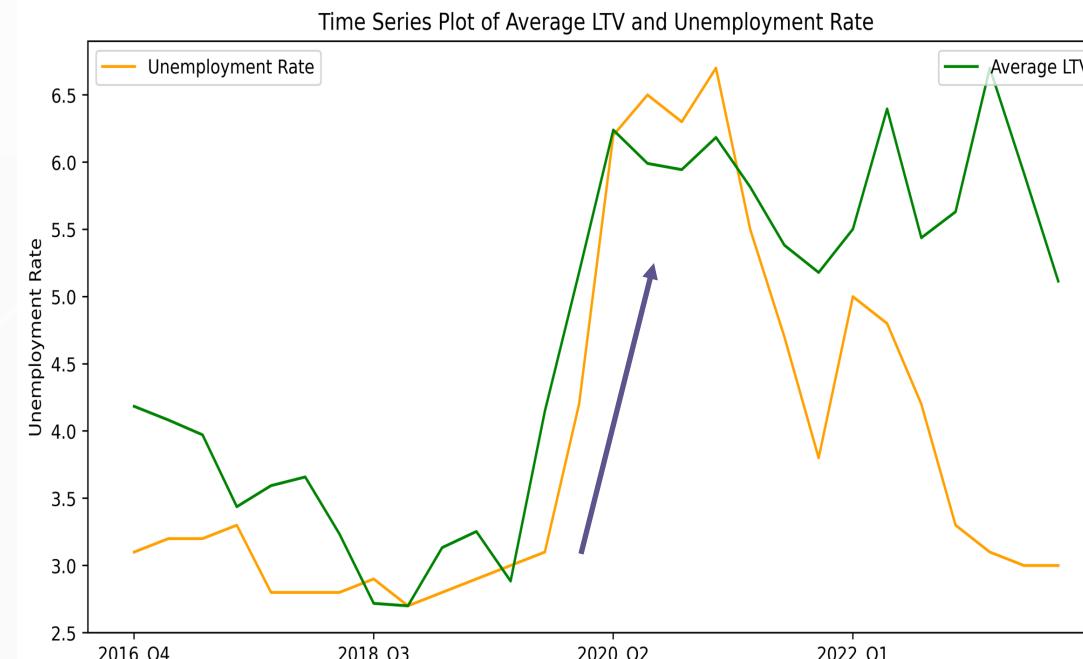
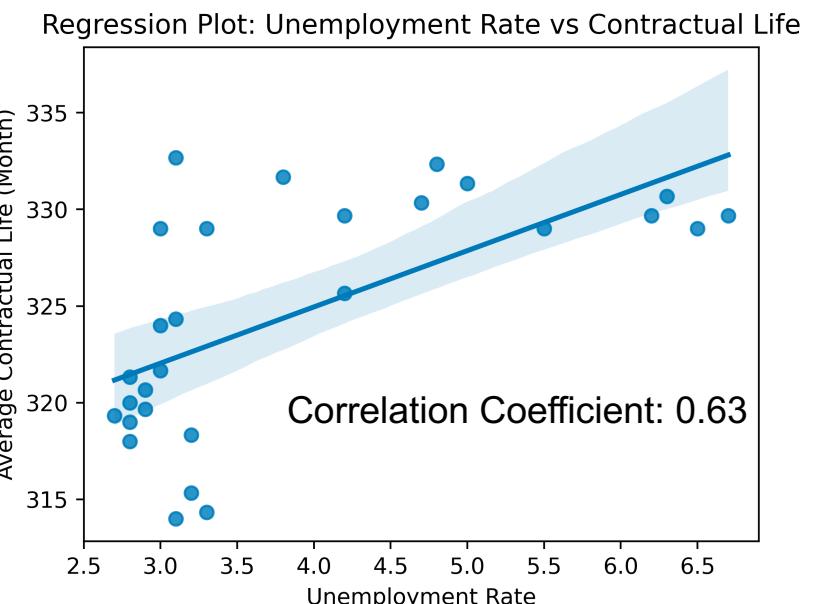
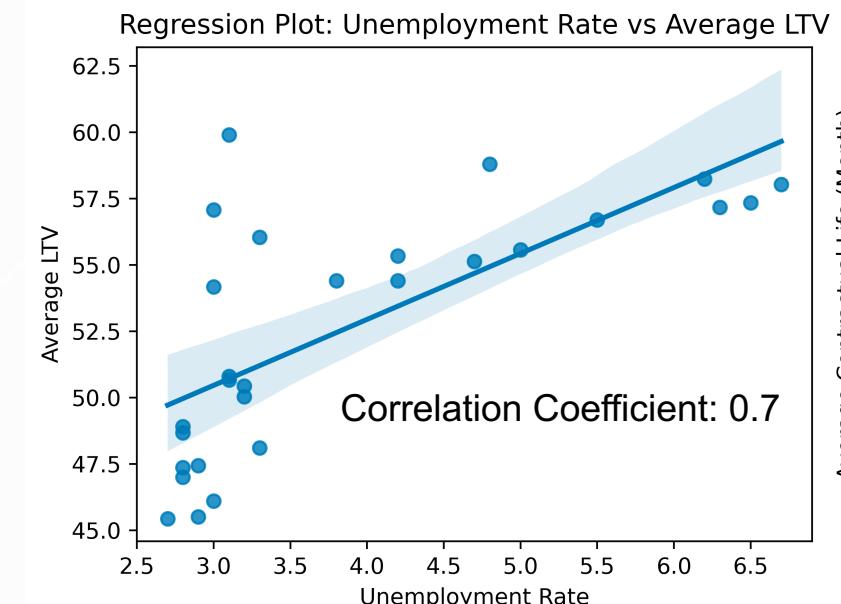
4, Conclusion



### Positive Correlation between Unemployment Rate and LTV & Tenors

DSR = Debt / Income

- From the start of COVID-19, the unemployment rate sharply and consistently increased, indicating a **weakening economy**. Borrowers' incomes became unstable as appraisals, bonuses were reduced, and jobs were lost
- With jobs losses, borrowers' income and **repayment ability declines**. Higher LTV loans were needed to **meet the borrowers' accessibility** to housing and affordability for properties price
- Facing increase of repayment risks from rising LTV and DSR, lenders preferred a longer contractual life to lower monthly installments, **reducing DSR pressure** to borrowers and **mitigating credit risk** to lenders



# 4.1 Conclusion

1, Introduction

3, Result

2, Methodology

4, Conclusion



## **Strong Financial health and stability of borrowers**



- Delinquency and rescheduled loan keep in a safety level
- Delinquency ratios have risen slightly in recent years, requiring continued monitoring

## **Demonstration resilience in lender risk management**



- The maintain of delinquency and rescheduled loan safe level with economic uncertainty during COVID-19, interest rates rising, unemployment fluctuating, indicate the effectiveness of lenders' stress testing and risk assessment
- Lenders carry continuous monitoring and timely responses to changing macroeconomic conditions

## **COVID-19 uncertainties**



- Sharp increases in LTV and tenor levels is observed in 2020 while keep as high level in the recent year

## **HIBOR and unemployment rate factors impact borrower and lender behaviors**



- Rising rates negatively affect application volumes while positively influencing approval rates
- Higher unemployment rate drive the lender to conduct more stress risk assessment for the RML (LTV, DSR)

# 4.2 Limitation & Improvement

1, Introduction

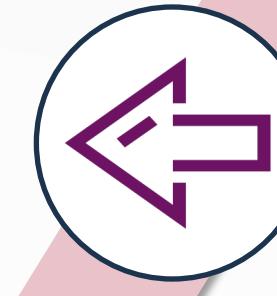
3, Result

2, Methodology

4, Conclusion



- Convert past values to **present values** using the inflation rate
- Consider the use of percentage change over time instead of difference or raw value

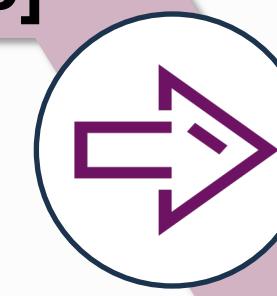


## Without Considering Inflation

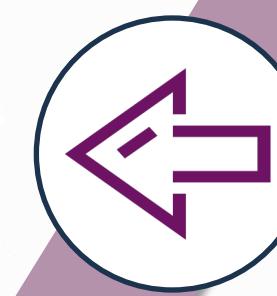
All values are **past values** (outstanding value, approved value, HKD deposits), which may limit the informativeness of the analysis.

## Latency of [Approved Percentage]

It is calculated as the approved number in the current month divided by the application number in the current month. As the approved application may **not within the same month**, this may lead to inaccurate analysis.



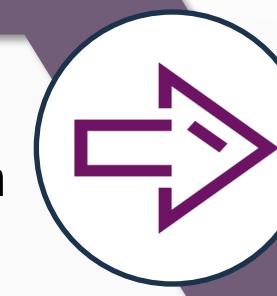
- Calculate as approved number in the current month divided by the application number in the **previous** month
- **Smooth** out the approved percentage by using the rolling average of the approved number and application number over three months



## Insufficient Economic Factors

**Limited** factors with only HIBOR and unemployment rate provide insight.

- **More** factors could be introduced, such as GDP (Gross Domestic Product) and CPI (Consumer Price Index), ^HSI (Performance of Hang Seng Index in stock market)



## Carried EDA in One Area Only

The EDA carried in RML area solely **not sufficient** to provide comprehensive and in-depth understanding of Hong Kong finance landscape

- **Extend** the EDA to explore different Hong Kong finance areas, like analyzing the loan engagement rate in the China market, cooperative loans by different sectors, and interbank loans



# Reference & Remark

- Property Price Ranking: <https://www.cbre.com.hk/press-releases/hong-kong-holds-spot-as-worlds-priciest-residential-property-market>
- HKMA Open Source Data: <https://www.hkma.gov.hk/eng/data-publications-and-research/data-and-statistics/monthly-statistical-bulletin/>
- C&SD Open Source Data: <https://www.censtatd.gov.hk/en/scode200.html>
- Hong Kong House Price Index: <https://tradingeconomics.com/hong-kong/housing-index>
- Other supported document are under the “Archive” File
- All data processing workflow are completed by jupyter - RML (outstanding).ipynb, RML (new).ipynb
- All files including data (raw), data (clean) are opened on github:  
[https://github.com/KyroKwok2021/EDA\\_HongKongRMLMarket](https://github.com/KyroKwok2021/EDA_HongKongRMLMarket)



The End