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The Capital Allocation Inherent in the Federal Reserve's Capital Stress Test

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EXECUTIVE SUMMARY

Post-crisis, U.S. bank regulators have imposed capital requirements that are very high relative to historical norms and current international standards. They have also imposed more granular capital requirements, determining the risk of each type of asset and imposing a particular capital requirement to it. A question arises as to whether this has made a fundamental change in U.S. finance: historically, banks decided how to allocate capital and thereby which businesses to enter or exit and which loans to underwrite based on risk adjusted returns on capital; bank capital requirements ensured that a cushion of capital was available in the event the bank erred in its judgments. Under the current regime, regulation appears to be playing a significant role in determining how capital is allocated and credit is underwritten because regulatory capital requirements are so high and granular that they could be driving banks into or out of certain asset classes.

This research note attempts to determine which businesses or assets are being favored and disfavored by post-crisis regulatory rules – most notably, the Federal Reserve's Comprehensive Capital Adequacy Review (CCAR) stress test, which is the binding capital constraint for a majority of large banks and their affiliates (including the nation's largest lenders and broker-dealers). While the models used by the Federal Reserve in its CCAR stress test remain secret, this note derives the capital requirements for various asset classes implicit in that test by examining the post-stress regulatory capital ratios produced by the stress tests controlling for differences in portfolio composition and equity distributions across banks.

The note then compares those capital requirements with the capital requirements similarly derived from banks' own modeled results in the Fed's stress testing process – the capital requirements they would impose on themselves if risk management and credit underwriting were left to them. It also compares the Federal Reserve's CCAR capital requirements to those imposed under the Basel standardized approaches to capital, a series of simplified models for measuring credit, market and other risks agreed to among global regulators, including U.S. regulators.

The results show that the Federal Reserve's CCAR stress test is imposing dramatically higher capital requirements on certain asset classes – most notably, small business loans and residential mortgages – than bank internal (Fed approved) models and Basel standardized models. For some asset classes – for example, commercial real estate – the Federal Reserve's CCAR stress test produces results similar to the results of the banks' modeled results, and lower capital requirements relative to the relevant standardized model.

In summary, the results in this note suggest that the asset allocation power of CCAR has been significantly overlooked, as has the potential effect of CCAR's choices with regard to the availability of credit to small businesses and other economic actors.

INTRODUCTION

In the aftermath of the global financial crisis, a series of key capital and other regulations has been enacted in the United States and elsewhere, including the Basel III capital and liquidity frameworks and the Federal Reserve's stress testing program. These regulations have made banks significantly more resilient, but their design and calibration have altered the incentives of banks to hold various assets and originate different types of loans.

Traditionally, banks allocated capital among their businesses based on their own assessment of risk-adjusted return on capital. Some regulatory capital requirements – most notably, a 50 percent risk weight for mortgages under the pre-crisis Basel I regime – affected bank capital allocation decisions, but generally banks assessed economic capital and decided asset allocation and credit underwriting. As capital requirements have grown significantly higher and more granular by asset post-crisis, that situation has changed.

In this research note, we attempt to identify which specific capital requirements are most likely to be "binding" for large banks and the implications of binding regulatory constraints for banks' capital allocation decisions. In particular, we reach four key conclusions:

1. Despite the large number of different capital requirements to which large U.S. banks are subject, the Federal Reserve's Comprehensive Capital Adequacy Review (CCAR) stress tests generally are the most stringent capital requirements, and therefore are mostly likely to constrain large banks in deciding how to allocate capital. Under those stress tests, large banks also provide their own estimates of post-stress regulatory capital ratios, but those tend to be generally less binding than the post-stress capital ratios resulting from the Federal Reserve's CCAR models and assumptions.[1]

2. Although the opacity of the Federal Reserve's CCAR models and assumptions makes it difficult to precisely identify CCAR's implicit capital requirements for different assets at any detailed level, we are able to estimate the implicit risk weights in U.S. stress tests using the post-stress capital ratios published by the Federal Reserve under CCAR and banks' own Dodd-Frank Act Stress Tests (DFAST) results over the past three stress testing cycles, 2014 through 2016. Specifically, for each major loan portfolio and for trading assets, we estimate the risk-weights that would best describe banks' post-stress regulatory capital ratios under the severely adverse scenario, controlling for differences in equity distributions. Our main findings can be summarized as follows:

» For *commercial and industrial* loans, CCAR capital requirements are 25 percent higher than under banks' own DFAST projections and 50 percent higher than under the Basel III standardized approach;

1 For example, the Federal Reserve assumes the estimated model parameters are the same for all bank holding companies due to the challenge of estimating a separate model for each bank and to avoid historical bank-specific results prevailing in future stress episodes. This approach implies, for example, that loss given default of a particular type of loan – a key determinant of expected losses - is the same across all banks despite demonstrated differences in banks' ability to recover the principal of a defaulted loan.

» For *commercial real estate* loans, CCAR capital requirements are 30 percent lower than under banks' own DFAST projections and 70 percent lower than under the Basel III standardized approach;

» For *small business* loans, CCAR capital requirements are 80 percent higher than under banks' own DFAST projections and 220 percent higher than under the Basel III standardized approach;

» For *first-lien mortgage* loans, CCAR capital requirements are 45 percent higher than under banks' own DFAST projections and 95 percent higher than under the Basel III standardized approach;

» For *consumer* loans, CCAR capital requirements are 15 percent lower than under banks' own DFAST projections and 45 percent lower than under the Basel III standardized approach;

» For *other* loans, CCAR capital requirements are 70 percent lower than under banks' own DFAST projections and 20 percent higher than under the Basel III standardized approach;

» Lastly, for *trading* assets, CCAR capital requirements are 20 percent higher than under banks' own DFAST projections and 340 percent higher than under the Basel III standardized approach.

Alternatively, if data for individual bank exposures were available it would be possible to compare directly losses generated by the Federal Reserve's models against other measures of expected loss.

3. Because CCAR is the binding capital requirement, banks will tend to shift lending away from sectors with higher implicit capital requirements under CCAR, sectors that are disfavored by the severe macroeconomic scenarios in the tests, and toward sectors with lower capital requirements[2]. For example, the results of our analysis are consistent with the slower growth of small business loans and mortgage loans at large banks, which have higher implicit capital requirements under CCAR, following the imposition of stress tests in 2011. In addition, large banks hold approximately 60 percent of all small business loans and closed-end mortgages on their books, and the increase in lending at banks not subject to stress tests has likely not offset the relative shrinkage in lending at banks subject to stress tests. In contrast, the capital requirements of commercial real estate loans are somewhat lower than those under the Basel III standardized approach, which is consistent with their being no meaningful differences in the growth of such loans at large banks versus other banks.

4. By imposing higher capital requirements on loans to small businesses and mortgage loans, stress tests are likely curtailing credit availability to the types of borrowers that lack alternative sources of finance. Both small businesses and the housing sector perform a very important role in the U.S. economy. For instance, small businesses account for more than 40 percent of private nonfarm gross domestic product and the

2 See an earlier TCH research note on "2016 Federal Reserve's Stress Testing Scenarios," March 2016. Available at https://www.theclearinghouse.org/-/media/action%20line/documents/volume%20vii/20160316%20tch%20research%20note%20ccar.pdf?la=en.

formation of new businesses contribute substantially for the creation of new jobs. Thus, by curtailing credit to these two key sectors of the U.S. economy, stress tests may be having an adverse impact on economic growth and contributing to the widening of income inequality among households. Conversely, our results also suggest that stress tests impose lower capital requirements for CRE and consumer loans, however these offsets are likely to be less important from an economic growth perspective as it likely reflects large banks' concentration in the lower-risk end of the CRE lending spectrum and still tight consumer lending standards.

ESTIMATING THE CAPITAL SURPLUS

The current framework to assess the capital adequacy of large U.S. banks is vast and complex. Under the Basel III standardized capital requirement, banks are subject to three risk-based capital ratios (common equity tier 1 capital ratio, a tier 1 capital ratio and total capital ratio); and a non-risk-based capital ratio (the tier 1 leverage ratio).[3] In addition to the standardized approach ratios, thirteen advanced approaches bank holding companies are required to calculate their risk-based capital ratios under the advanced approaches and are also subject to a supplementary leverage ratio. Large U.S. banks are also subject to CCAR stress tests in which banks' performance is assessed using post-stress capital ratios, three of which are risk-based and one of which is leverage-based. Moreover, these post-stress capital ratios also vary by stress scenario – with two scenarios (adverse and severely adverse) designed by Federal Reserve staff and one stress scenario designed by the BHC (with considerable Federal Reserve staff input) – and two different set of assumptions on payout policies (DFAST and CCAR). Thus, under the U.S. stress tests, large banks need to evaluate their regulatory capital ratios in a multitude of different ways. For convenience, Table 1 lists all capital requirements under Basel III and in stress tests.

In the remainder of this section we describe the methodology used to measure the "capital surplus" of each bank that participates in the stress tests. The capital surplus is the amount of capital in excess of the most binding regulatory capital requirement across all of the 28 requirements listed in Table 1. For instance, a bank passes the quantitative portion of the stress tests if its post-stress common equity tier 1 ratio is above 4.5 percent, its tier 1 risk-based capital ratio is above 6 percent, its total risk-based capital ratio is above 8 percent, and its tier 1 leverage ratio is above 4 percent. Thus, under the U.S. stress tests the capital surplus is defined as:

$$\text{Capital Surplus}^{j}_{CCAR} = \frac{\min\{CET^{j} - 4.5\% \times RWA^{j}, T1^{j} - 6\% \times RWA^{j}, TC^{j} - 8\% \times RWA^{j}, T1^{j} - 4\% \times Assets^{j}\}}{RWA^{j}},$$

where j = DFAST/Adverse, DFAST/Severely Adverse, CCAR/Adverse, CCAR/Severely Adverse. We also normalize the capital surplus by risk-weighted assets for convenience. [4]

3 In the U.S., the thirteen bank holding companies subject to the Advanced Capital Adequacy Framework 12 CFR Parts 208 and 225 (Advanced Approaches) are American Express Company, Bank of America Corporation, Bank of New York Mellon Corporation, Capital One Financial Corporation, Citigroup, Inc., Goldman Sachs Group, Inc., JPMorgan Chase & Co., Morgan Stanley, Northern Trust Corporation, PNC Financial Services Group, Inc., State Street Corporation, U.S. Bancorp, and Well Fargo & Company.

4 Since information on the post-stress capital ratios derived from the stress scenario designed by each BHC is not publicly available, the capital surplus under the stress tests excludes those results.

TABLE 1. CAPITAL REQUIREMENTS UNDER BASEL III AND STRESS TESTS

Regulatory capital ratio	Basel III	
	Risk-weighting	Requirement (%)
Common equity tier 1	Standardized approach	4.5 + CCB + GSIB surcharge + CCyB
	Advanced approaches	4.5 + CCB + GSIB surcharge + CCyB
Tier 1 risk-based capital ratio	Standardized approach	6.0 + CCB + GSIB surcharge + CCyB
	Advanced approaches	6.0 + CCB + GSIB surcharge + CCyB
Total risk-based capital ratio	Standardized approach	8.0 + CCB + GSIB surcharge + CCyB
	Advanced approaches	8.0 + CCB + GSIB surcharge + CCyB
Tier 1 leverage ratio	-	5.0
Suplementary leverage ratio	Advanced approaches	3.0 + 2.0 (GSIB only)

Regulatory capital ratio	Stress Tests		
	Payout Assumptions	Scenario	Requirement (%)
Common equity tier 1	DFAST	Adverse	4.5
Common equity tier 1	DFAST	Severely Adverse	4.5
Common equity tier 1	CCAR	Adverse	4.5
Common equity tier 1	CCAR	Severely Adverse	4.5
Common equity tier 1	CCAR	Bank Own Scenario	4.5
Tier 1 risk-based capital ratio	DFAST	Adverse	6.0
Tier 1 risk-based capital ratio	DFAST	Severely Adverse	6.0
Tier 1 risk-based capital ratio	CCAR	Adverse	6.0
Tier 1 risk-based capital ratio	CCAR	Severely Adverse	6.0
Tier 1 risk-based capital ratio	CCAR	Bank Own Scenario	6.0
Total risk-based capital ratio	DFAST	Adverse	8.0
Total risk-based capital ratio	DFAST	Severely Adverse	8.0
Total risk-based capital ratio	CCAR	Adverse	8.0
Total risk-based capital ratio	CCAR	Severely Adverse	8.0
Total risk-based capital ratio	CCAR	Bank Own Scenario	8.0
Tier 1 leverage ratio	DFAST	Adverse	4.0
Tier 1 leverage ratio	DFAST	Severely Adverse	4.0
Tier 1 leverage ratio	CCAR	Adverse	4.0
Tier 1 leverage ratio	CCAR	Severely Adverse	4.0
Tier 1 leverage ratio	CCAR	Bank Own Scenario	4.0

Note: The capital conservation buffer (CCB) is set at a level of 2.5%. The surcharge for global systemically important bank holding companies (GSIB surcharge) currently applicable to U.S. GSIBs ranges from 3.5% for JPMorgan Chase & Co.; 3.0% for Citigroup Inc., Bank of America Corporation and Morgan Stanley; 2.5% for Goldman Sachs and Wells Fargo & Company; and 1.5% for Bank of New York Mellon Corporation and State Street Corporation. The Basel III column lists the capital requirements after calendar year 2019 and thereafter (post-transition). Finally, the countercyclical capital buffer (CCyB) is currently set at a level of 0% in the U.S.

In addition, we calculate the capital surplus under Basel III and stress tests separately to assess the extent to which the capital requirements under each regulatory framework are binding. The capital surplus under Basel III is defined in a similar way, except that the capital thresholds change as follows:

1. Common equity tier 1 ratio req. = 4.5% (reg. min.)+ 2.5 % CCB + 0% CCyB + GSIB (varies across banks)

2. Tier 1 capital ratio req. = 6.0% (reg. min.)+ 2.5 % CCB + 0% CCyB + GSIB (varies across banks)

3. Total capital ratio req. = 8.0% (reg. min.)+ 2.5 % CCB + 0% CCyB + GSIB (varies across banks)

4. Tier 1 leverage ratio = 5.0% (well-capitalized requirement).

For the advanced approaches institutions, all ratios are calculated using both banks' internal models (which are subject to Federal Reserve review and prior approval) and the standardized approach. The capital surplus is then defined using the regulatory capital ratio that yields the lowest amount of excess capital above its requirement. Lastly, we also collected data on total leverage exposure for the advanced approaches institutions and include the enhanced supplementary leverage ratio in the calculation of the capital surplus for the GSIBs, but only at the end of 2015, the first year the information is available for such institutions.

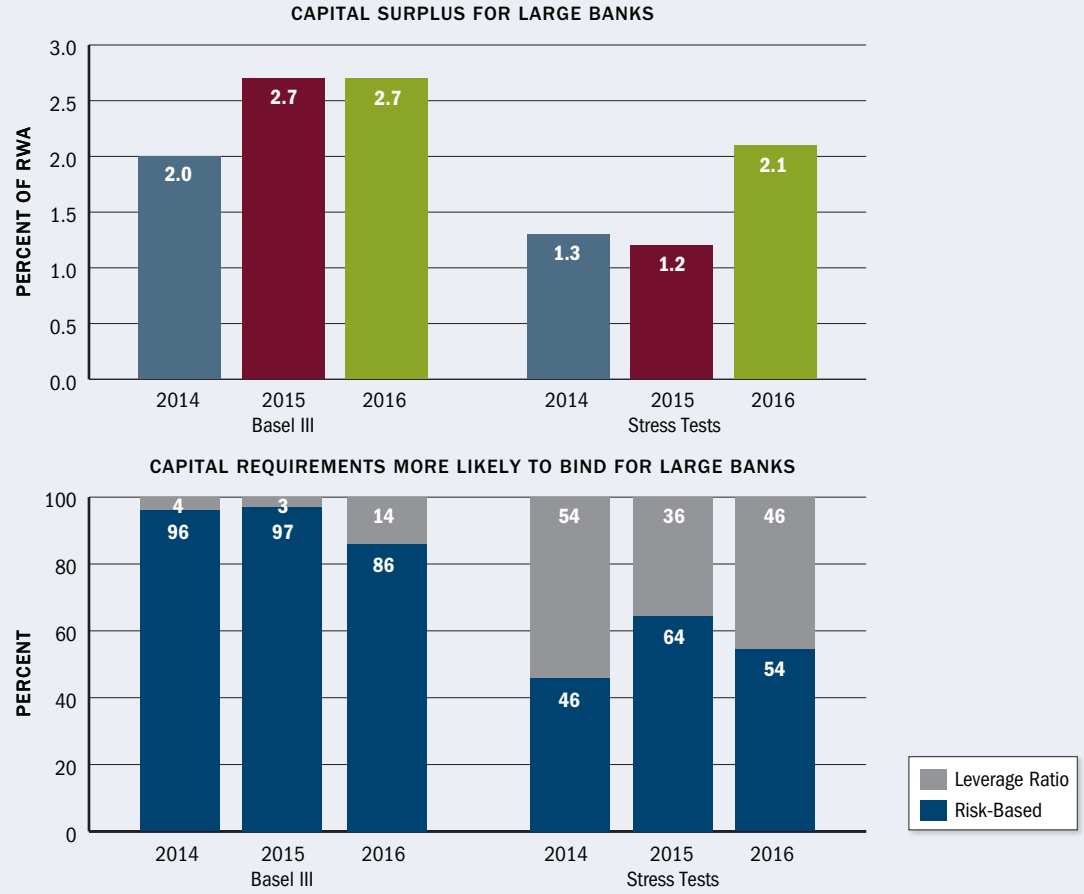
The top bar chart of Exhibit 1 shows the capital surplus for large banks over the past 3 years under Basel III and CCAR stress tests, respectively. [5] The capital surplus under the stress tests was roughly half of the capital surplus under Basel III up to 2015, and that difference was halved in 2016 due to an increase in capital surplus under the stress tests. Notably, the capital surplus under the stress tests increased in CCAR 2016 as compared to prior CCAR exercises, largely as a result of higher net revenues under stress, reportedly due to a fall in expenses associated with mortgage related settlements and a lower decline in fee income during stress as a result of negative short-term interest rates. [6] As shown in the bottom panel of Exhibit 1, the post-stress leverage ratio yields the lowest capital surplus for about half of the banks that participate in the stress tests. In contrast, under Basel III, the risk-based capital ratios are generally the binding requirement, although the inclusion of the enhanced supplementary leverage ratio in our sample in 2016 raised slightly the incidence of a binding leverage ratio under the current Basel III rules.

As noted above, the post-stress tier 1 leverage ratio is the requirement within the stress tests most likely to bind for approximately half of the banks that participate in such exercise. The leverage ratio as a post-stress minimum requirement operates in a significantly more risk-sensitive manner than does the point-in-time leverage ratio. Under the stress tests, banks with exposures that are very sensitive to

5 For clarity, the year referenced is with regard to the previous quarter of the applicable CCAR cycle. For instance, 2016 refers to data as of December 31, 2015.

6 See, "Dodd-Frank Act Stress Test 2016: Supervisory Stress Test Methodology and Results," box 2 on page 20, available at https://www.federalreserve.gov/newsevents/press/bcreg/bcreg20160623a1.pdf.

EXHIBIT 1



Note: Large banks includes all banks that participated in CCAR 2014, 2015 and 2016.

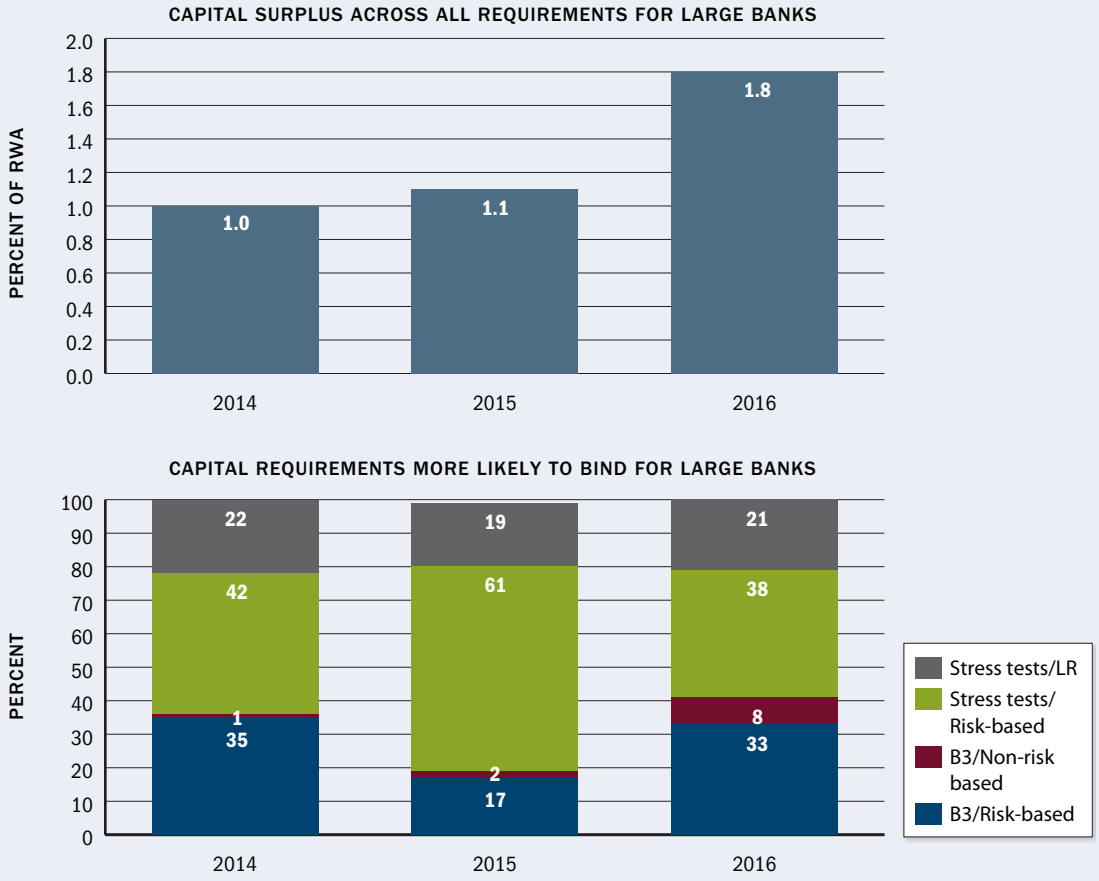
business cycle fluctuations experience very high losses under the Federal Reserve's supervisory scenarios. Thus a bank that expanded its balance sheet by increasing its holdings of risky assets would experience a large decline in its tier 1 capital over the stress tests' nine-quarter planning horizon. For these reasons, the leverage ratio requirement under stress tests behaves similarly to a risk-based capital requirement. The reason why it binds for approximately half of the banks is because the point-in-time requirement is closer to the stress test hurdle for the leverage ratio than for the risk-based measures.

The charts in Exhibit 2 depict the aggregate capital surplus for large banks across Basel III and stress tests. The capital surplus shown is equal to the lowest capital surplus across the Basel III and stress tests for each bank. As a result, the capital surplus shown in Exhibit 2 (1.8%) is lower than the capital surpluses under Basel III and stress tests individually depicted in Exhibit 1 (2.7% and 2.1%, respectively). Over the past three years the capital surplus at large banks approximately doubled. Currently, the capital surplus is at 1.8 percent of risk-weighted assets, in part due to the better than expected projected net revenues under CCAR 2016 explained above. As shown in the bottom panel of Exhibit 2, the post-stress risk-based capital requirements (in green) remain the regulatory capital ratios with the highest likelihood of being breached for large banks.

ESTIMATING RISK-WEIGHTS UNDER STRESS TESTS

The previous section demonstrates that CCAR post-stress capital requirements are the binding requirement for the majority of large banks. The stress tests map a bank's balance sheet into post-

EXHIBIT 2



Note: Large banks includes all banks that participated in CCAR 2014, 2015 and 2016.

stress regulatory capital ratios, and so can also be viewed as a process that generates risk-weights which can then be applied to exposures on the balance sheet, just like standardized or advanced approaches risk weights. In an ideal world, the Federal Reserve would publish the (average) risk-weights consistent with the projections for expected losses under the severely adverse scenario. However, the risk-weights under the severely adverse scenario are not provided and, moreover, the models used by the Federal Reserve are not disclosed to the banks or the public. Thus, we estimate the implicit risk weights in stress tests using the Federal Reserve's projection of banks' post-stress test regulatory capital ratios as well as information on banks' balance sheets. Specifically, we use a model to estimate the risk-weights that would best describe banks' post-stress regulatory capital ratios under the severely adverse scenario, controlling for differences in equity distributions across banks. We also repeated the analysis using banks' own DFAST submissions to report the differences between the Federal Reserve and the risk-weights implicit in banks' own stress test estimates.

In the second part of the analysis we use the estimated risk-weights to calculate the amount of capital banks are required to hold to make various types of loans while satisfying the minimum capital requirements imposed by the stress tests. Specifically, using the estimation results, we are able to calculate capital requirements under stress tests and compare them to requirements under the Basel III standardized approach. Lastly, we then examine whether the stress-test risk weights actually affect bank behavior – that is, whether they are incentivizing affected banks to deploy less capital to segments with higher implicit risk weights and more capital toward segments with lower risk weights.

Before we describe the statistical model, it is useful to provide some intuition on how the stress test results can be used to estimate the implicit risk weights in stress tests. In the stress tests, the Federal Reserve assesses

the impact of a severe macroeconomic scenario on the numerator of banks' regulatory capital ratios. This analysis requires projecting banks' loan losses and revenues over a nine-quarter planning horizon, and takes as a given banks' proposed capital actions (dividends and share repurchases). In particular, as economic conditions deteriorate significantly under the severely adverse supervisory scenario, loan loss provisions rise and pre-provision net revenues decline, causing a deterioration of a bank's capital over the nine-quarter planning horizon.[7] In contrast, the denominator of the risk-based capital ratios – risk-weighted assets – are essentially unchanged over the planning horizon. Thus, stress tests leave risk-weighted assets roughly unchanged, and all losses reduce capital levels directly; in effect, a bank must hold dollar-for-dollar post-stress capital against all such losses. Although there is no straightforward way of obtaining exact estimates of the stress test risk-weights using publicly available data, we use a model to estimate the risk-weights that would best describe banks' post-stress regulatory capital ratios. Estimates of the implicit risk-weights associated with the post-stress capital ratios allow a meaningful comparison to Basel III risk-weights under the standardized approach. This approach in turn yields an estimate of the risk weights for a granular range of exposures in the loan book and trading book, as well as operational risk. In particular, the estimated model is as follows:

$$\left.\frac{C_i^j}{RWA_i}\right|_{post-stress} = \frac{C_{i0}^j}{\sum_{n=1}^{N}\beta_n^j x_{in}} + \varepsilon_i \qquad (1)$$

where i indexes each bank, j indexes each of the risk-based capital ratios in stress tests; β_n represents the implied risk-weights and x_{in} denotes the various exposures that are subject to a non-zero risk weight under Basel III. The specification estimated in equation (1) immediately above has the following 10 subcomponents: (i) commercial and industrial (C&I) loans; (ii) commercial real estate loans; (iii) small business loans; (iv) first-lien residential real estate loans; (v) other residential real estate loans; (vi) consumer loans; (vii) other loans; (viii) trading assets; (ix) operational risk; and (x) securities. The estimate uses the post-stress risk-based capital ratios under CCAR, and the set of explanatory variables also includes total payouts to control for differences in equity distributions across banks.[8] Since the relationship between post-stress capital ratios and subcomponents of risk-weighted assets is nonlinear, the model is estimated using nonlinear least squares.[9] Lastly, the implicit risk-weights vary modestly across the three post-stress regulatory capital requirements shown on Table 2 because the maximum decline in a bank's regulatory capital requirements varies across the definitions of capital used in each measure.

7 Risk-weighted assets are weakly tied to the increase in the risk of the exposures or changes in the composition of banks' portfolios. For instance, market risk weighted assets are assumed to increase as the volatility of the portfolio's underlying assets rises under the severe macroeconomic scenarios. Credit risk weighted assets are calculated using the standardized approach, thus the risk-weights are invariant to the macroeconomic scenario. However, exposures on loans and securities are assumed to increase at average industry rate for total loans and non-loan assets, respectively.

8 It would have been more accurate to estimate the model using post-stress regulatory capital ratios before distributions. However, bank payouts are not readily available in DFAST/CCAR disclosures.

9 We have only included post-stress capital ratios under CCAR after 2014 (inclusive) even if Federal Reserve's DFAST post-stress regulatory capital ratios were lower.

TABLE 2: NONLINEAR LEAST SQUARE REGRESSIONS FOR POST-STRESS REGULATORY CAPITAL RATIOS

	Common Equity Tier 1				Tier 1 Capital				Total Capital			
	Banks' own DFAST		CCAR		Banks' own DFAST		CCAR		Banks' own DFAST		CCAR	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Commercial and Industrial loans	2.10*** (0.28)	2.03*** (0.23)	2.15*** (0.45)	2.13*** (0.40)	2.13*** (0.27)	2.02*** (0.19)	2.71*** (0.38)	2.49*** (0.32)	1.99*** (0.22)	1.90*** (0.16)	2.37*** (0.32)	2.22*** (0.27)
Commercial Real Estate loans	0.19 (0.44)	0.26 (0.45)	0.58 (1.02)	0.58 (1.01)	0.67* (0.37)	0.68** (0.32)	0.48 (0.41)	0.46 (0.43)	0.84** (0.34)	0.85*** (0.28)	1.13*** (0.37)	1.13*** (0.37)
Small Business loans	4.15*** (1.16)	3.70*** (1.04)	5.17** (2.23)	5.14** (2.12)	3.33*** (0.99)	2.97*** (0.95)	5.60*** (1.32)	5.27*** (1.38)	2.80*** (0.88)	2.46*** (0.85)	3.92*** (1.03)	3.63*** (1.06)
First Lien Closed-End mortgages	1.33*** (0.30)	1.36*** (0.28)	1.99*** (0.52)	1.99*** (0.50)	1.16*** (0.31)	1.15*** (0.25)	1.72*** (0.40)	1.67*** (0.39)	1.06*** (0.27)	1.04*** (0.23)	1.08*** (0.33)	1.05*** (0.32)
Other RRE loans	-0.37 (.48)	-	-0.08 (0.73)	-	-0.45 (0.55)	-	-0.89* (0.51)	-	-0.45 (0.45)	-	-0.62 (0.51)	-
Consumer loans	1.21*** (0.21)	1.11*** (0.05)	0.70*** (0.26)	0.70*** (0.26)	1.09*** (0.20)	1.08*** (0.06)	0.87*** (0.19)	0.90*** (0.19)	1.10*** (0.16)	1.07*** (0.06)	0.93*** (0.16)	0.96*** (0.16)
Other loans	1.37*** (0.31)	1.14*** (0.14)	0.25 (0.50)	0.25 (0.50)	1.58*** (0.46)	1.35*** (0.24)	0.33 (0.32)	0.41 (0.31)	1.58*** (0.45)	1.35*** (0.24)	0.59** (0.28)	0.64** (0.28)
Trading assets	1.99*** (0.22)	1.96*** (0.21)	2.55*** (0.31)	2.55*** (0.31)	2.14*** (0.15)	2.12*** (0.12)	2.56*** (0.24)	2.58*** (0.24)	1.92*** (0.12)	1.90*** (0.10)	2.27*** (0.20)	2.28*** (0.20)
Operational risk	-0.72 (0.61)	-	2.80** (1.25)	2.81** (1.23)	-0.77 (0.89)	-	2.22*** (0.81)	2.20*** (0.82)	-0.78 (0.82)	-	1.77** (0.72)	1.76** (0.74)
Securities	0.80*** (0.18)	0.78*** (0.10)	0.43** (0.21)	0.43** (0.21)	0.81*** (0.16)	0.85*** (0.10)	0.45*** (0.16)	0.47*** (0.16)	0.81*** (0.13)	0.84*** (0.09)	0.57*** (0.13)	0.58*** (0.13)
Payout ratio	0.29 (5.45)	-	22.12*** (6.81)	22.03*** (6.81)	3.94 (4.38)	-	15.99*** (5.08)	14.6*** (5.03)	3.16 (3.68)	-	11.04*** (3.91)	10.05** (3.98)
R^2 adjusted	0.98	0.98	0.97	0.97	0.98	0.98	0.98	0.98	0.99	0.99	0.98	0.98
Number of observations	89	89	94	94	89	89	94	94	89	89	94	94

Notes: Sample period is comprised of stress test results for the 2014, 2015 and 2016 cycles. The dependent variable in each specification is the post-stress regulatory capital ratio under banks' own DFAST submissions and CCAR. Each model is estimated using nonlinear least squares and robust standard errors are reported in parenthesis.
* p-value < 0.10; ** p-value < 0.05; and *** p-value < 0.01.

Table 2 presents the estimates of our model for the three risk-based regulatory capital ratios included in the stress tests. We do not include the tier 1 leverage ratio because our model requires the denominator of the regulatory capital ratio to be risk-weighted assets.[10] Within each regulatory capital ratio, we report the estimated implicit risk-weights using two different sources for the post-stress regulatory capital ratios – the CCAR results and banks' own DFAST results.[11] According to the entries in Table 2, almost all coefficients on the various portfolios have economically intuitive signs and are statistically significant at conventional levels. In a few cases where the coefficients are not statistically different from zero, we re-estimated the model setting those coefficients to zero, and those results are shown in column (2) of the table. [12]

10 Under the leverage ratio definition all risk-weights should be equal to 100 percent.

11 We were unable to find banks' own DFAST results for 5 bank-year observations so the sample size is slightly different.

12 The analysis shown on Table 2 combines all the data points for the past 3 CCAR cycles. The results are not significantly different if the analysis is conducted separately for each year.

Across all specifications in Table 2, risk-weights under CCAR are higher than risk-weights under banks' own DFAST results for the following portfolios:

» For C&I loans, implicit risk-weights are estimated to be between 190 and 200 percent under banks' own DFAST submissions across the three post-stress regulatory capital ratios, while they are estimated to be between 215 and 250 percent under CCAR – so, 20 percent higher;

» For small business loans, implicit risk-weights are estimated to be between 250 and 370 percent under banks' own DFAST submissions across the three post-stress regulatory capital ratios, while they are estimated to be between 360 and 530 percent under CCAR – so, 45 percent higher;

» For first-lien mortgage loans, implicit risk-weights are estimated to be between 105 and 135 percent under banks' own DFAST submissions across the three post-stress regulatory capital ratios, while are estimated to be between 105 and 200 percent under CCAR – so, 25 percent higher;

» Lastly, for trading assets, implicit risk-weights are estimated to be between 190 and 210 percent under banks' own DFAST submissions across the three post-stress regulatory capital ratios, while are estimated to be between 230 and 260 percent under CCAR – so, also 25 percent higher.

In contrast, for consumer loans and other loans, the estimated implicit risk-weights using the data from banks' own DFAST submissions are typically higher than the implicit risk-weights under CCAR. Thus, it is not always the case that banks' own implicit risk-weights are lower than the implicit risk-weights estimated using CCAR results based on the Federal Reserve's own models. In particular,

» For consumer loans, implicit risk-weights are estimated to be about 110 percent under banks' own DFAST submissions across the three post-stress regulatory capital ratios, while they are estimated to be between 70 and 90 percent under CCAR – so, 25 percent lower;

» Finally, for other loans, implicit risk-weights are estimated to be between 110 and 140 percent under banks' own DFAST submissions across the three post-stress regulatory capital ratios, while they are estimated to be between 25 and 65 percent under CCAR – so, 65 percent lower.

As evidenced by the relatively high R^2s, all nonlinear specifications fit the data quite well in our sample. As shown in Exhibit 3, the realized (x-axis) and predicted (y-axis) post-stress CCAR tier 1 capital ratios are close to the 45 degree line, suggesting that the model in equation (1) is a reasonable one. Specifically, for banks close to the 45 degree line – denoted by the green dots - the projected post-stress tier 1 capital ratios using our model are about the same as the post-

EXHIBIT 3: REALIZED VS. PREDICTED POST-STRESS TIER 1 CAPITAL RATIO

stress tier 1 capital ratios published by the Federal Reserve. In contrast, the yellow dots illustrate three cases in which the predicted post-stress tier 1 capital ratios are somewhat *higher* than the ones published by the Federal Reserve. Conversely, the red dots also show three cases in which the predicted post-stress tier 1 capital ratios are somewhat lower than the ones published by the Federal Reserve.

We now turn to the implications of these results to the capital allocation decisions of a typical large bank in our sample. In this analysis we assume that a bank is bound by the post-stress tier 1 capital ratio under CCAR. (The post-stress tier 1 capital ratio is the requirement most likely to bind in CCAR 2016). Exhibit 4 shows the amount of capital a bank needs to hold to originate different types of loans under the Basel III standardized approach, banks' own DFAST submissions and CCAR. The amount of capital required to originate a particular loan-type is derived as follows: Under the standardized approach, the risk-weight for C&I loans is 100% and, a G-SIB's Basel III Tier 1 capital requirement is 11% (minimum tier 1 capital requirement of 6.0%, plus capital conservation buffer of 2.5% plus GSIB surcharge of 3.5%); thus the amount of tier 1 capital required to originate a $100 C&I loan is equal to

$$k_{C\&I}^{\text{Basel III}} = 11\% \times 100\% \times \$100 = \$11.$$

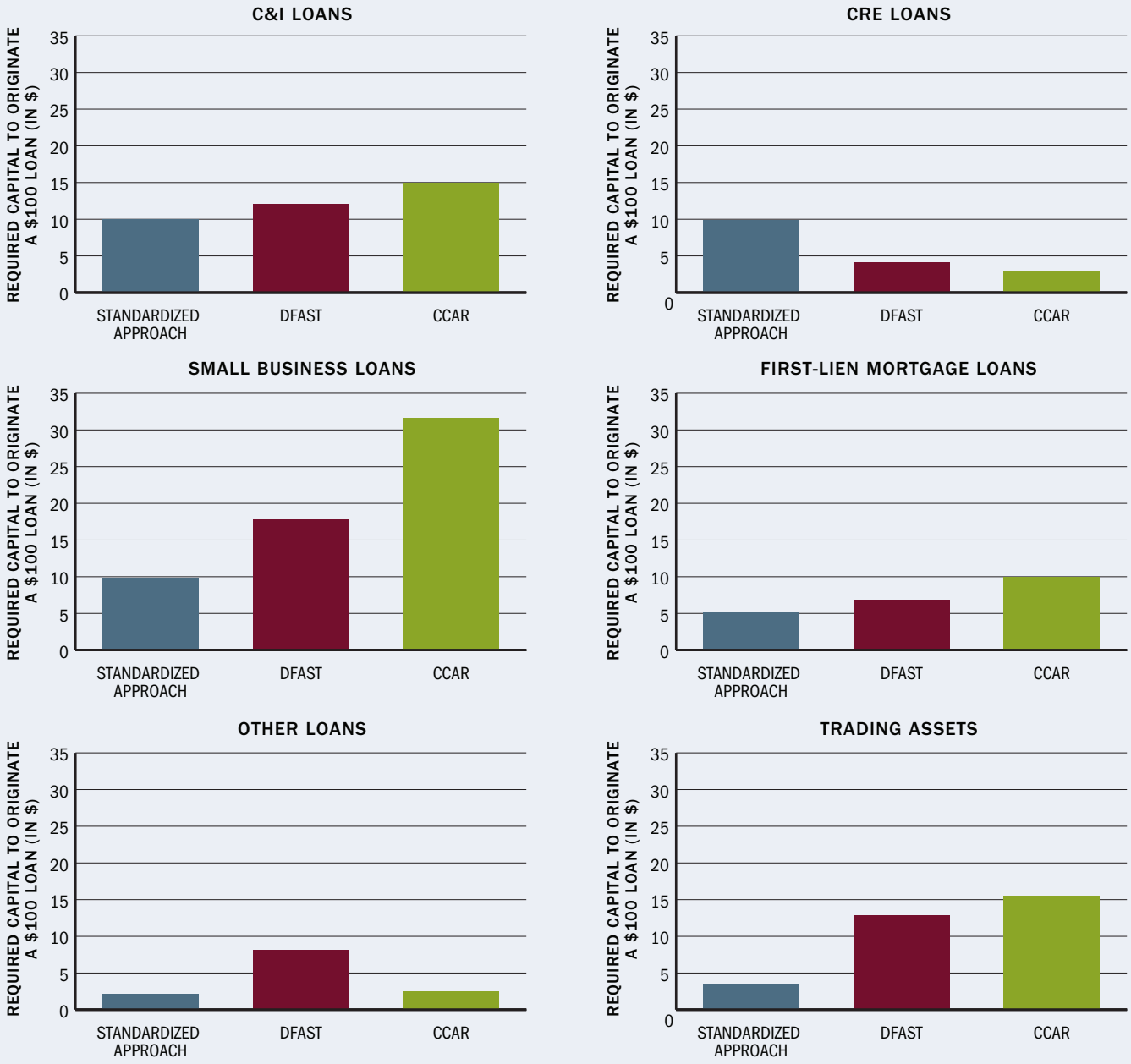
Since Basel III capital requirements vary across banks because of the GSIB surcharge, the average amount of capital required to originate a $100 C&I loan across all banks in our sample is $10, and this is the height of the left-most bar in the top panel of Exhibit 4. Similarly, under banks' own DFAST and under CCAR, the amount of capital required to originate a $100 C&I loan for a U.S. GSIB is, respectively:

$$k_{C\&I}^{\text{DFAST}} = 6\% \times 202\% \times \$100 = \$12, \text{ and}$$

$$k_{C\&I}^{\text{CCAR}} = 6\% \times 249\% \times \$100 = \$15.$$

where 202% and 249% are the estimated implicit C&I risk-weights coefficients presented in Table 2 using the post-stress tier 1 capital ratio under banks' own DFAST and under CCAR, respectively. Note that capital requirements under stress already take into account the lower post-stress tier 1 capital threshold of 6%, versus an average of 10% under banks' tier 1 capital point-in-time capital requirements.

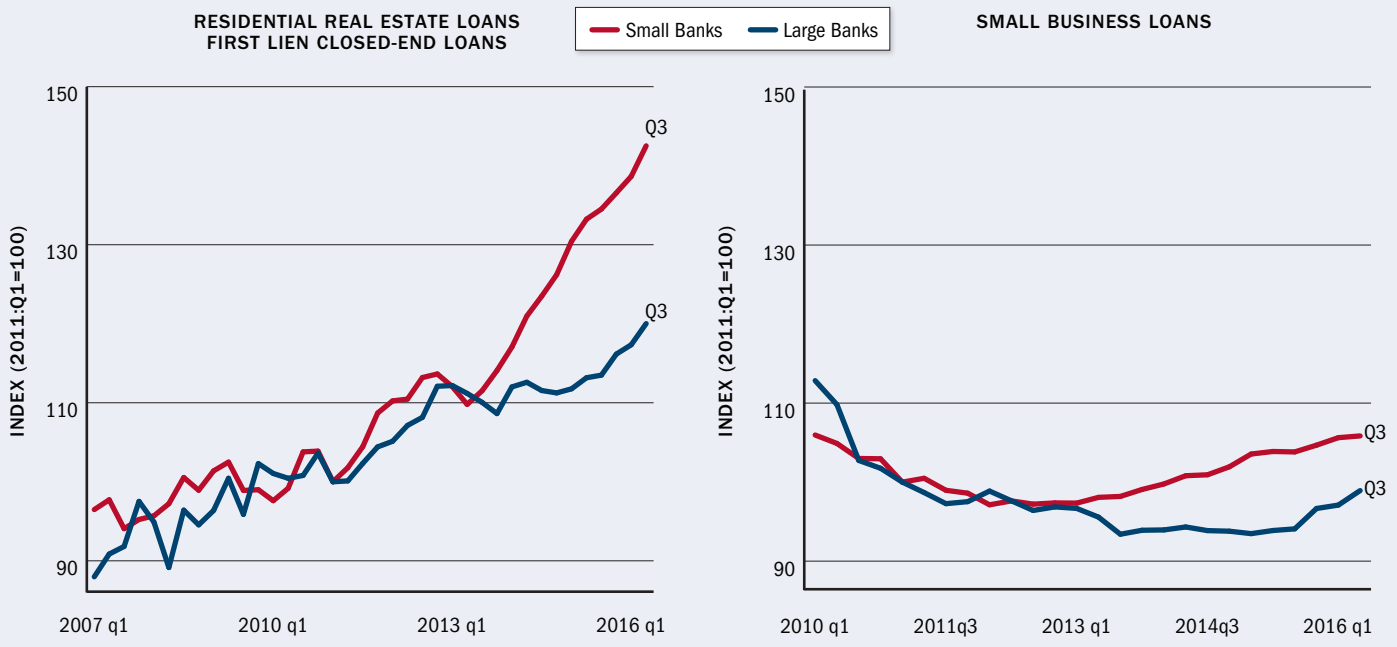
EXHIBIT 4: PORTFOLIO-LEVEL CAPITAL REQUIREMENTS



For the C&I loan portfolio we can make the following two observations: (i) the amount of capital required to originate a C&I loan is about 50 percent higher under CCAR relative to the Basel III standardized approach; and (ii) the required capital for C&I loans is higher under CCAR reflecting the higher likelihood of default of such exposures under stress. All of the above calculations are depicted in the top left panel of Exhibit 4.

We redo these calculations for the remaining five major portfolios included in our analysis. The chart in the top right panel of Exhibit 4 represents the amount of capital required to originate a CRE loan. The estimated capital requirement for CRE loans is lower under the stress tests than under Basel III standardized approach. This likely reflects the relatively high quality of CRE loans that are being originated by large banks, typically loans to finance nonfarm nonresidential properties (e.g., offices) in supply-constrained markets. As shown in the middle left panel of Exhibit 4, small business loans have the same capital requirements as C&I loans under the standardized approach; however under

EXHIBIT 5



the stress tests the implicit capital requirement for small business loans is twice as high under banks' own DFAST submissions and it is three times higher under CCAR. The significantly higher capital requirements under CCAR are consistent with the stress test scenarios assuming a recession that includes an increase in the unemployment rate that is very sudden and abrupt.

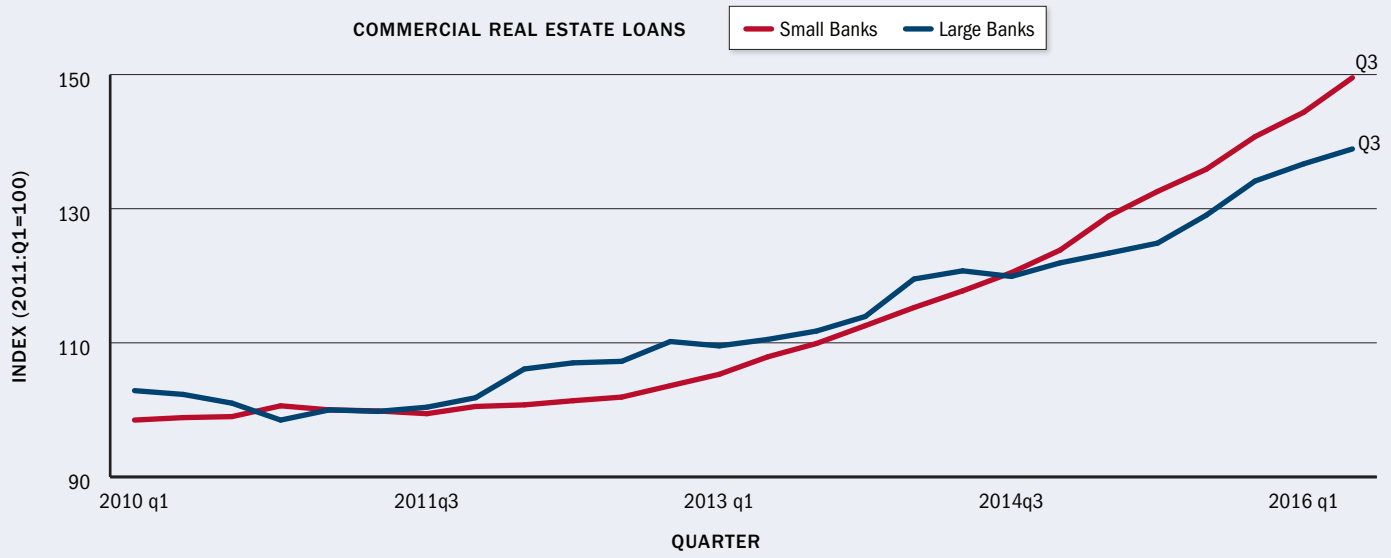
The middle right panel and lower panels of Exhibit 4 depict the capital requirements for first-lien mortgage loans, other loans and trading assets, respectively. For mortgage loans and trading assets, the capital requirements are 180 percent and 340 percent higher under CCAR, respectively, than under the Basel III standardized approach. For trading assets the higher capital requirements under CCAR are driven by the global market shock that is part of CCAR. The market shock also applies to DFAST, and the capital requirement under CCAR is 20 percent higher relative to DFAST. For mortgage loans, the doubling of capital requirements under CCAR likely reflect the severity of the macroeconomic scenario in the stress tests which includes a sizable decline in house prices, augmented by the fact that some banks still hold legacy mortgage loans. That said, the 20 percent difference in capital requirements between CCAR and DFAST is still significant, so part of the difference in capital requirements must also be driven by more stringent assumptions in the Federal Reserve's models.

Despite the large and sudden increase in the unemployment rate in the severely adverse scenario in stress tests, capital requirements for consumer loans are not higher under the stress tests relative to the Basel III standardized approach. This likely reflects the very high quality of such loans currently on banks' balance sheets, namely loans to borrowers with pristine credit scores and which have a very low likelihood of default, even under a recession that is worse than the one experienced during the past global financial crisis.

ARE STRESS TESTS AFFECTING BANKS' CAPITAL ALLOCATION DECISIONS?

Since post-stress capital levels under CCAR are the binding requirement for the majority of banks at least

EXHIBIT 6



after 2014, the significantly higher risk weights for these exposures could be expected to have an adverse impact on credit availability to asset classes that impose the highest relative CCAR losses – mortgages to households and loans to small businesses. Indeed, as shown in the left panel of Exhibit 5, while holdings of residential mortgage loans have stagnated somewhat at large banks, they have been growing at a moderate pace at banks not required to participate in the stress tests.[13] Moreover, as shown in the panel to the right, holdings of small business loans declined during most of the post-crisis period at banks subject to the stress tests, while holdings of such loans rose slightly at other banks.

In contrast, CCAR's implicit risk weights for CRE loans are roughly in line with the risk weights under the standardized approach and as depicted by the blue line in Exhibit 6, growth of CRE loans was in fact slightly stronger at large banks during most of the post-2011 period.

In summary, our analysis suggests that CCAR is having an adverse impact on credit provided by large banks in a majority of (but not all) asset classes.

13 These charts are based on an analysis described in TCH's blog post on "Is Tighter Bank regulation Restricting Loan Growth?" December 1, 2016.