



DBA5101

Managerial Economics

Group Project 2

Study of The Volcker Rule Effect

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1. Introduction & Problem Statement

The 2008 financial crisis was considered by many as the worst financial crisis since the Great Depression due to its ripple effects worldwide. Following the crisis, the U.S market regulators scrambled to impose strict regulations on the financial sector to maintain risk level. **The Volcker Rule (TVR)** was deployed as a part of the most important regulations, the **Dodd-Frank Act (DFA)**, to restrict banks' risky activities and reduce risk-taking by banks - specifically focusing on limiting proprietary trading and investments.

This report aims to analyse the effectiveness and impact of TVR on U.S **Bank Holding Companies (BHC)**. To quantify the impact, we measured the change in **Trading Asset Ratio (TAR)** before and after the TVR announcement in 2010. We expect that TAR would decrease if TVR is effective as banks would decrease risky trading activities. We introduced four robustness tests to ensure that our baseline model holds when some of our assumptions are tweaked.

Understanding how TVR affects different banks is also important, especially since the aim of the rule is to halt activities of banks that previously indulge in risky trading activities. As such, we further investigated how different banks reacted to TVR by segmenting banks based on their trading ratio in 2007 (pre-DFA announcement period) and measuring the impact of TVR on the TAR of different segments.

2. Data & Features

The dataset used was of the 2,473 BHCs selected financial data - mostly from balance sheet and income statement. The dataset has 81,560 entries and 14 features, and gives panel data covering the Q3 2004 to Q2 2009, and then from Q3 2010 to Q2 2015.

To maintain consistency throughout the report, we have created a table of all the variables used, and how they would address it moving forward ([See Appendix A](#)).

2.1 Exploratory Data Analysis (EDA)

Through our EDA, we found these relevant insights:

- **Unbalanced treatment group.** We found that the treated group only represents 1.25% (1,018 observations) of the datasets; this could increase the risk of facing unobserved bias.
- **Missing values.** We identified that half of the data (around 50.9% or 41,534 observations) are missing values in one or more columns. We however did not drop any rows as our models will automatically exclude missing values.
- **Defunct or new BHCs.** We identified that many BHCs do not have data before or after a certain period (either because they

went defunct or they were newly established). We filtered these data according to our models.

- **Control Variables.** Out of the 14 features, we found that 9 features (return on assets, leverage ratio, total assets, non-performing loan ratio, cost-income ratio, deposit ratio, real estate loan ratio, liquidity ratio and CPP recipient indicator) are highly correlated with TAR. They will be used as control variables in our models to account for covariates that might influence bank business models and risk appetite. Correlation matrix available for reference ([See Appendix B & E](#))

2.2 Feature Engineering

Since our focus is on creating robust models and measuring the banks' responsiveness, we created 5 new features:

- **Propensity matching score.** To minimise bias and better estimate intervention effect due to unbalanced sample (discussed in part 2.1), we did propensity score matching for treated banks versus unaffected banks to test for robustness of our models. As we were matching based on 2007 TAR, we excluded BHCs which were not active before 2007 or after 2007. We found that matching did improve the separability between our groups ([See Appendix H](#)). The propensity score column was merged to our dataset.

- **Creating interaction variables.** We created 2 interaction variables for our baseline models. *Affect* is the average TAR between Q3 2004 - Q2 2009. Meanwhile, *Affect (pre-2007)* is the average TAR between Q3 2003 - Q4 2006. These variables are times with a post announcement variable to measure the treatment effect.

- **Categorising data and creating dummy variables.** We created 2 dummy variables: Top 10 and Bottom 10, which identify the Affected BHCs with the highest and lowest TAR in 2007 to measure responsiveness between the groups.

The rationale of adopting these variables into our models will be explained in part 3.

2.3 Feature Selection

We selected TAR as our dependent variable. Affected BHC dummy variable was adopted to define the entity fixed effect, and the post announcement dummy to define the time fixed effect.

As mentioned in part 2.1, we also included 9 selected features as control variables. These variables remove endogeneity that are not captured by fixed effects in the model.

3. Model

As discussed in part 1 and 2, our baseline models will measure the effect of TVR on TAR.

3.1 Assumptions

A few assumptions we adopted for our models:

- Banks have not adjusted their TAR in 2007 as new regulations and financial crisis have not occurred.
- BHC that has a TAR equal or higher than 3% is considered a high trader and is thus most affected by TVR.
- Control variables capture covariates that might affect banks' trading and risk appetite.
- There is no major economic or regulatory shock to BHCs throughout the time period except TVR.
- Trading BHCs were geared towards trading activities which are now banned or limited by TVR.

3.2 Baseline Models

To test whether TVR announcement reduce the TAR of affected banks, we run the regression model outlined below. The model includes **after_DFA_1**, a dummy variable which equals '1' for the quarters post-DFA announcement (Q3 2010 - Q2 2015) and '0' prior (Q3 2004 - Q2 2009). It represents the status of the BHCs prior to and after the announcement to obtain a better idea of TVR on TAR.

Baseline Model 1

The first baseline model shown in **Appendix F, Table 1 - Column(1)** is a basic regression running **TAR** against **after_dfa_1** without control variables or fixed effect.

$$\text{bhc_avgtradingratio}_{i,t} = 0.00051 \times \text{after_DFA_1} + 0.0024$$

The coefficient obtained, 0.00051 (0.05%), is close to 0 with $R^2 = 0$, indicating no strong reduction in TAR.

Baseline Model 2

We ran the same again but added control variables (the 9 features chosen in part 2.3) to remove endogeneity and ensured that the relationship observed was indeed due to the regressed variables.

The result is as shown in **Appendix F, Table 1 - Column (2)**.

$$\text{bhc_avgtradingratio}_{i,t} = -0.0010 \times \text{after_DFA_1} + X_{i,t} + -0.0207$$

X = set of control variables

i = indicates a BHC

t = time - indicates a quarter

Similar to baseline model 1, the coefficient, 0.0010 (0.1%), is close to 0 with $R^2 = 0.234$ suggests that there is no significant reduction in TAR, even when control variables are considered.

Baseline Model 3

Not all or the majority of the banks would have high TAR prior to the DFA announcement, thus TVR would have minimal effect on them. To obtain a more accurate picture on how

banks with high TAR would be affected, we used the **affect** variable.

We run another model (**Appendix F, Table 1 - Column (3)**) with an interaction between **after DFA 1** & **affect**, which captures the varying degree of exposure to activities banned by TVR.

$$\text{bhc_avgtradingratio}_{i,t} = -0.00002 \times \text{after_DFA_1} + 0.993 \times \text{Affect} - 0.161 \times (\text{after_DFA_1} * \text{Affect}) + X_{i,t} - 0.002968$$

X = set of control variables

i = indicates a BHC

t = time - indicates a quarter

The results obtained - with $R^2 = 0.902$ illustrate a few key points:

- Firstly, **after DFA 1**, with coefficient, -0.00002 (-0.002%) has a negative but virtually insignificant effect;
- Next, **affect** was highly significant and positive, 0.993 (99.3%). This was expected as banks that had high TAR pre-DFA announcement were expected to still have a relatively high TAR post announcement (i.e. even if they reduced the TAR after announcement, it would still be higher than the typical BHC).
- The interaction **affect * after DFA 1** was highly significant and negative, - 0.161 (-16.1%), suggesting that the banks that were mostly affected (i.e. had higher TAR prior) did reduce their TAR more after the announcement.

Baseline Model 4

We ran model 3 again, but controlling for fixed effects, both time and entity. The results are shown in **Appendix F, Table 1 - Column (4)**.

$$\text{bhc_avgtradingratio}_{i,t} = 0.2024 \times (\text{after_DFA_1} * \text{Affect}) + \gamma_i + \delta_t + X_{i,t} + 0.0065$$

X = set of control variables

γ_i = entity fixed effects

δ_t = time fixed effects

i = indicates a BHC

t = time - indicates a quarter

Accounting for fixed effects, the values were highly significant and even more negative with coefficient -0.202 (-20.2%), further strengthening the expectation that the affected banks reduced their TAR post DFA announcement.

3.3 Robustness Test

To validate that the discussion of TVR impacted TAR, we ran a 'robustness check' - comparing changes in the coefficient and p-values against 4 different scenarios described below.

Fixed effects for both time and entity are accounted for in all of our robustness test models.

Robustness Test Model 1

We added the interaction variable, treat_3_b_avg * after_DFA_1, to measure the effect of TVR on BHCs with TAR equal or greater than 3% post announcement period .

$$\text{bhc_avgtradingratio}_{i,t} = -0.0234 \times (\text{treat}_3\text{b}_\text{avg} * \text{after_DFA}_1) + \gamma_t + \delta_t + X_{i,t} + 0.0058$$

We affirm that the TAR changes are significant ($p = 0.000$) when including a treatment dummy (See Appendix F, Table 2 - Column (1)). In fact, this test shows that BHCs with higher TAR prior to DFA announcement reduced their TAR by 2.34% more as compared to other BHCs.

Robustness Test Model 2

We further improved model 1 by balancing the treated group through propensity score matching.

$$\text{bhc_avgtradingratio}_{i,t} = -0.0256 \times (\text{treat}_3\text{b}_\text{avg} * \text{after_DFA}_1) + \gamma_t + \delta_t + X_{i,t} + 0.1759$$

After broadcasting the propensity score matrix (weight) into the larger dataset, we also find that the Volcker Rule discussion resulted in a reduction of TAR, with a very low p-value returned ($p = 0.000$). See (Appendix F, Table 2 - Column (2)).

Robustness Test Model 3

We ran a robustness test to replicate our findings in the pre-DFA announcement period by using the average of the TAR pre-DFA period (Affect pre-2007 variable).

$$\text{bhc_avgtradingratio}_{i,t} = -0.2053 \times (\text{affect}_2007 * \text{after_DFA}_1) + \gamma_t + \delta_t + X_{i,t} + 0.0057$$

Like before, we had a low p-value ($p = 0.000$). See (Appendix F, Table 2 - Column (3)).

Robustness Test Model 4

We excluded non-trading BHC from the model then ran model 3 again.

$$\text{bhc_avgtradingratio}_{i,t} = -0.2114 \times (\text{affect}_2007 * \text{after_DFA}_1) + \gamma_t + \delta_t + X_{i,t} + 0.0628$$

Narrowing to only BHCs with any trading activity, the result remains statistically significant ($p = 0.000$). See (Appendix F, Table 2 - Column (4)).

3.4 Measuring Responsiveness between BHCs

To measure the different responsiveness between banks, we adopted 2 different approaches:

1. Segmentation based on TAR Reduction. We identified BHCs which responded either most negatively or positively to the DFA announcement, and BHCs which responded the least (i.e: DFA announcement had minimal effect on their TAR). We then compared these bank segments to the Affected BHC group to observe whether our understanding of the effect of TVR on Affected BHC's TAR remains.

To determine the BHCs that responded the most and least, we ranked the top 10 most positive, top 10 most negative, and the middle 10 BHCs based on the difference between TAR after and before 2007 for each bank. We used 2007 TAR to avoid endogeneity as it is in pre-DFA announcement period. The middle 10 BHCs – BHCs with TAR difference close to 0 – represent the least responsive BHCs. The specific 10 BHCs for each ranking can be found in Appendix I.

We found that 7 out of 10 most negative BHCs were affected BHCs pre-2007 (see Appendix I, Graph IB). Unsurprisingly, this finding is consistent with our findings from before – high trading BHCs pre-2007 declined their trading activity significantly.

Out of the top 10 most positive BHCs, only 1 was an affected BHCs pre-2007. Thus, BHCs that actually increased trading after 2007 were mostly BHCs that didn't trade much or at all pre-2007 (see Appendix I, Graph IC).

It is to no surprise that the middle 10 BHCs are all unaffected BHCs - the most unresponsive BHCs were BHCs that simply do not trade.

2. OLS and Dummy variables introduction for top and least trading BHCs. We identified BHCs which traded most and least in 2007 (pre-DFA announcement period) and created dummy variables Top 10 and Bottom 10 (see part 2.2). We then measured the interaction effect of these dummy variables with the post-DFA announcement. We also tested the robustness of these models by doing propensity score matching to control for imbalance test samples.

Top 10 and Bottom 10 BHCs Models

Here, instead of defining top 10 and bottom 10 like in the first method, we ranked the top 10 or bottom 10 BHCs based on their TAR pre-2007 (see part 2.2 for more details). The baseline models are as follows:

Top 10 Baseline Model

$$\text{bhc_avgtradingratio}_{i,t} = -0.0293 \times (\text{after_DFA}_1 * \text{top10}) + \gamma_t + \delta_t + X_{i,t} + 0.0107$$

Bottom 10 Baseline Model

$$\text{bhc_avgtradingratio}_{i,t} = 0.0004 \times (\text{after_DFA}_1 * \text{btm10}) + \gamma_t + \delta_t + X_{i,t} + 0.0061$$

Most notably, the coefficient of after DFA 1 * top10 was -0.0293 (-2.93%) and the coefficient for after DFA 1 * btm10 was 0.0004 (0.04%) (See Appendix J, Top 10 Baseline Model, Bottom 10 Baseline Model).

To test for robustness, we did a propensity score matching to accommodate for the imbalance of top 10 or bottom 10 BHCs. The coefficient of after DFA 1 * top10 in the top 10 model grew more negative to - 4.03% and the coefficient of after DFA 1 * btm10 in the bottom 10 propensity model dropped to 0.02%.

Top 10 Baseline Model with Propensity Score Matching

$$\text{bhc_avgtradingratio}_{i,t} = -0.0403 \times (\text{after_DFA_1*top10}_{propensity}) + \gamma_i + \delta_t + X_{i,t} + 0.0829$$

Bottom 10 Baseline Model with Propensity Score Matching

$$\text{bhc_avgtradingratio}_{i,t} = 0.0002 \times (\text{after_DFA_1*btm10}_{propensity}) + \gamma_i + \delta_t + X_{i,t} + 0.0056$$

It is worth noting that the after DFA 1 * top10 coefficient in this model is more negative than the same coefficient in the baseline model and the Robustness Test Model 3, which implies that the higher a BHC's pre-2007 TAR, the bigger the decline of TAR. Similarly, the after DFA 1 * btm10 appears to be closer to 0 which implies that the lower the bank's TAR before 2007, the more unresponsive the bank is after DFA.

4. Conclusion

Based on our analysis on TVR announcement effects on BHCs, we conclude that TVR did reduce the TAR of BHCs from pre-announcement period by 20.1%; this remains significant after controlling for fixed effects and control variables. We further found that BHCs that are affected by TVR (defined as those with TAR greater than 3% in the pre-announcement period) reduce their TAR 2.34% more than other BHCs. Our findings are robust considering various robustness tests, such as including dummy variables to identify affected BHCs and excluding non trading BHCs.

We further investigated the responsiveness of BHCs using two methods. From the first method, we observed that the biggest trading declines consisted of mainly affected BHCs and the biggest trading increases predominantly consisted of unaffected BHCs. The top 10 unresponsive BHCs were, as expected, all unaffected BHCs that did not trade.

A second method was used to compare the responsiveness between affected and unaffected BHCs. Based on our models, we found that the most affected BHCs declined more heavily than the least affected BHCs - supporting our initial findings.

4.1 Insights & Application from Results

There exists a limitation to this report. The time period covered in this report ends in Q2 2015; TVR has not been fully rolled out by then. As such, there might be other long term effects which could not be observed in this report.

Our findings indicated that TVR indeed reduced trading activities as we saw a reduction of TAR. However, this does not necessarily reflect a reduction in risks. BHCs can simply increase the riskiness of the permitted trading activities, as the line between the permitted and proprietary trading is not clearly defined in TVR. An example could include using privately owned investment firms to carry on proprietary trading. As such, we propose suggestions whereby regulators could potentially increase TVR effectiveness below.

4.2 Considerations for Regulators

It is highly intuitive as BHCs would comply with government and market regulator's rules within the governed region and reduce their TAR post-DFA period. However, as discussed in part 5.1, BHCs have more than one way to comply with TVR. BHCs can still - and will likely - maintain their set riskiness level despite complying.

Market regulators and policy makers need to consider strengthened approaches as it is their shared mission to make sure the rule achieves its effectiveness:

1. Strict enforcement should be a priority when a new rule is introduced.
2. Define structured and clear definitions on what investment activities are permitted. This is to effectively narrow the BHCs' methods of finding interchangeable risky activities, and eliminate the possible loopholes altogether.
3. Lastly, policy makers should make sure to implement the rule with a high level of coordination. With the joint effort between different parties, regulators and BHCs can establish a clear and strict understanding of prohibited risky tradings and better standardize financial derivatives that might disrupt the market as a whole, and therefore accomplish a stable and healthy economy.

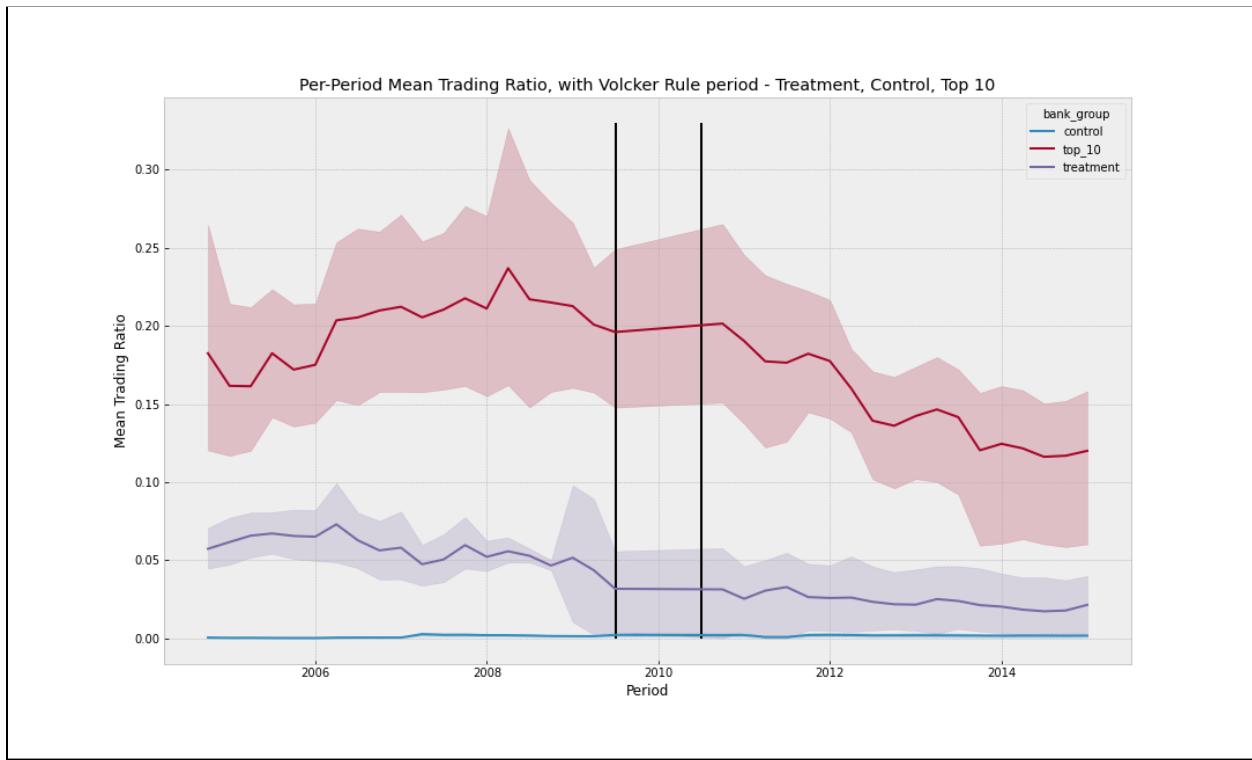
Reference:

Dombalagian, O. H. (2015). The Volcker Rule and regulatory complementarity. Capital Markets Law Journal, 10(4), 469–487. doi:10.1093/cmlj/kmv034

Appendix A - Feature or Referenced Name & Source

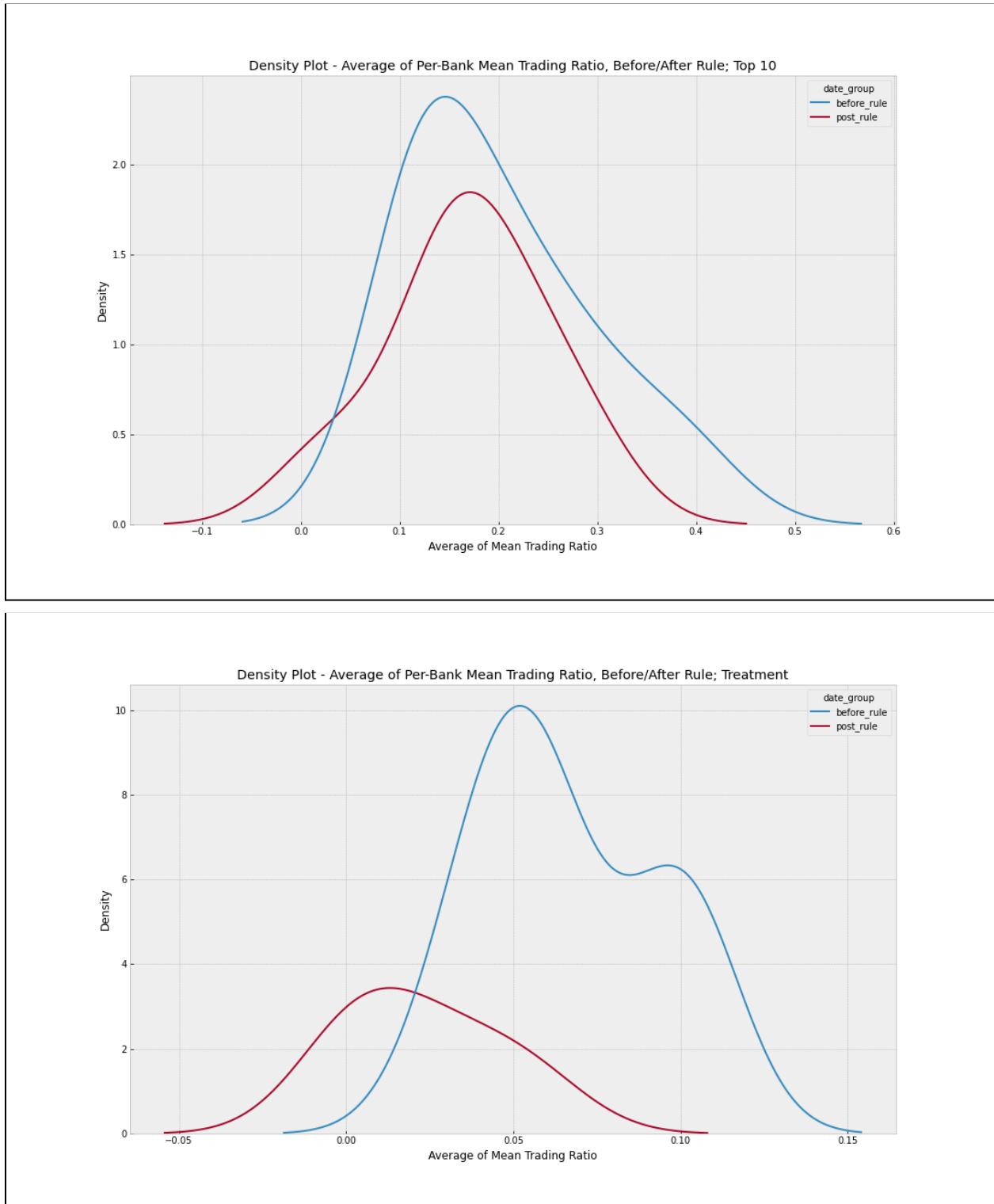
Feature/Referenced Name	Addressed in Report As	Abbreviated As	Source
The Volcker Rule	The Volcker Rule	TVR	Given in the problem set
Dodd-Frank Act	Dodd-Frank Act	DFA	
Bank Holding Companies	Bank Holding Companies	BHC	
rssd9001	Banks/Entity	-	
rssd9999	Quarter	Q	
bhc_avgtradingratio	Trading Asset Ratio	TAR	
treat_3_b_avg	Affected BHC	-	
after_DFA_1	Post DFA Period	-	
Affect	Average trading asset ratio during the pre-DFA period (Q3 2004 - Q2 2009)	-	Created for baseline, robustness and responsiveness models
Affect (pre-2007)	Average trading asset ratio prior to 2007 (Q2 2003 - Q4 2006)	-	
score	Propensity score/weightage from different variables (given context)	-	
top10	Dummy variable that equals one if BHCs TAR pre-DFA period is within top 10, and zero otherwise.	-	
bottom10	Dummy variable that equals one if BHCs TAR pre-DFA period is within bottom 10, and zero otherwise.	-	

Appendix B - Changes in Trading Asset Ratio (TAR)



Comments: In the above line plot, each quarter's mean TAR (with 95% confidence interval) is shown, split by 'control', 'test', and 'top 10'. The 3rd group are the top 10 BHCs (by highest mean TAR) in the period before 2007-01-01, while the 2nd group are those BHCs with a mean TAR above 3% in the period before 2007-01-01; the 1st group is all others.

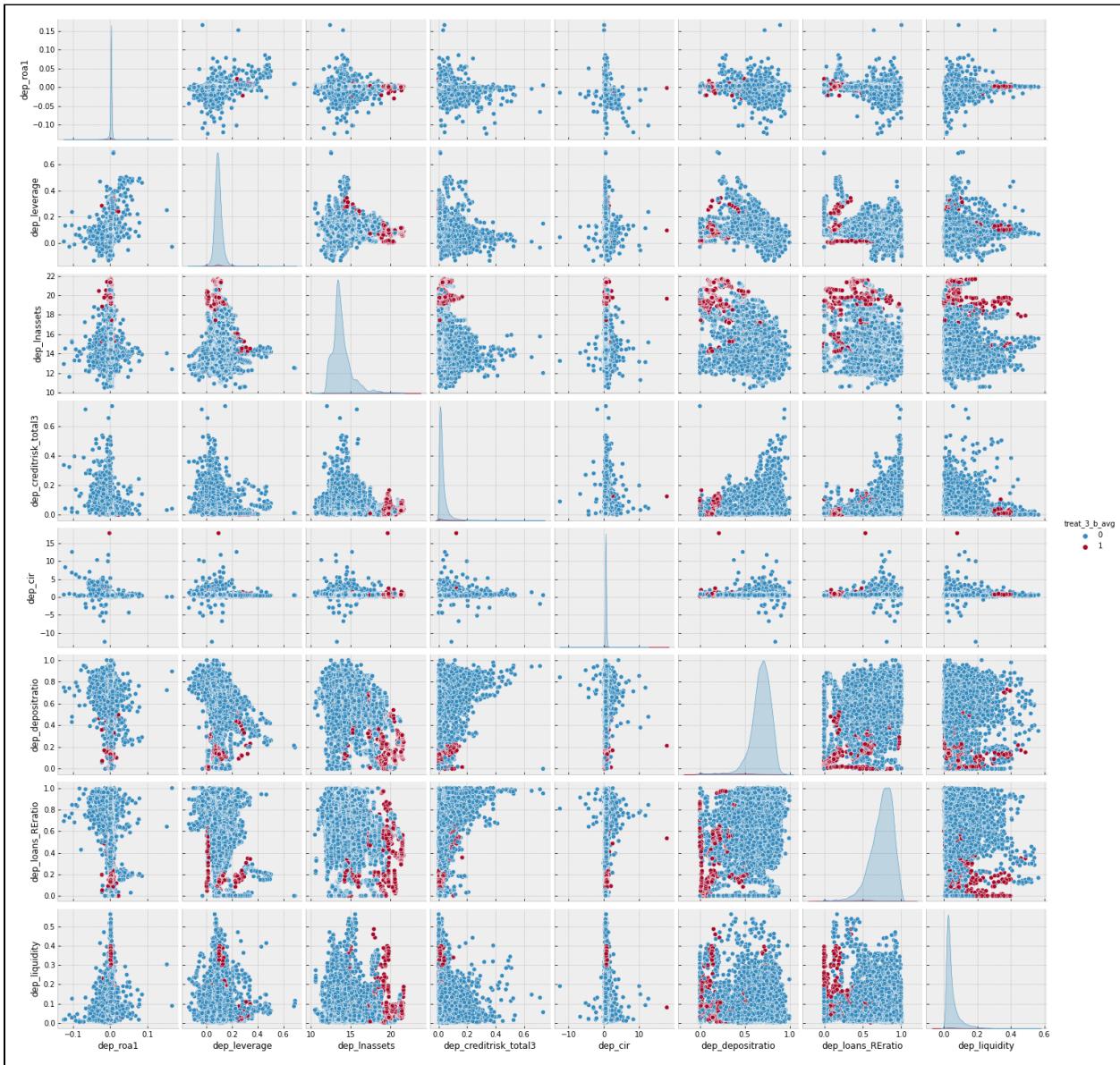
Appendix C - Distribution of TAR



Appendix D - Descriptive Statistics

	mean	std	min	25%	50%	75%	max
bhc_avgtradingratio	0.002504	0.019591	0.000000	0.000000	0.000000	0.000000	0.429727
dep_roal	0.001815	0.004791	-0.124166	0.001280	0.002240	0.003121	0.166087
dep_leverage	0.091910	0.035191	-0.136797	0.073609	0.089206	0.106323	0.693312
dep_lnassets	13.889765	1.393736	10.497587	13.134613	13.582672	14.317265	21.668251
dep_creditrisk_total3	0.028329	0.034504	0.000000	0.009989	0.018465	0.033357	0.734222
dep_cir	0.529095	0.281027	-12.478261	0.412016	0.500096	0.612487	17.822845
dep_depositratio	0.673262	0.125551	0.000000	0.621551	0.690575	0.753615	0.998093
dep_loans_RERatio	0.738046	0.157675	0.000000	0.658450	0.765438	0.849674	1.010109
dep_liquidity	0.049877	0.047876	0.000230	0.023769	0.034164	0.056514	0.564934

Appendix E - Correlation Matrix, plotted against treatment_3_b_avg



Appendix F - Table Overview of Results

TABLE 1 : OVERVIEW OF BASELINE VALUES

Standard errors are shown in brackets; Affect is the average trading ratio for BHCs prior to the DFA (i.e. Q3 2004 - Q2 2009); asterisks indicate significance levels * p<0.1, ** p< 0.05, *** p<0.01

Dependent Variable: Trading Asset Ratio		(1)	(2)	(3)	(4)
	After DFA	0.00051** (0.0002)	-0.0010*** (0.0002)	-0.00002 (0.00008)	
	Affect			0.993*** (0.003)	
	After DFA x Affect			-0.161*** (0.003)	-0.202*** (0.036)
Controls	NO		YES	YES	YES
FE	NO		NO	NO	YES
Observations	41,442		40,026	40,026	40,026
R-squared	0.00		0.234	0.902	0.925

TABLE 2: OVERVIEW OF ROBUSTNESS

Standard errors are shown in brackets; Affect (pre-2007) is the average trading ratio for BHCs prior to 2007; asterisks indicate significance levels * p<0.1, ** p< 0.05, *** p<0.01

Propen is abbreviated form of Propensity

Dependent Variable: Trading Asset Ratio		(1)	(2)	(3)	(4)
Robustness Test:		Treat Dummy	Propen Match	Pre-2007	Drop non-trade BHCs
After DFA x Affected BHC		-0.0234*** (0.0005)	-0.0256*** (0.0019)		
Affect DFA x Affect(pre-2007)				-0.205*** (0.0041)	-0.211*** (0.0125)
Controls & FE	YES		YES	YES	YES
Observations	40,026		2210	39,189	2343
R-squared	0.923		0.921	0.894	0.939

TABLE 3: OVERVIEW OF ROBUSTNESS BETWEEN BANKS

Standard errors are shown in brackets;

asterisks indicate significance levels * p<0.1, ** p< 0.05, *** p<0.01

Propen is abbreviated form of Propensity

Dependent Variable: Trading Asset Ratio				
	(1)	(2)	(3)	(4)
Robustness between Banks:	Top 10	Top 10 Propen	Btm 10	Btm 10 Propen
After DFA x Top10	-0.0293*** (0.001)	-0.0403*** (0.003)		
After DFA x Btm10			0.0004 (0.001)	0.0002 (0.000)
Controls & FE	YES	YES	YES	YES
Observations	40,026	691	40,026	709
R-squared	0.922	0.970	0.919	0.753

Appendix G - Baselines Models

Baseline Model 1

OLS Regression Results

Dep. Variable:	bhc_avgtradingratio	R-squared:	0.000			
Model:	OLS	Adj. R-squared:	0.000			
Method:	Least Squares	F-statistic:	6.419			
Date:	Sun, 17 Oct 2021	Prob (F-statistic):	0.0113			
Time:	18:13:03	Log-Likelihood:	1.0329e+05			
No. Observations:	41442	AIC:	-2.066e+05			
Df Residuals:	41440	BIC:	-2.066e+05			
Df Model:	1					
Covariance Type:	nonrobust					
	coef	std err	t	P> t	[0.025	0.975]
Intercept	0.0024	0.000	19.207	0.000	0.002	0.003
after_DFA_1	0.0005	0.000	2.534	0.011	0.000	0.001
Omnibus:	71532.559	Durbin-Watson:		0.198		
Prob(Omnibus):	0.000	Jarque-Bera (JB):	57471366.578			
Skew:	12.333	Prob(JB):		0.00		
Kurtosis:	183.761	Cond. No.		2.45		

Baseline Model 2

OLS Regression Results

Dep. Variable:	bhc_avgtradingratio	R-squared:	0.234			
Model:	OLS	Adj. R-squared:	0.234			
Method:	Least Squares	F-statistic:	1222.			
Date:	Sun, 17 Oct 2021	Prob (F-statistic):	0.00			
Time:	18:13:03	Log-Likelihood:	1.0595e+05			
No. Observations:	40026	AIC:	-2.119e+05			
Df Residuals:	40015	BIC:	-2.118e+05			
Df Model:	10					
Covariance Type:	nonrobust					
	coef	std err	t	P> t	[0.025	0.975]
Intercept	-0.0207	0.002	-13.677	0.000	-0.024	-0.018
after_DFA_1	-0.0010	0.000	-4.868	0.000	-0.001	-0.001
dep_lnassets	0.0043	7.27e-05	59.434	0.000	0.004	0.004
dep_leverage	-0.0495	0.003	-19.054	0.000	-0.055	-0.044
dep_roa1	0.0321	0.022	1.484	0.138	-0.010	0.075
dep_liquidity	-0.0006	0.002	-0.297	0.766	-0.005	0.003
dep_depositratio	-0.0337	0.001	-41.532	0.000	-0.035	-0.032
dep_loans_ERatio	-0.0138	0.001	-23.362	0.000	-0.015	-0.013
dep_cir	0.0010	0.000	2.921	0.003	0.000	0.002
dep_cpp_bankquarter	-0.0016	0.000	-4.407	0.000	-0.002	-0.001
dep_creditrisk_total3	0.0203	0.003	7.224	0.000	0.015	0.026

Baseline Model 3

Model:	OLS	Adj. R-squared:	0.902			
Dependent Variable:	bhc_avgtradingratio	AIC:	-294081.9286			
Date:	2021-10-17 18:13	BIC:	-293970.1639			
No. Observations:	40026	Log-Likelihood:	1.4705e+05			
Df Model:	12	F-statistic:	3.061e+04			
Df Residuals:	40013	Prob (F-statistic):	0.00			
R-squared:	0.902	Scale:	3.7714e-05			
	Coef.	Std.Err.	t	P> t	[0.025	0.975]
Intercept	-0.0030	0.0005	-5.4686	0.0000	-0.0040	-0.0019
after_DFA_1	-0.0000	0.0001	-0.2655	0.7906	-0.0002	0.0001
affect	0.9925	0.0025	402.1664	0.0000	0.9877	0.9974
after_DFA_1:affect	-0.1611	0.0031	-52.8179	0.0000	-0.1671	-0.1552
dep_Inassets	0.0002	0.0000	8.2577	0.0000	0.0002	0.0003
dep_leverage	0.0013	0.0009	1.3383	0.1808	-0.0006	0.0031
dep_roa1	-0.0051	0.0078	-0.6563	0.5116	-0.0203	0.0101
dep_liquidity	-0.0005	0.0007	-0.7087	0.4785	-0.0019	0.0009
dep_depositratio	0.0004	0.0003	1.2980	0.1943	-0.0002	0.0010
dep_loans_ERatio	-0.0007	0.0002	-3.5000	0.0005	-0.0012	-0.0003
dep_cir	0.0002	0.0001	1.4654	0.1428	-0.0001	0.0004
dep_cpp_bankquarter	-0.0002	0.0001	-1.9358	0.0529	-0.0005	0.0000
dep_creditrisk_total3	0.0017	0.0010	1.7238	0.0847	-0.0002	0.0037

Baseline Model 4

(full results not reported for brevity); Please see code for full results

Model:	OLS	Adj. R-squared:	0.920			
Dependent Variable:	bhc_avgtradingratio					
Date:	2021-10-17 18:13					
No. Observations:	40026	Log-Likelihood:	1.5253e+05			
Df Model:	2474	F-statistic:	187.9			
Df Residuals:	37551	Prob (F-statistic):	0.00			
R-squared:	0.925	Scale:	3.0569e-05			
	Coef.	Std.Err.	t	P> t	[0.025	0.975]
Intercept	0.0065	0.0028	2.3331	0.0196	0.0010	0.0120
affect	0.4958	0.0031	162.0655	0.0000	0.4898	0.5018
after_DFA_1	0.0012	0.0002	5.1344	0.0000	0.0007	0.0016
affect:after_DFA_1	-0.2024	0.0036	-56.8340	0.0000	-0.2093	-0.1954
dep_Inassets	-0.0002	0.0002	-0.9089	0.3634	-0.0005	0.0002
dep_leverage	0.0048	0.0018	2.6568	0.0079	0.0013	0.0084
dep_roa1	0.0064	0.0080	0.8020	0.4226	-0.0093	0.0222
dep_liquidity	-0.0012	0.0010	-1.2370	0.2161	-0.0032	0.0007
dep_depositratio	0.0007	0.0005	1.2763	0.2018	-0.0004	0.0018
dep_loans_ERatio	-0.0103	0.0007	-15.3243	0.0000	-0.0116	-0.0090
dep_cir	0.0003	0.0001	2.7172	0.0066	0.0001	0.0006
dep_cpp_bankquarter	-0.0000	0.0002	-0.0366	0.9708	-0.0003	0.0003
dep_creditrisk_total3	0.0010	0.0013	0.7165	0.4737	-0.0017	0.0036

Appendix H - Robustness Test Models

Robustness Test Model 1

(full results not reported for brevity); Please see code for full results

Model:	OLS	Adj. R-squared:	0.918			
Dependent Variable:	bhc_avgtradingratio					
Date:	2021-10-17 21:43					
No. Observations:	40026	Log-Likelihood:	1.5190e+05			
Df Model:	2474	F-statistic:	181.7			
Df Residuals:	37551	Prob (F-statistic):	0.00			
R-squared:	0.923	Scale:	3.1541e-05			
	Coef.	Std.Err.	t	P> t	[0.025	0.975]
Intercept	0.0058	0.0028	2.0374	0.0416	0.0002	0.0113
treat_3_b_avg	0.1306	0.0010	124.7300	0.0000	0.1285	0.1326
after_DFA_1	0.0010	0.0002	4.3251	0.0000	0.0006	0.0015
treat_3_b_avg:after_DFA_1	-0.0234	0.0005	-44.4243	0.0000	-0.0244	-0.0223
dep_Inassets	-0.0001	0.0002	-0.6707	0.5024	-0.0004	0.0002
dep_leverage	0.0022	0.0018	1.1733	0.2407	-0.0015	0.0058
dep_roa1	0.0062	0.0082	0.7595	0.4475	-0.0098	0.0222
dep_liquidity	-0.0004	0.0010	-0.4034	0.6867	-0.0024	0.0016
dep_depositoratio	0.0008	0.0006	1.3801	0.1676	-0.0003	0.0018
dep_loans_RERatio	-0.0096	0.0007	-14.0748	0.0000	-0.0109	-0.0082
dep_cir	0.0003	0.0001	2.5944	0.0095	0.0001	0.0006
dep_cpp_bankquarter	-0.0002	0.0002	-1.3127	0.1893	-0.0005	0.0001
dep_creditrisk_total3	-0.0000	0.0014	-0.0132	0.9895	-0.0027	0.0026

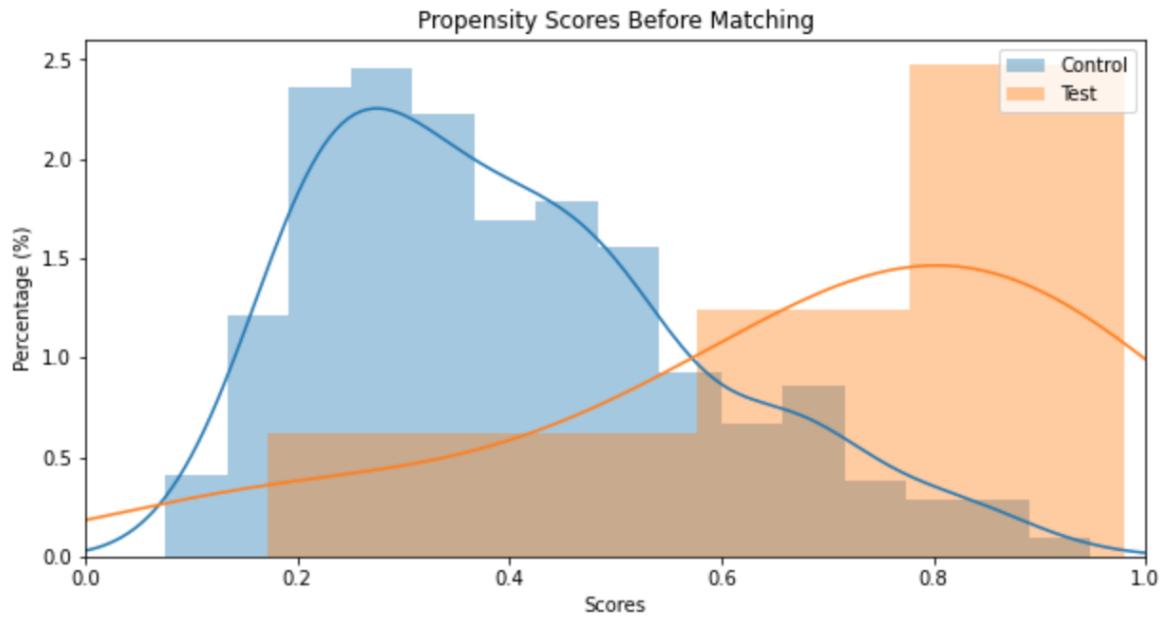
Robustness Test Model 2

(full results not reported for brevity); Please see code for full results

Model:	OLS	Adj. R-squared:	0.918			
Dependent Variable:	bhc_avgtradingratio		AIC: -12633.9771			
Date:	2021-10-22 22:09		BIC: -12138.0121			
No. Observations:	2210	Log-Likelihood:	6404.0			
Df Model:	86	F-statistic:	288.9			
Df Residuals:	2123	Prob (F-statistic):	0.00			
R-squared:	0.921	Scale:	0.00018537			
	Coef.	Std.Err.	t	P> t	[0.025	0.975]
Intercept	0.1759	0.0426	4.1289	0.0000	0.0923	0.2594
treat_3_b_avg	0.1780	0.0125	14.1918	0.0000	0.1534	0.2026
after_DFA_1	-0.0025	0.0022	-1.1017	0.2707	-0.0068	0.0019
treat_3_b_avg:after_DFA_1	-0.0256	0.0019	-13.7135	0.0000	-0.0293	-0.0220
dep_Inassets	-0.0103	0.0028	-3.6150	0.0003	-0.0158	-0.0047
dep_leverage	0.0653	0.0370	1.7637	0.0779	-0.0073	0.1379
dep_roa1	-0.2233	0.1417	-1.5757	0.1152	-0.5013	0.0546
dep_liquidity	-0.0417	0.0168	-2.4799	0.0132	-0.0747	-0.0087
dep_depositratio	0.0478	0.0071	6.7726	0.0000	0.0340	0.0617
dep_loans_ERatio	-0.0844	0.0082	-10.2667	0.0000	-0.1006	-0.0683
dep_cir	0.0007	0.0008	0.9344	0.3502	-0.0008	0.0023
dep_cpp_bankquarter	-0.0010	0.0016	-0.6074	0.5436	-0.0041	0.0022
dep_creditrisk_total3	0.2876	0.0414	6.9462	0.0000	0.2064	0.3688

Result of Propensity Score Matching for Affected BHC

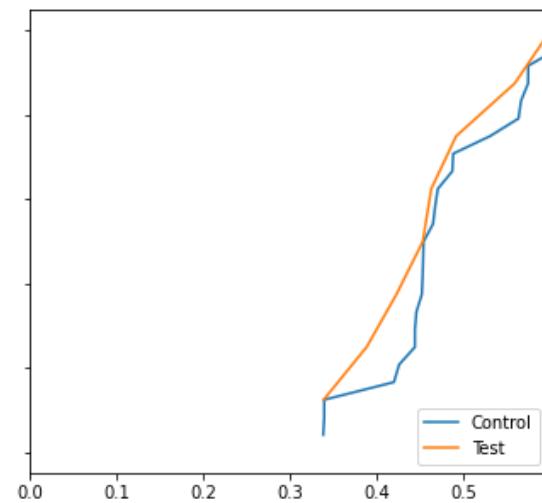
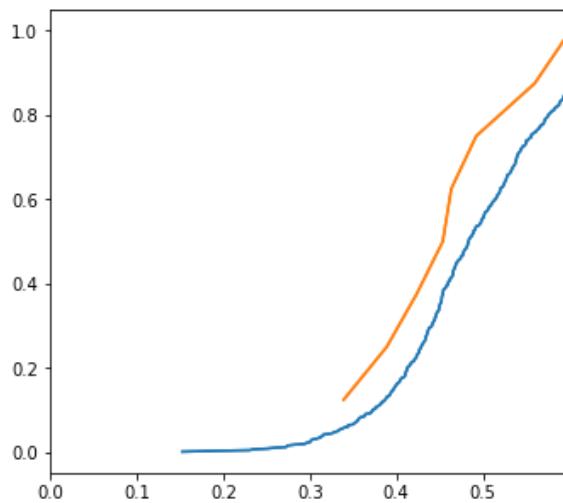
Test group is those with Affected BHC dummy equals to one (i.e: BHCs with TAR equal or higher than 3%), control group is BHCs with Affected BHC dummy equals to zero.



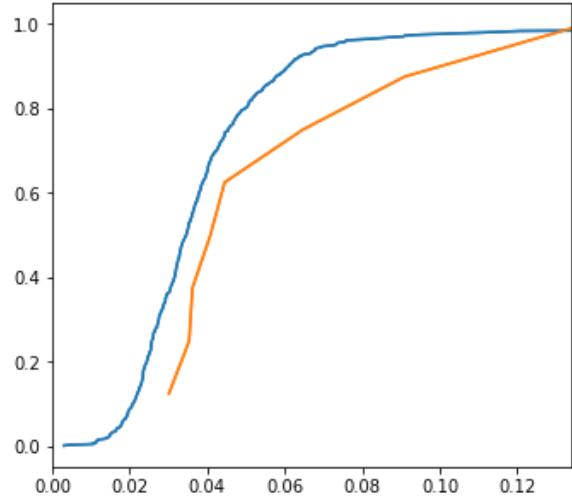
ECDF for Included Variables after Propensity Score Matching

ECDF for dep_cir before Matching
 KS p-value: 0.786
 Grouped Perm p-value: 1.0
 Std. Median Difference: -0.2252342926973893
 Std. Mean Difference: -0.263547542547701

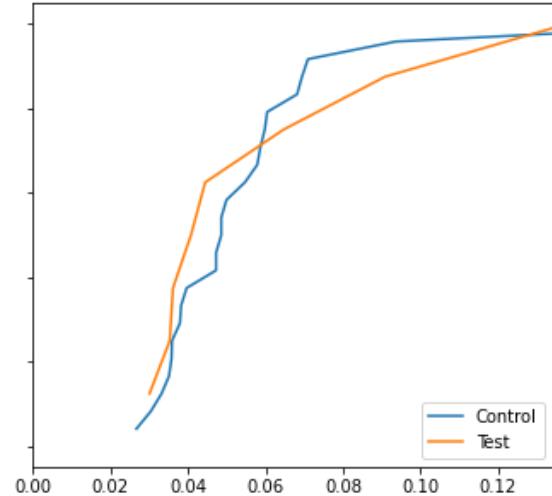
ECDF for dep_cir after Matching
 KS p-value: 0.896
 Grouped Perm p-value: 1.0
 Std. Median Difference: -0.008089305905325249
 Std. Mean Difference: -0.24755515986359672



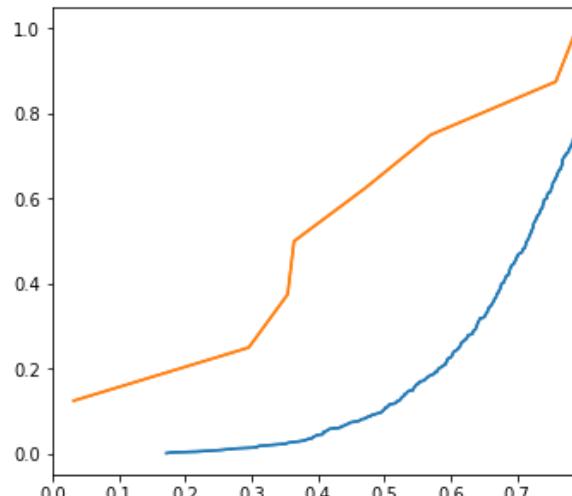
ECDF for dep_liquidity before Matching
 KS p-value: 0.11
 Grouped Perm p-value: 1.0
 Std. Median Difference: 0.3075932416138455
 Std. Mean Difference: 0.7735894225170614



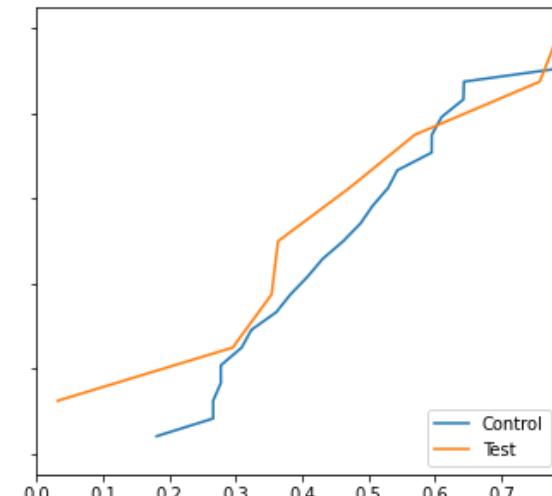
ECDF for dep_liquidity after Matching
 KS p-value: 0.765
 Grouped Perm p-value: 1.0
 Std. Median Difference: -0.18726241894879628
 Std. Mean Difference: 0.14039942573008074



ECDF for dep_loans_ERatio before Matching
 KS p-value: 0.007
 Grouped Perm p-value: 1.0
 Std. Median Difference: -2.009555656755529
 Std. Mean Difference: -1.5981557681808216



ECDF for dep_loans_ERatio after Matching
 KS p-value: 0.98
 Grouped Perm p-value: 1.0
 Std. Median Difference: -0.2783363996032491
 Std. Mean Difference: -0.1650300342267971



Robustness Test Model 3

(full results not reported for brevity); Please see code for full results

Model:	OLS	Adj. R-squared:	0.887			
Dependent Variable:	bhc_avgtradingratio					
Date:	2021-10-17 21:46					
No. Observations:	39189	Log-Likelihood:	1.5034e+05			
Df Model:	2427	F-statistic:	127.5			
Df Residuals:	36761	Prob (F-statistic):	0.00			
R-squared:	0.894	Scale:	2.9051e-05			
	Coef.	Std.Err.	t	P> t	[0.025	0.975]
Intercept	0.0057	0.0028	2.0678	0.0387	0.0003	0.0111
affect_2007	0.3530	0.0027	130.4496	0.0000	0.3477	0.3583
after_DFA_1	0.0009	0.0002	4.0521	0.0001	0.0005	0.0013
affect_2007:after_DFA_1	-0.2053	0.0041	-49.7072	0.0000	-0.2134	-0.1972
dep_Inassets	-0.0002	0.0002	-1.3265	0.1847	-0.0005	0.0001
dep_leverage	0.0054	0.0018	2.9758	0.0029	0.0018	0.0089
dep_roa1	0.0111	0.0080	1.3754	0.1690	-0.0047	0.0268
dep_liquidity	-0.0024	0.0010	-2.4100	0.0160	-0.0043	-0.0004
dep_depositratio	0.0004	0.0005	0.6751	0.4996	-0.0007	0.0014
dep_loans_ERratio	-0.0067	0.0007	-9.9577	0.0000	-0.0080	-0.0054
dep_cir	0.0004	0.0001	3.0387	0.0024	0.0001	0.0007
dep_cpp_bankquarter	0.0001	0.0001	0.7523	0.4519	-0.0002	0.0004
dep_creditrisk_total3	0.0019	0.0014	1.3898	0.1646	-0.0008	0.0045

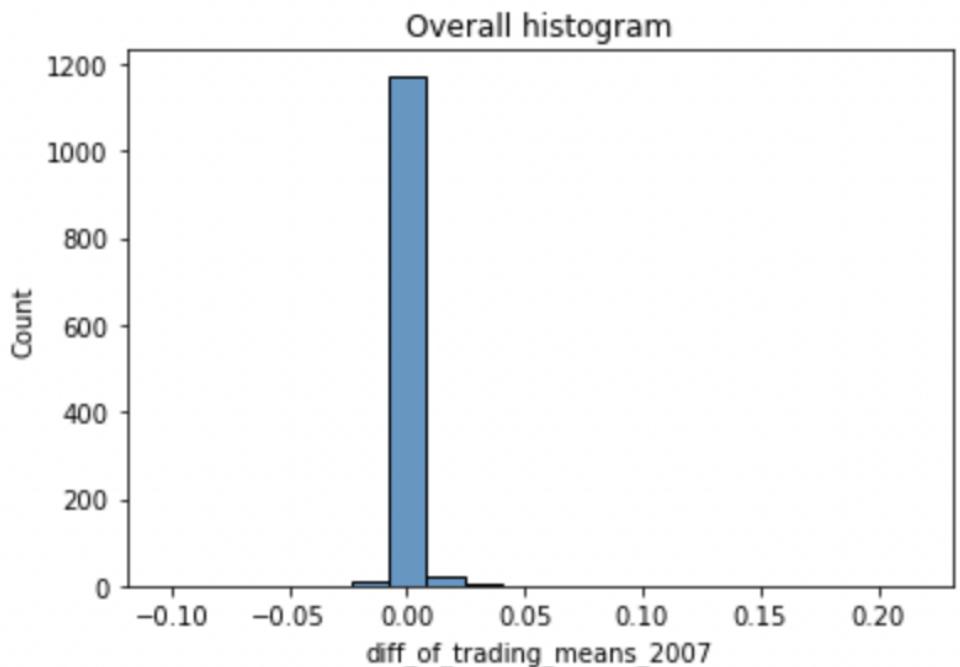
Robustness Test Model 4

(full results not reported for brevity); Please see code for full results

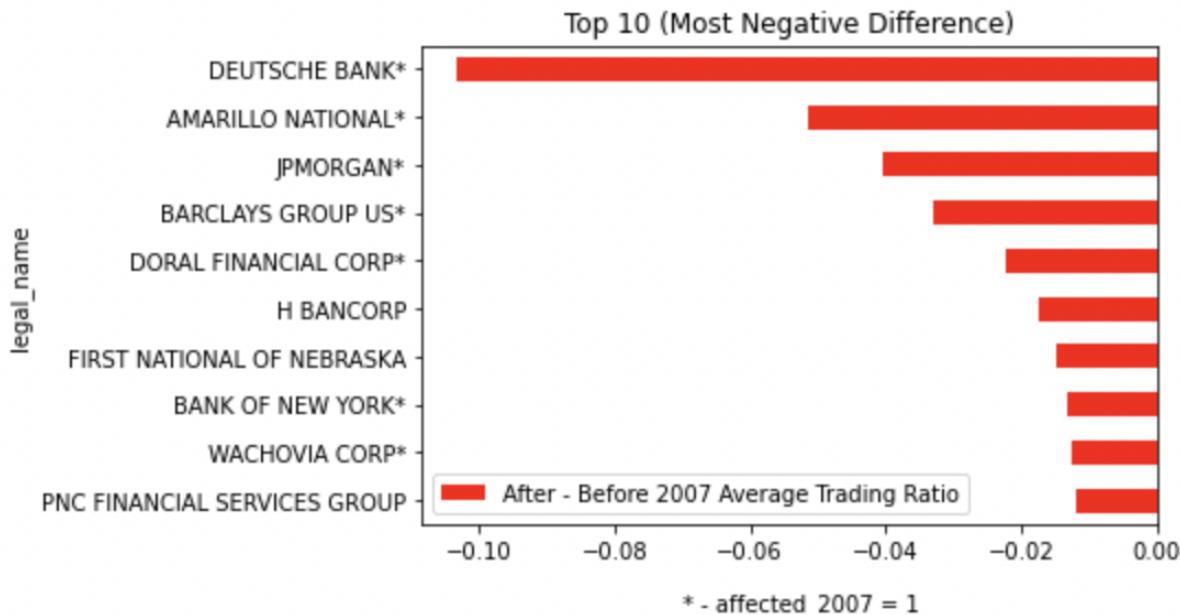
Model:	OLS	Adj. R-squared:	0.935			
Dependent Variable:	bhc_avgtradingratio					
Date:	2021-10-17 21:46					
No. Observations:	2343	Log-Likelihood:	6689.0			
Df Model:	144	F-statistic:	236.6			
Df Residuals:	2198	Prob (F-statistic):	0.00			
R-squared:	0.939	Scale:	0.00020680			
	Coef.	Std.Err.	t	P> t	[0.025	0.975]
Intercept	0.0628	0.0310	2.0260	0.0429	0.0020	0.1236
affect_2007	0.5954	0.0312	19.1072	0.0000	0.5343	0.6565
after_DFA_1	0.0072	0.0025	2.9107	0.0036	0.0023	0.0120
affect_2007:after_DFA_1	-0.2114	0.0125	-16.8709	0.0000	-0.2359	-0.1868
dep_Inassets	0.0009	0.0018	0.5035	0.6146	-0.0026	0.0043
dep_leverage	0.0037	0.0206	0.1795	0.8575	-0.0367	0.0441
dep_roa1	0.1197	0.1028	1.1639	0.2446	-0.0820	0.3214
dep_liquidity	-0.0127	0.0077	-1.6577	0.0975	-0.0278	0.0023
dep_depositratio	-0.0023	0.0053	-0.4266	0.6697	-0.0128	0.0082
dep_loans_ERatio	-0.0421	0.0053	-7.9764	0.0000	-0.0524	-0.0317
dep_cir	0.0015	0.0008	1.8892	0.0590	-0.0001	0.0031
dep_cpp_bankquarter	-0.0013	0.0015	-0.8411	0.4004	-0.0043	0.0017
dep_creditrisk_total3	0.0071	0.0196	0.3611	0.7181	-0.0313	0.0455

Appendix I - Top and Least Trading BHCs Graphs & Table

Graph IA: Overall Histogram on the (After - Before 2007) Average Trading Ratio Difference



Graph IB: Most Responsive BHCs - Top 10 Most Negative Trading Difference (After - Before 2007)



Graph IC: Most Responsive BHCs - Top 10 Most Positive Trading Difference (After - Before 2007)

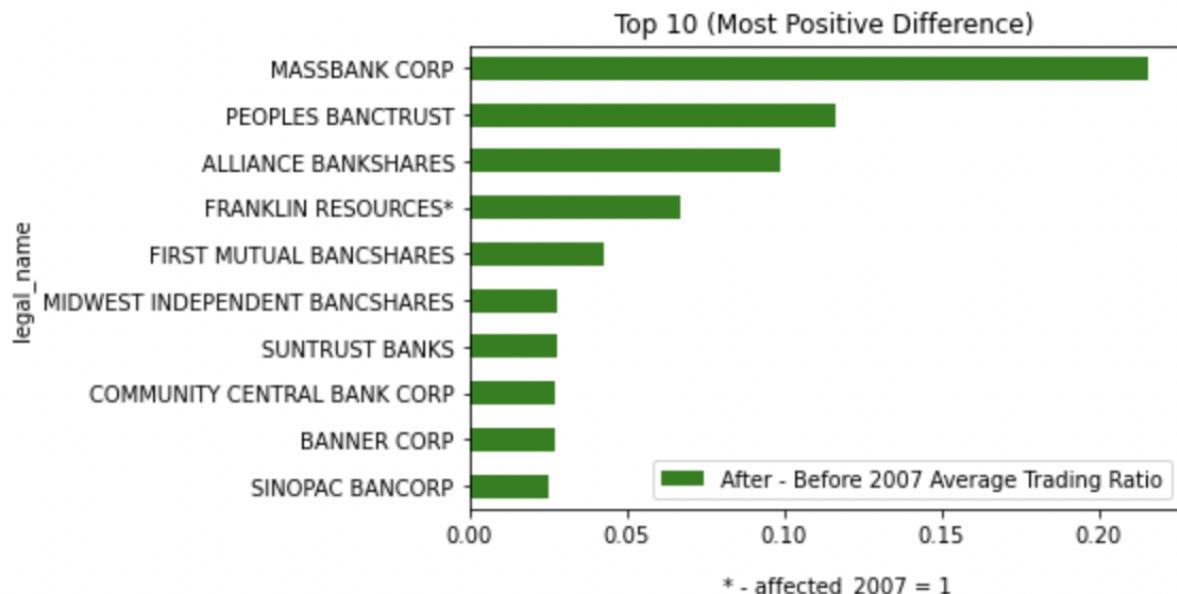


Table IA: Least Responsive BHCs - Middle 10 Trading Difference (After - Before 2007)

	rssd9001	affect_before_2007	affect_after_2007	diff_of_trading_means_2007	affect_2007	legal_name
0	1123915	0.0	0.0	0.0	0	KLEIN FINANCIAL INC
1	1123885	0.0	0.0	0.0	0	FARMER'S STATE CORP
2	1124659	0.0	0.0	0.0	0	HIGHLAND BANCSHARES INC
3	2856014	0.0	0.0	0.0	0	LEADERS GROUP INC
4	1081079	0.0	0.0	0.0	0	CITRUS & CHEMICAL BANCORP
5	1205950	0.0	0.0	0.0	0	GNB BANCORP
6	1099917	0.0	0.0	0.0	0	FIRST STATE BANCSHARES
7	1075881	0.0	0.0	0.0	0	CHESAPEAKE FINANCIAL SHARES INC
8	1117464	0.0	0.0	0.0	0	ACNB CORP
9	1080595	0.0	0.0	0.0	0	COMMUNITY BANCSHARES OF MISSISSIPPI

Appendix J - Top 10 and Bottom 10 BHCs Models

Top 10 Baseline Model

(full results not reported for brevity); Please see code for full results

OLS Regression Results

Dep. Variable:	bhc_avgtradingratio	R-squared:	0.922				
Model:	OLS	Adj. R-squared:	0.917				
Method:	Least Squares	F-statistic:	180.2				
Date:	Fri, 22 Oct 2021	Prob (F-statistic):	0.00				
Time:	20:13:18	Log-Likelihood:	1.5176e+05				
No. Observations:	40026	AIC:	-2.986e+05				
Df Residuals:	37551	BIC:	-2.773e+05				
Df Model:	2474						
Covariance Type:	nonrobust						
		coef	std err	t	P> t	[0.025	0.975]
	Intercept	0.0107	0.003	3.749	0.000	0.005	0.016
	after_DFA_1	0.0011	0.000	4.617	0.000	0.001	0.002
	top10	0.1371	0.001	124.736	0.000	0.135	0.139
	after_DFA_1:top10	-0.0293	0.001	-41.035	0.000	-0.031	-0.028
	dep_Inassets	-0.0004	0.000	-2.496	0.013	-0.001	-9.11e-05
	dep_leverage	0.0049	0.002	2.641	0.008	0.001	0.009
	dep_roa1	0.0077	0.008	0.938	0.348	-0.008	0.024
	dep_liquidity	-0.0016	0.001	-1.601	0.109	-0.004	0.000
	dep_depositratio	3.769e-05	0.001	0.068	0.946	-0.001	0.001
	dep_loans_ERratio	-0.0094	0.001	-13.719	0.000	-0.011	-0.008
	dep_cir	0.0004	0.000	2.906	0.004	0.000	0.001
	dep_cpp_bankquarter	-6.64e-05	0.000	-0.434	0.665	-0.000	0.000
	dep_creditrisk_total3	0.0011	0.001	0.815	0.415	-0.002	0.004

Bottom 10 Baseline Model

(full results not reported for brevity); Please see code for full results

OLS Regression Results

Dep. Variable:	bhc_avgtradingratio	R-squared:	0.919				
Model:	OLS	Adj. R-squared:	0.913				
Method:	Least Squares	F-statistic:	171.9				
Date:	Fri, 22 Oct 2021	Prob (F-statistic):	0.00				
Time:	20:14:19	Log-Likelihood:	1.5088e+05				
No. Observations:	40026	AIC:	-2.968e+05				
Df Residuals:	37551	BIC:	-2.755e+05				
Df Model:	2474						
Covariance Type:	nonrobust						
		coef	std err	t	P> t	[0.025	0.975]
	Intercept	0.0061	0.003	2.087	0.037	0.000	0.012
	after_DFA_1	0.0006	0.000	2.562	0.010	0.000	0.001
	btm10	0.0003	0.001	0.289	0.773	-0.002	0.002
	after_DFA_1:btm10	0.0004	0.001	0.567	0.571	-0.001	0.002
	dep_inassets	-0.0002	0.000	-0.894	0.372	-0.000	0.000
	dep_leverage	0.0021	0.002	1.119	0.263	-0.002	0.006
	dep_roa1	0.0029	0.008	0.352	0.725	-0.013	0.019
	dep_liquidity	-0.0022	0.001	-2.121	0.034	-0.004	-0.000
	dep_depositratio	-7.308e-06	0.001	-0.013	0.990	-0.001	0.001
	dep_loans_ERatio	-0.0076	0.001	-10.863	0.000	-0.009	-0.006
	dep_cir	0.0002	0.000	1.672	0.094	-3.84e-05	0.000
	dep_cpp_bankquarter	-5.419e-05	0.000	-0.346	0.729	-0.000	0.000
	dep_creditrisk_total3	0.0007	0.001	0.470	0.638	-0.002	0.003

Top 10 Model with Propensity Score Matching

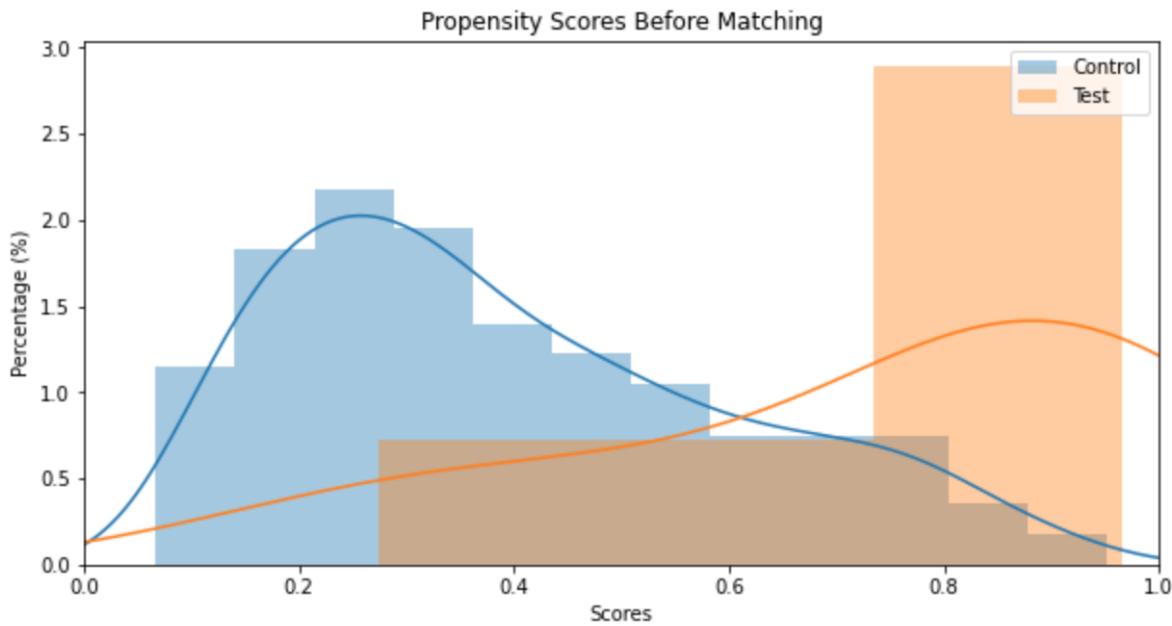
(full results not reported for brevity); Please see code for full results

OLS Regression Results

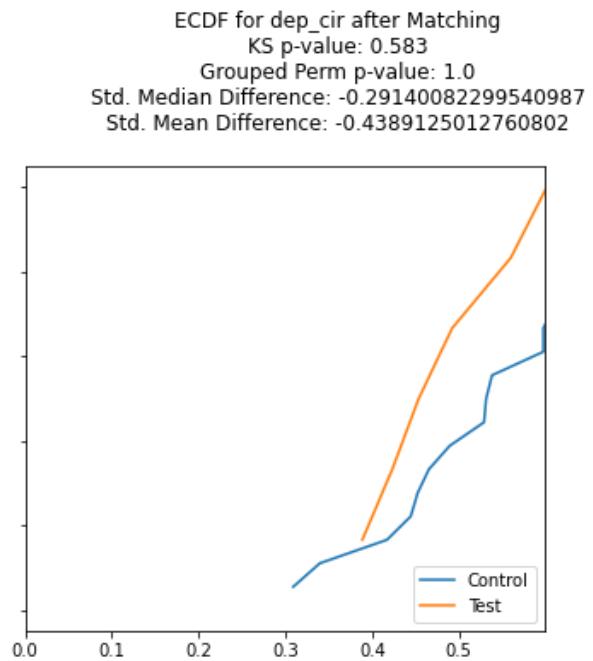
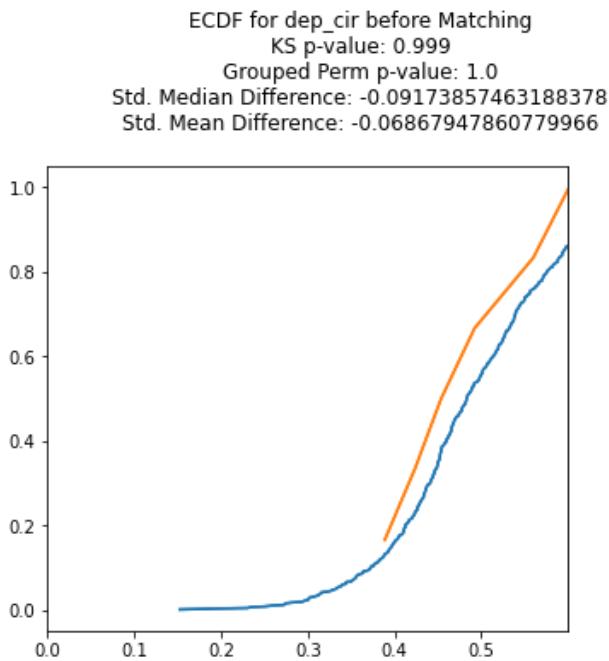
Dep. Variable:	bhc_avgtradingratio	R-squared:	0.970				
Model:	OLS	Adj. R-squared:	0.967				
Method:	Least Squares	F-statistic:	303.2				
Date:	Fri, 22 Oct 2021	Prob (F-statistic):	0.00				
Time:	20:20:45	Log-Likelihood:	2069.3				
No. Observations:	691	AIC:	-4003.				
Df Residuals:	623	BIC:	-3694.				
Df Model:	67						
Covariance Type:	nonrobust						
		coef	std err	t	P> t	[0.025	0.975]
	Intercept	0.0829	0.054	1.540	0.124	-0.023	0.189
	after_DFA_1	0.0083	0.003	2.413	0.016	0.002	0.015
	top10	0.1185	0.009	12.628	0.000	0.100	0.137
	after_DFA_1:top10	-0.0403	0.003	-16.107	0.000	-0.045	-0.035
	dep_Inassets	-0.0038	0.003	-1.163	0.245	-0.010	0.003
	dep_leverage	-0.0154	0.042	-0.368	0.713	-0.098	0.067
	dep_roa1	-0.1919	0.137	-1.397	0.163	-0.462	0.078
	dep_liquidity	-0.1220	0.017	-7.177	0.000	-0.155	-0.089
	dep_depositratio	-0.0165	0.008	-2.189	0.029	-0.031	-0.002
	dep_loans_ERatio	-0.0407	0.010	-3.987	0.000	-0.061	-0.021
	dep_cir	0.0202	0.004	4.769	0.000	0.012	0.029
	dep_cpp_bankquarter	-0.0133	0.003	-4.469	0.000	-0.019	-0.007
	dep_creditrisk_total3	0.1257	0.036	3.516	0.000	0.055	0.196

Result of Propensity Score Matching for Top 10 BHCs

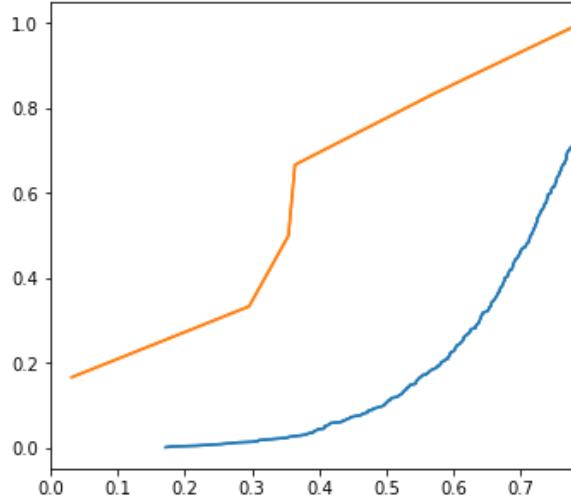
Test group is 10 BHCs with the highest TAR in 2007, the control group is all other BHCs.



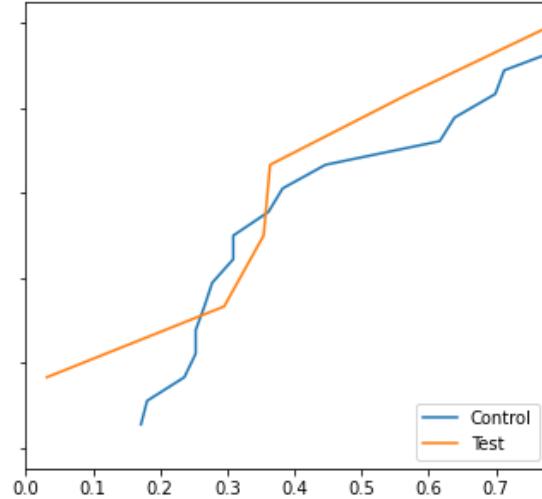
ECDF for Included Variables after Propensity Score Matching



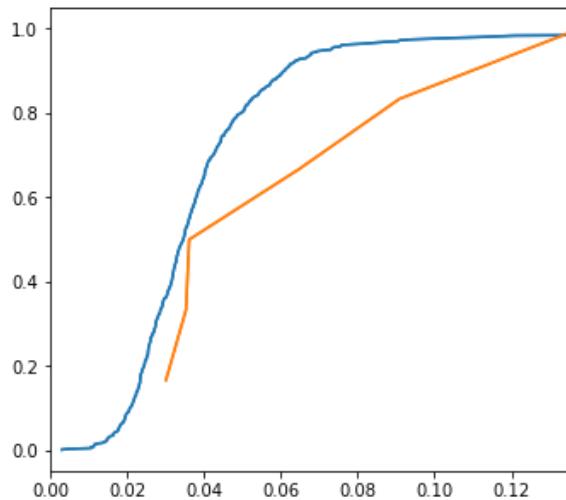
ECDF for dep_loans_ERatio before Matching
KS p-value: 0.006
Grouped Perm p-value: 1.0
Std. Median Difference: -2.404772146280457
Std. Mean Difference: -1.957338215468132



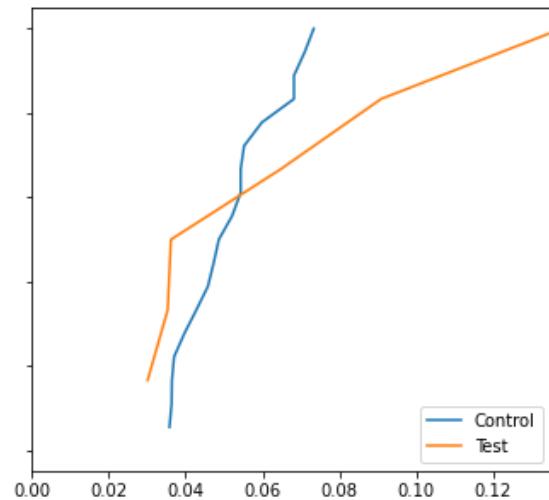
ECDF for dep_loans_ERatio after Matching
KS p-value: 0.924
Grouped Perm p-value: 1.0
Std. Median Difference: 0.10661327029918939
Std. Mean Difference: -0.13912934441436148



ECDF for dep_liquidity before Matching
KS p-value: 0.175
Grouped Perm p-value: 1.0
Std. Median Difference: 0.6043566334215376
Std. Mean Difference: 0.9951595561381099



ECDF for dep_liquidity after Matching
KS p-value: 0.247
Grouped Perm p-value: 1.0
Std. Median Difference: 0.003774577893214138
Std. Mean Difference: 0.6293711198943125



Bottom 10 Model with Propensity Score Matching

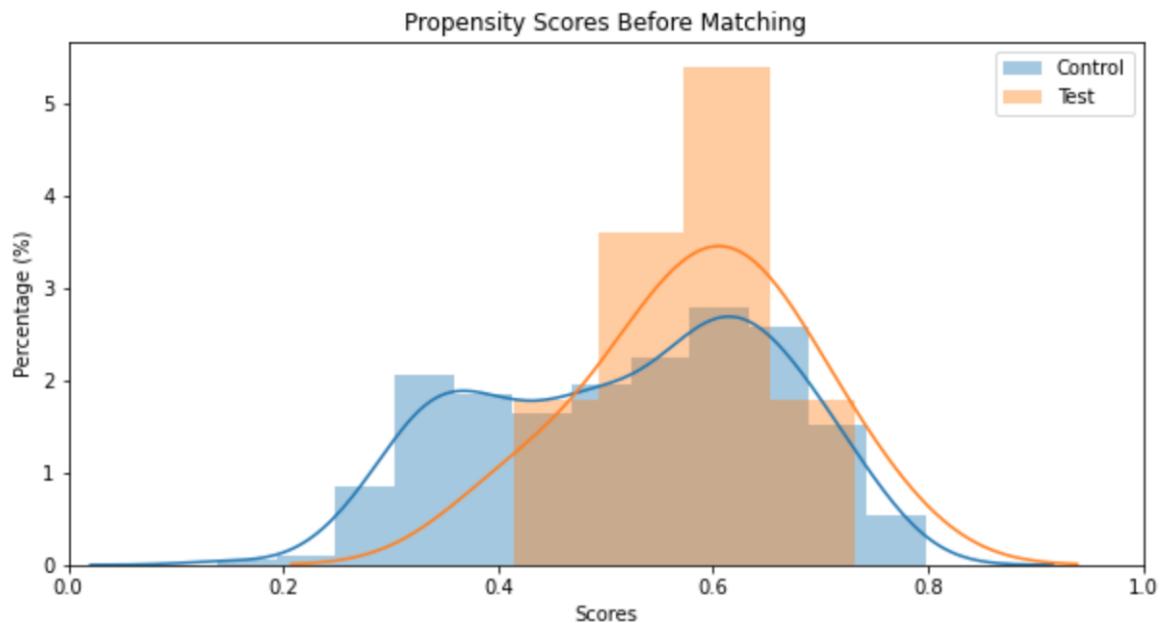
(full results not reported for brevity); Please see code for full results

OLS Regression Results

Dep. Variable:	bhc_avgtradingratio	R-squared:	0.753				
Model:	OLS	Adj. R-squared:	0.725				
Method:	Least Squares	F-statistic:	26.17				
Date:	Fri, 22 Oct 2021	Prob (F-statistic):	1.65e-148				
Time:	20:20:23	Log-Likelihood:	3792.1				
No. Observations:	709	AIC:	-7434.				
Df Residuals:	634	BIC:	-7092.				
Df Model:	74						
Covariance Type:	nonrobust						
		coef	std err	t	P> t	[0.025	0.975]
	Intercept	0.0056	0.007	0.767	0.443	-0.009	0.020
	after_DFA_1	0.0005	0.000	1.393	0.164	-0.000	0.001
	bottom10	-0.0004	0.001	-0.682	0.495	-0.001	0.001
	after_DFA_1:bottom10	0.0002	0.000	0.922	0.357	-0.000	0.001
	dep_lnassets	-0.0003	0.001	-0.576	0.565	-0.001	0.001
	dep_leverage	0.0064	0.006	1.137	0.256	-0.005	0.017
	dep_roa1	-0.0778	0.037	-2.082	0.038	-0.151	-0.004
	dep_liquidity	0.0003	0.002	0.171	0.864	-0.003	0.004
	dep_depositratio	-0.0020	0.001	-1.618	0.106	-0.004	0.000
	dep_loans_RRatio	0.0004	0.002	0.287	0.774	-0.003	0.003
	dep_cir	-0.0020	0.001	-2.647	0.008	-0.003	-0.001
	dep_cpp_bankquarter	3.306e-05	0.000	0.145	0.884	-0.000	0.000
	dep_creditrisk_total3	0.0012	0.004	0.268	0.789	-0.007	0.010

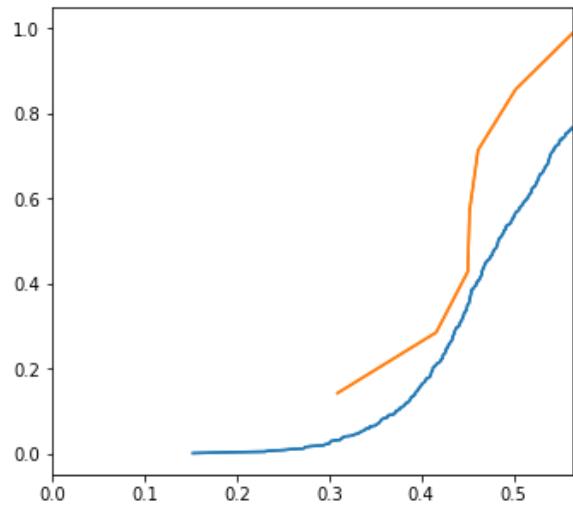
Result of Propensity Score Matching for Bottom 10 BHCs

Test group is 10 BHCs with the lowest TAR in 2007, the control group is all other BHCs.

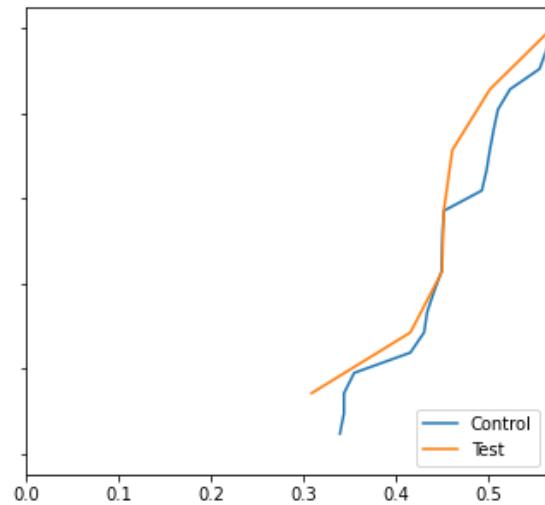


ECDF for Included Variables after Propensity Score Matching

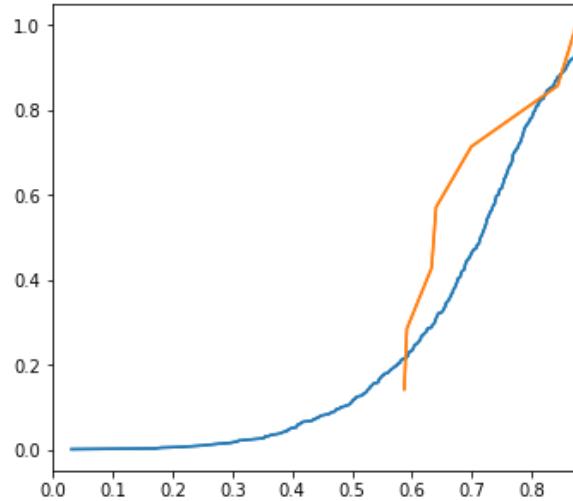
ECDF for dep_cir before Matching
 KS p-value: 0.447
 Grouped Perm p-value: 1.0
 Std. Median Difference: -0.28357753914786415
 Std. Mean Difference: -0.3870681790932733



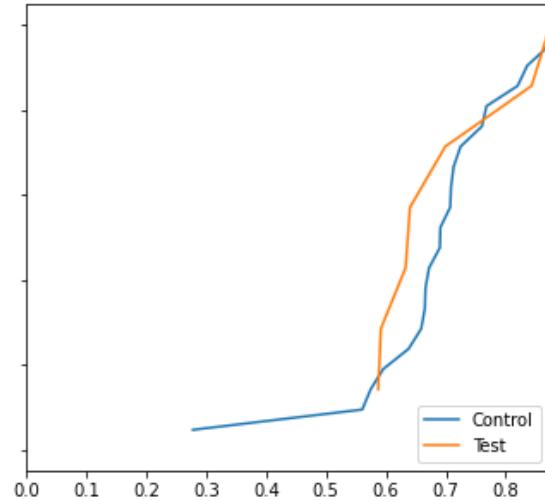
ECDF for dep_cir after Matching
 KS p-value: 0.961
 Grouped Perm p-value: 1.0
 Std. Median Difference: 0.01911853293226126
 Std. Mean Difference: -0.10268215327498263



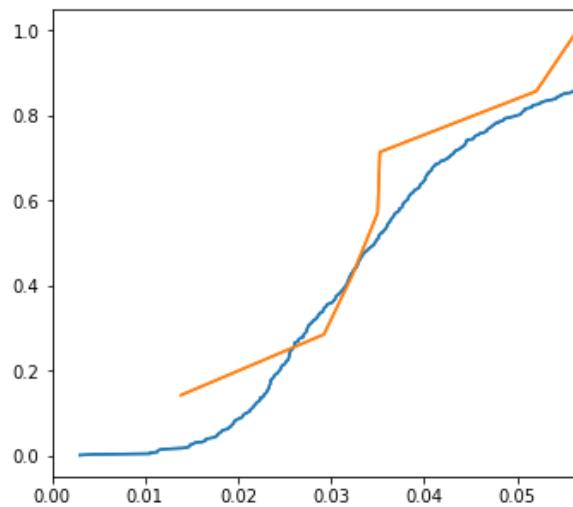
ECDF for dep_loans_ERatio before Matching
KS p-value: 0.627
Grouped Perm p-value: 1.0
Std. Median Difference: -0.5025823857702914
Std. Mean Difference: 0.054807094054467154



ECDF for dep_loans_ERatio after Matching
KS p-value: 0.491
Grouped Perm p-value: 1.0
Std. Median Difference: -0.4077372854838827
Std. Mean Difference: 0.03665201616515994



ECDF for dep_liquidity before Matching
KS p-value: 0.902
Grouped Perm p-value: 1.0
Std. Median Difference: 0.009710115594889098
Std. Mean Difference: -0.14664112218365197



ECDF for dep_liquidity after Matching
KS p-value: 0.509
Grouped Perm p-value: 1.0
Std. Median Difference: 0.3507674678248934
Std. Mean Difference: 0.4510379639206956

