# ESTIMATING THE EFFECT OF A BANKING REGULATION

**Group Project 2**

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# 1. Determining Impact to Banks' Trading Assets After DFA

**Data Preparation**

The dataset contained missing values, and in order to maintain data integrity and streamline the data analysis process, these missing values were first removed before carrying out any analysis. This elimination of missing data not only ensures the dataset's reliability but also reduces the complexity associated with managing incomplete information during analysis.

To determine the impact or "affectedness" of the Volcker Rule, the team calculated the average trading asset ratio for a bank holding company (BHC) over the 20 quarters leading up to introduction of the Volcker Rule. This period, referred to as the pre-DFA period, encompasses quarters from Q3 2004 to Q2 2009. This ensures that the matching process and subsequent analysis focus on the impact of the treatment itself rather than any other external factors. For this data, we labelled it as "*Affect*".

**Control Variables Selection**

By choosing fewer control variables in a regression model, it helps to avoid overfitting the model. The dataset has been filtered to pre-DFA period (Q3 2004 to Q2 2009) before the following analysis is carried out.

To select the variables, the team used Pearson correlation to understand the degree of association of the numerical variables with the Trading Asset Ratio. From ***Figure 1*** below, it shows that *dep_lnassets* and *dep_depositratio* are more associated with the Trading Asset Ratio, *bhc_avgtradingratio*.

```
Correlations with 'Output' column:
bhc_avgtradingratio       1.000000
dep_roa1                 -0.014601
dep_leverage             -0.045061
dep_lnassets              0.404403
dep_creditrisk_total3     0.015372
dep_cir                  -0.005097
dep_depositratio         -0.365469
dep_loans_REratio        -0.183954
dep_liquidity             0.071550
Name: bhc_avgtradingratio, dtype: float64
```

***Figure 1: Pearson Correlation between All the Numerical Variables and Trading Asset Ratio***

As for the categorical variable, the team carried out the one-way ANOVA and CPP appeared to be significant (P-value <0.05) to Trading Asset Ratio (see ***Figure 2***).

```
F-statistic: 25.513516767952233
p-value: 4.4245643999030296e-07
```

***Figure 2: ANOVA between Trading Asset Ratio and CPP***

Hence, the following control variables were used in our model.

| | |
|---|---|
| dep_lnassets | Total assets, natural logarithm of total assets |
| dep_depositratio | Deposit ratio, average deposits divided by average total assets |
| dep_cpp_bankquarter | CPP recipient indicator, capital Purchase Program indicator variable |

***Table 1: Selected control variables***

**Baseline Model**

The team began by testing a basic model (see ***Figure 3***) that incorporated a time indicator (*After_DFA_1*) and introduced our set of control variables (see ***Table 1***). In addition to this, we included the interaction term between the impact (of the DFA) and the post-DFA period; as well as a continuous variable '*Affect*' that captures the degree to which each bank is affected. In the next model, the team complemented the above model by adding on BHC and quarter fixed effect (see ***Figure 4***).

OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | bhc_avgtradingratio | R-squared: | 0.902 |
| Model: | OLS | Adj. R-squared: | 0.902 |
| Method: | Least Squares | F-statistic: | 6.120e+04 |
| Date: | Thu, 19 Oct 2023 | Prob (F-statistic): | 0.00 |
| Time: | 21:16:12 | Log-Likelihood: | 1.4705e+05 |
| No. Observations: | 40026 | AIC: | -2.941e+05 |
| Df Residuals: | 40019 | BIC: | -2.940e+05 |
| Df Model: | 6 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| const | -0.0033 | 0.000 | -7.128 | 0.000 | -0.004 | -0.002 |
| Affect | 0.9928 | 0.002 | 405.033 | 0.000 | 0.988 | 0.998 |
| after_DFA_1 | 1.992e-05 | 6.7e-05 | 0.297 | 0.766 | -0.000 | 0.000 |
| dep_lnassets | 0.0002 | 2.66e-05 | 8.760 | 0.000 | 0.000 | 0.000 |
| Affect*after_DFA_1 | -0.1604 | 0.003 | -52.682 | 0.000 | -0.166 | -0.154 |
| dep_depositratio | 0.0002 | 0.000 | 0.808 | 0.419 | -0.000 | 0.001 |
| bank_1 | -0.0002 | 0.000 | -1.773 | 0.076 | -0.000 | 2.34e-05 |

| | | | |
|---|---|---|---|
| Omnibus: | 51872.408 | Durbin-Watson: | 0.524 |
| Prob(Omnibus): | 0.000 | Jarque-Bera (JB): | 103636241.029 |
| Skew: | 6.360 | Prob(JB): | 0.00 |
| Kurtosis: | 251.957 | Cond. No. | 1.66e+03 |

***Figure 3: DiD OLS regression results***

OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | bhc_avgtradingratio | R-squared: | 0.925 |
| Model: | OLS | Adj. R-squared: | 0.920 |
| Method: | Least Squares | F-statistic: | 187.0 |
| Date: | Thu, 19 Oct 2023 | Prob (F-statistic): | 0.00 |
| Time: | 21:17:03 | Log-Likelihood: | 1.5239e+05 |
| No. Observations: | 40026 | AIC: | -2.998e+05 |
| Df Residuals: | 37557 | BIC: | -2.786e+05 |
| Df Model: | 2468 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| const | 0.0014 | 0.003 | 0.525 | 0.600 | -0.004 | 0.007 |
| Affect*after_DFA_1 | -0.1980 | 0.004 | -55.611 | 0.000 | -0.205 | -0.191 |
| bank_1020201 | 0.1353 | 0.002 | 54.187 | 0.000 | 0.130 | 0.140 |
| bank_1020340 | 0.0178 | 0.002 | 11.030 | 0.000 | 0.015 | 0.021 |
| : | : | : | : | : | : | : |
| bank_1 | -2.917e-05 | 0.000 | -0.194 | 0.846 | -0.000 | 0.000 |
| dep_lnassets | -0.0002 | 0.000 | -0.924 | 0.355 | -0.000 | 0.000 |
| dep_depositratio | 0.0004 | 0.001 | 0.686 | 0.493 | -0.001 | 0.001 |

| | | | |
|---|---|---|---|
| Omnibus: | 61760.798 | Durbin-Watson: | 0.675 |
| Prob(Omnibus): | 0.000 | Jarque-Bera (JB): | 187282655.081 |
| Skew: | 9.060 | Prob(JB): | 0.00 |
| Kurtosis: | 337.617 | Cond. No. | 2.46e+04 |

***Figure 4: DiD with Fixed Effects OLS regression results***

Referring to both ***Figure 3*** and ***Figure 4***, the coefficients for "Affect**after_DFA_1*" are negative. This suggests that a decrease in trading assets after the announcement in the treatment group compared to the control group.

## 2. Determining which Banks Responded the Most and Which Banks Least. Why?

The team computed trading asset ratios for each Bank Holding Company (BHC) both before and after the implementation of DFA. Initially, the team narrowed down the dataset to exclusively encompass the treatment banks. They then organized each bank based on unique identifiers, "*rssd9001*" and "*After_DFA_1*" to extract the average asset ratio values across all available quarters, spanning from 2Q 2004 to 2Q 2007. The team also computed the difference in asset ratios for each treatment bank between the periods pre- and post-DFA implementation. Any treatment bank that did not appear in both time frames was excluded from the analysis.

To identify the five banks most and least affected by the DFA implementation, the asset ratio values were sorted in descending order. Banks with a positive difference value, indicating an increase in the ratio after treatment, were excluded from consideration. This exclusion is in alignment with our Difference-in-Differences (DID) model, which suggests a negative correlation between the DFA implementation and asset ratio values. A positive difference value would be an outlier.

In summary, the bank with the most negative difference value reflects the maximum impact of the treatment, while the bank with the least negative magnitude represents the minimum impact. The outcomes are as shown below (see ***Figure 5***).

```
The top five most affected banks are:
[2162966, 1032473, 3123638, 1039502, 1951350]
The top five least affected banks are:
[1111435, 1094640, 1883693, 1131787, 1073757]
```

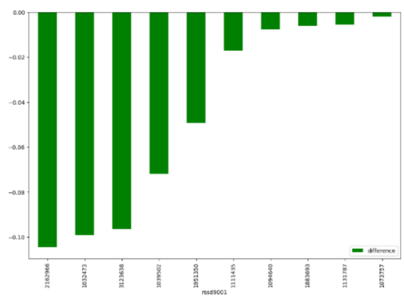
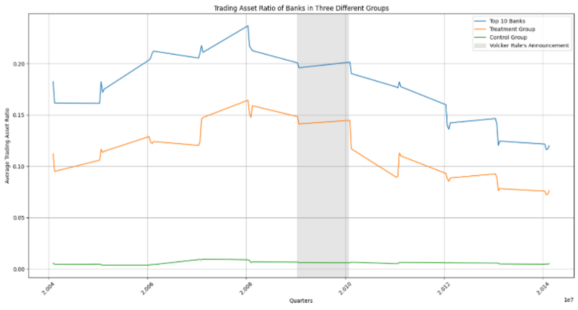



**Figure 5: Top 5 Most Affected Banks & Top 5 Least Affected Banks**




The blue line represents the average trading asset ratio of the 10 bank holding companies with the highest trading asset ratio in the 15 quarters before 2007. The orange line represents the average trading asset ratio of the treatment group (banks with an average trading asset ratio greater than 3%). The green line represents the average trading asset ratio of the control group (banks with a non-zero but less than 3% average trading asset ratio). The shaded gray region indicates the Volcker Rule's announcement period from 2009 Q3 to 2010 Q2.

***Figure 6: Trading Asset Ratios of Top 10 Banks pre and post DFA***

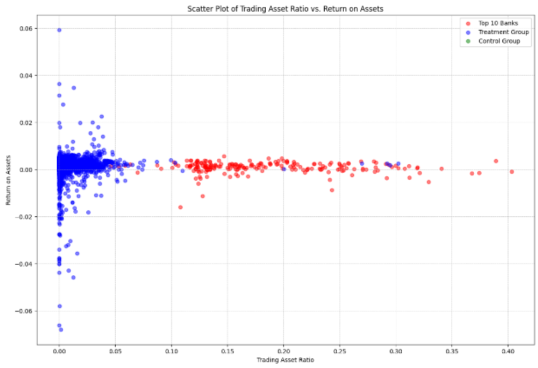



***Figure 7: Scatter Plot of Trading Asset Ratio vs Return on Assets***

From Figure 6, the Top 10 Banks generally have higher trading asset ratios compared to the other groups. This is consistent with the definition of this group, which includes banks with the highest trading asset ratios in the 15 quarters before 2007. The Treatment Group and Control Group banks seem to have a wider spread in trading asset ratios, with many banks clustered towards the lower end.

There isn't a strong visible pattern indicating that a higher trading asset ratio leads to a higher return on assets (or vice versa). This suggests that other factors might be influencing the return on assets. While some banks with higher trading asset ratios (especially among the Top 10 Banks) do have higher return on assets, there are also many banks with lower trading asset ratios that achieve similar returns.

The three groups overlap in the scatter plot (see Figure 7), especially in the region of lower trading asset ratios. This indicates that while the groups are distinguished by their trading practices, their performance (in terms of return on assets) can be quite similar. There isn't a distinct clustering of points for any group that would indicate a strong correlation between trading asset ratio and return on assets. Banks with similar trading asset ratios can have a wide range of return on assets values.

## 3. How should Banks or Regulators use Results from Robustness Tests?

Robustness test is a method used to stress test the reliability and validity of the results. In this context, it is used to check the impact of the Volcker Rule on Banks' behaviour, specifically their trading asset ratios and to see if the main results from the baseline model holds true and remain consistent for different methods, data sets, or assumptions.

| **Test 1: Treatment Dummy Model** | **Test 2: Propensity Score Matching Model** |
| --- | --- |
| Treatment dummies are often included as independent variables in regression models to control for the effect of treatment status.<br><br>**Bank and Time Dummies:** 'rssd9001' and 'rssd9999'<br>**Categorical Dummies**: 'CPP'<br>**Covariates**: 'dep_lnassets', 'dep_depositratio'<br>**Fixed Effects**: Yes | PSM uses arbitrary cutoff in robustness tests as an alternative method to define affectedness and to check against the main findings. If the results are similar, it gives more confidence in the main findings.<br><br>**Data used:** Q3 2004 pre-DFA; using only 1 quarter's data to avoid being overly precise.<br>**Propensity Score Estimation:** Log regression to estimate propensity score against selected covariates.<br>**Matching Methods:** 3 nearest neighbour.<br>**Balance Assessment:** Produces well-matched treatment and control groups.<br>**Causal Effect Est.:** Estimates the causal effect of treatment on outcome variable. |

OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | bhc_avgtradingratio | R-squared: | 0.922 |
| Model: | OLS | Adj. R-squared: | 0.917 |
| Method: | Least Squares | F-statistic: | 181.1 |
| Date: | Thu, 19 Oct 2023 | Prob (F-statistic): | 0.00 |
| Time: | 22:46:33 | Log-Likelihood: | 1.5179e+05 |
| No. Observations: | 40026 | AIC: | -2.986e+05 |
| Df Residuals: | 37557 | BIC: | -2.774e+05 |
| Df Model: | 2468 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| const | 0.0012 | 0.003 | 0.442 | 0.659 | -0.004 | 0.007 |
| treat_3_b_avg*after_DFA_1 | -0.0229 | 0.001 | -43.477 | 0.000 | -0.024 | -0.022 |
| bank_1020201 | 0.1353 | 0.003 | 53.362 | 0.000 | 0.130 | 0.140 |
| bank_1020340 | 0.0169 | 0.002 | 10.294 | 0.000 | 0.014 | 0.020 |
| : | : | : | : | : | : | : |
| bank_20141231 | 0.0004 | 0.000 | 1.315 | 0.189 | -0.000 | 0.001 |
| bank_1 | -0.0002 | 0.000 | -1.528 | 0.127 | -0.001 | 6.59e-05 |
| dep_lnassets | -0.0001 | 0.000 | -0.846 | 0.398 | -0.000 | 0.000 |
| dep_depositratio | 0.0006 | 0.001 | 1.020 | 0.308 | -0.001 | 0.002 |

| | | | |
|---|---|---|---|
| Omnibus: | 60660.138 | Durbin-Watson: | 0.647 |
| Prob(Omnibus): | 0.000 | Jarque-Bera (JB): | 166425791.632 |
| Skew: | 8.748 | Prob(JB): | 0.00 |
| Kurtosis: | 318.412 | Cond. No. | 2.46e+04 |

***Figure 6: DiD with Affected BHC (Treatment Dummy Model)***

OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | bhc_avgtradingratio | R-squared: | 0.927 |
| Model: | OLS | Adj. R-squared: | 0.926 |
| Method: | Least Squares | F-statistic: | 636.6 |
| Date: | Thu, 19 Oct 2023 | Prob (F-statistic): | 0.00 |
| Time: | 21:18:18 | Log-Likelihood: | 12836. |
| No. Observations: | 5587 | AIC: | -2.545e+04 |
| Df Residuals: | 5476 | BIC: | -2.471e+04 |
| Df Model: | 110 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| const | 0.3857 | 0.032 | 12.157 | 0.000 | 0.323 | 0.448 |
| treat_3_b_avg*after_DFA_1 | -0.0193 | 0.002 | -12.097 | 0.000 | -0.022 | -0.016 |
| bank_1020676 | -0.2303 | 0.014 | -16.703 | 0.000 | -0.257 | -0.203 |
| bank_1020902 | -0.1844 | 0.012 | -15.500 | 0.000 | -0.208 | -0.161 |
| : | : | : | : | : | : | : |
| bank_20140930 | 0.0100 | 0.003 | 3.012 | 0.003 | 0.003 | 0.017 |
| bank_20141231 | 0.0125 | 0.003 | 3.744 | 0.000 | 0.006 | 0.019 |
| bank_1 | -0.0192 | 0.002 | -10.967 | 0.000 | -0.023 | -0.016 |
| dep_lnassets | -0.0147 | 0.002 | -9.083 | 0.000 | -0.018 | -0.012 |
| dep_depositratio | 0.0526 | 0.006 | 8.616 | 0.000 | 0.041 | 0.065 |

| | | | |
|---|---|---|---|
| Omnibus: | 2111.937 | Durbin-Watson: | 0.127 |
| Prob(Omnibus): | 0.000 | Jarque-Bera (JB): | 28227.125 |
| Skew: | 1.429 | Prob(JB): | 0.00 |
| Kurtosis: | 13.634 | Cond. No. | 5.36e+03 |

***Figure 7: DiD using PSM Model***

The coefficients for "*treat_3_b_ave*after_DFA_1*" are negative, significant and similar in values for both robustness checks using Treatment Dummy (see Figure 6) and PSM (see Figure 7). This is consistent with the understanding that there is a decrease in trading assets post-DFA.

## Test 3: Pre-2007 Average Trading Asset Ratio

To ensure that we are comparing the average trading asset ratio without addition concern that it may be affected by the financial crisis (2008), the team only used the data from 2004 to 2007 before the crisis to check the results.

OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | bhc_avgtradingratio | R-squared: | 0.896 |
| Model: | OLS | Adj. R-squared: | 0.889 |
| Method: | Least Squares | F-statistic: | 130.9 |
| Date: | Thu, 19 Oct 2023 | Prob (F-statistic): | 0.00 |
| Time: | 21:19:10 | Log-Likelihood: | 1.4922e+05 |
| No. Observations: | 39189 | AIC: | -2.936e+05 |
| Df Residuals: | 36770 | BIC: | -2.729e+05 |
| Df Model: | 2418 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| const | 0.0017 | 0.003 | 0.619 | 0.536 | -0.004 | 0.007 |
| Affect*after_DFA_1 | -0.2127 | 0.004 | -54.897 | 0.000 | -0.220 | -0.205 |
| bank_1020201 | 0.1354 | 0.002 | 54.226 | 0.000 | 0.131 | 0.140 |
| : | : | : | : | : | : | : |
| bank_20140930 | 0.0005 | 0.000 | 1.703 | 0.089 | -7.71e-05 | 0.001 |
| bank_20141231 | 0.0006 | 0.000 | 1.899 | 0.058 | -1.85e-05 | 0.001 |
| bank_1 | 2.44e-05 | 0.000 | 0.161 | 0.872 | -0.000 | 0.000 |
| dep_lnassets | -0.0002 | 0.000 | -1.059 | 0.289 | -0.001 | 0.000 |
| dep_depositratio | 0.0005 | 0.001 | 0.977 | 0.329 | -0.001 | 0.002 |

| | | | |
|---|---|---|---|
| Omnibus: | 61320.562 | Durbin-Watson: | 0.674 |
| Prob(Omnibus): | 0.000 | Jarque-Bera (JB): | 190514729.136 |
| Skew: | 9.334 | Prob(JB): | 0.00 |
| Kurtosis: | 344.066 | Cond. No. | 2.42e+04 |

***Figure 8: DiD with Pre-2007 Ave. Trading Ratio***

## Test 4: Exclude non-trading banks

The team excluded all BHC with zero trading books (bhc_avgtradingratio = 0). These banks primarily engage in traditional banking activities, such as accepting deposits, making loans, and providing other banking services, but do not have significant trading operations.

OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | bhc_avgtradingratio | R-squared: | 0.904 |
| Model: | OLS | Adj. R-squared: | 0.899 |
| Method: | Least Squares | F-statistic: | 194.1 |
| Date: | Thu, 19 Oct 2023 | Prob (F-statistic): | 0.00 |
| Time: | 21:19:26 | Log-Likelihood: | 16756. |
| No. Observations: | 5691 | AIC: | -3.299e+04 |
| Df Residuals: | 5428 | BIC: | -3.124e+04 |
| Df Model: | 262 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| const | 0.1560 | 0.018 | 8.497 | 0.000 | 0.120 | 0.192 |
| Affect*after_DFA_1 | -0.2066 | 0.010 | -21.453 | 0.000 | -0.225 | -0.188 |
| bank_1020340 | -0.1232 | 0.006 | -19.542 | 0.000 | -0.136 | -0.111 |
| : | : | : | : | : | : | : |
| bank_20140930 | 0.0020 | 0.002 | 1.074 | 0.283 | -0.002 | 0.006 |
| bank_20141231 | 0.0025 | 0.002 | 1.335 | 0.182 | -0.001 | 0.006 |
| bank_1 | -0.0004 | 0.001 | -0.520 | 0.603 | -0.002 | 0.001 |
| dep_lnassets | -0.0012 | 0.001 | -1.331 | 0.183 | -0.003 | 0.001 |
| dep_depositratio | 0.0022 | 0.003 | 0.769 | 0.442 | -0.003 | 0.008 |

| | | | |
|---|---|---|---|
| Omnibus: | 4860.570 | Durbin-Watson: | 0.702 |
| Prob(Omnibus): | 0.000 | Jarque-Bera (JB): | 672536.788 |
| Skew: | 3.445 | Prob(JB): | 0.00 |
| Kurtosis: | 55.809 | Cond. No. | 8.69e+03 |

***Figure 9: DiD excluding non-trading banks***

The coefficients on the for "Affect**after_DFA_1*" are both negative, significant and similar in values for both robustness checks (see ***Figure 8*** and ***Figure 9***).

## Conclusion

The different robustness tests conducted above reinforces the reliability and stability of the results, affirming their consistency across various methodologies, datasets and assumptions. This substantiates the robustness of the baseline model, indicating that the findings are resilient and not contingent on specific conditions.