Systemically important banks: is there a TBTF premium?

Marianna Blix Grimaldi, Mats Christoffersson, Yuuki Ikeda and Jonas Niemeyer*

Jonas Niemeyer works in the Financial Stablility Department of the Riksbank. Marianna Blix Grimaldi works at the Swedish National Debt Office but was visiting the Riksbank's Research Department when working on this article. Mats Christoffersson works at the Swedish National Debt Office and Yuuki Ikeda is at Bank of Japan but was at the Bank for International Settlements when working on this article.

Too big to fail (TBTF) is a catchy phrase used to describe a systemically important bank (SIB) that is so entwined with the economy that its failure would impose significant losses on other firms or seriously impede the functioning of the financial system with consequent risks to the broader economy. As a result, when such large banks have been close to default, governments have traditionally used public funds to ensure payments of the bank's debt, to avoid it defaulting. Such a bail-out of a TBTF bank limits systemic risk, but it has economic costs. In fact, treating a bank as TBTF extends unlimited protection to all of the bank's creditors, not just depositors, giving the bank a funding advantage and incentives to take on more risk than other banks. In other words, the TBTF banks benefit from a TBTF premium. After the global financial crisis and in order to limit the TBTF problem, regulators imposed new stricter rules on the largest banks in an effort to control risk-taking and introduced a new process for resolving failures of large banks in a way that subjects the creditors of such banks to losses. However, as the financial system adapts, the TBTF problem remains a public concern. This article contributes to the literature and previous policy work on TBTF issues in several aspects. We estimate TBTF premiums from the period before the global financial crisis to March 2021 for a sample of 53 SIBs. We present novel evidence on regional variation of TBTF premiums, also within Europe. We show that, while the driving factors of TBTF premiums have not changed, their relative relevance has shifted significantly. Finally, we show the significant variation of TBTF premiums that exists among large banks.

1 Introduction

Some banks may be so large and complex that market participants think that public authorities would find it difficult to let them fail when they face financial problems. Such banks are typically called systemically important banks (SIBs) as they are considered to be too-big-to-fail (TBTF). When the market perceives a bank to be TBTF, it has real consequences. If market participants think that such a bank will be saved (i.e. bailed-out) by public authorities, the risk for its shareholders and bondholders will fall. Under such

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presumptions, shareholders will gain when the bank makes a profit but will not lose their investment if the bank defaults. Heads I win, tails you lose. Similarly, bondholders would be almost certain to get their investment and earned interest back. Therefore, if market participants think a bank is a SIB, it will affect the pricing of the bank's shares and bonds. If the perceived risk is lower, expected returns will be lower and thus prices higher. Thus, such banks will benefit from a TBTF premium (see FSB 2021). By using market prices, it is possible to estimate this market-implied TBTF premium. A relatively large literature, using different methodologies, has showed the existence of such a premium for SIBs in different countries.[1]

To estimate the TBTF premium in this article, we use a Merton-type model, in which a firm defaults when its asset value falls below a determined boundary. Such models estimate the probability that a firm defaults, and this probability depends on the firm's capital structure, i.e. its own funds in relation to its debt. While it is not the only approach available for estimating the TBTF premium, it is well suited to the problem at hand, see, for example, IMF (2014).

We contribute to the literature and previous policy work in several ways. First, by using data from SIBs from Europe, North America and Asia (Japan), we add novel evidence on the regional variation of TBTF premiums, especially for some European banks. Second, we investigate the determinants of TBTF premiums and how they vary by region. Third, we investigate the time dynamics of the determinants of TBTF premiums. Fourth, we analyse the differences in the TBTF premiums of global systemically important banks (G-SIBs) versus domestic systemically important banks (D-SIBs) in our sample.

The rest of the article is organized as follows. In section 2 we discuss why some banks are large and why this is a public policy concern as well as what has been done in terms of global standards to reduce the TBTF-problem after the global financial crisis (GFC) in 2008–2009. In section 3, we present the estimates of TBTF premiums. We document changes in TBTF premiums over time and across regions. We also present our analysis on the determinants of TBTF premiums and, assess the heterogeneity among SIBs. Section 4 concludes.

2 The TBTF issue

There is no universal definition of what constitutes a bank. Some countries define a bank as an entity that has a banking licence, which becomes a rather circular definition. Other countries focus their definition on banks' provision of payment services. Other countries focus their definition on banks' ability to take deposits and grant loans. Regardless of how they are defined, in most countries banks play a vital role in the economy by: a) providing payment services, b) taking deposits and granting loans and in doing so transforming liquid deposits into illiquid loans and c) being an intermediary to more advanced financial risk management for households and firms.

Similarly, there is no clear definition of which banks are SIBs and thus which banks could benefit from a TBTF premium. On a yearly basis, the Basel Committee on Banking Supervision (BCBS) establishes a list of about 30 banks that are defined as global systemically important banks (G-SIBs) for the coming year. The 75 banks with the largest leverage ratio exposure measure constitute the G-SIB sample banks.[2] For each of these banks, data are collected, 12 indicators are calculated and basic global market shares are calculated. In addition, supervisors may exercise discretion and adjust the mechanistic score, if warranted. As markets and banks develop, the yearly G-SIB list is not static but may change from one year to another. During the last few years, the BCBS has designated about 30 banks as G-SIBs.

1 A systemically important bank is defines as a bank that is deemed to be of such importance that the bank's failure may trigger a wider financial crisis, see BCBS (2013). Colloquially, such banks are often described as TBTF. FSB (2021) lists a number of references outlining TBTF premiums and how to estimate them.

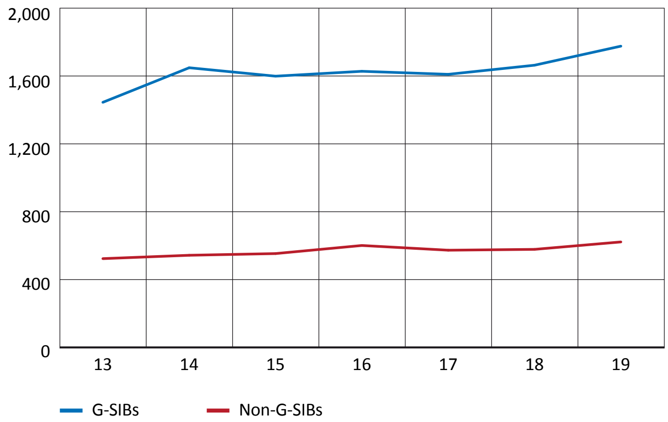
2 In reality, the G-SIB sample consists of 76 banks, see BCBS (2013). Somewhat simplified, a bank's leverage ratio exposures measure consists of its on-balance sheet items and most of its off-balance sheet items weighted with a factor, see BCBS (2017a).

Although some banking groups have entered the list and some exited, the list has been rather stable over the years. The G-SIB list is then endorsed by the Financial Stability Board (FSB) and published in November every year (see FSB 2020). The G-SIBs are the largest – and by the public authorities deemed the most systemically important – banking groups in the world. On a yearly basis, there are about 30 G-SIBs and about 75 banks in the G-SIB sample.

In addition, countries may define a bank as a domestic systemically important bank (D-SIB). This designation may also vary over time. Most – but not all – G-SIB sample banks are also D-SIBs. On the other hand, many D-SIBs are not included the G-SIB sample as they may be large in their home country but have limited global scale, so focusing on SIBs more generally would include more banks than are included in the G-SIB sample. In most of the empirical part of the article from section 3 and onwards, we use data from 53 banks, 26 that have been included in the G-SIB list at any point in time and 27 D-SIBs (see Appendix B).

On a global scale, many banks are large. For 2019, the World Bank reports an overall GDP for the world of 87,800 billion USD or approximately 78,150 billion EUR.[3] At the end of 2019, the aggregate size of the G-SIB sample banks was 81,320 billion EUR (BCBS G-SIB-database).[4] So the aggregate size of these 76 banks is larger than the total world GDP.

Figure 1. Average size of systemically important banks in the world
Billion EUR



Note. Size is measured as the leverage ratio exposure measure at year-end, averaged across the banks. Non-G-SIBs are the banks within the G-SIB sample that are not designated as G-SIBs.
Sources: www.bis.org/bcbs/gsib/, Bank reports and authors' own calculations

The SIBs have also remained large since the GFC. Using data from end 2013 to end 2019, Figure 1 plots the average size of the G-SIBs as well as that of the G-SIB sample banks that are not designated as G-SIBs (Non-G-SIBs). For G-SIBs, the average size (in terms of leverage ratio exposure measure) has been around 1 600 billion EUR. In Figure 2, two things stand out. On average, G-SIBs are substantially larger than Non-G-SIBs. Also, the G-SIBs have become slightly larger since 2013. It is also worth noting that most of the G-SIBs are highly complex. While there is no universal good measure of complexity, the average G-SIB has over a thousand subsidiaries in over 40 jurisdictions (FSB 2021). Most of these banks are also active in many different lines of banking business, further increasing complexity.

A relevant question in this context is why some banks are large and complex. There are several reasons for this.

A first reason is the existence of large non-financial corporates. When these large corporates need banking services they typically turn to large banks. To offer some services, such as corporate actions and fixed income offerings, to these large corporates, the bank will

3 The source for global GDP is the World Bank World Development Indicators https://data.worldbank.org/indicator/NY.GDP.MKTP.CD and this has been transformed using the end 2019 exchange rate.
4 In this context, size is measured as the leverage ratio exposure measure.

need a fairly large balance sheet, as it may have to absorb fairly large risks for a short period of time.

A second reason is that certain banking services may also include economies of scale and scope.[5] Payment services is an area where the marginal cost of an additional payment may be very low while there may be substantial fixed costs. This creates opportunities to profit from economies of scale and scope. A larger bank may also have greater opportunities to diversify risks. However, diversification necessitates good risk data aggregation and as banks grow in size that may become more difficult. Also, in some areas, the economies of scale and scope may be less pronounced. The empirical literature on this subject is not new but the evidence remains mixed. Berger et al. (1999) perform a literature review and find scant evidence of any substantial economies of scale or scope. More recently, Beccalli and Rossi (2017) document some economies of scope in the European banking sector. Also, Boot (2017) argues that technological developments such as fintech may increase the fixed costs and reduce some variable costs, i.e. potentially creating – or alternatively further enlarging – the scope for economies of scope and scale.

A third reason is that many large corporations, including banks, have a natural tendency to grow. Executives often prefer to manage larger firms as that increases their power and remuneration. This empire-building feature may be a driving force for the ever-increasing size of banks (Jensen and Meckling 1976 and Jensen 1986). Many banks have a disperse ownership which may accentuate this agency problem.

A fourth reason is that banks tend to become larger as a result of government actions. Given the important role that banks play in the economy, it is also very difficult to close down a bank. When a non-financial corporation faces economic challenges, it will shrink, close down or even go bankrupt. Few banks take that route. Instead, banks facing economic problems often elicit public interventions. A common public solution to a bank facing problems is to merge it with another bank. Indeed a common result of financial distress is that banks become even larger and fewer. Nordea is a case in point. It was created by merging a number of smaller banks following the various financial crises in the 1990s in the Nordic countries. Presently, consolidating some parts of the European bank sector is also being discussed as one of the possible solutions to the low profitability of some European banks (see, for example, ECB 2020).

A fifth reason is that some banks may be perceived to have an implicit government guarantee. Such guarantees would reduce the bank's funding costs and lower the risk of both shareholders and bondholders. This lower risk may reinforce empire-building features. Also, the controlling effect of shareholders on bank management may be undermined.

In the GFC 2008–2009, it became clear that some large and complex banks posed a substantial risk to the global economy. The failure of Lehman Brothers in 2008 had repercussions all over the world. It became clear that some banks needed stricter rules than other banks, simply because they posed larger risk to society. These banks were seen as TBTF and their existence became a public concern.

2.1 TBTF – a public policy concern

The existence of large and complex banks that are SIBs or TBTF banks is a public policy concern. Their potential failure or default can create large negative spill-over effects on the financial system and the real economy (see BCBS 2011 and FSB 2021). In other words, there are serious negative externalities of such a failure. Given the externalities, public authorities may be unwilling to let such a bank fail. Instead, in a crisis, public authorities may do what they can to save the bank. The perception that a SIB would be saved from default by public authorities diminishes the risk to shareholders and bondholders even in normal times.

5 Economies of scale arise when there are cost advantages of producing a single good, while economies of scope arise when there are cost advantages of producing a variety of similar but different goods.

This reduces the funding costs of these banks as market participants will demand a lower risk premium for such funding than for other banks that are not perceived as systemically important. Thus, one way to assess if market participants perceive a bank to be systemically important is to see if it has lower funding costs, i.e. if it benefits from a TBTF premium due to implicit government support.[6]

The GFC also showed that the negative externalities had wide cross-border implications. The failure of Lehmann Brothers had serious consequences for the financial sector in many countries. Many financial markets experienced severe stress and GDP fell in most parts of the world. Therefore, the need for coordinated action to limit these risks was abundantly clear. From a small-country perspective, the need to ensure sufficiently strict global minimum rules is even more important. The interdependency is larger for small countries than larger countries, but the main message from the crisis is that when there are financial problems in some of the worlds' largest and most complex banks, small and large countries are all likely to feel the economic consequences of those problems.

2.2 Responses to the TBTF issue after the GFC

In the aftermath of the GFC, G-20 leaders met in Pittsburgh in September 2009 to discuss financial markets and the world economy. There was full agreement to launch a vast series of global reforms to strengthen the financial regulatory framework with the aim of increasing the resilience of the global financial system, and to do so in a coordinated manner. Among other things, they agreed (G-20 2009):

1. to 'develop resolution tools and frameworks for the effective resolution of financial groups';
2. 'that prudential standards for systemically important institutions should be commensurate with the costs of their failure'; and
3. that there was a need to develop 'more intensive supervision and specific additional capital, liquidity, and other prudential requirements'.

The first bullet above indicates a desire to develop a more efficient way to deal with banks in distress than through a public bail-out. Notably, the second and third bullets highlight that some banks pose a greater risk to financial stability than others and that these banks need stricter prudential standards. Up until then, the Basel Committee, being the global standard-setter for banks, had developed common regulatory standards for all globally active banks, but largely without making any distinction between smaller and larger banks. In 2009 – for the first time – there was a political commitment for more stringent requirements for a subset of these banks, the SIBs.

With the agreement to impose stricter requirements on a subset of banks, the first important question was how to define these SIBs. In 2011, the Basel Committee developed a method to single out banks that it considers the most global systemically important – the G-SIBs.[7] G-SIBs have a surcharge on their capital requirement in the form of a separate G-SIB buffer. The higher the ranking among the G-SIB sample banks, the higher the surcharge. All relevant jurisdictions have implemented the G-SIB framework, and ensured that it has become a legal requirement for these banks (see BCBS 2016).

6 There may of course be other reasons why a bank benefits from lower funding costs. In our model, see section 3, we try to take these into account.

7 The framework was first agreed in November 2011, see BCBS (2011), and later updated in 2013, see BCBS (2013), and revised in 2018, see BCBS (2018). As part of the method, the Basel Committee collects data from all internationally active banks with a leverage ratio exposure measure larger than 200 billion EUR. The data consist of a number of balance sheet items, transaction items and other items – in total about 65 items – categorized into 12 indicators. The method then calculates the market share of all of these indicators and weighs them together to create a global weighted market share.

The Basel Committee also recognized that other banks may be systemically important on a domestic or regional basis, even if the failure of such a bank may not have global repercussions. It therefore developed a framework for dealing with D-SIBs (BCBS 2012). It is less prescriptive than the G-SIB framework but provides a number of principles to guide jurisdictions in dealing with D-SIBs. Jurisdictions should make an assessment whether any bank is a D-SIB but there is no requirement for defining any bank as such, nor to apply any surcharge, even if the framework recognizes such a surcharge as a useful tool.

Apart from the surcharge, SIBs are also subject to more intensive supervision. The exact way to implement and organize this is largely up to each jurisdiction to define.

Following the GFC, FSB also developed new standards for the recovery and resolution of G-SIBs (see FSB 2014). These standards have four basic components. First, banks should develop recovery plans for what they should do in a stressed scenario. Second, jurisdictions should develop a legal structure to facilitate resolution of a bank in a crisis. Third, resolution authorities should develop resolution plans for banks that may fail. Fourth, banks should have a certain level of Total Loss Absorbing Capacity (TLAC) (see FSB 2015).[8] TLAC-instruments include capital but also debt instruments that can be bailed-in, i.e. written down or converted to equity, when the bank is in resolution. The main purpose of the TLAC requirements is to ensure that a failing bank's shareholders and creditors can absorb sufficient losses in resolution, so that the public sector would not have to resort to using public funds in a bail-out. By ensuring that SIBs have sufficient private capital at risk, the purpose is to reduce the expectation that public funds would need to be used in a crisis. This would also force the market to better assess the risks as bank shareholders and holders of the bail-in-able debt would potentially suffer losses if the bank is put into resolution.

The first G-SIB buffer surcharge is only implemented for capital requirements in terms of risk-weighted assets. In 2017, the Basel Committee agreed that all G-SIBs should be subject to an additional surcharge buffer on their leverage ratio requirement (see BCBS 2017b). The new leverage ratio surcharge buffer was due for implementation on January 2022 but due the Covid-19 pandemic, implementation may be postponed by one year (see BCBS 2020).

Many jurisdictions apply the TBTF-standards to a larger set of banks, than only G-SIBs. D-SIBs are common in many countries and they typically also face higher capital requirements than other banks.[9] Also, requirements on bail-in-able debt for D-SIBs are becoming frequent in many countries. Some countries even apply such requirements on bail-in-able debt to other banks that are not formally SIBs[10]. Recovery and resolution planning as well as legal changes in the implementation of resolution frameworks have been approved in many countries. In that respect, the global standards have materially changed the system in many countries around the world.

3 Development of TBTF premiums

As discussed before, the presumption of government support gives rise to a so-called TBTF premium, which is embedded in market equity prices and credit spreads. It is worth noting that all market prices-based models measure market participants' *perceptions* of the development of TBTF premiums and are therefore imperfect measures of the premium in itself, which is unobservable. In the following, for the sake of brevity, we refer to those imperfect measures as TBTF premiums.

In this article, we focus on estimates based on a Merton-type structural credit-pricing model. It is the same model as in FSB (2021) and closely related to the model in Schweikhard

8 The European version is called Minimum Requirement for own funds and Eligible Liabilities (MREL).

9 In Sweden, Finansinspektionen has determined that three banks are D-SIBs, Handelsbanken, SEB and Swedbank and they all face a D-SIB surcharge.

10 In Sweden, nine banks are subject to requirements on bail-in-able debt, see www.riksgalden.se.

and Tsesmelidakis (2012) and Tsesmelidakis and Merton (2012). Appendix A describes the model.[11]

A commonly convenient way to define the premium is in terms of the difference between equity market-implied CDS, or fair-value CDS (*FVCDS*), and the observed CDS spread as below:

(1) $TBTF_{i,t} = FVCDS_{i,t} - CDS_{i,t}$

where i denotes bank$_i$ and t denotes time. The modelling of the *FVCDS* is based on the insight that a firm's equity and debt can be valued as options on the asset value of the firm.[12] This insight was originally introduced by Black and Scholes (1973) and subsequently developed by Merton (1974). In this framework, default occurs when the value of the firm's assets becomes lower than the value of its debt and is therefore insufficient to allow the firm to meet its contractual obligations. The firm's market asset value is unobservable, but it can be inferred from equity prices, the firm's liabilities structure and the business (asset value) risk of the firm. Over the past decades, this model has been widely applied as it provides a forward-looking measurement of the default probability and equity-implied credit spreads.

Another source of credit spreads is the CDS market. A CDS contract provides insurance against the risk of a default by a particular firm and provides a relatively direct and unbiased measure of the risk of default. In case of default, the seller of the CDS compensates the buyer for the losses that the buyer would otherwise incur on the amount insured. The insurance seller receives fixed periodic payments in return. The annual sum of those payments is usually expressed as a percentage of the face value of the CDS and quoted in basis points and is referred to as CDS spread. In this way, the CDS spread reflects the default risk of the firm.

The economic intuition behind the comparison as in (1) is that observed CDS spreads reflect *both* the probability of bank default *and* the likelihood and size of government support in case of default. In contrast, under the assumption that the government does not bail-out equity holders, the equity prices contain only information on the probability of default.[13] As a result, the equity price information allows the calculation of a hypothetical, 'equity-implied' *FVCDS* that is not affected by the probability of bailout.[14] The difference between the *FVCDS* and the observed *CDS* spread can therefore be interpreted as a measure of investors' expectations of government support.

3.1 Data used in the analysis

To compute *TBTF* premiums, we use data from Bloomberg and Markit (CDS). In the following analysis, we use macroeconomic variables that we collect from Bloomberg, with the exception of the variable Probability of Crisis, which we collect from the Stern-NYU's V-Lab initiative, which is based on Engle and Ruan (2019).[15] The source for the bank balance sheet variables such as return on equity, total capital ratio and total bank assets is the Fitch database.

11 There are different approaches to estimating TBTF premiums. The estimates of the premiums can differ significantly depending on the approach used. However, while the estimated level may differ, the pattern over time of the evolution of TBTF premiums is comparable, see for example IMF (2014) and FSB (2021).

12 A financial option is the right to buy or sell an underlying asset at a specified price on or before a specified maturity date. An option is particularly valuable when investors are more uncertain about the future value of the underlying asset.

13 The capital injection in a bailout can take several forms, such as loans, stocks, bonds or cash. While there is a possibility of the bank's shareholders being bailed out depending on the form of bailout, historically, for the large part, shareholders have suffered losses and not been bailed out in case of bank default. It is also worth noting that while both shareholders and bank creditors benefit from an implicit bank subsidy in terms of share prices and lower risk *ex-ante*, it is mainly bank creditors that benefit from a bail-out, *ex post*.

14 *FVCDS* and CDS may differ for other factors than the probability of bailout. For example, at times the *FVCDS* may be lower than the CDS. While it is not possible to exclude the influence of such factors, they have proved to be mostly transitory, see Dwyer et al. (2010).

15 See Volatility Laboratory (V-Lab), Stern Business School, New York University at http://vlab.stern.nyu.edu/welcome/risk/.

Market-based variables such as equity prices and volatility, CDS spreads, interest rates are at daily frequency whereas bank balance sheets are at quarterly frequency. Therefore, in order to mitigate unduly noise but keep as much information as possible from market-based data, we compute the TBTF premium on a monthly frequency by aggregating the market-based data and interpolating the quarterly bank balance sheet. We compute TBTF premiums for 53 SIBs. We select the banks according to the availability and quality of the data. In Appendix B, we list the banks in our sample and present some basic summary statistics of the data we use in our regression analysis.

3.2 Time variation of TBTF premiums

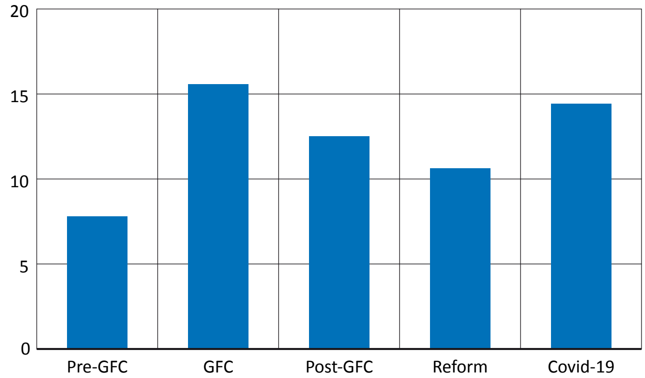
To evaluate TBTF premiums over time, we divide the time period into several sub-periods, corresponding to the period pre-GFC, the GFC, the post-GFC period and pre-reform period, the reform implementation period and the Covid-19 pandemic period as shown in Table 1. Figure 2 shows the TBTF premiums averaged across all countries in our sample for these sub-periods.

Table 1. Sub-periods analysed

Pre-GFC	GFC	Post-GFC	Reform	Covid-19
2004–2007	2008–2009	2010–2011	2012–2020:2	2020:3–2021:3

Note. The end of our sample is March 2021.

Figure 2. The TBTF premiums across sub-periods
Per cent



Note. Each bar represents the average TBTF premium in per cent in each sub-period. Pre-GFC denotes pre global financial crisis, i.e. 2004–2007; GFC denotes the global financial crisis, 2008–2009; Post-GFC denotes the period 2010–2011, i.e. post GFC and before the reform implementation period; Reform denotes the reform implementation period, 2012–(February) 2020; Covid-19 refers to the Covid-19 period, between March 2020 and the end of our period, i.e. March 2021. The TBTF premiums are computed at monthly frequency.
Sources: Bloomberg, Markit and authors' own calculations

Figure 2 shows three key results. First, TBTF premiums have declined from the peak of the GFC not only in the post-GFC period, but also continued to decline during the reform implementation period. The average premium has declined by about 6 percentage points corresponding to a decline in TBTF premiums of 60 per cent from the GFC to the reform implementation period. Second, TBTF premiums have not come down to pre-crisis levels but have remained 2–3 percentage points above throughout the reform implementation period. Thirdly, TBTF premiums have increased during the Covid-19 period, highlighting that theses premiums are highly time-dependent and indicating a positive correlation with the amount of market stress.

In order to corroborate our analysis above, we assess whether TBTF premiums are also statistically different across sub-periods by performing a panel regression analysis as follows:

$$(2) \qquad TBTF_{i,t} = \beta_0 + \beta_1 SubPeriod_1 + \beta_2 SubPeriod_2 + \beta_3 SubPeriod_3 + \beta_4 SubPeriod_4 + \varepsilon_{i,t}$$

where the dependent variable $TBTF_{i,t}$ is the TBTF premium for each $bank_i$ at time t. $SubPeriod_j$ with j equal to 1, 2, 3, and 4 denotes a dummy variable that takes value 1 for each corresponding period and zero otherwise. β_0 captures the average TBTF premium in the baseline period. The difference in TBTF premiums between the baseline and j period is measured by β_j.

We have five sub-periods. To measure the difference between the baseline and the other four sub-periods, we then run the analysis as in equation (2) five times, changing the baseline period to each of the five sub-periods as in Table 1. Table 2 shows the β_j values.

Table 2. TBTF premium differences among sub-periods, regression results

Sub-periods \ Baseline	Pre-GFC	GFC	Post-GFC	Reform
GFC	6.61*** (0.00)	–	–	–
Post-GFC	4.28*** (0.00)	−2.34*** (0.00)	–	–
Reform	2.70*** (0.00)	−3.91*** (0.00)	−1.57*** (0.00)	–
Covid-19	7.22*** (0.00)	−0.60 (0.50)	2.94*** (0.00)	4.52*** (0.00)

Note: Pre-GFC denotes pre global financial crisis, i.e. 2004–2007; GFC is the global financial crisis, 2008–2009; Post-GFC denotes the period during 2010–2011; Reform denotes the reform implementation period, 2012–2020:2; Covid-19 denotes the time period from 2020:3–2021:3. Robust p-values are presented in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The results relate to equation (2) where we include fixed-effects to control for the unobserved time-invariant heterogeneities across individual banks and countries. The baseline period is in columns. Each row reports the values of the estimated β_j from equation (2), i.e. the difference of the period on the row compared to the baseline (in column). Results are robust to different choices of the variance-covariance matrix estimator. Table 2 results are based on a variance-covariance matrix with cluster at bank level. The number of observations in each regression is 9,772.
Sources: Bloomberg, Markit and authors' own calculations

The differences in TBTF premiums across the sub-periods are all statistically significant, with the exception of the difference between the GFC and the Covid-19-period. For a further discussion of the time difference of TBTF premiums, see FSB (2021). The reasons why TBTF premiums in the reform implementation period have not fallen to pre-GFC levels are not fully clear. Later in the article, we therefore analyse how the *determinants* of TBTF premiums vary across time.

3.3 Regional variation of TBTF premiums

In this section, we analyse regional variation in the evolution of TBTF premiums. Similarly to Sarkar (2020), we analyse the dynamics of TBTF premiums for banks in Asia, Europe and North America, but we divide Europe in two sub-regions, the Nordic countries and the other European countries. Diversity within a certain region has been much less investigated in the literature and previous policy work on TBTF issues, and therefore our analysis contributes to that work with novel evidence on Europe.[16]

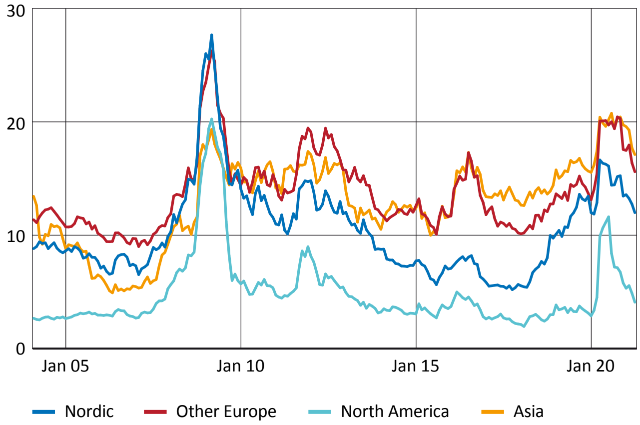
In this context, we define the *Nordic* region as Denmark, Norway, Sweden and Finland (from 2018), which share a similar structure of the economy, a well-integrated bank system within the region as well as cultural ties and history that – in many aspects – set them as a

16 In our analysis, we include banks from FSB countries such as Canada, France, Germany, Italy, the Netherlands, Japan, Spain, Switzerland, the UK and the US. We also include banks from Austria, Belgium, Denmark, Norway, Portugal, Sweden and Finland (from 2018). The period covered is January 2004–March 2021.

group apart from the other European countries.[17] Furthermore, none of them is a member of the Financial Stability Board. We label the other European countries as Other Europe (OE).[18]

Figure 3 illustrates the TBTF premium dynamics for the four regions – *Nordic*, *Other Europe*, *North America* and *Asia*.[19]

Figure 3. The TBTF premiums across regions
Per cent



Sources: Bloomberg, Markit and authors' own calculations

Figure 3 clearly displays regional variation in the evolution of TBTF premiums. TBTF premiums are highest for Asian banks and lowest for banks in North America. It also shows that there is a significant regional variation within Europe. The banks in the Nordic region appear to have lower TBTF premiums than in the other European countries in the sample, possibly reflecting structural differences among the regions and among banks. After the GFC, while banks in the Nordic region benefitted from an economic rebound and relative financial stability, banks in Other Europe have had relatively low profitability and comparably high levels of non-performing loans. The comparatively large increase in premiums for the Nordic banks observed during 2019 is possibly related to the fallout of money laundering investigations that involved several banks both in Denmark and Sweden which decreased equity shares prices and increased volatility, affecting their probability of default and TBTF premiums.

Figure 3 also shows that changes occurred in premiums between periods. While premiums significantly increased for all regions from the pre-GFC to the GFC-period, they have declined more for the North American and the Nordic banks in the following period. During the Covid-19 pandemic crisis, premiums rose for banks in all regions but increased significantly more for banks in the North American region, although from a much lower level. Compared to Europe, for example, premiums for the North American region almost tripled from the beginning of the pandemic to the peak during the summer 2020, whereas they increased about 30 per cent in Europe during the same period. By the end of the period in this analysis – end of March 2021 – premiums had declined significantly for both regions but not yet returned to pre Covid-19 crisis levels.

To investigate whether the differences we observe in Figure 3 are meaningful also in statistical terms, we perform a similar exercise as in the previous section, i.e. we run a panel regression analysis as in equation (3):

17 In October 2018 Nordea moved its headquarters from Sweden to Finland, becoming the largest D-SIB bank in Finland. Therefore *Nordic* includes banks in Finland but only from 2018.

18 Other Europe (OE) includes banks in Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, Switzerland, Portugal and the UK.

19 North America includes banks in the United States and Canada; Asia denotes banks in Japan.

(3) $TBTF_{i,t} = \beta_0 + \beta_1 Region_1 + \beta_2 Region_2 + \beta_3 Region_3 + y_t + \varepsilon_{i,t}$

where y_t denotes time (year) fixed-effects and $Region_j$ with $j = 1, 2$ and 3 is a dummy variable that takes value 1 for the corresponding region and zero otherwise. The intercept β_0 measures the average TBTF premium in the baseline region. Table 3 shows the results. The heading of the columns shows the baseline region. The numbers in each row correspond to the estimated value of the coefficients β_j in equation (3) and measure the difference in TBTF premiums between regions. For example, in the first column, the coefficient for Other Europe (OE) is about 4, i.e. the TBTF premium for the banks in OE is 4 percentage points higher than for banks in the Nordic region. The difference between North America (NA) and the Nordic region is about −3.6, which means that the premiums are about 3.6 percentage points lower for banks in NA. Notably, differences *within* Europe are compelling. In fact, the difference between NA and OE is close to −7.6 percentage points and therefore more than double compared to the Nordic region. In addition, the difference between OE and Asia is relatively small and not statistically significant. In contrast, the premiums for banks in Asia compared to banks in the Nordic region are about 3 percentage points higher and statistically significant. Finally, the TBTF premiums of North American banks are significantly lower than those of Asian banks.

Table 3. Differences among regions, regression results

Regions \ Baseline	Nordic	OE	Asia
OE	4.00*** (0.00)	–	–
Asia	3.23*** (0.03)	−0.77 (0.60)	–
NA	−3.59*** (0.00)	−7.59*** (0.00)	−6.82*** (0.00)

Note. Nordic denotes banks in the Nordic region, OE denotes banks in Other Europe, NA denotes North American banks. Robust p-values are presented in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The results relate to equation (3) where we include time-fixed effects. Each row reports the difference of that region on the row compared to the baseline (in column). Results are robust to different choices of the variance-covariance matrix estimator. In Table 3, we report the results based on a variance-covariance matrix with a cluster at bank level. The number of observations in each regression is 9,772.
Sources: Bloomberg, Markit and authors' own calculations

3.4 The determinants of TBTF premiums

3.4.1 Methodology and variables

In the previous section, we showed a significant regional variation. As discussed before, it is possible that this variation is related to structural differences at country level and to individual bank characteristics. In this section, we investigate the determinants of TBTF premiums that can be related to the observed variation by running the following panel regression model with fixed effects:

(4) $TBTF_{i,c,t} = \alpha + \gamma_i + \beta_m Macro_{c,t} + \beta_b Bank_{i,t} + \delta_c * year_t + Covid\text{-}19_t + \varepsilon_{i,t}$

where the explanatory variables $Macro_{c,t}$ and $Bank_{i,t}$ account for macro-financial variables for a given country *c* and bank-specific variables for a given bank *i*, respectively.[20] We briefly describe them below. The variable γ_i denotes bank fixed-effects, which controls for differences among banks.[21] $\delta_c * year$ is a country-year fixed-effect, which controls for country-

20 In an alternative specification, we have included the one-period-lagged TBTF among the controls. We find that the regression results are by and large unaffected by this change.

21 For convenience, γ_i can be thought of as shorthand for a set of dummy bank variables each multiplied by their respective regression coefficients, i.e. a dummy variable for each bank multiplied by its regression coefficient.

specific economic and financial environment that is not already captured in the $Macro_{c,t}$, including the effects of the Basel III regulation and resolution reform framework.[22] $Covid\text{-}19_t$ is a variable that takes value 1 during the period of the Covid-19 pandemic – defined as the period from March 2020 to the end of the sample March 2021, and zero otherwise. Finally, α – the intercept – gives us the average TBTF premium, given zero values for all of the explanatory variables and $\varepsilon_{i,t}$ is the error term.

The vector $Macro_{c,t}$ includes the following five variables:

a) the VIX index as a measure of market risk aversion,
b) a probability of financial crisis developed by the Stern-NYU's V-Lab initiative, which is based on Engle and Ruan (2019),
c) monetary policy influence as measured by the two-year country-specific government bond yield,
d) a measure of longer-term, structural development of the economy as measured by the natural rate of interest r*[23], and
e) the sovereign debt to GDP ratio.

The rationale for including the risk aversion and the probability of financial crisis measures is that default probabilities jump up during downturns and periods of heightened risk aversion and financial stress. Therefore, the implicit guarantees underlying TBTF premiums become particularly valuable in times of crisis. On these grounds, we expect changes in TBTF premiums to be positively correlated with both the VIX and the probability of financial crisis measure. We expect positive long-term, structural developments to be negatively associated with TBTF premiums if they result in economic growth improvements and higher competition in the bank sector (see Boyd and De Nicolo 2005, Boyd et al. 2007 and Schaeck et al. 2009).

The influence of monetary policy (as measured by the short-term government bond yield) is *a priori* ambiguous. On one hand, monetary policy tightening may increase the probability of bank default and thus potentially increase TBTF premiums. On the other hand, higher interest rates may signal buoyant economic conditions and increases in asset values and therefore lower probability of default and potentially lower TBTF premiums.

Similarly, the impact of sovereign debt is *a priori* unclear. Countries that have a lower debt-to-GDP ratio have more fiscal capacity to support banks that may eventually fail or run into problems and therefore may be more inclined to intervene in the banking sector when needed, implying higher TBTF premiums the lower the debt-to-GDP ratio. On the other hand, countries that run relatively large debts may be more dependent on banks absorbing a significant share of issued government debt. In the latter case, the sovereign sector and the bank sector are more tightly linked and dependent on each other than otherwise, resulting in an increase of the bailout probability and therefore of TBTF premiums.

We include in $Bank_{i,t}$ the following three variables:

a) the total capital ratio as a measure of the solvency of a bank,
b) the return on equity for measuring bank profitability, and
c) bank size as measured by total assets (in log terms)

We expect higher capital buffers and better profitability to lower the probability of bank default and therefore to be negatively associated with TBTF premiums. The effect of bank

22 A more direct measure of progress on the implementation of resolution reforms is the Resolution Reform Index (RRI) presented in FSB (2021). The scope of the RRI is limited to the FSB members and therefore is not available for all countries in our sample. Given this data limitation, we control for the influence of regulatory changes indirectly through the time-varying country fixed-effects.

23 r* denotes the natural interest rate, i.e. the real interest rate expected to prevail when an economy is at full strength and inflation is stable. Changes in r* relate to shifts in demographics, slowdown in trend productivity growth and global factors affecting real interest rates, see Holston et al. (2017).

size on TBTF premiums is ambiguous *a priori*. Larger banks may tend to be more systemic and therefore more likely to receive some support from public authorities in case of distress. On the other hand, larger banks are more likely to benefit from economies of scale and scope. They also tend to have more advanced risk management and investment diversification strategies (see Laeven et al. (2014) and our discussion in section 2). We summarize the expected effects of the different variables in Table 4.

Table 4. Variables in the analysis and their expected impact on TBTF premiums

Variables	Description	Direction
Size	Log of total assets	+/−
Solvency	Total Capital Ratio (TCR)	−
Profitability	Return-on-equity (ROE)	−−
ProbCr	Probability of systemic crisis	+
IntRate	2 year government bond yield	+/−
r*	Structural economic developments as measured by the natural interest rate	−
SovDebt	Ratio of sovereign debt to GDP	+/−
VIX	Market risk aversion	+

Note. Total Capital Ratio is defined as total capital held by a bank divided by its risk-weighted assets; VIX is the Chicago Board Options Exchange Volatility Index.

3.4.2 Regression results

Table 5 reports the results of our panel regression analysis.[24] The column *World* shows the regression results for all banks included in our sample. We find that higher bank capital and better profitability tend to lower the TBTF premium. The coefficient of bank size is positive with statistical significance. This suggests markets perceive that larger banks tend to be associated with larger TBTF premiums.

Next, turning to the estimates of macro variables in column *World*, as expected, higher probability of financial crisis and higher market risk aversion are associated with higher TBTF premiums. Higher interest rates are associated with higher TBTF premiums, giving some support to the hypothesis that tightening of monetary policy increases the probability of default of banks and therefore their TBTF premiums. Better structural economic developments (as measured by r^*) are associated with lower TBTF premiums whereas sovereign debt turns out to be statistically insignificant. The Covid-19 dummy is also insignificant.

24 The results presented in Table 5 are robust to changes in variables and period length. In particular, for our robustness checks we have used the Tier 1 capital ratio, ROA, the difference between the 10- and 2 year government bond yield and sovereign CDS.

Table 5. Panel regression results

Variables \ TBTF	World	Nordic	OE	Asia	NA
Size	0.75*** (0.00)	6.22*** (0.00)	1.19*** (0.00)	1.48*** (0.00)	−0.01 (0.97)
TCR	−0.10*** (0.00)	−0.08*** (0.00)	0.01 (0.81)	−0.19*** (0.00)	−0.07 (0.10)
ROE	−0.11*** (0.00)	−0.16*** (0.00)	−0.14*** (0.00)	−0.01 (0.46)	−0.03*** (0.00)
ProbCr	0.06*** (0.00)	0.09*** (0.00)	0.06*** (0.00)	0.04*** (0.00)	0.07*** (0.00)
IntRate	0.53*** (0.00)	0.50** (0.03)	0.61*** (0.00)	−3.56*** (0.00)	−0.11 (0.39)
r*	−1.82*** (0.00)	−1.89*** (0.00)	−0.62 (0.12)	−1.03** (0.05)	−3.16*** (0.00)
SovDebt	−0.02** (0.02)	0.04 (0.24)	−0.00 (0.81)	0.01 (0.52)	−0.16*** (0.00)
VIX	0.13*** (0.00)	0.15*** (0.00)	0.13*** (0.00)	0.10*** (0.00)	0.13*** (0.00)
D_Covid-19	0.34 (0.17)	−2.45*** (0.00)	0.83** (0.03)	−0.29 (0.44)	1.21*** (0.00)
No. Obs.	9,067	1,221	4,415	1,082	2,349
Adj. R-squared	0.89	0.91	0.86	0.90	0.79
Fixed-effects	Yes	Yes	Yes	Yes	Yes

Note. Size is the bank's total assets (log), TCR is the bank's total capital ratio, ROE denotes the bank's return-on-equity, ProbCr is the probability of systemic crisis, IntRate is the 2-year government bond yield, r* is the natural interest rate, SovDebt denotes the sovereign debt-to-GDP ratio, VIX is the Chicago Board Options Exchange Volatility Index and D_Covid-19 is a dummy variable with value 1 for the Covid-19 period covered by our analysis, i.e. from March 2020 to the end of the sample, March 2021. We include bank and country by year fixed-effects. Robust p-values are presented in parentheses *** p<0.01, ** p<0.05, * p<0.1.

When examining the results by regions, several differences emerge. Among macroeconomic variables, positive structural, long-term economic developments (measured by r^*) appear to be associated with lower TBTF premiums, as expected. Higher probability of crisis and VIX are associated with higher TBTF premiums for all regions whereas the results for sovereign debt are mixed depending on the region. An increase in the government bond yield increases the premiums for banks in Europe and it lowers them for banks in Asia, possibly reflecting structural differences in the banking sector and the economy. One interpretation is that in countries characterized by both weak economic growth and a dominant banking sector, an increase in interest rates is more likely to lead to an increase in bank probability of default and therefore higher TBTF premiums. This may be the case for many countries in Europe.

Turning to the effect of bank characteristics, there are large differences in the impact of the bank *size* variable. Specifically, the coefficient of bank size in the Nordic region is higher than in other regions, especially compared to Other Europe. This may reflect the fact that the banking sector in the Nordic region is particularly large in relation to the size of the economy. Thus, all else equal, even a small change in bank size has a comparatively larger impact on TBTF premiums in the Nordic region compared to in Other Europe. Bank profitability is negatively associated with TBTF premiums for every region, although the impact is larger for Europe than Asia and North America. The coefficients for banks' capital ratios have the expected sign for every region except Other Europe, and they are not statistically significant in Other Europe and North America. More specifically for the Nordic region, a one percentage point increase in TCR is associated with a reduction of 8 basis points in TBTF premiums. It is not obvious how to assess the economic significance of these estimates. Assuming – just for illustrative purposes – that a third of the outstanding debt could be bailed-out in a crisis, the analysis indicates that a one percentage point increase of TCR corresponds to a reduction in the implicit subsidy of about 2 per cent in terms of average GDP of the region (at current prices, 2019).[25] These estimates are highly uncertain but indicate that the economic impact of these TBTF premiums is not insignificant.

Finally, we examine the effect of the Covid-19 pandemic through the variable: *D_Covid-19*. TBTF premiums increased during the pandemic crisis and reached a peak during the summer of 2020. After that, they started to gradually decline for most countries and, in fact, for several countries by the end of our sample, i.e. March 2021, they had returned to levels close to those prevailing before the Covid-19 pandemic. The analytical results in Table 5 show that the Covid-19 shock increased TBTF premiums for the *World*, but this is not statistically significant. However, when analysed by region, there are significant differences. In fact, the Covid-19 period is associated with an increase in TBTF premiums for banks in Other Europe and North America whereas it has a negative sign for banks in the Nordic region (significant) and Asia (non-significant). These results are broadly in line with the evidence of the larger negative economic implications of the pandemic crisis for Other Europe and North America compared to the other regions we analyse; see, for example, IMF (2021). However, the results must be taken *cum grano salis* given the relatively short length of the Covid-19 period analysed. In addition, the interventions by public authorities eased market conditions and significantly influenced the ability of firms to withstand the economic consequences of the pandemic with potential confounding effects on TBTF premiums.

All in all, the analysis shows that the main driving factors of TBTF premiums and their significance differ across regions. Even within Europe, the determinants of TBTF premiums for banks in the Nordic region appear to be different from those of other European banks. In particular, bank size and capital appear to matter more for TBTF premiums in Nordic region than in Other Europe.

3.4.3 The relative influence of TBTF determinants has changed

In the previous section, we showed that bank size matters for the dynamics of TBTF premiums. Laeven et al. (2014) lists three main reasons why bank size matters for systemic risk and, ultimately, for TBTF premiums: a) large banks may benefit from better diversification, which reduces risks. They may also carry out market-based activities more competitively; b) the cost of debt for large banks is lower if they are perceived to be TBTF and c) large bank have specific corporate governance challenges, which increase their leverage and risk-taking. Thus, a larger bank size would be associated with lower TBTF premiums in the first case and higher in the following two.

Yet, the relative significance of the determinants of TBTF premiums may be changing over time. Antill and Sarkar (2018) document that bank size has become a less significant driver of systemic risk compared to other factors such as financial system interconnectedness and complexity. The reason for this change is still not fully clear.

In order to test whether this finding is also true for the TBTF premiums of banks in our sample, we deploy a modified specification of equation (2) that includes interaction terms between variables of interest and year dummy variables. This dynamic set-up enables us to assess whether a coefficient of interest evolves in a statistically significant manner over time.[26] Figure 4 shows the average coefficients of bank size by sub-periods. The larger the coefficient, the larger the impact that a change in assets has on premiums. The coefficient increased during GFC. Since then, it has declined. This suggests that the importance of bank size, while still being a key determinant of TBTF premiums, has been declining.

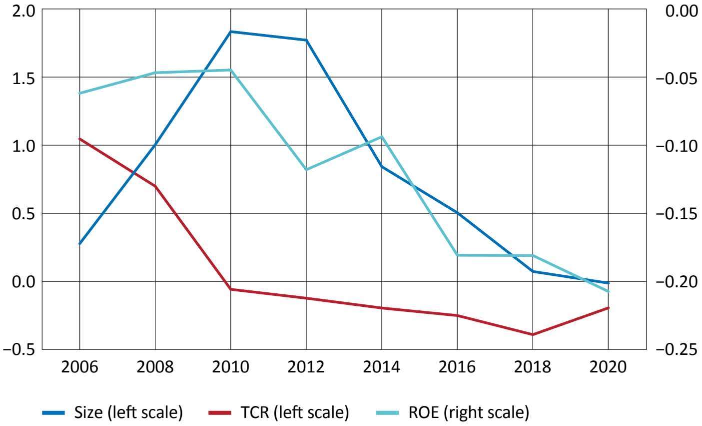
25 To translate the premiums in monetary terms we have multiplied it by the amount of debt that could be bailed out. However, the bailout-able debt is unknown *ex ante* and it is one reason why translating the premiums into monetary terms is not straightforward. In the text, we have assumed that one third of the outstanding debt would be bailed out, but these estimates are only for illustrative purposes.

26 We provide detailed results in Appendix C.

Figure 4 also shows that while the importance of bank size has fallen, the significance of bank profitability as an explanatory variable has steadily increased over the same period, as the coefficient has become increasingly negative. Goel et al. (2021) find that profitability has been a key determinant but often overlooked when analysing the response of SIBs to regulatory reforms. They argue that profitability has been a more important determinant of a bank's response to the TBTF regulation than factors such as the business model or domicile. They find that only banks that are less profitable have reduced their systemic footprint. Our results show that profitability has become more of a key driver of TBTF premiums after the GFC, suggesting that as banks' response to regulation was determined by the level of profitability, investors' perceptions of TBTF premiums correspondingly pivoted towards bank profitability.

In Figure 4, we also investigate the impact of bank capital on TBTF premiums. It has considerably changed over time. In the pre-GFC period, an increase in bank capital is associated with higher TBTF premiums, but this relationship has changed significantly over time. The impact of capital on TBTF premiums turned negative in the reform implementation period, implying that an increase in capital is associated with a reduction in TBTF premiums. This positive sign of the impact of capital on TBTF premiums before the GFC is in line with previous evidence on the inability of the pre-GFC capital regulation to prevent a crisis and the need for governments around the world to step in with emergency support and bail out the financial sector. In fact, capital adequacy ratios of banks that benefitted from bailout during the GFC tended to be even higher than those of other banks, see IMF (2009). In addition, many banks that were rescued during the GFC appeared to be in compliance with minimum capital requirements shortly before and even during the crisis. During the post-GFC period, Basel III rules made capital requirements more stringent and the requirements were gradually implemented. Our results suggest that market participants have come to view the new set of capital standards (and total bank capital) as increasingly more informative about bank performance and ability to withstand losses. Starting from 2010, total capital requirements are negatively associated with TBTF premiums. However, our analysis cannot exclude that these results may also be driven by the normalization of financial and economic conditions after the GFC.

Figure 4. The impact of bank size, profitability and capital on TBTF premiums over time
Coefficient



Note. Size is measured by bank total assets (log), TCR denotes total capital ratio and ROE is return on equity.
Sources: Bloomberg, Markit and authors' own calculations

From the perspective of the TBTF issue, the results on bank size, profitability and bank capital suggest that market participants' perception of what determines a bank to be TBTF has moved away from sheer size. It is reasonable that after the GFC and implementation of Basel III regulatory changes and bank resolution reforms, market perceptions have been recalibrated and that bank profitability and larger capital buffers have increasingly become more relevant for market participants' assessment of TBTF premiums.

Notably, the changing perceptions may have contributed to the higher level of TBTF premiums during the reform implementation period compared to in the pre-GFC period. As bank profitability declined dramatically after the GFC for a majority of banks in our sample and remained subdued for most of the period we examine, the heightened attention on bank profitability as a key driver of TBTF premiums may have contributed to keeping them at higher levels than during the pre-GFC period. In addition, our results point to a relatively larger influence of bank profitability compared to, for example, total capital. This suggests that the influence of increased capital ratios on market participants' assessment of TBTF may have been counterbalanced by the relatively poor development of bank profitability during the reform implementation period in many countries.

3.5 Heterogeneity among types of SIBs

In the literature and previous policy work, SIBs are commonly treated as a relatively uniform sample of banks.[27] But is this the case in reality? In this section, we analyse whether and to what degree G-SIBs and D-SIBs differ with respect to the evolution of TBTF premiums and whether and to what degree determinants of TBTF premiums vary between the two groups.[28]

In the following analysis, we classify our sample into G-SIBs and D-SIBs. We include a bank in the group of G-SIBs if it appears at least once on the G-SIB list, as published by the FSB, and apply its status through all the periods. We include banks in the D-SIB group that have been designated as such by national authorities. We limit this part of the analysis to European banks. There are two reasons for this: a) we avoid mixing potentially larger regional differences between European countries and other regions; b) we have a more balanced group of G-SIBs and D-SIBs from Europe.[29] The banks included can be found in Appendix B. In the analysis of this section, we use the subset of banks, i.e. 14 G-SIBs and 18 D-SIBs from the Nordic region and Other Europe.

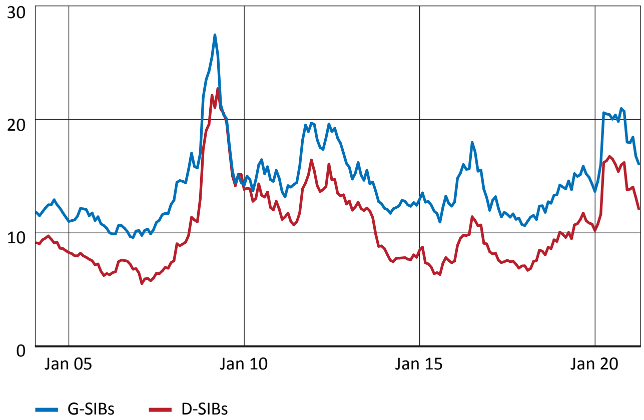
Figure 5 shows TBTF premiums for both European G-SIBs and D-SIBs over time.

27 BCBS (2019) contains a more general analysis of the differences between G-SIBs and other banks in the G-SIB sample. However, it does not deal with the TBTF premiums of these banks.

28 With regard to the impact of resolution reforms on TBTF premiums, FSB (2021) uses the RRI index in regression analysis and points out that its coefficient is larger for D-SIBs than G-SIBs and statistically significant only for D-SIBs. See FSB (2021) – Addendum to the Technical Appendix for details.

29 We use the list of D-SIBs regularly published by the European Banking Authority (EBA). We select the banks that have been continuously present over the period of our analysis and for which market data are available. Our D-SIB group includes Erste Bank, Raiffeisen Bank, KBC, Commerzbank, Danske Bank, BBVA, BFA (Bankia), Caixia, Banco Popular Español, Banco de Sabadell, Lloyds, Banca Monte dei Paschi di Siena, Intesa Sanpaolo, DNB, Banco BPI, SEB, Handelsbanken, and Swedbank. The G-SIB group includes Credit Suisse, UBS, Deutsche Bank, Santander, Crédit Agricole, BNP Paribas, Société Générale, Barclays, HSBC, RBS, Standard Chartered, Unicredit, ING, and Nordea. Nordea changed from being classified as a G-SIB to a D-SIB in 2019, but for sake of simplicity and because the period is relatively short, we keep it in the G-SIB group. Note that due to the availability of data for several countries, we have only G-SIBs (for example, Switzerland) or only D-SIBs (for example, Denmark).

Figure 5. TBTF premiums: G-SIBs vs. D-SIBs
Per cent



Sources: Bloomberg, Markit and authors' own calculations

Figure 5 shows that D-SIBs have lower TBTF premiums. After the GFC, the difference in premiums for the two groups has become larger as D-SIBs premiums have declined more than those of G-SIBs. In addition, the difference has reached a level close to that prevailing before the GFC.

What drives these results? We rerun the empirical analysis as in equation (4) but we add interaction terms between a G-SIB dummy and the variables in the vector *Bank*, i.e. size (total assets), capital (total capital ratio) and profitability (ROE), and in the vector *Macro* as follows:

(5) $$TBTF_{i,t} = \alpha + \gamma_i + \beta_{m1}Macro_{c,t} + \beta_{m2}Macro_{c,t} * G\text{-}SIB_{i,t} + \beta_{b1}Bank_{i,t} + \beta_{b2}Bank_{i,t} * G\text{-}SIB_{i,t} + \delta_c * year_t + Covid_t + \varepsilon_{i,t}$$

The G-SIB dummy takes value one for banks that are in the G-SIB group and zero otherwise.[30] The interaction terms measure the difference in the effect of being a G-SIB compared to other bank types, i.e., in our sample, D-SIBs.

30 The interaction term can be regarded as an adjustment to the slope coefficients of the variables in the vector *Bank*.

Table 6. Panel regression: G-SIBs vs. D-SIBs

Variables	TBTF
Size	1.66*** (0.00)
Size*G-SIB	−1.33*** (0.00)
TCR	−0.14*** (0.00)
TCR*G-SIB	0.14*** (0.00)
ROE	−0.13*** (0.00)
ROE*G-SIB	−0.11*** (0.00)
ProbCr	0.07*** (0.00)
ProbCr*G-SIB	−0.01*** (0.00)
IntRate	0.54*** (0.00)
IntRate*G-SIB	0.41*** (0.00)
r*	−0.62* (0.07)
r^* * G-SIB	−0.87*** (0.00)
SovDeb	0.03** (0.03)
SovDebt*G-SIB	−0.05*** (0.00)
VIX	0.12*** (0.00)
VIX*G-SIB	0.02** (0.05)
D_Covid-19	−0.17 (0.25)
No. Obs. Adj. R-squared Fixed Effects Region	5,636 0.88 *Yes* Europe

Note. Size is the bank's total assets (log), TCR is total capital ratio, ROE denotes return-on-equity, ProbCr is the probability of a systemic crisis, IntRate is the 2-year government bond yield, r* is the natural interest rate, SovDebt denotes the sovereign debt-to-GDP ratio, VIX is the Chicago Board Options Exchange Volatility Index and D_Covid-19 is a dummy variable with value 1 for the Covid-19 period covered by our analysis, i.e. from March 2020 to the end of the sample, March 2021. We only include banks from the Nordic region and Other Europe, see Appendix B for a list of the banks in the analysis. We include bank and country by year fixed effects. We present robust p-values in parenthesis, *** p<0.01, ** p<0.05, * p<0.1.

The results in Table 6 confirm our previous finding that, in general, an increase in bank size is associated with an increase in TBTF premiums. Larger banks have higher TBTF premiums. However, when the interaction term with the dummy for G-SIBs is included, the coefficient turns negative, indicating that the positive correlation between size and TBTF premium is driven by the D-SIBs and that the effect of size on TBTF premiums for G-SIBs is muted. Thus, size seems to be less of a TBTF premium driving factor for G-SIBs, potentially because they are already seen as TBTF, and that any additional size does not affect that assessment.

Similarly, in line with the overall results from Table 3, as a bank's capital increases, the TBTF premium falls significantly. However, that does not seem to be the case for G-SIBs, as we get a significantly positive coefficient for the interaction term between capital and G-SIB status. Thus if a G-SIB increases its capital, the bank's TBTF premium does not fall. Market participants still seem to assess it as TBTF.

Interestingly, the coefficient for the probability of a crisis also has a different sign for the multiplicative term. The coefficient for the probability of a crisis is similar to our results in Table 3, indicating that when the probability of a crisis increases, TBTF premiums increase significantly. However when looking at the G-SIBs only, the coefficient turns statistically significant and negative. A potential explanation is that G-SIBs already are considered to be

TBTF. It is also possible that the uncertainty about how to coordinate a resolution of a G-SIB is larger than for a D-SIB. Thus, in line with the result from Figure 5, as G-SIBs have higher TBTF premiums the additional increase may be lower as a crisis looms.

The effect of the sovereign debt-to-GDP is interesting. In the regression for the *World* (Table 3), the coefficient is negative and significant, indicating that the higher the sovereign debt is, the lower the TBTF premiums are. Looking at the Nordic region and Other Europe, the coefficients are not statistically significant. When we look at the same coefficient in Table 4, with data only from European banks, the coefficient becomes statistically significant and positive, indicating that as sovereign debt increases, TBTF premiums also increase. However, when multiplied by the G-SIB dummy, the coefficient is negative. In general terms, our results suggest that country-specific variables, such as public debt, matter less for G-SIBs than D-SIBs, potentially reflecting G-SIBs' less dependence on country-specific characteristics.

These results need to be interpreted with care because the number of European banks included in the analysis is relatively small. Nonetheless, they suggest that when factors such as bank size and bank capital are considered, there are clear differences in TBTF premiums between G-SIBs and D-SIBs, and these differences refer both to the levels of these premiums but also to the driving forces. This heterogeneity warrants further analysis and a continued monitoring by policy makers.

4 Conclusion

In this article, we provide an overview of the systemically important banks and the reforms to address too-big-to-fail (TBTF) problem. The overarching aim of the reforms was to increase the resilience of the banking system and mitigate the TBTF problem. The key elements of the framework comprise additional loss-absorbing capacity and resolution requirements for SIBs.

One quantitative approach to assess the effects of the reforms is to measure TBTF premiums. They increase because SIBs may benefit from an implicit funding subsidy that reflects the probability of bailout. Incentives to take on risk in financial institutions can also push TBTF premiums higher. This, in turn, increases both the likelihood and cost of bank failures.

In this article, we calculate the premiums using a Merton-type structural credit pricing model. We find that TBTF premiums diminished after 2012. This development coincides with the time when post-crisis reforms were announced and implemented for the countries in our sample.

However, our results show that there is a significant regional variation in the evolution of TBTF premiums, with reductions in premiums for Europe and Unites States but less for Asia. In addition, we show that while TBTF premiums have decreased for large European banks, there is considerable variation also within Europe. We provide novel evidence on banks in the Nordic region having lower TBTF premiums than other European banks.

We also analyse the determinants of TBTF premiums and find that the factors that affect the premiums have changed over time, in particular after the GFC. Bank size appears to matter less now than earlier, whereas the significance of bank capital and bank profitability as drivers of TBTF premiums has increased considerably. Notably, before 2010, higher bank capital signalled higher TBTF premiums, while after the GFC, higher bank capital signals lower TBTF premiums.

Furthermore, we investigate whether there are differences in the determinants of TBTF premiums of G-SIBs versus D-SIBs. Notably, we find that size is positively associated with TBTF premiums but primarily for D-SIBs. Compared to D-SIBs, TBTF premiums for G-SIBs are negatively associated with size. We also find some evidence that bank capital reduces TBTF premiums for D-SIBs whereas improvement in profitability lowers them for both G-SIBs and D-SIBs.

Finally, the Covid-19 crisis appears to have increased TBTF premiums in North America and Europe – but not in the Nordic countries, and not in Asia.

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Appendix A

Model description

The estimation of the equity-implied CDS spreads is based on a Merton-type structural credit pricing model developed by Finger et al. (2002) and applied, among others, in Schweikhard and Tsesmelidakis (2012) and Tsemelidakis and Merton (2012). It shares many key characteristics with the original Merton (1974) model.

As in Merton (1974), in this Merton-type model, equity and debt are valued as contingent claims on the firm's value and the distribution of the risk and return of the debt is based only on the firm's fundamentals, i.e. its liabilities structure, equity prices and equity volatility. Default occurs when the asset value falls below a certain default barrier. Notably, the level of the barrier is uncertain.

The basic assumption is that the asset value evolves accordingly as a geometric Brownian motion:

(6) $$\frac{dVt}{Vt} = \mu_v dt + \sigma_v dW_t$$

where W_t is a standard Brownian motion, σ_v is the asset volatility and μ_v is the asset drift. μ_v is set to zero for simplicity.

The default barrier is defined as the amount of the firm's assets that remain after default, i.e. is the amount of asset value recovered by debt holders, *LD*. *L* is the average recovery on the debt-per-share, *D*.

The uncertainty in the barrier is related to *L*, which is assumed to follow a lognormal distribution with average $\overline{L}$ and standard deviation λ. With an uncertain recovery rate, the default barrier can be reached unexpectedly, resulting in a default event.

The survival probability of the firm at time *t*, is then given by the probability that the asset value does not reach the default barrier before time *t* and can be expressed in closed form as:

(7) $$P(t) = \Phi\left(-\frac{At}{2} + \frac{log(d)}{At}\right) - d * \Phi\left(-\frac{At}{2} - \frac{log(d)}{At}\right)$$

where $d = \frac{V_0}{LD} exp\lambda^2$ and $A_t^2 = \sigma_v^2 t + \lambda^2$. Φ denotes the cumulative normal distribution function and σ_v the asset volatility. Note that the mean default barrier changes over time with the capital structure of the firm.

Finally, to convert the probability of survival into a equity-implied CDS or fair-value CDS *(FVCDS)* spread, two more parameters are specified, i.e. the risk-free interest rate *r*, and the probability of recovery of unsecured debt, *R*. Given the metrics above, *FVCDS* can be written as:

(8) $$FVCDS = r(1 - R)\,\frac{1 - P(0) + e^{r\xi}(G(t+\xi) - G(\xi))}{P(0) - P(t)e^{-rt} - e^{r\xi}(G(t+\xi) - G(\xi))}$$

where $\xi = \frac{\lambda^2}{\sigma_v^2}$, *r* is the deterministic risk-free interest rate, and *R* is the bond-specific expected recovery rate. The function $G(u)$ is as in Finger et al. (2002).

A key variable of the *FVCDS* is the asset volatility. Finger et al. (2002) show that it can be approximated by:

(9) $$\sigma_v = \sigma_S \frac{S}{S + \overline{L}D}$$

where *S* is the equity price, *D* is the debt per share and σ_S the equity volatility.

The input data and the calibration of the model

The computation of the *FVCDS* requires the following eight input variables: the equity price S, the debt per share D, the interest rate r, the average default threshold $\bar{L}$, the default threshold uncertainty λ, the bond recovery R, the time to expiration T, and the equity volatility σ_S. In short notation, the *FVCDS* can be written as follows:

(10) $$FVCDS = f(S_t, D_t, r_t, T - t, \sigma_t; R, \bar{L}, \lambda)$$

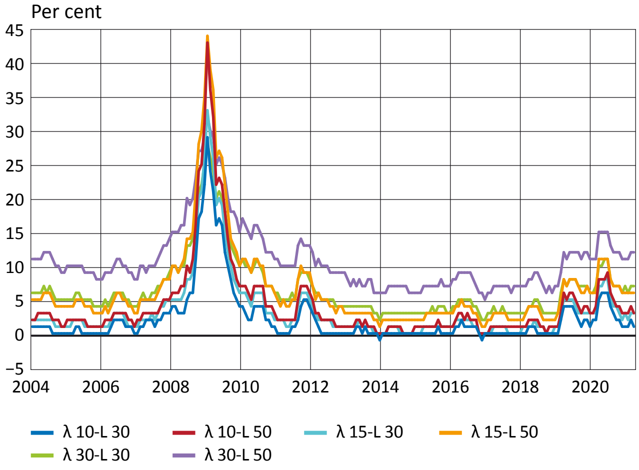
The three parameters $(R, \bar{L}, \lambda)$ are unobservable and were estimated by Finger et al. (2002). Following Schweikhard and Tsesmelidakis (2012), we set

- λ, the standard deviation of the recovery rate of the firm's debt, to 0.3
- R, the recovery rate of unsecured debt, to 0.5
- $\bar{L}$, the recovery rate averaged over all debt classes, to 0.5, as in Finger et al. (2002)
- The debt per share D is calculated as the balance sheet total liabilities over the number of outstanding shares
- The risk-free interest rate r is the one-year government bond yield
- The equity volatility σ_t is the historical volatility of equity returns
- S is equity prices

To estimate the *FVCDS*, all model input data are collected from Bloomberg whereas observed CDS data that are subtracted from *FVCDS* to compute TBTF premiums are collected from Markit CDS data.

To avoid unduly noise, we compute the *FVCDS* at monthly frequency from daily market data and quarterly balance sheet data. The balance sheet data are linearly interpolated. One advantage of interpolating quarterly balance sheet data compared to using the last observable as fixed value for the months through the quarter is that it mitigates potential problems related to balance sheet management, such as window dressing practices.

Figure A1. TBTF premiums for Swedbank



Source: Authors' own calculations

We have also done some robustness checks to assess how sensitive the model is to the parameters λ and $\bar{L}$. Figure A1 shows some different combinations of λ and $\bar{L}$ for Swedbank and how they affect the TBTF premium. Both parameters change the level of the TBTF premium, but not the pattern. There is also a trade-off between them. A higher value of λ can be off-set with a lower value of $\bar{L}$. The empirical regularities in Figure A1 are similar for all banks.

Appendix B

Table B1. List of banks included in the empirical analysis

Bank name	D-SIB / G-SIB	Country (headquarters)	Regional group
Banca Monte dei Paschi di Siena	D-SIB	Italy	Other Europe
Banco BPI	D-SIB	Portugal	Other Europe
Banco de Sabadell	D-SIB	Spain	Other Europe
Banco Popular Español	D-SIB	Spain	Other Europe
Bank of America	G-SIB	US	North America
Bank of Montreal	D-SIB	Canada	North America
Bank of New York Mellon	G-SIB	US	North America
Bank of Nova Scotia	D-SIB	Canada	North America
Barclays	G-SIB	UK	Other Europe
BBVA	D-SIB	Spain	Other Europe
BFA (Bankia)	D-SIB	Spain	Other Europe
BNP Paribas	G-SIB	France	Other Europe
Caixia	D-SIB	Spain	Other Europe
CIBC	D-SIB	Canada	North America
Citigroup	G-SIB	US	North America
Commerzbank	D-SIB	Germany	Other Europe
Crédit Agricole	G-SIB	France	Other Europe
Credit Suisse	G-SIB	Switzerland	Other Europe
Daiwa Securities Group, Inc.	D-SIB	Japan	Asia
Danske Bank	D-SIB	Denmark	Nordic
Deutsche Bank	G-SIB	Germany	Other Europe
DNB	D-SIB	Norway	Nordic
Erste Bank	D-SIB	Austria	Other Europe
Goldman Sachs	G-SIB	US	North America
Handelsbanken	D-SIB	Sweden	Nordic
HSBC	G-SIB	UK	Other Europe
ING	G-SIB	the Netherlands	Other Europe
Intesa Sanpaolo	D-SIB	Italy	Other Europe
JP Morgan Chase	G-SIB	US	North America
KBC	D-SIB	Belgium	Other Europe
Lloyds	D-SIB	UK	Other Europe
Mitsubishi UFJ Financial Group, Inc.	G-SIB	Japan	Asia
Mizuho Financial Group, Inc.	D-SIB	Japan	Asia
Mizuho Financial Group, Inc.	G-SIB	Japan	Asia
Morgan Stanley	G-SIB	US	North America
National Bank of Canada	D-SIB	Canada	North America
Nomura Holdings, Inc.	D-SIB	Japan	Asia
Nordea*	G-SIB	Sweden/Finland	Nordic
Raiffeisen Bank	D-SIB	Austria	Other Europe
RBS	G-SIB	UK	Other Europe
Royal Bank of Canada	G-SIB	Canada	North America
Santander	G-SIB	Spain	Other Europe
SEB	D-SIB	Sweden	Nordic
Société Générale	G-SIB	France	Other Europe
Standard Chartered	G-SIB	UK	Other Europe
State Street	G-SIB	US	North America
Sumitomo Mitsui Financial Group, Inc.	G-SIB	Japan	Asia
Sumitomo Mitsui Trust Holdings, Inc.	D-SIB	Japan	Asia
Swedbank	D-SIB	Sweden	Nordic
The Norinchukin Bank	D-SIB	Japan	Asia
Toronto-Dominion Bank	G-SIB	Canada	North America
UBS	G-SIB	Switzerland	Other Europe
Unicredit	G-SIB	Italy	Other Europe

Note. * In October 2018 the Nordea bank moved its headquarters from Sweden to Finland, becoming in 2019 the largest D-SIB bank in Finland.

Table B2. Summary statistics of key data used in the regression analysis

Variables	No. Obs.	mean	sd	p1	p25	p50	p75	p99
CDS spreads	9,772	95.85	106.33	6.61	33.62	69.62	117.94	542.45
TBTF	9,772	9.51	6.30	0.68	4.61	8.02	13.36	27.81
Total Assets	10,516	910,056	767,208	34,202	292,036	672,866	1,423,731	2,922,798
TCR	9,898	15.27	3.79	9.29	12.3	15	17.30	25.96
ROE	10,486	13.33	19.39	−38.95	8.41	13.62	19.48	36.61
ProbCr	10,764	26.66	28.94	0.01	1.75	14.75	47.68	96.93
IntRate	10,557	1.30	1.64	−0.79	0.09	0.80	2.39	5.12
r*	10,764	1.13	0.73	−0.09	0.50	0.94	1.72	2.61
SovDebt	10,764	91.81	44.79	30.66	59.38	85.71	111.53	215.97
VIX	10,764	18.92	8.76	10.26	13.44	16.10	21.84	57.74

Note. CDS spreads are the quoted CDS spreads in basis points, TBTF is the too-big-to-fail premium (%), Total Assets are bank total assets (USD million), TCR is total capital ratio (%), ROE denotes return-on-equity (%), ProbCr is the probability of financial crisis (%), IntRate is the 2-year government bond yield (%), r* is the natural interest rate, i.e. the real interest rate expected to prevail when an economy is at full strength and inflation is stable (%), SovDebt denotes the sovereign debt-to-GDP ratio (%), VIX is the Chicago Board Options Exchange Volatility Index (%-points). sd denotes standard deviation, p25 the 25-percentile, etc.

Appendix C

We show the coefficients on size – as measured by total assets (in log terms), bank profitability as measured by the return on equity – and bank capital as measured by total capital ratio, by year. A higher coefficient is associated with a higher TBTF premium.

Table C1. Coefficients by year

	TA (log)	TCR	ROE
2004	−1.05*** (0.01)	0.89*** (0.00)	−0.02 (0.12)
2005	0.10 (0.69)	1.18*** (0.00)	−0.04*** (0.00)
2006	0.43** (0.04)	0.89*** (0.00)	−0.09*** (0.00)
2007	0.94*** (0.00)	0.87*** (0.00)	−0.06*** (0.00)
2008	1.05*** (0.00)	0.51*** (0.00)	−0.03*** (0.00)
2009	1.92*** (0.00)	0.04 (0.77)	−0.06*** (0.00)
2010	1.74*** (0.00)	−0.19*** (0.00)	−0.03 (0.32)
2011	1.91*** (0.00)	−0.14*** (0.00)	−0.13*** (0.00)
2012	1.62*** (0.00)	−0.14*** (0.00)	−0.10*** (0.00)
2013	0.55** (0.03)	−0.33*** (0.00)	−0.09*** (0.00)
2014	1.12*** (0.00)	−0.09*** (0.00)	−0.10*** (0.00)
2015	0.57** (0.01)	−0.22*** (0.00)	−0.14*** (0.00)
2016	0.41* (0.09)	−0.32*** (0.00)	−0.23*** (0.00)
2017	0.12 (0.59)	−0.48*** (0.00)	−0.15*** (0.00)
2018	0.00 (0.99)	−0.33*** (0.00)	−0.21*** (0.00)
2019	−0.12 (0.59)	−0.16*** (0.00)	−0.20*** (0.00)
2020	0.07 (0.78)	−0.26*** (0.00)	−0.21*** (0.00)

Note. TA (log) denotes bank total assets in log terms, ROE is returns on equity and TCR refers to total capital ratio. We present robust p-values in parenthesis, *** p<0.01, ** p<0.05, * p <0.1.