The impact of negative interest rates on the stock returns of Japanese financial institutions

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Abstract

Japan's implementation of a negative benchmark rate target has negatively impacted the returns of its financial institutions. The conventional result that a lower rate environment is detrimental to bank profitability and results in lower returns extends into the case of non-conventional policy. We study different categories of financial institutions and provide findings and arguments for why deposit-takers (diversified banks and regional banks) suffer more from negative interest rates compared to investment banks and insurance companies.

Introduction

Fukuda's 2018 paper found a large negative impact on stock prices in Japan's financial sector after Japan's negative interest rate (NIR) announcement by measuring daily excess returns above the TOPIX (Tokyo Stock Price Index) using intervals from 5 to 20 days after the announcement. He argued that the zero bound for interest rates remains relevant for some rates, most notably, retail deposit rates. He investigated heterogeneity in these effects and argued that the profits of insurance companies are severely affected by declining investment returns while mandated to guarantee positive returns for policyholders.

We investigate the question of longer-term impacts by extending the window past 20 days, and control for relevant risk factors in attempts to segregate returns attributable to influences outside of negative interest rates. We extend our analysis in a similar direction of Fukuda's in analyzing heterogeneous effects on different types of financial institutions, including diversified banks, insurance companies, regional banks, and investment banks.

The findings of this paper can help assess externalities caused by Japan's unconventional monetary policy. Policies detrimental to equity prices of the financial sector can have prolonged effects on consumer confidence in these institutions and can cause higher costs of financing via equity and debt issuance through mechanics explained by Myers and Majluf (1984) as the pecking order theory. The findings can help identify which types of financial institutions are most affected by negative interest rates, adding additional considerations to unconventional monetary policy.

We plot the returns of the equal-weighted portfolio and the returns of the Nikkei 225 in Figure 1 and notice that the portfolio underperforms the Nikkei in the years that Japan announced various QE measures. We insert a line to indicate the date of NIR announcement.

Previous Related Work

There has been a considerable amount of literature on common risk factors that can explain the cross-section of stock returns. Within this literature, Kubota and Takehara (2018) tested a three-factor pricing model developed by Fama and French (1992) and its extension with five factors on monthly Japanese returns from 1978 – 2014. They concluded that the three-factor model has sufficient explanatory power over Japanese stock returns, where the RMW (robust minus weak – operating profitability measure) and CMA (conservative minus aggressive – investment level measure) factors are not statistically significant.

Outside of Japan, Viale et al. (2009) studied the cross-section of US bank stock returns over the period of 1986-2003. They conducted tests on various pricing models including the CAPM and the three-factor Fama-French model. They concluded that the CAPM and the three-factor Fama-French model do not contain sufficient explanatory ability on US bank stock returns. They noted that “previous empirical studies [...] have found that an interest rate factor adds substantial explanatory power” and instead suggest a model that includes risk exposure to “shocks”, or unexpected increases in interest rates.

Fukuda (2018) provided a descriptive analysis of the reaction of the Japanese bank equities following the Bank of Japan's NIRP announcement. This paper studied daily excess returns (above the Tokyo Stock Price Index, TOPIX) 5, 10, 15, and 20 business days following the announcement and found significant negative excess returns for financial sector equities.

Hong and Kandrac (2018) tried to identify the heterogeneous effects of NIRP on different types of banks in Japan. They found that "bank stock prices are negatively associated with its reserve holdings and positively associated with its share of wholesale deposit funding". They argued that the extent of the negative impact of NIR on a given bank is limited by their exposure via reserves, which is not affected as retail deposits are to a "zero-lower-bound" for rates.

Our paper enriches the work done on Japanese bank stock returns by Fukuda (2018) with a longer post-announcement dataset spanning from 2008 to 2019. We implementing an asset-pricing model following a similar methodology to Fama and French (1992) but focused particularly on a portfolio of 21 Japanese financial institutions. We then adapt the conclusions from Viale et. al (2009), which recommended a risk factor to capture "shocks" to interest rates, by introducing a negative interest rate (NIR) dummy variable to capture the effect. Hong and Kandrac (2018) argued that Japan's NIR announcement was "wholly unexpected" as a result of Governor Kuroda's misdirection. Our analysis is extended for 4 categories of financial institutions (diversified banks, insurance companies, regional banks, investment banks) where we try to find the effect of NIR on each one and reconcile these results with the findings of Hong and Kandrac (2018).

Data Description

We collected monthly returns data for all the Japanese banks listed on the Tokyo Stock Exchange from Bloomberg. From this list, there were some banks that had missing data or were recently listed. We kept data from the 21 banks that had at least 100 observations.

We collected Fama-French factors for Japan, specifically their 5 Factor and momentum factor returns, from Kenneth R. French's Data Library. This data included a risk-free rate, which we used in the excess returns calculation for our bank stocks.

Monthly data for the relevant policy rate in Japan, the monthly overnight unsecured interbank lending rate (which we will be referring to as the Bank of Japan (BOJ) rate), was collected from Bloomberg. We then constructed a dummy variable, Negative Interest Rate (NIR), that is equal to 1 when the BOJ rate is negative.

For our analysis of the 4 different financial institution types, the classification of the banks was done using Bloomberg's GICS Sub-Industry identifier.

The financial institutions' deposit-to-assets ratios were retrieved from Capital IQ.

The resulting time series dataset has 129 monthly observations from May 2008 to January 2019 and included the variables: BOJ rate, excess returns of the financial institution stocks, returns from a value-weighted (using market capitalization) portfolio of the individual banks, and Fama-French factor returns. Our data is measured in percentage points (i.e. 1% return is expressed as 0.01).

The Fama-French factors included: a size factor - small minus big (SMB), a value factor - high minus low (HML), an operating profitability factor - robust minus weak (RMW), an investment factor - conservative minus aggressive (CMA), and a momentum factor - winners minus losers (WML).

A detailed description of our data can be found in the appendix in Tables 1, 2, and 3.

Identification

<u>Preliminary Specification:</u>

Our objective is to identify any significant effect on returns after controlling for an effective benchmark model, where our variable of interest is a NIR dummy variable. We plan to assess the effect of the negative interest rate announcement using OLS. To motivate our choice of using OLS, we note its use in previous literature and briefly discuss its strengths and weaknesses. Kubota and Takehara (2010) attempted to identify the risk premium associated with a contrarian portfolio (as opposed to momentum) using a 3-Factor Fama-French benchmark model and running OLS. OLS is conducive to a relatively simple interpretation of its coefficients but is ineffective if assumptions on the properties of the disturbances are not met. Later in the paper, we will discuss in further detail the issues we run into with these assumptions and how we attempted to correct them.

Our initial specification:

$$equal\_port = \beta_0 + \beta_1 nir + \beta_2 boj\_rate + \beta_3 mktrf + \beta_4 smb + \beta_5 hml + \beta_6 rmw + \beta_7 cma + \beta_8 wml$$

Where NIR is the negative interest rate dummy, BOJ rate is the level of Japan’s policy rate, mktrf is the market risk premium, and SMB, HML, RMW, CMA, and WML are the Fama-French factors.

Although we note that the inclusion of the additional Fama-French factors beyond the original 3-Factor model may not yield significant predictive ability according to Kubota and Takehara (2018), we proceed with a full 5-Factor model plus a momentum factor approach, as we believe that exposure to the additional factors may help explain excess bank returns. For example, the profitability factor, RMW, may be important for banks, since bottom line growth and ROE are important metrics for investors (Chase 2014).

Including the BOJ rate in our regression allows us to retain information on the effect of changes in the level, and not just the sign, of the BOJ rate.

<u>Econometric Issues with the Preliminary Specification:</u>

After testing the robustness of our initial specification to various econometric problems, we find that our initial specification suffers from misspecification due to non-linearities and fails to pass heteroskedasticity tests, therefore giving biased estimates. The result of the heteroskedasticity tests is likely affected by various non-linear relationships within our data.

To correct these problems, we first look at misspecification and potential non-linearities. Our strategy was to regress the residuals from the initial regression on quadratic terms and interaction terms of the explanatory variables. We include quadratic transformations of all explanatory variables aside from NIR in this test. We only use interactions with the NIR dummy variable since that is our main variable of interest, we believe these effects might be important. We run the regression with robust standard errors. The regression output shows an R-squared of 24.58%. Upon inspection, we see that both quadratic and interaction terms contribute almost equally to the R-squared value (15.01% and 13.53% respectively when regressed on residuals by themselves).

To check for the joint significance of these non-linear variables, we complete joint hypothesis testing using two methods. The first method finds an F-statistic. In Stata, this is done by first running a regression using the robust option and then using the "test" command to test for joint significance of variables. The resulting F-statistic is asymptotically similar to the Wald statistic if performed this way (StataCorp 2015).

The test results tell us that the quadratic terms of mktrf, SMB, RMW, CMA, and BOJ rate, along with the interaction of NIR with mktrf, SMB, HML, CMA and BOJ rate are jointly significant. Secondly, we perform the Wald Test, yielding the same result (Figure 5). Hence, we decide to add these to the regression specification, and this effectively removed clear signs of several problems. We discuss this in detail later.

Final Specification:

The previous robustness tests help construct our final specification, where we include the variables that were jointly significant:

$$\begin{aligned} equal\_port = {} & \beta_0 + \beta_1 nir + \beta_2 boj\_rate + \beta_3 mktrf + \beta_4 smb + \beta_5 hml + \beta_6 rmw + \beta_7 cma \\ & + \beta_8 wml + \beta_9 boj\_rate^2 + \beta_{10} mktrf^2 + \beta_{11} smb^2 + \beta_{12} rmw^2 + \beta_{13} cma^2 \\ & + \beta_{14} nir.mktrf + \beta_{15} nir.smb + \beta_{16} nir.hml + \beta_{17} nir.cma + \beta_{18} nir.boj\_rate \end{aligned}$$

We will extend this analysis, replacing the dependent variable with:

1. Value-weighted portfolio returns
2. Four equal-weighted portfolios of one type of bank (diversified, insurance, investment, and regional)

The value-weighted portfolio assigns weights according to proportional market capitalization. GICS definitions for the various bank categories ("GICS." MSCI):

- Diversified: consumer and commercially oriented companies offering a variety of financial products and services, including lending products, insurance, securities and investment products
- Insurance: property & casualty (P&C) and life insurance companies
- Investment: primarily engaged in investment banking & brokerage services, including equity and debt underwriting, mergers and acquisitions, securities lending and advisory services
- Regional: significant business activity in retail banking and small and medium corporate lending, operating in limited geographic regions

Robustness Checks:

We subject this specification to tests for heteroskedasticity, serial correlation, unit root, and misspecification. We provide a discussion of each of these tests and their results below:

Heteroskedasticity

Breusch Pagan Test

This tests for linear forms of heteroskedasticity. The null hypothesis in this test is constant variance of residuals against the alternative that the variance of residuals is a linear function of the regressors.

The BP test fails to reject the null hypothesis for the final regression specification with a p-value of 68.88%. This provides evidence that the model does not suffer from linear forms of heteroskedasticity.

White Test

This tests for nonlinear forms of heteroskedasticity. The null hypothesis in this test is constant variance of residuals against the alternative that the variance of residuals is some nonlinear function of the regressors.

The White test fails to reject the null hypothesis for the final regression specification with a p-value of 37.01%. This provides evidence that the model does not suffer from nonlinear forms of heteroskedasticity.

ARCH

LM Test

The null hypothesis for the Autoregressive Conditional Heteroskedasticity (ARCH) Lagrange Multiplier test is that there are no ARCH effects against the alternative that the model suffers from ARCH p-lag disturbances.

The test gives a p-value of 77.93% and hence we fail to reject the null hypothesis.

Serial Correlation
Breusch-Godfrey Test

This tests for possible serial correlation in the model. The null hypothesis is that there is no serial correlation against the alternative that autocorrelation is present.

The test gives a p-value of 82.90%, failing to reject the null. Thus, we can conclude that the model does not exhibit serial correlation.

Unit Root Tests
Augmented Dickey-Fuller

We test for the presence of unit roots in our variables by using 13 lags as suggested by the simplified approach from Perron and Ng (1995) and using Schwert (1989) to determine the maximum value of lags. All our variables show stationarity except for the BOJ rate. This is not surprising since interest rates are expected to exhibit unit root behaviour. We decide not to correct this in our model since having the level of interest rate makes much more sense economically than the first difference. There are small efficiency losses using this approach, but it allows for the desired interpretability of the effect of interest rate on the portfolio excess return.

Misspecification
Ramsey RESET Test

This tests for potential misspecification, identifying whether non-linear combinations of the regressors are correlated with the residuals from the initial specification. This test can help conclude if some other nonlinear combination of current regressors can remove bias from the estimators.

The test rejects the null of no misspecification. The F-stat has decreased from 6.58 (3 and 117 degrees of freedom) for the initial specification to 4.39 (3 and 107 degrees of freedom) for the final regression. The p-value increased from 0.04% to 0.59%. Although our model still suffers from misspecification bias, where there are non-linearities we have not accounted for, it has decreased from the initial regression.

Influential Observations:

We perform the jackknife technique, identifying influential observations on the coefficient on the BOJ rate. Our results presented in Figure 3 of the appendix. We note that the BOJ rate 5 months prior to the NIR announcement date are influential, suggestive of speculative investments on financial institution stocks based on changes in the BOJ rate.

To check the robustness of our other models, we do the same set of tests with different dependent variables. The dependent variables used are as follows:

1. Value-Weighted Portfolio (a value-weighted portfolio of the 21 bank stocks)
2. Diversified Banks Portfolio (an equal-weighted portfolio of Diversified Banks)
3. Regional Banks Portfolio (an equal-weighted portfolio of Regional Banks)
4. Investment Banks Portfolio (an equal-weighted portfolio of Investment Banks)
5. Insurance Banks Portfolio (an equal-weighted portfolio of Insurance Banks)

The classification of the banks into different categories is done using Bloomberg's GICS Sub-Industry identifier.

A summary of the tests on all the models can be found in the appendix (Table 4).

Since this specification does not suffer from the heteroskedasticity that is captured from the BP and White test, we choose to use this model for inference. We plot the squared residuals against the NIR dummy and the BOJ rate in Figure 2 in the appendix.

To maintain robustness in the model's inferences, we calculate robust standard errors for 5 of the 6 models, using Newey-West standard errors for the regression with Diversified Banks Portfolio as the dependent variable, as it suffers from serial correlation along with linear heteroskedasticity.

Results

Our regression table can be found in Table 5 of the appendix. The final specification shows that a few factors are more important in explaining the variation in the portfolio of financial institutions' excess returns than others. Market Risk Premium and Robust minus Weak are highly significant individually along with the BOJ rate and the NIR dummy variable. Among the additional variables that we add to correct for the econometric issues, squared BOJ rate and interaction terms between the NIR dummy and High minus Low, and the NIR dummy and Conservative minus Aggressive are individually significant.

Our main variable of interest, the NIR dummy, has a statistically significant coefficient with a p-value of near 0% after calculating robust standard errors. The coefficient is also negative which makes intuitive sense since financial institutions are likely adversely affected by negative interest rates as their margins shrink. The magnitude of the coefficient suggests keeping everything else constant, being in a negative interest rate environment would, on average, decrease an equal-weighted portfolio of financial institutions' excess return by approximately 9 basis points. This interpretation is incomplete and may be misleading since the NIR dummy comes from the BOJ rate, and the NIR dummy has several interaction terms as well. Thus, we do a more elaborate study of our results.

The interpretation of our results:

We study the impact of the BOJ rate *becoming more positive* by 1 basis point keeping everything included in our specification constant. This is associated with a decrease in the equal-weighted portfolio's excess return of approximately 40 basis points, on average. This is counterintuitive if we look only at the net interest margin channel at its surface. A bank's profits would only increase with increases in the BOJ rate if the average maturity of their assets is lower than their liabilities, meaning they can "roll-over" their assets quicker and earn the higher rates (Philadelphia Fed 1980). The prevailing conditions with non-near-zero BOJ rates and an increasing rate environment predate Japan's 2013 QE asset purchase program, where the average maturities of a bank's bond portfolio (asset side) was relatively high, potentially higher than their liabilities (Bank of Japan 2014).

We study the impact of the BOJ rate *becoming negative* (going from 0 basis points to -1 basis points) keeping everything else constant. This is associated with a decrease in the equal-weighted portfolio's excess return of approximately 1,300 basis points, on average. This finding is consistent with the argument for deteriorating net interest margin and previous literature that identify *unexpected* changes in interest rates to explain the effects in bank stock returns, where the NIR announcement was widely regarded as a surprise accommodative policy (Viale et. al 2009; Hong and Kandrac 2018).

We study the impact of the BOJ rate *becoming more negative* by 1 basis point keeping everything else constant. This is associated with an increase in the equal-weighted portfolio's excess return by approximately 88 basis points, on average. This result implies that the adverse effect of negative interest rates is captured only in the transition from positive to negative rates. The increase in returns can be a result of the impacted banks responding to the policy by diversifying their operations and expanding overseas (Hong and Kandrac 2018).

Our results for the BOJ rate becoming negative (from a non-negative starting point) are consistent with the findings of Fukuda (2018), which found significant negative excess returns after the announcement of NIR policy. We retrieved a significant coefficient on NIR, consistent with the findings of Viale et al. (2009) that unexpected "shocks" to the interest rate produce a significant effect on bank stock returns. Our model provides estimates for incremental decreases, further into negative rate territory, and predicts a positive association with returns.

We perform a similar study on the value-weighted portfolio and portfolios of the four categories of financial institutions. The results are summarized in Table 6 of the appendix and can be analyzed using "Interpretation Platform Excel File".

Upon conducting further analysis, we discuss some of the results:

Regional banks are more sensitive to interest rate changes when compared to other types of banks. In a decreasing rate environment, large diversified banks were able to expand overseas and into other business areas, while regional banks had fewer options, most expanding into metropolitan areas that further depressed their margin (Deutsche Bank Research 2013). Also, as a result of competitive pressures, regional banks may also face difficulties with passing through rate hikes to their consumers via higher lending rates.

It is also interesting to note that an increase during the positive interest rate environment is most detrimental to the investment banks. This could be a result of these banks sourcing most of their funds through the wholesale market, where the cost of funding is likely more sensitive to interest rate changes (Wang 2018) and more expensive when compared to retail deposits.

Lastly, insurance companies are the least sensitive to the rate environment becoming negative from a previous non-negative environment. This makes sense, as their cash inflows from premiums received and cash outflows from insurance payouts are not impacted by monetary policy. However, their average investment returns declined substantially, which may explain the negative sign (Fukuda 2018).

These results are consistent with the findings of Hong and Kandrac (2018) in the case of BOJ rates *becoming negative*, where the returns for the institutions that take deposits, diversified and regional banks, are worse (more negative) when compared to investment banks and insurance companies. Within the deposit-takers, regional banks on average have a higher deposit-to-assets ratio and experience a larger negative effect.

Potential Modifications

Potential simplifications can be made whereby the benchmark model and control variables only include: (1) the market risk premium and its associated non-linearities and interactions with the NIR dummy or (2) the Fama-French 3-Factor Model and its various non-linearities and interaction terms. We find that these approaches fail to control for enough factors and our suggested model is preferred for inference. The results are reported in Table 7 of the appendix.

This model may benefit from extensions/changes to the benchmark model. Work done by Kubota, Takehara (2010) suggested adding a contrarian portfolio, replacing the Fama-French momentum factor. Viale et al. (2009) suggested using only 2 risk factors - market risk premium and shocks to the yield curve slope - with an ICAPM model. Adrian et al. (2015) acknowledge the importance of ROE as a performance metrics and suggest adding a financial sector ROE and financial sector risk premium factor.

The supplementary analysis we completed also implies that the Fama-French 5 Factor Model along with the momentum factor works well for the financial sector by testing the joint hypothesis on all factors in our final model. This extends the finding of Kubota and Takehara (2018) who conclude that the model does not work for Japanese stocks in general. Our output can be found in Figure 4 of the appendix.

We attempt to model and calibrate the skedastic function, our results are presented in Table 8. Using this approach, we are unable to remove signs of heteroskedasticity (both linear and non-linear forms). Enriching the calibration of the skedastic function is an area for future research.

Conclusion

Our results predict that the implementation of Japan's negative interest rate policy has on average decreased financial sector returns. We decomposed this effect and found that when rates were already positive, further increases to the BOJ rate are associated with a decrease in returns. We argue that although this runs against conventional thought regarding net interest margin, depending on the relative maturities of the financial institution's assets and liabilities, this can cause borrowing costs to be relatively higher than returns from assets. With a positive starting BOJ rate, we found large negative returns associated with the BOJ rate becoming negative, consistent with previous literature that found unexpected changes in interest rate to cause profound, perverse effects on returns. Further, we estimated positive returns associated with going further into negative rate region - although our data in this area is limited, this can lead to interesting policy implications regarding further "rounds" of Japanese NIR policy. However, this is a multi-faceted issue, as Tian (2018) explains that "leaning against the wind" with accommodative policy has been shown to increase dependence on wholesale funding and can thus decrease bank profitability.

We analyzed the impact on 4 types of financial institutions: diversified banks, insurance companies, investment banks, and regional banks. Our results agree with the findings of Hong and Kandrac (2018) in those institutions that depend more on deposits experience worse returns as a result of NIR policy. Each institution faces varying levels of positive returns associated with going further into negative interest rate region. This complicates any policy analysis, where regional banks seem to receive the greatest benefit, but are the smallest institutions within the sector.

This study can be extended into the EU, where the ECB implemented NIR in 2014, where we may observe different effects arising from a different composition of the financial sector, different relative asset/liability maturities, and different scale of asset purchasing.

Appendix

Figure 1: Normalized NIKKEI 225 Index vs Equal-Weighted Portfolio

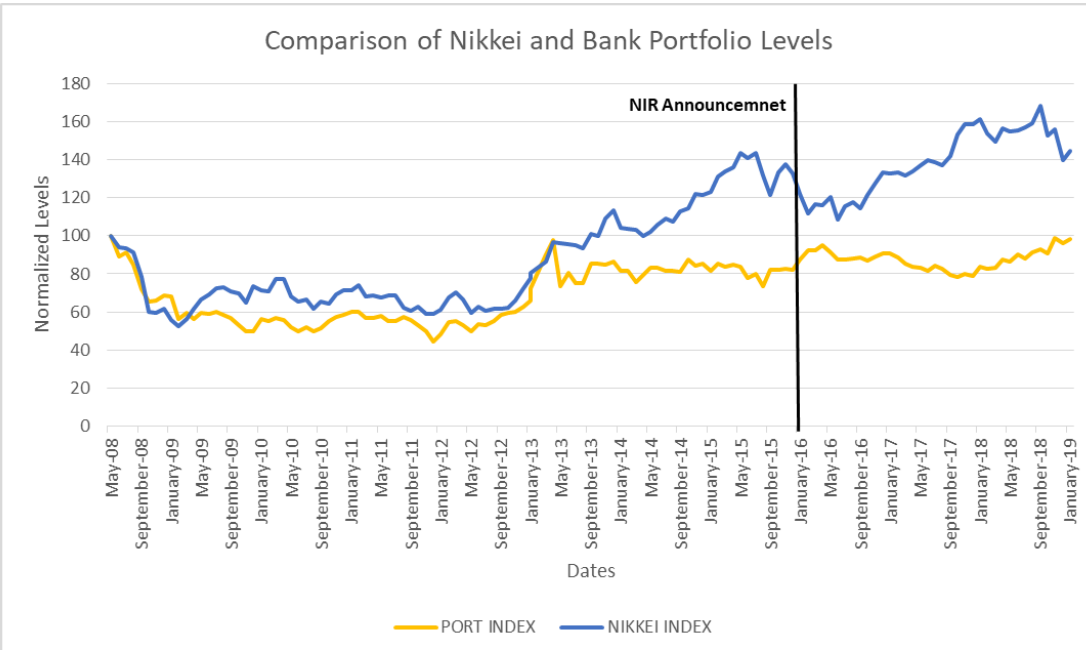

Figure 2: Graph for Evidence of Heteroskedasticity

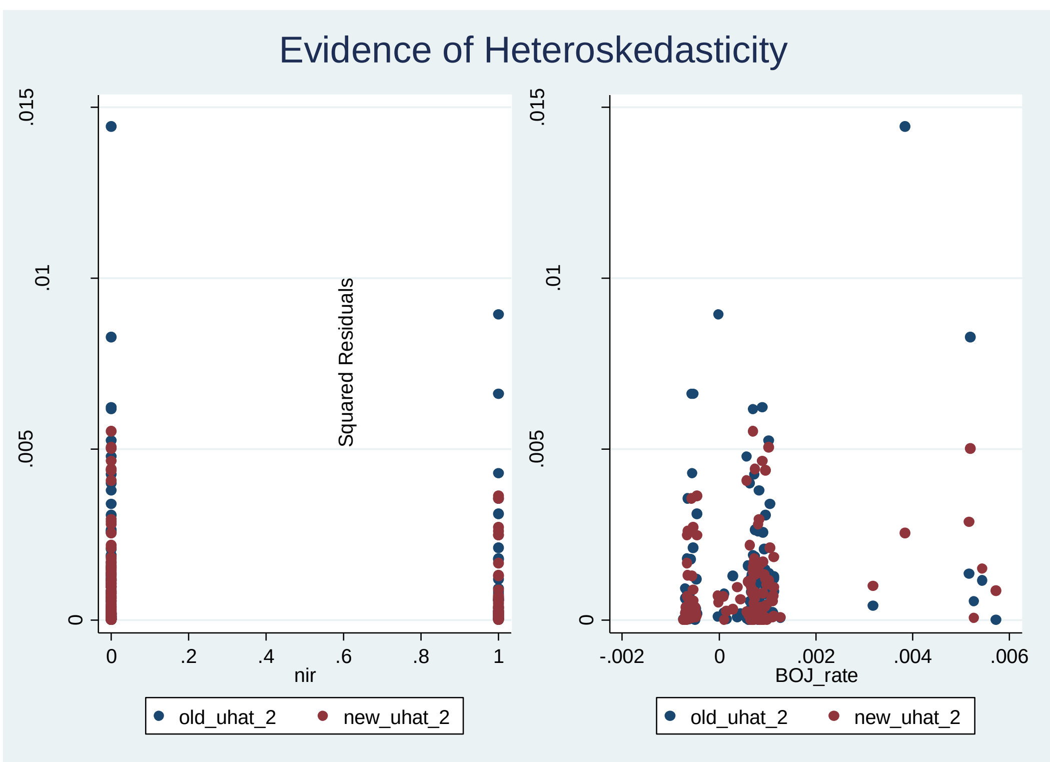

Figure 3: Jackknife Graph for Influential Observations of BOJ_Rate

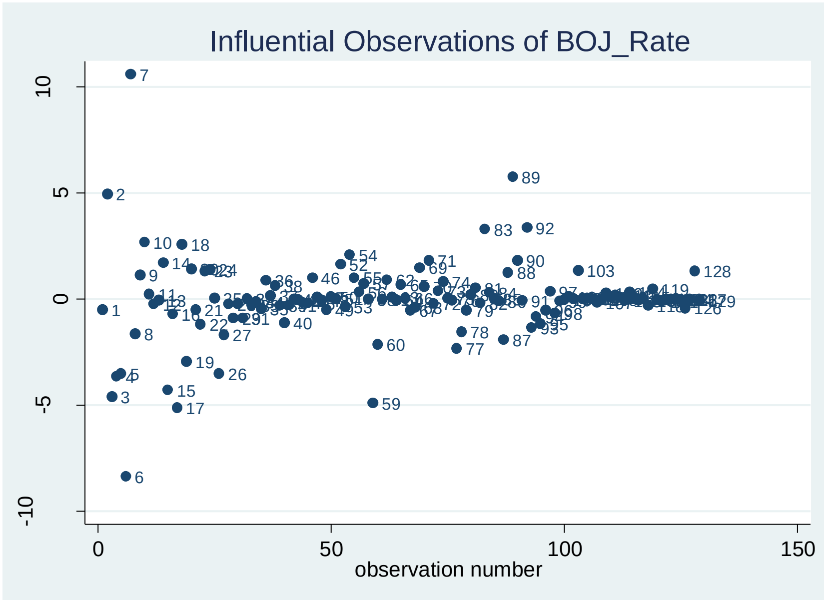

Figure 4: Testing for the Fama French 5 Factors Joint Significance

```
. test mktrf smb hml rmw cma wml

 ( 1)  mktrf = 0
 ( 2)  smb = 0
 ( 3)  hml = 0
 ( 4)  rmw = 0
 ( 5)  cma = 0
 ( 6)  wml = 0

       F(  6,   110) =   62.18
            Prob > F =    0.0000
```

Figure 5: Wald Test Explanation

We did a Wald Test manually by extracting the variance covariance matrix from Stata and calculating the Wald statistic in MATLAB with the desired restriction matrix and r vector. However, the Wald statistic is abnormally large (4,000+) but gives the same result.

Table 1: Variable Descriptions

Variable Description	
Variable Name	***Variable Description***
date	month and year of the observation in the format yyyymm
equal_port	excess returns of an equal weighted portfolio of 21 Japanese banks
val_port	excess returns of a value weighted portfolio of 21 Japanese banks
div_port	excess returns of an equal weighted portfolio of Japanese diversified banks
reg_port	excess returns of an equal weighted portfolio of Japanese regional banks
inv_port	excess returns of an equal weighted portfolio of Japanese investment banks
ins_port	excess returns of an equal weighted portfolio of Japanese insurance banks
nir	dummy with value 1 when boj_rate is negative
boj_rate	benchmark interest rate of Bank of Japan
mktrf	market excess returns on Japan
smb	small minus big portfolio return of Japanese stocks (size factor)
hml	high minus low portfolio return of Japanese stocks (value factor)
rmw	robust minus weak portfolio return of Japanese stocks (profitability factor)
cma	conservative minus aggressive portfolio return of Japanese stocks (investment factor)
wml	winners minus losers portfolio return of Japanese stocks (momentum factor)
mktrf2	squared value of mktrf
smb2	squared value of smb
hml2	squared value of hml
rmw2	squared value of rmw
cma2	squared value of cma
wml2	squared value of wml
nir_mktrf	interaction between nir and mktrf
nir_smb	interaction between nir and smb
nir_hml	interaction between nir and hml
nir_rmw	interaction between nir and rmw
nir_cma	interaction between nir and cma
nir_wml	interaction between nir and wml
nir_boj_rate	interaction between nir and boj_rate

Table 2: Financial Institution Information

Ticker	Variable Name	Name	GICS SubIndustry	Market Cap (JPY)	Value Port Weights	Bank Deposits/Assets
8303 JT Equity	s8303	Shinsei Bank Ltd	Regional Banks	403,835,092,992	1.14%	64.16%
8304 JT Equity	s8304	Aozora Bank Ltd	Diversified Banks	363,739,971,584	1.03%	60.47%
8306 JT Equity	s8306	Mitsubishi UFJ Financial Group Inc	Diversified Banks	7,711,356,354,560	21.84%	65.10%
8309 JT Equity	s8309	Sumitomo Mitsui Trust Holdings Inc	Diversified Banks	1,625,802,145,792	4.60%	64.24%
8316 JT Equity	s8316	Sumitomo Mitsui Financial Group Inc	Diversified Banks	5,380,698,537,984	15.24%	66.85%
8331 JT Equity	s8331	Chiba Bank Ltd/The	Regional Banks	545,278,296,064	1.54%	86.70%
8354 JT Equity	s8354	Fukuoka Financial Group Inc	Regional Banks	421,455,265,792	1.19%	69.82%
8355 JT Equity	s8355	Shizuoka Bank Ltd/The	Regional Banks	533,932,015,616	1.51%	83.46%
8369 JT Equity	s8369	Bank of Kyoto Ltd/The	Regional Banks	386,029,092,864	1.09%	82.28%
8411 JT Equity	s8411	Mizuho Financial Group Inc	Diversified Banks	4,364,970,491,904	12.36%	66.56%
8418 JT Equity	s8418	Yamaguchi Financial Group Inc	Regional Banks	261,710,086,144	0.74%	90.25%
8473 JT Equity	s8473	SBI Holdings Inc/Japan	N/A	551,412,957,184	1.56%	N/A
8570 JT Equity	s8570	AEON Financial Service Co Ltd	N/A	498,377,392,128	1.41%	N/A
8591 JT Equity	s8591	ORIX Corp	N/A	2,044,564,996,096	5.79%	N/A
8593 JT Equity	s8593	Mitsubishi UFJ Lease & Finance Co Ltd	N/A	489,125,445,632	1.39%	N/A
8601 JT Equity	s8601	Daiwa Securities Group Inc	Investment Banking & Brokerage	952,841,666,560	2.70%	N/A
8604 JT Equity	s8604	Nomura Holdings Inc	Investment Banking & Brokerage	1,431,661,969,408	4.05%	N/A
8725 JT Equity	s8725	MS&AD Insurance Group Holdings Inc	Property & Casualty Insurance	1,938,877,448,192	5.49%	N/A
8729 JT Equity	s8729	Sony Financial Holdings Inc	Life & Health Insurance	874,476,601,344	2.48%	N/A
8766 JT Equity	s8766	Tokio Marine Holdings Inc	Property & Casualty Insurance	3,743,879,528,448	10.60%	N/A
8795 JT Equity	s8795	T&D Holdings Inc	Life & Health Insurance	787,637,469,184	2.23%	N/A

Table 3: Summary Statistics

Summary Statistics				
Variable	***Mean***	***Std. Dev.***	***Min***	***Max***
mktrf	0.0037	0.0431	-0.1354	0.1089
smb	0.0045	0.0221	-0.0638	0.0563
hml	0.0004	0.0256	-0.0622	0.0707
rmw	0.0022	0.0155	-0.0449	0.0360
cma	0.0010	0.0190	-0.0566	0.0764
wml	-0.0005	0.0366	-0.1579	0.0846
boj_rate	0.0006	0.0012	-0.0007	0.0057
equal_port	-0.0034	0.0754	-0.3261	0.1644
val_port	-0.0036	0.0696	-0.3251	0.1428
div_port	-0.0051	0.0866	-0.5257	0.1525
reg_port	-0.0033	0.0738	-0.2820	0.1370
inv_port	-0.0083	0.1107	-0.3736	0.3260
ins_port	-0.0023	0.0776	-0.2962	0.1674

Variable	***Mean***	***Std. Dev.***	***# of 1's***	***# of Obs***
nir	0.2791	0.4503	36	129

Table 4: Summary of Tests for All Models

Summary of Tests for All Models						
Y/N	***Hetero (BP)***	***Hetero (White)***	***ARCH (LM)***	***AutoCorr (BG)***	***Misspec (RESET)***	***Size of Misspec***
Equal Portfolio	N	N	N	N	Y	Small
Value Portfolio	N	N	N	N	Y	Small
Diversified Banks	Y	N	Y	Y	Y	Large
Regional Banks	N	N	N	N	Y	Small
Investment Banks	N	N	N	N	N	NA
Insurance Banks	N	N	N	N	N	NA

Table 5: Regression Output for All Models (Robust SE for all models and N-W SE for Diversified)

	REGRESSION OUTPUT					
	Equal Weight	***Value Weight***	***Diversified***	***Regional***	***Investment***	***Insurance***
Negative Interest Rate Dummy	-0.0916***	-0.0759***	-0.0632**	-0.140***	-0.0917	-0.0928***
	(0.0247)	(0.0220)	(0.0199)	(0.0360)	(0.0473)	(0.0246)
BoJ Benchmark Rate	-42.42*	-40.04*	-22.91	-38.23*	-81.03*	-66.29**
	(17.81)	(16.91)	(20.78)	(17.83)	(37.91)	(21.38)
Market Risk Premium	1.307***	1.200***	1.300***	1.215***	1.686***	1.127***
	(0.0880)	(0.0812)	(0.104)	(0.0871)	(0.194)	(0.120)
SMB (Size)	-0.237	-0.246	-0.339	0.102	-0.422	-0.802***
	(0.157)	(0.148)	(0.190)	(0.181)	(0.263)	(0.214)
HML (Value)	0.314	0.284	0.324	0.392*	0.204	0.0568
	(0.224)	(0.193)	(0.461)	(0.171)	(0.501)	(0.313)
RMW (Profitability)	-1.014***	-0.930***	-1.386***	-0.727*	-1.646**	-0.895**
	(0.275)	(0.239)	(0.231)	(0.278)	(0.610)	(0.322)
CMA (Investment)	-0.152	0.0262	-0.238	0.00706	-0.413	0.269
	(0.273)	(0.240)	(0.268)	(0.272)	(0.652)	(0.267)
WML (Momentum)	-0.172	-0.185	-0.306	-0.117	-0.399	-0.320*
	(0.127)	(0.117)	(0.184)	(0.123)	(0.264)	(0.144)
Squared Market Risk Premium	-1.665	-1.630	-2.727	-0.573	-2.358	-1.772
	(1.295)	(1.181)	(2.088)	(1.297)	(3.135)	(1.585)
Squared SMB (Size)	-3.787	-3.953	-3.855	-3.100	-7.433	-8.065
	(4.583)	(4.042)	(4.895)	(5.046)	(8.608)	(6.446)
Squared RMW (Profitability)	-6.552	-1.474	-6.211	-32.82**	40.40	21.39
	(10.50)	(8.917)	(15.14)	(10.77)	(23.02)	(11.45)
Squared CMA (Investment)	-5.210	-9.262	-22.80*	-7.739	4.970	-5.819
	(6.411)	(6.367)	(8.907)	(5.140)	(9.429)	(5.824)
Squared BoJ Benchmark Rate	6679.3*	6413.4*	3821.6	6330.4*	12883.0*	11018.0**
	(3057.6)	(2934.6)	(3175.3)	(3082.5)	(6159.7)	(3468.2)
NIR*Market Risk Premium	-0.335	-0.408	-0.680*	-0.0330	-0.574	-0.187
	(0.240)	(0.214)	(0.270)	(0.261)	(0.408)	(0.278)
NIR*SMB	0.449	0.245	0.507	0.349	0.872	0.735
	(0.449)	(0.393)	(0.397)	(0.532)	(0.693)	(0.625)
NIR*HML	0.800*	0.673*	0.622	1.102**	0.945	1.033**
	(0.359)	(0.307)	(0.485)	(0.407)	(0.704)	(0.371)
NIR*CMA	-1.497***	-1.552***	-1.457*	-2.265***	-1.207	-1.407*
	(0.422)	(0.369)	(0.606)	(0.519)	(0.854)	(0.538)
NIR*BoJ Benchmark Rate	-43.96	-27.23	-38.13	-133.0*	57.23	3.271
	(38.50)	(33.77)	(29.81)	(59.46)	(71.29)	(37.83)
Constant	0.0361**	0.0338**	0.0305*	0.0359**	0.0491*	0.0497**
	(0.0123)	(0.0116)	(0.0139)	(0.0119)	(0.0241)	(0.0148)
Number of Observations	129	129	129	129	129	129
R-Squared	0.827	0.828	N/A	0.795	0.681	0.762
F-Statistic	27.89	27.55	86.42	24.02	19.72	37.09

Standard errors in parentheses

* p<0.05 ** p<0.01 *** p<0.001

Table 6: Interpretation Table

		Impact on Portfolio Returns (in basis points)					
Existing Environment	***Change***	***Equal Weight***	***Value Weight***	***Diversified***	***Regional***	***Investment***	***Insurance***
Positive Int. Rates	***increase by 1 bp***	(40)	(38)	(22)	(36)	(77)	(63)
Zero Int. Rate	***decrease by 1 bp***	(1,292)	(1,416)	(1,415)	(1,668)	(1,164)	(872)
Negative Int. Rate	***decrease by 1 bp***	88	69	62	173	28	66

Table 7: Regression Output for Simplified Versions [(1): Our Model, (2): FF-3, (3): CAPM]

	REGRESSION OUTPUT		
	(1)	**(2)**	**(3)**
	Equal Weight	***Equal Weight***	***Equal Weight***
Negative Interest Rate Dummy	-0.0916***	-0.0710	-0.0964
	(0.0247)	(0.0387)	(0.0533)
BoJ Benchmark Rate	-42.42*	-45.53*	-56.02*
	(17.81)	(19.72)	(22.83)
Market Risk Premium	1.307***	1.395***	1.437***
	(0.0880)	(0.0871)	(0.0924)
SMB (Size)	-0.237	-0.264	
	(0.157)	(0.160)	
HML (Value)	0.314	0.524**	
	(0.224)	(0.189)	
RMW (Profitability)	-1.014***		
	(0.275)		
CMA (Investment)	-0.152		
	(0.273)		
WML (Momentum)	-0.172		
	(0.127)		
Squared Market Risk Premium	-1.665	-1.644	
	(1.295)	(1.297)	
Squared SMB (Size)	-3.787	-5.684	
	(4.583)	(4.910)	
Squared RMW (Profitability)	-6.552		
	(10.50)		
Squared CMA (Investment)	-5.210		
	(6.411)		
Squared BoJ Benchmark Rate	6679.3*	6981.5*	9159.0*
	(3057.6)	(3412.2)	(3865.5)
NIR*Market Risk Premium	-0.335	-0.104	-0.333
	(0.240)	(0.272)	(0.346)
NIR*SMB	0.449	0.202	
	(0.449)	(0.519)	
NIR*HML	0.800*	0.748*	
	(0.359)	(0.319)	
NIR*CMA	-1.497***		
	(0.422)		
NIR*BoJ Benchmark Rate	-43.96	-9.047	-36.70
	(38.50)	(63.21)	(86.59)
Constant	0.0361**	0.0328*	0.0314*
	(0.0123)	(0.0132)	(0.0154)
Number of Observations	129	129	129
R-Squared	0.827	0.766	0.657
F-Statistic	27.89	31.09	44.58

Standard errors in parentheses

* p<0.05 ** p<0.01 *** p<0.001

Table 8: Regression Output for Weighted Lease Square with weights $w_i = 1/\max\{h_i, 0.01\hat{\sigma}^2\}$

REGRESSION OUTPUT

	Equal Weight
Negative Interest Rate Dummy	-0.0170
	(0.0100)
BoJ Benchmark Rate	-4.523
	(3.502)
Market Risk Premium	1.338***
	(0.0894)
SMB (Size)	-0.397*
	(0.176)
HML (Value)	0.591**
	(0.185)
RMW (Profitability)	-1.020**
	(0.316)
CMA (Investment)	-0.589*
	(0.274)
WML (Momentum)	-0.185
	(0.129)
Constant	0.00281
	(0.00617)
Number of Observations	129
R-Squared	0.782
F-Statistic	53.87

Standard errors in parentheses
* p<0.05 ** p<0.01 *** p<0.001

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