Understanding the difference in risk taken by banks with and without a bailout guarantee during a financial crisis

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Abstract

The difference in difference methodology was used to make causal inference on observational data of the 2008 financial crisis. It was revealed that banks with a bailout guarantee from the government take on significantly more risk during the financial crisis than those without. Data was collected from banks in OECD countries that were not directly affected by the toxic assets that led to the crisis and the final model controlled for bank size to prevent confounding variables in predicting bank risk. The results were deemed trustworthy as no assumptions were clearly violated.

Keywords: Financial Crisis, Bailout Guarantee, Bank Risk, Causal Inference, Difference-in-Difference

Introduction

Smoking in adults cannot be experimentally studied by randomly assigning people to smoke at it is unethical. In such cases, observational studies are conducted, causal inference methodologies are used and meaningful results are obtained. Similarly, it is difficult and unethical to subject banks to pressures of bankruptcy to see how they would behave. However, events such as the 2008 financial crisis allow us to conduct observational studies on financial institutions that would have been impossible to simulate. This paper will study one such impact on banks around the world due to The Great Recession.

One of the major concerns and critiques of how the 2008 financial crisis was handled was which banks received financial aid from the U.S. government to prevent them from dissolving due to insufficient funds. Generally, the big banks with a lot of assets and financial connections to several industries were bailed out of bankruptcy while the smaller banks were allowed to fail. The government's assumption here was that if big banks failed, its rippling effect would crumble the economy even more. This assumption is evident in other countries as well; bigger banks are generally given a bailout guarantee in case of another financial crisis meaning they would never fail. A guarantee like this has several implications. According to the moral hazard hypothesis, banks with such a guarantee are less careful at monitoring the risk of their investments(Flannery, 1998). Banks have an incentive to invest in risky assets as it leads to higher returns on investment, however, too much risk would mean a higher chance of bankruptcy which the government would need to help out with money collected through taxes. This is inefficient for the economy as that money could have been used for more useful purposes such as infrastructure, subsidies, research and development etc.

To test this hypothesis, data on banks around the world will be used to check whether banks really take on more risk during a crisis if they are backed with a bailout guarantee. This data includes information on risks different banks have taken over the years, size of the banks, the bank's country's economic attributes and whether they received a bailout guarantee during the 2008 financial crisis. Using this data, the following research question will be answered, "How does bank risk differ for banks with and without bailout guarantee during a financial crisis?"

Data

The data collected contains a sample of banks from OECD (Organisation for Economic Co-operation and Development) countries that were not directly affected by the 2008 financial crisis. While this may seem counter-intuitive, banks from countries directly affected by the financial crisis such as North American countries and several European countries had stake in a lot of 'toxic' assets that led to the crisis itself. It is unhelpful to consider these countries as the banks' 'toxic' assets owned before the crisis would explain much of the risk during the crisis, interfering with the ability to measure the change in risk due to a bailout guarantee. Since the 2008 financial crisis was a worldwide phenomenon, other countries not directly engaged in these 'toxic' assets are considered. Total risk of assets owned by banks in this data set is measured through the natural log of Z_Score, a common unit used in finance. It has an inverse relationship with risk, as risk increases, the value of $ln(Z\_Score)$ decreases.

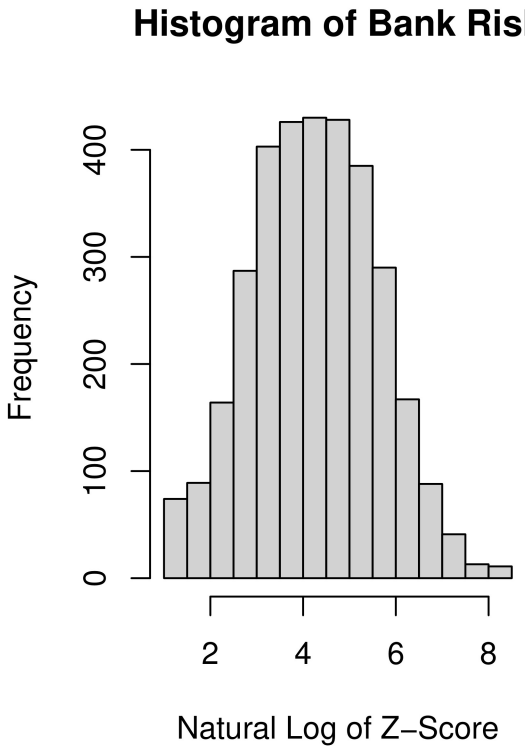
The probability that a bank would receive a bailout guarantee was collected from major rating agencies. Those that would receive it are given a score of 1 while those that don't are given 0 in the 'treated' column. Size of banks are related with the amount of risk that they take therefore to compensate for this confounding variable, amount of assets owned by a bank and its liquidity ratio will be used to assess and control the size of banks. Amount of assets owned by banks is measured by the natural log of assets and liquidity ratio is measured through the ratio of liquid assets to short term liabilities. Information on both these variables were collected pre-crisis (before 2007) to avoid problematic observations due to the effect of crisis on these variables. The last important variable in our data set is the year that the data point for a given bank was collected. This information is used to filter the data to only include years 2005 to 2010. This is further divided into two parts. A new categorical variable called crisis is formed with years 2005, 2006 and 2007, considered as the pre-crisis period, given a value of 0 and years 2008, 2009 and 2010, the crisis period, given a value of 1.

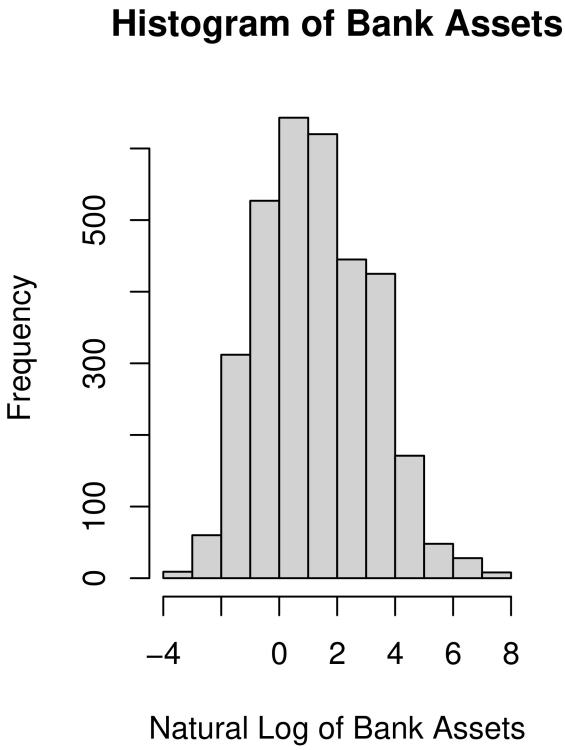
The main data set contains more variables on the economic attributes of the country that the bank is situated in however, since they do not contribute to the study, they will dropped from the data. A glimpse of the main variables is given in the Appendix Table A1. This final data set was obtained by only selecting the important variables mentioned above and dropping rows with information that is not available. Columns 'treated' and 'crisis' were converted to categorical variables. Given below are numerical summaries of risk ($ln(Z\_Score)$), assets ($ln(Assets)$) and liquidity ratios of banks. Following is a table with numerical summaries of the variables.

Table 1: Numerical Summary

	dt (N = 3,296)
Bank ID	
minimum	10,582.00
median (IQR)	26,369.00 (18,169.00, 33,248.00)
mean (sd)	28,272.30 ± 10,713.25
maximum	52,637.00
Year	
minimum	2,005.00
median (IQR)	2,009.00 (2,008.00, 2,010.00)
mean (sd)	2,008.31 ± 1.47
maximum	2,010.00
LN(Z_Score), winsorized at 1%	
minimum	1.13
median (IQR)	4.23 (3.28, 5.21)
mean (sd)	4.24 ± 1.35
maximum	8.15
crisis	
0	800 (24)
1	2,496 (76)
treated	
0	2,572 (78)
1	724 (22)
Natural logarithm of Total assets fixed (2007) before crisis	
minimum	-3.32
median (IQR)	1.17 (-0.12, 2.64)
mean (sd)	1.28 ± 1.89
maximum	7.66
Liquid assets over short funding ratio fixed (2007) before crisis	
minimum	0.00
median (IQR)	0.17 (0.07, 0.28)
mean (sd)	0.22 ± 0.32
maximum	5.85

The data set contains more information on banks during the crisis period with 2,496 data points compared to 800 data points pre-crisis. Similarly, more data points are available on banks without bailout guarantee at 2,572 compared to those with guarantee at 724. While there is huge difference in the number of data points in these 4 scenarios, there are a significant amount of data points in each which would presumably allow us to conduct a meaningful study. Continuous data like the bank risk and assets owned seem to have a normal distribution as their mean and median fall close to center of the range. This will be helpful in making accuracy claims of the linear model showcased later. Histograms of these two variables are showcased below to check for normality. Liquidity ratio, on the other hand, seems highly skewed towards the lower range according to the numerical summary table.





Methods

The difference-in-difference methodology will be used in this study. As mentioned earlier, this is a great way to make causal inference on observational data. This methodology compares the change in a dependent variable for a treatment group and a control group under two different scenarios. Difference in difference can be easily represented in the functional form through linear regression as a dummy variable. For instance consider the following formula:

$$Y_{i,t} = \beta_0 + \beta_1 \text{Treatment group dummy}_i + \beta_2 \text{Time dummy}_t + \beta_3 (\text{Treatment group dummy} \times \text{Time dummy})_{i,t} + \beta_4 \text{Control Variable} + \epsilon_{i,t}$$

The coefficient of the interaction variable between the treatment and time dummy variable, β_3 is the main interest of the difference in difference study. It will answer the research question, what is the difference of risk taken by banks with and without bailout guarantee. For this study the dependent variable is the bank risk, the treatment group is banks with bailout guarantee and the control group is banks without it. The change in risk for these two groups is measured over the pre-crisis and during crisis scenarios represented by the time dummy. β_4 is the coefficient for the control variable. In this case it would be the size of the bank. This control variable should be able to better explain the variation in the dependent variable thus indirectly increase the significance of other predictors including the interaction term.

There are four main 'threats to validity' to watch out for in this method (Alexander, 2021). First are non-parallel trends. It mentions that the pre-treatment differences in the dependent variable should be consistent. This assumption can never be proved because in observational studies, the treatment group

cannot be controlled to check if the differences in the dependent variable are consistent. The second threat to look out for is changes in the composition of data or compositional differences. For instance, there are more data points for the during crisis period than pre-crisis. It should not be the case that these extra banks are the reason for the change in risk. Therefore it is assumed that all banks in the data have similar characteristics for their given size. Third is the argument of long-term effects and reliability. Too long of an observational study would mean higher probability of other factors affecting the results and too short would lead to doubts on the reliability of the study. We assume that the three years for the pre-crisis and during crisis period are sufficient time periods to give reliable results. The fourth and last threat to validity stems from functional form dependence. It mentions that the treatment and control group should have similar outcomes at the baseline else the difference in difference effect may be extremely sensitive to the functional form. This threat will be assessed in the results.

Results

As mentioned in the methods section, a linear model was created and Table 2 below gives an estimate and significance of the coefficients.

Table 2: Linear Model Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	4.5328	0.0650	69.71	0.0000
crisis1	-0.3447	0.0681	-5.06	0.0000
treated1	-0.0242	0.1032	-0.23	0.8146
ln_assets_pre2007	0.0415	0.0159	2.60	0.0093
liquidAssetsToStFunding_pre2007	-0.1479	0.0736	-2.01	0.0445
crisis1:treated1	-0.3576	0.1210	-2.96	0.0031

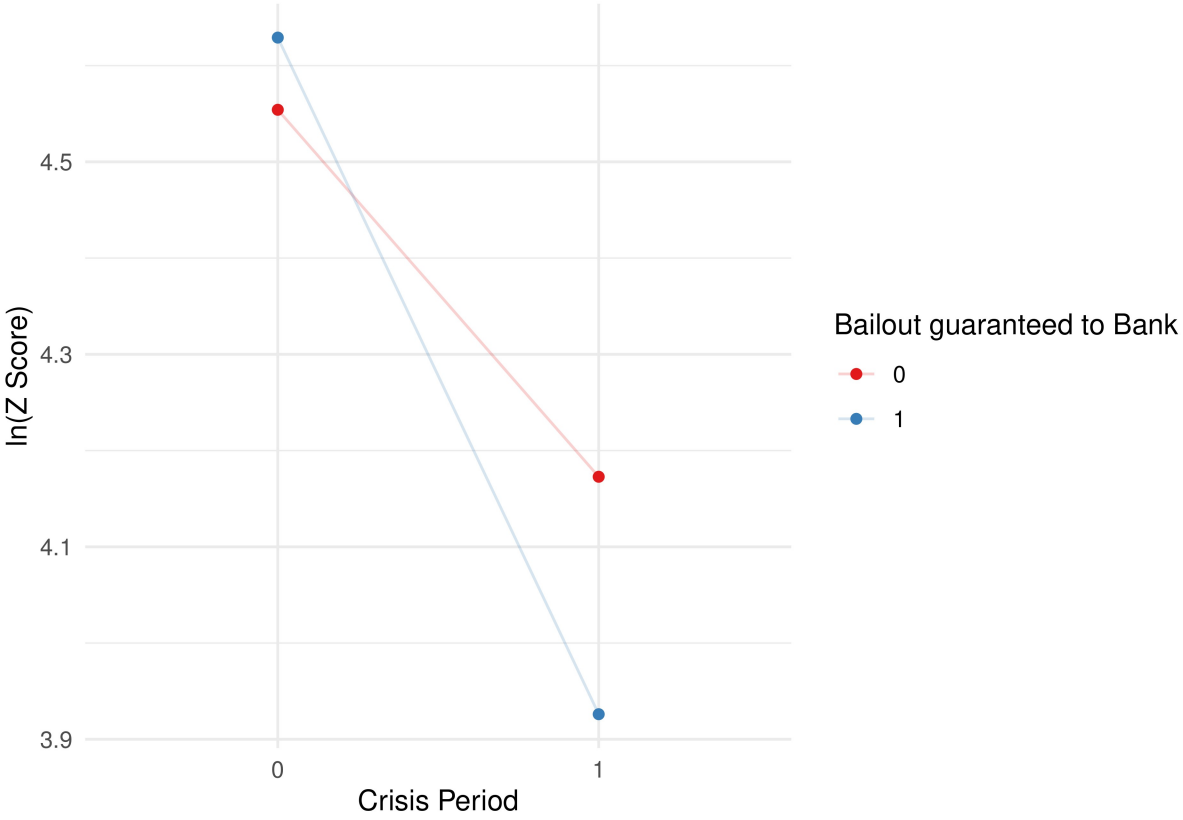
Pr(>|t|) indicates the p-value of the coefficients. A p-value of less than 0.05 indicates a 95% confidence level in the estimate. The only coefficient estimate with a p-value more than 0.05 is that of the treatment group. This indicates that, given all else equal during the pre-crisis period, whether the bank was a part of the treatment group or the control group, it didn't have a significant impact on the bank risk. This supports the parallel trends assumption and extinguishes any concerns of functional form dependence as the banks with and without bailout guarantee are shown to have similar outcomes at the baseline over the period of three years before the crisis.

The main variable of interest is the interaction term between the treatment group and the crisis period. It has an coefficient estimate of -0.3576 and it is highly significant with a p-value of 0.0031. This means that going into the crisis, banks of the same size, that were a part of the treatment group had on average a ln(Z Score) of 0.3576 units lower than banks without a bailout guarantee. A lower Z Score is associated with higher bank risk. Thus, it proves the moral hazard hypothesis that banks are less careful and thus take on more risk when assured with a bailout guarantee. Size of the banks, measured with assets owned and liquidity ratio, is also significant in predicting bank risk. More assets owned tend to lead to lower bank risk while higher liquidity ratio tend to lead to higher bank risk on average.

The coefficient of determination or adjusted R^2, tells a different story. At 0.0263655, this is a relatively low value which indicates that very little of the variation in the response is explained by the variables in the linear model. Even though they are significant variables, this low score indicates that the bank risk can be better explained through more predictors. However, as far as the purpose of this study goes, the hypothesis is supported with a significant value. The functional form of the difference in difference method is given below:

$$\begin{aligned} Y_{i,t} = 4.5328 &- 0.0242 \text{ Treatment Group}_i - 0.3447 \text{ During Crisis}_t - 0.3576(\text{ Treatment group} \times \text{During Crisis})_{i,t} \\ &+0.0415 \text{ Assets Owned} - 0.1479 \text{ Liquidity Ratio} + \epsilon_{i,t} \end{aligned}$$

The change in the Z Score is observable in the following graph too. As can be seen, both the treatment (blue) and control group (red) start off at a similar baseline pre-crisis. However, the Z Score drops significantly more for the treatment group indicating a higher risk taken by banks with bailout guarantee during crisis.



Conclusions

The results of this study supported the moral hazard hypothesis through the difference in difference causal inference methodology. Specifically it supported the belief that banks with bailout guarantee (treatment group) during a crisis are more willing to take on risk than those without a bailout guarantee (control group). The risk taken by the treatment group was 0.3576 ln(Z Score) units lower than that of the control group. ln(Z Score) has an inverse relationship with risk. That is, a lower Z Score means higher bank risk. The final model obtained is given below

$$Y_{i,t} = 4.5328 - 0.0242 \text{ Treatment Group}_i - 0.3447 \text{ During Crisis}_t - 0.3576(\text{ Treatment group} \times \text{During Crisis})_{i,t} + 0.0415 \text{ Assets Owned} - 0.1479 \text{ Liquidity Ratio} + \epsilon_{i,t}$$

Applying the results of this study to the assumption that bigger banks generally have a higher probability of a bailout guarantee, it would mean that bigger banks are likely to take on more risk. This also means that bigger banks are more likely to earn higher returns on investments. This is unfair for smaller banks with no bailout guarantee while bigger banks are benefiting at the expense of federal reserves. This study has several implications for regulators as they must take action against big banks or support smaller ones to maintain level playing ground for a free and competitive banking market.

Most of the assumptions of the difference in difference methodology were satisfied. While it cannot be proven, the parallel trends movement and the functional form independence were supported by three years

of data with similar baselines for both the treatment and control group pre-crisis. More rigorous methods and better variables could have been used to predict the bank risk as adjusted coefficient of determination was relatively low. Future work could involve testing more variables related to the banking industry to predict risk. This could give more accurate depictions on the effects of bailout during a crisis. Lastly, given the recent changes due to the pandemic, more observational studies can be conducted to assess the effectiveness of rules regulators must have instated for banks with bailout guarantee after the 2008 financial crisis. This would study if these banks are more responsible of the risk that they take now.

In this era of information, a lot more data is going to be available for observational studies to assess the economic and financial outcomes of banks. This study was one of many that can allow us to better predict outcomes and prevent crises in the future. Such studies would also better inform the public on how their hard earned money, paid as taxes, is used by the government.

Bibliography

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All analysis for this report was programmed using `R version 4.0.4`.

Appendix

A1: Ethics Statement

It is important to remember that this is an observational study and that any associations found between bank risk and bailout guarantee during a crisis does not explicitly prove causation. One of the reasons for this is confounding variables that need to be controlled for. While bank size was controlled in this study, the coefficient of determination indicated that there were many other factors needed to be taken into account. This study also supports reproducibility as one can replicate this study by simply following the data and methods sections which clearly indicate the steps taken to achieve the results.

A2: Materials

	indexNumber	year	w__ln__zScore	crisis	treated	ln__assets__pre2007	liquidAssetsToStFunding__pre2007
1	10233.00	2009.00	2.16	1	0	-0.16	
2	10233.00	2010.00	2.11	1	0	-0.16	
3	10582.00	2009.00	3.02	1	0	3.99	1.15
4	11622.00	2008.00	3.54	1	0	-1.49	5.85
5	11622.00	2010.00	2.45	1	0	-1.49	5.85
6	11622.00	2009.00	3.44	1	0	-1.49	5.85
7	11907.00	2009.00	3.72	1	0	3.14	0.46
8	11907.00	2010.00	3.83	1	0	3.14	0.46
9	12043.00	2008.00	1.13	1	0	-2.34	0.16
10	12043.00	2009.00	1.90	1	0	-2.34	0.16