OECD Journal: Financial Market Trends
Volume 2016/1

Estimating the size and incidence of bank resolution costs for selected banks in OECD countries

by
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This report provides estimates of the costs associated with bank resolution both in terms of the expected costs that might arise should a bank fail (i.e. as "ex-post" costs), as well as the cost associated with the likelihood that a solvent bank might fail (i.e. as "ex-ante" costs) over the next year. It finds that expected resolution costs (ex-post costs) have dropped recently due to higher average capital ratios and a lower level of bank liabilities as a percentage of GDP. The annualised value of these expected resolution costs (ex-ante costs), which increased sharply after 2008, has since subsided, but remains well above its 2008 level. Overall, the estimates produced in this report support the notion that recent financial sector reforms have had an impact on reducing the costs associated with bank failure, including the expected costs to taxpayers. However, estimates are in most cases yet to return to pre-crisis levels.

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Executive summary

Since the onset of the global financial crisis, the issue of bank resolution has received continued attention from policymakers and market participants alike. This report provides estimates of the costs associated with bank resolutions – both in terms of the expected costs that might arise, should a bank fail, (i.e. as "ex-post" costs), as well as the annualised cost associated with the likelihood that a solvent bank might fail (i.e. as "ex-ante" costs). Besides assessing the magnitude of these costs, this report also provides estimates of the share of resolution costs that would be borne by bank creditors and taxpayers. Taxpayers are expected to be concerned only if implicit government guarantees are perceived to be material.

There are many ways in which these cost estimates could be produced. The present report uses two different estimation strategies. The first approach uses cross-sectional information for some specific years and is based on the binomial options pricing model, as applied by Snethlage (2015) to systemically important banks in New Zealand. The second approach uses contingent claim analysis to draw inferences from financial market data available at relatively high frequency, measuring the risk and costs associated with bank failures over time. In this report, the contingent claim analysis has been applied by the Swedish National Debt Office to produce estimates for large Swedish banks that are presented as a case study. A third approach, based on the European Commission's SYMBOL model, is applied to European banks in the companion article "Reducing and sharing the burden of bank failures" (Cariboni et al., 2016).

The results in the present report are based on a sample of 212 large and medium-sized banks based in 25 OECD countries across the years 2008-14. The main findings are as follows:

- Expected resolution costs (ex-post costs) for all banks in the sample have averaged at just over 7% of GDP over the sample period. However, this measure dropped to 6% of GDP as at 2014 due to higher average capital ratios and a lower level of bank liabilities as a percentage of GDP.
- The annualised value of these expected resolution costs (ex-ante costs) increased sharply after 2008, reaching a peak of 0.24% of GDP in 2012. While this measure has since subsided, it remains well above its 2008 level.
- Estimated implicit guarantees rose significantly between 2008 and 2009, reflecting increases in the risk of bank failure and the likelihood of government support. Total implicit guarantees are estimated at 0.15% of sample countries' GDP as at 2014, below the estimated peak of 0.18% of GDP in 2012.
- Taxpayers, as opposed to bank creditor, estimated exposures to bank resolution costs (implicit contingent liabilities) have declined steadily since 2009 to around 4% of GDP, but

continue to represent over half of the total exposure to estimated resolution costs for banks in the sample.

Overall, the estimates produced in this report support the notion that recent financial sector reforms have had an impact on reducing the costs associated with bank failure, including the expected costs to taxpayers. However, estimates are in most cases yet to return to pre-crisis levels. We would expect these indicators to continue to improve as reforms bed in and crisis-affected economies continue to recover, though continued monitoring of these measures would help verify whether this will be the case.

I. Introduction

Events over recent years have illustrated that systemic banking failures can entail substantial fiscal costs and that the expectation of government support creates distortionary implicit guarantees for systemically important banks.

In response, the regulatory reform agenda has focussed on reducing taxpayers' exposure to the costs of banking failures, and on reducing implicit guarantees of bank debt. The policy rationale for transferring bank failure risk to creditors is well established. Among other things, the use of bail-outs as opposed to bail-ins, reinforce expectations that implicit guarantees exist, which in the case of bank debt can have severe adverse real economic costs (see *e.g.* Denk et al, 2015). Providing a viable alternative to bail-outs also help to reduce implicit contingent liabilities on sovereign balance sheets.

It is important to realise though, that the reduction or elimination of implicit guarantees does not eliminate the direct costs associated with bank failure (see also especially the companion report "Reducing and sharing the burden of bank failures", Cariboni et al., 2016). Regardless of how banks are resolved, bank failures will entail a cost that must be borne by somebody. Bail-in tools developed in recent years aim at ensuring that creditors – not taxpayers – are liable for the cost of resolving failed banks. They transfer risk, but do not eliminate it.

The present report is motivated by an interest in understanding both the magnitude and the incidence of the various costs and risks associated with bank failure and in monitoring how they evolve over time as regulatory reforms are designed and gradually implemented. The report presents estimates of these quantities from two different estimation strategies. The first approach uses cross-sectional information for some specific years and is based on the binomial options pricing model, as applied by Snethlage (2015) to systemically important banks in New Zealand. The second approach uses contingent claim analysis to draw inferences from financial market data available at relatively high frequency, measuring the risk and costs associated with bank failures over time. In particular, the contingent claim analysis is applied to Sweden as a case study. The advantage of using two different strategies to track estimates of the magnitude of bank failure resolution costs over time is that the results obtained will be less dependent on the strengths and weaknesses of any particular model.

When looking at the expected incidence of bank failure resolution costs between taxpayers and bank creditors, the report bases its estimates on publically available information contained in bank credit ratings. However, it is acknowledged that the likelihood of taxpayer support for a given bank in a given jurisdiction is highly uncertain and subjective, and that communication of estimates is challenging.[1] Accordingly, the estimates discussed here should not be seen as official estimates and judgements around

the size of implicit guarantees. If realised, any pay-outs from contingent liabilities are the responsibility of individual jurisdictions to make.

The results presented here complement the companion report (Cariboni et al., 2016) results regarding simulated government contingent liabilities arising from the banking sector via the SYMBOL model, a well-established tool applied by the European Commission to prepare quantitative analyses supporting the preparation of the Commission's legislative initiatives. While SYMBOL is used in particular to estimate *ex-post* costs of a potential banking crisis and the impact of alternative regulatory settings in EU member countries, the present note considers a geographically wider set of countries and places a sharp focus on the evolution over time of the distribution of bank failure costs between taxpayers and bank creditors based on estimates of implicit bank debt guarantees.

Estimates presented in the present report have several valuable uses for policymakers. Firstly, they allow one to assess the impact of recent regulatory reforms in terms of the reduction in the failure risk and implicit/explicit guarantees associated with systemic banks, as perceived by market participants. Secondly, they provide a basis for analysing the potential impacts of bail-in in terms of expected losses for bank creditors as well as bank funding costs. They also provide an indication of the size of any implicit guarantees and contingent liabilities that may remain on government balance sheets should a particular country deem that bank bail-outs remain a possibility.

The remainder of this report is structured as follows. Section II presents the conceptual framework that is used in considering the cost and incidence of the risks associated with systemic bank failure. Section III describes the data set used for the analysis presented in the report. Section IV presents estimates of the cost and incidence measures across the years 2008-14, and discusses how these estimates have evolved over this period. Section V introduces the conceptual framework of the contingent claim approach and shows alternative resolution cost estimates for the case of Sweden during the period 2006-15. Finally, Section VI provides some concluding remarks.

II. Conceptual framework

Building on Snethlage (2015), the present report utilises the definitions below to conceptualise the various costs and risks associated with bank failure. At the outset, it should be noted that these concepts only relate to the direct financial costs and risks, as opposed to the broader economic externalities that are often associated with systemic banking crises, such as the cumulative output loss attributable to banking sector distress.

Cost measures

There are two general ways to place a "cost" measure on the risk associated with bank failure: as an *ex-post* cost, or as an *ex-ante* cost. These terms can be defined as follows.

Ex-post costs

The *ex-post* cost of bank failure is a measure of total resolution costs. It can be defined as the direct financial cost for resolving a bank after it has failed. In other words, ex-post is equivalent to the immediate cost that would be required to return an insolvent bank to the point where it is solvent again, in that the market value of its assets is at least equal to its total liabilities (i.e. a zero net-asset position). In this case, the bank's assets will be just sufficient to ensure that the bank could meet all of its financial obligations as they fell due,

provided it could access the necessary liquidity in the interim. It is useful to distinguish between bail-in and bail-out.

If a failed bank is resolved through a bail-in of bank creditors, the *ex-post* cost is equivalent to the total value of debt that is written down or written off, less the fair value of any equity that is received in exchange for bailed-in debt. The *ex-post* cost may also include pay-outs made by deposit guarantee schemes, resolution funds, or national treasuries that involve losses being borne on behalf of creditors.

If a bank is resolved through a bail-out, the *ex-post* cost is equivalent to the total amount of equity capital provided less the fair value of this equity at the point of bail-out. In reality, this fair value will be very difficult to assess, even if equity is subsequently sold off.[2] However, this definition of cost presents a theoretical value of the cost to taxpayer of bailing out a failed bank.

For the large part, the *ex-post* cost of bank failure is the same regardless of whether a bank is resolved through bail-out or bail-in. However, this assumes that choice of resolution tool does not affect the size of the total losses faced by the bank. Both bail-out and bail-in may, in certain circumstances, have different effects on financial markets, other financial institutions, and broader economic activity. This, in turn, may affect the extent of losses faced by the failed bank and therefore the *ex-post* cost of its failure.

Ex-ante costs

Bank failures do not occur often but with some regularity throughout modern banking. As such, the *ex-post* measure defined above is a relatively poor measure of the amount of risk that exists outside of banking crises. However, even if a bank does not fail in a given period, this does not mean that there was no risk *ex-ante* that a bank *might* have failed in that period. This financial risk – like any financial risk – has an associated financial cost to whoever bears the risk. So even if failure does not end up occurring in a given period, there was risk – and therefore a cost – that was borne by somebody (either explicitly or implicitly).

The *ex-ante* cost of bank failure refers to the amount of financial risk associated with the fact that a bank might fail in a given 12-month period. In other words, it represents the value of a bank's expected *ex-post* cost defined above that is adjusted for the risk-adjusted probability of bank failure occurring in that 12-month period.

In theory, the financial risk associated with bank failure is borne by a bank's unsecured creditors, who bear the *ex-ante* cost of that bank's failure. To be willing to bear this risk, creditors are in turn compensated through a yield or interest rate on their investment in the bank that is higher than what they would expect to receive on an equivalent risk-free investment. As such, the *ex-ante* cost is effectively transferred back to the bank through a higher funding cost that reflects the risk that the bank may fail in a given period. Even then, banks may pass much of this cost onto borrowers through marginally higher interest rates on lending.

The situation where the ex-ante cost of bank failure is borne by banks and their borrowers can be seen as desirable, as it acts to mitigate moral hazard. This is because those who create (deliberately or inadvertently) risk in the banking sector also face the cost of the risk that they create. It is well established that the avoidance of moral hazard helps promote the soundness and efficiency of the banking system.

Incidence measures

The cost measures defined above do not attempt to reflect the incidence of the risk of bank failure across taxpayers and bank creditors. We define "implicit contingent liability" and, "implicit guarantee" to represent taxpayers' share of the *ex-post* and *ex-ante* costs, respectively.

Implicit contingent liability

The implicit contingent liability associated with the failure of a given systemic bank refers to the implicit risk to sovereign balance sheet that crystallises in the event that governments choose to provide extraordinary public support to a failed or failing bank.[3] Payments made by industry-funded resolution funds or deposit insurance schemes are not considered to be part of this implicit contingent liability given that they represent explicit exposures, and that costs are, in the first instance, borne by industry, over time.[4]

The expected size of this contingent liability can be thought of as the expected fiscal cost of a systemic bank failure, should a bank fail. In other words, this cost represents the portion of *ex-post* cost that governments would expect to bear, on average, in the event of a bank's failure. As such, the size of the fiscal contingent liability is some percentage (between 0% and 100%) of the total *ex-post* cost of bank failure.

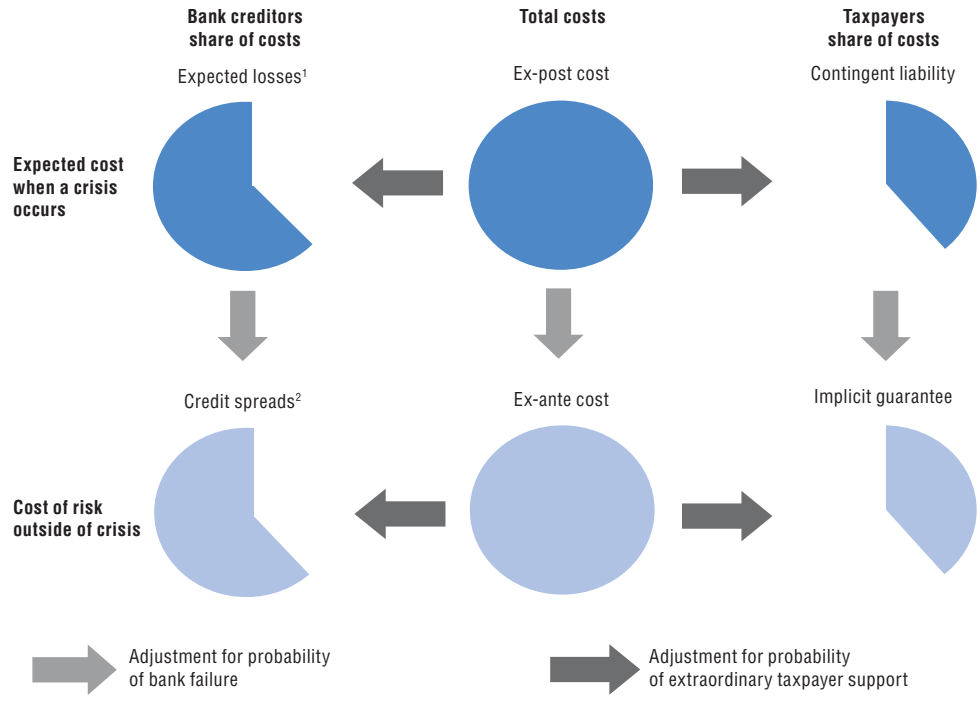
Implicit guarantee

Historically, systemic banks have often benefited from implicit government guarantees. When there is an implicit guarantee for a systemically important bank, sovereign balance sheets are seen as effectively bearing the financial risk of that bank's failure on behalf of that bank's creditors. As such, the implicit guarantee can be thought of as some percentage (between 0% and 100%) of the *ex-ante* costs of bank failure that is borne (implicitly) by taxpayers instead of investors. Alternatively, the implicit guarantee can be thought of as the *ex-ante* value of the fiscal contingent liability defined above. In either case, the implicit guarantee measures taxpayers' implicit share of the financial risk of bank failure.

Because implicit guarantees reduce creditors' exposure to risk, they reduce the compensation that creditors require on their investments, resulting in an implicit taxpayer subsidy for systemic banks. This bank's funding cost does not fully reflect the level of risk banks take and may encourage greater risk taking that would be the case without implicit guarantees. It may also provide a competitive advantage for those banks deemed to be implicitly guaranteed, as earlier work by the OECD Committee on Financial Markets (CMF) concluded.

It is now well-established that implicit guarantees can result in an implicit subsidy for banks on their cost of funding. The distinction between the two measures is that the implicit guarantee reflects the implicit cost to taxpayers, whereas the implicit subsidy reflects the benefit this implicit guarantee brings to banks. So while the size of this implicit subsidy and the size of the underlying implicit guarantee are closely related, they need not be the same. For example, if an implicit guarantee results in credit rating uplifts, this may offer banks additional funding cost benefits than what can directly be attributable to the credit risk borne implicitly by taxpayers.

Figure 1. **Relationship between the different cost concepts**



1. Including any losses borne by industry funded deposit insurance scheme or resolution funds on behalf of bank creditors.
2. Including any applicable deposit insurance premiums and resolution levies.

Source: Authors' compilation.

III. Data and methodology

The first approach adopted in this paper uses a sample of 212 OECD-based banks (see Annex A1). Data on bank balance sheets and credit ratings are collected from Bankscope (where data was not available through Bankscope, it was collected from individual bank financial statements) at year-end dates in the 2008-14 period. The range of dates implies that estimates would be available, broadly speaking, before (the peak of) the global financial crisis, around its peak and also for a more recent period when data should already reflect most of the effects of the bank regulatory reform.[5]

Table 1. **Descriptive statistics for sample of banks**

	2008	2009	2010	2011	2012	2013	2014
Number of banks[1]	183	188	207	209	210	208	201
Total bank assets							
USD billions	46,026	47,870	53,327	55,997	55,827	54,835	50,718
% of sample countries' GDP	113%	120%	129%	130%	126%	121%	108%
Average bank size							
USD billions	252	255	258	268	266	264	252
% of sample countries' GDP	21.2%	22.0%	22.5%	22.7%	21.8%	21.0%	18.5%
Average standalone credit rating							
Moody's rating	A2	Baa1	Baa1	Baa1	Baa2	Baa3	Baa3
Index (Aaa=20)	14.4	13.0	12.6	12.2	11.2	10.9	10.9
Average rating uplift (notches)	2.5	3.1	3.0	2.5	2.7	2.8	2.7
Average equity/assets	5.5%	6.4%	6.5%	5.9%	6.3%	6.9%	7.0%

1. The number of banks in the sample is lower in 2008 and 2009 where data is unavailable for the 15 banks from Canada and South Korea. Collectively, these banks represented 7.5% of total assets in the sample in 2010.

Source: Authors' compilation.

The estimates are generated using an adaptation of the binomial options pricing model of Cox, Ross, and Rubenstein (1979), where the risk of bank failure is seen as analogous to that under a financial option on a bank's assets that pays off if the bank becomes insolvent. Following Snethlage (2015), this enables the various cost concepts to be estimated as follows:[6]

$$\text{E(ex-post cost)} = \text{E(loss-given-default)} \times \text{total liabilities} \quad (1)$$

$$\text{Ex-ante cost} = \text{E(ex-post cost)} \times \text{risk-neutral probability of failure} \quad (2)$$

$$\text{Implicit contingent liability} = \text{E(ex-post cost)} \times \text{probability of bail-out} \quad (3)$$

$$\text{Implicit guarantee} = \text{ex-ante cost} \times \text{probability of bail-out} \quad (4)$$

Cost estimates are firstly calculated on a per-bank basis, and then aggregated across banks for a given country. Country-level estimates expressed as a percentage of domestic GDP are summarised in Annex A3.[7] These estimates are then averaged across countries both on a GDP-weighted and an evenly-weighted basis for reference.

IV. Cost estimates

Expected ex-post costs

The expected *ex-post* costs for the banks in the sample are estimated by multiplying each bank's total liabilities by an estimate of the loss-given-default (LGD) that bank is expected to face in resolution. The expected loss rate for a given bank is not directly observable, so it is necessary to develop an approach to estimate a banks' LGD based on bank characteristics. The first approach used in this report is summarised in Box 1 and discussed in details in Annex A2. The contingent claim approach is addressed in Section V with a technical summary in Annex A4.

Estimates of expected *ex-post* costs according to the first approach are presented in Figure 3 below. These costs have stayed relatively constant across the sample period, given that expected loss rates given failure, and bank liabilities as a percentage of GDP have stayed relatively steady over the sample period. However, general increases in bank capital ratios and reductions in the size of major banks across European countries in particular have contributed to a noticeable decline in those expected resolution costs in recent years.

Ex-ante costs

To measure the level of risk associated with the likelihood of banks failing in a given period, we estimate e*x-ante* costs by multiplying expected *ex-post* cost for a given bank by that bank's risk-neutral probability of failure (RNPF).[8] Using RNPFs accounts firstly for the likelihood of that bank failing. It also accounts for risk aversion, reflecting the tendency for bank failures to coincide with downturns in markets and broader economic activity. Because the risk of bank failure entails a degree of systematic risk (i.e. non-diversifiable risk), the risk of bank failure "costs" more to society than expected losses alone. It is therefore important to adjust for this systematic risk when estimating the *ex-ante* costs associated with bank failure. For this reason, this paper uses RNPFs to account for this systematic/non-diversifiable risk. The methodology used to estimate these RNPFs across credit ratings, and across the sample period, is summarised in Box 2. In the contingent claim approach, RNPFs are derived endogenously and therefore does not need to be estimated outside the model. We will return to this later in the report.

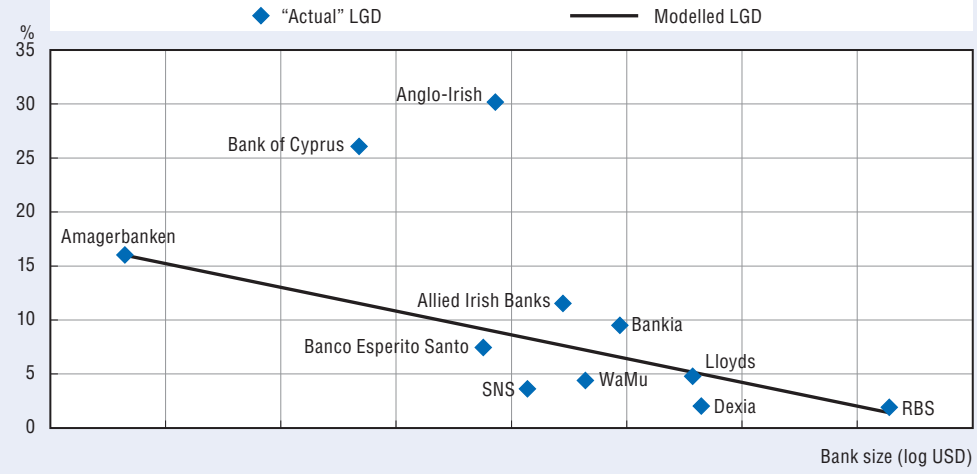
Box 1. **Estimating bank-specific expected loss rates**[1]

To provide a systematic basis for estimating LGDs for OECD-headquartered banks, this paper draws on both historical loss rates for failed banks (a backward-looking view), and credit spreads based on bank bond prices (a forward-looking view). A more in-depth discussion of this information is presented in Annex A2. For the purpose of this paper, bank-specific LGDs are estimated using the following specification:

$$LGD = 0.38 - 0.022 \cdot \ln(Assets) - 0.67 \cdot \frac{Equity}{Assets}$$

In basic terms this specification means that, the larger the bank is, and the higher the bank's capital ratio, the lower the loss rate for a given bank is expected to be as a percentage of total assets. Larger banks are generally expected to face lower loss rates given greater diversification geographically and across exposures and business lines. Banks that are better capitalised are also expected to face lower loss rates given that, for any given shock, there is more capital available to absorb losses (though the impact of debt is largely reflected in the probability of failure as opposed to the cost of failure if failure occurs). Unfortunately, we were not able to identify a specification that could account for structural differences in the riskiness of bank assets across banks and across countries.

Figure 2. **Estimates of LGDs from recent bank resolutions**



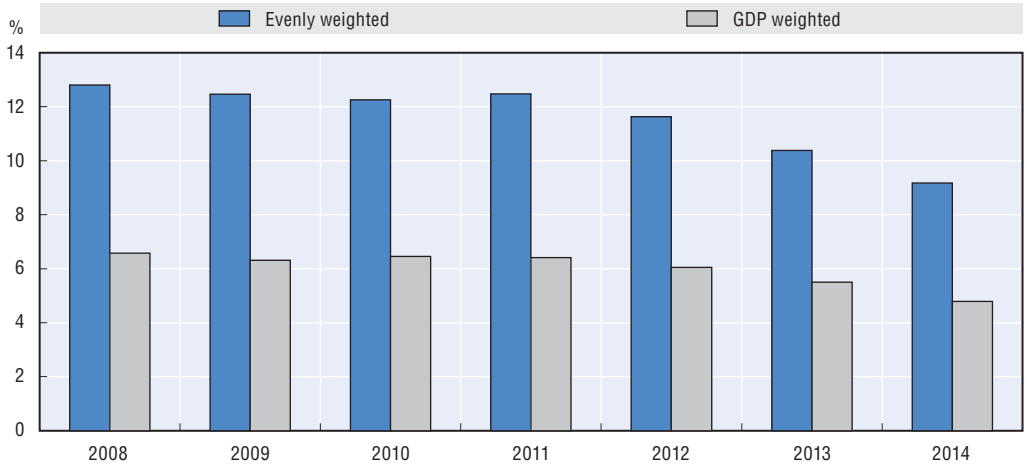
Source: Authors' calculations.

As illustrated in Figure 2, the specification above appears to provide a reasonable fit for the loss rates experienced in recent notable bank failures. However, the cases of Anglo-Irish Bank and Bank of Cyprus[2] highlight that even if expected LGDs are relatively low, the actual losses experienced can be much higher in particularly severe failure scenarios.

1. The negative relationship between size and LGDs implies that mergers between banks would *ceteris paribus* reduce the estimated *ex-post* costs. However, this does not account for impact that higher banking sector concentration could have on the indirect costs of bank failure to the broader economy and financial system as well as the effect on risk-taking by larger banks that tend to benefit from more substantial implicit guarantees. Greater risk-taking might not only affect the probability of default but also the LGD. Despite these shortcomings of the approach adopted here, we believe that it provides a somewhat more realistic description of LGD in practise than the standard approach of just assuming a fixed rate of LGD.
2. *Note by Turkey:* The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".
Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Figure 3. **Estimates for aggregate expected *ex-post***

As a percentage of GDP, averaged across OECD countries

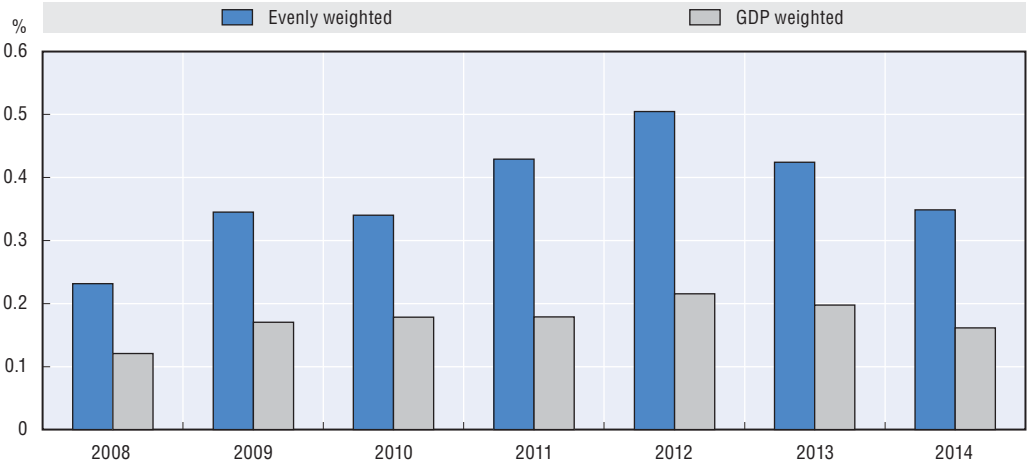


Source: Authors' calculations.

Estimates of the *ex-ante* cost of bank failure derived from the first approach are summarised in Figure 4 below. The estimated cost of bank failure risk exhibited a significant increase between 2008 and 2009, largely due to an increase in the probability of failure across this period. The increase between 2010 and 2013 was driven largely by further increases in bank failure risk in the European Union, in particular among countries such as Greece, Portugal, and Italy. The reduction in measured risk between 2013 and 2014 is largely attributable to a reduction in expected resolution costs, though a reduction in the probability of failure reflected in improving bank credit ratings was also a factor.

Figure 4. **Estimates for aggregate *ex-ante* costs of bank failure**

As a percentage of GDP, averaged across OECD countries



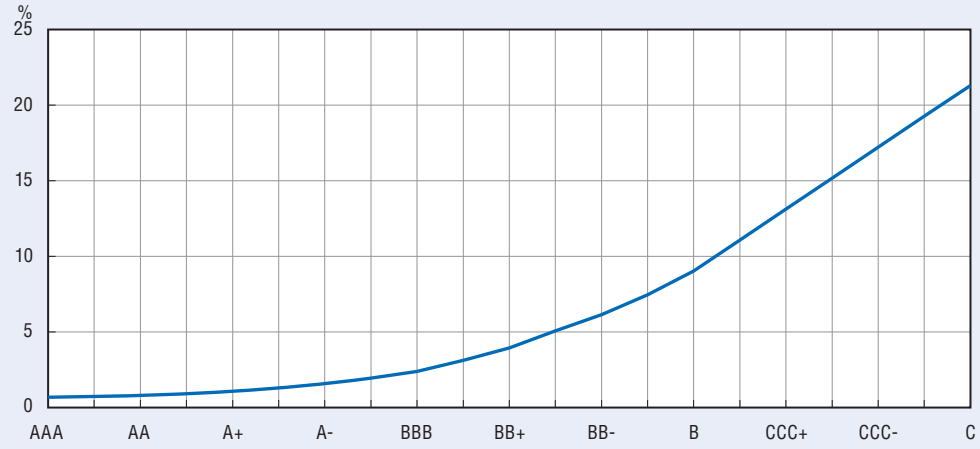
Source: Authors' calculations.

Box 2. **Estimating bank-specific risk-neutral default probabilities**

To estimate a bank's risk-neutral probability of failure (RNPF) in a given period, we map their standalone credit rating against the estimates of risk-neutral default probabilities in Hull, Predescu, and White (2005). These estimates were produced based on the basic intuition that the spread between the yield of a corporate bond and a risk-free security with similar maturity and liquidity represents the market's assessment of the credit risk associated with that bond. This credit risk can be broken down into two components: the bond's probability of default, and the bond's expected loss-given-default. Because of investors' aversion to systematic risk, the probability of default built into bond prices is analogous to the RNPF defined above. Standalone credit ratings are used given that we are interested in the implied probability of failure, which may be higher than the implied probability of default in the case of expectations of extraordinary government support.

The RNPFs used in this paper are presented in Figure 5 below. Note that this analysis assumes a fixed relationship between credit ratings and RNPFs. Using a time-varying relationship would see estimated RNPFs fluctuate over time with market sentiment, but may not provide as accurate an estimate of the level of long-term risk.

Figure 5. **Estimates of RNPFs across credit ratings**



Source: Hull, Predescu, and White (2005).

These probabilities are based on data between 1970 and 2003. To test their applicability, we estimate RNPFs over the period July 2010 to June 2015 using Bloomberg composite indices for liquid US dollar corporate bonds across AAA, AA, A, BBB, BB, and B credit ratings. On a monthly basis, we take the spread between five-year index rate and the five-year US dollar swap rate. We then divide this spread by the 60% rule-of-thumb LGD for corporate bonds to estimate a monthly RNPF for each credit rating. Averaging these monthly across the sample yields very similar RNPF estimates to those produced by Hull et al. We therefore consider the Hull et al. probabilities to be suitable for the purposes of the present analysis.

Implicit guarantees

Implicit guarantees can be thought as the share of the *ex-ante* costs of bank failure that governments bear on behalf of banks and their creditors. Translating *ex-ante* cost estimates into implicit guarantee estimates therefore requires an adjustment for the expected

probability of extraordinary taxpayer support to prevent unsecured creditors bearing losses in the event of a bank's failure (i.e. the probability of bail-out).

The probability of a given bank being bailed out cannot be directly observed. In reality it is highly uncertain what actions future governments will take in a crisis. The present paper does not attempt to make a subjective judgement around the likelihood of bailout for given banks in given jurisdictions. Instead, we follow Snethlage (2015) in backing out an implied probability of bail-out from the credit rating uplifts banks receive for the likelihood of government support in the event of their failure. This methodology is summarised in Box 3.

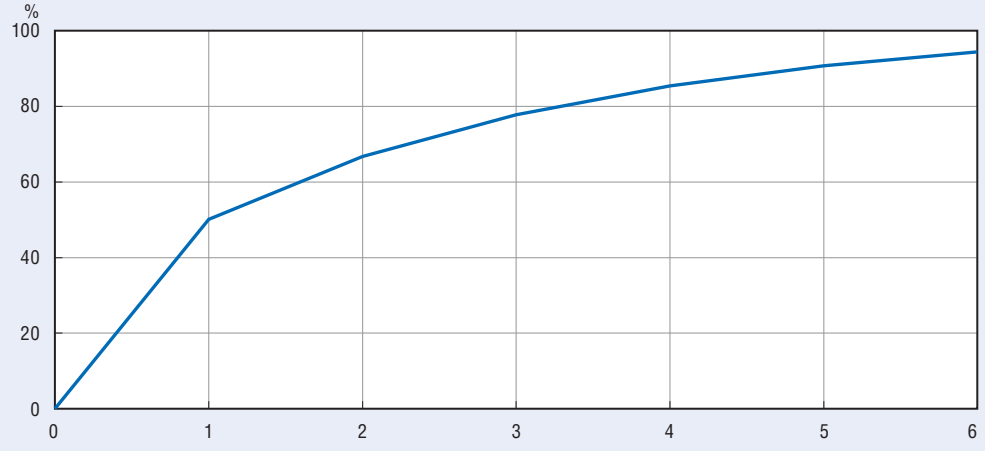
Box 3. **Estimating bank-specific probability of bail-out**

The likelihood of taxpayer support for banks is extremely subjective and highly uncertain. However, it is now well-established that bank credit ratings can provide useful information about the level of (perceived) implicit government support for banks (see, for example, Haldane, 2010; Schich and Lindh, 2012). This situation reflects the observation that credit rating agencies factor in the likelihood of government support into corporate credit ratings, and provide ratings uplifts to those banks for which government support is considered likely.

Bank credit rating uplifts are calculated for each bank in the sample as the number of notches between a bank's standalone credit profile and a bank's long-term issuer rating (where this is not available, we use senior unsecured debt ratings. If this is not available, we use long-term foreign currency deposit ratings). If data is unavailable, or if standalone ratings are higher than long-term issuer ratings, ratings uplift is set to zero.

To translate ratings' uplifts into estimated bail-out probabilities, this paper uses the relationship from Snethlage (2015), which is presented in the chart below. These probabilities are based on the ratio between the implied probability of failure (based on standalone credit ratings) and the implied probability of default (based on "all-in" credit ratings).

Figure 6. **Estimates of bail-out probabilities based on credit rating uplifts**

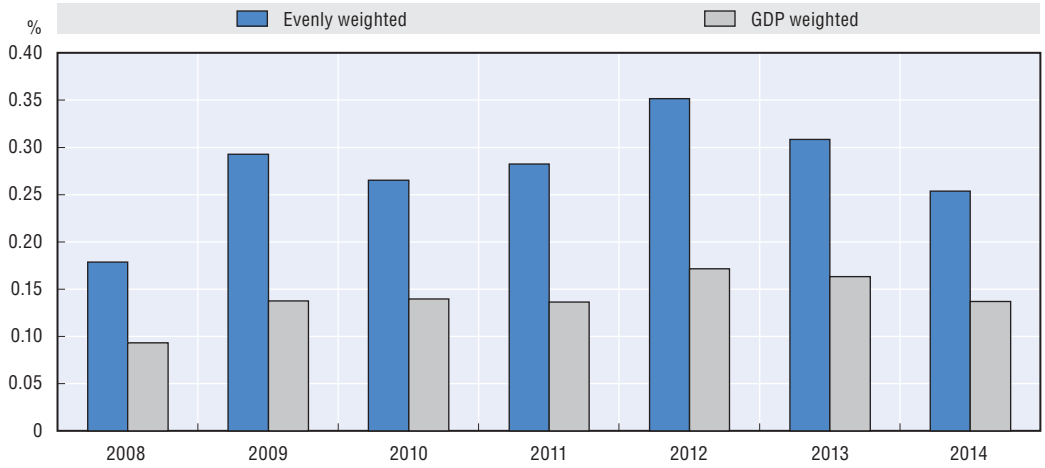


Source: Snethlage (2015).

Estimates of implicit guarantees aggregated across our sample OECD banks are presented in Figure 7 below. The estimated risk to taxpayers associated with implicit bank guarantees almost doubled between 2008 and 2010, due to increasing bank failure risk, and increases in expectations of public support for banks. Implicit guarantees continued to rise between 2010 and 2013, largely due to an increase in the aggregate risk of bank failure as implied by declining bank credit ratings. However, implicit guarantees have since fallen to below the levels seen in 2010, noticeably in countries which have been among the early adopters of bail-in regimes.[9]

Figure 7. **Estimates of implicit guarantees**

As a percentage of GDP, averaged across OECD countries



Source: Authors' calculations.

In general, changes in implicit guarantees under this methodology are driven by four factors:

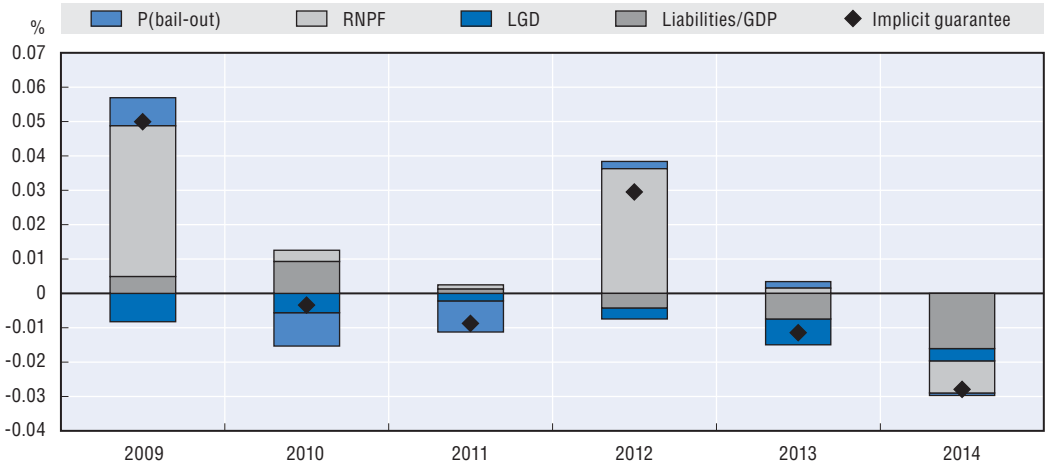
- *Probability of government support (p(bail-out))* – if governments are seen as more supportive of banks (e.g. due to past actions to support banks), this increases banks' credit ratings uplifts and therefore the estimates of implicit guarantees. Similarly, if governments are seen as less likely to bail-out banks (e.g. due to a reduction in sovereign creditworthiness, or announcements around bail-in policies), ratings uplifts and estimated implicit guarantees will decrease.
- *Risk-neutral probability of failure (RNPF)* – if the risk-adjusted likelihood of bank failure increases, so too does the present value of potential government support and therefore the estimated size of implicit guarantees.
- *Loss-given-default (LGD)* – if banks expected loss rates in insolvency increase (e.g. due to falling capital ratios or shrinking balance sheets), so too does the expected cost of bank resolution and therefore the estimated size of implicit guarantees.
- *Bank liabilities to GDP* – if bank's indebtedness grows relative to the size of the economy, so too do expected resolution costs and therefore estimates of implicit guarantees

To examine what has been driving changes in estimated implicit guarantees between 2008 and 2014, Figure 8 decomposes the change in total implicit guarantees (as a percentage of GDP) into changes in these four components. The large increases in estimated implicit guarantees between 2008-09 and 2011-12 were mostly driven by an

increase in the probability of bank failure (i.e. RNPF). An increase in the perceived probability of government support also added to the increase in implicit support between 2008 and 2009. However, perceptions of government support subsequently fell, quite possibly in response to the refinement of bank failure resolution regimes in many and the deterioration in sovereign strength in some countries.[10] Part of the decline in implicit guarantee estimates since 2012 has been due to increased capital ratios (which reduce both total liabilities and expected LGDs). However, most of the change has been attributable to the shrinking of bank balances sheets relative to GDP.

Figure 8. **Decomposition of changes in implicit guarantee estimates**

As a percentage of GDP



Source: Authors' calculations.

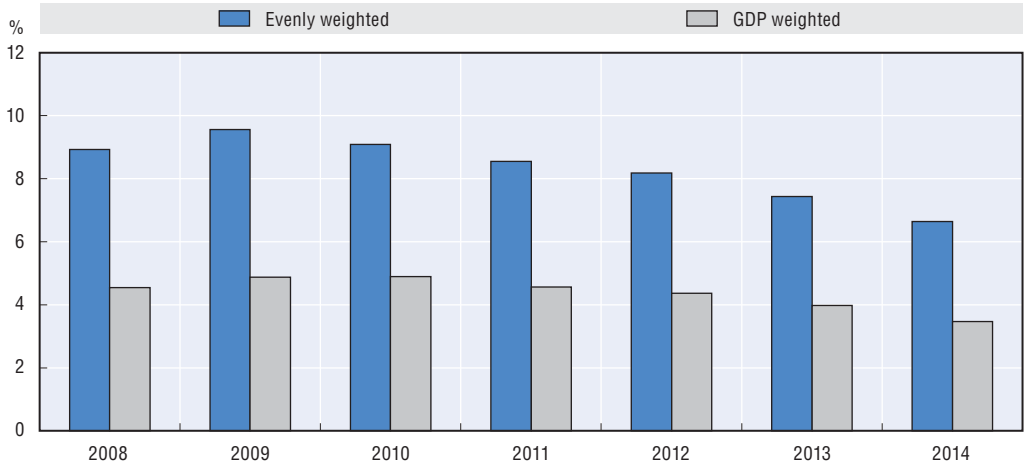
Implicit contingent liabilities

The implicit guarantee estimates presented above give an indication of the risk that taxpayers bear outside of crises (i.e. *ex-ante*). However, they provide a relatively poor indication of the cost to taxpayers that may actually result in the event of bank failure because of the large upfront costs associated with bank bail-outs. Measures of the implicit contingent liability provide a better indication of the gross exposure to taxpayers. For a given bank, this gross exposure can be thought as the expected cost to taxpayers in the event of that bank's failure. In practice, this can be calculated by multiplying the expected *ex-post* costs estimates by the assumed probability of bail-out for that bank.

Estimates of implicit contingent liabilities aggregated across our sample OECD banks are presented in Figure 9. These estimates relate closely to the expected resolution costs discussed earlier. In general, the expected cost to taxpayers resulting from implicit guarantees has not been as volatile as the risk to taxpayers. However, we do see that attempts to reduce the need for government support of failed or failing banks have helped reduce taxpayers risk exposure since its peak during the global financial crisis.

Figure 9. **Estimates of implicit contingent liabilities**

As a percentage of GDP, averaged across OECD countries



Source: Authors' calculations.

V. Bank resolution costs under the contingent claim approach[11]

This section draws on results from an alternative estimation approach, the so-called "contingent claim approach", using a subset of the data considered in the first approach.[12] The contingent claim approach uses information contained in financial market prices.[13]

The use of financial market price data conveys a number of attractive features. Market prices reflect the aggregate expectations of actual investors in the market and, at least for larger banks, they are almost continuously available. Thus, they can provide a timely and forward-looking measure of risks. In addition to that, if considering this approach, the probability of bank failure, as well as the ex-post cost of bank failure, are derived endogenously and do not need to be estimated outside the model.[14] Besides, under this approach, the definition of bank failure is explicit, that is a bank fails when the market value of its assets falls below a critical threshold.[15]

Like in the binomial approach – the first approach presented in this report, the ex-ante cost of bank failures is computed through multiplying the probability of bank failure by the loss that the bank would make if failure were to occur. Although the market value of bank assets is not directly observable, it can be derived from the equity value, whereas the uncertainty surrounding the asset values can be computed from the volatility of equity. Data on the market value of bank equity and its volatility are readily available for most of the OECD countries.

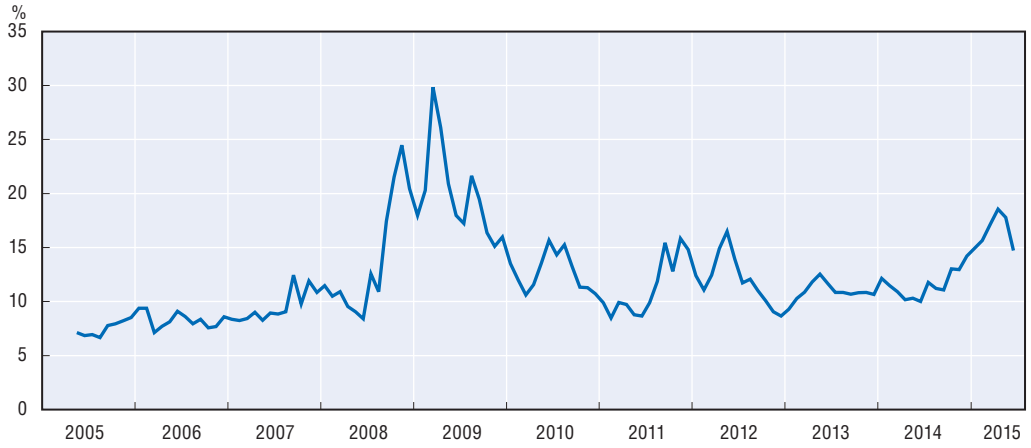
An application of the contingent claim approach to the Swedish bank sector

The contingent claim approach is applied to Sweden as a complement to the binomial approach used before. The contingent claim approach requires equity values and equity volatility data, which are available at daily frequency.[16] Sweden is a good example also because its banking sector is large as a share of GDP, thus making a banking failure potentially very costly; although the banking sector is well capitalised by international standards. It is worth noticing that the results shown here may not fully reflect the impact of the regulatory reforms that were launched in the wake of the global financial crisis to limit resolution costs and implicit bank guarantees.[17]

Expected ex-post costs

Estimates of the expected *ex-post* cost for Sweden are shown in Figure 10. The estimated loss for the aggregate Swedish banking sector increased significantly during 2008-10, to reach about 30% in terms of GDP at its peak. Since then it has declined substantially and stayed in a range between 10-15% on average, yet it remains above the levels prior to 2008. The increase in 2011-12 should be viewed against the growing strains in European financial markets and possible concerns about the vulnerability and exposure of Swedish banks to their European counterparts. More recently, the renewed turbulence in European markets is reflected in the increase of estimated *ex-post* cost. Thus, should the banking sector fail, the losses attributable to non-equity holders in June 2015 would be equivalent to an estimated (around) 15% of GDP.[18]

Figure 10. **Estimates of the aggregate expected ex-post cost for Sweden**
As a percentage of GDP, 2005-15



Source: Authors' calculations.

Ex-ante costs

The *ex-post* cost is the total amount of the loss incurred by the banking sector, if the whole sector fails with certainty. The overall implied *ex-ante* cost is calculated for each bank by multiplying the probability of failure by the loss that the bank would come about if it fails (i.e., the ex-post cost) and then aggregating the individual ex-ante costs across banks.

It is assumed here, following standard practise in contingent-claims applications, that a bank fails when the value of its assets does not meet the amount of debt owed to its creditors at maturity. The evaluation of bank future assets requires the estimation of asset volatility, which is done by using the volatility of the bank equity options and a scaling factor, which takes the bank leverage into account. One distinct advantage of using option prices is that they incorporate information about investors' views on future development of the bank value. For example, an increase in equity volatility means that the investors view a bank failure more likely to happen in the next 12-month period and, as a result, the estimated *ex-ante* cost increases.[19] The nature of options imply that the cost measures derived from their prices under the contingent claims approach are sensitive to near-term changes in the perceived risk of failure. Particularly at times of impending stress, the estimated cost measure might provide a timely signal of heightened risk that

complements the measure derived under the binomial approach, which is less noisy but adapts more slowly to changing market conditions.

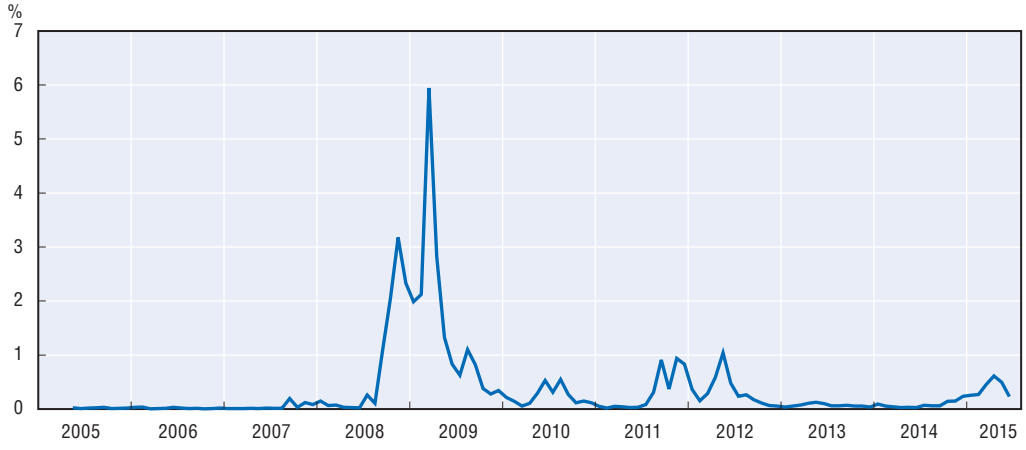
In Sweden, the *ex-ante* cost grew significantly between 2008 and 2009, driven by a sharp rise in the probability of default. This increase possibly reflects the view that the Swedish banking sector was viewed as vulnerable because of its relatively large exposures towards the Baltic countries. By the end of 2009, the ex-ante cost declined substantially, probably reflecting the improved general market conditions. Despite some increase in 2011 and 2012, the ex-ante cost remained at a much lower level compared to that reached during the global financial crisis experienced in the years 2008-09 (Figure 11).

Although the turbulence in international financial markets has rekindled in recent months, the ex-ante cost has remained stable and is currently at a very low level. This is likely due to two main factors: i) the impact of a very expansionary monetary policy; ii) larger bank liquidity and capital buffers. Both factors tend to diminish the investor's perceived likelihood that the bank will fail in the near term. Notwithstanding, the currently observed low level of the ex-ante cost can also reflect the announcement of the new resolution regulation.

The *ex-ante* and *ex-post* costs of bank failure might be considered and used as reference values for determining the level of total (i.e. not risk-weighed) bail-inable debt. The *ex-post* cost is the total expected loss that bank creditors may have to sustain in the event of a bank failure. Under these circumstances, it can be seen as a reference for the upper bound of the total bail-inable debt that a bank could be asked to hold. The *ex-ante* cost is the total expected loss that bank creditors would suffer if a bank fails, weighed by the probability of that bank failing. In this perspective, it can be thought of as a minimum level of the total bail-inable debt a bank should hold. Consequently, the reference value for the total bail-inable buffer can be set between the *ex-ante* and *ex-post* cost, weighing in different aspects, such as balancing the benefits of holding a higher buffer against the costs associated with that buffer. Some practical issues and difficulties regarding bail-in are also discussed in the companion report (Cariboni et al., 2016).

Figure 11. **Estimates of the ex-ante cost for Sweden**

As a percentage of GDP, 2005-15



Source: Authors' calculations.

Comparing the results of the two approaches for the Swedish banking sector

For the *ex-ante* cost, the forward looking nature of the contingent claim approach means that it can be used as an early warning indicator. Thus, signalling rising risks ahead of financial turbulence, although the signal may become noisy from time to time. By contrast, the binomial approach is more stable or slower-moving over time and it does not reflect information about future developments of bank risks and resolution costs in a timely manner. In addition to that, it may not completely account for country heterogeneities that can be significant during periods of financial stress.

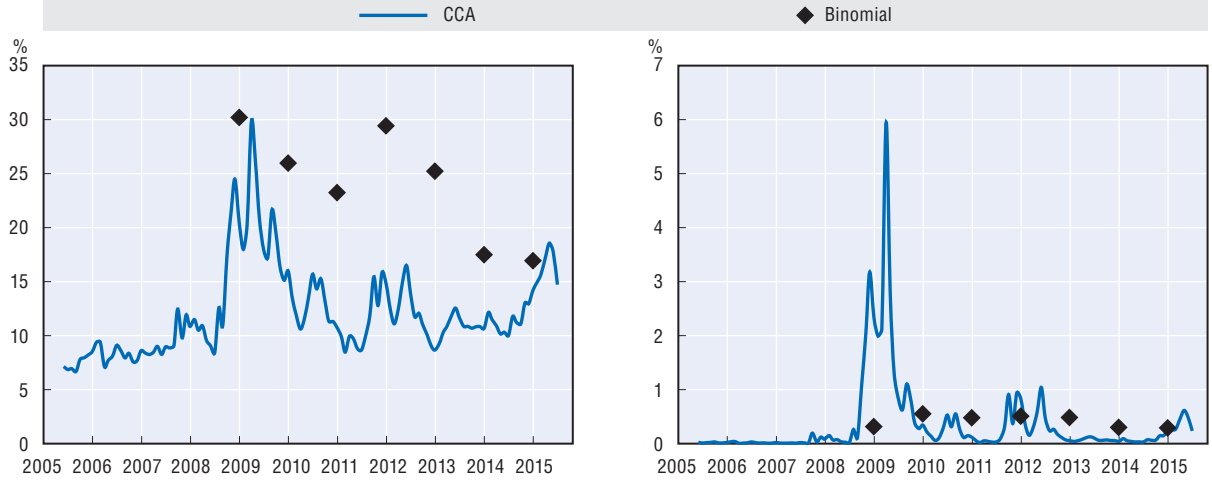
Despite the methodological differences, the results derived from the binomial and the contingent claim approach are qualitatively similar. Both approaches show that the expected ex-post resolution costs of the Swedish banks have fallen from the peak of the global financial crisis and that the ex-ante costs are currently at a low but somewhat higher level than that observed before the period of the global financial crisis in the years 2008-10 (see Figure 12).

Compared to the contingent claim approach, the *ex-post* estimates from the binomial approach are higher, whereas the *ex-ante* cost has remained fairly unchanged throughout the sample period. While these differences may be informative, they should not be over-interpreted, since they partly reflect the different features of the two approaches. The approaches should be viewed as being complementary, as their joint application allows one to give a better understanding and a more comprehensive picture of how bank resolution costs can evolve over time.

Undoubtedly, having more than just one model brings out a wider range of features than each single approach can provide by itself. As for Sweden, the comparison of estimates from the two approaches can easily be provided. The same type of comparison can be done for most OECD countries.

Figure 12. **Comparison of the two approaches**

Estimates of ex-post (left panel) and ex-ante cost (right panel) for Sweden, as a percentage of GDP, 2005-15



Note: CCA stands for contingent claim approach; Binominal stands for binominal options pricing model.
Source: Authors' calculations.

VI. Discussion at the CMF meeting and concluding remarks

Estimates of potential systemic bank failure costs and their associated fiscal liabilities are useful for policy makers that need to monitor, prevent and manage potential financial

crises. They are also helpful for empirically assessing the effects of bank regulatory reform. Furthermore, they can be pivotal for evaluating the transparency of policy institutions. There is, however, no single best measure of systemic bank failure costs, as earlier discussions by the OECD Committee on Financial Markets (CMF) had already concluded. In fact, it is exactly that insight which motivated CMF delegates to suggest the Secretariat explores alternatives to empirical measures of the value of implicit guarantees, broadening the perspective by including the public finance dimension.

The two approaches described in this report provide different measures of resolution costs and they well complement each other by bringing out different perspectives on how risk may unfold. Both approaches are structural models, developed as part of the well-known and widely used stream of option-pricing techniques. The companion report (Cariboni et al., 2016) SYMBOL model is a simulation-based model. It uses bank balance sheet data to simulate the loss distribution of a given sample of banks, explicitly accounting for the regulatory setting in the European Union. Despite the fact that the methodological approaches of the two reports are considerably different, they both recognise the potential for significant resolution costs of bank failure and the possibility of some public finance costs arising in the case of the materialisation of tail risks. Those potential costs are time-variant but they will not be zero, as long as market participants perceive bailing out and the possibility of public support as material. That means that some public finance exposures to the private financial sector might still remain.

The CMF discussed at length the two reports. It was strongly supportive of the work on financial sector guarantees and contingent fiscal liabilities and it especially emphasised the usefulness of the horizontal comparison and diversity of methodologies applied in the two reports. Delegates expressed their view that the work done is relevant for a range of policy issues. The measures discussed were recognised as being very helpful for identifying and monitoring resolution costs as well as for measuring progress made in reducing these costs over time, as regulatory reforms are gradually being implemented. The use of these measures for additional and broader policy purposes were also discussed. Some Committee members considered whether the estimates of resolution costs could be used as a reference tool for determining the total amount of bail-inable debt and thus as one possible input in the setting of TLAC/MREL requirements. There was also a suggestion to use the estimates to measure the potential impact on bank funding costs if/when market expectations of bail-in bed in. One more issue that delegates touched on was the use of the resolution costs measures for external communication purposes. Some members expressed their concern about national authorities publishing estimates of implicit guarantees because it would embed existing perceptions of public guarantees remaining in place, despite the advancement made in the regulatory and supervisory areas. Other members pointed out that the understanding of the impact of external communication around bail-in/bail-out issues in bank failure resolution cases is at an early stage and it is perhaps less advanced than in other areas such as monetary and fiscal policy. The understanding gained in the latter areas could help furthering knowledge regarding the communication on the issue of implicit guarantees. It was recognised that the issue of external communication of estimates of implicit contingent liabilities is an important issue. Yet far more needs to be done to fully understand the possible impact on market behaviour and incentives. The CMF finally suggested follow-up work on how the results of this report could be communicated and used in day-to-day policy.

Notes

1. The relevance of this observation has been underscored by interventions from delegates to the OECD Committee on Financial Markets (CMF) in previous discussions on the broader subject area.
2. This is because the fair value of equity will be equal to the present value of any dividends paid and proceeds arising from the sale of equity. Determining the fair risk-adjusted discount rate to compute this present value is far from straightforward.
3. This could include support through capital injections, asset purchases and/or debt guarantees.
4. There is a risk that taxpayers will ultimately be liable for some of this cost should industry funding be insufficient. However, we do not attempt to quantify such risks as part of the implicit contingent liability measure.
5. It should be noted that the comparability of results for different dates is complicated where the sample of banks available in different years is changing due to failures and/or mergers.
6. The implicit contingent liability and implicit guarantee estimates assume that no costs would be met by deposit insurance funds or resolution funds in the event of a taxpayer-funded bail-out.
7. GDP data is collected from the OECD Economic Outlook database.
8. Note that we differentiate between a bank's probability of failure and their probability of default given that failure can occur without a bank defaulting should the government intervene by bailing-out or putting a bank in resolution.
9. The results found here are similar to those in Arslanalp and Liao (2015), who use a similar methodology to estimate the fiscal contingent liabilities arising from implicit guarantees.
10. Earlier OECD discussions on the topic concluded that in some countries part of the decline in the estimated value of implicit bank debt guarantees reflected a deterioration of the strength of the sovereign seen as providing the guarantee. This interpretation is consistent with recent theoretical work that explains how the value of a bank debt guarantee depends on the strength and size of both the bank and the guarantor (Estrella and Schich, 2015).
11. The views expressed in this section do not necessarily reflect the official views of the Swedish National Debt Office.
12. This section uses data for the four largest Swedish banks and results are presented as a case study. Balance sheet data are at consolidated level.
13. There are various reasonable alternatives for estimating resolution costs. For the Swedish case, besides from being suitable from an analytical perspective, an important reason for choosing this specific method considered here is that it has been applied before by several international institutions to the case of the Swedish banking sector, including the IMF, e.g. in its Financial Stability Assessment Program in 2012 (see IMF Sweden Country Report 2012).
14. See, for example, IMF (2014).
15. The methodological details of this approach are presented in Annex A4. As regards the critical threshold, a common approach is to set it equal to the value of the short-term plus 50 per cent of long -term borrowing (see e.g. IMF (2014) and Moody's KMV). Other approaches include Noss and Sowerbutt (2012), who choose the level of the minimum capital requirement as the critical threshold. Alternatively, one could also choose the level of TLAC as critical threshold.
16. Together with the equity values and volatility of equity, the contingent claim approach uses bank liabilities from balance sheet data as an input.
17. This section uses data for the four largest Swedish banks and results are presented as a case study. Balance sheet data are at consolidated level. It should be noted that the estimates in this section do not reflect the implementation of the EU Bank Recovery and Resolution Directive (BRRD) which, in Sweden, will enter into force in February 2016 and whose aim is to reduce bank implicit guarantees. For this reason, this section provides an estimate of the ex-ante and ex-post costs as defined previously in the report, and it does not attempt to estimate implicit guarantees or implicit contingent liabilities.
18. The ex-ante and ex-post cost are computed on a five year horizon.
19. When option prices are not available, an alternative is to use the historical equity prices.

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ANNEX A1

The sample of banks

The sample of banks was chosen as follows. The starting point was the sample of banks considered in Schich and Lindh (2012), which was then extended to include additional countries (Australia, Canada, Japan, Korea, Mexico, New Zealand, United States) and banks considered in EC (2014).* Banks were retained in the final sample as long as two conditions were fulfilled. First, that balance sheet and credit rating data were available for the full sample period (for example, data was not fully available for Banco Pastor, Agricultural Bank of Greece, Cajamar Caja Rural Sociedad Cooperativa de Crédito, Banco Español de Crédito SA). Second, when more than one bank from the same group was present in the sample, only the headquarter bank was retained. Exceptions were made when an overseas subsidiary of the banking group held over 10% of banking assets in a country at some point in the sample period. Subsidiaries included in this exception are marked with an asterisk in the table below.

The banks in the final sample are presented in Table A1.1. The sample consists of 212 banks for 25 countries, with at least four banks for each country apart from Luxembourg (with two banks) and Finland (with three banks).

Table A1.1. **List of banks included in the sample**

Australia	Australia and New Zealand Banking Group Ltd
	Bank of Queensland Ltd
	Commonwealth Bank of Australia
	Macquarie Bank Ltd
	National Australia Bank Ltd
	Suncorp-Metway Ltd
	Westpac Banking Corporation
Austria	BAWAG P.S.K. AG
	Erste Group Bank AG
	Hypo Tirol Bank
	Oesterreichische Volksbanken AG
	Raiffeisen Bank International AG
	UniCredit Bank Austria AG-Bank Austria
	Vorarlberger Landes-und Hypothekenbank AG
Belgium	Belfius Banque SA
	BNP Paribas Fortis SA/ NV[1]
	ING Belgium SA/NV-ING[1]
	KBC Bank NV

* The authors are grateful for excellent data assistance from Oana Toader.

Table A1.1. **List of banks included in the sample** *(cont.)*

Canada	Bank of Montreal
	Bank of Nova Scotia (The)
	Canadian Imperial Bank of Commerce
	National Bank of Canada
	Royal Bank of Canada
	Toronto Dominion Bank
Denmark	Danske Bank A/S
	Jyske Bank A/S
	Nordea Bank Danmark A/S
	Nykredit Bank A/S
	Spar Nord Bank
	Sydbank A/S
Finland	Aktia Bank Plc
	Nordea Bank Finland Plc[1]
	Pohjola Bank plc
France	Credit Agricole CIB SA
	Banque Fédérative du Crédit Mutuel
	Banque PSA Finance SA
	BNP Paribas SA
	BPCE SA
	Crédit Agricole S.A.
	Dexia Crédit Local SA
	RCI Banque SA
	Société Générale SA
Germany	Bayerische Landesbank
	Commerzbank AG
	DekaBank Deutsche Girozentrale AG
	Deutsche Apotheker- und Aerztebank eG
	Deutsche Bank AG
	Deutsche Pfandbriefbank AG
	Deutsche Postbank AG
	DZ Bank AG-Deutsche Zentral-Genossenschaftsbank
	HSH Nordbank AG
	Hypothekenbank Frankfurt AG
	Landesbank Baden-Wuerttemberg
	Landesbank Berlin AG
	Landesbank Hessen-Thueringen Girozentrale
	Münchener Hypothekenbank eG
	Norddeutsche Landesbank Girozentrale
	Sparkasse KölnBonn
	Volkswagen Bank GmbH
	Portigon AG
	WGZ-Bank AG
Greece	Alpha Bank AE
	Eurobank Ergasias SA
	National Bank of Greece SA
	Piraeus Bank SA
Ireland	Allied Irish Banks plc
	Bank of Ireland
	Depfa Bank Plc
	Permanent TSB Plc
	Ulster Bank Ireland Limited[1]

Table A1.1. **List of banks included in the sample** *(cont.)*

Italy	Banca Carige SpA
	Banca delle Marche SpA
	Banca Monte dei Paschi di Siena SpA
	Banca Popolare di Milano SCaRL
	Banca Sella Holding SpA
	Banco Popolare – Società Cooperativa
	Cassa di Risparmio di Bolzano SpA
	Cassa di risparmio di Ferrara SpA
	Credito Valtellinese Soc Coop
	Intesa Sanpaolo
	UniCredit SpA
	Unione di Banche Italiane Scpa-UBI Banca
Japan	Aozora Bank Ltd
	The Bank of Tokyo – Mitsubishi UFJ Ltd-Kabushiki Kaisha Mitsubishi Tokyo UFJ Ginko
	Chiba Bank Ltd.
	The Chugoku Bank, Ltd
	The Gunma Bank Ltd
	The Higo Bank
	Hiroshima Bank Ltd
	Joyo Bank Ltd.
	Mizuho Bank Ltd
	The Norinchukin Bank
	Ogaki Kyoritsu Bank
	Resona Bank Ltd
	San-In Godo Bank, Ltd
	Shinkin Central Bank
	Shoko Chukin Bank Ltd
	Sumitomo Mitsui Banking Corporation
	The Suruga Bank, Ltd
	Bank of Yokohama, Ltd
Luxembourg	Banque et Caisse d'Epargne de l'Etat Luxembourg
	Banque Internationale à Luxembourg SA
Mexico	Banco del Bajio
	Banco Santander (Mexico) SA[1]
	BBVA Bancomer[1]
	Banco Mercantil del Norte S.A. – BANORTE
Netherlands	ABN AMRO Bank NV
	Credit Europe Bank N.V.
	ING Bank NV
	Nederlandse Waterschapsbank
	NIBC Bank N.V.
	Bank Nederlandse Gemeenten NV, BNG
	Rabobank Nederland
	Royal Bank of Scotland NV (The)-RBS NV
	SNS Bank N.V.
New Zealand	ANZ Bank New Zealand Limited[1]
	ASB Bank[1]
	Bank of New Zealand[1]
	Westpac New Zealand Limited[1]

Table A1.1. **List of banks included in the sample** *(cont.)*

Norway	DNB Bank ASA
	Nordea Bank Norge ASA[1]
	Sparebank 1 Nord-Norge
	SpareBank 1 SMN
	SpareBank 1 SR-Bank ASA
	Sparebanken More
	Sparebanken Sor
	Sparebanken Vest
	Storebrand Bank ASA
Portugal	Banco BPI SA
	Banco Comercial Português, SA
	Banco Espirito Santo SA
	BANIF – Banco Internacional do Funchal, SA
	Caixa Economica Montepio Geral
	Caixa Geral de Depositos
South Korea	Busan Bank
	Daegu Bank Ltd.
	Hana Bank
	Industrial Bank of Korea
	KB Kookmin Bank
	Korea Development Bank
	Korea Exchange Bank
	Shinhan Bank
	Woori Bank
Spain	Banca March SA
	Banco Bilbao Vizcaya Argentaria SA
	Banco de Sabadell SA
	Banco de Valencia SA
	Banco Popular Espanol SA
	Banco Santander SA
	Bankia, SA
	Bankinter SA
	Caixabank. S.A.
	Caja Laboral Popular Coop de credito
	Ibercaja Banco SAU
Sweden	Landshypotek Bank AB
	Länsförsäkringar Bank AB (Publ)
	Nordea Bank AB (publ)
	Skandinaviska Enskilda Banken AB
	Svenska Handelsbanken
	Swedbank AB
Switzerland	Banque Cantonale Vaudoise
	Clientis AG
	Credit Suisse AG
	EFG Bank AG
	Raiffeisen Schweiz Genossenschaft
	St. Galler Kantonalbank AG
	UBS AG
	Zuger Kantonalbank
Turkey	Akbank T.A.S.
	Turkiye Garanti Bankasi A.S.
	Turkiye is Bankasi A.S.
	Yapi Ve Kredi Bankasi A.S.

Table A1.1. **List of banks included in the sample** *(cont.)*

United Kingdom	Bank of Scotland Plc
	Barclays Bank Plc
	Co-operative Bank Plc (The)
	Coventry Building Society
	HSBC Bank plc
	Leeds Building Society
	Lloyds Bank Plc
	National Westminster Bank Plc
	Nationwide Building Society
	Principality Building Society
	Royal Bank of Scotland Plc (The)
	Skipton Building Society
	Standard Chartered Bank
	West Bromwich Building Society
	Yorkshire Building Society
United States	BancorpSouth Bank
	Bank of America, NA
	Bank of Hawaii
	Bank of New York Mellon (The)
	Branch Banking and Trust Company
	Citibank NA
	Comerica Bank
	Discover Bank
	First National Bank of Omaha
	FirstMerit Bank NA
	Frost Bank
	Goldman Sachs Bank USA
	JP Morgan Chase Bank, NA
	Morgan Stanley Bank, NA
	New York Community Bank
	Old National Bank
	People's United Financial, Inc
	Regions Bank
	Silicon Valley Bank
	State Street Bank and Trust Company
	Synovus Bank
	TCF National Bank
	Trustmark National Bank
	Webster Bank NA
	Wells Fargo Bank, NA

1. Included as foreign-owned subsidiary holding over 10% of domestic banking assets.
Source: Authors' calculations.

ANNEX A2

Estimating bank-specific loss-given-default

Expected loss-given-default (LGD) for a given bank is inherently subjective and cannot be directly observed. In computing our estimates of bank resolution costs we draw on three key sources of information around the loss rates of failed banks.

FDIC resolutions

The United States *Federal Deposit Insurance Corporation* (FDIC) has resolved almost 3 000 failed instituions since 1980. On average, these tend to be smaller institutions, with less than USD 1 billion in total assets. However, the number of such failures provides a useful sample for assessing determinants of bank loss rates.

For example, Schaeck (2008) investigates the drivers of FDIC loss rates for a sample of over 1000 resolutions between 1984 and 2003, and identifies a strong statistical and economic relationship between bank size and FDIC loss rates, whereby losses tended to be smaller for larger institutions (Table A2.1). Other measures of solvency, asset quality, business model, and business growth also proved to be significant indicators, although at lower degrees of economic significance.

Table A2.1. **Regression of loss rates in FDIC resolutions, 1984-2003**

	Sample mean	Range of coefficients	Statistical significance
Total assets (log)	4.56	-0.013 – -0.021	***
Real estate owned/total deposits	0.04	0.67 – 0.70	***
Loans past due/total deposits	0.02	0.32 – 0.45	***
Non-loan income/total deposits	0.01	3.9 – 4.1	***
Total equity/total deposits	0.02	-0.37 – -0.46	***
Assets growth for year prior to failure	-0.14	0.041 – 0.050	**

Note: *** denotes statistical significance at the 1% level, ** denotes significance at the 5% level.

A more recent study by Balla, Prescott, and Walter (2015) also shows a strong negative relationship between size and FDIC loss rates, with estimated coefficients of -0.02 for the 1986-1992 and -0.04 for the 2007-13 peiod (both of which are significant at the 1% level). Other significant explanatory variables include interest receivable and the ratio of on-call an insured deposits to total deposits.

Other bank resolutions

Bank failures over recent years provide one source of information about what resolution costs could be expected for future bank failures. Even with past failure, however, estimating LGDs is not straightforward. Firstly, it is difficult to know the total amount of liabilities outstanding prior to the bank's resolution. Secondly, it is difficult to know the true upfront cost of failure, especially in cases involving multiple resolutions or varying losses accross different creditor classes. Finally, it is very difficult to know the true value of any equity claims held by governments or bank creditors after the point of resolution. Even if equity is subsequently sold, there is an implicit opportunity cost to holding equity in a recently-failed bank that is very difficult to quantify.

Historical resolution costs are based on the sum of any government capital injections, write-downs of bank creditors, and other losses on unsecured liabilities realised during standard insolvency proceedings. Balance sheet data is then taken as at the banks' last balance date prior to resolution. LGDs are then calculated as total resolution costs divided by total pre-failure liabilities. Estimates are produded for a sample of banks that have failed since the onset of the global financial crisis, and are summarised in Table A2.2 below.

Table A2.2. **Estimates of upfront resolution costs for recent bank resolutions**

Year	Bank (country)	Total assets[1]	Resolution	Estimated LGD (%)
2008	Washington Mutual (USA)	USD 309 billion	FDIC receivership. Assets, deposits and secured debt sold to JP Morgan for USD 1.9 billion.	4.4[2]
2008/12	Dexia (Belgium, France)	EUR 605 billion	Capital injections of EUR 6.4 billion and EUR 5.5 billion. Currently being wound down.	2.0
2008/09	Lloyds Banking Group (UK)	GBP 322 billion	Capital injections from state totalling GBP 20.3 billion. Some of this cost has been recovered through subsequent sales of equity.	3.6
2008/09	Royal Bank of Scotland (UK)	GBP 1 840 billion	Bailed out at a cost of GBP 45.5 billion. Some of this cost has been recovered through subsequent sales of equity.	2.6
2011	Anglo-Irish Bank (Ireland)	EUR 101 billion	Bailed out at a cost of EUR 29.3 billion. The bank is currently being wound down.	30.1
2011	Allied Irish Banks (Ireland)	EUR 182 billion	Bailed out at a cost of EUR 19.8 billion. The bank remains 99% state-owned.	8.4
2011	Amagerbanken (Denmark)	EUR 4.1 billion	Haircut of 41% on uninsured creditors, later reduced to 16%.	16.0
2012	Bankia (Spain)	EUR 298 billion	Received a total of EUR 22.4 billion in capital from the state, with a further EUR 4.8 billion in write-downs for junior bondholders.	9.5
2013	SNS Reaal (Netherlands)	EUR 134 billion	Total resolution cost of EUR 4.7 billion through equity injections and the write-down of subordinated debt.	3.6
2013	Bank of Cyprus (Cyprus[3])	EUR 31 billion	Conversion of roughly EUR 8 billion in deposits to equity. The bank's shares relisted in December 2014 with a market capitalization of around EUR 2 billion.	19.5
2014	Banco Espirito Santo (Portugal)	EUR 91 billion	Conversion of EUR 1.3 billion in junior debt into equity, and a EUR 4.9 billion equity injection from the state.	7.4

1. As at last available balance date prior to resolution.
2. Based on recovery rates on unsecured debt.
3. *Note by Turkey:* The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".
   Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: Bank balance sheets, Moody's (2009), news reports, authors' calculations.

The results from applying a basic regression analysis to this sample of 11 bank failures are summarised in Table A2.3. Again, size is a key determinant of loss rate, and is statistically significant despite the small sample size. The results also suggest that a 1% increase in equity as a percentage of total assets reduces expected losses by approximately 1%. While this is a fairly intuitive result, it lacks statistical significance.

Table A2.3. **Regression results from estimated historical LGDs**

	Coefficient	SE	Coefficient	SE
Intercept	0.519	0.188	0.599	0.205
Total assets (log)	-0.033	0.015	-0.036	0.015
Equity/assets			-1.09	1.10
R squared	*35.2%*		*42.3%*	

Source: Authors' calculations

Bank bond prices

The return that bondholders require for holding bank debt is likely to reflect, in part, the expected loss rate that bondholders might expect to face in resolution. Bond prices can therefore provide an additional source of information about expected loss rates.

To generate market-based estimates of expected loss rates, we compile a sample of 219 unsecured senior bank bonds across 36 banks headquartered in OECD countries. Bonds used in the sample are limited to those that are fixed-coupon "bullet" bonds, with a remaining maturity of 4-6 years, and denominated in Euros or US dollars. For each bond, we first take the spread between the mid-yield price and the relevant point on the swap curve for the respective currency. We then divide this spread by the risk-neutral probability of failure (RNPF) that corresponds with the bond's credit rating (based on the relationship in Hull et al, 2005) to generate an implied LGD for each bond.*

In order to estimate the expected LGD for a given bank, we average the implied LGD across the bonds issued by that bank. We then multiply this average LGD by the ratio of the bank's long-term market funding to total liabilities based on data from Bankscope. This reflects an expectation that in resolution, these liabilities are likely to bear a large part of the cost, given the preference for depositors that exists in most OECD jurisdictions, and the ability of shorter-term funding to withdraw from the bank prior to its failure.

To test the determinants of bond-based LGD estimates, we run a basic regression of implied LGDs against size, capitalization, and credit ratings. The results summarised in Table A2.4. show similar statistical relationships to those discussed above. However, the coefficients lack statistical significance given the large degree of "noise" in the sample.

The bond price analysis provides a useful "sense check" to the estimates modelled based on empirical analyses. However, the accuracy of this method is limited by several factors. Firstly, it is impossible to know with certainty the RNPF that is being priced into bank bond yields. Even if credit-rating based estimates are unbiased on average, a given bank may be seen as more likely or less likely to default than what is implied by its credit rating alone. Secondly, fundamental credit is unlikely to be the only driver of bond prices, as other bank-specific or bond-specific risk premiums and liquidity premiums are likely to

* In doing so, we assume that expectations of extraordinary government support affect the probability of default but not the loss-given-default.

Table A2.4. **Comparison of modelled and bond price-implied LGD estimates (average across country)**

Country	Coefficient	Standard error	Coefficient	Standard error
Intercept	0.329	0.174	0.329	0.177
Total assets (log)	-0.014	0.013	-0.013	0.015
Equity/assets	-0.707	0.480	-0.709	0.488
Credit rating			-0.001	0.006
R squared	*9.2%*		*9.3%*	

Source: Bloomberg, authors' calculations.

be at play. Furthermore, bond prices may be relatively insensitive to a bank's funding structures if the likelihood of failure is seen a low (even though funding structure would affect loss rates should failure occur, they could evolve substantially prior to failure).

Approach used

To construct a single specification for producing resolution cost estimates, we start by taking the average estimated slope coefficients for log size and capital-to-asset ratios from the three regression analyses presented above. We then set the intercept value to minimise the average difference between modelled LGDs and "actual" from the recent bank failures presented in Table A2.2. This results in the following:

$$LGD = 0.38 - 0.022 \cdot \ln(Assets) - 0.67 \cdot \frac{Equity}{Assets}$$

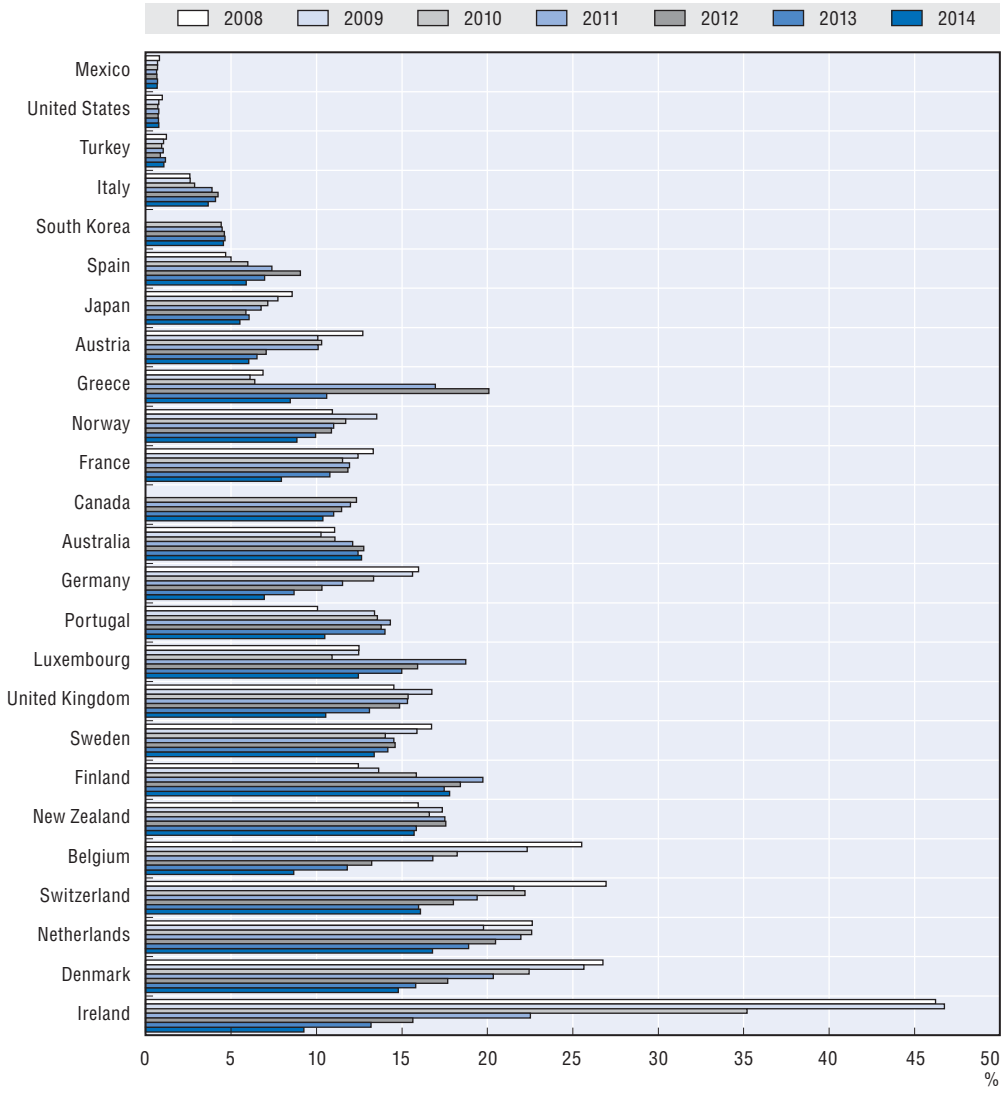
In the few cases where data is unavailable for a given bank at a given point in time, the LGD for that bank is set to 10% in line with the sample average. Furthermore, a minimum LGD of 1% is applied to account for the possibilities of very low or even negative LGD estimates for banks with characteristics that are outside of the sample considered in the linear regression models described above.

Unfortunately, we were unable to include in the specifications characteristics that reflect the riskiness of a bank's assets. In practice, factors such as the "culture" of lending, the quality of the legal and insolvency system, and the state of the macroeconomic environment may influence LGDs. We believe that the simple estimations considered here to determine LGD are nonetheless a preferable approach to just assuming a fixed rate of LGD, as is commonly done.

ANNEX A3

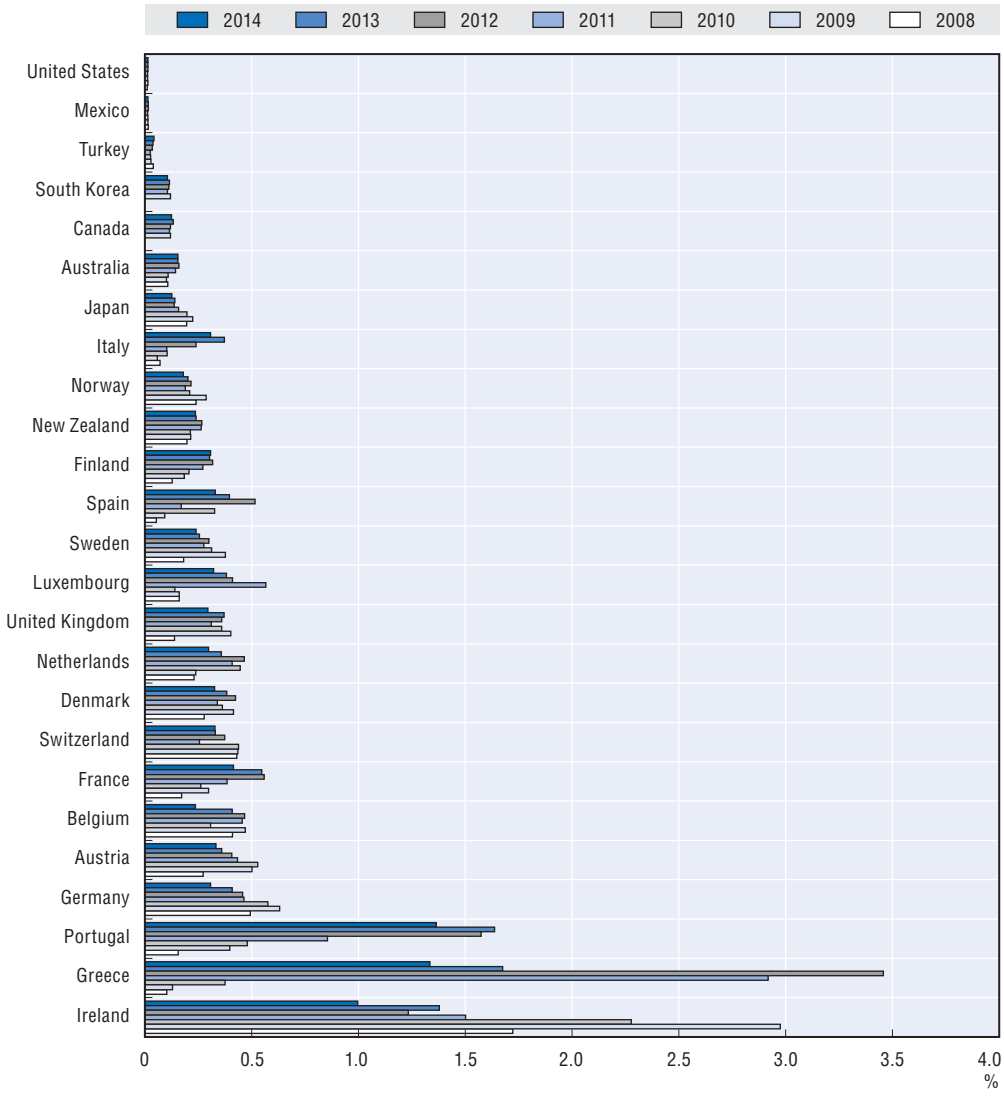
Estimation results across countries

Figure A3.1. **Expected ex-post costs**



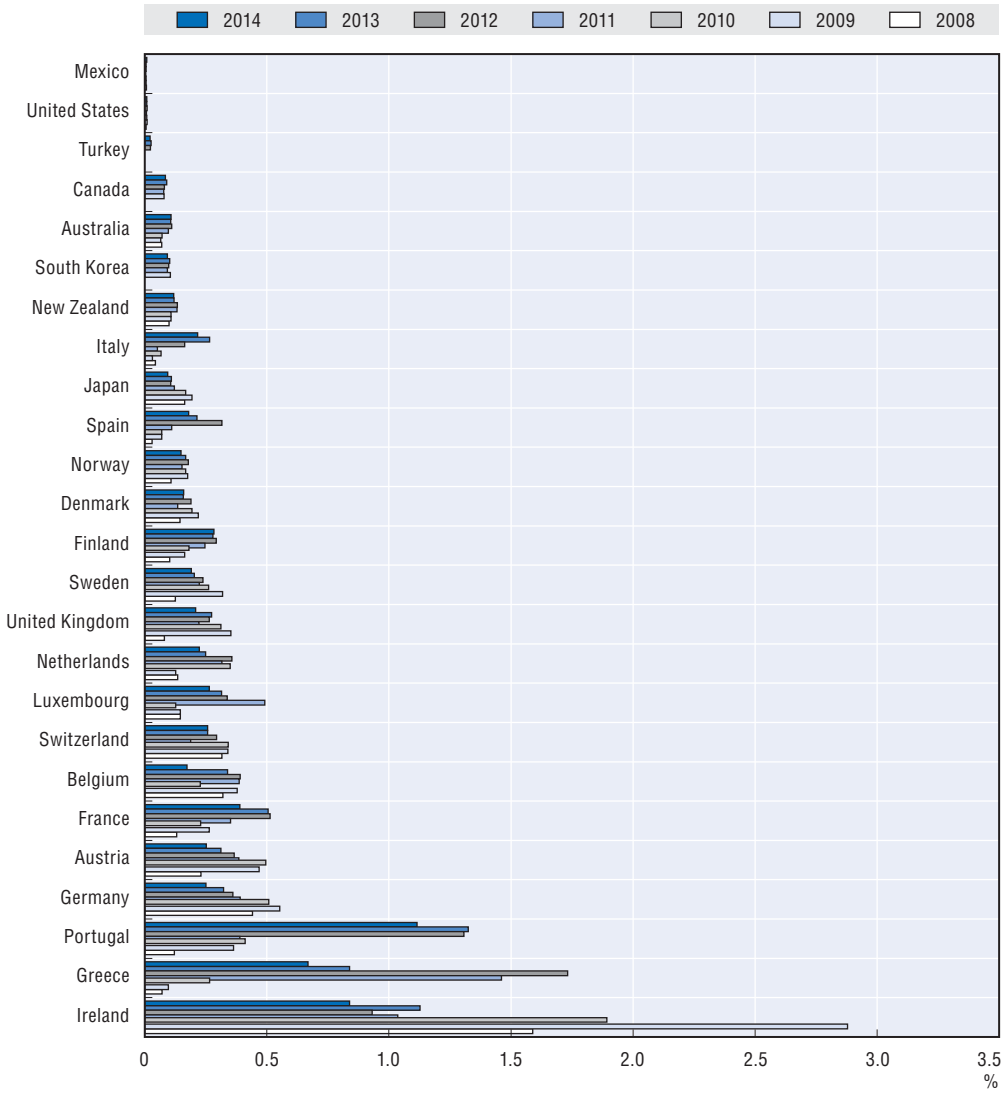
Source: Authors' calculations.

Figure A3.2. **Ex-ante costs**



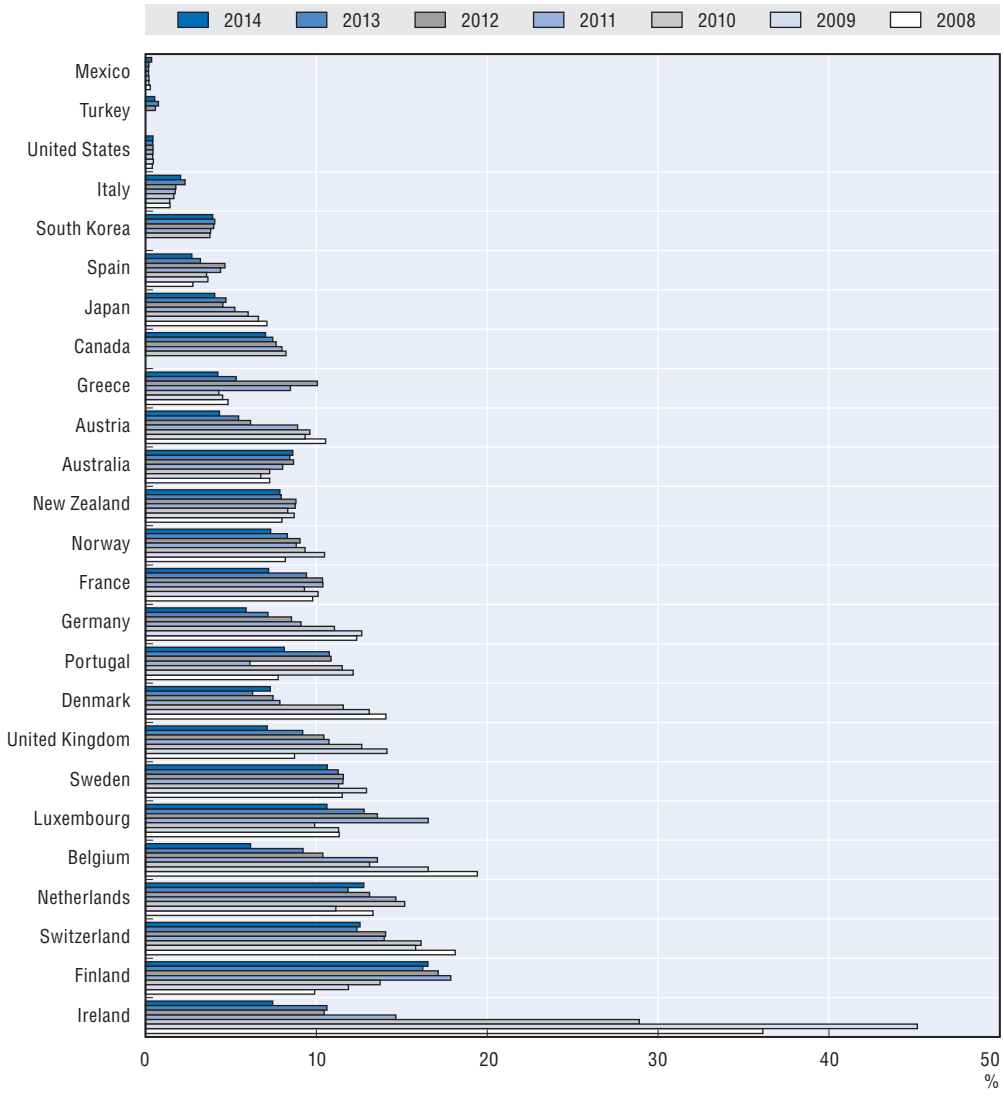
Source: Authors' calculations.

Figure A3.3. **Implicit guarantees**



Source: Authors' calculations.

Figure A3.4. **Implicit contingent liabilities Source: Authors' calculations**



Source: Authors' calculations.

ANNEX A4

The contingent claim approach

The contingent claim approach is a generalization of the option pricing theory pioneered by Black and Scholes (1973) and Merton (1974), which applied to the analysis of credit risk is commonly referred to as the "Merton model". The contingent claim approach assumes that the total market value of assets, A, at any time t, is equal to the sum of equity market value, E, and its risky debt, D, maturing at time T. Asset value is a log-normal distributed random variable and can fall below a critical threshold, B, which constitutes the failure barrier. Commonly, the threshold is defined as the value of payment commitments at maturity T. When such a threshold is chosen, a bank fails if it is unable to honour its promised payments at T.

Equity is defined as a residual claim on assets once debt-holders are paid out. Therefore, the firm's equity can be seen as an implicit call option on the firm's assets with an exercise price equal to B:

$$\mathrm{E(t)} = \mathrm{A(t)N(d_1)} - \mathrm{Be^{-r(T-t)}N(d_2)} \tag{1}$$

where: $\mathrm{d_1} = \frac{\ln(\frac{\mathrm{A(t)}}{\mathrm{B}}) + (\mathrm{r} + \frac{1}{2}{\sigma_A}^2)(\mathrm{T-t})}{\sigma_A\sqrt{\mathrm{T-t}}}$ and $\mathrm{d_2} = 1 - d_1$

The relationship between the volatility of equity σ_E and assets σ_A are described by the following equation:

$$\sigma_E \, \mathrm{E(t)} = \mathrm{N(d_1)} \, \sigma_A \, \mathrm{A(t)} \tag{2}$$

Equity volatility can either be measured using the realised volatility of historical equity prices or using the implied volatility of traded equity options which is a more forward-looking measure. The market value of assets and its volatility are determined within the model by simultaneously solving equations (1) and (2). The ex-ante cost of failure for a given time horizon $\tilde{\mathrm{T}}$ is equal to the value of a put option on the firm's assets A with the exercise price equal to B:

$$\text{Ex-ante cost}(\mathrm{t}, \tilde{\mathrm{T}}) = \mathrm{Be^{-r\tilde{T}}N(-d_2)} - \mathrm{A(t)N(-d_1)}$$

The probability of failure is given by:

$$P(A(\tilde{\mathrm{T}}) \leq B) = \mathrm{N}\left(-\frac{\ln(\frac{\mathrm{A(t)}}{\mathrm{B}}) + (\mathrm{r} - \frac{1}{2}{\sigma_A}^2)(\tilde{\mathrm{T}} - \mathrm{t})}{\sigma_A\sqrt{\tilde{\mathrm{T}} - \mathrm{t}}}\right)$$

Given the ex-ante cost and the probability of failure, the ex-post must be equal to the following:

$$\text{Ex-post cost}(t, \tilde{T}) = \frac{\text{Ex-ante cost}(t, \tilde{T})}{P(A(\tilde{T}) \leq B)}$$

Note that the specification in the basic model described above does not account for skewness and kurtosis of equity returns. These shortcomings of the Merton model can be addressed in several ways. In the analysis of the Swedish bank sector presented in the main text (Section V), this is done by using the observed volatility smile.

From:
OECD Journal: Financial Market Trends

Access the journal at:
http://dx.doi.org/10.1787/19952872

Please cite this article as:

Blix Grimaldi, Marianna*, et al.* (2016), "Estimating the size and incidence of bank resolution costs for selected banks in OECD countries", *OECD Journal: Financial Market Trends*, published online first.

DOI: http://dx.doi.org/10.1787/fmt-2016-5jlvbslktw7j