2021-22 Scenario

Mortgage Lending

Instructor's Version

A Program of The Actuarial Foundation

Modeling the Future Challenge

Introduction

For many people in the United States, home ownership is often a benchmark of stability and financial independence. However, many are unable to afford to purchase their own home without financing assistance from a lending institution. Thus, many hopeful homeowners will rely on a mortgage in order to purchase their home. While there are many types of mortgages, a mortgage in the simplest sense is a loan awarded to a borrower where the house itself is held as collateral. The interest rate on a conventional mortgage is influenced by many factors including (but not limited to) inflation, the loan-to-value ratio, and credit score. A borrower's credit score is a predictive index of the applicant's likelihood of repaying the loan that is determined by their payment history, total amount owed over all credit lines, length of credit history, diversity of credit accounts, and number of new credit lines opened or hard inquiries performed by lenders within a recent time frame.

Mortgage lending has been the subject of additional scrutiny over the past decade when the unprecedented growth of the subprime mortgage lending market began in 1999 by U.S.-government sponsored mortgage lenders Fannie Mae and Freddie Mac led to risky mortgage lending to "subprime borrowers" who had low credit scores and higher risks of defaulting on loans. These subprime borrowers were allowed to take out adjustable-rate mortgages where the monthly payments started small but grew to much larger than they were able to afford after several years. When these borrowers   and by 2008, subprime borrowers were defaulting on their mortgages at high rates which caused turmoil in the financial markets and ensuing collapse of the stock market and housing crash of 2008 and ensuing Great Recession.

With this background in mind, the XYZ Mortgage Company is reviewing their data from mortgages leant in 2010. XYZ has decided to hire you as a consulting actuary to help them analyze their data and make recommendations about how to define which loans they should make and at what interest levels.

Data Description

The spreadsheet attached to this scenario provides 7 fields:

- date of origin of the loan
- term (15 years or 30 years)
- purchase price of the home
- loan amount
- interest rate
- credit score of the borrower
- whether or not the mortgage was delinquent as of 1/1/2019 (1 is delinquent, 0 is not)

Some questions require written answers, some mathematical calculations, and some require both. The questions follow the five steps of the Actuarial Process and additional perspective can be found by referencing each section of the Actuarial Process Guide.

Part 1:
Problem Definition

Questions from this part of the scenario build upon Part 1 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

1. **Describe in a few sentences what risks are associated with mortgage underwriting? Identify at least two groups that may be at risk of loss due to mortgage underwriting practices.**

   Lending institutions are at risk of the borrower defaulting on the loan and then having to engage in a lengthy and costly foreclosure process. Borrowers are at risk of being allowed to take out a loan that they will become delinquent on or eventually defaulting on which will affect their credit score and future lending and quality of life opportunities.

2. **Describe in no more than a few sentences an example of how insurance may be used to help mitigate or manage the risk of loss with mortgage brokering you noted in question 1. (hint: reference the Actuarial Process Guide Section 1.3 and conduct some external research, if needed)**

   When borrowers are considered more "risky" and/or don't have a full 20% down payment for the loan, they may be required to acquire mortgage insurance. This additional monthly cost to the borrower allows the lender to extend a mortgage eligibility offer that might not have been available otherwise. It is a protection to the mortgage lender to ensure that a borderline borrower is able to secure a loan with less risk to the lender as the insurance policy would cover the loss if the borrower defaults on the loan. From ConsumerFinance.gov

3. **Describe in no more than a few sentences an example of how implementing new policies, procedures, or systems to help change behaviors of those involved may be used to help mitigate loan delinquencies and losses you noted.**

   Similar to the changes in approach needed after the 2008 housing bubble crisis that led to the Great Recession, implementing policies that require certain credit scores or mortgage insurance policies for more risky borrowers. Financial literacy videos and training in an engaging and entertaining way for borrowers prior to closing to ensure that they are informed of the impacts of taking out the loan and ways of

Part 2:
Data Identification & Analysis

The following questions relate to Part 2 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

4. **Preview the questions in the Mathematical Modeling section. In the dataset provided describe at least one way in which you might want to adjust or manipulate the data to make it more useful for an analysis. (hint: reference Actuarial Process Guide section 2.2)**

   Answers may vary. We will need to compute the purchase price to loan ratio for computations in the math modeling section.

5. **In the dataset provided describe one way in which you might want to clean the data to make it more accurate for an analysis.**

   In the "Delinquent as of 1/1/2019" column, some of the 0's are listed as "no" and 1's are listed as "yes" so it should be changed to be consistent. Since the spreadsheet is listed as having 0's and 1's, these should all be changed.

6. **Beyond the data provided in the attached spreadsheet, what other information or data could be valuable in analyzing the risks associated with this scenario? (hint: reference Actuarial Process Guide section 2.1)**

   Answers may vary. Data regarding other factors in the borrower's loan application that were taken into account when awarding the loan would be helpful in seeing the larger picture regarding risk to the lender. Having the guidelines on the metric for how the interest rate was determined would be helpful in determining whether the interest rate was appropriate.

The following questions relate to Part 3 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

7. **What percentage of the loans are currently delinquent?**

   311 out of the 10,000 loans are delinquent, or 3.11%.

8. **Find the average interest rate for all borrowers with a credit score of at least 620 and the average interest rate for all borrowers with a credit score of less than 620.**

   1,066 of the 10,000 loans are to those with credit scores less than 620. Their average interest rate is 4.577%. The other 8,934 loans have credit scores of 620 or more. Their average interest rate is 4.42%.

9. **Find the average loan to purchase price ratio for all of the 15-year loans.**

   3,084 of the 10,000 loans are 15-year loans. Their loan to purchase price ratio is just a hair under 0.80.

10. **Identify the minimum, maximum, mean, and standard deviation of the purchase price and then again for the loan amount.**

	max	min	mean	stdev
purchase price	2,632,200	100,000	319,786	245603.9161
loan amount	2,129,400	75,800	255,878.75	197043.1676

11. **How many standard deviations above the mean purchase price is the most expensive home? What does this suggest about the most expensive home?**

    The most expensive home is $2,632,200. This is (2632200 – 319785.84) / 245603.916 = 9.415 standard deviations above the mean.

12. Compute the probability that someone with a credit score of less than 600 will become delinquent in a given year on their loan.

    There are 408 loans to those with credit scores under 600. 14 of those, or 3.43% are delinquent.

13. Assuming the value calculated in number 1, find the probability that out of the next 100 loans that at least 5 will end up delinquent in a given year.

    In a cumulative binomial probability calculation, 20.1%

14. Find the probability that a loan to someone borrowing more than 80% of the purchase price will end up delinquent in a given year.

    4,986 of the loans had a loan to price ratio of MORE than 0.8. 214 of them, or 4.29%, ended up delinquent.

15. Find the difference between the mean interest rates between 30 and 15 year loans.

    The 6,916 30-year loans had an average interest rate of 4.61%. The 3,084 15-year loans had an average interest rate of 4.04%. The difference in mean interest rates is 0.57%.

16. **Assuming that XYZ loses an average of $164,563 for every delinquent loan, what is the expected value of loan lending by XYZ (assuming the interest rate is 4.44% and average interest paid is $152,946)?**

    EV=(chance delinquent)*(value of delinquency)+(chance not delinquent)*(value of not delinquent)

    EV=(0.0311*-164563)+((1-0.0311)*(255878.75+152946))=$390,992.391

17. **Find the probability that of the next twenty-five 15-year loans, none of them will become delinquent.**

    97 of the 3,084 15-year loans, or 3.145%, became delinquent. The probability that none of the next 20 will be delinquent is (1 - .03145) ^ 20 = 0.53.

The following questions relate to Part 4 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

18. **Suppose delinquency rates for all loans from XYZ Mortgage from 2011-2014 were 3.2%, 3.31%, 3.44%, and 3.46%, respectively. Use a linear regression model with the 2010 delinquency rate and these four new data points to predict the delinquency rate for loans issued in 2018. What is the correlation coefficient? Is a linear regression model on this data a good way to project the future delinquency rates? Why or why not? Include a labeled graph in your response.**

    The least-squares regression model with those 5 points is rate = -185.824 + 0.094 * (year). This makes the 2018 prediction 3.868%. Correlation coefficient is 0.9837, which suggests that there is a strong correlation and the trend is very linear.

19. **Suppose the delinquency rate for 2015 was low – 3.04%. By how much would this reduce the prediction for the delinquency rate for loans in 2018?**

    With the new point, the prediction for 2018 is now 3.348%, or 0.52% less than the previous prediction.

20. Different types of loans have different requirements and ways of determining eligibility. Compare the mean and standard deviation of the loan to purchase price ratio and the percent delinquent for current loans with borrowers in the following FICO credit score categories: Bad (300-619), Fair (620-689), Good (690-719), and Excellent (720-850). Explain what this tells us about the risks associated with lending based on credit score? Interpret the standard deviations you see in terms of what it means for risks in each category.

The "Bad" category has the highest chance of delinquency and is nearly twice as high as any of the other categories. However, there is less variability within the "Bad" category (lower standard deviation) leading us to conclude that it is consistently more risky. All categories have roughly the same mean loan to purchase price ratio of roughly 80%.

	Bad (300-619)	Fair (620-689)	Good (690-719)	Excellent (720-850)
Mean *loan/pp ratio*	0.8008849107	0.7996241162	0.7998535517	0.8012342862
Stdev *loan/pp ratio*	0.02881721216	0.02925294537	0.02916248609	0.02901553693
# Delinquent	55	166	60	32
% Delinquent *as of 1/1/2019*	55/1055=5.02%	167/5788=2.89%	60/2058=2.92%	32/1088=2.94%

21. The length of mortgage awarded is also a factor to consider for XYZ in lending. Complete the table and note any relevant observations on the possibility of risk between the 15-year and 30-year mortgages.

Answers may vary. There is a slightly higher chance of delinquency in the 15-year mortgages but there is greater variability in the 30-year mortgages.

	% Delinquent	Average Loan to Purchase price Ratio	Standard Deviation of Loan to Purchase Price Ratio
15-year Mortgage	99/3084=3.21%	0.7997553724	0.0289869213
30-year Mortgage	212/6916=3.07%	0.8000612636	0.02924052834

22. **Is there a bigger risk (in terms of delinquency) to loans originating in the winter (before March 20)? Explain and justify your response and offer some suggestions as to why this may be the case.**

There were 2,194 loans originating before March 20. 68 of those, or 3.099%, were delinquent. This is less than the overall rate of 3.11, so there may be a reduced risk to loans in the winter.

The following questions relate to Part 5 of the Actuarial Process. It may be valuable to review this section of the Actuarial Process Guide before answering the questions below.

23. **Is the correlation between credit score and delinquency a credible method of predicting whether a loan should be awarded based solely on credit score? Justify your response.**

    According to this data, the correlation between credit score and delinquency is -0.02398802127, which indicates that there is little to no correlation and thus credit score is not a credible predictor of delinquency.

24. **Give and justify an evidence-based recommendation (based on delinquency rate) on lending more than 80% of the purchase price.**

    The answer to #14 shows that 4.29% of loans of more than 80% of value ended up delinquent. As this is a lot more than the 3.11% overall rate, it is risky and unadvisable for the bank to loan more than 80% of the purchase price. The bank should charge a higher interest on mortgages with loan to purchase price ratios above 80%, to be compensated for the greater risk.

25. **Give an evidence-based recommendation on lending to customers with a credit score under 620. What steps could be taken by lenders to cover the risk they assume when lending to borrowers with credit scores under 620? Explain and justify your response.**

    41 of the 1,066 loans to those with credit scores under 620 ended up delinquent. This rate of 3.846% is greater than the overall rate of 3.11%, suggesting it is risky to loan to those with low credit scores. A higher interest rate could mitigate that risk.

26. **Should XYZ increase the marketing of their 15-year loans or their 30-year loans? Why? Give an evidence-based rationale for your recommendation.**

    As seen in #9, the delinquency rate for 15-year loans is slightly higher, but not by much. The answer to #8 shows that 30-year loans make considerably more interest. With more interest, and about the same (if not fewer) delinquencies, the company should increase the marketing of their 30-year loans.