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Do Strategic Interaction Effects Drive Excess Capital Financing of Banks?

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Abstract

This memo examines the excess capital financing of Danish banks. Excess capital is the level of capital held by a given bank minus the present regulatory capital.

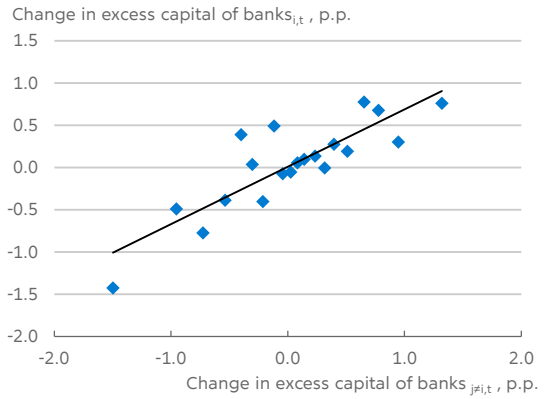
We find empirical evidence consistent with the hypothesis that banks act strategically to hold similar levels of excess capital as their competitors. In particular we find that when a bank observes a 100 basis point increase in the average excess capital among its competitors it increases its own level of excess capital by 14.4 basis points in the following quarter. Our results suggest that strategic interaction is an important but not the main driver of banks' changes in excess capital.

These results suggest that policymakers should consider strategic interaction when forecasting how banks adjust to changes in capital requirements.

Introduction

In this empirical analysis we study how banks react to changes in their competitors' capital by studying the behavior of capital financing among Danish banks and mortgage credit institutions.[1] Data show that all Danish banks and mortgage institutions hold capital in excess of the capital requirements (including buffer requirements) and we therefore focus our analysis on this excess capital. Banks may hold excess capital for many reasons (see box 1 below). The purpose of this economic memo is to investigate a new potential driver of excess capital not previously studied in the literature: strategic interactions between banks and their competitors. That is that a bank may in part target their excess capital levels to be similar to their competitor banks.

Banks tend to increase their excess capital if other banks also do so Figure 1



Anm.: Binned scatter plot of bank X quarter observations showing that banks increase their excess capital (y-axis) at the same time as their competitors (x-axis).
Kilde: Own calculations.

[1] We consider banks and mortgage credit institutions at the group level.

Empirical evidence suggests that bank capital is slow to adjust (e.g. Brewer et al 2008) since it can be costly for a bank to raise capital in the financial markets with short notice. Given this slow adjustment banks have excess capital to insure against unexpected shocks. Excess capital is therefore an observable that can also be used by banks to communicate relative strength.

Banks with more excess capital than competitors may be perceived as safer investments – conferring an advantage to the bank in raising funds in debt markets. Conversely, banks that have excess capital have space to expand lending via debt financing: there is a potential opportunity cost.[2] Equity investors may punish banks for playing it too safe (financing with too much excess capital relative to competitors thereby lowering their return on equity).

Optics aside, a bank's excess capital may confer a benefit to the bank in preserving their relative market power against adverse shocks. If an adverse shock pushes the bank closer to regulatory limits then having excess capital will limit undesirable adjustments to the bank's balance sheet. If for example the bank was either forced to deleverage or to issue additional capital under unfavorable conditions. If so, excess capital may also limit their loss of market size (and therefore market power) in response to adverse shocks. The effect on market power only matters if it limits their losses relative to competitors. Therefore, this market power component of excess capital should be driven by strategic assessment of competitors' excess capital.

Strategic interaction as a driver of excess capital may be particularly interesting to the dynamics of credit supply following a change in regulation (either temporary – e.g. a buffer release, or permanent). If banks target similar levels of excess capital to other banks, this could lead to potential instability in the response of banks following a change in regulation. The ensuing adjustment may happen slowly or quickly. Slow adjustment may be driven by banks that do not want to deviate from the average market level of excess capital. However, adjustment could accelerate quickly if a leader bank chooses to adjust, driving the market average level of excess capital in a given direction.

Understanding if the strategic interaction effect exists and the potential size of the effect is important to policy. Particularly when assessing the impact of changes in capital regulations since the size and timing of the banks' responses may be impacted by strategic interaction. We find that the excess capital of a bank's competitors has a quantitatively limited but statistically significant impact on the bank's own level of excess capital. Specifically, we find that a 100 basis point increase in the average level of excess capital among a bank's competitors is associated with a 14.4 basis point increase in the bank's own level of excess capital in the following quarter. This finding is robust across model specifications, inclusion of various controls as well as varying the estimation sample. The inclusion of the strategic interaction in our econometric model improves the model fit by 3.1 %. This suggests that the strategic interaction effect exists but plays a limited role in banks' decision making.

Institutional Setting

Bank capital, as a percentage of risk exposure amount (REA)[3], is made up of the capital required by regulation plus excess capital. All Danish banks are subject to a number of different (regulatory) capital requirements[4] divided into Pillar 1 and Pillar 2 requirements plus capital buffers.

According to Pillar 1 banks are required to hold 8% percent of their risk exposure amount in capital and

[2] Given the tax deductibility of debt financing there is an opportunity cost to the bank of financing with capital if there is regulatory space to finance with debt.

[3] Also known as risk weighted assets (RWA).

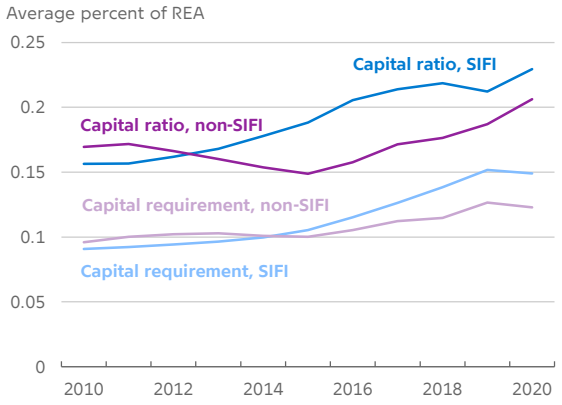
[4] Capital regulation is summarized here in more detail (Danish only): https://www.finanstilsynet.dk/Nyheder-og-Presse/Pressemeddelelser/2018/kapitalplaner_og_kapitalmaalsetninger071118

this applies to all banks. Pillar 2 consists of bank specific requirements. The size of the Pillar 2 requirements depends on bank specific risks. A bank's individual solvency requirement is given by the sum of its Pillar 1 and Pillar 2 capital requirement. Additionally, banks are subject to capital buffer requirements: the countercyclical capital buffer (CCyB, first activated in 2019), the capital conservation buffer (phased in from 2016) and for systemically important financial institutions (SIFI)[5] the SIFI buffer (phased in from 2015). The size of the SIFI buffer depends on the SIFI bank's importance for the financial sector as a whole. Here we take the "total capital requirement" to mean the sum of Pillars 1 & 2 as well as all buffer requirements. Thus, the total capital requirement faced by a bank varies from year to year but due to the introduction of the capital buffers requirements have in general been increasing over the period we study (2010-2020). The lowest capital requirement observed in our data is 8% and the highest requirement is 19.36%. Figure 2 illustrates how banks' capital ratios as well as their capital requirements have evolved during the period we study among both SIFIs and medium sized (non-SIFI) banks.

Banks face regulatory actions by the Danish FSA for falling below their required level of capital. The consequence of breaching the capital requirements depends on which requirement is breached and ranges from restrictions on dividend payments and performance-based salaries to closure of the bank by the Danish FSA. However, even under the mildest regulatory action banks may also experience reputational costs potentially driving increased funding costs. In line with this all banks in our data hold capital in excess of the capital requirements.

Capital requirements and capital ratios have been increasing duing the period we study

Figure 2



Note: The figure shows for each year the average capital ratio and capital requirement among SIFIs and non-SIFIs.
Source: Own calculations.

Data

Our data are collected by the Danish FSA and cover Danish banks and mortgage credit institutions. Our analysis focuses on the largest systemically important institutions and medium sized banks, based on the classification at the end of 2020.[6] This gives us a total of 18 credit institutions consolidated at the group level. Our sample includes both mortgage institutions unattached to Danish financial institutions, pure deposit banks as well as combined institutions but we refer to all of them as banks for simplicity. The data contain quarterly information on bank characteristics (balance sheet and income components) and the individual banks capital requirements from 2010-2020. Table 1 presents summary statistics.

[5] A description of the definition of a SIFI can be found here (Danish only): https://www.finanstilsynet.dk/Nyheder-og-Presse/Pressemeddelelser/2019/Aarlig-udpegning-af-SIFI-institutter-270619

[6] The banks included in our analysis are the banks from the most recent stress test (Spring 2021) performed by Nationalbanken.

Table 1: Summary statistics

	Mean	Std. deviation
Total assets, mio. DKK	363791.6	(794135.5)
Return on assets	0.5	(0.6)
Return on equity	4.9	(5.3)
Share of REA	59.1	(23.1)
SIFI	23.3	(42.3)
Total capital requirement, share of REA	11.1	(2.0)
Excess capital, share of REA	6.7	(2.9)
N	722	

Note: Summary statistics
Source: Own calculations.

future capital requirements. In our analysis it is therefore crucial to account for other factors in banks' capital strategies that could drive them to hold similar levels of capital.

To isolate the effect of strategic interaction, we need to consider other factors that both potentially correlate with the excess capital of a bank's competitors and at the same time might also influence the bank's choice of excess capital target (summarized in box 1).

Drivers of Excess Capital Boksx 1

- **Bank: size, profitability**
- **Bank riskiness**
- **Anticipated regulatory changes**
- **Anticipated mergers or acquisitions**
- **Tightness of regulation**
- **Outcome of stress test**
- **Organic growth**

Empirical Analysis

In the empirical analysis we examine if and how strategic interaction among banks may influence banks' choice of capital. Specifically, we ask if a bank considers the excess capital of its competitors when setting its own excess capital target. We measure excess capital as the bank's total capital minus the amount of capital the bank is required to hold by regulators (Pillars 1 & 2 plus capital buffers). Excess capital is expressed as a percentage of risk exposure amount (REA):

$$(1)\ ExcessCap = \frac{Actual\ Capital - Required\ Capital}{REA}$$

In the raw data we observe that banks tend to increase their excess capital when their competitors do so. Figure 1 shows a strong positive correlation between the change in bank i's excess capital and its competitors' change in excess capital. However, that banks take the excess capital of their competitors into account is not the only plausible explanation for such a pattern. Banks could for example experience the same shock or anticipate the same change in

In our data we do not observe the excess capital target of a bank. We use a partial adjustment model based on the approach in Brewer, Kaufman, and Wall (2008) to estimate banks' target excess capital in terms of observables. The partial adjustment model captures the idea that the bank adjusts, over many quarters, towards a long-run excess capital target. The partial adjustment model also allows for the possibility that a bank's target may change over time as the bank's information set changes. Using this approach, we can examine the determinants of excess capital targets indirectly by examining how these determinants affect changes in realized excess capital over time. Since our data are quarterly data measure time in quarters.

In practice we assume that the change in bank i's realized excess capital at time (quarter) t can be decomposed into a voluntary change ($\Delta^{voluntary} ExcessCap_{i,t}$) moving bank i towards its target at time t and an involuntary change due to exogenous shocks ($E_{i,t}$):

$$(2) \quad \Delta ExcessCap_{i,t} = \Delta^{voluntary} ExcessCap_{i,t} + E_{i,t}$$

The voluntary change in excess capital depends on bank i's target and is defined as:

$$(3) \quad \Delta^{voluntary} ExcessCap_{i,t} \equiv \delta(ExcessCap_{i,t}^{Target} - ExcessCap_{i,t-1})$$

where $ExcessCap_{i,t}^{Target}$ denotes bank i's target excess capital at time t and δ measures the speed of adjustment towards the target. If δ is less than 1, then banks are only able to partially adjust their excess capital towards their target at time t. [7] Accordingly, a bank's change in excess capital can be written as:

$$(4) \ \Delta ExcessCap_{i,t} = \underbrace{\delta(ExcessCap_{i,t}^{Target} - ExcessCap_{i,t-1})}_{Voluntary\ change} + \underbrace{E_{i,t}}_{Involuntary\ change}$$

$ExcessCap_{i,t}^{Target}$ is the long-run excess capital target of bank *i* at time *t*. This target may change over time. We assume that this target is composed as as follows:

$$(5) \quad ExcessCap_{i,t}^{Target} = Observed\ Bank\ Characteristics_{i,t-1} + ExpFutureRequirement_{i,t-1} + StrategicConsiderations_{i,t-1} + UnobservedBankCharacteristics_i + QuarterFE_{t-1} + \epsilon_{t-1}$$

For notational simplicity we suppress the coefficients on the explanatory variables in equation (5). To the extent that we can include all the relevant determinates of bank i's target excess capital in (5), we can estimate how banks' capital structure depends on strategic considerations.

In the following sections we discuss what we include to account for these factors. We conclude the section by specifying our baseline model for analysis and discussing how to interpret the coefficients estimated in our model.

Observed Bank Characteristics

Bank specific characteristics that may influence a bank's choice of excess capital target include: size, profitability, risk, anticipated mergers or acquisitions, ownership structure, and the total capital requirement the bank faces.

Larger bank's may for example have different business models to smaller banks (e.g. more market than deposit funded, or better diversified assets). To control for bank size, we include log assets in the model.

A bank's profitability is also important to consider as more profitable banks, all things equal, can more easily increase their capital via retained earnings. This could motivate lower excess capital targets: if a bank can more easily increase its capital the bank may choose less excess capital since changes are less costly (and the opportunity cost of capital is higher). In our baseline model we measure profitability by the return on assets (ROA). Specifically, we follow Brewer et al (2008) and define:

$$ROA_t = \frac{ResultBeforeTax_t}{0.5(TotAssets_t + TotAssets_{t-1})}.$$

where $ResultBeforeTax_t$ are profits before taxes.

It is also important to control for a bank's riskiness because banks with riskier assets may need to hold more excess capital to insure against future shocks. We control for bank i's riskiness by including risk exposure amount (i.e. risk weighted assets) as a share of total assets. [8]

Another relevant factor to include could be upcoming anticipated mergers or acquisitions

[7] If δ is equal to 1, then banks can fully adjust to their target excess capital within one quarter. In this case (4) simply reduces to: $ExcessCap_{i,t} = ExcessCap^{*}_{i,t} + E_{i,t}$.

[8] There are of course multiple ways we could measure banks' risk exposure as well as profitability and the measures we use are non exhaustive. Our findings are robust alternative definitions of profitability (ROE) and bank risk exposure (capital requirement excluding buffers divided by total assets) as well.

because banks that expect to acquire a competitor may need to build up capital in advance of the actual take over.

We also include a dummy for whether the bank is listed on the stock exchange or not since publicly traded banks can more directly raise equity and may be affected differently by strategic interaction effects (e.g. facing more direct market pressures).

Finally, it is important to consider the total capital requirements that each bank faces. Because it is possible that the level of the total capital requirement a bank faces could impact the amount of excess capital the bank chooses to hold. For example, if such capital requirements are very high one could imagine that banks hold less excess capital on average. In contrast under very low capital requirements one could imagine that banks may want to hold more excess capital in order to insure themselves against future shocks even if not required by authorities. It is also possible that the effect of total capital requirement level works in the opposite direction. It is possible for us to include these capital requirements because we observe for each bank the capital requirements the bank faces at each quarter in our data.

Given these considerations we replace the first term of (5) by the following:

$$(6) \quad ObservedBankCharacteristics_{i,t-1} = \alpha_1' ROA_{i,t-1} + \alpha_2' LnAssets_{i,t-1} + \alpha_3' RWA_{i,t-1} + \alpha_4' UpcomingMA_{i,t-1} + \alpha_5' TotalReq_{i,t-1} + \alpha_6' PubliclyTraded_{i,t-1}$$

Where $ROA_{i,t-1}$ and $LnAssets_{i,t-1}$ reflect bank i's return on assets and log total assets respectively. $RWA_{i,t-1}$ is bank i's risk weighted assets as a share of total assets at time $t-1$. To control for anticipated mergers and acquisitions in the next year we include a dummy that takes the value 1 if bank i in period $t-1$ expects[9] a merger or acquisition in period $t+4$: $UpcomingMA_{i,t-1} = E[MA_{i,t+4}]_{i,t-1}$. Finally the two last terms in (6) refers to the total capital requirement of bank i at time $t-1$ and an indicator for the bank being publicly traded at time $t-1$, respectively.

As (6) shows we include one measure of each of the factors discussed above to control for how each of these motives may affect a bank's choice of excess capital. There are of course many ways to capture these bank characteristics, we argue that the factors included in (6) are the most obvious bank characteristics that might influence a bank's choice of excess capital.

Expected Future Capital Requirements

During the period we study (2010-2020) Danish capital regulations changed multiple times. These changes were pre-announced, giving banks time to adjust. Banks may for example prefer accumulating capital via retained earnings. To the extent that it is costly for banks to adjust their capital quickly from one period to the next period, banks may start building up more capital in period t if they expect higher capital requirements in the future.

To capture expectations of future capital requirements, we include an indicator for increasing future requirements which takes the value 1 if total capital requirements are higher one year (four quarters) ahead. This indicator captures the bank level expectation of their individual future capital requirement. In the baseline model we only include a control for increasing future total capital requirements[10] but in the robustness analysis we show that our findings are robust to controlling for the pillar 2 capital requirements as well.

Concretely, we include expected future capital requirements given the information available at time $t-1$ in our baseline model in the following way:

$$(7) \quad ExpFutureRequirement_{i,t-1} = \alpha_7' E[\mathbf{1}\{TotalReq_{i,t+4} > TotalReq_{i,t-1}\}]_{i,t-1}$$

[9] In our data we only observe a merger or acquisition if it occurs, It is possible that a bank acts in expectation of a merger or acquisition that fails to occur, which we cannot control for.

[10] Total requirements are the sum of pillar 1 and pillar 2 requirements plus buffer requirements.

$$= \alpha_7' \mathbf{1}\{TotalReq_{i,t+4} > TotalReq_{i,t-1}\}$$

$$= \alpha_7' IncreasingReq_{i,t-1}$$

where $IncreasingReq$ is a dummy taking the value 1 if the total required capital in period t + 4 is higher than in period t. We could of course have included indicators further into the future but it seems like a reasonable assumption that the importance of future capital requirements diminishes with distance in time.[11] However, our findings are robust to simultaneously including a dummy for increasing capital requirements both two, three and four years ahead (period t+8, t+12, and t+16 respectively) as well.

Strategic Considerations

Finally, we include in our model a term to capture the strategic considerations of banks: that is the extent to which banks may base their own choice of target excess capital on the observed excess capital levels of their competitors. We include in our baseline model the average excess capital of bank i's competitors. We define a bank's competitors as those banks in the same group as classified by the Danish FSA. This leaves us with two competitor groups: systemically important financial institutions (SIFIs) and non-SIFI's.

Specifically, we include the leave-one-out group average of excess capital at time $t-2$. This is because at time $t-1$, when a bank forms its target excess capital for time t, it cannot observe its competitors' contemporaneous excess capital level. The bank's information about its competitors' excess capital stems from its competitors quarterly reports, which are typically released within the first two months upon closing of a quarter. We therefore include the average excess capital of the competitors at time $t-2$ instead.

In the model we denote the average excess capital by $\overline{ExcessCap}_{\neq i,t-2}$. Taking a simple average of its competitors' excess capital is of course a very simple measure of their excess capital. One could easily imagine that banks only consider the excess capital of their very close competitors even though we in our baseline model only consider banks within the same group as competitors. We address this concern with different sample restrictions in the robustness sections. This results in a strategic consideration term in the following way:

$$(8) \quad StrategicConsideration_{i,t-1} = \beta_1' \overline{ExcessCap}_{\neq i,t-2}$$

Substituting (8) into (5) means that finding a positive β_1 would be consistent with strategic interaction among banks.

Unobserved Bank Specific Characteristics

Even though we include many bank specific characteristics and capital requirements there are still bank specific characteristics that we do not fully capture. For example, banks may differ in their risk appetite or their business model. This could e.g. be their degree of dependence on international financial markets or their use of standard vs advanced internal ratings-based methods (IRB methods) for computing risk weights. It is also possible that ratings agencies treat different banks differently (above and beyond the observables in our dataset). We could of course include controls taking e.g. the degree of internationalization into account but banks' business models could differ in many other ways and thus it would never be possible to include a fully comprehensive set of controls. Moreover, some bank specific characteristics as for example risk appetite may even be unobservable. Instead we include bank fixed effects to consider any bank specific unobservable characteristics. We denote these fixed effects by $BankFE_i$.

Time Fixed Effects

On top of the bank fixed effects we include quarter fixed effects. This takes out changes in excess capital driven by macroeconomic shocks common to all banks in the sample. Inclusion of the quarter fixed effects therefore ensures that what we measure is not driven by GDP growth, inflation, changes in capital requirements that are common to all banks or changes in monetary policy – to the extent that these

[11] With the exception of very large future changes.

impact banks the same way. Time fixed effects additionally absorb changes over time to rating agencies' treatment of banks that impact all banks the same.

Baseline Model

Having described every term in equation (10) we are now ready to spell out the target excess capital equation:

$$(9)\quad ExcessCap^{*}_{i,t} = \alpha_1' ROA_{i,t-1} + \alpha_2' LnAssets_{i,t-1} + \alpha_3' RWA_{i,t-1} + \alpha_4' UpcomingMA_{i,t-1} + \alpha_5' TotalReq_{i,t-1} + \alpha_6' PubliclyTraded_{i,t-1} + \alpha_7' IncreasingReq_{i,t-1} + \beta_1' \overline{ExcessCap}_{\neq i,t-2} + \omega' BankFE_i + \gamma' QuarterFE_t + \epsilon_{i,t-1}$$

Substituting (9) into (3) we get our baseline empirical model[12]:

$$(10)\quad \Delta ExcessCap_{i,t} = \alpha_1 ROA_{i,t-1} + \alpha_2 LnAssets_{i,t-1} + \alpha_3 RWA_{i,t-1} + \alpha_4 UpcomingMA_{i,t-1} + \alpha_5 TotalReq_{i,t-1} + \alpha_6 PubliclyTraded_{i,t-1} + \alpha_7 IncreasingReq_{i,t-1} + \beta_1 \overline{ExcessCap}_{\neq i,t-2} + \omega BankFE_i + \gamma QuarterFE_t - \delta ExcessCap_{i,t-1} + \epsilon_{i,t-1}$$

The coefficient of interest $\beta_1$measures the change in bank i's excess capital as a share of RWA when the average excess capital of bank i's competitors (banks $\neq i$) increases by 100 basis points Thus, the β_1 coefficient measures the potential strategic motivation of changes in excess capital. We do not claim that the model above (10) perfectly identifies strategic motives in banks' capital strategy but we interpret our findings from model (10) as an indication of strategic motives if β_1 is positive and significant.

Empirical Results

In this section we discuss the results from estimation of our baseline model (equation 10) and the robustness of our findings.

The last column of Table 2 displays the result of estimating the baseline model (equation 10) where we have highlighted the row with the coefficient of interest. Column (1) to (4) to the left show how the strategic interaction coefficient changes as we add more controls. The coefficient on competitor average excess capital (β_1) increases across the specifications but does not switch sign or change by an order of magnitude. Once we include time and bank fixed effects in our model the coefficient does not change much. This indicates that the difference in the controls across specifications is not what drives the sign and significance of the β_1 coefficient.

Our results are consistent with a strategic interaction motive to hold excess capital, that is: an increased excess capital among a bank's competitors causes the bank to increase its excess capital.

Estimations of our baseline model suggest that when a bank observe that the average excess capital[13] of its competitors has increased by 100 basis points the bank increases its own excess capital by 14.4 basis points in the following quarter. This is a reduced form estimate. Thus, our model does not capture fully the general equilibrium effects of strategic interaction. [14]

[12] Note that coefficients in equation 10 are equal to the coefficient with a prime in equation 9 times the adjustment coefficient δ. Eg $\alpha_1 = \delta\alpha_1'$.

[13] Recall that excess capital is measured in terms of % of risk weighted assets.

[14] This means that our estimate cannot simply be extrapolated to calculate the total response in the sector to one banks' decision to change its excess capital.

Our estimations indicate that strategic interaction impacts banks' capital formation since the explanatory power of our model increases non-negligibly if we include strategic interaction: If we compare the adjusted R2 between our baseline model with and without strategic interaction the explanatory power of the former is 3.1% higher than the latter.[15] This increase in the adjusted R2 is more than three times larger than the increase in explanatory power in our baseline model with and without bank profitability (measured by return on assets) as a control.[16] However, this also highlights that even though our model indicates that strategic interaction is important for capital formation in banks it is not the main driver of banks' changes in excess capital.

Our baseline estimation also suggests that banks close around 22.3% (δ) of the gap between their target and actual excess capital in each quarter.

The baseline model in column (5) also suggests that riskier banks and more profitable banks are less likely to build up excess capital. Return on Assets (ROA) as well as riskiness enters the model significantly even though we include bank fixed effects. This means that in quarters where a given bank is riskier (has higher REA share[17]) or is more profitable it is less likely to increase its share of excess capital. Increases in future capital requirements or future merges and/or acquisitions do not yield significant estimates but are nevertheless important to include to control for these excess capital motives. Similarly increasing capital requirements yields a positive but non-significant coefficient indicating that higher future capital requirements can serve as a motive to hold more excess capital. Finally, the coefficient on bank size is negative (larger banks may be less likely to build up excess capital) but not statistically significant.

Robustness

In Table 3 and Table 4 we test the robustness of our findings where the coefficient of interest is highlighted. In Table 3 we test if the suggestive evidence of strategic interaction persists across different extensions of our baseline model (5). In column (1) we test the functional form assumption in our baseline model and instead assume a log-linear reaction of banks to an increase in their competitors' excess capital. This estimation also yields a significant estimate and suggests that when the average excess capital of a bank's competitors increases by 1 percent the bank increases its own excess capital by 1.02 basis points. For the average bank in our sample this would correspond to an increase in excess capital from 6.74 to 6.75 following a 1 percent increase in excess capital among its competitors. In column (2) we add the future $(t+1)$ pillar 2 requirements as a control into the baseline model because these reflect bank specific capital requirements in order to address bank specific risks or future losses. In that sense the pillar 2 capital requirements can be seen both as an expected future capital requirement but also as a forecast of bank specific shocks that the banks should hold enough capital to resist. Our findings are robust to adding this extra control.

In column (3) we include a dummy indicating if the bank's competitors could be expecting increasing future requirements which do not affect our coefficient of interest. In column (4) we address the choice of lags included in the model by including an extra lag of all controls included our baseline model. However, most of these coefficients do not enter the model significantly and including them does not affect our findings.

Finally, in column (5) we include an alternative set of fixed effects by including Bank×Year fixed effects instead of the Bank fixed effects and the quarter fixed effects. Effectively this amounts to controlling for bank and year specific shocks or characteristics. These fixed effects also capture year specific events common to all banks since we do not condition on the year specific effects to be different across banks but simply allow for it. Thus, this specification allows

[15] The adjusted R2 in our baseline model is 29.64 whereas estimating our baseline model without the strategic interaction term yields an adjusted R2 of 28.74.
[16] The adjusted R2 increases by 0.88% when we include ROA in our baseline model compared to our baseline model without ROA.
[17] The ratio of risk weighted assets (RWA) to total assets.

us to control for e.g. changes in bank specific business models or bank specific losses in a given year that we do not observe directly in the data. However, this does not allow us to control as extensively for time specific shocks since we still need some variation to estimate from and thus it is not our preferred specification. In this specification we find a similar but less significant estimate compared to our baseline specification regarding the importance of strategic interaction among banks. However, including these fixed effects reduces the variation we are estimating from considerably but even so the coefficient is significant at the 15.4 percent level.

In Table 4 we test the robustness of our findings across different subsamples of our main sample. In column (1) we leave out year 2020 from our estimations since the corona pandemic could lead to different capital strategies among banks than outside the pandemic and since banks during 2020 were prohibited to payout dividends. In column (2) we leave out the largest Danish bank (Danske Bank) as it operates more internationally than the other Danish banks. In both column (1) and (2) we find we find a positive and significant estimate for β_1 of similar size as in our baseline sample.

Finally, in column (3) of Table 4 we estimate if the response to competitors' excess capital differs among the two groups of banks. The larger banks (SIFIs) have different access to market funding and are less dependent on deposits (relative to smaller banks). SIFIs may therefore have a more active capital strategy and thus react more to their competitors' strategy. However, we do not find any significant difference in the reaction between SIFI's and non-SIFI's.

Other Regulations

In addition to capital requirements in terms of risk-weighted assets focused on in this memo, banks face other forms of regulation. These include: (i) the leverage ratio, and (ii) the minimum requirement for own funds and eligible liabilities (MREL). These were not in force for the majority of our sample, however they were announced during our sample period. In the following we discuss how the effect of banks anticipating and pre-adjusting to these requirements could impact our results.

The leverage ratio requires that banks hold equity that is at least 3% of total (unweighted) assets. This requirement has entered into force from June 2021[18], which is outside of our sample period. In principle we might assume that banks that were below the leverage ratio requirement before June 2021 may have started to accumulate more capital in advance of the requirement. However, during our sample period all banks fulfilled the 3% requirement and with a substantial buffer to the leverage requirement.[19]

The MREL was anticipated as early as 2014[20]. This requirement only entered into force in July 2019, and only for the largest Danish banks[21]. Small and medium-sized Danish banks have until January 2023 to fully meet the MREL[22]. In our data we do not observe the MREL. Therefore, the only way to address the impact of the MREL is to introduce a dummy variable equal to 1 in the time periods in which the banks face the MREL. To the extent that banks are equally impacted by MREL[23] this would be identical to the time fixed effects already incorporated into our baseline specification and we cannot estimate such an indicator separately from our time fixed effects since it would be identical across all banks. Our findings are robust to allowing for the possibility that the MREL impacts individual

[18] Danmarks Nationalbank Analysis (Financial Stability), No. 12, May 2021 (link).

[19] During the Danish central bank's stress testing only some SIFI's have in the most recent stress test (Spring 2021) in a very severe stress scenario breached the leverage requirement. In none of the prior stress tests did any bank breach the leverage requirement, even in the most severe stress scenario.

[20] https://www.nationalbanken.dk/en/publications/Pages/2014/12/Financial-stablility-2nd-Half-2014.aspx

[21] For the smaller banks the MREL requirements are phased over multiple years and not fully phased in before 2023.

[22] https://www.nationalbanken.dk/en/publications/Pages/2019/05/Banks-face-new-requirements-in-the-stress-test.aspx

[23] https://www.dfsa.dk/News/Press-releases/2020/minimum_requirements_funds_liabilities_Covid19 This is the case in the specifications that separate banks out by groups.

banks differently (i.e. by adding time fixed effects interacted with bank fixed effects).

A further note of caution should be emphasized regarding the fact that we do not observe the extent to which banks' increase or decrease excess capital in response to the outcome of the stress test process. Changes in this observed excess capital therefore could be driven by banks' internal decision making or decision making together with regulators as part of the stress test process. However, this is only a threat to our identification to the extent to which the outcome of the stress test process is correlated across banks.

Conclusions

In this memo we find that the data are consistent with the hypothesis that banks' excess capital choice is based in part on strategic considerations of what their competitors do. We find that when the average excess capital[24] of a banks' competitors increases by 100 basis points the bank increases its own excess capital by 14.4 percentage points (Table 2). Including the strategic interaction term in our preferred specification increases the explanatory power of our model by 3.1% indicating that strategic interaction has an impact on the capital formation of banks. We cannot definitively rule out other drivers of excess capital.

Cautious interpretation of the results suggest that regulators should consider strategic interaction effects when forecasting the response of banks to both regulatory changes (e.g. adjustment in the level of capital requirements and around buffer releases).

This could for example be relevant when forecasting the banks' response to the upcoming introduction of the Basel output floor. To the extent that banks cannot observe how their competitors will be impacted by the introduction of the output floor it is possible competitors will mistake a bank's accumulation of excess capital in preparation for an adjustment of their risk weights for accumulation of excess capital due to other reasons. If that is the case strategic interaction may drive competitor banks to also accumulate excess capital (even if they are unaffected by the output floor). If banks on the other hand communicate to the each other that they are increasing excess capital in anticipation of increasing capital requirement it removes the strategic interaction motive. Some banks have even engaged publicly in such communication[25]. Such communication should mute the effect strategic interaction in response to the output floor introduction. Even so our findings suggest any impact will be quantitively small.

Strategic interaction could also be of particular importance around buffer releases. Banks may first adjust slowly in response to a buffer release, given the level of their competitors' excess capital will be high. But then may adjust quickly, particularly if a leader bank moves to take the space opened up by the buffer release. The strategic interaction effect we see in our data is quantitatively small. However, our sample primarily includes periods of regulatory tightening. It is possible a relaxation of the capital requirements (i.e. a buffer release) implies a different quantitative impact of strategic interaction.

[24] Recall that excess capital is measured in terms of % of risk weighted assets.

[25] For example have Nykredit announced in their annual report that they have reserved a certain amount of their excess capital to meet future Basel related requirements.

Table 2: Main results

	(1)	(2)	(3)	(4)	(5) Baseline
Excess capital, t-1	-0.0742***	-0.0620***	-0.144***	-0.159***	-0.223***
	(0.0149)	(0.0135)	(0.0207)	(0.0215)	(0.0249)
Excess capital ratio of competitors, t-2	0.00595	0.0333	0.0894**	0.102**	0.144***
	(0.0342)	(0.0340)	(0.0451)	(0.0459)	(0.0498)
Return on assets, t-1				0.168*	0.181*
				(0.0965)	(0.102)
Log. assets, t-1				-0.00332	-0.00577**
				(0.00238)	(0.00262)
Share of RWA, t-1				-0.0103	-0.0204**
				(0.00860)	(0.00947)
Upcoming m/a, t-1				-0.000643	-0.00148
				(0.00156)	(0.00159)
Total capital requirement, t-1					-0.102**
					(0.0463)
Increasing capital requirement, t-1					0.000379
					(0.00117)
Constant	0.00490**	0.00226	0.00398	0.0463*	0.0921***
	(0.00245)	(0.00243)	(0.00312)	(0.0278)	(0.0325)
Bank FE	No	No	Yes	Yes	Yes
Quarter FE	No	Yes	Yes	Yes	Yes
R-Adjusted R2	0.0316	0.234	0.250	0.253	0.296
N	705	705	705	705	651

Note.: The table shows the relationship between bank i's change in excess capital (the dependent variable) and the average excess capital of its competitors with various controls. The baseline model refers to our estimation of equation (10). Standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.010
Source: Own calculations.

Table 3: Robustness (model specification)

	(1)	(2)	(3)	(4)	(5)
Excess capital, t-1	-0.225***	-0.218***	-0.228***	-0.202***	-0.708***
	(0.0249)	(0.0256)	(0.0262)	(0.0431)	(0.0594)
Return on assets, t-1	0.182*	0.156	0.138	0.112	0.0790
	(0.102)	(0.104)	(0.107)	(0.109)	(0.102)
Log. assets, t-1	-0.00592**	-0.00500*	-0.00636**	-0.00510	0.00368
	(0.00262)	(0.00268)	(0.00291)	(0.00942)	(0.00973)
Share of REA, t-1	-0.0205**	-0.0196**	-0.0134	-0.00844	-0.0362
	(0.00947)	(0.00973)	(0.0108)	(0.0209)	(0.0275)
Upcoming m/a, t-1	-0.00148	-0.00141	-0.00275	-0.0000160	-0.000432
	(0.00159)	(0.00161)	(0.00171)	(0.00241)	(0.00290)
Total capital requirement, t-1	-0.103**	-0.0209	-0.0517		0.363***
	(0.0462)	(0.0635)	(0.0538)		(0.120)
Increasing capital requirement, t-1	0.000364	0.000391	0.000717		0.00262*
	(0.00117)	(0.00118)	(0.00121)		(0.00142)
Log excess capital ratio of other banks, t-2	0.0102***				
	(0.00337)				
Pillar 2 capital requirement, t+1		-0.00122*			
		(0.000709)			
Excess capital ratio of competitors, t-2		0.144***	0.246***	0.337**	0.114
		(0.0513)	(0.0603)	(0.135)	(0.0798)
Total capital requirement of competitors, t-2			-0.368***		
			(0.0951)		
Increasing capital requirement (competitors)			0.000776		
			(0.00162)		
Constant	0.131***	0.0859**	0.121***	0.0677**	-0.0216
	(0.0368)	(0.0333)	(0.0376)	(0.0335)	(0.122)
Additional lag	No	No	No	All controls	No
Bank FE	Yes	Yes	Yes	Yes	No
Quarter FE	No	Yes	Yes	Yes	No
BankYear FE	Yes	No	No	No	Yes
Adjusted R2	0.297	0.297	0.309	0.257	0.320
N	651	634	583	688	648

Note: The table shows the robustness of our baseline result. The dependent variable is the change in excess capital of bank i. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.010

Source: Own calculations.

Table 4: Robustness (sample selection)

	(1)	(2)	(3)
Excess capital, t-1	-0.236***	-0.247***	-0.216***
	(0.0264)	(0.0264)	(0.0254)
Return on assets, t-1	0.214**	0.198*	0.166
	(0.107)	(0.102)	(0.103)
Log. assets, t-1	-0.00428	-0.00754***	-0.00647**
	(0.00284)	(0.00266)	(0.00262)
Share of RWA, t-1	-0.0224**	-0.0198**	-0.0180*
	(0.0105)	(0.00944)	(0.00958)
Upcoming m/a, t-1	-0.00181	-0.000860	-0.00170
	(0.00168)	(0.00159)	(0.00159)
Total capital requirement, t-1	-0.106**	-0.0394	-0.0539
	(0.0516)	(0.0498)	(0.0522)
Increasing capital requirement, t-1	0.000357	0.000881	0.000508
	(0.00120)	(0.00120)	(0.00117)
Excess capital ratio of competitors, t-2	0.167***	0.185***	0.246***
	(0.0570)	(0.0528)	(0.0730)
SIFI Indicator			0.00205
			(0.00901)
SIFI # Excess capital ratio of competitors, t-2			-0.0991
			(0.116)
Constant	0.0756**	0.101***	0.0872***
	(0.0351)	(0.0320)	(0.0324)
Bank FE	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
Adjusted R2	0.295	0.299	0.301
N	590	611	651

Note.:The table shows the relationship between bank i's change in excess capital (the dependent variable) and the average excess capital of its competitors with various sample restrictions. In (1) we exclude 2020, in (2) we exclude Danske Bank. In (3) we examine the difference in strategic interaction between group 1 and group 2 banks. Standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.010

Source: Own calculations.

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