Credit Risk Analysis Project

1. Introduction

This project involves analyzing the credit risk of a mortgage loan portfolio using the **Standardized Approach** and the **Internal Ratings-Based (IRB) Approach** under **Basel III/IV**. The goal is to calculate **Risk-Weighted Assets (RWA)** and **capital requirements** based on the data provided, and to compare the results from both approaches. The analysis includes the following steps:

- Data Cleaning and Preprocessing

- Risk Calculation using Basel III/IV Standards

- Visualization of Key Results

- Comparison of Standardized and IRB Approaches

You can access the spreadsheets with the raw and processed data, as well as the analysis results, at the following links:

- [Logistic Regression to obtain Probability of Default](#)
- [Spreadsheet with Results - Standardized Approach and IRB Approach](#)

2. Data Cleaning and Preprocessing

The dataset provided contains mortgage loans with various features. The cleaning and preprocessing steps included:

Handling Missing Data

- Dropped rows with missing both **MORTDUE** and **VALUE**
- Filled rows missing **MORTDUE** OR **VALUE** assuming an LTV of 0.45 as indicated in the task instructions
- Imputed **JOB** missing values with "Other"
- Deleted rows missing values in 4 columns or more
- Imputed missing **YOJ** values with median (7)
- Imputed missing **DEROG** values with median (0)
- Imputed missing **DELNQ** values with median (0)
- Imputed missing **CLAGE** values with median (77.1)
- Imputed missing **NINQ** values with the mode (0)
- Imputed missing **DEBTINC** values with median (35.29)

Feature Engineering

- Calculated the **Loan-to-Value (LTV)** ratio for each loan as:
  $LTV = MORTDUE/VALUE$
- Calculated **Probability of Default (PD)** using **logistic regression** in Python. The PD values were then exported to the spreadsheet for further use in the **IRB Approach**.

3. Analysis

Risk-Weighted Assets (RWA)

We calculated the **RWA** under both the **Standardized Approach** and the **IRB Approach**:

- **Standardized Approach**: We used the **LTV** to assign **Risk Weights** (50%, 75%, 100%) and calculated **RWA** using:
  $RWA = MORTDUE \times Risk\ Weight$
- **IRB Approach**: We used the **Probability of Default (PD)** and **Loss Given Default (LGD)** (assumed to be 45%) to calculate **RWA**:
  $RWA = MORTDUE \times PD \times LGD$

Capital Requirements

- **Capital Requirement (8% of RWA)** was calculated for both approaches.

- **Tier 1 Capital Requirement (6% of RWA)** was also calculated.

4. Main Results

Metric	Standardized Approach	IRB Approach
RWA (Risk-Weighted Assets)	$233,919,219	$34,465,161
Capital Requirement (CR)	$18,713,538	$2,757,213
Tier 1 Capital	$14,035,153	$2,067,910

5. Visualizations

The following visualizations were created to help interpret and compare the results of the analysis:

a. Histogram of LTV Ratios

A **histogram** was created to visualize the distribution of **Loan-to-Value (LTV)** ratios in the dataset. This helped identify the proportion of high-risk loans based on LTV.
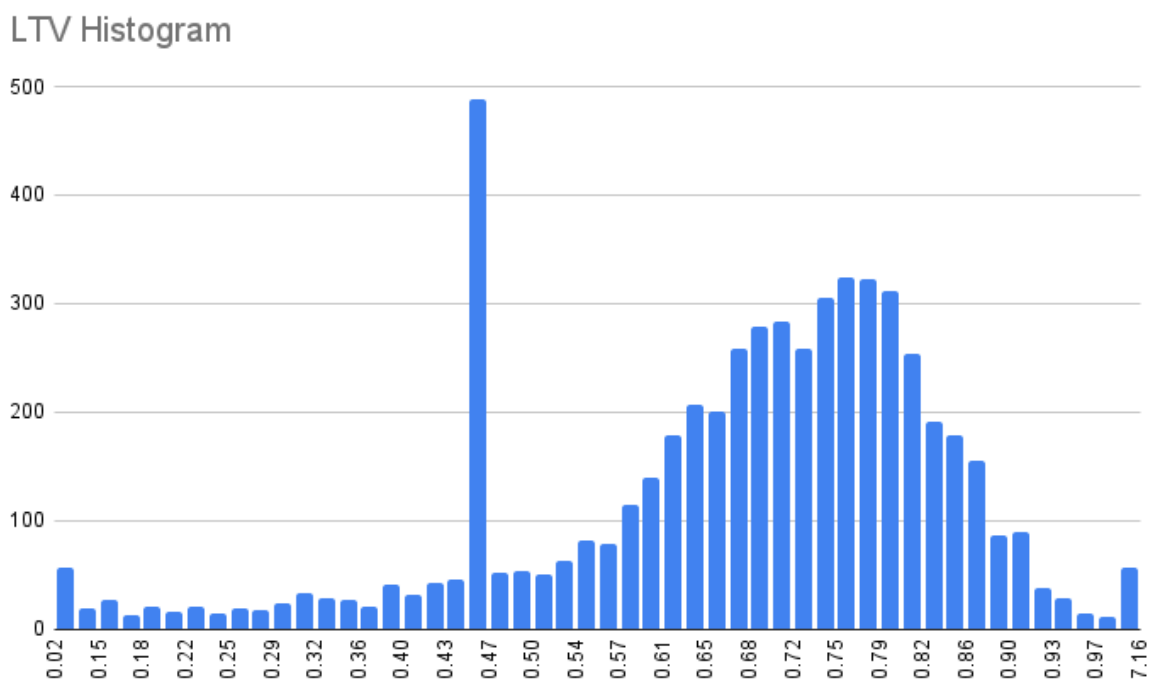

This histogram displays the distribution of Loan-to-Value (LTV) ratios. The spike at 0.45 represents loans with imputed LTV. The distribution shows a concentration of LTVs between 0.60 and 0.80, indicating a significant portion of loans has moderate LTV.

b. Bar Chart: Total RWA by Approach

A **bar chart** was created to compare the total **RWA** under the **Standardized Approach** and the **IRB Approach**. This allowed us to compare the overall **credit risk exposure** between the two approaches.
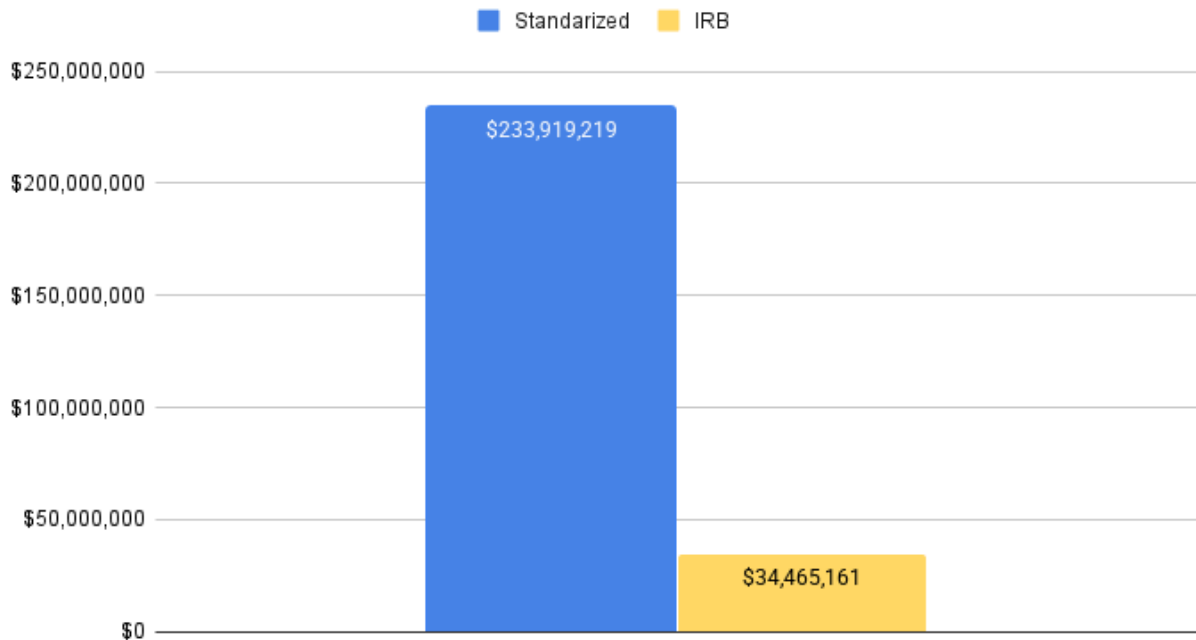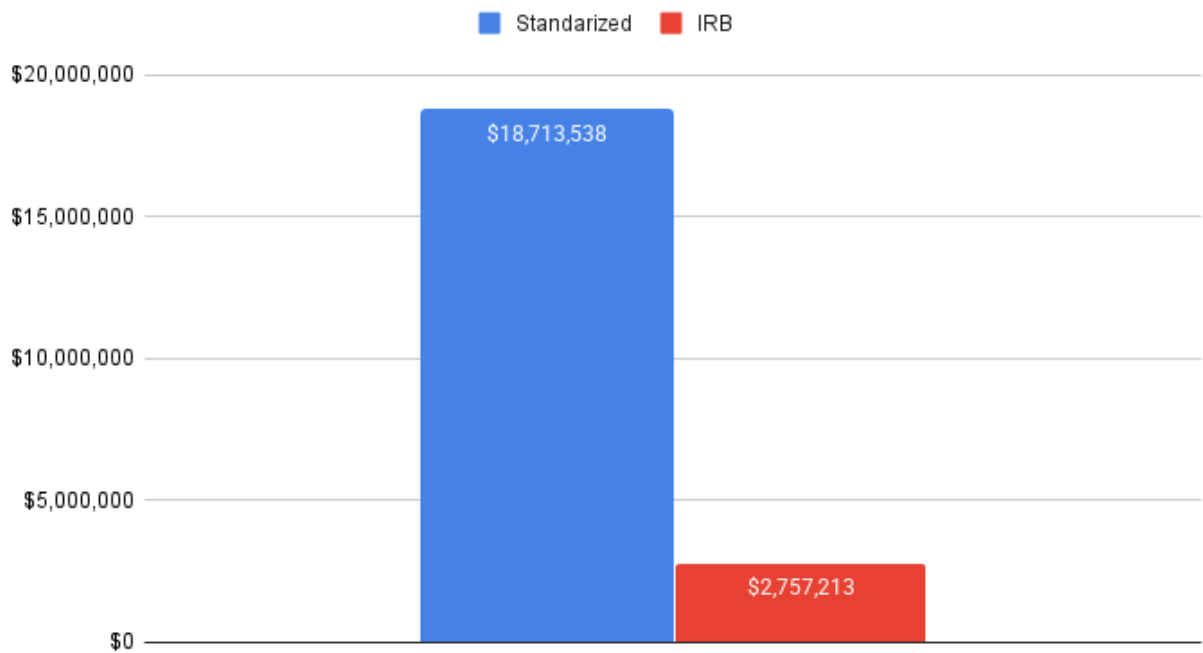

The IRB approach results in a significantly lower RWA than the Standardized Approach, suggesting a lower overall credit risk assessment under the IRB model.

c. Capital Requirement Comparison

A **bar chart** was generated to compare the **capital requirements** (8% of RWA) for both approaches.

Total Capital Requirement by Approach

Similar to the RWA comparison, the IRB approach requires substantially less capital, reflecting the lower RWA.

d. Risk Weights Distribution

A **bar chart** was used to visualize the distribution of loans across different **risk weight categories** based on their **LTV** ratio under the **Standardized Approach**.

Number of Loans by Risk Weight
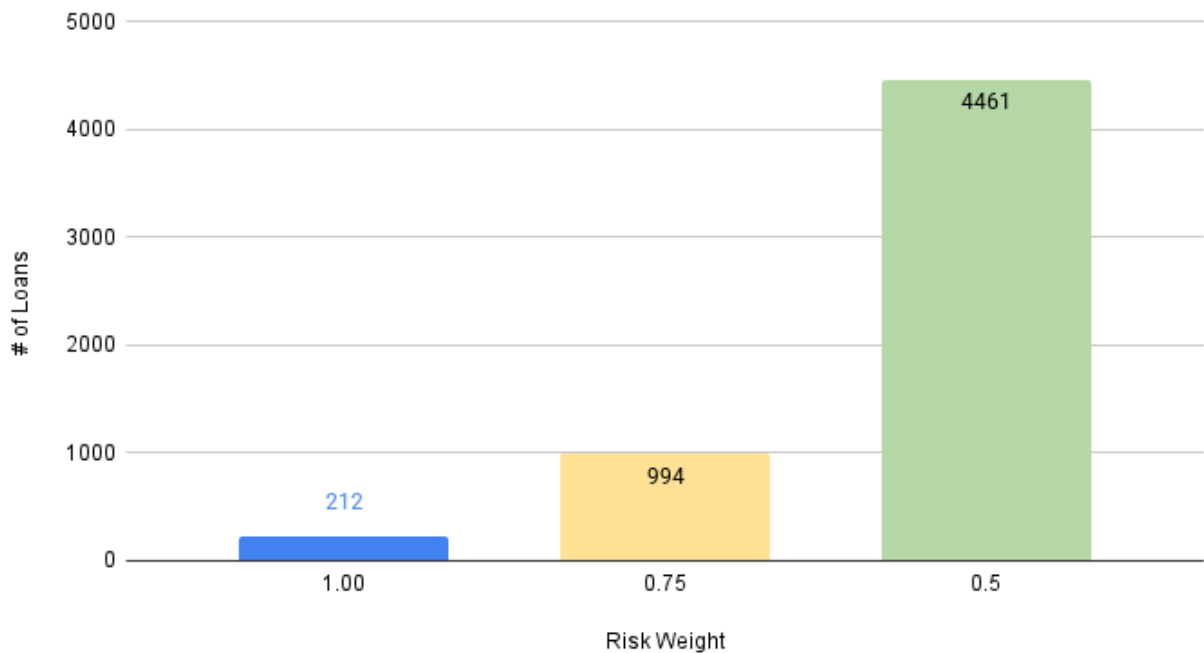
Most loans fall into the 50% risk weight category, indicating a large portion of loans has lower LTVs.

e. RWA (Standarized) vs. LTV

This scatter plot illustrates the relationship between LTV and RWA under the Standardized Approach. There's a clear positive correlation, with RWA generally increasing as LTV rises, as expected under the standardized framework.
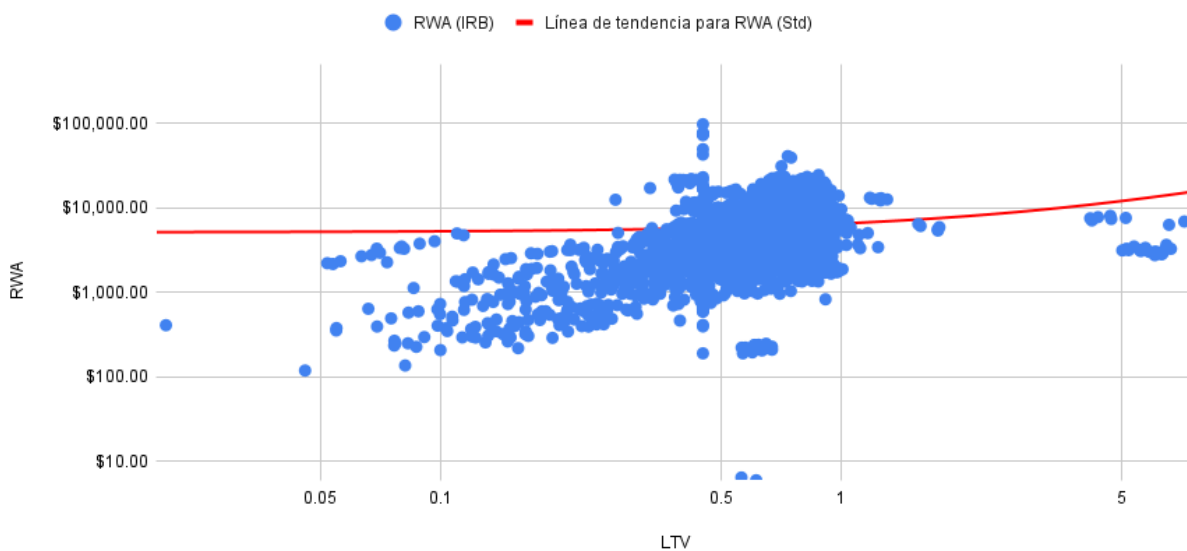
RWA (Standarized) vs. LTV
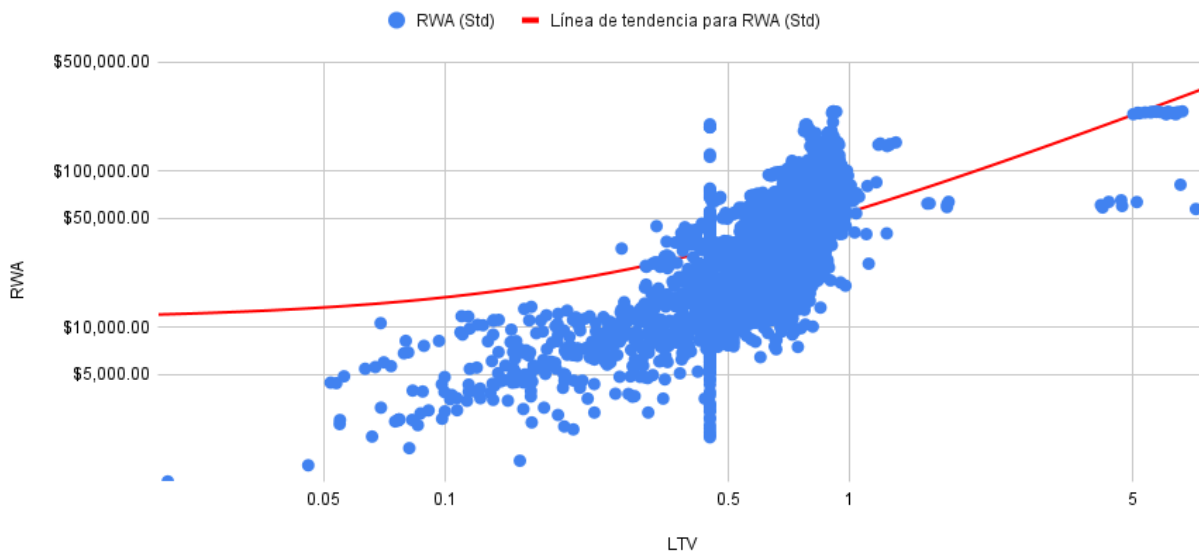
f. RWA (IRB) vs. LTV

This scatter plot shows the relationship between LTV and RWA under the IRB Approach. Compared to the Standardized Approach, the relationship is weaker, indicating that other factors in the PD model influence RWA. RWA values are generally lower than in the Standardized Approach.
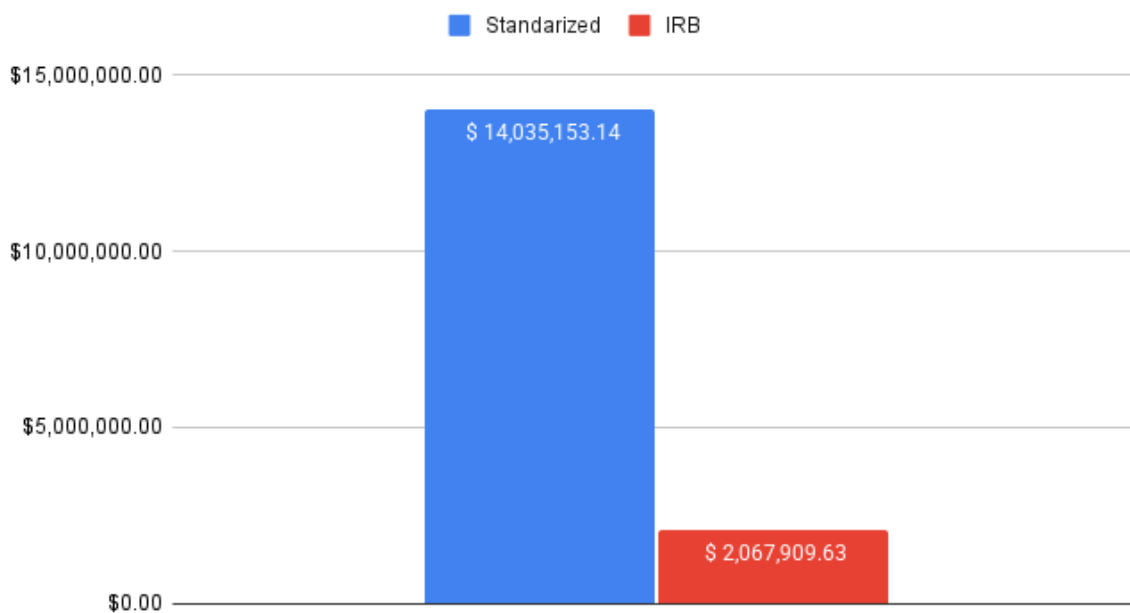

RWA (IRB) vs. LTV

g. Tier 1 Capital, Standarized vs. IRB

This chart compares Tier 1 capital requirements under both approaches. It mirrors the total capital requirement comparison, with the IRB approach requiring significantly less Tier 1 capital.

6. Conclusions

Key Insights:

1. **RWA Comparison**: The **IRB Approach** resulted in **lower total RWA** for the portfolio compared to the **Standardized Approach**, primarily due to the more granular **PD** estimates used in the IRB model.

2. **Capital Requirements**: As expected, the **IRB Approach** required **less capital** than the **Standardized Approach**, reflecting the **lower perceived risk** in the loans based on their individual **PD** estimates.

3. **Impact of LTV**: Loans with higher **LTV ratios** (i.e., more than 80%) contributed significantly to the **higher capital requirements** under the **Standardized Approach** due to their higher **risk weights**.

Recommendations:

- **Risk Management**: Banks could potentially reduce their capital requirements by using **Internal Ratings-Based models** (IRB), as long as they can accurately assess **PD** and **LGD** for each loan.

- **Regulatory Adjustments**: Further adjustments or refinements in the **Basel III/IV** framework could make it easier for smaller institutions to adopt IRB models, ensuring that **capital requirements** more closely align with **actual risk exposures**.

Conclusions:

- This analysis demonstrates a clear difference in credit risk assessment between the Standardized and IRB approaches. The IRB approach, utilizing a PD model, generally results in significantly lower RWA and capital requirements compared to the Standardized approach, which relies primarily on LTV for risk weighting.
This highlights the potential for IRB models to provide a more refined and potentially less conservative view of credit risk. However, it also underscores the critical importance of accurate PD and LGD modeling and the need for robust validation and regulatory oversight of IRB models.

  The visualizations effectively illustrate these differences, showing how the IRB approach's risk sensitivity leads to a different relationship between LTV and RWA compared to the standardized rules.