THE RELATIONSHIP BETWEEN MACRO FACTORS AND DELINQUENCY RATE ON COMMERCIAL REAL ESTATE LOANS

by

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Abstract

This study investigates the effect of changing macroeconomic variables on the delinquency rate on commercial real estate loans between Quarter 1, 1991 and Quarter 3, 2019. We use the Vasicek one-factor Gaussian copula model to examine the delinquency rate on commercial real estate loans. We find four macroeconomic variables, unemployment rate, 10Y and 2Y yield spread, Home Price Index growth rate and average nonfinancial firms' debt to equity ratio, to be best fit in the model. We further perform sensitivity analysis and conduct stress tests to identify how value variation of macroeconomic factors influence the predicted delinquency rate and conclude that financial institutions should always keep enough capital to prevent liquidity issues in crisis.

Keywords: Vasicek One-factor Model; Commercial Real Estate Loans; Delinquency Rate; Sensitivity Analysis; Stress Test

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Glossary

HPI	S&P/Case-Shiller U.S. National Home Price Index
SD	Standard Deviation

1. Introduction

The 2008 financial crisis started in the subprime market and soon spread to the commercial market. While various studies have been conducted on the default of the residential mortgages, few researches have been done on commercial real estate loans. In this paper, we examine the relationship between the macroeconomic factors and the delinquency rate on commercial mortgages. Specifically, we seek to answer the following two questions: (1) Which macroeconomic factors drive the default of commercial real estate loans? (2) How high will the delinquency rates of commercial real estate loans reach during unexpected recessions?

The financial sector has been through a sequence of dramatic changes. Firstly, the significant increase of off-balance-sheet derivatives, the increasing use of securitized products and the rising complexity and diversity of financial systems have made financial institutions exposed to more risks. Basel II Advanced Internal Ratings-Based (AIRB) framework was developed to help large institutions to set their minimum regulatory capital requirements by allowing the use of their measures for key drivers of credit risk (Aas, 2005). In our paper, we use this approach as the basis of our research and combine it with the multiple-factor linear regression model to investigate which macroeconomic factors affect the delinquency rate on commercial real estate loans significantly.

Performing macro stress tests is also essential since it is a way to help financial institutions to evaluate the adequacy of existing capital. Stress tests also help banks to forecast the consequences of unexpected macro shocks, which weaken the stability of large banks (Ricardo Schechtmana, 2012). Before the economic crisis, investors tended to miss the encountering risks and underestimate their levels. Thus, in this research, we

conduct macro stress tests to simulate hypothetical scenarios and compute the predicted delinquency rates to see whether banks will default under these circumstances.

2. Literature & Methodology

We use the Vasicek one-factor credit loss model for the design of stress-tests, which serves as the basis of the Basel II (Basel Committee on Bank Supervision) internal rating based (IRB) approach. In this model, credit risk in a portfolio is divided into two categories, systematic and idiosyncratic risk. Systematic risk indicates the effects of unexpected macroeconomic shocks on the credit-worthiness of obligors. Idiosyncratic risk, on the other hand, represents the effects of risk inherent to individual obligor (Aas, 2005). This model is a one-period default model, which means the loss only occurs when an obligor defaults over a fixed time horizon (Luis Ortiz-Gracia, 2011).

Based on the Vasicek one-factor model, the firm-value of obligor *n*, V_n, is defined in the equation as shown below, where Y is the common latent factor indicating the state of the economy or business cycle, ρ_n is the correlation between the assets of obligor *n*, ε_n is the idiosyncratic noise component which represents risks connected to obligor *n*. The latent factor, Y and the idiosyncratic noise component, ε_n are independent and standard normally distributed.

$$V_n = \sqrt{\rho_n}Y + \sqrt{1-\rho_n}\varepsilon_n$$

In the second equation shown as below, we introduce a threshold level, T_n. If the firm-value V_n is below the threshold level T_n, obligor *n* will default. We define $T_n = N^{-1}(p_n)$, where $N(x)$ is the standard normal cumulative distribution function and $N^{-1}(x)$ denotes its inverse. The parameter p_n is the unconditional default probability of obligor *n*. Hence, under the condition where the common latent factor Y was given as y_t, we could calculate the conditional probability of default for obligor *n* by

$$p_n(y_t) = P(V_n < T_n \mid Y = y_t) = N\left(\frac{T_n - \sqrt{\rho}y_t}{\sqrt{1-\rho}}\right)$$

In this model, the following assumptions are made:

1) Portfolios must be 'asymptotically fine-grained', which means that each loan must consist of an infinite number of negligible exposures. Hence, idiosyncratic risk is diversified away on the portfolio level.

2) An 'asymptotic single risk factor' (ASRF) assumption must be made. The ASRF assumption indicates that only systematic risks have a material effect on portfolio losses, while the idiosyncratic risk associated with individual exposures tends to be cancelled out. Moreover, all systematic risk, like industry or regional risk, is modelled with only one systematic risk factor, which is the common latent factor, Y (Aas, 2005).

3) Asset correlations ρ_n is equal to the common asset correlation ρ for all n. In the Vasicek model, correlations between loans are driven by their link to the common latent factor, Y. Thus, we can simplify the real correlation structure as $\rho_n = \rho$, which allows the Vasicek framework to provide a straightforward calculation of the default risk of a portfolio (Chatterjee, 2015).

Consequently, the conditional probability of default depends on the single systematic factor Y, which reflects to what extent the state of the economy or business cycle affects the possibility of a portfolio's default.

Based on the previous model, we can work backward to get the latent factors using the historical data of delinquency rate. We then apply the selected data to the multi-

factor linear regression model to find out which macroeconomic variables can best explain the latent factor. We finally perform stress tests to see to what extent the predicted delinquency rate will react to different scenarios of macro factors.

3. Data and Statistics Summary

3.1 Data selection

All the data is quarterly, seasonally adjusted data between Quarter 1, 1991 and Quarter 3, 2019 from the Federal Reserve Bank of St. Louis. First, we use the Delinquency Rate on Commercial Real Estate Loans (Excluding Farmland) of All Commercial Banks, Percent, as the dependent variable. Delinquent loans and leases refer to the ones that are thirty days or more past due and are still accruing interest, as well as those in nonaccrual status. We draw four macro factors from four separate datasets in Federal Reserve Bank of St. Louis: (1) Unemployment Rate, Percent. The unemployment rate is calculated by the number of people unemployed divided by the total labor force, including both employed and unemployed people. (2) S&P/Case-Shiller U.S. National Home Price Index, Percent Change. The S&P CoreLogic Case-Shiller Home Price Indices are the leading measures of U.S. residential real estate prices, tracking changes in the value of residential real estate both nationally as well as in 20 metropolitan regions. (3) The Average Debt to Equity Ratio of Nonfinancial corporate business, Percent. The debt to equity ratio is a measure of a corporation's financial leverage, and shows to which degree companies finance their activities with equity or with debt. (4) 10-Year Treasury Constant Maturity Minus 2-Year Treasury Constant Maturity, Percent. The following four figures show the historical trends of the macro indicators against the delinquency rate on commercial real estate loans respectively.

Figure 1 Historical Trends of Unemployment Rate and Delinquency Rate

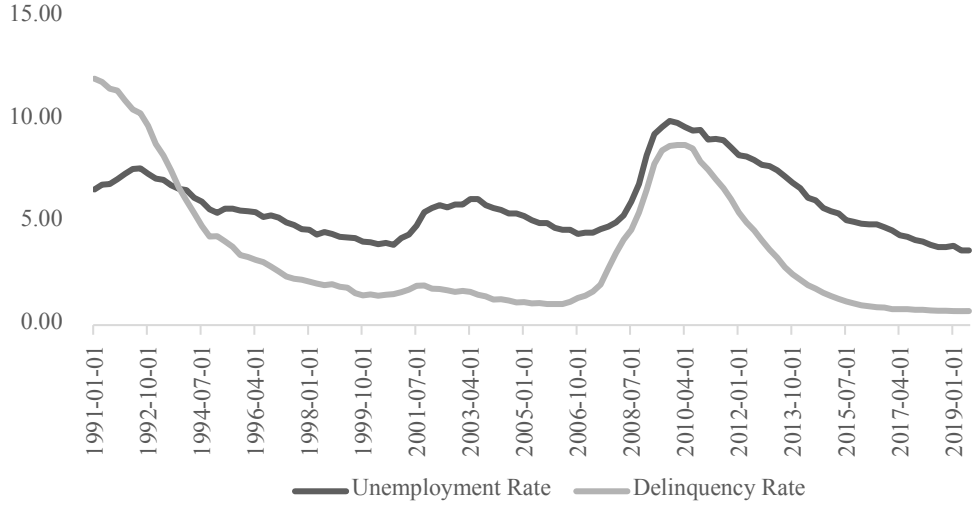


Figure 2 Historical Trends of 10Y and 2Y Yield Spread and Delinquency Rate

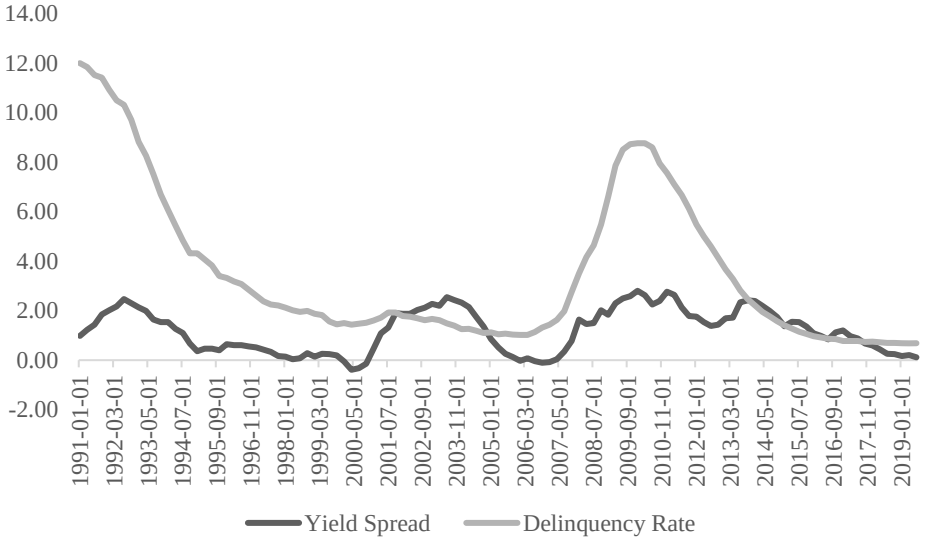


Figure 3 Historical Trends of Home Price Index Growth and Delinquency Rate

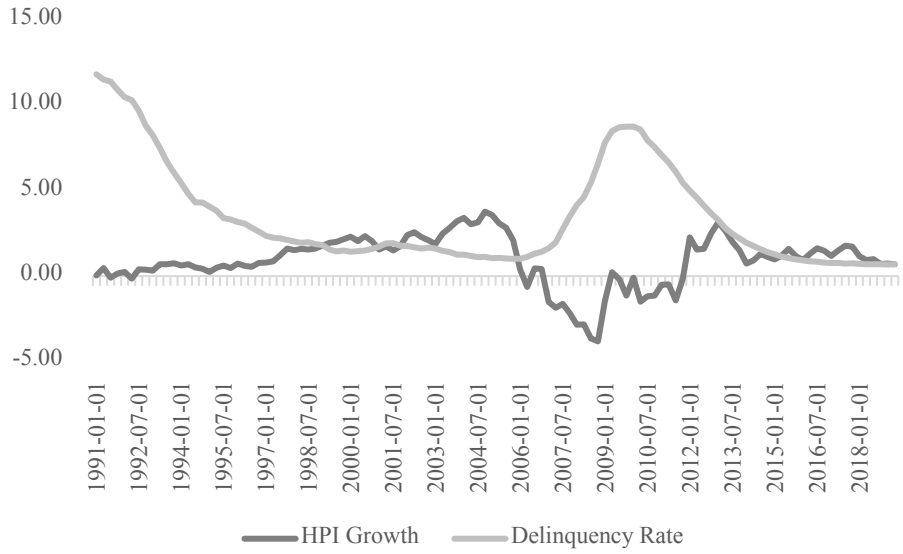
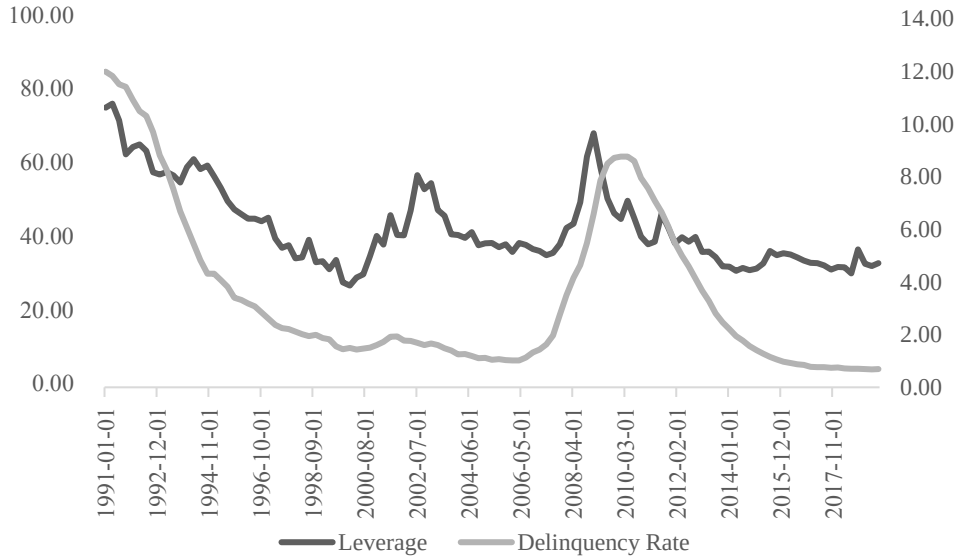


Figure 4 Historical Trends of D/E Ratio and Delinquency Rate



As we can see from the graphs above, all macroeconomic factors have a clear trend during the recession periods, the 1990-1992 Recession, 2000-2001 Internet Bubble, and 2008-2009 Great Recession. Specifically, the unemployment rate and average debt to equity ratio of nonfinancial corporate business (D/E Ratio) are likely to increase at the beginning of the recession and to peak at the end of the recession, while the home price index growth (HPI Growth) drops coincidently with the recession. However, the 10-Year Treasury Constant Maturity Minus 2-Year Treasury Constant Maturity (10Y and 2Y Yield Spread) has been inverted before the recession starts.

3.2 Regression Model

3.2.1 Calculate Latent Factors

There are two parts in our regression model. The first part is to get the latent factor *y*. We first calculate the average delinquency rate and its standard deviation to normalize actual delinquency raw data. In the Vasicek model, the corporate exposures correlation is between 12% and 24% based on the Basel II IRB risk-weighted formula (Chatterjee, 2015). Based on the historical fact that borrowers tend to default on commercial real estate loans together during crisis, we assume the common correlation among all commercial real estate loans portfolio is close to the upper bound, which in our analysis is assumed at 20%. Then we calculate the predicted delinquency rate based on the Vasicek one-factor model. Finally, we use optimization function to minimize the sum of squared errors, which are the squared differences between the estimated delinquency rate and the actual delinquency rate, to find the best estimated latent factors.

3.2.2 Regression Between Latent Factor and Macroeconomics Indicators

In the second part of the regression model, we run a regression based on OLS (Ordinary Least Squares) Estimation to find the relationship between four macroeconomic factors and the latent factor. In the following regression equation, y represents the latent factor, x_1 - x_4 refer to macroeconomic factors, where x_1 is unemployment rate; x_2 is 10Y and 2Y yield spread; x_3 is HPI growth; x_4 is D/E ratio. The intercept is represented as a and the corresponding beta coefficients are b_1 - b_4. ε represents the error term.

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \varepsilon$$

3.2.3 Regression Results

After running the regression between the latent factor and the four macro indicators, we get the following equation

$$y = 2.80 - 0.34 * Unemployment\ Rate + 0.21 * 10Y\ and\ 2Y\ Yield\ Spread + 0.07 * HPI\ Growth - 0.03 * D/E\ Ratio + \varepsilon$$

The following three tables exhibit the regression results. The first table lists the regression results for each parameter in the regression equation as well as their corresponding t statistics and P value. The t statistics and P-value show that all variables are statistically significant at a 5% level. The second table provides the analysis of variances, including sum of squares and F-statistics. The third table lists estimation parameters of this regression, such as R squared and adjusted R squared. An adjusted R squared of 87% means 87% of the change in the dependent variable is explained by the change in independent variables.

Table 1 Results of Regression Model at 95% Significance Level

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	2.80	0.16	17.69	0.00	2.49	3.12
Unemployment Rate (%)	-0.34	0.03	-11.89	0.00	-0.40	-0.28
10Y and 2Y Yield Spread (%)	0.21	0.05	4.41	0.00	0.12	0.31
HPI Growth (%)	0.07	0.02	3.57	0.00	0.03	0.11
D/E Ratio (%)	-0.03	0.00	-10.95	0.00	-0.04	-0.02

Table 2 Analysis of Variance

ANOVA	df	SS	MS	F	Significance F
Regression	4	54.93	13.73	185.87	0.00
Residual	110	8.13	0.07		
Total	114	63.06			

Table 3 Regression Model Estimation Parameters

Regression Statistics	
R Square	0.87
Adjusted R Square	0.87
Standard Error	0.27
Observations	115

4. Stress Test

Stress test is one of the most common methods for banks to assess credit risk originating from their loans outstanding. We conduct stress tests using three methods: (1) stress tests for hypothetical statistical scenarios; (2) stress tests under control variate method; and (3) stress tests for simulated recessions. We assume some extreme scenarios which have never happened before but could happen in the future to see whether financial institutions can maintain a certain level of capital under those circumstances.

4.1 Stress Test for Hypothetical Scenario

First, we calculate estimated latent factors based on the regressed coefficients and intercept. Next, we estimate delinquency rate by using latent factor data as the input variable in the Vasicek one-factor Gaussian copula model.

We create some hypothetical scenarios from a statistical analysis perspective by changing all macroeconomic indicators. Under our hypothetical scenarios, we calculate predicted delinquency rate when all macroeconomics variables move to an unfavourable direction at 0.5 standard deviation, 1 standard deviation, 1.5 standard deviations and 2 standard deviations away from the historical average value synchronously. As all macroeconomics variables move into the unfavourable direction at the same degree simultaneously, we have the worst possible scenario.

Table 4 shows the results of stress test for hypothetical scenarios. The model predicts a default rate of 21.90% if the unemployment rate increases to 9.09% (2 standard deviations above the average); HPI Growth decreases to -2.04%; T10Y and 2Y Yield Spread becomes inverted at -0.55%; and D/E ratio increases to 65.46%. This represents

the worst hypothetical recession we may encounter, even though we have never had a delinquency rate at 21.90% since 1991. From the statistical analysis perspective, we expect a 20.57% delinquency rate at the worst 5% case. Moreover, during a moderate recession, when all macroeconomics variables move 1 standard deviation away from their average towards an unfavourable direction, the model leads to a predicted delinquency rate of 8.73%, which is quite close to the historical delinquency rate during the recession.

Table 4 Hypothetical Scenario Stress Test

	Hypothetical Scenario			
	0.5 SD	1 SD	1.5 SD	2 SD
Unemployment Rate (%)	6.67	7.48	8.28	9.09
10Y and 2Y Yield Spread (%)	0.76	0.33	-0.11	-0.55
HPI Growth (%)	0.16	-0.57	-1.31	-2.04
D/E Ratio (%)	48.97	54.47	59.97	65.46
Latent Factor	-0.75	-1.33	-1.91	-2.49
Predicted Delinquency Rate (%)	4.96	8.73	14.31	21.90

4.2 Stress Test Based on Control Variate Method

4.2.1 Change Unemployment Rate

Here we hold the other three variables as the historical mean and only change the unemployment rate. Table 5 provides the outcomes of delinquency rate at three corresponding different unemployment rate levels (10%, 20% and 25%). Firstly, we apply the historically highest unemployment rate 25% in 1929 and generate an extremely high expected delinquency rate 90.31%. If we adjust the unemployment rate to 20% or 10%, the forecasted default rate will go up to 67.47% and 10.75%, respectively. From a

series of experiments, we can see that the unemployment rate is a key driver of a high delinquency rate on commercial real estate loans.

Table 5 Stress Test for Unemployment Rate

	Unemployment 10%	Unemployment 20%	Unemployment 25%
Unemployment Rate (%)	10.00	20.00	25.00
10Y and 2Y Yield Spread (%)	1.20	1.20	1.20
HPI Growth (%)	0.89	0.89	0.89
D/E Ratio (%)	43.48	43.48	43.48
Latent Factor	-1.56	-4.95	-6.64
Predicted Delinquency Rate (%)	10.75	67.47	90.31

4.2.2 Change 10Y and 2Y Yield Spread

Here we only assign value changes for 10Y and 2Y Yield Spread and keep the other three variables at their historical mean. Table 6 provides the outcomes of delinquency rate at three corresponding different 10Y and 2Y Yield Spread levels (-0.5%, -1.5% and -2%). In the scenario of a -2.00% 10Y and 2Y yield spread, which is the historical minimum that happened in March 1980. The predicted default rate is 5.51%, which is moderate compared with the delinquency rate during historical recessions. Then we test -1.50% and -0.50%, the two lowest values after downward trends. The forecasted default rate are 4.94% and 3.94% respectively. Therefore, predicted delinquency rate on commercial real estate loans will increase as 10Y and 2Y yield spread gets worse. The decrease of 10Y and 2Y yield spread lead a slight impact on the forecasted delinquency rate.

Table 6 Stress Test for 10Y and 2Y Yield Spread

	Yield Spread -0.5%	Yield Spread -1.5%	Yield Spread -2%
Unemployment Rate (%)	5.87	5.87	5.87
10Y and 2Y Yield Spread (%)	-0.50	-1.50	-2.00
HPI Growth (%)	0.89	0.89	0.89
D/E Ratio (%)	43.48	43.48	43.48
Latent Factor	-0.53	-0.74	-0.85
Predicted Delinquency Rate (%)	3.94	4.94	5.51

4.2.3 Change D/E Ratio

In this part, we examine how the D/E ratio affects the delinquency rate of commercial real estate loans while keeping all other variables at a historical average level. Table 7 provides the outcomes of delinquency rate at three different D/E ratio levels (60%, 80% and 100%), which corresponds to above-average leverage scenario, high leverage scenario and extremely high leverage scenario.

The first scenario illustrates a recession where the average debt to equity ratio goes up to 60%, like in the early 1950s, 2000-2001 or 2008-2009 recession. Over these periods, the firm leverage ratio is above average, and our model forecasts a delinquency rate of 4.53%. If the average debt to equity ratio increases to 80% in the second scenario, our predicted delinquency rate would be 8.17%. Finally, when we assume an extremely high leverage ratio like in the 1981 recession, the average firm debt to equity ratio was over 100%, dramatically close to bankruptcy level, and the delinquency rate is expected to go up to 13.69%. To sum up, D/E ratios positively affect commercial real estate delinquency rate, and it has a moderate effect compared with the HPI growth rate and 10Y & 2Y yield spread.

Table 7 Stress Test for D/E Ratio

	D/E Ratio 60%	D/E Ratio 80%	D/E Ratio 100%
Unemployment Rate (%)	5.87	5.87	5.87
10Y and 2Y Yield Spread (%)	1.20	1.20	1.20
HPI Growth (%)	0.89	0.89	0.89
D/E Ratio (%)	60.00	80.00	100.00
Latent Factor	-0.66	-1.26	-1.85
Predicted Delinquency Rate (%)	4.53	8.17	13.69

4.2.4 Change National Home Price Index (HPI) Growth

In this part, we will examine how changing the National Home Price Index growth rate affects the delinquency rate of commercial real estate loans. The results are shown in Table 8. It is necessary to mention that HPI growth rate data is not available until Q1 1987. We apply an HPI growth rate of -3.92% in 2008, which is the lowest level since Q1 1987, to one of our simulated scenarios.

The first scenario illustrates a recession when the home price index growth rate drops to -4% level which produces an expected delinquency rate of 3.86%. For stress test purpose, we create two additional scenarios represent more serious situations compared with the first one. If HPI growth decreases to -7% level, the expected delinquency rate go up to 4.84%. When a horrible recession comes, and HPI growth goes down to -10% level, the forecasted commercial real estate loan delinquency rate increases to 6.00%. As we can see from the result, HPI growth has a negative effect on the delinquency rate, even though this influence is not significant.

Table 8 Stress Test for HPI Growth

	HPI -4%	HPI -7%	HPI -10%
Unemployment Rate (%)	5.87	5.87	5.87
10Y and 2Y Yield Spread (%)	1.20	1.20	1.20
HPI Growth (%)	-3.92	-7.00	-10.00
D/E Ratio (%)	43.48	43.48	43.48
Latent Factor	-0.51	-0.72	-0.93
Predicted Delinquency Rate (%)	3.86%	4.84%	6.00%

4.2.5 Yield Curve Inverse with Unexpected Unemployment Rate

The yield curve has been a powerful tool to forecast the upcoming recession. Six out of seven yield curve inverses indicated the approaching recessions in the past. Table 9 exhibits the estimated delinquency rate under a scenario where we combine a negative yield spread with an unexpected unemployment rate. When yield spread is inverted to -2%, the lowest level in history, which indicates an approaching recession; the unemployment rate increases to 10%; HPI Growth remains at an average level of around 0.89% and nonfinancial firms have an average D/E ratio of 43.48%, the corresponding expected delinquency rate is 29.16%.

Table 9 Stress Test for Yield Curve Inverse with Unexpected Unemployment Rate

	Yield Inverted
Unemployment Rate (%)	10.00
10Y and 2Y Yield Spread (%)	-2.00
HPI Growth (%)	0.89
D/E Ratio (%)	43.48
Latent Factor	-2.25
Predicted Delinquency Rate (%)	18.46%

4.3 Stress Test Based on Historical Recessions

In the first part of stress tests, we create some hypothetical scenarios from a statistical analysis perspective and compute the predicted delinquency rate. Then we use the control variate method to see how each macro factor influences the delinquency rate. Now we tend to simulate some actual historical scenarios, for example, the 1980 recession, the 2008-2009 financial crisis, the great depression, to see how the expected delinquency rate changes under these extreme circumstances. The results are shown in Table 10.

4.3.1 The Financial Crisis in 2008-2009

Before the 2008-2009 economic crisis, some trends emerged in the banking industry. On the one hand, securitization became increasingly popular. Banks repackaged loans and passed them on to various financial investors, which gave rise to incremental use of financial instruments such as collateralized debt obligations (CDOs), credit default swaps (CDS). On the other hand, since most investors prefer assets with short maturities, banks increasingly financed their assets with shorter maturity instruments, resulting in the maturity mismatch. This strategy also raised the popularity of shadow banks and structured products such as short-term repurchase agreements. Structured products were supposed to be of low default and low correlation, helping banks lower funding interest rates, making regulatory and rating arbitrage, and gaining more favourable ratings. However, they also led to cheap credit and low lending standards, which carried a foreshadowing of the coming recession.

Losses on subprime mortgages were a trigger for the crisis, while shadow banking added the source of crucial vulnerabilities. The disruptions in the U.S. short-term debt

markets forced a shortage of U.S. dollars in global markets; the reduction of policy rates made banks more reluctant to lend money; meanwhile, the financial institutions tended to hoard liquidity, which finally transmitted the crisis to the real economy. Thus, we choose the worst amount of each variable during the recession to simulate the worst case. The unemployment rate went up to a maximum of 10.00% in October 2009, the worst 10Y and 2Y yield spread was -0.15% in November 2006, the HPI growth rate reached the lowest at -3.82% in 2008, and D/E ratio hit the maximum at 68.94% in Q1 2009. We input those data and get the forecasted delinquency rate as 18.46%, which is much higher than the actual delinquency rate of 8.76% in Q1, 2010. The difference may be because we plugged in the worst values from different timings. Among all variables, the yield spread between 10Y and 2Y bond yield spread got the minimum value before the 2008 financial crisis, and the home price index growth rate was the historical lowest during 2008, while the other two factors did not reach the worst levels until the end of the recession.

4.3.2 The 1981 Recession

The 1981 recession was one of the worst recessions that the U.S. has encountered in history. Unlike previous traditional recessions, key indicators of the 1981 recession include a high inflation rate, a negative GDP growth rate, and a high leverage ratio. To simulate the 1981 recession for the stress test, we assume unemployment rate goes up to the worst level during the recession at 10.80%, 10Y and 2Y yield spread inverted to the worst level at -2.14%, average nonfinancial firms D/E ratio reaches 102.44% and HPI growth drops to 0.89%. Our assumption is based on the actual but the worst cases of macroeconomic data during the 1981 recession. Even though not all macroeconomics variables approach to the worst level simultaneously, these assumptions give us the worst

possible scenario that could happen when the recession comes into place. We expect a delinquency rate of 55.33%, significantly higher than the historical value. The recession was initially caused by increasing oil prices from OPEC countries, from which the U.S. had to import oil to maintain its industrial production level. As one of the key components of GDP, the net export of U.S. declined due to a massive increase in oil import cost, leading to a negative GDP growth rate. When the economic growth rate slowed down below its potential output, firms needed fewer labours, so that the unemployment rate would be higher. An increasing unemployment rate would put downward pressure on consumption, which accounts for about 70% of the U.S. GDP; hence, the recession would be further worsening. Meanwhile, the U.S. federal reserve has two main goals to achieve, including keeping inflation target at 2% and keeping GDP growth rate stable. During stagflation, the U.S. federal reserve must make a trade-off between those two goals. At that time, the average debt to equity ratio has reached 80%-100%, the highest level in U.S. history. When federal reserve increases interest rates to fight against high inflation, firms face colossal stress on their debt service and are more likely to default.

4.3.3 The Great Depression in 1929-1933

We replicate the great depression from August 1929 to March 1933 using the worst cases for each macro factors in U.S. history. This is to see the highest level of delinquency rate with the worst scenario which has never happened before. After plugging in all the data, as shown in Table 10, we get the expected delinquency rate as 99.66%, which means almost all the investors default on commercial real estate loans.

Table 10 Historical Recession Stress Test

	1981 Recession	Recession Like 2008	The Great Depression
Unemployment Rate (%)	10.80	10.00	25.00
10Y and 2Y Yield Spread (%)	-2.14	-0.15	-2.14
HPI Growth (%)	0.89	-3.82	-3.82
D/E Ratio (%)	102.44	68.94	102.44
Latent Factor	-4.31	-2.95	-9.45
Predicted Delinquency Rate (%)	55.33%	29.16%	99.66%

5. Conclusion

Using the historical data of unemployment rate, 10Y and 2Y bond yield spread, HPI Growth and D/E ratio of nonfinancial business between Quarter 1, 1991 and Quarter 3, 2019, we find some essential linkages between commercial real estate loans delinquency rate and the four macroeconomic factors.

When recessions occur and more commercial real estate loans obligors' default, financial institutions face substantial potential losses. That is because commercial real estate loans outstanding are vital components of financial institutions' assets. Financial institutions will have liquidity issues when their assets are shrinking during the recession and owners' equity becomes negative. If one commercial bank gets into trouble and could not meet capital requirements, other financial institutions are likely to face the same situation. Financial contagion will lead to further bankruptcy and a negative GDP growth rate. As we can see from this study, the delinquency rate of commercial real estate loans could reach more than 20% during the worst scenario. Even though the U.S. has never had commercial real estate loans delinquency rate over 12%, financial institutions should consider the potential high default risk and keep enough capital to survive during the recession.

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