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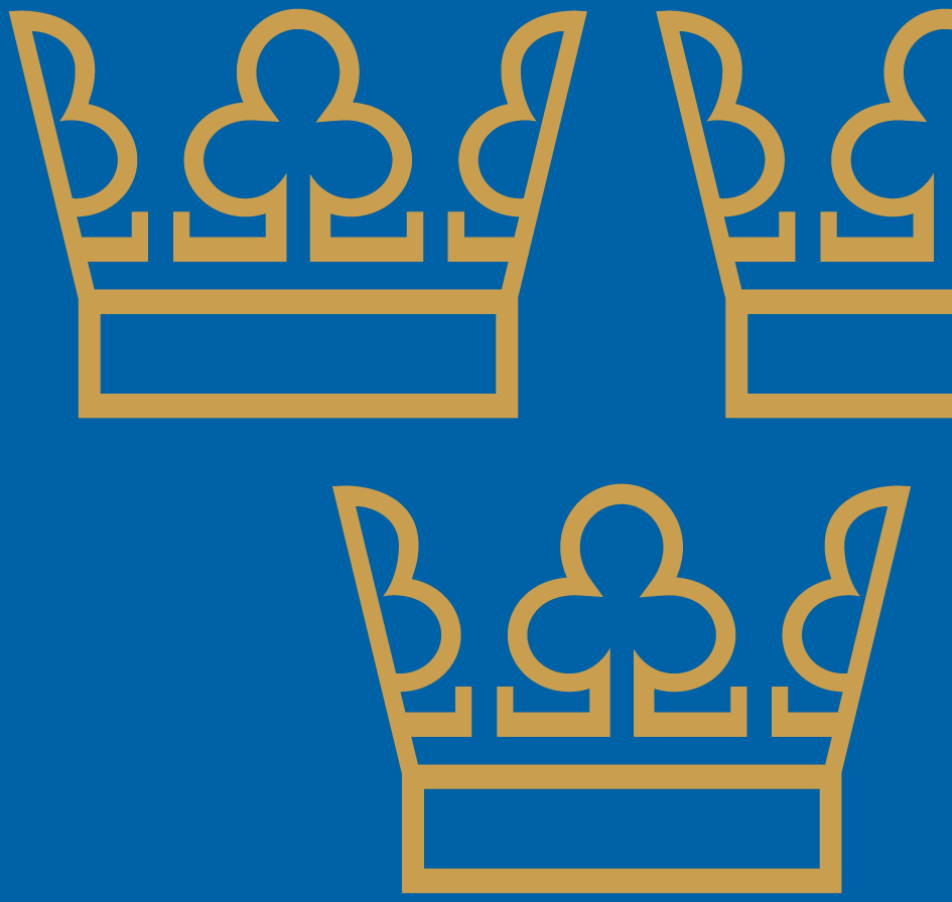
Marianna Blix Grimaldi, Alberto Crosta, Åsa David, Johan Linder



FI Analysis

The value of an implicit state guarantee for systemic banks

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This analysis is a cooperation between FI and the National Swedish Debt Office. The authors work at the the Economic Analysis office and Bank Policy and Credit Risk Models department at FI and at the Economic Analysis office and General staff department at the Swedish National Debt Office.

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Summary

According to an analysis by Finansinspektionen and the Swedish National Debt Office, the value of an implicit state guarantee for the major Swedish banks has decreased substantially since the financial crisis in 2008–2009.

States have on several occasions made the assessment that some banks could be too large and systemically important for the economy to be allowed to go bankrupt. This has been evident, for example, in the most recent financial crises. Market participants have therefore assumed that lenders to systemically important banks are protected from losses through an implicit state guarantee. This kind of implicit guarantee translates into reduced risks for the banks' lenders, and thus reduces funding costs for the banks in the form of lower interest rates on funding. This interest rate discount is usually called the too-big-to-fail (TBTF) premium.

Banks that do not need to fully carry the costs of their risk-taking tend to increase their profit by taking on higher risks than what they would have done otherwise; this increases both the probability of future financial crises occurring and their severity. The TBTF premium also distorts competition on the market.

Broadly speaking, the size of the premium is determined by the market's assessment of the state's willingness to give support to systemically important banks as well as the probability that the need for support will arise. This means that, all else equal, the TBTF premium will increase when the probability of default increases. Therefore, the TBTF premium might increase even when the state's willingness to provide support has not changed.

Based on the lessons learned from the global financial crisis in 2008–09, the EU countries have introduced extensive new financial regulation. Higher capital and liquidity requirements increase the banks' loss-bearing capacity, and a new crisis management procedure (resolution) is meant to manage systemically important institutions that are failing without burdening state finances. Taken together, these measures should decrease the TBTF premium. The resolution framework should lower the market's expectation of state support for systemically important banks, while the higher capital and liquidity requirements decrease the risk of bank default and thus the need for state support.

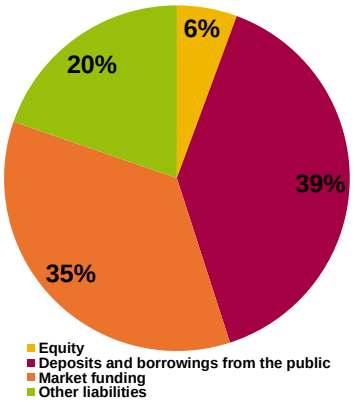
To analyse the change in the TBTF premium over time for the four largest banks in Sweden, we use a composite TBTF indicator. The results show that the composite TBTF premium for the four major banks has decreased since the financial crisis, from approximately 250 basis points in the autumn of 2009 to approximately 25 basis points in the autumn of 2018.

This decline is likely to be related to the increase in the capital and liquidity requirements since the financial crisis in 2008–2009 and improvements in the profitability in the major banks. As a whole, this has affected the default risk in the banks and thus the value of an implicit state guarantee. According to the credit rating institutions, the resolution framework has decreased the probability of state support for banks, which may have further contributed to

the decrease in the TBTF indicator. Market participants appear to agree with this assessment, but the remaining small but positive TBTF premium in the autumn of 2018 indicates that there may be some uncertainty regarding how the state will react during a systemic crisis.

Diagram 1. Banks have high percentage of debt funding

Per cent



Source: Annual reports for 2017.

Note: The major banks' equity and liabilities as of Q4 2017.

Why does the state regulate banks?

Banks play a central role in maintaining the financial system's fundamental functions and are therefore important for the functionality and growth of the economy. In contrast to other firms, banks utilise a high percentage of debt in their financing (Diagram 1). Because the banks' liabilities in general have shorter maturities than the banks' assets, banks are exposed to refinancing risks and thus are vulnerable to shocks to the credit market. A high degree of debt financing means a lower percentage of equity that can absorb potential losses and thus impaired resilience to shocks. The banks' capital levels have therefore been subject to different types of regulation for a long time.

Banks that are not viable are normally wound down. However, bankruptcy proceedings can turn out to be too costly for society if applied to systemically important banks, and therefore many market participants have not considered this to be a credible alternative. The potentially high welfare costs of winding down a systemically important bank are also the reason why governments, central banks and financial supervisory authorities have issued guarantees and taken other types of support measures for the banking sector. This was the case for Sweden, for example, both during the Swedish financial crisis in the 1990s and during the global financial crisis in 2008–09. Altogether, this has led to an expectation among market participants that some banks benefit from an implicit state guarantee that protects the banks' creditors from losses. Since the financial crisis in 2008–09, decision-makers around the globe have introduced extensive new financial regulation that aims to strengthen bank resilience and reduce the occurrence of such guarantees.

STATE SUPPORT MEASURES FOR SWEDISH BANKS

During the Swedish banking crisis in the 1990s, the Government issued a general bank guarantee to maintain the market's and the public's confidence in the banking system. The Government guaranteed that banks would meet their obligations on time. To reduce the risk of sudden bank runs, a state deposit insurance was then introduced in 1996. The deposit guarantee aimed at protecting depositors from losses if a bank would go bankrupt. Banks have contributed to the deposit insurance fund through fees. Currently, the deposit scheme provides insurance for deposits up to SEK 950,000.

During the financial crisis in 2008, Parliament adopted the so-called Support Act, which gave the Government a mandate to establish agreements for providing liquidity and capital support to viable banks and other credit institutions. The act also offered the state the possibility of taking over and recapitalising non-viable banks. Pursuant to this act, the Government adopted a general guarantee program to support the banks' medium-term funding as well as a capital contribution program. To ensure the banks' short-term funding, the Riksbank and the Swedish National Debt Office also adopted a number of liquidity support measures.

State guarantees increase confidence in the banking system in the short term, but they also transfer part of the cost of the banks' risk-taking from the banks to the state. As a result, the banks' debt financing will be priced lower than what would otherwise be the case.

Banks that do not fully carry the costs of their risk-taking can increase their profit by taking on higher leverage than what they would have done otherwise.[1] These banks also face incentives to become bigger and more complex. This increases the probability that both future financial crises will occur and they will be more severe. The market's expectation that the state will provide support to some large, systemically important banks also distorts competition since the non-systemic banks cannot expect the same type of support and thus will not have access to debt financing that is as inexpensive.

Since the most recent financial crisis, the banking sector has become subject to stricter regulation than before. The aim has been to strengthen the banks' resilience and their ability to recover as well as to reduce the need for state support in the event of a bank crisis. The new regulation has also limited the state's possibilities for using state funds to support banks.

NEW RULES AFTER THE GLOBAL FINANCIAL CRISIS

During the financial crisis in 2008–09, many governments felt they had to use state funds to save banks in crisis. One lesson learned was that there was no framework and procedures for managing defaults in systemically important banks; they were simply too big to fail. In 2009 the G20 countries agreed to propose measures to handle these problems. A decision was therefore taken at a global level to develop a joint framework for bank crisis management (the resolution framework). In the EU, this resulted in the adoption of the Bank Recovery and Resolution Directive (BRRD) in 2014, which was introduced into Swedish law in 2016 through the Resolution Act.

When a bank is entered into resolution, the state takes over control via a resolution authority. In Sweden, this authority is the Swedish National Debt Office. A key principle in resolution is that the bank's losses and costs for recapitalisation are to be carried by the banks' shareholders and lenders. In order to make this possible, the resolution framework requires banks to have sufficient volumes of capital and debt instruments that can be written down or converted to equity to cover losses – so-called bail-inable debt. The resolution framework also contains provisions on crisis prevention measures, such as recovery planning. The new legislation limits the state's possibilities for providing support to banks in crisis. State support can no longer be used to cover losses or recapitalisation needs of banks in crisis. It may only be given to institutions that are solvent and viable. All forms of support must be financed via special financing arrangements.[2]

Another lesson learned from the financial crisis was that there was too little equity in the banking system. The Basel Committee, which is the global partnership forum for banking supervision, made the assessment at an early stage that the capital requirements needed to be

1 This is an example of moral hazard – a type of a market failure. With leverage we refer to the debt versus equity relation. High leverage means less equity compared to the risk that the bank would take.

2 Support that is preventive in nature is financed via the stability reserve. The resolution reserve is used to finance measures in resolution (for example, supporting the liquidity supply in an institution that is undergoing resolution). Given the fulfilment of certain conditions, the deposit insurance fund can also be used in resolution. The banks pay regular fees to the deposit insurance fund and the resolution reserve. The fees to the stability reserve were terminated with the introduction of the resolution reserve.

tightened.[3] In 2010, the Committee agreed on the first parts of the Basel III capital adequacy standard, which primarily aims to raise the capital requirements for large international banks and sharpen the focus on liquidity risks in regulation and supervision. Since then, the new Basel III capital and liquidity requirements have been gradually rolled out, and the implementation is still ongoing. In the EU, these changes resulted in the introduction of the Capital Requirements Directive (CRD IV) and the Capital Requirements Regulation (CRR) in 2014.[4]

The total capital requirements for banks aim primarily to strengthen their resilience and thus reduce the risk that financial crises will occur. The requirements also contain buffer components that aim to maintain the supply of credit during crises. The capital requirements are supplemented by the resolution framework, which mainly aims to reduce the costs to taxpayers when crises occur.

Taken together, the new capital and liquidity rules together with the new resolution requirements should have led to a reduction in the too-big-to-fail premium.

What is the too-big-to-fail premium?

Based on experiences from previous financial crises, market participants have assumed that creditors to systemically important banks are protected from losses by a so-called implicit state guarantee. The market's expectation of an implicit state guarantee thus refers primarily to the types of state support that offer creditors credit risk insurance. This implicit guarantee reduces funding costs for the banks in the form of lower interest rates on funding. This interest rate discount is usually called the too-big-to-fail (TBTF) premium. Both the state's willingness to provide support to systemically important banks and the probability that the need for support will arise affect the TBTF premium. This means that, all else equal, the TBTF premium will increase when the probability of default increases. Therefore, the TBTF premium might increase even when the state's willingness to provide support has not changed.[5]

WHICH INSTITUTIONS CAN BE EXPECTED TO RECEIVE STATE SUPPORT?

Due to their size or close interconnectedness with other central parties in the financial system, some banks are considered to be systemically important. They carry out operations that are critical for the financial system. They are larger and more complex than other institutions and impose greater risks on financial stability. It is primarily these types of institutions that have been considered to be too big to fail in previous financial crises and benefit from an implicit guarantee. There are probably a number of Swedish banks that can be considered to benefit

3 The banks' capital levels have been subject to different types of regulation for a long time. In 1988, the Basel Committee adopted a joint communication establishing minimum requirements for the banks' capital levels (Basel I). Since then, work to adjust and adapt these capital requirements has been ongoing – Basel II was published in 2004 and started to be rolled out in the EU in 2007.

4 The Directive and the Regulation/// entered into force in 2013 but were first introduced into Swedish law in 2014.

5 This can occur for example during a systemic crisis, when both the probability of default (PD) and the size of investors' losses given default (LGD) are usually high.

Table 1. Previous analyses of the TBTF premium that included Swedish banks

Ange enhet

	Period	TBTF premium	Method	Sample
Sveriges Riksbank (2011)	2002–2010	86 bp	Credit rating-based	Major banks
OECD (2012)	2012	SEK 44 billion	Credit rating-based	Major banks
IMF (2014)	2013	30–100 bp	Credit rating-based/structural	Developed economies
FI (2015)	2014	71 bp	Credit rating-based/structural	Major banks

Source: Authors' compilation.

Note: The IMF's analysis is based on a sample of around 100 banks. This sample includes three of the major Swedish banks, the results of which are reported under the category *developed economies.*

to varying extents from an eventual TBTF premium, but this analysis is limited to the four major banks operating in Sweden.[6]

WHAT TYPES OF DEBT HAVE BEEN COVERED BY A GUARANTEE?

During previous financial crises, the reactions of governments and authorities have varied, and it is therefore difficult to draw a clear line between the part of debt covered and the part that is not. However, it is reasonable that the market participants do not expect the entire funding structure of banks to be covered by an implicit guarantee. In the analysis, we therefore assume that the market's expectation of state support does not include share capital and subordinated debt.[7] Subordinated debt is typically included in the bank's own funds and holders of subordinated debt are the first to carry losses in the bank after the shareholders during bankruptcy. We also exclude deposits and covered bonds since they have an explicit cover, both in the event of bankruptcy and in resolution.[8] As a result, it is primarily senior creditors, excluding covered bonds, which may benefit from an implicit guarantee.

PREVIOUS ANALYSIS OF THE TBTF PREMIUM IN SWEDEN

Sveriges Riksbank, the OECD, the IMF and Finansinspektionen, among others, have previously analysed the TBTF premium using samples that include the Swedish banks (Table 1). All of the analyses show that the TBTF premium has been significant, but its value varies over time and is dependent on the estimation method (see Appendix 3 for a more in-depth review of the results from previous analyses).

The analyses that report the premium over time show that the TBTF premium increased in conjunction with the global financial crisis in 2008–09. Since then, the TBTF premium has fallen, but the value was still significant at the end of the analysed period in each study.

Each analysis in Table 1 is based on different periods and samples of banks and uses different methods to estimate the implicit guarantee. It is therefore difficult to draw direct comparisons between the results. In the IMF's study, the TBTF premium for developed economies, for example, as per 2013 was approximately 100 basis points according to the structural model, but 30 basis points according to the credit rating-based model. However, over comparable periods, the TBTF premium in the analyses shows a similar pattern regardless of the estimation method.

Models to estimate the TBTF premium

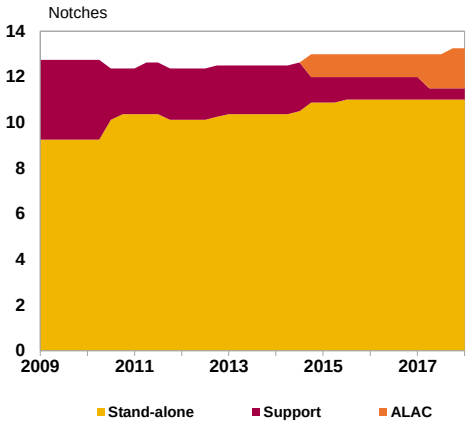
The approaches used to estimate the TBTF premium in the literature have different strengths and weaknesses and are based on different types of data. In order to reduce the dependence of the estimate on a

6 The analysis period runs up to Q3 2018, which is before Nordea moved to Finland.

7 Subordinated debt refers to debenture loans – an interest-bearing debt instrument with lower priority than bonds and other types of borrowing. Debenture loans generally serve as different forms of own funds instruments (AT1 and T2).

8 Large parts of the deposits are covered by the deposit insurance, and in the event of a default the public has a right of priority to the bank's remaining assets. Covered bonds are guaranteed by a specific, high-quality cover pool consisting of loans to states and municipalities as well as mortgages. They also have a special right of priority over other senior debt.

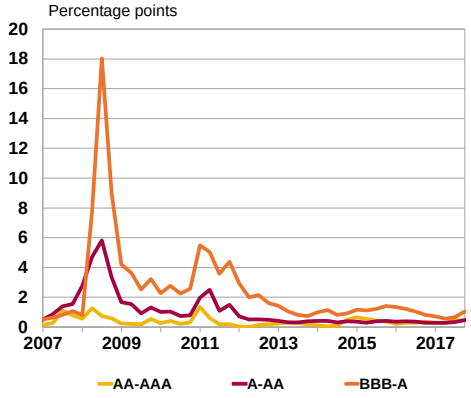
Diagram 2. Decrease in the percentage of the credit rating attributable to the support lift.



Source: Thomson Reuters, Moody's and S&P

Note: The average credit rating of the major banks on a numeric scale from 1–16 that corresponds to the rating firms' rating scales.

Diagram 3. Average difference in interest rate cost between credit ratings.



Source: Thomson Reuters Datastream

Note: Average interest rate spread between different credit ratings for European financial firms according to Iboxx EUR Financials' annual yield spread.

specific method to the greatest extent possible, we compute the TBTF premium using three models: a credit rating-based model and two market price-based models.

CREDIT RATING MODEL

The credit rating model is based on the credit rating firms' assessment of the probability of government support. It takes into account the state's possibility[9] for and willingness to provide support to the banks. The assessment includes the major banks' credit ratings, and a higher rating can then be translated to lower funding costs for the bank.

The model is based on S&P's and Moody's credit ratings of the major banks. The methods and definitions used by these credit rating institutions differ in some respects, but in general they follow the same principles. Somewhat simplified, they first rate the bank's individual financial strength, a so-called stand-alone rating, without taking the bank's access to external support into account. They then assess the probability of state support, which generates a rating uplift and results in a total credit rating – a long-term issuer rating (Diagram 2). The difference in these two ratings constitutes the rating uplift for state support.[10] Since 2015 and 2017, respectively, both Moody's and S&P also add a rating uplift for banks with additional loss-absorbing capacity (ALAC). The figures used to calculate the TBTF premium only include the part of the rating uplift that refers to state support.

To estimate how the rating uplift affects the banks' funding costs, we use the Iboxx EUR Financials Index, which shows the average funding costs per credit rating for European financial firms. The difference in funding costs between the credit ratings shows how many basis points a higher credit rating is worth. For example, in Q12019, the interest rate costs for a firm with a credit rating of AA were 580 basis points lower than the costs for a firm with a credit rating of A (Diagram 3), while only 75 basis points separated firms with a credit rating of AAA from those with a credit rating of AA (Diagram 3). A one-notch rating increase thus generates a higher interest rate discount the further down on the rating scale the bank is located. The size of the interest rate discount, and thus the value of an implicit guarantee, also increases when the interest rate spreads are large. In 2009–2010, risk premiums decreased from the exceptionally high levels of the financial crisis (Diagram 3) but rose again in conjunction with the European debt crisis in 2011–2012. The risk premiums have since then remained fairly stable at relatively low levels.

For each bank, the TBTF premium is estimated as

$$TBTF_t^{Bp} = Rating\ lift_t * Interest\ rate\ spread_{i,t}, \quad (1)$$

Bp is basis points for each time period t and $Interest\ rate\ spread_{i,t}$ is the interest rate spread from the Iboxx index for credit rating i.

THE SENIORITY-BASED MARKET-PRICE MODEL

The seniority-based market-price model compares the probability of default based on price differences between CDS contracts with senior

9 Measured by the country's credit rating.

10 Support from both the parent company and the state are included in the external support, but since the analysis is based on the banks' parent companies only the state support is relevant.

debt versus subordinated debt[11] as the underlying asset. We thus assume that a part of the price difference reflects a lower probability of default for senior debt than subordinated debt. This difference is driven by assumptions by the market that the state will protect holders of senior debt but not holders of subordinated debt.

CDS contracts can be viewed as an insurance contract that transfers the credit risk in the underlying asset from the buyer of the contract to the seller. The contract is typically priced using a reference rate, with an additional spread for the bank's specific credit risk. This interest rate spread is therefore a measure of the market's assessment of the bank's creditworthiness, and the price information from the CDS contract can be used to derive the implicit probability of default (PD). The calculation of PD also takes into account the size of the loss given default (LGD), which is higher for subordinated debt (equation A1 in Appendix 1). The difference in the risk-neutral probability of the bank failing in the different types of debt is used to derive the TBTF premium in basis points in accordance with Zhao's study from 2018.[12]

The seniority-based model calculates the TBTF premium in basis points as the difference in the probability of default according to

$$TBTF_t^{bp} = CDS_{i,t}^{Fair\ value} - CDS_{i,t}^{Observed}. \quad (2)$$

$CDS^{observed}$ uses the probability of default calculated using CDS contracts with senior debt. This is compared to a theoretical equivalent, $CDS^{fair\ value}$, which is calculated using information from CDS contracts with subordinated debt as the underlying asset (see Appendix 1 for more information about the model).

STRUCTURAL MARKET-PRICE MODEL

The structural market-price model estimates the probability that the bank will fail based on information from the equity market versus the credit market under the assumption that shareholders are not subject to any state support. The difference in the probability of default (and therefore in the CDS premium) is used to derive the value of the implicit state guarantee.

Just like in the seniority-based model, the method uses information from CDS contracts with the bank's senior debt as the underlying asset. The observed CDS spreads are then compared to the theoretical equivalent based on information from the equity market ($CDS^{fair\ value}$) . The theoretical spreads are estimated in accordance with the version of Merton's structural model presented in Schweikhard and Tsesmelidakis (2012). [13]

According to Merton's model, shareholders and creditors have a claim on the bank's assets, and, compared to the creditors, shareholders have a subordinated claim on the bank's assets. The equity of a firm can therefore be modelled as a call option on the firm's assets, where the strike price is set at a specific threshold. If the firm's assets fall below the threshold, the firm is assumed to fail. In accordance with

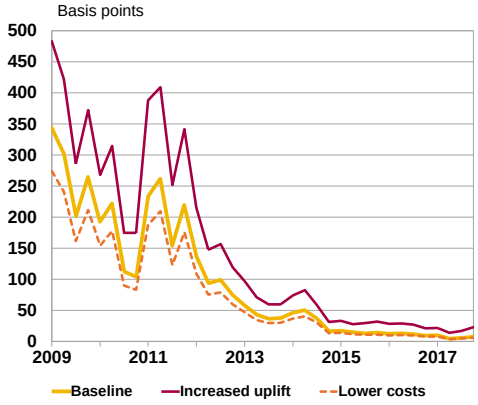
11 The data the model uses for subordinated debt refers to debenture loans, which as a rule comprise different types of own funds instruments (AT1 and T2).

12 *Market-based estimates of implicit government guarantees in European financial institutions, European Financial Management*, 24(1), pp. 79-112.

13 *The Impact of Government Interventions on CDS and Equity Markets*, University of Oxford, the Oxford-Man Institute and Saïd Business School.

Diagram 4. TBTF premium according to the credit-rating model

Basis points

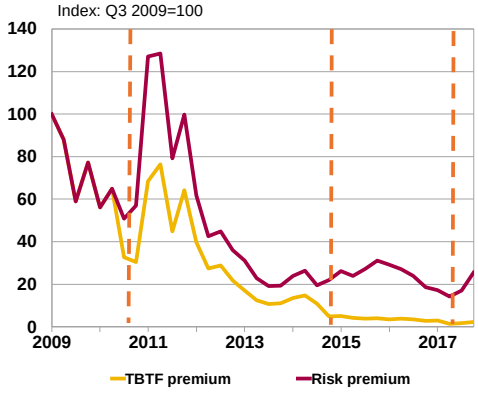


Source: Calculations by FI

Note: TBTF premium, average. The dashed orange line shows the TBTF premium under the assumption that the major Swedish banks have 20 per cent lower funding costs than the average for European financial firms. The dashed red line shows how a one-notch higher rating lift affects the TBTF premium.

Diagram 5. TBTF premium decreased more than the risk premiums on the market.

Index: Q3 2009=100



Source: Thomson Reuters Datastream and calculations by FI.

Note: The risk premium is represented by the difference in the funding costs for European financial companies with different creditworthiness according to the Iboxx EUR Financials Index (an unweighted average of the difference between companies with a credit rating of AA compared to a credit rating of A and a credit rating of A compared to a credit rating of BBB).

Schweikhard and Tsesmelidakis (2012), we assume that the threshold corresponds to the debt's total market value, adjusted for recovery of 50 per cent of the debt value.

The equity-implied probability of default will exceed the equivalent probability on the credit market to the extent market participants expect the state to prevent default by protecting senior creditors, but not shareholders.

Similarly to the seniority-based model, the TBTF premium is expressed in basis points and as in equation (2). But, instead of information from subordinated CDS contracts, information from the equity market is used to calculate $CDS^{fair\ value}$ (see Appendix 2 for more information about the model).

Estimates of the TBTF premium

TBTF PREMIUM ACCORDING TO THE CREDIT-RATING MODEL

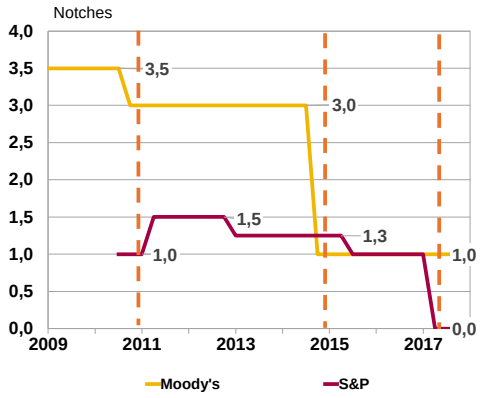
The results from the credit rating model show that the TBTF premium for systemically important banks has decreased since the financial crisis, from approximately 350 basis points to approximately 10 basis points (Diagram 4). The credit rating institutions are transparent in their assessments of the probability of state support. The results from the credit rating-based model are therefore relatively easy to interpret.

The decrease in the TBTF premium is driven in part by the decrease in the market risk premiums[14] since the financial crisis (Diagram 5). The difference in funding costs for financial firms with different creditworthiness has decreased in general – which means that the value of an implicit state guarantee is currently relatively low. If the interest rate spreads increase, the value will increase again. This type of fluctuation in the TBTF premium is not necessarily linked to changes in the state's willingness to provide support, but rather to the variation in the probability of default over time. However, the decrease in the TBTF premium is the result of the credit rating institutions lowering the banks' rating uplift since they assess the probability of state support to have decreased in recent years. The TBTF premium shifts downward as the rating uplift is lowered. Since 2015, the rating uplift's effect on the bank's total creditworthiness is so small that the TBTF premium is less sensitive to changes in the risk premiums on the market.

According to Moody's credit rating, Swedish banks had a relatively high rating uplift of three to four notches right after the financial crisis. This was because the Swedish government took measures to support the banking sector, like the guarantee program for Swedish banks. In 2011, Moody's gradually began to lower the high rating uplift from the previous few years (Diagram 6). This reduction was justified by the commencement of the phase-out of state support measures in Sweden at the same time as the major banks' financial

14 The market's risk premiums are represented by the difference in the funding costs for European financial companies with different creditworthiness according to the Iboxx EUR Financials Index (an unweighted average of the difference between companies with a credit rating of AA compared to a credit rating of A and a credit rating of A compared to a credit rating of BBB).

Diagram 6. Rating lift has decreased since the crisis.



Source: Thomson Reuters, Moody's and S&P

Note: Average rating lift for state support for the four major banks according to Moody's and S&P.

strength improved and regulators around the world began to consider the introduction of a resolution framework.[15]

In June 2015, Moody's lowered the rating lift for state support by an additional two notches for the four major banks. The rating firm made the assessment that the rules for orderly resolution had decreased the probability of state support for senior debt. A one-notch rating uplift remained since the major banks were considered to be so systemically important that there was still a moderate probability of state support.[16] However, the effect of the final credit rating is small. Moody's added two notches of rating uplift since the credit rating agency expects the banks' loss-bearing capacity to strengthen due to the new minimum requirements on bail-inable debt.

In June 2017, S&P made the assessment that the Swedish government would offer the major banks extraordinary support if needed.[17] The low rating uplift of only one notch was motivated by the assessment that the major banks' stand-alone ratings were strong. If the banks' financial strength were to decrease, S&P stated that it would probably increase the rating uplift to two notches. In November 2017, S&P revised its assessment of the probability of state support downward to "uncertain".[18] It replaced the rating uplift for state support with a corresponding rating uplift for loss-bearing capacity.[19] The rating uplift for state support was thus lowered from one notch to zero.

The credit rating institutions' estimate of the probability of state support – the rating uplift – is a key component in the model. A one-notch higher rating uplift results in a significant increase in the TBTF premium (Diagram 4), primarily during periods when risk premiums are high. Because the major banks' stand-alone ratings are currently high[20], the need for a rating uplift is relatively small. If the market conditions are impaired and the banks' financial strength weakens, or if the credit rating firm assesses there to be an increase in the state's willingness to provide support, the rating uplift could rise again.

The model's results are also affected by how we value the rating uplift. Compared to other European banks, the major banks have access to relatively inexpensive funding. The Iboxx index for European financial firms' average funding costs per credit rating could therefore overestimate the value of the TBTF premium. In the sensitivity analysis, we therefore assume funding costs for the major Swedish banks that are 20 per cent lower than the Iboxx index.

15 See, for example, Moody's (2011).

16 Moody's 2015. Rating Action: Moody's concludes a review of six Nordic banking groups and their subsidiaries.

17 S&P Global Ratings (2017). Ratings Direct: Skandinaviska Enskilda Banken AB (publ).

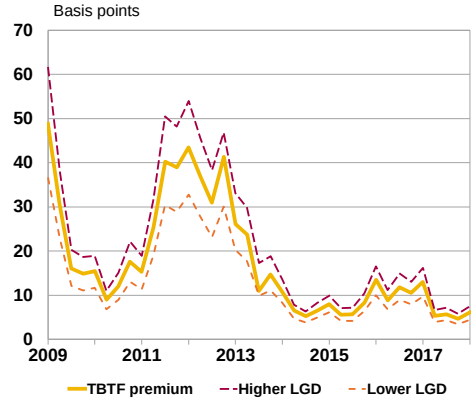
18 S&P Global Ratings (2017). Ratings Direct: Swedish Bank Ratings Affirmed Amid Housing Market Transformation; Five Outlooks Revised To Stable.

19 In February 2017 the Swedish National Debt Office decided that the minimum requirements on bail-inable debt instruments may only be met with capital and subordinated debt instruments. Because of this, the banks will need to issue a new type of debt instrument with relatively low seniority. These reserves of loss-bearing debt create a buffer for other lenders, including holders of senior debt. Should the need for loss-absorbing capital and the recapitalisation exceed the MREL requirements, the bail-inable debt will also as a rule be applied to senior lenders.

20 As at Q3 2018, the major banks each had a stand-alone rating of between A and A+ according to S&P and A3 and A2 according to Moody's.

Diagram 7. Seniority-based model

Basis points

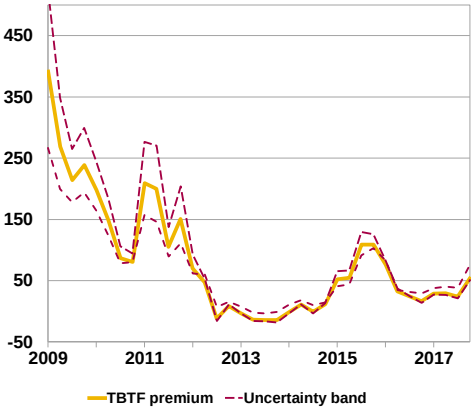


Source: Calculations by FI.

Note: TBTF premium, average. The uncertainty band shows how sensitive calculations are to assumptions about LGD.

Diagram 8. Structural market-price model.

Basis points

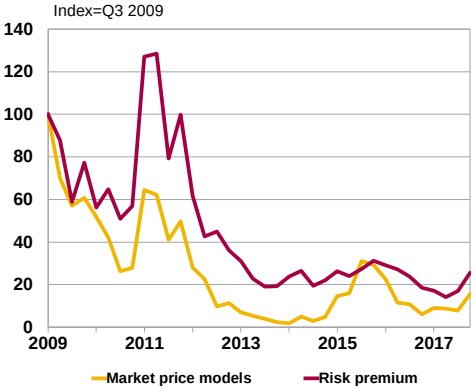


Source: Calculations by the Swedish National Debt Office.

Note: The uncertainty band shows how the premium would look given the assumption of a significantly lower or higher degree of repayment, respectively.

Diagram 9. TBTF premium according to the market-price models

Index=Q3 2009



Source: Calculations by FI and the SNDO.

Note: The TBTF premium is an unweighted average of the results from the seniority-based market-price model and the structural market-price model.

However, the analysis shows that the effect of potentially lower funding costs is limited (Diagram 4).

TBTF PREMIUM ACCORDING TO THE MARKET-PRICE MODELS

The TBTF premium from the market-price models follows well the upswings and downswings in the economy and financial markets over time (Diagrams 7 and 8). It falls after the financial crisis in 2007–2009, increases during the European debt crisis in 2011–2012 and stabilises then at relatively low levels. However, starting in 2015, the model results do not show the same trend break as in the credit rating institutions' assessment (Diagram 9). The TBTF premium rises in 2015–2016, reflecting greater market volatility during that period. The increased volatility is related to the confidence crisis in primarily German and Italian banks, during the second half of 2016.

The models are based on market information, and there are probably many factors that contribute to the development of the TBTF premium over time. The Swedish National Debt Office analysed which factors contributed to the reduction in the resolution costs[21] arising as a result of a default (see Blix Grimaldi and Linder, 2018). It is reasonable to assume that the same factors lie also behind the changes in the TBTF premium. The report from the Swedish National Debt Office, like the credit rating institutions, refers to regulatory reforms and favourable economic development as key factors driving the bank resolution costs. The minimum requirement on bail-inable debt is also found to have contributed to the decline in resolution costs.

The market price-based models are based on the assumption that the market's expectation of an implicit state guarantee only include senior creditors. During the financial crisis, European governments reacted differently.[22] Subordinated debt was saved in some cases, but in others it was allowed to default. Due to the uncertainty about how the state will react in a crisis, it is reasonable that market participants include an expectation of implicit state guarantees even for subordinated debt. This could explain why the estimated TBTF premium according to the seniority-based, market-price model is lower than in the other models.

Even shares can be covered to some extent by an expectation of state support – but to less of an extent than senior and possibly subordinated debt. During the financial crisis, share capital was wiped out in several banks when the bank failed, for example as a result of a reconstruction or by the state taking over the bank without compensation for the shareholders. In other cases, the equity capital was diluted in conjunction with the government's recapitalization of the bank. Most recently, equity holders bore significant losses, but they were allowed to keep their equities, thus potentially allowing them to benefit from future earnings. Bank recapitalization by the government can be viewed as a subsidy for equity holders compared to the case where the equity capital bore the losses. Empirical studies have shown that even equity holders benefit from an ex-ante implicit

21 I.e. the losses to bank creditors.

22 See, for example, Schich and Kim (2012), Appendix 3, and Laeven and Valencia (2010), Table A.3.

government guarantee.[23] However, these studies do not include Swedish banks, and their results do not necessarily apply to Sweden.

The resolution framework should reduce the market's uncertainty regarding how the state will react in a crisis. If the market's expectation of some state support for subordinated debt and shares goes down or is eliminated, the loss given default (LGD) for these instruments should increase. How this affects the estimated TBTF premium depends on the effect of the resolution framework on LGD for senior CDS contracts. To fulfil the MREL requirements, the banks will need to issue a new type of debt instrument with relatively low seniority. These loss-bearing liabilities create a buffer for other creditors, including holders of senior debt. Should the need for loss-absorbing capital and the recapitalisation exceed the MREL requirements, the bail-inable debt will also, as a rule, be applied to senior creditors. If LGD increases more for shares and subordinated debt than for senior debt, affected parameters in the models may need to be recalibrated as the banks issue new MREL instruments.[24]

COMPOSITE TBTF INDICATOR

The three models are based on different types of data and take into account different perspectives. The seniority-based market-price model uses only data from the credit market, while the structural market-price model also uses data from the equity market. In contrast, the credit rating-based model is based on the credit rating institutions' assessments of the banks' creditworthiness, which in turn is based on both market data and qualitative analysis.

The market-price models respond timely to changes in the volatility of the equity market. Market participants tend to react more quickly and strongly to current and expected risk. The market-price models therefore tend to capture well market fluctuations. The assessments of the credit rating institutions, on the other hand, are more sluggish since they are not updated as frequently. As a result, the market-based premium tends to increase more during crisis periods when uncertainty on the market is high (Diagram 10).

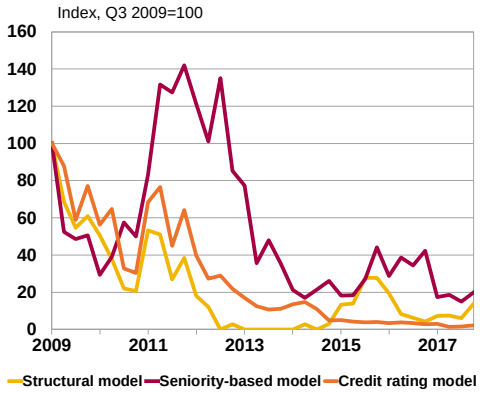
Despite such differences, all of the models show a similar pattern over time, but levels vary. The estimated TBTF premium according to the seniority-based market-price model is significantly lower than in the other models (Diagram 11). This is probably because market participants have a certain expectation of implicit state guarantees for subordinated debt as well. It is worth noting that the difference between the models has decreased as the TBTF premium has fallen.

The results from the three different model are summarized in a composite measure by simply taking an equally weighted average of the model results (Figure 10). This indicator thus takes into account information from the credit market, the equity market and the credit rating institutions. It provides a general overview of the analysis, and

23 Tsesmelidakis and Merton (2012), for example, show that shareholders to some extent are covered by the expectation of state support. However, they also show that the value of such an implicit guarantee for the share capital is limited according to the market's prices and that it only occurs in conjunction with the issuances. Creditors, on the other hand, benefit from the bank's expected TBTF status both during and after the issue occasion.

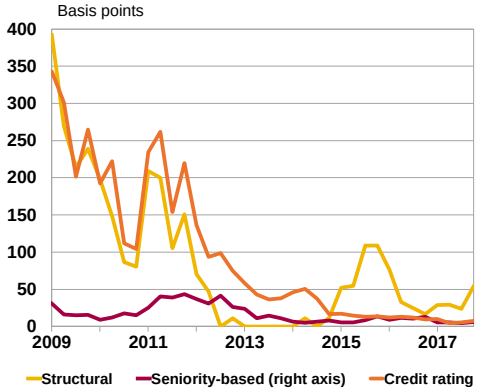
24 In particular, the seniority-based model is based large on historical data for LGD from the period before the BRRD was introduced and may therefore need to be recalibrated with updated data in the future.

Diagram 10. Similar patterns in the models.



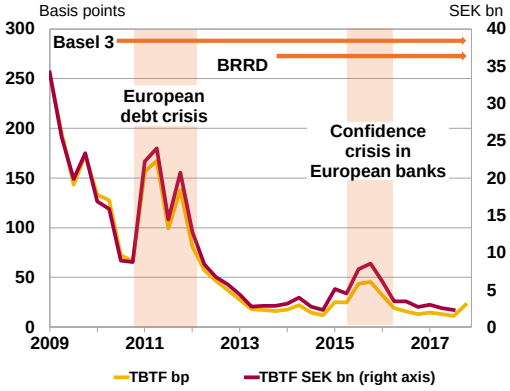
Source: Calculations by FI and the National Swedish Debt Office.
Note: Ange anmärkning

Diagram 11. Different models generate different levels.



Source: Calculations by FI and the National Swedish Debt Office.
Note: Ange anmärkning

Diagram 12. The value of the TBTF indicator is small but positive.



Source: Calculations by FI and the Swedish National Debt Office.
Note: The TBTF indicator after compiling the results from the different models.

should be less affected by any of the challenges of each specific model.

The total value of the TBTF premium in SEK billion for each bank at each point in time is given by the TBTF premium indicator multiplied by the banks' outstanding senior debt and can therefore be expressed as follows:

$$TBTF_t^{Mdkr} = \sum TBTF_{i,t}^{bp} * D_{i,t}. \quad (3)$$

$D_{i,t}$ is the outstanding stock of senior debt for bank i at period t.

In the years prior to the 2008–2009 financial crisis, the market's risk premiums were close to zero (Diagram 3), and the TBTF indicator was low. During the financial crisis, uncertainty and mistrust on the markets were high, and the market's risk premiums sky-rocketed. The expected probability of state support increased, and the TBTF premium was high. Since then, the TBTF indicator has decreased, from approximately 250 basis points in the autumn of 2009 to around 25 basis points in the autumn of 2018. This corresponds to a decrease from approximately SEK 35 billion to SEK 3 billion.

This decrease is probably due in part to higher capital and liquidity buffers for the banks following the phase-in of Basel III. As profitability improved, the major banks have increased their capital levels.[25] The resolution framework also helped strengthen the banks' loss-bearing capacity while simultaneously reducing the state's possibilities for providing state support to banks in crisis.

The TBTF indicator tends to increase during crises. The value rose both during the European debt crisis in 2011–2012 and the confidence crisis among European banks in 2016 driven mainly by the results of the market-based models. The results of the credit rating model are less affected by the increase in the risk premium during the confidence crisis.

Notably, the TBTF indicator decreased more than the market risk premium in the years following the 2008–2009 financial crisis. This suggests that market participants and rating agencies may perceive the resolution framework to have reduced the probability of state support to the banking sector.[26]

The remaining value of the TBTF premium indicates that market participants may consider there remain some uncertainty regarding how the state will react following a systemic crisis. This interpretation is supported by Moody's decision to keep one notch in the rating uplift since it considers the major banks to be so systemically important that there is some positive probability of state support. The value of the TBTF indicator in the autumn of 2018 was therefore small but positive. However, the risk premiums on the market are currently low and the value of an implicit guarantee is bound to increase when uncertainty on the market rises.

25 The total own funds for all the major banks in aggregate has increased by around 45 per cent, and the capital ratio (own funds divided by risk-weighted assets) by around 70 per cent.

26 For example, S&P has chosen to completely remove the rating uplift for state support from the major banks' credit ratings.

Conclusions

Financial crises have shown repeatedly that some banks with financial problems have been judged to be too big and important for the economy for states to let them fail. Market participants have therefore often assumed that creditors to these banks are protected from losses by a so-called implicit state guarantee. This implicit guarantee reduced funding costs for the banks. Such funding cost discount is also known as the too-big-to-fail premium.

Based on the lessons learned from the global financial crisis in 2008–2009, the EU countries have introduced new and extensive financial regulation. The resolution framework should lower the market's expectation of state support for systemically important banks, while the higher capital and liquidity requirements decrease the risk of default and thus the need for state support. Taken together, these measures should have reduced the TBTF premium.

We use a credit rating-based model and two market price-based models to estimate the TBTF premium for the four major banks operating in Sweden. The results from the three models are used to create a composite TBTF indicator that is less affected by specific model assumptions and possible model biases. The composite TBTF indicator is used to analyse how the premium has changed since the financial crisis.

The size of the premium is determined in part by the market's assessment of the state's willingness to provide support to systemically important banks and in part by the probability that the need for support will arise. The latter entails that, all else equal, the premium increases when the probability of default increases even when the state's willingness to provide support does not change.

The results show that the TBTF indicator for the four major banks has decreased since the financial crisis, from approximately 250 basis points in the autumn of 2009 to approximately 25 basis points in the autumn of 2018. This decline is due to a number of factors. Since the financial crisis in 2008–2009, the risk premiums on the market have fallen. The capital and liquidity requirements have been raised, and profitability in the major banks has improved. As a whole, this has reduced the default risk in the banks and thus the expected value of an implicit state guarantee. According to the credit rating institutions, the resolution framework, which has also decreased the probability of state support for banks has contributed to the overall decrease in the TBTF indicator. Market participants appear to agree with this assessment, but the remaining positive TBTF premium indicates that they also consider there remain some uncertainty regarding how the state will react during a crisis. In the autumn of 2018, the TBTF indicator was thus at a relatively low but positive level.

References

Acharya,V. Anginer,D. and Warburton, J. (2016), *The End of Market Discipline? Investor Expectations of Implicit Government Guarantee*, MPRA paper.

Balasubramnian, B. and Cyree, K. (2018), *Has market discipline on banks improved after the Dodd-Frank Act?*, Journal of Banking and Finance 41, 155-166.

Bijlsma, M.J., Lukkezen, J. and Marinova, K. (2014), *Measuring Too-Big-To-Fail Funding Advantages from Small Banks' CDS Spreads*, TILEC Discussion Paper No. 2014-012.

Blix Grimaldi, M. and Linder, J. (2018), *Measuring Swedish Bank Resolution Cost*, Riksgälden Focus Report.

Blix Grimaldi, M. Hofmeister, J. Schich, S. and Snethlage, D. (2016), *Estimating the size and incidence of bank resolution costs for selected banks in OECD countries*, OECD Journal: Financial Market Trends, vol. 2016/1.

Cappiello, L. Engle, RF. and Sheppard, K. (2006), *Asymmetric Dynamics in the Correlations of Global Equity and Bond Returns*, Journal of Financial Econometrics, Oxford University Press, vol. 4(4), 37-572.

Chan, L. and Zhang, K. (2009), *Efficient factor GARCH models and factor-DCC models,* Quantitative Finance, 9(1), pp. 71-91.

Duffie, D. (1999), *Credit swap valuation*, Financial Analysts Journal 55, 73–87.

Haldane, A. (2010), *The $100 billion question*, BIS Review 40.

Engle, R. (2007), *High dimension dynamic correlations*, Working Paper.

Finansinspektionen, (2015), *The Too-Big-To-Fail Guarantee for Swedish Systematically Important Banks*, FI Analysis 1, Finansinspektionen.

Finansinspektionen (2017), *Stability in the Financial System 2017:2*, Stability Report, Finansinspektionen.

Finger, C., Finkelstein, V., Lardy, J., Pan, G., Ta, T., Tierney, J. (2002), *CreditGrades Technical Document*, Risk Metrics Group.

Gray, D., and Jobst, A. (2011), *Modelling systemic financial sector and sovereign risk*, Sveriges Riksbank Economic Review.

Kelly, B., Lustig, H., van Nieuwerburgh, S. (2012), *Too-Systemic-To-Fail: What Option Markets Imply About Sector-wide Government Guarantees*, Centre for Economic Policy Research Working Paper.

Kumar, A. and Lester, J. (2014), *Do deposit rates show evidence of too big to fail effects? An updated look at the empirical evidence through 2012 among US banks*, Oliver Wyman.

Laeven, L., and Valencia, F. (2010), *Resolution of Banking Crises: the Good, the Bad, and the Ugly*, IMF Working Paper No. 146.

Merton, R. (1974), *On the pricing of corporate debt: The risk structure of interest rates*, Journal of Finance 29, 449-470.

Moody's Investor Service, (2011), *Rating Action: Moody's upgrades Swedbank AB's BFSR to C- from D+; A2/P-1 ratings affirmed (Sweden)*, Rating action report.

Moody's, (2015), *Rating Action: Moody's concludes review on 6 Nordic banking groups and their subsidiaries*, Rating action report.

Noss, J. and Sowerbutts R. (2012), *The implicit subsidy of banks*, Bank of England working paper.

Palhau Mora, P. (2018), *The "Too Big to Fail" Subsidy in Canada: Some Estimates*, Bank of Canada Staff Working Paper.

Philippon, T. and Salord, A. (2017), *Bail-ins and Bank Resolution in Europe: A Progress Report*, Geneva Special Report on the World Economy 4, ICMB and CEPR Press.

Santos, J. (2014), *Evidence from the Bond Market on Banks' 'Too-BigTo-Fail' Subsidy*, Federal Reserve Bank of New York, Economic Policy Review 20, 29-39.

Schich, S. and Lindh, S. (2012), *Implicit guarantees for bank debt: where do we stand?*, OECD Journal: Financial Market Trends, vol. 2012/1.

Schich, S. and Kim, B.H. (2012), *Developments in the Value of Implicit Guarantees for Bank Debt: The Role of Resolution Regimes and Practices*, OECD Journal: Financial Market Trends, vol. 2012/2.

Sveriges Riksbank, (2011), *Appropriate capital ratio in major Swedish banks – an economic analysis*, Appendix B, Sveriges Riksbank.

Sveriges Riksbank (2018), *Financial Stability 2018:2*, Financial Stability Report, Sveriges Riksbank.

Schweikhard, F. A. and Tsesmelidakis, Z. (2012), *The Impact of Government Interventions on CDS and Equity Markets*, University of Oxford, the Oxford-Man Institute and Saïd Business School.

S&P Global Ratings (2017), *Ratings Direct: Skandinaviska Enskilda Banken AB (publ)*, rating report.

S&P Global Ratings (2017), *Ratings Direct: Swedish Bank Ratings Affirmed Amid Housing Market Transformation; Five Outlooks Revised To Stable, rating report*.

Tarashev, N., Zhu, H. (2008), *The pricing of portfolio credit risk: Evidence from the credit derivatives market*, Journal of Fixed Income 18, 5–24.

Tsesmelidakis, Z. and Merton, R. C. (2013), *The Value of Implicit Guarantees*, MIT.

Ueda, K., and Weder di Mauro B. (2012), *Quantifying Structural Subsidy Values for Systemically Important Financial Institutions*, IMF Working Paper No. 12/128.

Zhao, L. (2018), *Market-based estimates of implicit government guarantees in European financial institutions*, European Financial Management, 24(1), pp. 79-112.

Appendix 1: The seniority-based market-price model

To calculate the value of an implicit guarantee, we estimate the risk-neutral probability of default (PD) from observed five-year CDS spreads (s_t) according to Duffie (1999) and Tarashev and Zhu (2008):

(B1) $$PD_{i,t}^{j} = \frac{a_t s_{i,t}^{j}}{a_t LGD_j + b_t s_{i,t}^{j}},$$

where $$a_t = \int_t^T e^{-r_t \tau} d\tau \text{ and } b_t = \int_t^T \tau e^{-r_t \tau} d\tau.$$

PD is calculated per type of debt (j = senior/subordinated) and institution (i = bank 1/bank 2/…). We use six-month Euroswap interest rates as the risk-free interest rate r_t, which we assume to be constant during the maturity of the five-year CDS contract. LGD is the bank's loss given default, a constant that based on historical data is estimated to be 30–70 per cent[27] of the bank's total liabilities depending on the type of bank and debt[28].

We estimate expected losses with and without the expectation of state support, pursuant to Zhao (2018):

(B2) $$L_{i,t+1}^{Subsidised,k} = LGD_{SEN} * 1_{default,PD_{i,t}^{SEN}}^{k},$$

(B3) $$L_{i,t+1}^{Fair-value,k} = LGD_{SEN} * 1_{default,PD_{i,t}^{SUB}}^{k},$$

where $1_{default}^{k}$ is an indicator function between 0 and 1, which is 1 if bank *i* fails given a specific scenario *k* at *t* + 1. The banks fail when their assets fall below the default threshold. By assuming that PD follows a normal distribution, we can estimate the default threshold for each type of debt *j*, bank *i* and time *t* according to the formula $N^{-1}(PD_{i,t}^{j})$, where $N^{-1}()$ is the inverse function of the cumulative standard normal distribution. We approximate the asset value using returns on equity, and for each scenario *k* we consider that a default in one bank leads to several banks failing due to correlation between the banks' assets[29]. We therefore simulate default of all banks using Monte Carlo simulations[30].

An assumption in the model is that state support is only expected given the occurrence of a financial crisis; otherwise, we assume that the state lets the market take care of failing institutions. However, the

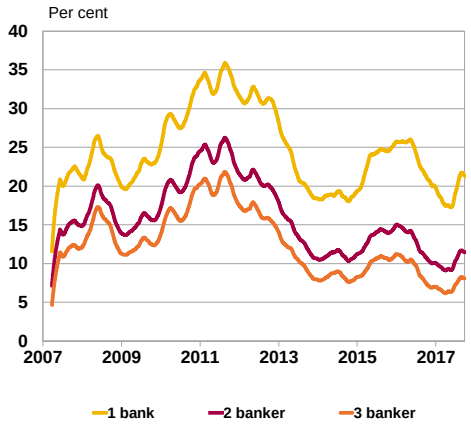
27 The values are based on Moody's average recovery rates during the period 1982-2012 and in the OECD article by Grimaldi et al. (2016).

28 We use LGD=40% for senior debt and LGD=60% for subordinated debt in our analysis, but we test the effects of other LGD levels on the TBTF premium in the sensitivity analysis.

29 Interconnectivity is based on a so-called DCC factor model that takes into account time-varying correlations + asymmetric GARCH effects of returns on equity. See Engle (2007), Zhao (2015), Huang et al. (2009), Cappiello et al. (2006), Tarashev and Zhu (2008), and Zhang and Chan (2009), among others, for details on the DCC factor model and the asymmetric GARCH model.

30 We use 10,000 simulations/scenarios of returns on equity.

Diagram B1. Estimated probability of a financial crisis.



Source: Thomson Reuters and calculations by FI.
Note: A financial crisis that requires state support is defined as the number of systemically important banks in the EU that need to fail at the same time.

Swedish banking system is so interconnected that a default in one of the four major banks would probably lead to problems in the other three banks, making state support relevant according to the model's assumptions. It is also possible that the state will choose to support systemically important banks in the event of a serious financial crisis within the EU. We model this by describing an EU-driven financial crisis where at least two systemically important banks within the EU fail at the same time[31].

The TBTF premium for each bank is calculated then in accordance with Zhao (2018) as the expected value of the difference in expected losses depending on the type of debt multiplied by an indicator function $1^{k}_{distress}$ that is 1 if a financial crisis occurs:

(B4) $$TBTF^{bp}_{i,t} = E\left[\left(L^{Fair\ value,k}_{i,t+1} - L^{Subsidised,k}_{i,t+1}\right) * 1^{k}_{distress}\right].$$

The aggregate TBTF premium according to the seniority-based model is calculated ultimately as the average of individual TBTF premia:

(B5) $$TBTF^{bp}_{AGG,t} = \frac{1}{N}\sum_{1}^{N} TBTF^{bp}_{i,t},$$

where N = 4 (SEB, Nordea, Swedbank, Handelsbanken) in our analysis.

SENSITIVITY ANALYSIS

We investigate how the TBTF premium in the seniority-based model is affected by the two main parameters in the model: LGD and the indicator function for financial crises. We focus in particular on the impact of the calibration of LGD since this affects the TBTF premium both through PD (equation B1) and expected losses with and without state support (equations B2 and B3). We test different combinations of LGD for senior and subordinated debt (from 20 to 50 per cent for senior LGD and a difference between LGD for subordinated debt and senior debt between 0 and 40 per cent[32]). We find no significant impact of the difference between LGDs on the TBTF premium, which is in line with the results from Zhao (2018). This is because subordinated LGD only has a marginal impact on subordinated PD. Different values of senior LGD have an impact on the levels of the TBTF premium, but the pattern of the premium does not change.

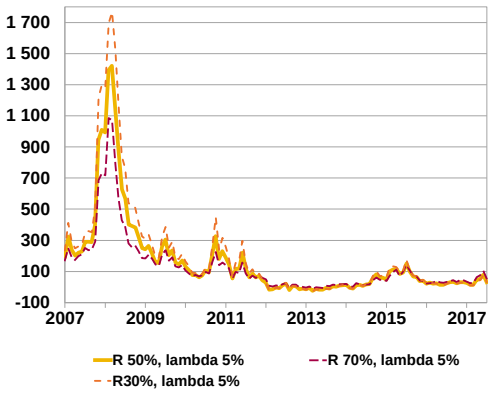
When it comes to our definition of financial uncertainty driven by the development of European banks in equation B4, we tested the impact of an increase in the number of systemically important EU banks that fail at the same time that would trigger a financial crisis where state support becomes necessary. Diagram B1 shows the three-month moving average of the (simulated) probability of a financial crisis. The results show that there is no significant effect if we increase the number from two EU banks to three, and there is an increase if we limit the number to one. However, we assume that state support in Sweden will not be necessary/justified with the default of only one systemically important European bank.

31 We include nine EU banks to calculate our EU-driven financial crisis: BNP Paribas, Banca Monte dei Paschi di Siena, Banco Santander, Commerzbank, Credit Agricole, Deutsche Bank, Intesa San Paolo, Societe Generale, and Unicredit

32 The values are based on Moody's average recovery rates during the period 1982-2012 and in the OECD article by Grimaldi et al. (2016).

Diagram B2. Impact of the degree of repayment on the results of the model.

Basis points

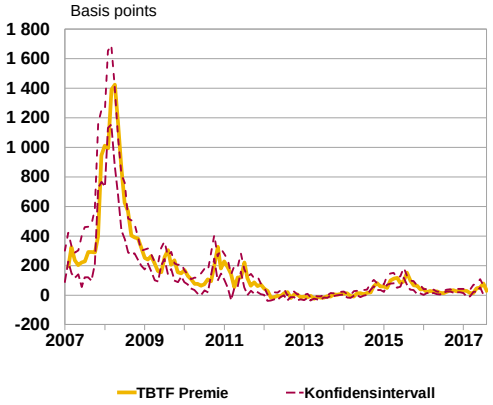


Source: Swedish National Debt Office

Note: The average of the TBTF premium for different assumptions regarding degree of repayment.

Diagram B.3 TBTF premium with confidence interval.

Basis points



Source: Swedish National Debt Office

Note: The average of the TBTF premium with confidence interval, a standard deviation.

Appendix 2: Structural market-price model

The structural model in this analysis is based on Finger et al. (2002) and its further development applied to financial firms by Schweikhard and Tsesmelidakis's (2012) [33]. Merton's (1974)[34] is the first structural model and it remains the common framework for structural modelling.

MODEL DESCRIPTION

Similarly to the Merton's original model, the Schweikhard and Tsesmelidakis's (2012) assume that the value of the asset pool is follows a diffusion process:

(B6) $$\frac{dV_t}{V_t} = \mu_V dt + \sigma_v dW_t,$$

where W_t is a Brownian motion, σ_v the asset volatility and μ_V the asset drift.

Consistent with Schweikhard and Tsesmelidakis (2012), we model the default threshold as a $\bar{L}D$, where D is the amount of total debt per share and $\bar{L}$ is the average of the degree of repayment for the entire debt in the event of default. L follows a log normal distribution with average $\bar{L}$ and standard deviation λ . Thus, under this specification default can occur at any time and is triggered by the asset value falling below the value of the threshold.

Finger et al. (2002) assumes a stationary financial leverage implying equal debt, equity and asset drifts. Since it is the relationship between the drift of the asset and the drift of the default barrier that affects the probability of default, the drift term , for simplicity, is set to zero in equation (B6).

The implicit asset value volatility is a function of the share price and the default barrier $\bar{L}D$[35] :

(B7) $$\sigma_v = \sigma_S \frac{S}{S+\bar{L}D},$$

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

The probability that default will not occur before time t is given by:[36]

(A8) $$P(t) = \Phi\left(-\frac{A_t}{2} + \frac{\log(d)}{A_t}\right) - d \cdot \Phi\left(-\frac{A_t}{2} - \frac{\log(d)}{A_t}\right),$$

where

$$d = \frac{V_0 e^{\lambda^2}}{\bar{L}D} = \frac{S_0 + \bar{L}D}{\bar{L}D} e^{\lambda^2}$$
$$A_t^2 = \sigma_V t + \lambda^2.$$

Given this input, we are able to calculate, for a given instrument-

33 Finger, Christopher C., Finkelstein, Vladimir, Lardy, Jean-Pierre, Pan, George, Ta, Thomas, and John Tierney, 2002, CreditGrades technical document, Risk Metrics Group.

34 Merton, Robert C., 1974, On the pricing of corporate debt: The risk structure of interest rates, Journal of Finance 29, 449-470.

35 See Finger et al., 2002, for the background to this correlation.

36 Finger et al., 2002 refers to Lardy, Finkelstein, Khuong-Huu and Yang (2000)

specific degree of repayment R, a market-based (*fair value*) CDS premium. The levels for L, R and λ are calibrated so the fair value spread approximately matches the CDS contracts quoted on the market during periods of low systemic risk (under the assumption that the value of implicit guarantees are expected to be very low).

Based on Schweikhard and Tsesmelidakis's (2012):

(B9) $$c^{fair-value} = r(1 - R)\frac{1-P(0)+e^{r\xi}(G(t+\xi)-G(\xi))}{P(0)-P(T)e^{-rt}-e^{-r\xi}(G(t+\xi)-G(\xi))},$$

(B10) $$G(u) = d^{z+\frac{1}{2}}\,\Phi\left(-\frac{\log(d)}{\sigma\sqrt{u}} - z\sigma\sqrt{u}\right) + d^{-z+\frac{1}{2}}\,\Phi\left(-\frac{\log(d)}{\sigma\sqrt{u}} + z\sigma\sqrt{u}\right),$$

with $z = \sqrt{\frac{1}{4} + 2r/\sigma^2}$.

c is an approximate expression for the CDS spread whose premium corresponds to the expected loss. The difference between $c^{fair-value}$ and the observed market quote can therefore be interpreted as the TBTF premium:

(B11) $$c^{fair-value} - c^{market} = TBTF\ premium$$ [37]

In the calculations, we use

- Standard deviation for degree of repayment $\lambda = 0.05$
- Degree of repayment for the entire debt $L = 0.5$
- Degree of repayment senior debt, $R = 0.5$
- Risk-free interest rate $r = 5 - year\ treasury\ bond\ rate$

SENSITIVITY ANALYSIS

To investigate how sensitive the estimation of the TBTF premium is to different assumptions about the degree of repayment for the entire debt, L. Following Finger et al.(2002), R is assumed to be the same as L.[38] We compare the assumption of 50 per cent degree of repayment (L) with significantly lower and higher L (Diagram B2). The analysis shows that the results are relatively robust.

We also use an alternative method to estimate the size of the model estimation's uncertainty and the robustness of the estimated TBTF premium. (Diagram B3). The years 2013–2014 were characterised by low volatility in the CDS spreads quoted on the market. Under the assumption that this coincided with low systemic risk and that the TBTF premium therefore can be expected to have been low and relatively constant, we define the model's uncertainty as the variation in the model values during this specific period. Because the estimate only applies to the specific period, we also make the assumption that the more sensitive the model is to changes in the input parameters the

37 The liquidity premium on the CDS market can affect the development of the TBTF premium if the liquidity premium is not constant during the period in question, which it is assumed to be. These induced fluctuations in the TBTF premium are still relatively small. The TBTF premium can also be affected slightly by the choice of approximation of the probability of default and inconsistencies in interest rate conventions.

38 Note that L includes both more senior and less senior debt compared to R.

larger the error in the TBTF premium in absolute terms, both of which are assumed to be reflected in the variation in the estimated TBTF premium. The corresponding confidence interval around the point estimate is then only dependent on the volatility in the TBTF premium:

(B12) $$\widehat{TBTF} \pm \sigma_{aktuell\ period}.$$

The volatility estimate for the period in question is the volatility for the closest observations.

Appendix 3: Results from previous analyses

Implicit state guarantees for systemically important banks are nothing new in the literature. The global financial crisis in 2008–2009 renewed interest in state support for banks and what this means for financial stability and the real economy. Several publications relate implicit state guarantees to banks' funding costs (for example Noss and Sowerbutts (2012)). The main idea is that banks the market participants consider to be too big to fail benefit from lower funding costs, which also determines the size of the implicit subsidy. Ueda and di Mauro (2012) and Haldane (2010), for example, use the banks' credit ratings to calculate the value of an implicit state guarantee. Another group of studies, including Oxera (2011) and Jobst and Gray (2013), instead use structural models to calculate the value of the implicit state guarantee. Finally, there are also a number of publications that, like this analysis, use several different methods to estimate the implicit state guarantee (for example Blix Grimaldi et al. (2016) and BoE (2012, 2015), FI (2015)). In contrast to the analysis of this study, however, the other authors do not compile the results into an aggregate indicator. Table A3 provides a summary of some of the publications on the implicit state guarantee.

Table A3.

Author and title	**Method**	**Sample**	**Estimated TBTF premiums**
Palhau Mora (2018). *The "Too Big to Fail" Subsidy in Canada: Some Estimates.* Bank of Canada Staff Working Paper	Credit rating-based model Structural model	Six largest banks in Canada, 1995-2017	CAD 1.5 and 1.7 billion (credit rating); 3 billion on average for each bank (structural)
Kumar and Lester (2014). *Do deposit rates show evidence of too big to fail effects? An updated look at the empirical evidence through 2012 among US banks*. Oliver Wyman.	Cost benefit method, based on deposit rates on money market accounts.	US banks	30 bp (2005-2010), 4 bp (2010-2012).
Bijlsma et al. (2014). *Measuring Too-big-to-fail funding advantages from small banks' CDS spreads*. CPB Netherlands Bureau of Policy Analysis.	Funding advantage based on CDS spreads	European banks; 2008-2011.	67 bp for large banks and 121 bp for Global Systemically Important Financial Institutions (GSIFIs).

Tsesmelidakis and Merton (2012). *The value of implicit guarantees.* University of Oxford, Working Paper.	Structural model of credit risk – uses CDS information	US financial institutions	200-350 bp at peak
Balasubramnian and Cyree (2018). *Has market discipline on banks improved after the Dodd-Frank Act?* Journal of Banking and Finance	Funding advantage based on subordinated debt	US banks	TBTF discount of 187 basis points in the yield spreads during the pre-DFA period, but the TBTF discount is reduced by 176 basis points during the post-DFA period.
Santos (2014) *Evidence from the Bond Market on Banks' "Too-Big-to-Fail" Subsidy* Federal Reserve Bank of New York	Funding advantage based on primary market bond issuance	US banks 1985-2009	31-121 basis points; $80 - $3 million for an average bond issue.
Schweikhard and Tsesmelidakis (2012) *The Impact of Government Interventions on CDS and Equity Markets,* Oxford University	Structural model of credit risk – uses CDS information	US banks, 2002-2010	50-200 bp
Gray and Jobst (2011) *Modelling systemic financial sector and sovereign risk* Sveriges Riksbank Economic Review	Structural model of credit risk – uses CDS information	US financial institutions 2007-2010 Swedish bank sector	0.5 per cent of GDP over the sample period. SEK 200 billion
Blix Grimaldi et al. (2012) *Estimating the size and incidence of bank resolution costs for selected banks in*	Binomial options pricing model and structural credit risk model	212 large and medium-sized banks based in 25 OECD countries, across the years 2008-14	Total implicit guarantees are estimated at 0.15% of sample countries' GDP as at 2014, below the estimated

OECD countries, OECD.			peak of 0.18% of GDP in 2012
Ueda and di Mauro (2012) *Quantifying Structural Subsidy Values for Systemically Important Financial Institutions*, IMF	Funding cost advantage based on credit rating data	End of 2007 and end of 2009	60bp end of 2007; 80bp end of 2009.
Noss and Sowerbutts (2012) *The Implicit Subsidy of Banks* Bank of England	Funding cost advantage and structural credit risk model	Six major UK banks	120 billion GBP at peak (funding cost method) vs. 350 billion GBP at peak (structural approach)
Zhao (2018) *Market-based estimates of implicit government guarantees in European financial institutions*, European Financial Management	Portfolio credit risk based on CDS spreads (senior + subordinated debt) and asset returns correlations	EU banks and insurance companies, 2005-2012	50bp peak over subprime crisis (2008) and 80bp peak over sovereign crisis (2011)

Source: Ange källa
Note: Ange anmärkning