BANK OF ENGLAND

Financial Stability Paper No. 32 – February 2015

Estimating the extent of the 'too big to fail' problem — a review of existing approaches

Caspar Siegert and Matthew Willison

BANK OF ENGLAND

Financial Stability Paper No. 32 – February 2015

Estimating the extent of the 'too big to fail' problem — a review of existing approaches

Caspar Siegert and Matthew Willison

The authors are grateful to Lucy Chennells, Bill Francis, Andrew Haldane, Damien Lynch, Menno Middeldorp, Joseph Noss, Victoria Saporta, Rhiannon Sowerbutts, Jamie Thompson, Belinda Tracey and Peter Zimmerman for their help and advice.

caspar.siegert@bankofengland.co.uk
Caspar Siegert, Bank of England, Threadneedle Street, London, EC2R8AH
matthew.willison@bankofengland.co.uk
Matthew Willison, Bank of England, Threadneedle Street, London, EC2R8AH

ISSN 1754–4262

Contents

Estimating the extent of the 'too big to fail' problem – a review of existing approaches

Caspar Siegert and Matthew Willison

How big is the 'too big to fail' (TBTF) problem? Different approaches have been developed to estimate the impact being perceived as TBTF might have on banks' costs of funding. One approach is to look at how the values of banks' equity and debt change in response to events that may have altered expectations that banks are TBTF. Another is to estimate whether debt costs vary across banks according to features that make them more or less likely to be considered TBTF. A third approach is to estimate a model of the expected value of government support to banks in distress. We review these different approaches, discussing their pros and cons. Policy measures are being implemented to end the TBTF problem. Approaches to estimating the extent of the problem could play a useful role in the future in evaluating the success of those policies. With that in mind, we conclude by outlining in what ways we think approaches need to develop and suggest ideas for future research.

1 Introduction

The disorderly failure of a large financial institution could cause widespread disruption to the financial system. Because of this, authorities have often in the past been reluctant to see large institutions fail and preferred to use public funds to save them. To the extent that this is anticipated by a bank's debt holders, these 'too big to fail' (TBTF) institutions may benefit from funding costs that are artificially low and insensitive to risk, a form of implicit subsidy from the government. Implicit subsidies could lead to resource misallocation in the economy because institutions are incentivised to choose excessively high levels of risk since their funding costs do not fully reflect the level of risk-taking. Moreover, banks that are not yet TBTF may have incentives to grow to being inefficiently large, in order to boost their chances of receiving government support.

This TBTF problem is far from new. The term attracted widespread attention in the mid-1980s after the authorities in the United States provided Continental Illinois (the seventh biggest bank in the United States at the time) with capital and liquidity assistance and guaranteed its uninsured creditors to avoid triggering wider systemic problems (Davison (1997)). But concerns about whether larger banks would be allowed to fail existed before the demise of Continental Illinois (eg Mayer (1975)) and the term itself appeared to have first been used to refer to non-financial companies that received government support in the United States during the 1970s (Stern and Feldman (2004)). TBTF became a major policy issue again after governments around the world decided to support large financial institutions in light of the ramifications for the financial system of the failure of Lehman Brothers in 2008. Doing so put public funds at risk and may have re-established perceptions that some financial institutions are TBTF.(1)

The existence of the TBTF problem is now widely accepted by academics, politicians and regulators across the world. In 2009, G20 leaders called on the Financial Stability Board (FSB) to propose measures to reduce the systemic and moral hazard risks associated with systemically important financial institutions (SIFIs). The FSB has developed a framework for addressing the TBTF problem that includes:

- Methodologies to identify institutions that are systemically important (for banks see Basel Committee on Banking Supervision (2013), for insurers see International Association of Insurance Supervisors (2013), and for non-bank, non-insurer financial institutions see Financial Stability Board and International Organization of Securities Commissions (2014));

- Policies to reduce the likelihood of SIFIs failing such as additional capital requirements (eg Basel Committee on Banking Supervision (2013)) and enhanced supervision (Financial Stability Board (2012));

- Policies to reduce the impact of SIFIs failing by ensuring arrangements are in place to effectively resolve those institutions (see Financial Stability Board (2011)).

As part of its work on reducing the impact of the failure of a global systemically important bank (G-SIB) the FSB is currently consulting on policy proposals to ensure that G-SIBs have sufficient capacity to absorb losses in resolution without requiring public support or threatening financial stability (Financial Stability Board (2014)). The policy proposals on such 'total loss-absorbing capacity' were welcomed by the G20 leaders at their Brisbane summit in November 2014.

Steps towards dealing with TBTF banks have also been taken domestically in the United Kingdom. A special resolution regime for failing banks was introduced in the United Kingdom in 2009, after the crisis at Northern Rock in 2007 demonstrated that the UK authorities did not have the powers necessary to ensure an orderly resolution of a failing UK bank (Brierley (2009)). The regime has subsequently been amended, in light of international developments in resolution, and has most recently been changed to ensure that it complies with the European Bank Recovery and Resolution Directive, which was finalised in April 2014. Ending TBTF is also one of the medium-term priorities for the Financial Policy Committee (FPC) (Bank of England (2013)). The FPC will review and, where necessary, influence the design and implementation of reforms to address the TBTF problem.

While policies for dealing with the TBTF problem have been developed, a large number of studies have been written that seek to measure the implicit subsidies that financial institutions, and in particular banks, receive due to being perceived as being TBTF.

These measures could be used for a number of purposes:

- They could be used to evaluate the success of policies intended to end TBTF. For instance, implicit subsidies could be used to assess whether policies designed to ensure all failed banks can be resolved without the use of public funds or significant disruption to the financial system are perceived to be credible by investors.(2)

- Estimates of implicit subsidies could be used as an input into the calibration of policies designed to reduce the TBTF

(1) See Laeven and Valencia (2013) for an overview of the direct costs of government support to financial institutions.
(2) If investors perceive that failed banks can be resolved without the use of public funds or significant disruption to the financial system, they are likely to be more prepared for the possibility that they will be exposed to losses on any holdings of bank debt instruments. This would reduce the risk that the resolution of bank induces an abrupt repricing of other banks' debt instruments.

problem. For example, the size of banks' capital requirements might be set such that the private costs of additional capital requirements offset any private benefits banks receive due to being TBTF.

- Implicit subsidies might also be used as a control variable in analyses of other phenomena in the banking system. For example, a bank's TBTF status is likely to be correlated with its size and scope. So if one is interested in the extent to which economies of scale and scope exist in the banking system one should control for estimates of the extent to which a bank is TBTF. Davies and Tracey (2014) find that once one controls for TBTF status, banks in their sample no longer benefit from economies of scale.

Given the risks to financial stability posed by the TBTF problem, it is important to understand how implicit subsidies have been estimated and why there can be substantial differences in these estimates. In this paper we review the approaches that have been used to estimate TBTF implicit subsidies. We discuss the theoretical and practical advantages and disadvantages of the different approaches and discuss why the sizes of implicit subsidies estimated using different approaches vary. We conclude that it is important to develop measures of implicit subsidies that can be updated regularly in order to evaluate the success of policies to solve the TBTF problem. Moreover, we argue that it is important to look at the incentive effects of implicit subsidies rather than focusing primarily at the distributive effects and propose some ways to quantify incentive effects. Finally, our review suggests that due to the problems associated with accurately measuring implicit subsidies, it is important to always look at the results of a range of different approaches.

2 Economic costs associated with 'too big to fail'

There are a number of reasons why having banks that are TBTF is socially inefficient. One reason is that there may be costs arising from public injections of equity capital into TBTF banks that do fail. These could be costs in terms of societal fairness — for instance, if one considers it is undesirable to transfer funds from the general public to bank creditors. Public injections might also generate deadweight costs (eg if public injections are in part funded by taxation and those taxes are distortionary). Measures of the value of the government's implicit support for TBTF banks could be one proxy for these costs. But in some cases a government may make a profit on its equity investment; any costs would need to set against uncertain future profits.

Another reason why the TBTF problem is socially inefficient is that it can distort behaviour *ex ante*. The distortions arise because TBTF banks may enjoy lower debt costs as debt holders expect that if these banks were threatened with failure they would be bailed out rather than default on their debt liabilities. TBTF banks' funding advantages could induce TBTF banks to make inefficient decisions. For example:

- TBTF banks may make investments that absent the funding advantage would have negative net present value.

- Expectations that a bank will be bailed out if it gets into trouble may mean its funding costs are less sensitive to its riskiness, which could give a bank an incentive to invest in riskier assets. This moral hazard effect would distort financing and investing decisions. It would also make bailouts more likely and hence increase the expected costs of public capital injections discussed above.

- If a government bails out the creditor but not the shareholders of a bank, then this may give banks an incentive to substitute debt funding for equity funding.(1) Again, this would result in a less resilient financial system.

- These problems are reinforced by the fact that by obtaining cheaper funding, TBTF banks enjoy a competitive advantage relative to other banks and so can grow faster. Plus, banks might be induced to merge in an attempt to attain TBTF status. This might result in banks that are inefficiently large.

- This could also lead to a banking system that is more concentrated, which may imply that negative idiosyncratic shocks to individual banks, which may not be large enough to force the government to inject new capital, translate into a larger reduction in the total supply of financial services than if there were no TBTF banks.

3 Methodologies and results

A number of approaches have been used to estimate the implicit subsidies associated with being TBTF. We divide these approaches into three broad categories: 'event studies'; 'cross-sectional studies'; and 'models of bank default'. In this section, we will describe the key features of the different categories and summarise the results obtained by the various studies that fall into each category.

Our classification system, which is based on the modelling approach used, is different from the one that can be found in other papers. Other papers draw a distinction between approaches that produce a 'funding cost advantage' enjoyed by a TBTF bank and those that produce a 'contingent claim' that holders of a TBTF bank's debt have on the government that could bail out the bank were it to fail. The former

(1) The implicit subsidy would exacerbate any incentives for inefficiently high levels of debt that are due to the tax-deductibility of interest income (Modigliani and Miller (1958, 1963)).

approach estimates the reduction in a banks' interest expenses that is due to TBTF status (usually expressed in basis points), while the latter approach determines the expected value of the transfer from the government to a TBTF bank's creditors.

In principle, the results of any of the empirical approaches that we discuss can be expressed as a funding cost advantage or as the expected value of the transfer from the government to a bank's creditors (ie a contingent claim).(1) If the market for debt financing is perfectly competitive and if investors have rational expectations and are risk-neutral, both approaches measure exactly the same thing. Since debt holders compete to provide funding to the bank, they will pass on any benefit they receive from the bank being bailed out in the event of its failure in the form of lower interest rates. So, assuming a given funding structure, the overall funding cost advantage that the bank receives in a given year (ie the funding cost advantage in basis points multiplied by the amount of debt) should be equal to the expected bailout that debt holders expect to receive from the government in that year.

We tend to concentrate on those results that are either expressed as a funding cost advantage or that allow us to easily convert the results into funding cost advantages. This measure is comparable across banks and is not influenced by the size of a country's banking sector (unlike the expected value of transfers from governments). But in order to illustrate the magnitude of some of the other estimates in the literature and their sensitivity to certain assumptions, we will also report some results that are expressed as an expected value of transfers from governments.

Event studies

Approaches in this category identify events that could have changed whether a bank is (or is perceived to be) TBTF and look at the impact of those events on values of a bank's equity and debt. Approaches use either changes in (actual or perceived) policy towards TBTF banks or firm-specific events that might change a bank's TBTF status (eg mergers).

Policy changes

This approach was developed in the aftermath of the 1984 bailout of Continental Illinois and the subsequent testimony to Congress by the Comptroller of the Currency in which he admitted that the eleven largest banks in the United States were TBTF. O'Hara and Shaw (1990) evaluate the reaction of those banks' share prices to a Wall Street Journal story on the Comptroller's testimony and show that share prices of those banks the story suggested were the eleven banks in question rose by 1.3% immediately after the announcement.(2)

Morgan and Stiroh (2005) complement this study by looking at the effects of the testimony on US banks' bond ratings and spreads. They find the ratings of banks announced as being TBTF deteriorated by only around 1.1 notches in a nine quarter period after the Comptroller's testimony, compared with a deterioration of 2.2 notches in the same period for other banks. This difference is statistically significant. The testimony also led to a 32 basis points reduction in bond yields of those TBTF banks relative to other banks, although this difference is not statistically significant. They also analyse whether the sensitivity of debt costs to risk is different for TBTF banks by looking at whether the relationship between a bank's bond spread and its ratings (as a proxy for the level of a bank's riskiness) is different for TBTF banks. Estimating a linear relationship between spreads and ratings, they find the relationship for TBTF banks was flatter than for other banks after the Comptroller's testimony. For instance, before the testimony, a one notch deterioration in the rating led to a 14.5 basis points rise in spreads for TBTF and non-TBTF banks. But after the testimony, the same change in ratings led to a 40 basis points increase in a non-TBTF bank's spread compared to only a 15 basis points rise for a TBTF bank. In other words, in the period after the testimony, bond spreads of TBTF banks became less sensitive to risk than the bond spreads of non-TBTF banks.

Morgan and Stiroh (2005) also look at the persistence of the effect on bank bond spreads. They estimate the spread-ratings relationship using data from 1993–98, which is the period after the 1991 Federal Deposit Insurance Corporation Improvement Act (FDICIA) in the United States that should have reduced the probability that a bank's uninsured claimholders would be bailed out. But they find for those banks that were labelled as TBTF in 1984 and the successors to those banks, the spread-ratings relationship was still flatter than those of other banks following FDICIA.

Balasubramnian and Cyree (2011) look at the impact of the rescue of the hedge fund Long Term Capital Management (LTCM) on bank debt spreads. Although LTCM was not bailed out by the government, the role of the Federal Reserve Bank of New York in brokering the private-sector rescue of LTCM could have supported expectations that systemically important financial firms would be supported in the event of them getting into trouble. They find that yield spreads on subordinated debt and debentures issued by US bank holding companies were lower for bigger banks both before and after the LTCM rescue, but that the extent to which yields were lower was more pronounced after the rescue. In other words, expectations that some banks were TBTF existed before the LTCM rescue but those expectations strengthened following the rescue.

(1) This implicitly assumes that equity holders will not benefit from a bailout directly because their claims are fully wiped out when a bank is bailed out. While this assumption is standard in many papers, we discuss whether this assumption is in fact realistic.

(2) They define the event as the publication of the Wall Street Journal story, which was on the day after the Comptroller's testimony, because the TBTF statement was not included in the description of the hearing that was included on the Dow Jones tape on the day of the hearing.

Other papers consider the effects of policy interventions during the recent crisis. Baker and McArthur (2009) look at how the recent crisis affected the premium that small banks had to pay on their debt relative to banks with more than US$100 billion in total assets. This premium increased by 9–49 basis points during the crisis as numerous bailouts reinforced TBTF expectations. This corresponds to 3%–18% of the average funding cost of small banks in the pre-crisis period (which was 280 basis points). But they do not control for bank riskiness. The change in premia paid by small banks might be an inaccurate measure of the funding advantage that large banks derive from being TBTF if the relative riskiness of large and small banks changed during the crisis.

In a similar vein, Veronesi and Zingales (2010) examined the effect of the announcement of revisions to the Troubled Asset Relief Program (TARP) in the United States on the values of equity shares, preferred shares and bonds of the banks that were covered by this programme. While it was mainly debt holders that benefited from the government's investment in banks' preferred shares, holders of equity and preferred shares could also have benefited since the support provided meant their claims had a greater potential to recover in value in the future than if the support had not been provided. Overall, TARP increased the value of claims on banks covered by the programme. But the observed changes in share and bond prices are likely to capture the effect of the capital injection itself as well as expectations of future bailouts.

Acharya, Anginer and Warburton (2014) examine the responses of financial firms' bond spreads to the government rescue of Bear Stearns and the decision not to rescue Lehman Brothers. Both decisions may have caused investors to update their expectations of the extent to which banks are TBTF (albeit in opposing directions).(1) Indeed they find that spreads of larger banks decreased relative to other banks following the Bear Stearns rescue and increased relative to other banks following the Lehmans collapse. These effects are statistically significant.

Comments

The TBTF effects that these papers measure can be interpreted as a lower bound on the overall effect since they measure the additional effect that these policies had relative to any TBTF expectations that already existed. The more that investors were able to anticipate the government's actions beforehand, the less additional information was contained in a policy event itself. Estimated changes in values of claims on banks would therefore be underestimates of overall TBTF subsidies. O'Hara and Shaw (1990) provide some evidence that these papers might only pick up the effect of changes in TBTF perceptions. They note that while the raw returns on the stock of nine of the eleven TBTF banks named in the Wall Street Journal story were positive on the day of the story, the raw return on Continental Illinois' stock was zero. Continental Illinois had, of course, been bailed out by that time so the Comptroller's statement may have conveyed no news about its TBTF status.

While events such as the Comptroller's testimony about TBTF following the bailout of Continental Illinois may serve as neat natural experiments, the magnitude of the changes in banks' stock and bond prices may not be very informative of current levels of the TBTF subsidies, given the changes to the banking industry over time. For instance, in the case of the results based on the bailout of Continental Illinois, the subsequent repeal of the Glass-Steagall Act, which previously separated retail banking and investment banking activities, might be expected to have made US bank holding companies more complex, which may have increased the TBTF problem to the extent authorities became more reluctant to allow them to fail. Even results that rely on the recent crisis, like those in Acharya, Anginer and Warburton (2014), may have dated quickly given the enormous changes in the banking system resulting from the crisis and the policy responses to it.

It is not surprising that the TBTF status should reduce a bank's debt costs because a bailout is meant to keep a bank from defaulting on its obligations. To understand the reaction of banks' share prices to changes in TBTF status observed by O'Hara and Shaw (1990) one needs to think more carefully about the underlying effects. News that a bank is TBTF could increase its share price for two reasons.

First, the share price increase would reflect a TBTF bank's lower debt costs since shareholders hold a residual claim on the bank's profits. If an increase in the expectation that a bank will be bailed out reduces debt costs and these benefits are not fully passed on to the bank's customers or employees this will increase expected profits and hence raise a bank's share price. Thus, share price reactions could be an indirect measure of the impact of TBTF expectations on debt costs. But cross-sectional studies that compare TBTF and non-TBTF banks should fail to find this effect if they control for bank profitability.

Second, a capital injection into a bank that would otherwise have failed may mean that shareholders' claims are diluted rather than being wiped out entirely as they would be if the bank became insolvent. If existing shareholders are not wiped out entirely they are partially insured in case of failure and will demand lower expected returns in order to invest into the bank. Consequently, share prices will be higher for a TBTF bank than for a non-TBTF bank for a given level of bank profitability.

The contrast between whether one would identify an effect of TBTF status on a banks' share price if one controlled for

(1) Other results in Acharya, Anginer and Warburton (2014) are discussed later in this paper.

profitability and if one did not suggests a possible empirical strategy for identifying which of these two reasons may be more important in explaining the benefits shareholders might extract from a bank being TBTF.

Merger analysis

The second approach looks at events unrelated to a change in policy that may alter an individual bank's probability of being bailed out. The general approach is to look at mergers between banks that are individually unlikely to be TBTF that form entities that are likely to be TBTF. The value created for the banks' shareholders by a merger may represent the subsidy the combined entity receives for becoming TBTF.

Kane (2000) observes that bank 'mega-mergers' in the United States created more value for the acquiring bank if the involved banks were headquartered in the same state. Kane attributes this finding to an increase in political influence which leads to lower funding costs or to local monopoly power.

Molyneux, Schaeck and Zhou (2010) use a similar approach to estimate the effect of TBTF on premia paid by an acquirer in large European bank mergers. They perform a regression of the premium paid in a merger on a large set of explanatory variables and interpret the residual as the price paid to obtain TBTF status.

Brewer and Jagtiani (2011) look at US mergers between 1991 and 2004 and estimate that an acquirer paid around US$15.3 billion in extra premium for a target that would put the combined entity beyond a threshold of US$100 billion in total assets.(1) The estimate can be seen as a lower bound on the overall shareholder value created by this kind of merger since it does not include any rents captured by the acquirer.

Penas and Unal (2004) use mergers to calculate the funding cost advantages enjoyed by TBTF banks. Their identification strategy relies on the assumption that bond prices should not gain from any of the other benefits a merger might generate because bondholders do not share in the profits earned by the bank.(2) The paper defines a bank as TBTF if it owns more than 2% of total industry assets and calculates that attaining TBTF status was associated with an average reduction in bond spreads of 14.8 basis points between 1991 and 1997.

Comments

These studies have the advantage of using exogenous events that affected a bank's TBTF status but did not change its inherent riskiness. But this approach has three potential shortcomings.

The first is whether other benefits generated by the merger (eg economies of scale) are properly controlled for in order that the benefits associated with the change in TBTF status can be isolated. The second is the classifications for whether or not a merger results in a TBTF bank can seem arbitrary (eg recall Penas and Unal's 2% assumption). Third, event studies by their very nature cannot be replicated. Hence this approach (like the one that uses policy events) does not allow us to estimate funding cost advantages at regular points over time.

Cross-sectional funding cost advantages

Approaches in this category analyse cross-sectional variation in banks' funding costs to measure the extent to which TBTF banks enjoy a funding advantage relative to non-TBTF banks. The papers differ from each other primarily with respect to how they define TBTF banks. TBTF banks are either defined as all banks that exceed a certain size threshold or banks that receive credit ratings incorporating the possibility of government support that are stronger than the ratings based on their inherent financial strength.

Size-based definitions of TBTF

Acharya, Anginer and Warburton (2014) offer one of the most comprehensive analyses of funding cost advantages. For a set of US financial firms(3) over the 1990–2012 period, they estimate a relationship between bond spreads and indicators of whether a firm is TBTF, while controlling for the riskiness of firms proxied by an estimate of a firm's so-called 'distance to default'.(4) The indicators are calculated for each year separately.

Acharya, Anginer and Warburton (2014) consider a number of different indicators of a firm's relative size as measures of its TBTF status.

One indicator is a set of three dummy variables for where a firm lies in the distribution of firm sizes. The first variable takes a value of one if the firm is among the largest 10% of firms in the sample (ie firms in the top decile of the size distribution) and zero otherwise. The second takes the value of one if the firm is between the 60th and 90th percentiles of the distribution of firm sizes, and the third takes a value of one if a firm is between 30th and 60th percentiles of the distribution. The first two dummy variables have a negative effect on bond spreads, while the third variable has a positive effect, but only the first effect is statistically significant. This result suggests that the impact of size on spreads is mainly driven by the very largest financial firms.

(1) US$100 billion coincides with the amount of total assets of the largest US bank that was allowed to fail and which did not have systemic spillovers (Haldane (2010)).
(2) This assumption might not hold true in some cases. Bondholders could also benefit. If the profits derived from the merger were retained, this would reduce the risk of the bank defaulting on its bonds.
(3) Financial firms are defined in terms of Standard Industrial Classification codes and include banks, broker-dealers, exchanges, insurance companies and other financial firms.
(4) Distance to default is a measure of the distance between the market value of a firm's assets and the face value of its debt (which is the value of assets at which it defaults on its debt), estimated using a Merton model. A firm is less likely to default if it has a greater distance to default.

Using the methodology described above, Acharya, Anginer and Warburton (2014) show that bond spreads for firms in the top decile of the size distribution were approximately 30 basis points lower on average over 1990–2012 but this advantage increased to more than 100 basis points in 2009. They calculate a measure of the overall TBTF subsidy per annum in each year by multiplying the estimated effect of TBTF status on bond yields for that year by the value of uninsured liabilities. The subsidy was US$30 billion per annum on average but increased during the crisis, peaking at over US$150 billion in 2009

Acharya, Anginer and Warburton (2014) also examine whether debt costs are less sensitive to risk for firms that are TBTF. They find evidence that the relationship between spreads and distance to default was flatter for firms in the top decile of the size distribution, which is consistent with the result in Morgan and Stiroh (2005) discussed above.

Lester and Kumar (2014) complement the findings by Acharya, Anginer and Warburton (2014) by using a very similar methodology with a sample restricted to holding companies with major commercial and investment banking activities. At the same time they extend the time series under consideration up to 2013. For the years 2009 to 2011 the funding cost advantage they identify is very similar to the one obtained by Acharya, Anginer and Warburton (2014). But they show that in 2013 TBTF banks had in fact a funding *disadvantage* — although the difference between TBTF and other banks' funding costs was small (8 basis points) and not statistically significant. One key feature of this study is that it only considers bonds issued from the top-level bank holding company (BHC) of US banks. The announcement of policies designed to make firms resolvable may mean investors' perceptions of the likelihood that holding companies will be bailed out have fallen — for instance in November 2013 Moody's reviewed the ratings for US BHCs, concluding that investors in debt issued by the holding companies of US G-SIBs could no longer expect to be bailed out by the US government. However, at this time, Moody's still assumes that creditors of their operating subsidiaries may receive government bailouts.

Araten and Turner (2012) obtain considerably lower estimates for funding cost advantages than Acharya, Anginer and Warburton (2014) even for the years prior to 2011. They estimate that between 2002 and 2011 US BHCs with more than US$500 billion in total assets had a funding cost advantage of only nine basis points relative to other BHCs.(1) One reason why their estimates might not be very big is that the funding advantage is a weighted average of differences in large and small BHCs' costs of different types of funding. For one type of funding (Fed Funds and reverse repo), large BHCs actually have higher funding costs. The estimated funding advantage enjoyed by large BHCs increases to 15 basis points when Fed Funds and reverse repo are excluded. But this estimate is still somewhat smaller than the estimates in Acharya, Anginer and Warburton (2014), which is surprising given that their sample includes fewer pre-crisis years.(2)

Hindlian *et al* (2013) compare bond spreads for US banks and find that the spreads for the largest six banks (defined as those with total assets above US$500 billion) were either the same or very slightly smaller than bond spreads for other US banks in the IBOXX Investment Grade Index. The average funding advantage over the 1999 to mid-2007 period was a mere 6 basis points. The funding advantage enjoyed by the biggest six banks widened sharply during the crisis and then reversed to become a funding disadvantage for most of 2011 and 2012. As of 2013, the funding disadvantage was around 10 basis points. The funding advantages are derived by a straightforward comparison of bond spreads — the authors do not control for other differences across the banks (eg riskiness) like in other studies. These low (or negative) funding cost advantages may be driven by a possible correlation of bank size and bank riskiness or by the fact that other banks IBOXX Index are also of considerable size (and hence might also be TBTF).

Hindlian *et al* (2013) argue that any funding advantages enjoyed by larger banks might be due to bonds issued by these banks being more liquid. They present various pieces of evidence that support this argument. They show how the bonds issued by the big six banks are traded much more frequently and that even for bonds issued by these banks there is a difference in spreads for 'on the run' (ie most recently issued) bonds and 'off the run' (past issued) bonds.(3) Finally, they look at non-financials and show that funding advantages of larger non-financials are more pronounced than for banks. But this result should be approached with caution — 'size' of non-financials is defined in terms of revenue instead of assets as it is for banks. Since revenues might be more strongly influenced by a firm's current health than are assets, it should not be surprising that these firms with higher revenues can borrow on cheaper terms.

Santos (2014) looks in more detail at the question of whether funding cost advantages are driven by liquidity effects. The paper shows that between 1985 and 2009, the five largest US banks in the year enjoyed an average funding cost advantage of 41 basis points relative to smaller banks (using credit ratings to control for differences in risk). This advantage

(1) The US$500 billion threshold is the threshold for defining a 'major' systemically important financial institution (SIFI) in measures to strengthen the regulation and supervision of SIFIs proposed by the Federal Reserve Board in December 2011. In the same proposals, the threshold for defining a SIFI is US$50 billion.
(2) One possible explanation is the difference in the definition of TBTF firms used by Acharya, Anginer and Warburton (2014) and Araten and Turner (2012). Unfortunately, Acharya, Anginer and Warburton (2014) do not specify the dollar amount to which the top decile corresponds, meaning it is not possible to compare the set of TBTF firms in the two papers.
(3) Although they do not present evidence that the 'on/off the run' spread is statistically significantly different from zero.

is even larger for non-financials. However, when limiting the sample to firms with a similar riskiness (firms rated AA and A), the advantage of large banks is higher than the advantage enjoyed by their non-bank or non-financial counterparts. The difference between the funding cost advantages for banks and non-financials was 16 basis points for A-rated firms and 92 basis points for AA-rated firms. A potential explanation is that the funding cost advantage that a bank enjoys is specific to its level of riskiness. Just controlling for differences in risk would fail to account for this, while looking at a subsample allows us to identify the funding cost advantage that is specific to this subgroup. We discuss how estimates of TBTF implicit subsidies and risk interact later in the paper.

Jacewitz and Pogach (2014) concentrate on the effect of implicit guarantees on deposit rates. As is recognised by the authors, this approach could suffer two shortcomings if not carefully conducted. First, there is no obvious reason why explicitly insured deposits should benefit from implicit government guarantees (they are explicitly guaranteed already). Second, in contrast to bond yields deposit rates are also likely to be affected by the quality of the service provided by the bank. For instance, if large banks have a large branch network they could compete for depositors by offering a better service at lower interest rates than competitors with smaller branch networks. Estimates of funding cost advantages enjoyed by banks for being TBTF could be biased upwards if these factors are not taken into account.

Jacewitz and Pogach (2014) address both of the challenges at the same time by looking at the differences between interest rates on US banks' money market deposits with a minimum required balance of US$25,000, which was less than the maximum amount covered by FDIC deposit insurance, and on deposits with a minimum required balance of US$100,000, which was above the deposit insurance threshold. The safety of the first type of deposit should be relatively less affected by whether the bank is TBTF because it is explicitly insured up to the threshold. At the same time, the quality of the service provided by a bank is assumed to be the same for both types of deposit.(1) Thus, the interest rate differential between the two types of accounts should only capture the risk premium that a bank has to pay on uninsured deposits. That premium would be lower for banks that are TBTF since in that case the deposits above the deposit insurance threshold would be implicitly insured.

The paper shows that between 2006 and 2008, after controlling for differences in observable risk-taking, this risk premium was on average 39 basis points lower for banks that exceeded US$200 billion in total assets, which the authors assume to be due to TBTF. This is broadly consistent with the results Acharya, Anginer and Warburton (2014) obtain for bond yields. Furthermore, when the deposit insurance threshold was lifted to US$250,000 in 2008, the discount on large banks' deposit rates disappears.

Beyhaghi, D'Souza and Roberts (2014) show that the 'Big 6' Canadian banks enjoyed funding cost advantages of 70 basis points on subordinated debt and 80 basis points on deposits relative to (much) smaller Canadian banks. They obtain the funding costs faced by different banks by dividing the interest expenditure associated with certain forms of funding (according to accounting data) by the level of the corresponding liabilities. The magnitude of the funding cost advantages they find may be due to the stark difference in the size of the two groups of banks that they compare: the Big 6 banks account for 93% of total banking assets in Canada. But the effect in relation to deposits may also be partially driven by the fact that due to their extensive networks big banks might be able to offer better services and hence attract deposits at lower interest rates (in the sense Jacewitz and Pogach (2014) try to control for).

Gandhi and Lustig (2013) find indirect evidence that TBTF status might affect a bank's funding costs. They discover an anomaly in the pricing of large banks' equities. They attribute this anomaly to an underpricing of tail risk and suggest that this may be driven by expected bailouts. But it is not clear via which of the two channels described above equity prices are being affected. Also, the approach used in the paper does not allow us to determine the implicit subsidy received by these large banks.

Comments

Estimating TBTF effects using cross-sectional data on bank debt costs has the advantage that the results are already expressed as funding cost advantages. This metric is more easily comparable across banking systems of different sizes than estimates expressed as the expected transfers from the government to banks.

But a general problem with this kind of approach is that TBTF effects may be confounded with other size effects, as with the merger analysis. For instance, if larger banks are more easily able to diversify their assets they should be less risky and bond spreads should be (all else equal) lower. Working in the opposite direction, larger banks may be large because they are more leveraged, which would also make them more risky. While most of the papers do control for linear size effects, any non-linear effects of size may still be picked up by the TBTF funding advantage measure and may bias the estimates of TBTF implicit subsidies in either direction.(2)

(1) This assumption may not be satisfied for all banks and accounts because some banks explicitly link certain services to minimum balance thresholds.

(2) Not adequately controlling for size may introduce a bias since size may be correlated with riskiness and hence with the risk premium that a bank would have to pay for its debt if it was not considered TBTF. This is only a problem to the extent that we cannot perfectly control for a bank's riskiness directly. It seems, however, unlikely that doing so is possible in practice.

An advantage of this approach over the event study approaches is that it is possible that the estimates of TBTF effects can be periodically updated. This is important if one wants to track changes in the extent of the TBTF problem rather than merely to prove that the problem can exist.

Ratings-based definition of TBTF

A second part of this strand of the literature uses credit ratings to identify banks that are TBTF. Some rating agencies issue ratings that take into account the likelihood banks would receive government support if they get into trouble (so-called support ratings) and ratings that do not (so-called standalone ratings). The difference between these two ratings, the 'ratings uplift', is a measure of the government support that a rating agency expects a bank to receive.

There are two reasons why the ratings uplift may be a useful measure of a bank's TBTF status. The ratings uplift may contain information that is closely correlated with the actual TBTF status of a bank. If this is the case the ratings uplift is a good *proxy* of TBTF. But the usefulness of ratings as a measure does not in fact depend on the quality of the rating agencies' assessments of the likelihood of government support. To the extent that bank debt costs are affected by credit ratings, ratings may *cause* TBTF funding cost advantages. Even if the government were never to bail out a bank, the *ex-ante* effects of TBTF expectations could still arise if ratings agencies issue ratings that investors believe.

Most studies use ratings not as an explanatory variable in a regression but to directly infer funding advantages enjoyed by TBTF banks from the credit ratings by using average bond yields associated with particular ratings. Calculating the funding advantage amounts to taking the difference between bond yields associated with the support rating and bond yields associated with the standalone rating.

One example for this approach is Ueda and di Mauro (2013). This paper shows that the average ratings uplifts experienced by a cross-country sample of around 800 banks was associated with a funding cost advantage of 60 basis points at end-2007 and 80 basis points at end-2009. The ratings uplift is translated into a funding cost advantage by using historical data on the spreads associated with different ratings for a five-year bond reported in Soussa (2000). The fact that historical bond spreads are used implies that changes in funding advantages over time only reflect changes in ratings uplifts over time and not potential changes in the risk premium that investors demand to purchase lower-rated bonds. This may explain why the funding cost advantage changes much less between 2007 and 2009 than in other studies. But the level of the funding cost advantage is still surprisingly high given that the averages are based on 800 banks and not all of these banks are likely to be TBTF.

The International Monetary Fund (IMF) (2014) uses a similar methodology to compare the funding cost advantages that are enjoyed by large banks both across regions and across time. It finds that prior to the crisis systemically important banks in the United States (euro area) received an average funding cost advantage of 5 basis points (20 basis points).(1) This advantage peaked at 30 basis points (80 basis points) around 2010 and was still at 15 basis points (60 basis points) at the end of 2013. The fact that IMF (2014) uses historical bond yields may imply that this analysis also tends to underestimate the cyclicality in implicit subsidies. But given that this paper concentrates on very large banks that are likely to benefit from considerable ratings uplift, it is surprising that the identified funding cost advantages tend to be lower than the ones found by Ueda and di Mauro (2013).

While Rime (2005) focuses on the determinants of rating uplifts, he also calculates the average funding cost advantage enjoyed by large banks (the corresponding sample consists of banks with more than US$400 billion in total assets). Between 1999 and 2003 this advantage lay between 30 and 80 basis points for the largest banks with a low intrinsic stability (as measured by their stand-alone rating) and between 0 and 20 basis points for the largest banks with high intrinsic stability. The precise size of the subsidy depends on whether Moody's or Fitch ratings are used. This makes a substantial difference because ratings may differ across rating agencies. The same historical bond yields are used regardless of which agencies' ratings are used.(2)

Noss and Sowerbutts (2012) use average bond yields in each given year to calculate implicit subsidies for four major UK banks (Barclays, HSBC, Lloyds, and Royal Bank of Scotland) in each year in the period 2007–10.(3) The value of the implicit subsidy varies markedly from year to year in this period. For instance, the subsidy is less than £5 billion in 2007 but balloons to over £120 billion in 2009 before dropping back to just below £40 billion in 2010 (see Chart 1 in their paper).

This paper shows clearly how several factors, not only ratings, can affect the value of the implicit subsidy calculated using this approach. Changes in ratings uplifts do make a contribution; eg the average uplift approximately doubles between 2007 and 2009, the period over which the implicit subsidy increases. But the average uplift is unchanged between 2009 and 2010 while their estimate of the value of the implicit subsidy declines. The other two factors that are changing over time are the value of banks' liabilities — the cost of which are sensitive to ratings — and the yields

(1) Systemically important banks are defined as banks that were either identified by the FSB to be G-SIBs in 2013 or were one of the three largest banks in a given country.
(2) An interesting feature of Rime (2005) is that the author does not attribute all of the rating uplift to TBTF effects. Instead, the estimates are based on the additional rating uplift that large banks obtain relative to the average of all banks in the sample (banks with more than US$1 billion in total assets).
(3) An earlier version of this work was presented in Haldane (2010).

associated with different ratings. If the relationship between yields and ratings varies over time — eg steepening in a downturn — it may mean this approach produces estimates of TBTF implicit subsidies that are volatile and/or vary over the cycle (see page 18 for a discussion of whether we should care about cyclical variation).

Using the methodology of Noss and Sowerbutts (2012) to express their results in terms of funding cost advantages, we find an average advantage of 630 basis points for the four UK banks in 2009. A potential explanation for these very high numbers is that in 2009, two of the banks (Lloyds and Royal Bank of Scotland) were already receiving explicit government support.

Furthermore, in all of these papers investors are assumed to demand the same risk premium irrespective of whether an AAA-rating is due to a high standalone rating or due to strong expectations of government support. The assumption that investors do not distinguish between the sources of support might explain in part the tendency of the ratings uplift approaches to estimate high funding cost advantages. If investors put less weight on the ratings uplift than on an institution's inherent strength this would result in lower actual funding cost advantages than the ones implied by this approach.

Keppo and Yang (2015) address these concerns. The authors obtain banks' funding costs from balance sheet data and regress this on ratings uplifts and standalone ratings. This way they can predict the funding cost advantage enjoyed by banks with a certain ratings uplift. They distinguish between the effects on deposit funding and wholesale funding costs, but do not distinguish between secured or unsecured wholesale funding or insured or uninsured deposits. For deposits, the funding costs were 30 basis points lower than they would be without any ratings uplift for a G-SIB and 17 basis points for a non-G-SIB over a time period from 1990 to 2011.(1) For wholesale funding, the funding advantages were 100 basis points and 60 basis points, respectively.

Keppo and Yang (2015) show that an increase in the rating uplift does not have the same effect as an increase in the standalone rating. This is consistent with investors weighting the factors that contributed to a given rating differently. But the estimates suggest that investors put more weight on the ratings uplift than on a bank's inherent strength. Hence, accounting for the differential effect of the two potential sources of a rating *increases* the estimates of the funding cost advantage.

Why might this be? A possible explanation that would be consistent with the results is that investors believe rating agencies correctly identify which banks may be TBTF but do not correctly identify the size of the differences in the likelihood that these banks would be bailed out. This would mean investors would demand higher risk premia from banks with low ratings uplifts than would be suggested by the rating and they demand lower risk premia from banks with high ratings uplift than would be suggested by the rating.

Finally, Alfonso, Santos and Traina (2014) provide evidence that ratings uplift and bank behaviour might be linked. The paper shows that between 2007 and 2013, banks that had higher ratings uplift subsequently had more impaired loans and net charge-offs. For the average bank in their sample, expected government support increased the ratio of non-performing loans by up to 8%. This suggests that banks with higher ratings uplift might receive funding at costs that do not fully reflect the riskiness of their balance sheets, which induces them to take more risks. In concentrating on the distortive effects of TBTF subsidies, the paper is related to Acharya, Anginer and Warburton (2014) who also consider the effect of TBTF status on the sensitivity of funding costs to risk.

Comments

As with the cross-sectional analysis based on size, these approaches have the advantage that the results are already expressed in terms of funding advantages.

Which of ratings-based and size-based approaches are better for estimating TBTF implicit subsidies? Assume that investors are able to tell whether ratings are informative about the probability that banks would be bailed out and only take ratings into account to the extent that they do contain information. Whether the size-based or ratings-based approach is better rests on whether we expect size or ratings to be a less noisy measure of TBTF status. A potential reason for why size might be a less noisy measure is that rating agencies could use flawed methodologies that misjudge the likelihood that banks would receive support. On the other hand, if a bank's TBTF status is determined by factors other than just its size (eg interconnectedness) and these factors are taken into account by rating agencies, measures of TBTF status based on ratings might be relatively less noisy.

Some might prefer size to ratings purely on the grounds that the latter are subjective and hence may be considered inaccurate. But the *ex-ante* effects of TBTF depend on whether investors' believe that a bank is TBTF and not on whether in fact a bank would be bailed out in the event of its distress. If investors take ratings at face value, then ratings may have a strong influence on funding costs and may hence be a less noisy measure of TBTF status even if those ratings are inaccurate. Empirical evidence that support ratings affect banks' debt costs (like that in Keppo and Yang (2015)) is important to assess whether investors' beliefs are affected in this way.

(1) The authors define banks as G-SIBs in each and every year if they were included in the FSB's 2012 list of G-SIBs.

Finally, there are some practical problems that must be addressed when using ratings uplifts. One potential problem is that in some instances, the ratings uplift does not only capture expected government support, but also expected support from other sources such as holding companies or large shareholders. If these other sources of support are important for the ratings of a significant number of banks, estimates of TBTF funding advantages based on ratings uplifts might be biased upwards. Another practical problem is that a standalone rating and a support rating may not be available for the same legal entity (eg the former is only available for the operating company while the latter is only available for the holding company). Comparing the ratings in a case like this could lead to inaccurate measures of the extent of TBTF status because the rating of the holding company would reflect in part the rating agency's view of the stability of any non-bank subsidiaries.

Models of bank default

The studies that we have summarised so far do not provide their own assessments of the likelihood that banks fail and are bailed out. Instead, the studies rely exclusively on the judgement of market participants (embedded in prices of banks' debt and equity) or rating agencies to derive the funding advantages enjoyed by TBTF banks. We will now turn to a number of papers that explicitly model the probability of bank failure. The probability of failure can then be used as an input for estimating the (expected value of) implicit subsidies, which depend on this probability.

There are a variety of different approaches that involve modelling the likelihood of future bank defaults in order to calculate implicit subsidies. We will distinguish between two classes of approaches. The first approach assumes that the government saves banks with certainty if they fail.(1) The size of the expected capital injection is calculated by modelling the probability that a bank fails and by multiplying this probability by the amount of capital that is needed to recapitalise a bank to a level assumed to be high enough for it be considered solvent. Even if we take as given that a government would recapitalise banks to the assumed level, the resulting number can be seen as an upper bound on the expected capital injection that a bank receives, since in reality a government might only provide support with a probability less than one.

The second approach goes one step further and uses credit default swap (CDS) premia to estimate the probability with which the market expects the government to support a bank. CDS premia reflect market expectations of a bank default, ie the joint probability of a bank failing and it not receiving government support. Estimates of this joint probability can be backed out of CDS premia and then compared with the model-based probability of the bank failing, to calculate an estimate of the probability the government will provide support.

Certain government support

The first approach is used by Oxera (2011) and Noss and Sowerbutts (2012) in order to quantify the expected value of capital injections into large UK banks if they were to get into distress. The papers assume that the government provides support whenever the average capital ratio of the largest UK banks falls below a critical threshold. Oxera (2011) obtains an expected capital injection of £5.9 billion for the large UK banks in 2010. In their key specification, Noss and Sowerbutts (2012) obtain values of £45 billion in 2007 and £150 billion in 2009. According to Noss and Sowerbutts (2012), the differences between their estimates and those obtained by Oxera (2011) can be explained by different discount factors and assumptions on the timing of government support.(2)

In order to derive the probability that the value of a bank's assets falls below a critical threshold, the papers need to measure the volatility of a bank's assets. This is done by using the volatility of a bank's equity price and a simple scaling factor in order to map this volatility into the volatility of the underlying asset value.(3) But Noss and Sowerbutts (2012) demonstrate that the results depend crucially on how equity price volatility is measured. It can either be measured using the historical variance of equity prices. Or it can be measured using more forward-looking measures of volatility.

One such forward-looking measure is the volatility implied by the prices of equity options. The higher the price of an option, the larger the implied volatility. But in times of uncertainty option prices tend to increase relative to the values of the underlying shares. When using option-implied volatilities, this price increase is taken as evidence of higher expected equity price volatility. This rise in equity price volatility increases the estimated probability of default and hence estimates of implicit subsidies.

Using a simple scaling factor to translate equity volatility into asset volatility is theoretically justified only if the value of assets cannot fall below the value of a bank's debt; ie the debt is risk-free. In this case, all changes in the value of assets are fully reflected in changes to the value of equity and not any of the other claims on the bank. Conceptually, this assumption is not convincing given that we are ultimately interested in the risk premia that banks have to pay to debt holders. But Oxera (2011) shows that accounting for the fact that bank

(1) Some papers assume that the government only intervenes if, in aggregate, banks fall below a certain average capital ratio. We ignore this distinction here.
(2) Noss and Sowerbutts (2012) assume that the government will decide on a potential bailout as soon as the assets of the banking sector fall below a given threshold, while Oxera (2011) assume that the government will only intervene if the asset values are sufficiently low at the end of the year.
(3) This factor depends on the level of bank leverage. This is the case even if debt is riskless. In this case all fluctuations in a firm's asset value are borne by shareholders. But for a given level of asset risk a bank's level of capitalisation determines how large these fluctuations are relative to the average value of equity in issuance.

debt is risky has no material influence on their estimates. To do so, they rely on the Merton (1974) model which accounts for the fact that some of the downside risk of a bank is carried by debt holders.

While Oxera (2011) shows that explicitly accounting for the fact that bank debt is risky has no effect on their results, this result seems to be specific to their sample. If a Merton model predicts that the probability of default is very low, then the two approaches produce similar results. However, for other banks and time periods the Merton model predicts that banks default on their debt with high probabilities. For these samples we would expect the estimate of asset volatility to strongly depend on whether we account for such defaults or not.

Comments

The estimates obtained by both of these papers capture the expected value of the capital support provided by the government.

To the extent that these government transfers are necessary to absorb losses and to protect creditors they are indeed a pure subsidy.

However, once sufficient equity has been injected to result in a positive (book) value of equity, any additional injection that is intended to increase the bank's capital ratio will directly increase the value of the government's equity investment. While from the government's point of view injecting further capital may still not be a positive net present value investment (taking into account the opportunity cost of making the injection), it is not a pure subsidy. In some situations equity injections may even turn out to be profitable for the government. This seems to have been the case for some of the bailouts in the recent crisis (see Veronesi and Zingales (2010)).

If an equity injection is profitable for a government, it raises the question why the bank could not find a private-sector investor or investors. There are at least two possible explanations for why a bank may not have been able to. One is that although the investment turned out to be profitable *ex post* it was not in expectations terms *ex ante*. In this case the equity injection still constitutes a subsidy since the investment had a negative net present value at the time of the intervention. Or other investors might be willing to invest in the bank but have insufficient funds to do so. In this case of a lack of private investors with sufficiently deep pockets, the equity injection may have been beneficial for the government even from an *ex-ante* perspective and may not have constituted a subsidy in the strict sense.(1)

Another qualification is that due to the underlying assumption that the government provides support with certainty, this approach is not particularly suitable to calculate funding cost advantages. If the government bails out TBTF banks with certainty, the funding cost advantage would always be equal to the difference between the cost of debt for a non-TBTF bank and the funding cost of the government.

Another issue to be considered is whether it makes sense for implicit subsidies to vary cyclically in the way that they tend to do when using models of bank default (regardless of the specific way in which equity price volatility is measured). It does make sense for equity-implied default risk to increase during periods of uncertainty as there is a larger probability of substantial drops in asset prices. Moreover, this would necessarily increase the value of implicit guarantees.

But estimating asset volatility by using equity price volatility may overestimate the cyclicality of default risk, which in turn means the cyclicality of implicit subsidies is overestimated by this method. For instance, estimates of the value of a put option on banks' assets that were based on CDS premia have been considerably more stable in the period since 2005 than estimates based on equity prices (**Chart 1**). One would not expect to see that difference if changes in investor risk aversion were the key factor driving the cyclicality of model-implied default risk because presumably those changes would be reflected in CDS premia as much as in equity prices.(2)

Chart 1 Price of a put option on the assets of the largest UK banks(a)

(a) Sum of estimated price of put options on the assets of Barclays, HSBC, Lloyds Banking Group and Royal Bank of Scotland. Equity-implied put option prices were calculated using the short-term volatility of equity prices and a Merton model. The strike price of the put option is set to an accounting-based measure of outstanding liabilities. CDS-implied probabilities were calculated using CDS prices.

(1) Another possibility is that private sector investors may be able to collectively recapitalise the bank to a sufficiently high level but suffer from a co-ordination problem, which the government is able to solve by providing one large equity injection.

(2) However, part of the differences may be explained by the fact that debt holders are partially protected against default risk due to government guarantees. This would mean that the value of CDSs varies less over time than the risk of the underlying assets and CDS prices may underestimate the true cyclicality of default risk (see discussion in 'Estimated probability of government support' on page 15).

Estimated probability of government support

The second approach compares the default risk that is derived from the option-implied volatility of equity prices (in a way similar to that described above) to the default risk that is implied by CDS premia. The key assumption underlying this approach is that equity prices do not reflect any expectations of bailout since equity holders expect to be fully wiped out in case of distress — regardless of whether the government provides support or not. Thus, the probabilities of default that are implied by equity prices are not affected by expected bailouts. Conversely, CDSs will only pay out in cases where the bank does not fully honour its liabilities. This will be the case if the bank fails and the government does not provide support. Hence, the difference between the two measures of default risk can be used to assess the probability of government support.

The equity-implied probabilities of default are calculated using variants of the Merton model discussed above. The probabilities are then translated into a 'fair-value spread', which is the risk premium that bondholders would have to receive in order to compensate them for the possible default. This is done by calculating the bond spread that would make the investor indifferent between investing in the risky bank debt and an assumed alternative investment opportunity. Subsequently, this risk premium can be compared to the risk premium implied by CDS prices.

Li, Qu and Zhang (2011) find that pre-crisis, funding cost advantages of the 20 largest financial institutions in Europe were 3 basis points higher than for smaller European institutions. For a corresponding US sample this gap was 23 basis points. In the period immediately after the crisis, the gap was 51 basis points for European institutions and 56 basis points for US institutions. Depending on their specification, Schweikhard and Tsesmelidakis (2012) obtain funding cost advantages of between 10 basis points and 350 basis points during the crisis. In a companion paper, Tsesmelidakis and Merton (2012) use the same methodology to calculate how much of this funding cost advantage benefits shareholders and how much of it benefits debt holders. Shareholders only benefit from the funding cost advantage enjoyed by being TBTF at the time debt is issued. Debt holders benefit from the bank's TBTF status at the time of issuance, but also benefit from increases in the likelihood that a bank will be bailed out after the debt is issued. The value of a bank's TBTF status to debt holders also increases if the credit quality of the bank deteriorates because that makes an implicit guarantee more valuable. Tsesmelidakis and Merton (2012) find that roughly one third of implicit subsidies in the crisis were captured by shareholders. However, their data do not allow us to assess whether any of the subsidies were passed on to customers or captured by employees.

For the United States, United Kingdom and euro area systemically important banks, the IMF (2014) obtains funding cost advantages of between 5 basis points and 10 basis points in the years prior to the crisis. In 2009 implicit subsidies peaked at between around 45 basis points for banks in the euro area and 90 basis points for banks in the United States, before declining again. In the euro area, the euro crisis led to another peak towards the end of 2012, which may partially explain why at the end of 2013 funding cost advantages were still much more pronounced in the euro area (around 70 basis points) than in the United States (around 15 basis points).

Comments

A major drawback of this approach is that it is based on comparing two very different financial instruments, namely equity and (derivatives of) debt. Attributing any difference between the default risks implied by the prices of these two very different instruments to implicit subsidies is assuming a very high level of market efficiency.

In particular, it assumes that equity and bond markets are fully integrated; ie there are no restrictions that mean certain classes of investors can only trade equities or bonds.

Moreover, the approach is subject to a number of additional assumptions which may explain the large variations of the estimates. A particularly strong assumption is that equity prices are unaffected by expected bailouts. As we have seen in the context of event studies, this is unlikely to be the case in reality. Tsesmelidakis and Merton (2012) provide additional evidence that shareholders capture some of TBTF implicit subsidies, which should affect equity prices. But it is not clear in what direction the fact that TBTF expectations are embedded in the price of equity could bias the results. This is due to the fact that the estimates depend on the volatility of equity prices and it is unclear how the volatility is affected by implicit government guarantees.

Finally, as we argued in the previous section, estimating asset volatility by using equity price volatility may overestimate the cyclicality of default risk. If we compare equity-implied default risk to the more stable CDS-implied default risk, then this may quite mechanically lead to cyclical estimates of TBTF banks' funding cost advantages.

4 Common patterns and caveats

A couple of patterns emerge from the papers we have reviewed.

There is evidence that banks can receive TBTF implicit subsidies across a range of different estimation approaches. In other words, finding evidence does not appear to depend on adopting a specific approach.

There seems to be no direct link between funding cost advantages and the type of debt instrument that we look at; see **Table A**. While this does not imply that there are no differences at all, these differences are masked by the considerable amount of variation between different estimates for any given debt instrument. But estimates of funding advantages do change if one excludes certain debt instruments that are less likely to be affected by default risk (eg repo financing and other forms of secured lending). Araten and Turner (2012) show that doing so can double the average funding cost advantage.

Table A Range of funding cost advantages for different types of bank debt liabilities

Type	Long-term average funding cost advantage (basis points)
Bonds[a]	(-6)–80
General wholesale funding[b]	60–100
Deposits[c]	17–80
All sources of funding[d]	18

(a) Based on Acharya, Anginer and Warburton (2014), Baker and McArthur (2009), Beyhaghi, D'Souza and Roberts (2014), Li, Qu and Zhang (2011), Morgan and Stiroh (2005), Penas and Unal (2004), Rime (2005), Santos (2014), Schweikhard and Tsesmelidakis (2012), and Ueda and di Mauro (2013).
(b) Based on Keppo and Yang (2015).
(c) Based on Beyhaghi, D'Souza and Roberts (2014), Jacewitz and Pogach (2014), and Keppo and Yang (2015).
(d) Based on Araten and Turner (2012) (excludes Fed funds, non-interest bearing deposits and repo financing).

Models that use ratings uplifts seem to result in somewhat higher estimates of the funding cost advantage (**Table B**). More work is needed in order to understand the differences between results using the size-based and the rating-based approach. One possibility is that investors do not fully heed support ratings. In this case the literature that uses ratings uplifts would overestimate the true extent to which ratings uplifts affect funding costs. However, preliminary evidence presented by Keppo and Yang (2015) appears to be inconsistent with this hypothesis. Alternatively, ratings uplifts may be a less noisy measure of TBTF status than size which may result in higher estimates. We discuss this issue in more detail below.

Table B Range of funding cost advantages for different approaches

Approach	Long-run average (basis points)	2009 (basis points)
Event studies[a]	15–32	78
Cross-sectional studies		
Size-based[b]	30	>100
Ratings-based (historic yields)[c]	0–80	60–80
Ratings-based[d]	47	630
Models of bank default[e]	(-6)–25	10–350

(a) Based on Baker and McArthur (2009), Morgan and Stiroh (2005), and Penas and Unal (2004).
(b) Based on Acharya, Anginer and Warburton (2014).
(c) Based on IMF (2014), Rime (2005), and Ueda and di Mauro (2013).
(d) Bank calculations. Calculated using the methodology in Noss and Sowerbutts (2012) using the average yields associated with a particular rating in each year (rather than long-run averages). The large numbers for 2009 may be driven by the fact that half of the sample received government support in that year.
(e) Based on IMF (2014), Li, Qu and Zhang (2011), and Schweikhard and Tsesmelidakis (2012).

Estimates of funding cost advantages for the crisis are much higher than the long-run average estimates. This most likely reflects how investors' assessments of the risk that a bank will fail will vary procyclically. The same may be true for the probability with which they expect a failed bank to be bailed out. It could also reflect how risk appetite goes down in a crisis, pushing up risk premia. Fluctuations in estimates are particularly pronounced if we use models of bank default that rely on the equity-implied asset volatility.

5 Where next?

The literature on implicit subsidies enjoyed by TBTF banks has developed fast in recent years but it is unclear whether it has necessarily delivered everything that policymakers need.

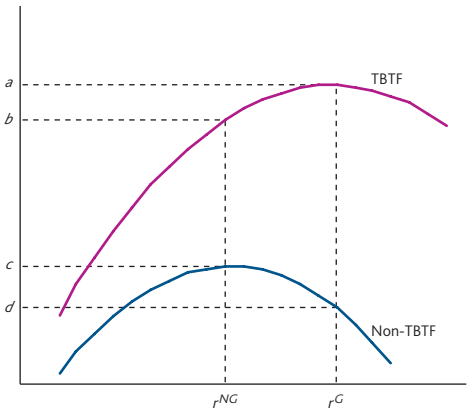
Issues

What are we seeking to measure?

Many of the studies we have discussed try to estimate any implicit subsidies received by TBTF banks. But these subsidies are not straightforward to define if one takes into account how TBTF status might change a bank's behaviour.

Figure 1 illustrates this with a stylised example. The blue line is a non-TBTF bank's profits as a function of the 'riskiness' of its assets. Its optimal level of riskiness is r^{NG} (*NG* stands for no TBTF guarantee of a bank's debt). The magenta line is the profit function of a TBTF bank (*G* stands for TBTF guarantee of a bank's debt). The TBTF bank's profit function is above and to the right of the non-TBTF bank's profit function. This reflects how the TBTF guarantee means a TBTF bank's funding costs are lower and less sensitive to risk than those of a non-TBTF bank. It implies that the implicit subsidy is increasing in asset risk. It follows that the TBTF banks' optimal level of riskiness, r^{G}, is higher than r^{NG}.

Figure 1 TBTF implicit subsidies and risk-taking



In our figure we assume that TBTF and non-TBTF banks are identical except for the fact that one benefits from an implicit government guarantee while the other does not. In particular, we do not assume that they differ in size in order to highlight

the effect the guarantee itself has on a given bank. Moreover, we assume that the only choice a bank's management can take is asset riskiness.

The estimate of the TBTF funding advantage using an approach that performs a regression of profits on TBTF status, while controlling for all relevant factors apart from banks' endogenous choice of risk, would be equal to *a*–*c*.

If one used this approach but also controlled appropriately for the effect of asset riskiness, the estimated funding advantage would be equal to *a*–*d*, if the level of riskiness was set equal to the level chosen by a TBTF bank, or equal to *b*–*c*, if the level of riskiness was set equal to the level chosen by a non-TBTF bank.

The funding cost advantage enjoyed by TBTF banks for their actual level of riskiness, ie *a*–*d*, may be more informative for policy purposes since this can be translated into the expected bailout cost that the government faces.

This assumes, however, that one can control for riskiness in a way that generates risk-specific funding cost advantages. Empirically, one could do so by regressing profit on asset riskiness interacted with a TBTF dummy in order to estimate how the funding cost advantage changes with different levels of risk. This also allows one to assess the difference in the slopes of the two profit functions. However, most of the empirical literature estimates the funding cost advantage at an average level of riskiness.

Figure 1 also highlights other measures a policymaker might be interested in. We have discussed that *a*–*d* corresponds to the expected fiscal cost of government bailouts. However, the benefit to a bank of being TBTF is only *a*–*c*. Hence, the deadweight loss that arises because a bank is TBTF would be *c*–*d* (ie the reduction in the true profit of a TBTF bank because it is induced to increase asset riskiness to an inefficiently high level). The size of *c*–*d* crucially depends on the difference in the slopes of the two profit functions (which is what distorts the bank's risk-taking incentives).

Our discussion assumes that banks actually choose levels of risk that maximise profits. In reality a bank might not be able to optimise exactly, which would mean that the benefit that banks derive from being TBTF may differ from *a*–*c*.

In summary, if one takes into account how TBTF status could distort a bank's investment decisions, the measure of the effect of being TBTF could be defined in a number of different ways.

Levels or changes?

Some of the studies reviewed above try to estimate the absolute value of TBTF funding advantages/implicit subsidies while other studies estimate changes in this value (eg changes around a specific event like a merger).

Whether we want to measure levels or changes partly depends on the question. If we just want evidence that the TBTF problem can exist, either would do. If we wanted to assess whether a certain policy increased or decreased the TBTF problem, then changes that occur around the introduction of that policy would seem to be the appropriate measure. If we want a measure of how the problem is evolving over time, then a measure of the level that can be estimated on a frequent basis would be better.

Which banks are TBTF?

A problem in many of the studies discussed above is that one needs to identify the set of TBTF banks before one can estimate the effects of being TBTF on funding costs. Clearly we cannot identify TBTF banks as those receiving a funding advantage because that would amount to circular reasoning. Instead, existing papers have used potentially noisy proxies for TBTF status. Misclassification of banks as TBTF introduces attenuation bias that will bias estimates of the effects of being TBTF downwards. For instance, if one misclassified TBTF banks as non-TBTF banks this would reduce the estimate of the average funding cost of non-TBTF banks and thereby reduce the estimate of the funding cost advantage of TBTF banks. Conversely, if one misclassified non-TBTF banks as TBTF this would raise the estimate of the average funding cost of TBTF banks. But again the implication would be that the estimate of the funding cost advantage of TBTF banks would be lower than if banks were correctly classified.

Thus, most of the cross-sectional approaches discussed above would have some tendency to underestimate funding cost advantages of TBTF banks. A possible explanation for why ratings-based approaches produce higher estimates for funding cost advantages than size-based approaches is that ratings uplifts are a less noisy measure of TBTF status than bank size.

Some of the approaches that do not rely on comparing TBTF and non-TBTF banks do not have to suffer from attenuation bias. In the case of event studies based on policy changes, if one defines the set of TBTF banks to only include those banks one is very sure are TBTF, then a comparison of those banks' funding costs before or after the event will not be biased by the exclusion of other TBTF banks. Of course, if banks that are not TBTF were misclassified as being affected by the policy change, an attenuation bias could again arise.

For merger-based event studies, we face similar challenges as with other approaches. We have to identify situations where the pre-merger entities are not TBTF, while the post-merger entity is TBTF. Estimates may be biased if one makes mistakes in identifying these situations — for instance, using too low a

threshold of total assets over which a merged entity is assumed to be TBTF.

Should we care about cyclical variation?

One theme from the studies we have reviewed is that estimates of the extent of the TBTF problem tend to be higher in the crisis. So should one use estimates of TBTF effects from crisis periods or peaceful periods? Again the decision rests on what we are aiming to measure.

If we only want to know whether banks receive TBTF implicit subsidies, we would not necessarily be too concerned about cyclical variation.

If one wants to know the cost of bailouts that a government may face in the near future, it would be more appropriate to use the most recent estimates. Since a government may be most concerned about the fiscal cost of potential bailouts during a crisis, it may want to use crisis-specific estimates. Another factor may be that if the probability of bank failures is higher, investors are incentivised to put more effort into thinking about the probability of government support conditional on failure. This implies that during times of stress, market prices may be more informative.

Increases in estimates of implicit subsidies during crisis periods could also reflect shifts in investor risk aversion or other changes in market sentiment. Any judgement of whether it is desirable to capture these effects will depend on whether we are interested in the cost of implicit subsidies to the government or their value to investors.

If one is concerned about the distortionary impact TBTF status might have on a bank's risk-taking incentives, then it would be more appropriate to measure TBTF effects at the times that banks are raising debt finance. Banks might be more likely to issue debt in non-crisis periods (when their balance sheets are expanding and when it may be cheaper to issue), in which case it might be better to use estimates of TBTF effects from those periods. Alternatively, banks might choose to issue more debt when in distress in order to increase leverage and 'gamble for resurrection'. When banks tend to issue debt is ultimately an empirical question.

In summary, there are reasons for using both point in time estimates of implicit subsidies and long-run averages, which strip out cyclical variation or shifts in market sentiment. Long-run averages could be particularly useful as a means to evaluate the long-term impact of policy changes designed to reduce the TBTF problem.

Implications for stability of the supply of financial services

Thus far we have discussed how TBTF status might induce changes in riskiness at the level of an *individual bank* (which could manifest in the form of riskier assets or higher leverage). But a macroprudential policymaker might be concerned about the implications that has for the stability of the *banking system's* supply of financial services.

If TBTF banks face incentives to take excessive risks, then having TBTF banks might increase the volatility of the system's supply of financial services, such as lending to the real economy.

If a bank responds to losses by reducing lending (and substituting lower risk assets in an attempt to support its risk-weighted capital ratio), this could lead to a reduction in total lending if other banks do not increase their lending in response. Other banks might not fully substitute for the retracting bank because there are costs of expanding lending (eg the costs of hiring more staff to assess loan applicants) or because other banks lack information to assess the quality of borrowers that were previously served by the retracting bank (banks build up relationships with borrowers over time enabling them to monitor them more efficiently).

If other banks cannot substitute perfectly, larger (potentially TBTF) banks' reduction in lending would have a greater impact on the total supply of lending.

However, we might expect such effects to be present even if we have solved the TBTF problem and large banks are no longer incentivised to take excessive risks. At least in part, these macroprudential risks appear to be a potential consequence of having a concentrated banking system rather than of TBTF *per se*.

6 Ideas for future research

A wide range of approaches to estimating implicit subsidies that banks receive for being TBTF has been developed and there seems to be robust evidence that in the past large banks did benefit from substantial funding cost advantages. But we think that in the future, from a policy perspective it would be helpful to concentrate research on developing measures of implicit subsidies with two key features.

First, we may want to develop measures that can be updated on a regular basis (eg on an annual basis) in order to keep track of how funding cost advantages change over time and assess whether policies to end TBTF have been successful or how much more remains to be done.

Second, such measures should focus on the *ex-ante* moral hazard implications of TBTF rather than the expected value of bailouts. In particular, it would be helpful to keep track of the effect that implicit subsidies have on banks' risk-taking incentives. Ways to explore the relationship between implicit subsidies and risk-taking have already been proposed by

Acharya, Anginer and Warburton (2014), Alfonso, Santos and Traina (2014), and Morgan and Stiroh (2005).

Our review suggests that one should not restrict oneself to a specific approach or measure of TBTF status. In the light of the advantages and drawbacks of the different approaches, wherever possible it is desirable to use multiple approaches. This is what the Bank has tried to do (eg see Noss and Sowerbutts (2012), who use approaches based on ratings and on equity prices). The merits of using multiple approaches, of course, applies more generally to economic modelling, since no model is perfect. And one should recognise that it may never be possible to measure with absolute precision implicit subsidies received by TBTF banks.

And, if ratings are used, it would be important to test empirically how far support ratings affect banks' funding costs rather than to simply assume that the relationship is similar to that between stand-alone ratings and funding costs of non-financial firms.

Going beyond the effect of implicit subsidies on individual banks, it would be interesting to explore the links between TBTF status, the behaviour of banks and the structure of the banking system, and the aggregate supply of financial services. We believe that the potential effects of TBTF on aggregate outcomes could be of particular interest to policymakers.

References

Acharya, V V, Anginer, D and Warburton, A (2014), 'The end of market discipline? Investor expectations of implicit government guarantees', *mimeo*.

Alfonso, G, Santos, J A C and Traina, J (2014), 'Do 'too-big-to-Fail' banks take on more risk?', *Federal Reserve Bank of New York Economic Policy Review*, Vol. 20, No. 2, pages 41–58.

Araten, M and Turner, C (2012), 'Understanding the funding cost differences between globally systemically important banks (G-SIBs) and non G-SIBs in the United States', *mimeo*.

Baker, D and McArthur, T (2009), 'The value of the 'too big to fail' big bank subsidy', *mimeo*.

Balasubramnian, B and Cyree, K B (2011), 'Market discipline of banks: why are yield spreads on bank-issued subordinated notes and debentures not sensitive to bank risks?', *Journal of Banking and Finance*, Vol. 35, pages 21–35.

Bank of England (2013), *Financial Stability Report*, November, available at www.bankofengland.co.uk/publications/Documents/fsr/2013/fsrfull1311.pdf.

Basel Committee on Banking Supervision (2013), 'Global systemically important banks: updated assessment methodology and the higher loss absorbency requirement', July.

Beyhaghi, M, D'Souza, C and Roberts, G S (2014), 'Funding advantage and market discipline in the Canadian banking sector', *Journal of Banking and Finance*, Vol. 48, pages 396–410.

Brewer, E and Jagtiani, J (2011), 'How much would banks be willing to pay to become 'too-big-to-fail' and to capture other benefits?', *Federal Reserve Bank of Philadelphia Working Paper No. 11-37*.

Brierley, P (2009), 'The UK Special Resolution Regime for failing banks in an international context', *Bank of England Financial Stability Paper No. 5*, available at www.bankofengland.co.uk/research/Documents/fspapers/fs_paper05.pdf.

Davies, R and Tracey, B (2014), 'Too big to be efficient? The impact of too-big-to-fail factors on scale economies for banks', *Journal of Money, Credit and Banking*, Vol. 46, No. 1, pages 219–53.

Davison, L (1997), 'Continental Illinois and 'too big to fail', *An examination of the banking crises of the 1980s and early 1990s, Federal Deposit Insurance Corporation*, Vol 1, Chapter 7, pages 235–57.

Financial Stability Board (2011), 'Key Attributes of Effective Resolution Regimes for Financial Institutions', October.

Financial Stability Board (2012), 'Increasing the intensity and effectiveness of SIFI supervision', November.

Financial Stability Board (2014), 'Adequacy of loss-absorbing capacity of global systemically important banks in resolution: consultative document', November.

Financial Stability Board and International Organization of Securities Commissions (2014), 'Assessment methodologies for identifying non-bank non-insurer global systemically important financial institutions', January.

Haldane, A G (2010), 'The $100 billion question', available at www.bankofengland.co.uk/archive/Documents/historicpubs/speeches/2010/speech433.pdf.

Hindlian, A, Lawson, S, Murillo, J, Sadan, K, Strongin, S and Subramanian, B (2013), 'Measuring the TBTF effect on bond pricing', *Goldman Sachs Global Markets Institute*, May.

Gandhi, P and Lustig, H (2013), 'Size anomalies in U.S. bank stock returns', *Journal of Finance*, forthcoming.

International Association of Insurance Supervisors (2013), 'Global systemically important insurers: initial assessment methodology', July.

International Monetary Fund (2014), *Global Financial Stability Report*, April.

Jacewitz, S and Pogach, J (2014), 'Deposit rate advantages at the largest banks', *Federal Deposit Insurance Corporation Center for Financial Research Working Paper Series FDIC CFR WP2014-02*.

Kane, E J (2000), 'Incentives for banking megamergers: what motives might regulators infer from event-study evidence?', *Journal of Money, Credit and Banking*, Vol. 32, No. 3, pages 671–701.

Keppo, J and Yang, J (2015), 'The value of too-big-to-fail subsidy', *mimeo*.

Laeven, L and Valencia, F (2013), 'Systemic banking crises database', *IMF Economic Review*, Vol. 61, No. 2, pages 225–70.

Lester, J and Kumar, A (2014), 'Do bond spreads show evidence of too big to fail effects?', Oliver Wyman, April.

Li, Z, Qu, S and Zhang, J (2011), 'Quantifying the value of implicit government guarantees for large financial institutions', *Moody's Analytics Quantitative Research group*, January.

Mayer, T (1975), 'Should large banks be allowed to fail?', *Journal of Financial and Quantitative Analysis*, Vol. 10, No. 4, pages 603–10.

Merton, R C (1974), 'The pricing of corporate debt: the risk structure of interest rates', *Journal of Finance*, Vol. 29, No. 2, pages 449–70.

Modigliani, F and Miller, M H (1958), 'The cost of capital, corporation finance and the theory of investment', *American Economic Review*, Vol. 48, No. 3, pages 261–97.

Modigliani, F and Miller, M H (1963), 'Corporate income taxes and the cost of capital: a correction', *American Economic Review*, Vol. 53, No. 3, pages 433–43.

Molyneux, P, Schaeck, K and Zhou, T M (2010), 'Too-big-to-fail and its impact on safety net subsidies and systemic risk', *Centre for Applied Research in Finance Working Paper 09/2010*.

Morgan, D and Stiroh, K (2005), 'Too big to fail after all these years', *Federal Reserve Bank of New York Staff Report No. 220*.

Noss, J and Sowerbutts, R (2012), 'The implicit subsidy of banks', *Bank of England Financial Stability Paper No. 15*, available at www.bankofengland.co.uk/research/Documents/fspapers/fs_paper15.pdf.

O'Hara, M and Shaw, W (1990), 'Deposit insurance and wealth effects: the value of being 'too big to fail', *Journal of Finance*, Vol. 45, No. 5, pages 1,587–600.

Oxera (2011), 'Assessing state support to the UK banking sector', *mimeo*.

Penas, M F and Unal, H (2004), 'Gains in bank mergers: evidence from the bond markets', *Journal of Financial Economics*, Vol. 74, No. 1, pages 149–79.

Rime, B (2005), 'Do too-big-to-fail expectations boost large banks issuer ratings?', *mimeo*.

Santos, J A C (2014), 'Evidence from the bond market on banks' 'too-big-to-fail' subsidy', *Federal Reserve Bank of New York Economic Policy Review*, Vol. 20, No. 2, pages 29–39.

Schweikhard, F and Tsesmelidakis, Z (2012), 'The impact of government interventions on CDS and equity markets', *mimeo*.

Soussa, F (2000), 'Too big to fail: moral hazard and unfair competition?', chapter 1 in *Financial stability and central banks: selected issues for financial safety nets and market discipline*, Bank of England.

Stern, G H and Feldman, R J (2004), *Too big to fail: the hazards of bank bailouts*, Brookings Institution Press.

Tsesmelidakis, Z and Merton, R C (2012), 'The value of implicit guarantees', *mimeo*.

Ueda, K and di Mauro, B W (2013), 'Quantifying structural subsidy values for systemically important financial institutions', *Journal of Banking and Finance*, Vol. 37, No. 10, pages 3,830–42.

Veronesi, P and Zingales, L (2010), 'Paulson's gift', *Journal of Financial Economics*, Vol. 97, No. 3, pages 339–68.