EUROPEAN CENTRAL BANK
EUROSYSTEM

Occasional Paper Series

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Liquidity in resolution: estimating possible liquidity gaps for specific banks in resolution and in a systemic crisis

No 250 / November 2020

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Abstract

This paper contributes to the debate on liquidity in resolution by providing a quantitative assessment of liquidity gaps of banks in resolution in the euro area. It estimates possible ranges of liquidity gaps for significant banks under different assumptions and scenarios. The findings suggest that, while the average liquidity gaps in resolution are limited, the averages hide significant outliers. The paper thus shows that, under adverse circumstances, the instruments currently available to provide liquidity support to financial institutions in the euro area would be insufficient.

Keywords: Liquidity, resolution, bank runs, systemic crisis, contagion, Monte Carlo simulations

JEL codes: G01; G21; G28, G33, C63

Non-technical summary

Liquidity in resolution was identified by the Financial Stability Board (FSB) at the end of 2014 as an outstanding issue that needed to be addressed to complete the reform agenda.[1] This was confirmed by the results of the first resolvability assessment process (RAP) for global systemically important banks (G-SIBs), which concluded that there "*was need for more analysis and understanding of funding, liquidity needs and availability of unencumbered collateral in resolution*"[2]. In particular, it was noted that "*Insufficient liquidity to maintain critical operations and meet increased margin requirements, the risk of termination or inability to roll over short-term borrowing or the loss of access to alternative sources of credit all have the potential to hinder the execution of the preferred resolution strategy*"[3]. To address these impediments to resolution, the FSB published guiding principles on the temporary funding needed to support the orderly resolution of a G-SIB[4] and funding strategy elements of an implementable resolution plan[5].

In recent years, some jurisdictions, such as the United States[6] and the United Kingdom[7], have addressed the need to ensure liquidity in resolution by setting up frameworks for this purpose. In the EU, the issue has been discussed in the context of completing the banking union, but the discussions are still ongoing.

This paper aims to contribute to the debate by providing analysis of liquidity gaps of banks in resolution in the euro area. A liquidity gap in resolution implies that the bank, although recapitalised by the application of resolution measures, still faces a shortage of liquidity owing to a combination of two factors. First, there are net liquidity outflows (e.g. from deposit outflows and/or when creditors are not willing to roll over maturing debt) and the bank has insufficient liquidity buffers after resolution to meet regulatory requirements. Second, the bank cannot currently obtain sufficient funding in the market or in regular monetary policy operations to meet its liquidity needs (e.g. because it lacks unencumbered assets and eligible collateral). In order for resolution to be successful, such liquidity gaps need to be addressed.

The paper estimates possible ranges of liquidity gaps for significant banks in resolution, including in a systemic crisis, assuming different scenarios and severity levels. As such, it contributes to the debate in two ways. First, it is – to the best of our knowledge – the first publication of a methodology developed to measure and estimate possible liquidity gaps in resolution. Second, by providing approximate estimates of the possible liquidity gaps, it can facilitate ongoing discussions in the EU on the design and calibration of policy choices to address liquidity gaps in resolution.

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1 See Financial Stability Board (2014).
2 See Financial Stability Board (2015).
3 Ibid.
4 See Financial Stability Board (2016).
5 See Financial Stability Board (2018).
6 See Deslandes and Magnus (2019).
7 See Bank of England (2017).

The methodology developed in the paper takes inspiration from financial sector stress tests, which have proved to be an important tool for assessing the robustness of the financial system and evaluating system-wide risks.[8] However, this paper has a different objective than ordinary stress tests, and therefore takes a different approach. In particular, the aim of the paper is not to determine whether or not a specific bank can withstand stressed conditions, as the presumption is that the bank has failed and has entered into resolution, although the underlying reason for the failure is not modelled. In addition to using recent stress tests as a reference point, the paper also studies a number of real past cases – bank runs or banks that required public intervention[9] – in order to calibrate different scenarios and stress levels. The liquidity needs observed in some of these cases also serve as yardsticks to compare the estimated ranges of results against. However, determining the underlying causes and the likelihood of the different scenarios is outside the scope of this paper.

By subjecting banks to stress that is similar to stress tests, the analysis shares some of the limitations of regular stress testing. One of those is the static balance sheet approach, which does not take into account the fact that banks can react to adverse conditions, e.g. by generating additional collateral or engaging in securitisations. There are in fact several factors in the methodology, and in the assumptions made, that may affect the estimated liquidity gaps, either positively or negatively. Therefore the main methodological features and their possible impact on the results are discussed in the paper.

The findings suggest that, while the average liquidity gaps in resolution are limited, the averages hide significant outlier banks and scenarios. For the banks which, after simulating an idiosyncratic crisis scenario, have liquidity gaps in resolution, the average need can reach €19.4 billion under the most adverse scenario if liquidity buffers are applied.[10] However, there are outlier banks with a maximum liquidity gap of €184 billion, or a maximum relative liquidity gap corresponding to 26% of the bank's total assets.[11] In the case of a systemic crisis with multiple failing banks and contagion, the average liquidity gaps span from €0.10 billion to €93.07 billion, or from 0.01% to 4.4% of the total assets of the failing bank in each simulation run. However, the tails of the distributions reveal extremely high liquidity gaps, especially in the case of a "slow burn" scenario where the 95th percentile of the distribution can exceed €313 billion. The results also show that the inclusion of contagion mechanisms has a limited effect on average liquidity needs, but a more severe effect on tail events, thus increasing liquidity gaps by up to 12%. For a systemic crisis involving the simultaneous resolution of two G-SIBs, liquidity gaps in resolution are in line with the results obtained in the case of a systemic crisis involving the resolution of multiple banks. The average outcomes range from €2.7 billion to almost €150 billion (from 0.1% to approximately 5.5% of the failing G-SIB's total assets). In the most adverse

8 See, for example, Halaj and Laliotis (2017) and Basel Committee on Banking Supervision (2013b).

9 This means that the banks were either bailed out or subject to some kind of resolution action.

10 This average only takes in account banks that present liquidity needs above zero and excludes all banks with no liquidity needs in resolution.

11 The banks with the highest needs in absolute and relative terms are not necessarily the same bank.

simulated crisis, the liquidity gaps in the case of the resolution of two G-SIBs can reach extremely high values in excess of €330 billion.

The remainder of this paper is organised as follows. Section 1 makes observations on the financial crisis and selected past bank failures. The methodology, assumptions and calibration are outlined in Section 2, which also discusses the caveats and limitations of the approach used. Section 3 presents the main findings on liquidity gaps in the case of single bank failures. The possible ranges of liquidity gaps in a systemic crisis are described and discussed in Section 4. Section 5 concludes. Detailed results, robustness checks and summaries of the real bank failures studied are provided in the Annex.

1 Observations and lessons from past crises

Observations and lessons learnt from the financial crisis and specific bank resolution cases may provide useful insights for analysing possible liquidity gaps in resolution. In this section we observe the liquidity needs in the recent crisis and in some specific bank failures, as well as the duration and magnitude of different bank runs. These observations may contribute to the design and calibration of the scenarios upon which the simulation of a future bank resolution will be based. The section also provides points of reference for the results generated.

It should be highlighted, however, that for several reasons it is extremely challenging to come up with a set of concrete conclusions from past cases. For instance, some of the cases of failing banks date back to well before the Bank Recovery and Resolution Directive (BRRD)[12], rendering it difficult to capture the impact of the new resolution tools in the EU. Similarly, there are several cases where different strategies to deal with bank failures – including bailouts – were implemented. Thus many of the past cases are unique, both in terms of the underlying risks and in terms of the urgency of resolution or public intervention.

1.1 Liquidity aid in the financial crisis and selected past cases

During the period between 2008 and 2017, the main part of the State aid measures – both approved and used – were in the form of liquidity aid instruments, mainly in the form of guarantees. As the financial crisis was unfolding in Europe, EU Member States played a crucial role by providing State aid to ensure financial stability.[13] The State aid was in the form of capital aid (i.e. recapitalisations and impaired asset measures) and liquidity aid (i.e. guarantees and other liquidity measures). Although approved, not all measures were used in the end, making the used amounts of State aid more relevant for this study.

Based on European Commission data on State aid to banks over the period 2008-2017 (see Table 1), the amount of liquidity measures used peaked at €906 billion in the EU (€714 billion in euro area).[14] For the first five years (2008-2012), the average amount of liquidity measures used was €675 billion. The cumulative maximum amount of liquidity measures approved reached more than €3,600 billion, while the maximum amount used reached almost €1,300 billion.

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12 Directive 2014/59/EU of the European Parliament and of the Council of 15 May 2014 establishing a framework for the recovery and resolution of credit institutions and investment firms and amending Council Directive 82/891/EEC, and Directives 2001/24/EC, 2002/47/EC, 2004/25/EC, 2005/56/EC, 2007/36/EC, 2011/35/EU, 2012/30/EU and 2013/36/EU, and Regulations (EU) No 1093/2010 and (EU) No 648/2012, of the European Parliament and of the Council (OJ L 173, 12.6.2014, p. 190).

13 State aid could be granted to ailing banks in accordance with the State aid framework and within the scope of Article 107(1) of the Treaty on the Functioning of the EU, either as a precautionary buffer in going concern cases, or as actual aid in cases of resolution and liquidation.

14 See European Commission (2019).

Despite the discrepancies observed in the annual data between the approved and used amounts, mainly owing to the use of measures that had been approved in previous years, the picture of the liquidity measures is of particular interest (see Chart 1).

Table 1
State aid to banks over the period 2008-2017

Aid approved

(EUR billions)

Aid instrument	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total / Max.
Recapitalisations	269.9	110	184	37.5	150.8	29.6	20.3	18.8	8.5	25.7	855.1
Impaired assets measures	4.8	338.5	78	6.3	157.5	14.7	3.5	1	0	0	604.3
Total capital aid	274.7	448.5	262	43.8	308.3	44.3	23.9	19.8	8.5	25.7	1,459.4
Guarantees	3,097.3	87.6	54.8	179.7	275.8	76	38.7	165.4	310.7	328.5	3,415.7
Other liquidity measures	85.5	5.5	66.8	50.2	37.5	9.7	1.7	0	0	14.2	243
Total liquidity aid	3,182.8	93.1	121.6	229.9	313.2	85.7	40.4	165.4	310.7	342.7	3,658.6

Aid used

(EUR billions)

Aid instrument	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total / Max.
Recapitalisations	115.2	90.7	93.5	35	90.8	20.5	7.6	11.3	0	11.3	475.9
Impaired assets measures	9.8	79.5	54	0	35.4	9.5	0.3	0.3	0.5	0	189.2
Total capital aid	125	170.2	147.4	35	126.3	30	7.9	11.6	0.5	11.3	665.1
Guarantees	400.4	835.8	799.8	589	492.1	352.3	204.5	170.6	126.1	110.8	1,188.1
Other liquidity measures	22.2	70.1	62.6	60.6	44.3	34.6	31.6	21.8	12.4	10.9	108.4
Total liquidity aid	422.6	906	862.5	649.5	536.4	386.9	236.2	192.4	138.5	121.7	1,296.5

Source: European Commission (2019).
Note: The last column shows the total capital aid for the period 2008-2017 or the maximum outstanding amount of liquidity aid during the period, since liquidity aid is not cumulative.

In terms of GDP and total assets, the liquidity measures used in the euro area peaked in 2009 at 7.6% of GDP and 2.4% of total assets. At euro area country level, the peak of the guarantee type of liquidity measures was in Ireland in 2009 (at €284.3 billion, i.e. 21.5% of total assets and 173% of GDP), while the peak of other liquidity measures was in the Netherlands in 2009 (at €30.4 billion, i.e. 1.4% of total assets and 4.9% of GDP).[15]

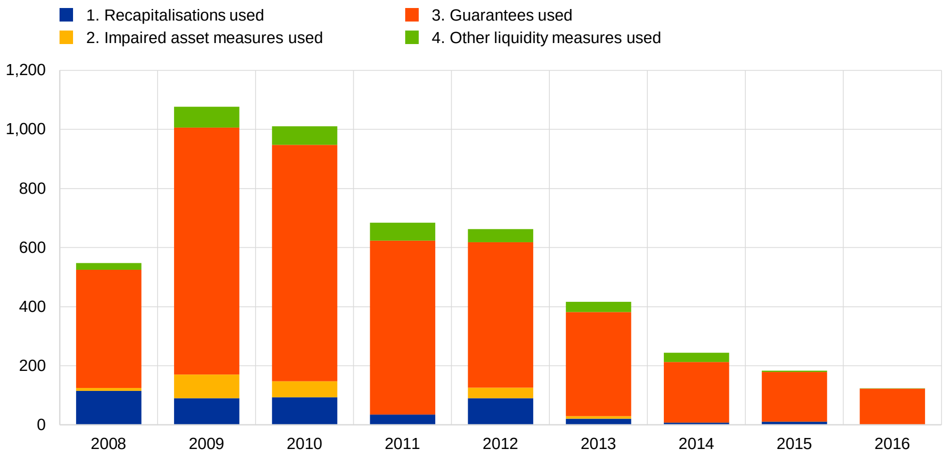
In view of the scope and aim of the paper, the above figures should be treated with caution for two main reasons. First, not all State aid measures were provided to banks in resolution. In fact, most of the State aid support was provided to banks in distress to ensure the stability of the financial system, addressing both capital and liquidity shortfalls. Second, bailouts were in common use before the BRRD was implemented.

[15] Based on European Commission data and ECB calculations.

Chart 1

Composition of used State aid measure, 2008-2017

(EUR billions)



Sources: European Commission and ECB estimations.

In addition to EU State aid data, we also draw on literature on specific cases of past bank resolutions.[16] In this paper, we have focused on certain selected cases for which liquidity needs are reported. Summaries of these cases can be found in Section A.5 of the Annex, while Table 2 provides an overview of the observed liquidity provided in these cases. The liquidity provided to banks ranges from €9 billion to €105 billion, and from 8.8% to 24.8% of total assets.

Table 2

Summary of liquidity provisioning in selected past cases

(EUR billions and percentages of total assets)

Bank	Liquidity need (EUR billions)	Liquidity need (% of TA)
Dexia 2008	95.8	14.7%
Dexia 2013	85	23.8%
Hypo Real Estate	105	24.8%
Banco Popular	13	8.8%
Cyprus Popular Bank	9	27%

Sources: Individual cases and ECB estimations.
Note: For Dexia 2013 the figures refer to the cap on the liquidity aid granted, not the actual use.

1.2 Deposit outflows in past cases

Run-off rates in historic cases of deposit outflows vary both in magnitude and duration. Table 3 shows the deposit run-off rates experienced by nine European and US banks since 2007, which range from 1.6% to 56%.

[16] See, for example, BCBS (2013b) and World Bank Group (2016).

Table 3

Deposit outflows in past cases in Europe and the United States, 2007-2016

(billions in local currency and percentages of total deposits)

Bank	Start of outflow	Duration	Size in billions (currency)	Run-off rate	Monthly run-off rate
Northern Rock	14 Sep 2007	few weeks	13 (GBP)	56%	56%
		first 4 days*	4.6 (GBP)*	20%*	100%*
IndyMac	27 Jun 2008	2 weeks	1.55 (USD)	8.4%	17.6%
Dexia	end-Sep 2011	1 month	7 (EUR)	8.75%	8.75%
Sovereign	11 Jul 2008	-	0.7 (USD)	1.6%	-
	1 Sep 2008	1 month	2.9 (USD)	6.2%	6.2%
Washington Mutual	11 Nov 2008	23 days	9.1 (USD)	4.9%	6.5%
	8 Sep 2008	16 days	18.7 (USD)	10.1%	18.6%
Wachovia	15 Apr 2008	2 weeks	15 (USD)	3.6%	7.8%
	15 Sep 2008	5 days	8.3 (USD)	2.0%	11.8%
	26 Sep 2008	8 days	10 (USD)	2.4%	9.0%
National City	15 Mar 2008	2 days	5 (USD)	5.1%	55.6%
	11 Jul 2008	5 days	4.5 (USD)	4.6%	25.3%
	15 Sep 2008	25 days	4.5 (USD)	4.6%	5.7%
Banco Popular	1 April 2017	2 months	18 (EUR)	24%	12%
		3 days*	6 (EUR)*	8%*	80%*
Cyprus Popular Bank	June 2012	9 months	10 (EUR)**	40%	4.4%
ING direct	Sep 2008	3 months	4.9 (EUR)	3.1%***	1%***
Landsbanki (Icesave in UK)	April 2008	3-4 days	0.2 (GBP)	4.3%***	32.1% - 42.8%***
Average				12.2%	17.5%
Median				5.1%	10.4%

Sources: Rose (2015) for the US banks; National Audit Office (2009); Special Investigation Commission (2010); ING (2009); and the cases described in Section A.5 of the Annex.
Notes: The monthly run-off rate is the monthly average for the runs lasting one month or above, while for runs lasting less than a month the theoretical monthly run-off rate is approximated (assuming the same pace would continue for 30 days). “Deposits” includes deposits from various different counterparties (e.g. households, non-financial corporations, other financial customers, credit institutions).
* For Northern Rock and Cyprus Popular Bank, the more intense beginning or end-phase of the run, respectively, are only reported in the table for information and are not included in the calculation of the averages and medians.
** Only the lower estimate of the deposit outflows in Cyprus Popular Bank is used in the table.
*** Both ING Direct and Landsbanki ‘s Icesave accounts were internet banks. Owing to their exceptionality, the run-off rates from these two banks are not included when calculating the average and median rates in the table.

It should be noted that each case has specific features and took place in jurisdictions with very different crisis management frameworks at the time. In particular, while many deposits in US banks were covered by the Federal Deposit Insurance Corporation or had preferential treatment in the creditor hierarchy, the original EU Deposit Guarantee Schemes (DGS) Directive of 1994[17] only required a minimum level of harmonisation between domestic deposit guarantee schemes in the EU. For example, the deposit run in Northern Rock started when the existing deposit guarantee scheme protected only the first GBP 2,000 of savings in full and 90% of the

17 Directive 94/19/EC of the European Parliament and of the Council of 30 May 1994 on deposit-guarantee schemes.

next GBP 33,000.[18] This proved disruptive for financial stability and the EU internal market, especially during the financial crisis of 2007-2009.[19]

With these caveats in mind, the average run-off rate among the cases is 12.2%, with a median run-off rate of 5.1%. The average or theoretical monthly run-off rates span from 4.4% to 56%, with an average of 17.5% and a median of 10.4%. The average and median run-off rates, however, mix slow burn cases (with low average monthly run-off rates over a long period) and fast burn cases (with high average run-off rates over a short period). Therefore it makes sense to differentiate between the cases, e.g. between cases lasting one month or less and cases lasting several months.[20]

The actual average and median run-off rates are higher in the slow burn cases than in the fast burn cases. In the sample, two banks, Cyprus Popular Bank and Banco Popular, suffered protracted runs of over one month, for which the total run-off rates were 40% and 24%, respectively. Some banks faced several fast burn runs spread out over a longer period, in particular Wachovia with three runs over five months and National City with three runs over six months. The latter two cases could also be regarded as protracted runs with different phases, and therefore both classifications will be considered. Classifying Wachovia and National City as slow burn cases, alongside Cyprus Popular Bank and Banco Popular, would lead to an average run-off rate of 21.6% and a median of 19.2% among the four cases. This is displayed in Table 4.

Table 4

Actual and monthly average/median rates for slow burn and fast burn cases

(percentages)

Crisis type	Actual average (median)	Monthly average (median)
Slow burn	21.6% (19.2%)	5.1% (3.4%)
Fast burn	13.7% (8.4%)	18.9% (13.2%)

Sources: Table 3 and ECB calculations.
Notes: Slow burn cases are: Cyprus Popular Bank, Banco Popular, Wachovia and National City. Fast burn cases are Northern Rock, IndyMac, Dexia, Sovereign and Washington Mutual. The monthly averages are calculated as in Table 3. For Northern Rock and Cyprus Popular Bank, the more intense beginning or end phases of the run, respectively, are only reported in Table 3 for information and are not included in the calculation of the averages and median in this table (or in Table 3).

As Table 4 shows, the slow burn average monthly run-off rates are naturally much lower than the average theoretical monthly run-off rates for the fast burn cases. The slow burn average monthly run-off rate is 5.1%, compared to a theoretical monthly run-off rate of 18.9% for the fast burn cases.[21] In the former, the deposit outflow is of low intensity but long lasting, while, in the latter, the deposit outflow is short-lived but of high intensity.

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[18] See Financial Services Compensation Scheme (2017).

[19] An amending directive in 2009 required EU countries to increase their protection of deposits, first to a minimum of €50,000, and then to a uniform level of €100,000 by the end of 2010. In 2014 the EU adopted a new DGS Directive – Directive 2014/49/EU of the European Parliament and of the Council of 16 April 2014 on deposit guarantee schemes (OJ L 173, 12.6.2014, p. 149).

[20] There are no clear definitions of what “fast burn” and “slow burn” cases are. Hence the one month threshold is chosen arbitrarily.

[21] Wachovia and National City are classified as slow burn cases.

The average theoretical monthly run-off rate for the fast burn cases is slightly lower than the average actual run-off rate in the slow burn cases. For the fast burn cases, the average actual run-off rate is 13.7%, and the average theoretical monthly run-off rate is 18.9%.[22] This can be compared to an average actual run-off rate of 21.6% for the slow burn cases (including Wachovia and National City). If the runs in Wachovia and National City are included as separate fast burn cases, the average actual monthly run-off rate would decrease to 9.1%, but the average theoretical monthly run-off rate would increase to 19.1%.[23]

1.3 Key takeaways from past cases

From the observations above, one inference is that it is important to test different crisis scenarios in the analyses by applying a broad range of possible cases both prior to and after the "failing or likely to fail" (FOLTF) assessment. It is hard to draw very firm conclusions from the specific cases above, particularly as the regulatory environment was different or has changed since many of them took place. Nonetheless, the observations provide a picture of the overall scenarios and possible outcomes that can occur in the case of a resolved bank (or set of banks). In particular, there are some important issues to take note of:

- **Liquidity needs can be substantial in a crisis and significantly outweigh other forms of support, such as recapitalisation.** In 2008-2017, the largest part of the State aid measures used was in the form of liquidity aid.
- **Liquidity needs are likely to arise after resolution actions.** The analysis of past cases shows that liquidity needs can be substantial even after public intervention (e.g. resolution or public recapitalisation).
- **Liquidity needs are case-specific and may vary significantly depending on many factors.** The past cases analysed in this section show provisioning of liquidity to banks ranging from 8.8% to 27% of the bank's total assets. However, the numbers should be treated with caution, as each case is very different. In particular, it is not conclusive that these would have been the liquidity gaps if the banks had undergone resolution as assumed in this paper. Hence, the numbers mainly serve as indicators against which to compare the estimated results in this paper.

[22] The median values are 8.4% (actual) and 13.2% (theoretical), respectively.

[23] The median rates would also decrease to 4.9% (actual) and 10.4% (theoretical).

2 Methodology and data

The model used in this paper differs from standard liquidity stress tests, in particular the assumption that the assessed banks enter into resolution and are successfully resolved. Thus, although the model shares some similarities with many liquidity stress tests, there are some key differences. First, the emphasis is placed on liquidity gaps after the bank has failed and entered into resolution, rather than on whether the bank will fail under the applied stress. Second, as the failure is taken as given, the underlying cause of it (liquidity problems, solvency problems, or a combination of both) is not directly modelled.[24] The model is abstracting from the exact path and processes that triggered the resolution. Third, stress is applied both before and after the predetermined point when the bank is assumed to be FOLTF. In the former case, to derive the state of the bank upon entry into resolution, and in the latter case, to derive the liquidity gaps in resolution.

A liquidity gap in resolution implies that the bank, although recapitalised by the application of resolution measures, still faces a shortage of liquidity. This liquidity shortage may occur because: (i) there are net liquidity outflows (e.g. from deposit outflows and/or when creditors are not willing to roll over maturing debt) after the bank is placed in resolution; (ii) the bank has no or insufficient liquidity buffers after resolution to meet regulatory requirements; and (iii) the bank cannot currently obtain sufficient funding in the market or in regular monetary policy operations to meet its liquidity needs (e.g. because it lacks access or lacks unencumbered assets and eligible collateral). In order for resolution to be successful, such liquidity gaps need to be addressed to avoid the bank being assessed as FOLTF again.

The starting point for the analysis of liquidity gaps in resolution is the contractual inflows and outflows, counterbalancing capacity and contingencies reported by banks for different maturity buckets.[25] Behavioural inflows and outflows and haircuts are then applied on the basis of an assumed crisis scenario. In order to test a range of conditions of a bank entering into resolution, different pre-FOLTF scenarios are applied.

The analysis is performed on a static balance sheet and maturity ladder, in which only some items are changed on the basis of exogenous assumptions. Thus, any dynamic flows and adjustments of the bank in the crisis period (pre- and post-FOLTF) are not taken into account. Furthermore, for the sake of simplicity, the maturity buckets in the pre-FOLTF period are aggregated into one time bucket. While this simplification will ignore the exact path of the liquidity position into resolution, it has the benefit of circumventing the need to make various assumptions on the exact distribution of the elevated net outflows in each maturity bucket, as well as the need to make assumptions regarding the timing and magnitude of possible (failed) recovery actions prior to the FOLTF assessment. More importantly, it delivers a state of the

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24 However, the model will move forward the point of FOLTF for banks that cannot meet the liquidity stress with their CBC.

25 Taken from the COREP data reported in template C66.00 "Maturity ladder".

bank at the point of FOLTF, which is needed for the subsequent assessment of the liquidity gaps in resolution.

The state of the bank is given by its counterbalancing capacity (CBC). The CBC represents the stock of unencumbered assets or other funding sources which are legally and practically available to the institution at the reporting date to cover potential liquidity gaps. For the purposes of this paper, the state of the bank may range from a bank entering into resolution with a significant part of its CBC still present to a bank with most of this capacity consumed in the period before being assessed as FOLTF.

Once placed in resolution, existing creditors/clients may still withdraw their money and market participants may stand back from immediately providing liquidity. It is assumed that confidence in the resolved bank is not restored immediately after the resolution decision is taken.[26] The net outflows post-FOLTF are also case-dependent, based on, for example, idiosyncratic characteristics of the bank, the events that took place prior to resolution, the implemented resolution strategy and tools, and prevailing market conditions. All these factors can vary and are hard to predict and model. To capture part of this uncertainty, different scenarios are also applied in the post-FOLTF period.[27] However, where applicable, the maturity buckets in this predefined period will not be aggregated.

Given the above, the result of the analysis will not produce exact figures of the liquidity gaps in resolution, but rather plausible broad ranges for various crisis scenarios.[28] Furthermore, the methodology is applied to a set of banks in order to mimic two possible crises. First, it is applied to each bank in the sample to determine how big the liquidity gaps of banks in the euro area would be, both on average and in extreme cases, if one bank is resolved (see Section 3). Second, the methodology is applied to different sets of banks that are assumed to fail simultaneously in order to quantify the funding gaps in the context of a simulated systemic crisis (see Section 4). This scenario is further developed to account for two different types of systemic event: a crisis due to several banks in the system being resolved at the same time, in which contagion effects are also considered (see subsection 4.2), and a crisis involving two G-SIBs failing simultaneously (see subsection 4.3). It is outside the scope of this paper to attempt to model and determine the likelihood of the different scenarios tested.

2.1 Description of the model

The analysis estimates the liquidity that a bank would need from an external source after entering into resolution, given its state at FOLTF and when facing a period of continued stressed conditions. The starting point is the maturity ladder

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[26] The success of resolution is not questioned in the study. It is assumed that outflows will continue for a while after the application of resolution tools until there is confidence in the resolution measures, access to market funding is restored, and liquidity buffers reach a new stable level (in terms of counterbalancing capacity).

[27] The analysis is limited by the decision not to model different causes of failure in different states of the world followed by different applications of resolution measures and tools.

[28] To complement these ranges, descriptions of the main model caveats, which can either increase or decrease the estimated liquidity gaps in resolution, are explained in subsection 2.4.

(and balance sheet) of a going concern bank in business-as-usual mode. A crisis scenario is then applied to its maturity ladder for a certain period of time, mainly by assuming increased deposit outflows and decreased inflows. For this purpose, two periods are used throughout the analysis, divided as follows:

Pre-FOLTF period: Stressed inflows and outflows are applied to the steady-state maturity ladder for a predetermined period of time, after which it is assumed that the bank is declared as FOLTF. At the end of this period, it is assumed that an FOLTF assessment is performed and resolution actions are implemented (i.e. bail-in, see subsection 2.4). The effect of the net liquidity outflows on the bank's cumulative CBC at the point of FOLTF will be derived.[29]

Post-FOLTF period: The starting point is the status of the bank at FOLTF, broadly given by its remaining deposit stock and its current CBC level. Then elevated net outflows are again applied for a given period of time. In addition, a haircut is applied on the bank's remaining CBC.[30] During this period it is assumed that confidence will eventually return and inflows will begin to surpass outflows (see Figure 1 below). The minimum cumulative CBC level is the point from which the liquidity funding need is measured.

Two pre-FOLTF periods are considered: a fast burn scenario lasting four weeks, and a slow burn scenario lasting six months. These periods seem reasonable for several reasons. First, there is a clear distinction in duration between the two crises. Second, some of the bank cases in subsection 1.2 showed prolonged runs of around half a year, while other bank cases displayed runs shorter than a month. Third, the slow burn pre-FOLTF period would be aligned with the stressed period assumed in the ECB Sensitivity Analysis of Liquidity Risk – Stress Test 2019 (LiST 2019)[31]. The fast burn crisis would be much shorter than this, and also shorter than the three months of stress used in the top-down liquidity stress test in Stress-Test Analytics for Macroprudential Purposes in the euro area (STAMP€)[32]. Two post-FOLTF periods are also applied. It is assumed that the post-FOLTF period in the fast burn crisis is eight weeks, while in the slow burn crisis it is set to three months. The difference is due to the structure of the maturity ladder (see footnote 24), which does not have a more granular maturity bucket after six months. The peak funding gap is assumed to take place within these respective periods.

Figure 1 illustrates the model and which liquidity gaps are measured. It shows the liquidity position of the bank getting worse, depicted by its decreasing CBC level. The CBC deteriorates both before FOLTF (between T_1 and T_2) and after FOLTF (between T_2 and T_3), when liquidity outflows are much higher than inflows. To meet the net outflows, the bank uses its CBC, which, as a consequence, decreases. As illustrated in Figure 1, net outflows are assumed to continue post-FOLTF and, if these are substantial, the cumulative CBC could theoretically break below zero at some

29 If the cumulative CBC becomes negative before the assumed FOLTF point in a scenario, the FOLTF will be anticipated and be assumed to come at the latest point in time at which the cumulative CBC would still be positive (see subsection 2.2.3).

30 The calibration of the scenarios is detailed in subsection 2.2.

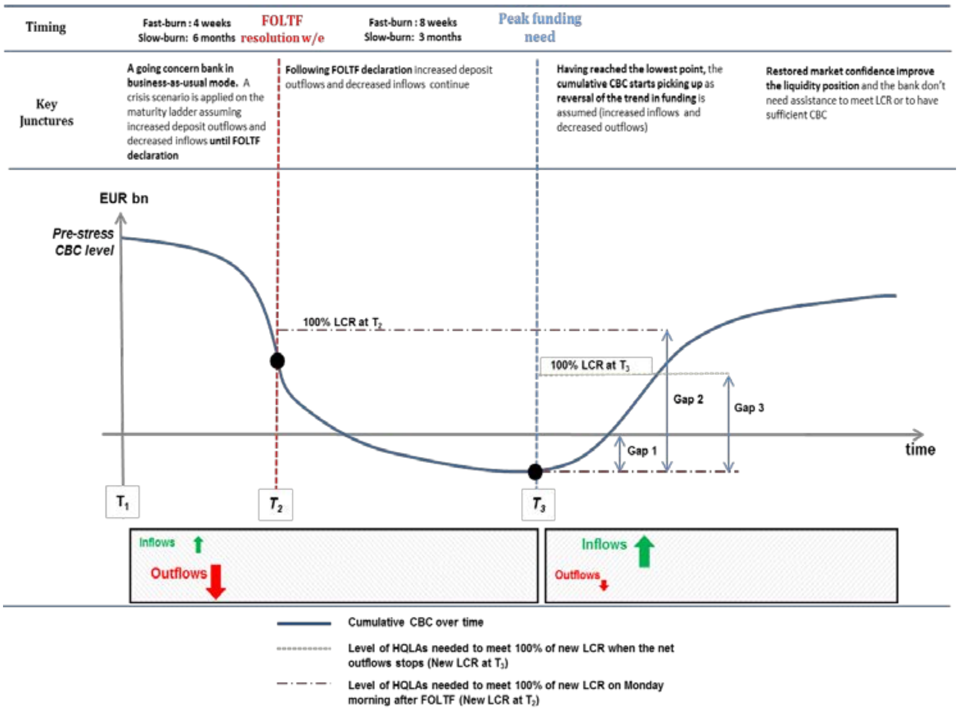
31 See ECB (2019a; 2019b).

32 See Halaj and Laliotis (2017).

point.[33] For the analysis, the level of the theoretical cumulative CBC for the bank at two points in time are of interest, namely at FOLTF (T_2 in Figure 1) and at the peak funding need (T_3 in Figure 1). The exact paths towards these points are not modelled. Hence the smoothness of the CBC curve in Figure 1 is only illustrative, since only the start and end points are calculated in the model.

Figure 1

Illustration of the model: the evolution of the CBC and the liquidity gaps measured



At some point after the resolution intervention, the situation is assumed to stabilise and the cumulative CBC starts to improve. This breaking point would determine the peak funding need in resolution[34], as shown in Figure 1. It is from this minimum theoretical cumulative CBC level (at T_3 in Figure 1) that the liquidity gap in resolution will be measured. More formally, the cumulative counterbalancing capacity (CCBC) at time t is defined as:

$$CCBC_t = CBC_0 + \sum_{n=1}^{t} \Delta CBC_n + \sum_{n=1}^{t} Inflows_n - \sum_{n=1}^{t} Outflows_n$$

Where CBC_0 is the stock level of CBC at steady state and ΔCBC is the contractual changes in the CBC for the maturity buckets up to time *t* which existed at the steady-state reporting date. The sums of inflows and outflows are generated by the assumed stressed conditions, both pre- and post-FOLTF.

[33] In reality, liquidity would be provided to the bank in order not to become illiquid. The only thing in Figure 1 which indirectly captures such liquidity provisioning is the fact that, eventually, market confidence builds up as the successful resolution becomes clearer. However, in theory, the CBC could break zero if the liquidity provided to the bank is not considered, as in Figure 1.

[34] From this point onwards, the bank is expected to be able to start repaying the liquidity provisioning and eventually move to a new steady-state CBC level.

What to measure towards (the target level) is more of an open question, and the choice of target will generate different liquidity gaps. Three different target levels are used in the paper, as shown in Figure 1, resulting in the measuring of three liquidity gaps, namely:

- **Gap 1, which is the liquidity potentially needed to keep the bank's CBC level above zero.** Banks for which the CBC level is sufficient to cover the liquidity stress (both before and after FOLTF) would not have any liquidity gap under this measure. Gap 1 is defined as:[35]

  $$Gap\ 1 = Max(0{,}0 - Min[CCBC_t])$$

- **Gap 2, which is the liquidity potentially needed to maintain the level of liquid assets required to meet the new liquidity coverage ratio (LCR) on the Monday morning after FOLTF throughout the process.** In other words, it uses 100% fulfilment of the new LCR on the Monday morning (at time T_2) as the target level for measuring the liquidity gap (at time T_3). Gap 2 is defined as:

  $$Gap\ 2 = Max(0, liquid\ assets\ to\ meet\ LCR_{T2} - Min[CCBC_t])$$

- **Gap 3, which is the liquidity potentially needed to meet the new LCR at the turning point (at time T_3).** In other words, it uses 100% fulfilment of the new LCR at time T_3 as the target level for measuring the liquidity gap. Gap 3 is defined as:

  $$Gap\ 3 = Max(0, liquid\ assets\ to\ meet\ LCR_{T3} - Min[CCBC_t])$$

While Gap 1 does not allow CBC to become negative, it can still be fully depleted, which would not be very confidence building in resolution. To instil confidence, one may want to provide the bank with a liquidity buffer. Gaps 2 and 3 introduce such buffers by using new LCR levels as liquidity targets.[36] The LCR which the bank would face at T_2 and T_3, respectively, would require lower amounts of liquid assets than before, given the realised stressed net outflows. The LCR at T_2 only takes into account the stressed inflows/outflows until FOLTF, while the LCR at T_3 takes into account all stressed inflows/outflows for this deduction and would be lower. Consequently, Gap 2 is more conservative than Gap 3, as it implies that the bank would have an additional confidence building buffer on top of 100% LCR at T_3.[37]

Box 1
Methodology used for approximating post-FOLTF LCR values

The liquidity coverage ratio (LCR) has been introduced as a supervisory standard with the aim of promoting the short-term resilience of the liquidity risk profile of banks. In particular, the LCR ensures

[35] The minimum CCBC could theoretically occur in any of the maturity buckets between periods T_2 and T_3, hence Min[$CCBC_t$] refers to the time bucket generating the minimum CBC level.

[36] In addition, it may also be appropriate that the resolved bank is able to fulfil a (new) LCR throughout the stressed post-FOLTF phase.

[37] Thus Gap 2 does not measure the liquidity gap on the Monday morning, but rather the gap to reach a higher target level than Gap 3. The liquidity gap on the Monday morning, which would be the gap between the cumulative CBC level at T_2 and the new LCR at T_2 in Figure 1, is not measured.

that banks have an adequate stock of unencumbered high-quality liquid assets that can be converted easily and immediately into cash in order to meet liquidity needs in a 30-calendar-day liquidity stress scenario.[38] The formula for calculating the LCR is:

$$LCR = \frac{HQLA}{Total\ net\ cash\ outflows}$$

These three items are available in COREP data[39] for the banks in the sample, where HQLA is the high-quality liquid assets the bank holds to meet at least 100% LCR.[40]

"Total net cash outflows" (the denominator of the LCR formula) at steady state is retrieved for all banks in the sample. It is defined as the total expected cash outflows minus total expected cash inflows in the specified stress scenario for the subsequent 30 calendar days. Total expected cash outflows are calculated by multiplying the outstanding balances of various types of liabilities and off-balance-sheet commitments by the rates at which they are expected to run off or be drawn down.[41] For each scenario applied to a bank in the sample, we have specific outflows and inflows derived by stressing the items on the maturity ladder. Since these outflows and inflows have already happened when a new LCR is calculated, they are no longer on the bank's balance sheet to feed into the calculation of a new LCR denominator at FOLTF (or at the time of the peak funding need). For example, assume that €50 million of stable deposits ran off before a bank was declared FOLTF. Stable deposits usually attract a run-off factor of 5% when calculating the total net cash outflows in the LCR,[42] so the new LCR denominator after FOLTF must be 5% of €50 million (i.e. €2.5 million) smaller than the steady-state LCR denominator, all other things being equal.

What should be deducted from the steady-state LCR denominator to approximate the new LCR denominator at FOLTF are all (weighted) stressed outflow and inflow items, which is:

$$Net\ Outflows_{T2} = \sum_{r=1}^{8} \sum_{t=1}^{FOLTF} Outflows_{r,t} * Stress_r^{out} * Weight_r^{out} - \sum_{r=1}^{6} \sum_{t=1}^{FOLTF} Inflows_{r,t} * Stress_r^{in} * Weight_r^{in}$$

"Stress" indicates the stress levels applied to the different inflow and outflow items, while "weight" indicates the weights of the corresponding items in the LCR calculation (see Table A below). Following the methodology proposed by the Basel Committee on Banking Supervision (BCBS), the inflows are aggregated up to a cap of 75% of total expected outflows.[43] These weighted stressed net outflows are deducted from the old steady-state LCR denominator, as reported in the COREP template, to proxy the new LCR denominator at FOLTF. The same method is used to derive the LCR

38 Please note that the short-term liquidity objectives promoted by the LCR are complemented by the net stable funding ratio (NSFR), which has a time horizon of one year and thus creates additional incentives for banks to fund their activities with more stable sources of funding on an ongoing basis.

39 Common reporting (COREP) is the standardised reporting framework issued by the European Banking Authority (EBA) for the reporting under the Capital Requirements Directive (CRD IV). The liquidity reporting can be found in the liquidity coverage templates (C72.00 – C76.00).

40 In the EU, the LCR has been applicable since 1 October 2015, but it was implemented gradually. Full implementation at a minimum of 100% was reached in January 2018.

41 See BCBS (2013a).

42 Ibid.

43 Ibid.

at peak funding need (at time T3 in Figure 1), by also considering the outflows and inflows post-FOLTF.

Table A shows the LCR rates used in the approximation, which are based on the rates reported in the BCBS standards for liquidity monitoring.

Table A

Run-off rates, drawdown rates and similar factors used to derive total net cash outflows in the LCR

(percentages)

Outflow item	Factor
Stable retail deposits	5%
Other retail deposits	10%
Operational deposits	25%
Non-operational deposits from credit institutions	100%
Non-operational deposits from other financial customers	100%
Non-operational deposits from central banks	100%
Non-operational deposits from non-financial corporates	40%
Non-operational deposits from others	20%
Inflow item	**Factor**
Retail customers	50%
Non-financial corporates	50%
Credit institutions	100%
Other financial customers	100%
Central banks	100%
Other counterparties	50%

Sources: BCBS (2019).

While most rates are harmonised across jurisdictions, as outlined in the Basel standard, a few parameters are to be determined by supervisory authorities. For such cases, plausible rates have been picked for the purpose of the approximation and are as indicated in Table A above.

The new LCRs at these two points are approximated on the basis of the old LCR adjusted for net outflow levels. An exact calculation of the LCR requires specific weights to be applied to specific items in the formula (see BCBS, 2013a). Unfortunately, not all of items on the maturity ladder match the items in the LCR formula. Therefore, an exact calculation of the new LCR based on all its sub-components is not possible. However, the values can be approximated by deducting the weighted stressed outflow and inflow items from the steady-state LCR denominator (see Box 1 for the methodology).

2.2 Scenario design

When designing the scenarios, the assumptions have been exogenously determined and not modelled or calibrated according to specific bank or balance sheet information. The levels are based on internal assumptions, while taking into account what is used in stress test scenarios (see Box 2) and what can be observed in past crisis cases (see subsection 1.2 above).

The scenarios studied include a slow burn and a fast burn crisis case, which differ both in duration and in the rates applied. Two crisis levels (severe and very severe) are also tested for both the pre- and post-FOLTF periods, which will make it possible to combine them in order to obtain a range of results. This is done for both a fast burn and a slow burn crisis case, generating eight different crisis scenarios in total.

The run-off rates are always the total rates of outflows over the defined period. For example, a run-off rate of 50% on operational deposits in the pre-FOLTF period means that half of all the operational deposits that matured in this period were not rolled over.

2.2.1 Run-off rates

Three general assumptions are made regarding the relationship between the scenarios and the run-off rates applied.

Assumption 1: Post-FOLTF run-off rates are lower than the run-off rates pre-FOLTF. The assumption that total run-off rates after FOLTF are lower than before FOLTF is based on what has been observed in a number of real cases.[44] Post-FOLTF run-off rates are assumed to be as follows:

- in the severe post-FOLTF scenario, the outflows are 50% of the corresponding pre-FOLTF rates;
- in the very severe post-FOLTF scenario, the outflows are 75% of the corresponding pre-FOLTF rates.

It should be noted that the scaling (50% and 75%) is not based on estimations, but rather used in this paper as plausible rates which achieve two rule-based levels of severity in the resolution phase.

Assumption 2: The run-off rates in the fast burn scenario are 10% lower than in the slow burn scenario. This assumption is supported by the observation of real bank runs, where the average total run-off rate in the fast burn cases (13.7%) is lower than the average total run-off rate in the slow burn cases (21.6%) (see Table 4 above). Taking into account that, on average, these fast burn cases lasted approximately three weeks, rather than the four-week pre-FOLTF period applied in this paper for the fast burn scenario, a somewhat smaller difference can be applied.[45]

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[44] This also follows from the assumption that the resolution tool will be effective and increase confidence. It should be noted that this relationship concerns the total outflows prior to and after FOLTF, respectively, and not the day-by-day outflows. Therefore, even with this assumption, it may be possible that most outflows after FOLTF happen during the first few days after the resolution measures were taken, and thus be high on a day-by-day basis (even higher than just before FOLTF).

[45] The average theoretical monthly run-off rate of the fast burn cases is 18.9% (see Table 4). This can be viewed as the average run-off rate if scaled up for a period of one month, which is still slightly lower than the average total run-off rate in slow burn cases (21.6%).

Assumption 3: The run-off rates in the very severe scenario are 40% higher than in the severe scenario. This assumption is made in order to have a basic rule determining the difference in severity between the severe and very severe scenarios. The choice of 40% is in line with the approximate difference between rates for the scenarios used in ECB for liquidity risk stress testing (2019a).

When adhering to these three general assumptions, it is possible to derive all the run-off rates by assuming the pre-FOLTF very severe run-off rates in the slow burn scenario. The run-off rates for the very severe slow burn scenario have been chosen on the basis of what is used in liquidity stress tests (see Box 2) and on what can be observed is some real cases (see Section 1.2). The resulting numbers are reported in Table 5 (slow burn) and Table 6 (fast burn).

In addition to the run-off rates of deposits, a decrease of inflows from loans and advances is also assumed in the analysis.[46] The stress levels applied are the same in the fast burn and slow burn scenarios, and the rates are assumed to remain the same both before and after FOLTF. However, two decreased levels are used according to crises of different severity: -10% in the severe scenario, and -20% in the very severe scenario.

Table 5

Slow burn crisis stress levels, aggregated run-off rates of deposits pre- and post-FOLTF

(percentages)

	Pre-FOLTF rates		Post-FOLTF rates (with severe pre-FOLTF rates)		Post-FOLTF rates (with very severe pre-FOLTF rates)	
Item	Severe	Very severe	Severe	Very severe	Severe	Very severe
Stable retail deposits	12.9%	18.0%	6.4%	9.6%	9.0%	13.5%
Other retail deposits	21.4%	30.0%	10.7%	16.1%	15.0%	22.5%
Operational deposits	35.7%	50.0%	17.9%	26.8%	25.0%	37.5%
Non-operational deposits from credit institutions	70.0%	100.0%	35.0%	52.5%	50.0%	75.0%
Non-operational deposits from other financial customers	70.0%	100.0%	35.0%	52.5%	50.0%	75.0%
Non-operational deposits from central banks	28.6%	40.0%	14.3%	21.4%	20.0%	30.0%
Non-operational deposits from non-financial corporates	28.6%	40.0%	14.3%	21.4%	20.0%	30.0%
Non-operational deposits from others	28.6%	40.0%	14.3%	21.4%	20.0%	30.0%
Inflows	-10.0%	-20.0%	-10.0%	-20.0%	-10.0%	-20.0%

46 Although applied uniformly, it should be noted that it has not been taken into account whether such a decrease is possible in all Member States.

Table 6

Fast burn crisis stress levels, aggregated run-off rates of deposits pre- and post-FOLTF

(percentages)

Item	Pre-FOLTF rates		Post-FOLTF rates (with severe pre-FOLTF rates)		Post-FOLTF rates (with very severe pre-FOLTF rates)	
	Severe	Very severe	Severe	Very severe	Severe	Very severe
Stable retail deposits	11.6%	16.2%	5.8%	8.7%	8.1%	12.2%
Other retail deposits	19.3%	27.0%	9.6%	14.5%	13.5%	20.3%
Operational deposits	32.1%	45.0%	16.1%	24.1%	22.5%	33.8%
Non-operational deposits from credit institutions	70.0%	100.0%	35.0%	52.5%	50.0%	75.0%
Non-operational deposits from other financial customers	70.0%	100.0%	35.0%	52.5%	50.0%	75.0%
Non-operational deposits from central banks	25.7%	36.0%	12.9%	19.3%	18.0%	27.0%
Non-operational deposits from non-financial corporates	25.7%	36.0%	12.9%	19.3%	18.0%	27.0%
Non-operational deposits from others	25.7%	36.0%	12.9%	19.3%	18.0%	27.0%
Inflows	-10.0%	-20.0%	-10.0%	-20.0%	-10.0%	-20.0%

2.2.2 Applying a CBC haircut

For both the fast burn and slow burn crisis scenario, a haircut is applied to the CBC as a proxy for some events not modelled. These events are, for example, asset price falls, higher derivative collateral posting requirements, some high-quality liquid assets being trapped/immobile in foreign subsidiaries, etc. This simplified approach is applied due to lack of decomposed stock data on CBC components, making it hard to apply a more granular approach.[47]

Different haircuts are used depending on the type of crisis (idiosyncratic or systemic), the size of the failing bank, and the severity of the scenario. The CBC haircuts assumed in the idiosyncratic scenario are summarised in Table 7.

Table 7

Haircuts applied to the CBC

(percentages)

Severity level	Smallest banks	Average sized banks	G-SIBs
Severe	1%	1.5%	3%
Very severe	3%	4.5%	9%

[47] The haircut is applied to the cumulative CBC at FOLTF, and only at this point. Thus, it contributes less than these percentages to the funding gaps considered in the next sections of the paper. In particular, for banks with very little CBC left at FOLTF, the application of the haircut will have a very small impact on the estimated funding gap.

The larger haircut for large banks is motivated by the fact that their failure is likely to have a market impact (e.g. on asset prices) and the fact that they would be subject to higher derivative collateral posting requirements. Idiosyncratic failures of small domestic banks would not have a major impact on markets, nor do they have large derivative portfolios. A small CBC haircut for small banks can also be motivated by the fact that they have a rather limited variation in CBC (e.g. due to a focus on local government bonds, or mortgage-backed securities). Average sized banks are assumed to face half the level of haircuts applied to G-SIBs.[48] The distinction above applies to the idiosyncratic crisis scenario only, while for the systemic crisis scenario we apply the same two values for all banks: 3% and 9% for the severe and very severe scenarios, respectively.[49]

2.2.3 Anticipation of the resolution decision

It cannot be ruled out, in particular for the most severe scenarios, that some banks will not be able to meet the stressed net outflows before the predetermined FOLTF point without exhausting their CBC. In other words, their theoretical cumulative CBC would become negative before they are assessed as FOLTF and placed in resolution. Since it is not reasonable to assume that the CBC of a bank entering resolution can be negative, the option of anticipating the resolution decision is used in such cases.

If the cumulative CBC is negative for a bank at FOLTF, the resolution decision is assumed to take place earlier. The FOLTF point is moved to take place in the maturity bucket prior to the one originally set as the last one before FOLTF. By doing this, fewer liabilities will reach maturity before FOLTF and therefore will not run off and draw on the CBC. This process is repeated (if needed) until a point is reached where the bank still has some CBC left, and FOLTF is assumed to take place at this point instead. The duration of the post-FOLTF period remains the same as before, but it is shifted to start after the new FOLTF point. This process is used throughout this paper for all cases and scenarios.

Box 2
Comparison of pre-FOLTF run-off rates with run-off rates used in LiST 2019

Tables A and B compare the total pre-FOLTF run-off rates on deposits and the decrease in inflows from loans and advances used in this paper, for both slow burn and fast burn crises, with those used in LiST 2019.

In general, looking at the pre-FOLTF period, the run-off rates applied in this report are lower than the rates applied in the LiST 2019 adverse scenario. However, this report also adds outflows after the FOLTF, which push the total outflows closer to the LiST levels.

48 As a threshold to separate the smallest banks from “average sized” banks, we use total assets of €200 billion.

49 A robustness analysis of the CBC haircuts was performed (see Section A.4 of the Annex) by applying the higher CBC haircuts to the smaller banks and smaller CBC haircuts to the larger banks. Extremely small changes in the results were obtained, which also shows that the level of CBC haircuts applied in this study does not seem to be one of the main drivers of liquidity gaps.

Table A

Slow burn run-off rates and LiST 2019 rates (total)

(percentages and percentage points)

Item	List 2019		Slow burn rates		Difference from LiST 2019	
	Adverse	Extreme	Severe	Very severe	Severe	Very severe
Stable retail deposits	18%	27%	13%	18%	-5 pp	-9 pp
Other retail deposits	39%	48%	21%	30%	-18 pp	-18 pp
Operational deposits	37%	50%	36%	50%	-1 pp	0 pp
Non-operational deposits from credit institutions	100%	100%	70%	100%	-30 pp	0 pp
Non-operational deposits from other financial customers	100%	100%	70%	100%	-30 pp	0 pp
Non-operational deposits from non-financial corporates	52%	76%	29%	40%	-23 pp	-36 pp
Non-operational deposits from others	52%	76%	29%	40%	-23 pp	-36 pp
Money due from loans and advances	-9%	-9%	-10%	-20%	1 pp	11 pp

Sources: ECB (2019a; 2019b).

Table B

Fast burn run-off rates and LiST 2019 rates (total)

(percentages and percentage points)

Item	List 2019		Slow burn rates		Difference from LiST 2019	
	Adverse	Extreme	Severe	Very severe	Severe	Very severe
Stable retail deposits	18%	27%	12%	16%	-6 pp	-11 pp
Other retail deposits	39%	48%	19%	27%	-20 pp	-21 pp
Operational deposits	37%	50%	32%	45%	-5 pp	-5 pp
Non-operational deposits from credit institutions	100%	100%	70%	100%	-30 pp	0 pp
Non-operational deposits from other financial customers	100%	100%	70%	100%	-30 pp	0 pp
Non-operational deposits from non-financial corporates	52%	76%	26%	36%	-26 pp	-40 pp
Non-operational deposits from others	52%	76%	26%	36%	-26 pp	-40 pp
Money due from loans and advances	-9%	-9%	-10%	-20%	1 pp	11 pp

Sources: ECB (2019a; 2019b).

2.3 Systemic crisis model

In the systemic crisis scenario, several banks are assumed to be resolved simultaneously and to have coinciding liquidity gaps in resolution. The methodology applied to each single bank to derive its liquidity gaps is the same as described above. What differs here is the number of banks assumed to fail at the same point in time, and how such banks are selected through Monte Carlo simulations.

In particular, three different ways have been designed to account for contagion effects across banks and countries. First, banks are randomly resolved in each simulation run, meaning they are selected as banks in distress based on their probability of default (PD) only, and without considering cross-bank interlinkages (i.e. there is no contagion). Second, for comparison, the number and selection of banks considered as failing is based on their estimated PDs and on the correlation of each bank with the other institutions in the sample (i.e. contagion is considered).

Third, two G-SIBs are assumed to be resolved simultaneously to assess the consequences of a systemic crisis due to few but complex and systemic banks in distress. While the G-SIB-related crisis does not need to rely on simulations, since all the possible combinations of two crisis G-SIBs can be tested, the other two systemic crisis scenarios require Monte Carlo simulations.

2.3.1 Monte Carlo simulations with and without contagion

The effect of contagion in a systemic crisis is captured through a change in banks' PDs due to their correlation with the other banks in distress. PDs are first estimated for each bank using an early-warning model based on bank-specific, banking sector-specific and country-specific factors.[50] In each simulation run, when contagion is not included, banks have a probability of being extracted and selected as failing on the basis of their high or low PD relative to other banks in the sample. When contagion is included, bank-specific PDs are increased or decreased on the basis of their positive or negative correlation with banks that have already been selected as being in distress.

Contagion is proxied through correlations between banks' market returns on equity. The adjustment of banks' PDs to account for interdependent distress events is described in equation (1), where j indicates the bank previously selected as failing, $\rho_{i,j}$ is the correlation between all the other banks i in the sample and bank j, and c is a discretionary rescaling factor that has been set at 0.1. If all the banks with an "adjusted" PD higher than the 95th percentile of the "original" PD distribution have been selected as failing, the algorithm stops; if not, another bank is selected from the sample as failing on the basis of the "adjusted" PD distribution. As a consequence, in each simulation run the number of failing banks differs.

$$Adjusted\ PD_i = \min(1, Original\ PD_i * (1 + c * \rho_{i,j})) \qquad (1)$$

In the algorithm used to select failing banks, banks' PDs are adjusted according to their correlation with all the banks that have previously been selected as failing. This provides a proxy for direct and indirect contagion channels. The rescaling factor c in equation (1) to adjust banks' PDs has the purpose of limiting the impact of contagion on banks' PDs without affecting the relative riskiness of the banks. As $\rho_{i,j} \in [-1,1]$, c will limit the adjustment of banks' PDs due to the contagion channel to no more than ten percentage points. The purpose of *c* is thus only to limit the potential shift of banks' PDs in absolute terms, without changing the relative riskiness (ranking) of the banks in the sample.

50 Banks' PDs were estimated using the model described in Carmassi et al. (forthcoming).

2.4 Main methodological features and their impact on the results

Estimating the level of the liquidity gaps in resolution is, for several reasons, quite a challenge. In particular, liquidity needs in resolution may vary significantly depending on: (i) the severity and type of the crisis (idiosyncratic or sectoral, national or global); (ii) the financial situation of the bank at the point of FOLTF declaration; (iii) the length of time until the resolved entity fully recovers and access to markets is restored; (iv) market response and market capacity; and (v) the tool and resolution strategy applied. These factors, either individually or in combination, are key to determining how the level of the liquidity gaps in resolution may increase or decrease.

While the methodology in this paper has the benefit of being fairly simple and transparent, some key assumptions are made which may drive the results in different directions. The following should be noted:

Only an "open bank bail-in" is assumed to be applied to the banks in resolution. Thus, other types of resolution, e.g. a multiple point of entry resolution strategy[51] or a splitting of the bank into a good bank and a bad bank, have not been taken into account. The use of other resolution tools would have an impact on the liquidity gaps. For example, the "sale of business" tool could potentially lower or even remove the liquidity gaps if the acquirer is financially strong and instils confidence. The "asset separation" tool could separate troubled assets from the parts of the bank which provide critical functions, implying the provision of liquidity to a smaller part of the bank.[52] The "bridge bank" tool, especially if only the parts which provide critical functions are transferred to the bridge bank, may reduce liquidity gaps compared to the whole bank being resolved.[53] Finally, the power that resolution authorities have to impose a temporary moratorium (stay) on payment and delivery obligations for up to 48 hours could stop, or at least delay, outflows.[54]

For the sake of simplicity, and to keep the focus on liquidity rather than on solvency, it is assumed that only the minimum requirement for own funds and eligible liabilities (MREL) is being bailed in and that this is sufficient to restore capital levels. Thus there is no injection of capital from any public source, including the Single Resolution Fund (SRF) and the deposit guarantee scheme (DGS).[55]

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51 For banks with a multiple resolution strategy, third-country subsidiaries would be resolved by the host authorities. Therefore, the banking group resolved would be smaller than the consolidated banking group, which could prospectively reduce the liquidity needs in resolution.

52 It should be noted that maturity mismatches can still create further liquidity needs (even if authorities can change the maturity of liabilities).

53 It may take time for the new entity to get a rating and be recognised as a credible counterparty by investors and other institutions, which may in turn lead to further liquidity needs. Particularly in cases where the bridge bank tool is used primarily to buy time to find an acquiring bank, this may lead to increased liquidity needs.

54 In some cases, a stay may trigger (further) panic and increase the likelihood of a broader "run" once it is lifted.

55 The DGS to which the institution is affiliated can also contribute to the funding, as specified in Article 79 of the Single Resolution Mechanism (SRM) Regulation, provided that this action ensures that depositors continue to have access to their deposits. See Regulation (EU) No 806/2014 of the European Parliament and of the Council of 15 July 2014 establishing uniform rules and a uniform procedure for the resolution of credit institutions and certain investment firms in the framework of a Single Resolution Mechanism and a Single Resolution Fund and amending Regulation (EU) No 1093/2010 (OJ L 225, 30.7.2014, p. 1).

Furthermore, this assumption also implies that no short-term liabilities, such as uncovered deposits, are assumed to be bailed in. Given this assumption, the bail-in will not affect the estimated liquidity gaps.[56] If the loss levels and bail-in were allowed to exceed the MREL, this could have several potential implications. On one hand, the liabilities that were bailed in would not be able to run after resolution; on the other hand, applying haircuts to short-term liabilities (including deposits) could imply higher run-off rates post-FOLTF. Furthermore, after a bail-in corresponding to 8% of total liabilities and own funds, the SRF could potentially be used for solvency support (limited to 5%). This would inject capital into the bank and would indirectly improve its CBC. This may lower the need for liquidity, but a bail-in exceeding the MREL may in turn affect inflow and outflow behaviours ex post, possibly adding to the remaining liquidity gaps.

The analysis is performed on a static balance sheet and maturity ladder in which only some items are changed on the basis of exogenous assumptions. Thus, any dynamic flows and adjustments of the bank in the crisis period (pre- and post-FOLTF) are not taken into account. This has several implications. First, since only a limited number of items are stressed and a simple haircut is applied to the CBC, some precision of the final outcomes is lost.[57] Second, credit claims which are currently not eligible as collateral in central banks are not taken into account as a possible source of liquidity. This is the case even if some of them – in a dynamic scenario – could receive approval for eligibility if they fulfil the relevant conditions and are submitted with correct documentation. Third, the CBC is assumed to be used without assuming any likely order in which various assets or items would be used. For banks with some CBC left when the resolution funding need is measured, it is not taken into account what this CBC consists of. It is assumed that the remaining CBC assets can be used to meet the new LCR, which may not be the case if, for example, they are less liquid assets of lower quality. Fourth, given the static approach, it is assumed that the bank will not be able to generate additional CBC at the point of liquidity stress, e.g. by securitisation. Finally, for the deposits which are stressed, it is assumed that the deposits which do not run off are to be rolled over, but in such a way that they are not sticky and can still run off after an FOLTF determination.[58]

The new LCR requirements after FOLTF are approximated and not calculated exactly. To derive the exact LCR one would need to have all the items in the LCR formula for each bank, derive how they were affected and perform a new calculation. In addition, for Gaps 2 and 3, it is assumed that post-resolution the bank and authorities aim for a 100% LCR target level for confidence building purposes, thereby limiting the risk of sequential crises, even though Bank for International Settlements (BIS) rules allow a breach during periods of stress.

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56 Since only MREL instruments are being bailed in, no deposits or other short-term liabilities will be written down or converted into equity. Thus these can still run post-FOLTF and are also still there as items that are included in the LCR calculations after FOLTF.

57 With detailed CBC stock data, haircuts and collateral calls could be applied with more granularity, and possibly be linked to a down-grading of the bank’s rating.

58 We lack data on the original maturity of various deposits maturing in a time bucket of the maturity ladder, so we need to make an assumption. This simplifying assumption will somewhat overestimate the amount of runnable deposits after FOLTF, as some may have been rolled over into longer-term deposits.

The systemic crisis analysis is based on Monte Carlo simulations underpinned by several assumptions, all of which influence the results. In particular, the sequence for the banks entering into resolution is not modelled. Instead, it is assumed that they enter into resolution at the same time and that the maximum funding needs occur at the same time. This assumption is likely to overestimate the funding needs. In reality, banks may enter into resolution at different stages and/or their funding needs may occur at different times. In addition, for a specific scenario tested, all the banks faced the same stressed scenario. In other words, it is not assumed that the banks failed in various slow and fast burn scenarios of different severities.[59] Owing to a lack of data regarding banks' exposures, the contagion effect has been approximated by estimating market-based correlations. If the efficient market hypothesis holds, all prices reflect available information and, therefore, market returns on equity should also accurately reflect shared sources of risk (e.g. two banks in the same country are affected by the same country-level sources of risk). Finally, the 95th percentile threshold to select failing banks is discretionary.

2.5 Data and sample of banks

The bank sample comprises 86 euro area financial institutions, representing approximately 76% of euro area banks' total assets. For all banks, the maturity ladder and CBC have been extracted from COREP and refer to the first quarter of 2018. Balance sheet items, such as total assets, are taken from regulatory data reporting (FINREP).

The business model does not seem to have a significant impact on the CBC level relative to the size of the bank. Table 8 summarises banks' total assets and CBC by business model. On average, the ratio of CBC to total assets remains approximately 20% in almost all business models. The only exception is custodian and asset management companies, which on average report a CBC to total assets ratio almost three times higher. This comes from the business model of these institutions; custodian banks mainly focus on providing underwriting/custodian services to other financial services providers.

[59] This assumption makes it likely that the less severe systemic scenario underestimates the need in a systemic event (since a few banks may face more severe stress), while it is likely that the more severe systemic scenario overestimates the need (since a few banks may face less severe stress).

Table 8

Total assets and CBC of banks in the sample by business model

(EUR billions and percentages of total assets)

Business model	Number of banks	Sum of total assets (EUR billions)	Average CBC/TA ratio (%)
Corporate/wholesale lenders	9	1,433.8	22.4%
Custodians and asset managers	5	203.5	53.3%
Diversified lenders	23	2,044.8	23.4%
G-SIBs	7	4,876.2	20.5%
Retail lenders	10	4,554.3	16.3%
Sectoral lenders	11	577.9	22.9%
Small domestic lenders	7	816.8	35.3%
Universal banks	11	40.4	20.2%

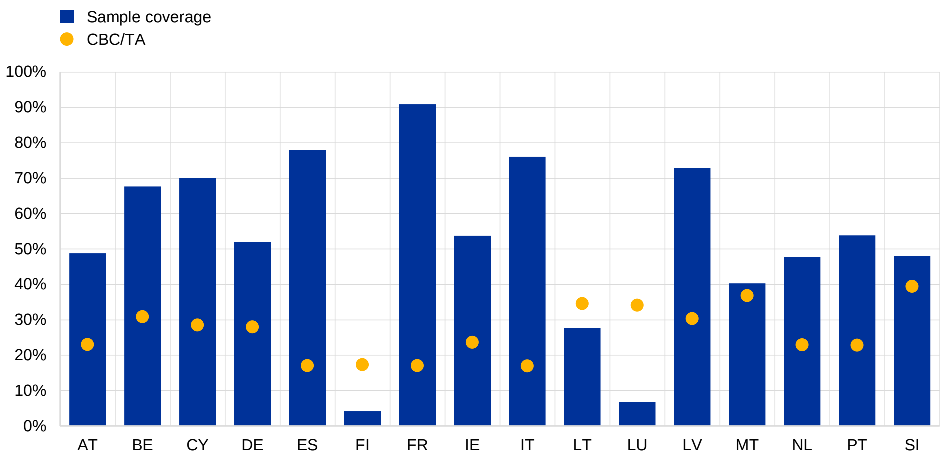
Source: ECB calculations based on COREP data.
Note: Universal banks that are G-SIBs are included under "G-SIBs".

The sample coverage is heterogeneous across countries, while variations in relative CBC remain limited. Chart 2 shows the total assets of the banks in the sample by country, together with the average ratio of CBC to total assets of the banks in each country. Whereas France, Italy, Spain, and Cyprus are represented in the sample with more than 70% of all banks' total assets, the sample representativeness in Finland and Luxembourg is lower than 10%. The average CBC is between 20% and 30% in almost all countries: the lowest values are observed in Italy and Spain (17% of total assets), while the highest level is recorded in Slovenia (39% of total assets).

Chart 2

Ratio of CBC to total assets and sample coverage by country

(percentages)



Source: ECB calculations based on COREP and ECB Statistical Data Warehouse data.
Note: The sample coverage is the ratio of the sum of banks' total assets in the sample to the sum of banks' total assets in the population.

3 Possible liquidity gaps in resolution of individual banks

This section presents the main results for the combinations of scenarios and liquidity gaps tested on the banks in the sample. For each bank in the sample, the three liquidity gaps (Gaps 1, 2 and 3) are derived for both a slow burn and a fast burn crisis with four combinations of severity levels (pre- and post-FOLTF), as explained in subsections 2.1 and 2.2. Thus the three liquidity gaps are derived for eight combinations of scenarios (see Table 9).

Table 9
Scenarios for both slow and fast burn cases

Scenario	Pre-FOLTF stress	Post-FOLTF stress
Severe – severe (S-S)	severe	severe
Severe – very severe (S-VS)	severe	very severe
Very severe – severe (VS-S)	very severe	severe
Very severe – very severe (VS-VS)	very severe	very severe

3.1 Estimated liquidity gaps[60]

Looking at all three gaps and all crisis scenarios, the average liquidity gaps range from €0.03 billion to €10.8 billion.[61] The highest average relative liquidity gap corresponds to 4.2% of total assets. These relatively low numbers are driven by the fact that many banks do not have any liquidity gaps, especially for Gap 1 and the less severe scenarios. Looking only at the gaps with liquidity buffers (Gaps 2 and 3) and the banks which face positive liquidity gaps in resolution (from 16% to 56% of the total number of banks in the sample), the average gaps increase to from €3.1 billion to €19.4 billion.

The average numbers, however, disguise significant outlier banks and outcomes. To better understand the extreme cases, Charts 3 and 4 below show the distributions of liquidity gaps per bank and simulated scenario. Each point along the x-axis represents one of the sample of 86 banks and the black dots represent liquidity gaps in various simulated scenarios for that bank. The dashed red line represents the average liquidity gap per bank (across scenarios), while the vertical confidence intervals (min/max) indicate the volatility of the liquidity gaps per bank depending on the severity of the stress levels. The horizontal red line in Chart 3 indicates the target level that the Single Resolution Fund should reach by 31 December 2023 (equal to at least 1% of the amount of covered deposits of all credit institutions within the Banking Union): this amount is expected to be just over €60 billion.[62]

60 More detailed results are provided in the Annex.

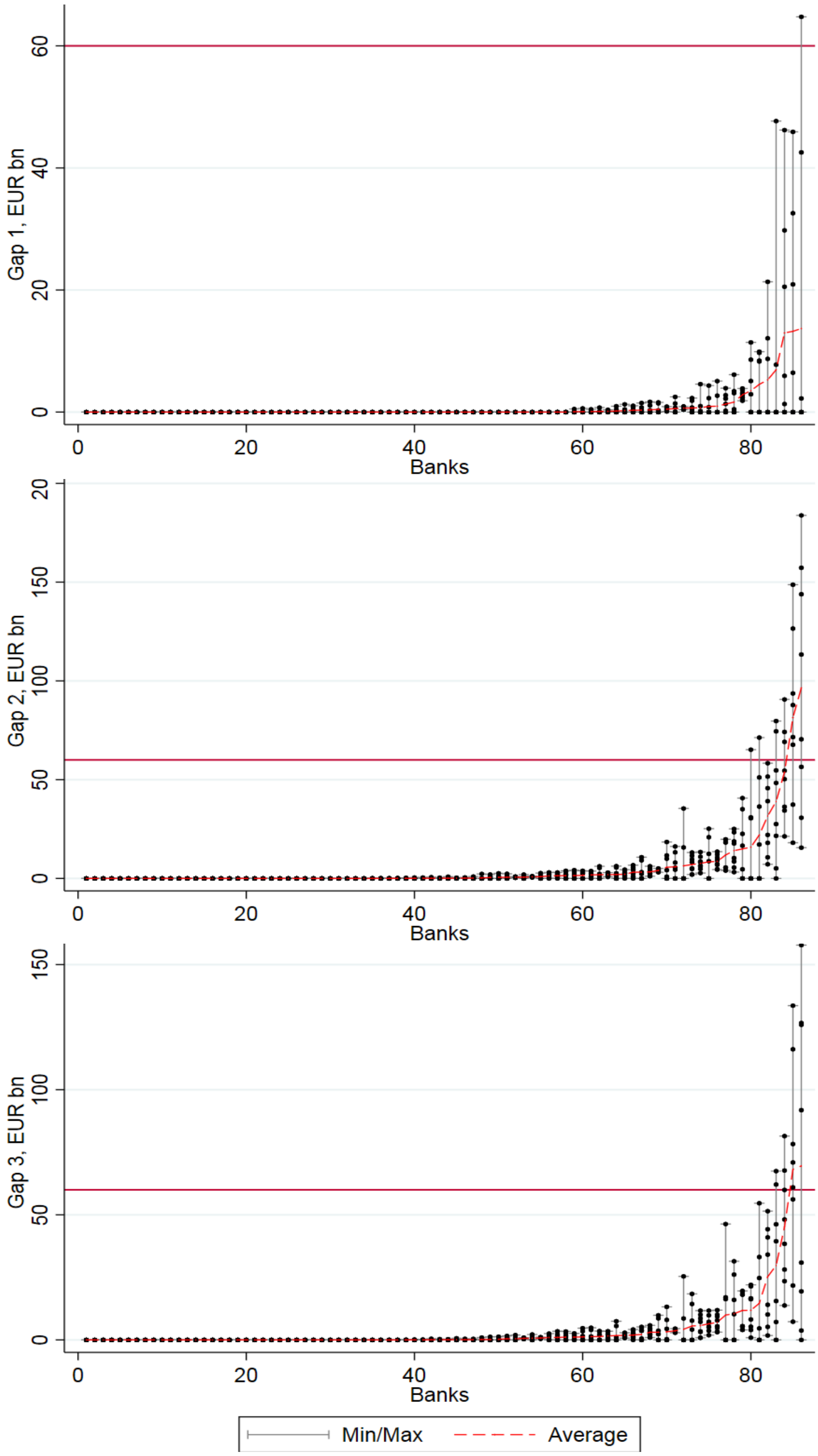
61 The lowest average need is for Gap 1 in a fast burn S-S scenario, while the highest average need is for Gap 2 in a slow burn VS-VS scenario (see Section A.1 of the Annex for details).

62 See Single Resolution Board (2020).

Chart 3

Distribution of liquidity gaps across different banks and scenarios, absolute size

(EUR billions)

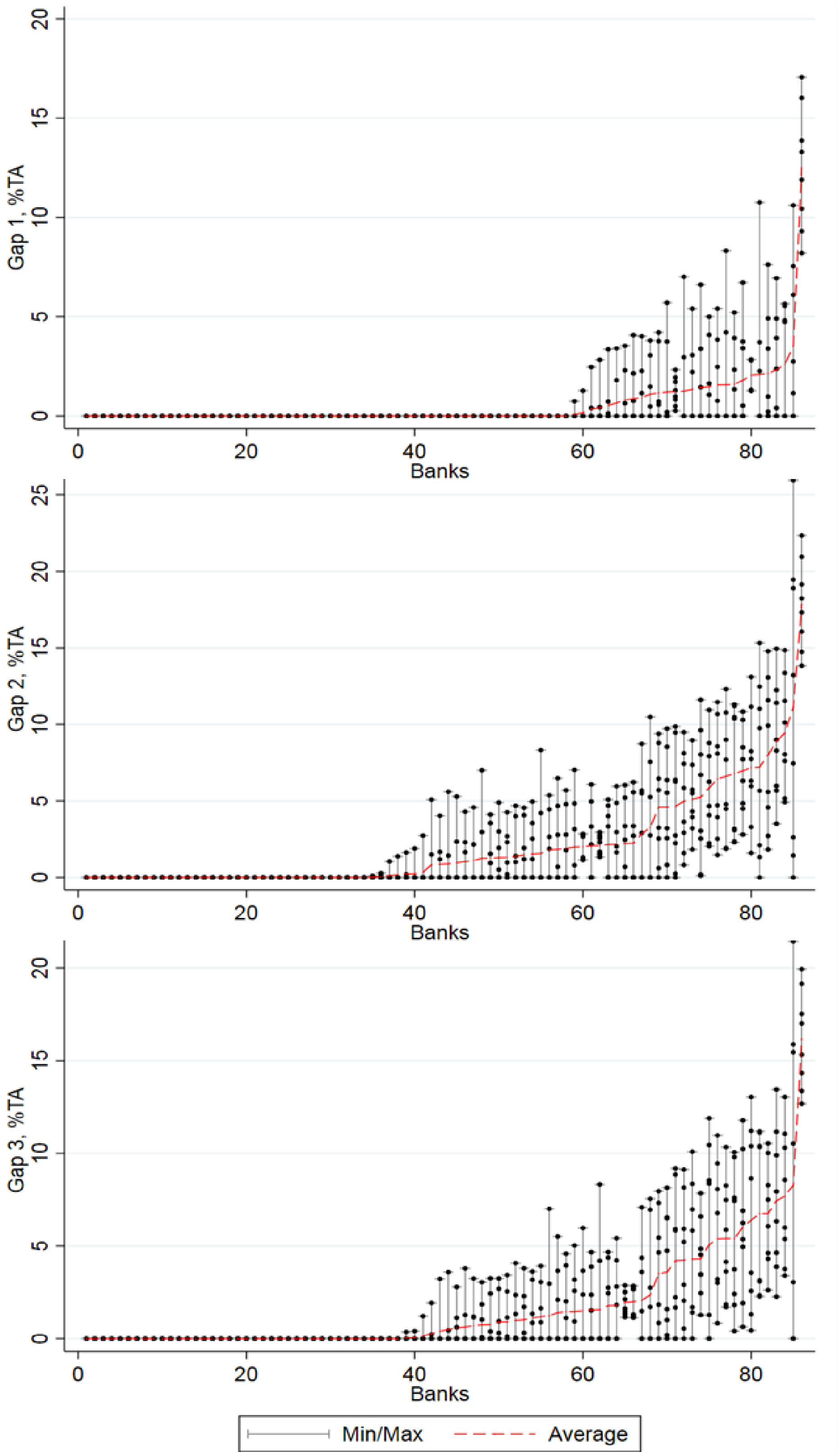


Source: ECB calculations based on COREP and FINREP data.

Chart 4

Distribution of liquidity gaps across banks and scenarios, relative size

(percentages of total assets)



Source: ECB calculations based on COREP and FINREP data.

Under extreme circumstances some banks could generate liquidity gaps far above the size of the SRF and its backstop. Charts 3 and 4 show that even Gap 1 (no liquidity buffer) could reach values close to €65 billion, or 17% of total assets, and that Gap 2 (with the highest liquidity buffer) could be close to €184 billion, or 26% of total assets.[63] The latter is broadly on a par with the level of liquidity provisioning observed in the cases of Dexia (23.8% in 2013), Hypo Real Estate (24.8%) and Cyprus Popular Bank (27%).

The range of results is driven by the heterogeneity of the banks in the sample, the different scenarios tested and the different gaps measured. The main drivers of the estimated needs are the type of crisis (slow burn or fast burn), the severity of the stress level (severe or very severe), and the liquidity buffer applied (Gap 1, 2 or 3) are the main drivers of the estimated needs. In addition, the pre-crisis level of banks' CBC also strongly affects the results.

Banks' business models seem to explain partly, but not fully, the different liquidity gaps of the banks in the sample. The results in Table 10 show that universal banks and G-SIBs have higher liquidity gaps in absolute terms, mainly due to their size. Relative to total assets, retail lenders have the largest liquidity gaps (followed by universal banks and G-SIBs), although differences between business model categories are not particularly strong.

Table 10

Liquidity gaps per business model

(EUR billions and percentages of total assets)

Business model	Number of banks	Average total assets (EUR billions)	Average liquidity needs (EUR billions)	Average liquidity needs (% of TA)	95% liquidity needs (% of TA)
Corporate/ wholesale lenders	9	159.00	0.37	0.13	1.03
Custodians and asset managers	5	40.70	0.03	0.25	1.48
Diversified lenders	23	90.90	0.97	1.20	7.60
G-SIBs	7	1,350.00	22.90	1.78	8.15
Retail lenders	10	71.80	1.12	2.57	9.47
Sectoral lenders	11	74.30	0.23	0.60	3.34
Small domestic lenders	7	5.44	0.03	0.77	6.10
Universal banks	11	377.00	7.51	2.09	10.39

Source: ECB calculations based on COREP and FINREP data.
Note: Universal banks that are G-SIBs are included under "G-SIBs".

One plausible explanation for the small difference between business models could be that the methodology in this paper mainly stresses deposits and not explicitly, for example, derivative collateral posting requirements. Applying funding shocks that adequately impact some business models more than others, e.g. because of their roles in central counterparties, their complex group structures with more segregated liquidity pools, and large derivative portfolios, may reveal a

[63] The highest absolute liquidity gap and the highest liquidity gap relative to total assets are not observed in the same bank.

different picture. Future research would therefore be welcome to shed some more light on the determining factors for various business models.

4 Possible liquidity gaps in a systemic crisis

This section presents the main results obtained in the case of a simulated systemic crisis. As highlighted in the previous section, banks' PDs are adjusted to account for market-based correlations across banks in a second application of the methodology. In a systemic crisis, this allows the contribution of contagion to be identified. For this purpose, subsection 4.1 will focus on the magnitude of the crisis obtained in each simulation run to put the corresponding liquidity gaps – described in subsection 4.2 – into perspective.

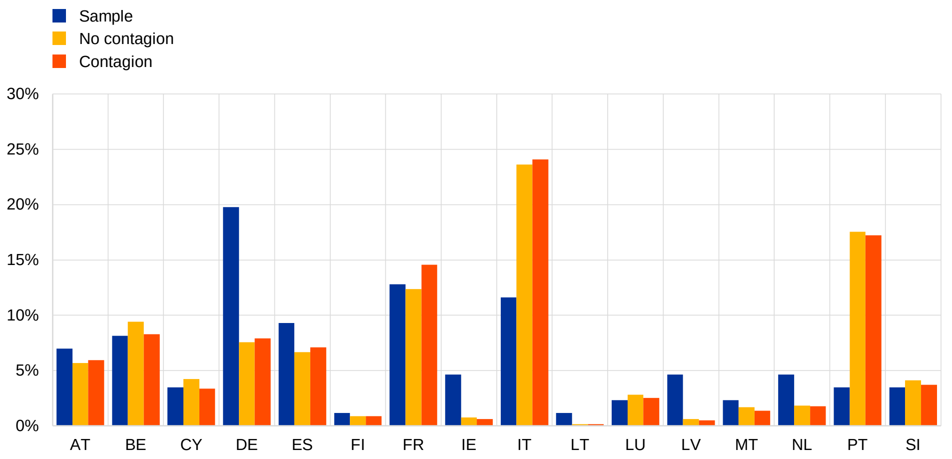
4.1 Magnitude of the simulated crisis

Some banking sectors are more likely to be involved in a systemic crisis due to both an idiosyncratic and a contagion-based component. Chart 5 compares the share of banks in the original sample with the share of banks extracted as defaulting in the crisis with and without contagion. A decrease in the share of banks with respect to the sample representativeness indicates a relatively low PD in the scenario without contagion, and relatively low correlations with distressed banks in the scenario with contagion.

Chart 5

Share of banks in the sample and in distress (with and without contagion) by country

(percentages of banks)



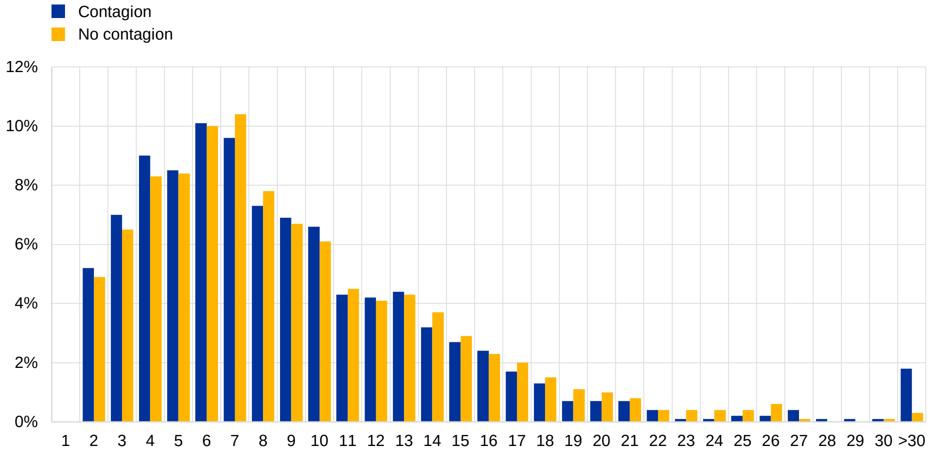
Source: ECB calculations based on COREP and FINREP data.
Notes: The chart shows the extent to which a country is represented in the original sample of 86 banks and in the samples of failing banks selected with and without contagion. The results are presented in percentages of the total number of banks.

The inclusion of contagion particularly affects extreme systemic crises in terms of the number of failing banks and the likelihood of such an event. As shown in Chart 6, on average 8.9 banks are identified as failing if contagion is not taken into account, while this number increases to 9.2 when contagion is included. Although these average values are comparable, they mask substantial differences in terms of the right tail. While in the case of no contagion, only 0.3% of the simulated crises imply more than 30 banks failing, when contagion is included this share rises to 1.5%. In Chart 6 a much longer right tail is observable when we account for the contagion mechanism.

Chart 6

Distribution of simulated systemic crises as a function of number of banks in distress

(x-axis: number of banks in distress in each simulated crisis; y-axis: relative frequency of each simulated crisis, percentages)



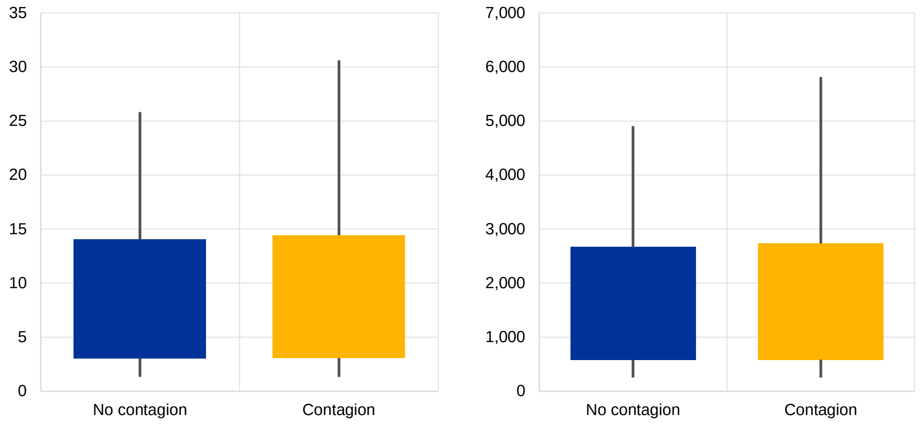
Source: ECB calculations based on COREP and FINREP data.
Note: The chart shows the frequency of sample sizes drawn in the 1,000 Monte Carlo simulations.

In median terms, the systemic crisis corresponds to the distress of banks accounting for approximately €1.4 trillion in total assets, corresponding to 7.5% of the combined total assets of the banks in the sample. Chart 7 shows the distribution of the total assets of the banks entering resolution in the two scenarios without and with contagion, and in absolute and relative terms. The left panel indicates that, while the inclusion of contagion does not really affect the size of the simulated crisis in median terms, the situation changes when looking at more extreme cases, as contagion could lead to almost €6,000 billion of banks' total assets in distress, while this does not even reach €5,000 billion when contagion is not included. The right panel confirms this trend, and shows that in the case of contagion more than 30% of the total assets in the sample could be considered as failing, although the median amount remains close to 7.5%.

Chart 7

Distribution of total assets of banks in distress in absolute (left panel) and relative (right panel) terms

(left panel: total assets of banks in distress, EUR billions; right panel: total assets of banks in distress relative to total assets of banks in the sample, percentages)



Source: ECB calculations based on COREP and FINREP data.
Notes: In the boxplots, the rectangle represents values from the 25th to the 75th percentile, the horizontal line inside the rectangle is the median, and the vertical lines represent values below and above the 25th and 75th percentiles.

4.2 Liquidity gaps in a systemic crisis

In the case of a systemic crisis, average liquidity gaps remain, on average, below €50 billion, but in extreme circumstances, liquidity gaps can reach values close to €200 billion. Although even Gap 2 is, on average, €43 billion without contagion and only €3 billion more when accounting for banks' interconnectedness, the extreme right tails of the distributions of liquidity gaps reveal a much more severe situation. When contagion is included in the methodological steps, liquidity gaps can reach around €200 billion. As highlighted in the previous section, this is far beyond the size of the SRF and the SRF backstop. In addition, the results in Table 11 confirm that the inclusion of contagion particularly affects the extreme cases, while the effects on average outcomes remain more limited.

Table 11

Liquidity gaps without and with contagion

(EUR billions)

	No contagion			Contagion		
	Gap 1	Gap 2	Gap 3	Gap 1	Gap 2	Gap 3
Average	7.89	43.00	33.57	8.01	45.83	35.66
95th percentile	49.52	179.19	147.70	49.17	196.14	163.68

Source: ECB calculations based on COREP and FINREP data.

The higher results obtained in the case of contagion are due solely to the higher number of failing banks in the simulated crises. Table 12 shows the liquidity gaps in the different scenarios relative to the total assets of the banks in distress in each simulation run: these ratios thus abstract from the higher number of failing banks if contagion is included. The outcomes reported in the table confirm that the relative magnitudes of the systemic crisis in the two cases (without and with contagion) are closely comparable. This means that the higher liquidity gaps due to the contagion mechanism are not the consequence of particular banks identified as failing, but merely of the higher number of banks considered in distress in each simulated crisis.

Table 12
Liquidity gaps without and with contagion

(EUR billions)

	No contagion			Contagion		
	Gap 1	Gap 2	Gap 3	Gap 1	Gap 2	Gap 3
Average	0.46	2.09	1.62	0.44	2.03	1.57
95th percentile	2.39	6.50	5.48	2.32	6.28	5.29

Source: ECB calculations based on COREP and FINREP data.

More than 80% of the simulated crises lead to (strictly positive) liquidity gaps. The results reported in Table 13 summarise the liquidity gaps when considering only the simulated crises leading to positive liquidity gaps. The results thus show that, if a systemic crisis materialises, the average liquidity gap could be above €50 billion, and in extreme cases it could even exceed €200 billion.

Table 13
Liquidity gaps without and with contagion (only if positive)

(EUR billions)

	No contagion			Contagion		
	Gap 1	Gap 2	Gap 3	Gap 1	Gap 2	Gap 3
Average	13.72	50.68	40.72	14.05	54.33	43.56
95th percentile	61.28	189.13	161.85	63.26	210.88	174.35
Simulation with needs >0	57.50	84.84	82.45	57.03	84.35	81.86

Source: ECB calculations based on COREP and FINREP data.

4.3 Estimated liquidity gaps when two G-SIBs are resolved

The estimated liquidity gaps for all possible combinations of two out of the seven euro area G-SIBs failing are presented in this subsection. On average, the simulation of two failing G-SIBs accounts for slightly more than €2.7 trillion total assets, which is higher than what is observed in the simulation with a systemic crisis.[64]

The liquidity gaps can range, on average, from approximately €10 billion (Gap 1) to €75 billion (Gap 2). The latter figure corresponds to approximately 2.8% of the failing G-SIBs' total assets. The average numbers, however, disguise significant outliers. In the most adverse simulated crisis, the liquidity gaps in the case of the

64 Total assets of banks selected as failing are €1.8 billion and €2 billion for no contagion and contagion, respectively.

resolution of two G-SIBs can reach extremely high values, exceeding €330 billion for Gap 2 and €290 billion for Gap 3.[65] As shown in Table 14, these maximum needs correspond to 10.2% to 11.6% of total assets, which is somewhat above the liquidity needs in the Banco Popular case, but below the other cases studied (see Section 1 above).

Table 14

Cumulative liquidity gaps for resolution of two out of seven G-SIBs for all crises and scenarios

(EUR billions and percentages of total assets)

	Gap 1	Gap 2	Gap 3
Average, EUR billions	9.87	74.49	56.78
Maximum. EUR billions	115.67	335.75	294.63
Average, % of TA	0.40%	2.77%	2.12%
Maximum. % of TA	5.64%	11.58%	10.2%

Source: ECB calculations based on COREP and FINREP data.

The high absolute amounts compared to the systemic crisis above are driven by the larger size of the resolved G-SIBs. Detailed results for all gaps and scenarios are provided in Section A.2 of the Annex.

65 These two maximum liquidity gaps occur in the slow burn VS-VS scenario for a specific combination of two G-SIBs.

5 Conclusion

For individual bank failure scenarios, the average liquidity gaps in resolution may be rather contained, but these hide significant outliers. The highest average gap, which happens in the worst slow burn crisis scenario, is €10.8 billion or 4.2% of a bank's total assets. This corresponds to, in relative terms, about half of the liquidity that Santander provided to Banco Popular after acquiring it in 2017. However, the numbers are pushed down by many banks having no or only limited liquidity gaps for many scenarios, especially when no liquidity buffer is applied.

For specific banks and scenarios some liquidity gaps in resolution can be much larger – up to €184 billion, or 26% of a bank's total assets. This is more aligned in relative terms with the liquidity aid provided in the crisis management or resolution of Dexia, Hypo Real Estate and Cyprus Popular Bank.

The wide range of results is driven by the heterogeneity of the banks included in the sample, the different crisis scenarios and the liquidity buffers applied in resolution. Although the results show that universal banks, G-SIBs and, albeit only in relative terms, retail lenders are associated with higher liquidity gaps in resolution, it is not possible to statistically conclude that a bank's business model is the determining factor driving the results. This could be a result of the methodology under which mainly deposits are being stressed.

In the systemic crisis scenarios, liquidity needs in resolution can reach values in excess of €313 billion when accounting for contagion effects and in the most severe crisis. The results also show that the inclusion of contagion mechanisms has a limited effect on average liquidity needs, while it more severely affects tail events. In the latter case, contagion increases extreme liquidity needs in a systemic crisis by approximately 12%, owing to the larger number of banks affected as a result of the crisis spread.

In a scenario in which two (out of seven) G-SIBs fail at the same time, liquidity gaps in resolution can be very large for some specific G-SIBs and scenarios. On average, the liquidity gaps range from zero to approximately €150 billion, depending on the crisis type and the scenario. Nonetheless, the maximum liquidity gap can be close to €120 billion even without liquidity buffers and higher than €330 billion when the largest buffer is applied. The relatively high absolute amounts are driven by the relatively large balance sheet size of the typical G-SIB.

In adverse circumstances, the instruments currently available to provide liquidity support to financial institutions in the euro area would be insufficient. The results above show that whilst the current framework in the banking union could handle potential liquidity gaps for many individual resolution cases, there is a risk of insufficient capacity to provide adequate liquidity support if some banks enter resolution under adverse and severe scenarios. Furthermore, the results show that the capacity of the SRF would be insufficient to handle many systemic events, in particular in the light of a potentially high number of institutions affected if contagion effects spread losses across the banking sector.

Annex

A.1 Detailed results in idiosyncratic resolution

In absolute terms, and considering all the banks, the average Gap 1 ranges from €0.03 billion to €3.4 billion, corresponding to 0.1% to 1.7% of a bank's total assets. These numbers, however, mask significant outliers. In absolute terms, Gap 1 can even reach a value close to €65 billion, or 17% of total assets (see Table A.1).

When considering only the banks reporting strictly positive liquidity gaps, the overall results substantially increase, and the average values range from €0.8 billion to €10.8 billion, or 2.7% to 5.3% of a bank's total assets. These averages are calculated after excluding from the sample the banks for which we obtain zero liquidity gaps, as this allows a better understanding of the magnitude of liquidity gaps in such a crisis situation. It is worth noting that the percentage of banks that actually encounter liquidity gaps can range from 3.5% to 31.4% of the sample. Therefore, in the worst case scenario, approximately one third of the banks in our sample would require liquidity support in resolution.

The severity of the stress levels plays a crucial role in determining banks' liquidity gaps. For example, in the VS-S and VS-VS scenarios, the number of affected banks (with strictly positive liquidity gaps) is four to seven times higher than in the S-S and S-VS scenarios.

Table A.1
Gap 1 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)				Liquidity gaps (only considering the banks facing needs)		
Crisis type	Scenario	Average (EUR billions)	Maximum (EUR billions)	Average (% of TA)	Maximum (% of TA)	Average (EUR billions)	Average (% of TA)	Percentage of banks with a gap
Slow burn	S-S	0.13	8.30	0.19%	9.30%	2.83	4.15%	4.65%
	S-VS	0.16	8.43	0.24%	11.90%	2.30	3.39%	6.98%
	VS-S	1.66	42.55	0.81%	13.87%	5.95	2.90%	27.91%
	VS-VS	3.39	64.75	1.65%	17.07%	10.79	5.26%	31.40%
	Overall	1.33	64.75	0.72%	17.07%	7.53	4.07%	17.73%
Fast burn	S-S	0.03	1.86	0.11%	8.21%	0.79	3.25%	3.49%
	S-VS	0.04	2.37	0.16%	10.43%	0.75	3.34%	4.65%
	VS-S	0.27	6.45	0.41%	13.31%	1.78	2.70%	15.12%
	VS-VS	1.15	32.59	0.97%	16.03%	4.48	3.78%	25.58%
	Overall	0.37	32.59	0.41%	16.03%	3.02	3.37%	12.21%
Overall		0.85	64.75	0.57%	17.07%	5.69	3.79%	14.97%

Source: ECB calculations based on COREP and FINREP data.

In absolute terms and considering all the banks, the average Gap 2 ranges from €1.1 billion to €10.8 billion, corresponding to an average of 0.6% to 4.2% of a

bank's total assets. Gap 2 is higher than Gap 1 owing to the application of a liquidity buffer. Gap 2 adds a liquidity buffer to Gap 1 by adding a target level of liquidity equal to the amount of high-quality liquid assets needed to fulfil a 100% LCR on the Monday morning after FOLTF.

However, significant outliers, implying much higher liquidity gaps in resolution, can be observed in both absolute and relative terms (see Table A.2). The maximum value in absolute terms is approximately €184 billion, observed in the case of a slow burn simulated crisis and very severe stress levels both before and after FOLTF. In relative terms, the maximum liquidity gaps range from 13.8% to 26% of a bank's total assets.

As observed in the case of Gap 1, the results strongly increase if we consider only the banks reporting positive liquidity gaps rather than the entire sample. In this case, the results range from approximately €5 billion to almost €20 billion. In relative terms, this corresponds to liquidity gaps ranging from 2.5% to 7.5% of a bank's total assets. The percentage of banks with strictly positive liquidity gaps ranges from approximately 20% to 56%. In other words, if the stress levels before FOLTF are very severe, around half of the banks in the sample would require liquidity support.

Table A.2

Gap 2 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)				Liquidity gaps (only considering the banks facing needs)		
Crisis type	Scenario	Average (EUR billions)	Maximum (EUR billions)	Average (% of TA)	Maximum (% of TA)	Average (EUR billions)	Average (% of TA)	Percentage of banks with a gap
Slow burn	S-S	2.20	67.69	0.79%	14.74%	11.14	3.98%	19.77%
	S-VS	3.70	87.79	1.32%	17.33%	14.46	5.14%	25.58%
	VS-S	7.51	143.88	2.77%	19.15%	15.75	5.80%	47.67%
	VS-VS	10.80	183.80	4.21%	25.95%	19.35	7.54%	55.81%
	Overall	6.05	183.80	2.27%	25.95%	16.26	6.10%	37.21%
Fast burn	S-S	1.09	21.32	0.55%	13.84%	4.92	2.49%	22.09%
	S-VS	2.66	56.47	1.05%	16.07%	10.39	4.11%	25.58%
	VS-S	6.00	113.38	2.25%	18.23%	12.59	4.72%	47.67%
	VS-VS	9.50	157.27	3.62%	20.96%	17.38	6.62%	54.65%
	Overall	4.81	157.27	1.87%	20.96%	12.83	4.98%	37.50%
Overall		5.43	183.80	2.07%	25.95%	14.54	5.54%	37.32%

Source: ECB calculations based on COREP and FINREP data.

In absolute terms, and considering all the banks, the average Gap 3 ranges from €0.5 billion to approximately €9 billion, corresponding to liquidity gaps ranging from 0.4% to 3.6% of a bank's total assets. Maximum values can get close to €160 billion in absolute terms, or reach more than 21% of a bank's total assets in relative terms (see Table A.3).

Like Gaps 1 and 2, the results strongly increase if only the banks reporting strictly positive liquidity gaps are considered rather than the entire sample. In this case, the results range from approximately €3 billion to €17 billion. In relative terms, this corresponds to liquidity gaps ranging from 2.5% to 6.7% of a bank's total assets. As with Gap 2, if the stress levels before FOLTF are very severe, around half of the banks in the sample would require liquidity support. This is because there is still a liquidity buffer, albeit lower than in Gap 2 (see subsection 2.1). On average, Gap 3 is approximately 20% lower than the average Gap 2, the difference being due to the lower liquidity target set. This difference between Gap 3 and Gap 2 is reduced to 15% when considering only the banks reporting strictly positive liquidity gaps in resolution.

Table A.3

Gap 3 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)				Liquidity gaps (only considering the banks facing needs)		
Crisis type	Scenario	Average (EUR billions)	Maximum (EUR billions)	Average (% of TA)	Maximum (% of TA)	Average (EUR billions)	Average (% of TA)	Percentage of banks with a gap
Slow burn	S-S	1.51	56.18	0.62%	13.37%	8.65	3.57%	17.44%
	S-VS	2.48	70.94	0.98%	15.32%	10.68	4.21%	23.26%
	VS-S	6.43	125.97	2.37%	17.52%	14.54	5.36%	44.19%
	VS-VS	9.04	157.79	3.57%	21.43%	16.89	6.67%	53.49%
	Overall	4.86	157.79	1.88%	21.43%	14.06	5.44%	34.59%
Fast burn	S-S	0.50	13.78	0.40%	12.67%	3.06	2.47%	16.28%
	S-VS	1.46	23.50	0.73%	14.33%	6.61	3.30%	22.09%
	VS-S	4.62	91.85	1.80%	17.01%	10.18	3.97%	45.35%
	VS-VS	7.50	126.67	2.93%	19.15%	15.73	6.15%	47.67%
	Overall	3.52	126.67	1.47%	19.15%	10.71	4.46%	32.85%
Overall		4.19	157.79	1.67%	21.43%	12.43	4.97%	33.72%

Source: ECB calculations based on COREP and FINREP data.

A.2 Detailed results in the systemic crisis

For the systemic crisis, the simulation is divided into two exercises, according to whether contagion effects have been included in the analysis or not. In this way, it is possible to evaluate the extent to which contagion mechanisms affect banks' liquidity needs in a stressed scenario.

Without contagion

The cumulative Gap 1 (see Table A.4) ranges, on average, from €0.1 billion to €30.4 billion, corresponding to 0.01% to 1.82% of a failing bank's total assets. However, if liquidity buffers are not considered (Gap 1), extreme liquidity needs can be almost €100 billion (or 4.33% of a bank's total assets). By considering only simulations with strictly positive liquidity gaps, average liquidity gaps increase, ranging from €0.91 billion to €30.43 billion. In relative terms, this corresponds to liquidity needs ranging from 0.06% to 1.82% of a bank's total assets.

Table A.4

Gap 1 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)				Liquidity gaps (only considering simulations in which banks are facing needs)		
Crisis type	Scenario	Average (EUR billions)	95th percentile (EUR billions)	Average (% of TA)	95th percentile (% of TA)	Average (EUR billions)	Average (% of TA)	Percentage of simulations with a gap
Slow burn	S-S	2.74	8.31	0.19%	1.15%	7.06	0.48%	38.80%
	S-VS	2.92	8.94	0.20%	1.17%	6.82	0.46%	42.80%
	VS-S	15.18	54.36	0.84%	2.48%	15.18	0.84%	100.00%
	VS-VS	30.43	99.86	1.82%	4.33%	30.43	1.82%	100.00%
	Overall	12.82	63.47	0.76%	2.86%	18.20	1.08%	70.40%
Fast burn	S-S	0.10	0.48	0.01%	0.04%	0.91	0.06%	11.50%
	S-VS	0.13	0.49	0.01%	0.04%	0.99	0.07%	12.80%
	VS-S	2.08	8.77	0.11%	0.51%	3.85	0.20%	54.10%
	VS-VS	9.52	38.62	0.51%	2.04%	9.52	0.51%	100.00%
	Overall	2.96	16.89	0.16%	0.83%	6.63	0.36%	44.60%
Overall		7.89	49.52	0.46%	2.39%	13.72	0.80%	57.50%

Source: ECB calculations based on COREP and FINREP data.

The average Gap 2 ranges from €8.24 billion to €87.31 billion (from 0.39% to 4.51% of a bank’s total assets), but this masks extreme outliers. The 95th percentile can reach values of €278.8 billion, or almost 9% of a bank’s total assets. Across all the simulation runs considered in this analysis, around 85% give rise to strictly positive liquidity needs.

Table A.5

Gap 2 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)				Liquidity gaps (only considering simulations in which banks are facing needs)		
Crisis type	Scenario	Average (EUR billions)	95th percentile (EUR billions)	Average (% of TA)	95th percentile (% of TA)	Average (EUR billions)	Average (% of TA)	Percentage of simulations with a gap
Slow burn	S-S	18.20	86.99	0.88%	3.74%	27.12	1.31%	67.10%
	S-VS	28.72	108.99	1.29%	4.54%	39.56	1.78%	72.60%
	VS-S	59.28	206.07	2.89%	6.98%	59.28	2.89%	100.00%
	VS-VS	87.31	278.78	4.51%	8.97%	87.31	4.51%	100.00%
	Overall	48.38	195.18	2.39%	7.13%	56.96	2.82%	84.93%
Fast burn	S-S	8.24	30.68	0.39%	1.28%	12.11	0.57%	68.00%
	S-VS	19.49	72.55	0.84%	2.63%	27.46	1.18%	71.00%
	VS-S	46.93	162.14	2.13%	5.08%	46.93	2.13%	100.00%
	VS-VS	75.82	244.04	3.77%	7.26%	75.82	3.77%	100.00%
	Overall	37.62	162.94	1.78%	5.63%	44.39	2.10%	84.75%
Overall		43.00	179.19	2.09%	6.50%	50.68	2.46%	84.84%

Source: ECB calculations based on COREP and FINREP data.

The average Gap 3 ranges from approximately €4 billion to €73 billion (from 0.23% to 3.72% of a bank's total assets). Looking at extreme cases, the 95th percentile can exceed €240 billion, corresponding to 7.80% of a bank's total assets. Similarly to what is observed for Gap 2, approximately 83% of the overall simulations result in strictly positive liquidity needs, meaning some form of liquidity support would be needed.

Table A.6

Gap 3 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)				Liquidity gaps (only considering simulations in which banks are facing needs)		
Crisis type	Scenario	Average (EUR billions)	95th percentile (EUR billions)	Average (% of TA)	95th percentile (% of TA)	Average (EUR billions)	Average (% of TA)	Percentage of simulations with a gap
Slow burn	S-S	13.98	64.68	0.73%	3.41%	22.62	1.18%	61.80%
	S-VS	20.34	90.22	0.98%	3.90%	29.74	1.43%	68.40%
	VS-S	50.40	180.70	2.39%	6.18%	50.40	2.39%	100.00%
	VS-VS	73.04	240.38	3.72%	7.80%	73.04	3.72%	100.00%
	Overall	39.44	166.40	1.95%	6.22%	47.78	2.37%	82.55%
Fast burn	S-S	3.98	15.94	0.23%	0.91%	6.48	0.37%	61.40%
	S-VS	11.19	41.03	0.52%	1.66%	16.45	0.77%	68.00%
	VS-S	35.91	128.90	1.54%	4.20%	35.91	1.54%	100.00%
	VS-VS	59.74	193.45	2.88%	6.03%	59.74	2.88%	100.00%
	Overall	27.70	130.35	1.29%	4.61%	33.64	1.57%	82.35%
Overall		33.57	147.70	1.62%	5.48%	40.72	1.97%	82.45%

Source: ECB calculations based on COREP and FINREP data.

With contagion

If contagion effects are included, the average Gap 1 (see Table A.7) does not change relative to previous cases, but outliers significantly increase. On average, liquidity needs if buffers are not considered range from €0.1 billion to €31.4 billion (from 0.01% to 1.77% of a failing bank's total assets). The 95th percentile, however, can even exceed €112 billion, or 4.20% of a bank's total assets. This is 12% higher than the extreme values obtained if contagion effects are not included. By only considering simulations with strictly positive liquidity gaps, averages only slightly increase in the milder scenarios.

Table A.7

Gap 1 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)				Liquidity gaps (only considering simulations in which banks are facing needs)		
Crisis type	Scenario	Average (EUR billions)	95th percentile (EUR billions)	Average (% of TA)	95th percentile (% of TA)	Average (EUR billions)	Average (% of TA)	Percentage of simulations with a gap
Slow burn	S-S	2.49	8.79	0.17%	1.06%	6.81	0.46%	36.50%
	S-VS	2.65	8.94	0.18%	1.08%	6.48	0.44%	40.80%
	VS-S	15.57	55.24	0.81%	2.49%	15.57	0.81%	100.00%
	VS-VS	31.42	112.91	1.77%	4.20%	31.42	1.77%	100.00%
	Overall	13.03	65.78	0.73%	2.80%	18.80	1.05%	69.33%
Fast burn	S-S	0.10	0.48	0.01%	0.04%	0.75	0.06%	13.20%
	S-VS	0.12	0.49	0.01%	0.04%	0.82	0.06%	14.30%
	VS-S	2.07	8.54	0.10%	0.52%	4.03	0.20%	51.40%
	VS-VS	9.67	41.43	0.49%	2.10%	9.67	0.49%	100.00%
	Overall	2.99	16.08	0.15%	0.74%	6.68	0.34%	44.73%
Overall		8.01	49.17	0.44%	2.32%	14.05	0.77%	57.03%

Source: ECB calculations based on COREP and FINREP data.

The addition of contagion effects increases average values by 3 to 6%, while extreme liquidity needs may increase by up to 13%. When accounting for contagion, the average Gap 2 varies from €8.53 billion to €93.1 billion, ranging from 0.4% to 4.4% of a bank's total assets. The 95th percentile can exceed €313 billion, or almost 9% of a bank's total assets. As in the previous case, approximately 85% of the simulation runs generate liquidity needs higher than zero.

Table A.8

Gap 2 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)				Liquidity gaps (only considering simulations in which banks are facing needs)		
Crisis type	Scenario	Average (EUR billions)	95th percentile (EUR billions)	Average (% of TA)	95th percentile (% of TA)	Average (EUR billions)	Average (% of TA)	Percentage of simulations with a gap
Slow burn	S-S	18.88	86.99	0.83%	3.81%	28.22	1.24%	66.90%
	S-VS	29.99	119.27	1.23%	4.37%	42.19	1.73%	71.10%
	VS-S	63.14	225.00	2.82%	6.87%	63.14	2.82%	100.00%
	VS-VS	93.07	313.25	4.40%	8.95%	93.07	4.40%	100.00%
	Overall	51.27	210.26	2.32%	6.99%	60.68	2.74%	84.50%
Fast burn	S-S	8.53	32.48	0.36%	1.22%	12.75	0.54%	66.90%
	S-VS	20.45	83.40	0.79%	2.63%	29.26	1.14%	69.90%
	VS-S	50.56	177.55	2.08%	5.04%	50.56	2.08%	100.00%
	VS-VS	82.01	268.66	3.72%	7.19%	82.01	3.72%	100.00%
	Overall	40.39	174.15	1.74%	5.51%	47.97	2.06%	84.20%

Crisis type	Scenario	Liquidity gaps (all banks) Average (EUR billions)	95th percentile (EUR billions)	Average (% of TA)	95th percentile (% of TA)	Liquidity gaps (only considering simulations in which banks are facing needs) Average (EUR billions)	Average (% of TA)	Percentage of simulations with a gap
Overall		45.83	196.14	2.03%	6.28%	54.33	2.41%	84.35%

Source: ECB calculations based on COREP and FINREP data.

The contribution to liquidity needs due to contagion effects is in line with that observed for Gap 2. The average cumulative Gap 3 (see Table A.9) ranges from €4 billion to €77.8 billion, or 0.2% to 3.6% of a bank's total assets. The 95th percentile can exceed €268 billion, or 7.76% of a bank's total assets.

Table A.9

Gap 3 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)				Liquidity gaps (only considering simulations in which banks are facing needs)		
Crisis type	Scenario	Average (EUR billions)	95th percentile (EUR billions)	Average (% of TA)	95th percentile (% of TA)	Average (EUR billions)	Average (% of TA)	Percentage of simulations with a gap
Slow burn	S-S	14.30	68.91	0.69%	3.36%	23.41	1.12%	61.10%
	S-VS	21.10	90.22	0.93%	3.96%	31.22	1.37%	67.60%
	VS-S	53.53	197.49	2.31%	6.13%	53.53	2.31%	100.00%
	VS-VS	77.75	268.30	3.62%	7.76%	77.75	3.62%	100.00%
	Overall	41.67	176.77	1.89%	6.10%	50.71	2.30%	82.18%
Fast burn	S-S	3.97	15.17	0.21%	0.83%	6.69	0.35%	59.30%
	S-VS	11.58	44.99	0.49%	1.59%	17.30	0.73%	66.90%
	VS-S	38.54	144.18	1.49%	4.21%	38.54	1.49%	100.00%
	VS-VS	64.48	214.33	2.84%	5.98%	64.48	2.84%	100.00%
	Overall	29.64	137.96	1.26%	4.48%	36.35	1.54%	81.55%
Overall		35.66	163.68	1.57%	5.29%	43.56	1.92%	81.86%

Source: ECB calculations based on COREP and FINREP data.

G-SIB crisis

The results obtained in the case of the simultaneous failure of two G-SIBs are in line with the liquidity needs in a systemic crisis, although evidence on the overall resilience of G-SIBs can be inferred by looking at detailed outcomes. Tables A.10, A.11 and A.12 report the average and maximum liquidity needs if liquidity buffers are considered or not considered in the calculation, and for different severities and durations of the simulated crisis. Overall, average liquidity shortfalls relative to banks' total assets remain quite limited, and never exceed 5.5%. In absolute terms, the simultaneous resolution of two G-SIBs could generate average liquidity needs in excess of €100 billion, albeit in very severe scenarios.

In the case of a simulated crisis of severe intensity and if no liquidity buffers are considered, the simultaneous resolution of any two G-SIBs would give rise to liquidity needs. Unlike in the other cases studied above, this means that, overall, G-SIBs are relatively resilient to potential losses, under the assumption that they could entirely release their liquidity buffer and excluding the costs associated with restoring it. When the intensity of the simulated crisis increases, the liquidity needs (expressed in absolute terms) increase accordingly.

Average results could potentially mask extreme outlier cases, mainly owing to the larger size of the banks under resolution. Maximum liquidity needs could reach values in excess of €335 billion, corresponding to approximately 11.6% of the total assets of the two G-SIBs under resolution. Although higher in absolute terms, the relative liquidity needs are in line with the outcomes obtained in a generic systemic crisis. Thus, the extreme outliers are mainly driven by the relatively large size of the banks assumed to be simultaneously resolved.

Table A.10

Gap 1 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)			
Crisis type	Scenario	Average (EUR billions)	95th percentile (EUR billions)	Average (% of TA)	95th percentile (% of TA)
Slow burn	S-S	14.30	68.91	0.69%	3.36%
	S-VS	21.10	90.22	0.93%	3.96%
	VS-S	53.53	197.49	2.31%	6.13%
	VS-VS	77.75	268.30	3.62%	7.76%
	Overall	41.67	176.77	1.89%	6.10%
Fast burn	S-S	3.97	15.17	0.21%	0.83%
	S-VS	11.58	44.99	0.49%	1.59%
	VS-S	38.54	144.18	1.49%	4.21%
	VS-VS	64.48	214.33	2.84%	5.98%
	Overall	29.64	137.96	1.26%	4.48%
Overall		35.66	163.68	1.57%	5.29%

Source: ECB calculations based on COREP and FINREP data.

Table A.11

Gap 2 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)			
Crisis type	Scenario	Average (EUR billions)	95th percentile (EUR billions)	Average (% of TA)	95th percentile (% of TA)
Slow burn	S-S	28.34	103.14	1.07%	3.48%
	S-VS	50.87	162.94	1.91%	5.63%
	VS-S	103.40	273.63	3.85%	9.20%
	VS-VS	148.18	335.75	5.52%	11.58%
	Overall	82.70	335.75	3.09%	11.58%

		Liquidity gaps (all banks)			
Crisis type	**Scenario**	**Average (EUR billions)**	**95th percentile (EUR billions)**	**Average (% of TA)**	**95th percentile (% of TA)**
Fast burn	S-S	12.77	40.66	0.48%	1.34%
	S-VS	35.42	100.85	1.32%	3.45%
	VS-S	85.66	197.26	3.16%	6.42%
	VS-VS	131.24	263.24	4.86%	8.78%
	Overall	66.27	263.24	2.45%	8.78%
Overall		74.49	335.75	2.77%	11.58%

Source: ECB calculations based on COREP and FINREP data.

Table A.12

Gap 3 results

(EUR billions and percentages of total assets)

		Liquidity gaps (all banks)			
Crisis type	**Scenario**	**Average (EUR billions)**	**95th percentile (EUR billions)**	**Average (% of TA)**	**95th percentile (% of TA)**
Slow burn	S-S	17.76	64.64	0.71%	2.89%
	S-VS	31.49	106.54	1.21%	4.05%
	VS-S	89.16	245.37	3.32%	8.25%
	VS-VS	124.32	294.63	4.63%	10.20%
	Overall	65.68	294.63	2.47%	10.20%
Fast burn	S-S	2.71	9.84	0.11%	0.50%
	S-VS	17.72	48.17	0.68%	2.05%
	VS-S	66.73	165.14	2.47%	5.38%
	VS-VS	104.35	217.28	3.87%	7.39%
	Overall	47.88	217.28	1.78%	7.39%
Overall		56.78	294.63	2.12%	10.2%

Source: ECB calculations based on COREP and FINREP data.

A.3 Robustness checks – random sampling

The random sampling methodology is used to check the effects directly due to the inclusion of an estimated probability of default in the analysis. According to the algorithm described in subsection 2.3, the number of failing banks in each simulation run relies on the distribution of banks' PDs. To abstract from this dependence, the robustness check proposed here is based on a random selection of the resolved banks in each simulation run, but with the same distribution of number of defaulting banks as obtained before. More precisely, we will consider the distribution of number of banks failing in each simulation run presented in subsection 4.1. In each simulation run, we will now sample the same number of banks in distress, but based on a random algorithm. This allows the liquidity needs to be compared on a level playing field, as they refer to the same number of failing banks, the difference between the two deriving only from the effect of the estimated PDs.

The results based on the random sampling of the banks in distress are in line with the previous ones, thus confirming the robustness of the analysis. In absolute terms, the outcomes obtained according to the robustness check described above are slightly higher than the liquidity needs in subsection 4.2. This means that, on average, the banks selected through random sampling are slightly bigger than the banks selected as failing on the basis of their estimated PD.

Table A.13

Liquidity gaps without and with contagion, and with random sampling

(EUR billions)

	No contagion			Contagion			Random sampling (no contagion)			Random sampling (contagion)		
	Gap 1	Gap 2	Gap 3	Gap 1	Gap 2	Gap 3	Gap 1	Gap 2	Gap 3	Gap 1	Gap 2	Gap 3
Average	7.89	43.00	33.57	8.01	45.83	35.66	8.04	50.89	39.52	8.29	52.47	40.75
95th percentile	49.52	179.19	147.70	49.17	196.14	163.68	49.64	212.87	176.30	50.47	215.73	179.39

Source: ECB calculations based on COREP and FINREP data.

A.4 Sensitivity analysis

Run-off rates on inflows and outflows

The sensitivity analysis presented here is aimed at assessing how much liquidity needs can change in response to a variation in run-off rates. To do this, all the run-off rates, applied to both outflows and inflows, are reduced by 10% and 20%. This exercise is repeated for the idiosyncratic and systemic crises, and the results are reported in Tables A.14 and A.15, respectively.

The results show that liquidity needs are highly dependent on the chosen level of run-off rates. In the case of an idiosyncratic crisis (see Table A.14), average liquidity needs fall by 30 to 50% if run-off rates (stress levels) are reduced by 10%, and by 50 to 80% in the case of a 20% reduction in run-off rates. The decrease in terms of maximum liquidity needs is less pronounced, with an average reduction of 22% or 43% if stress levels decrease by, respectively, 10% or 20%. Similar conclusions can be drawn when looking at the number of banks reporting liquidity needs higher than zero.

Table A.14

Cumulative liquidity gaps in an idiosyncratic crisis for different run-off rates

(EUR billions and percentages)

Gaps	100% stress levels			90% stress levels			80% stress levels		
	Average	Max.	Banks gap>0	Average	Max.	Banks gap>0	Average	Max.	Banks gap>0
Gap 1	0.85	64.75	14.97%	0.43	45.50	10.76%	0.18	25.12	6.83%
Gap 2	5.43	183.80	37.32%	4.06	157.13	32.27%	2.86	127.45	25.15%
Gap 3	4.19	157.79	33.72%	2.91	124.23	26.74%	1.94	99.22	19.91%

Source: ECB calculations based on COREP and FINREP data.

In a systemic crisis, liquidity needs remain substantial even in the case of reduced run-off rates, although they show high sensitivity to the choice of stress level. Table A.15 confirms the results described above and shows that liquidity needs can be reduced by up to 50% in the case of a 10% decrease in run-off rates, or by up to 80% if run-off rates are decreased by 20%. The overall relationship between run-off rates and liquidity needs is displayed in Chart A.1, which summarises the results in a systemic crisis, distinguishing between different gaps and samples of banks.

Table A.15

Cumulative liquidity gaps in an idiosyncratic crisis for different run-off rates

(EUR billions and percentages)

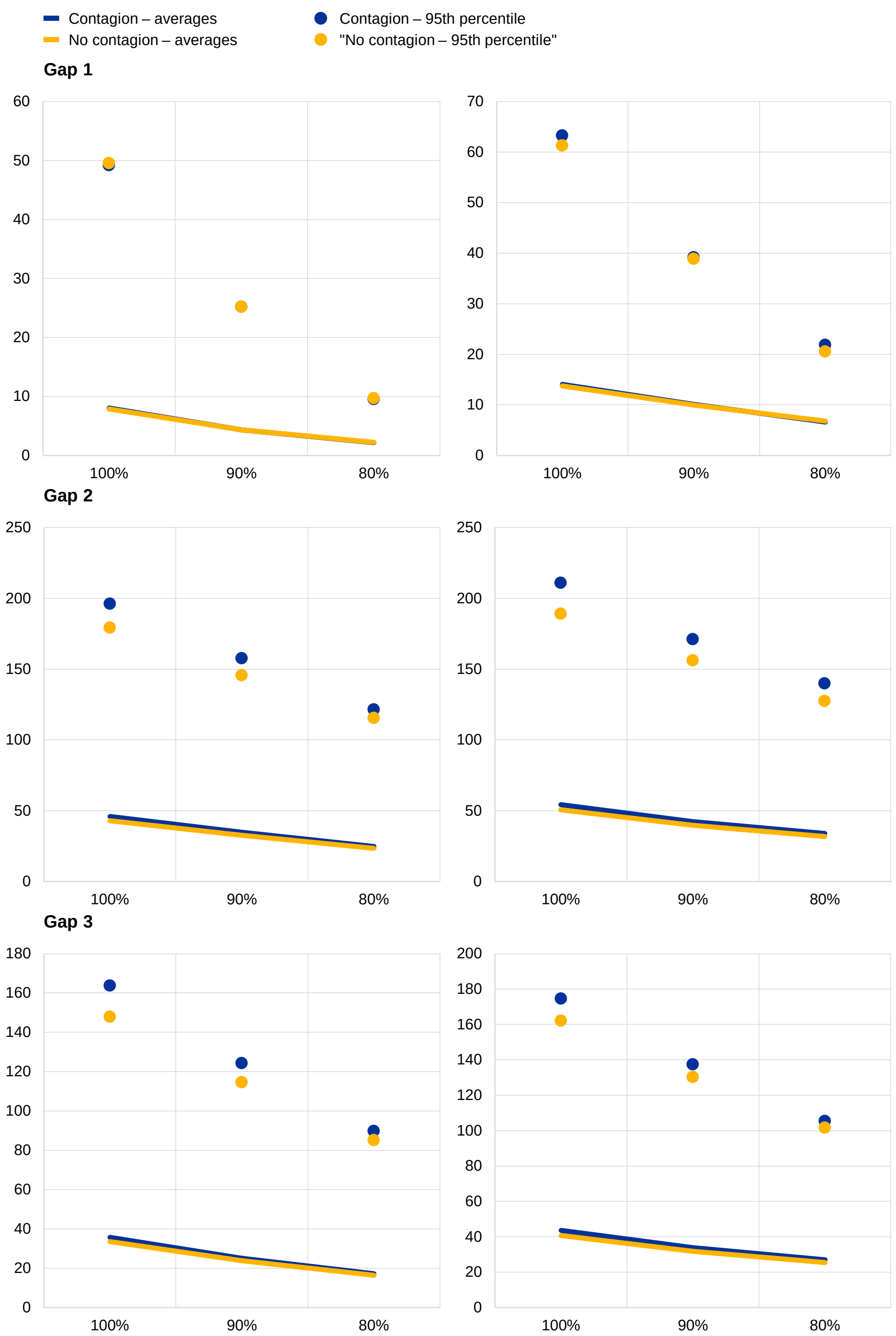
Gaps	100% stress levels			90% stress levels			80% stress levels		
	Average	Max.	Banks gap>0	Average	Max.	Banks gap>0	Average	Max.	Banks gap>0
Gap 1	8.01	49.17	57.03%	4.35	25.19	43.18%	2.17	9.54	32.63%
Gap 2	45.83	196.14	84.35%	34.75	157.70	82.13%	24.75	121.38	73.06%
Gap 3	35.66	163.68	81.86%	25.13	124.13	74.15%	17.20	89.66	63.60%

Source: ECB calculations based on COREP and FINREP data.

Chart A.1

Changes in liquidity needs according to different run-off rates

(y-axis: liquidity needs, EUR billions; x-axis: run-off rate tested, percentages of original run-off rate)



Source: ECB calculations based on COREP and FINREP data.
Notes: Right panels: all simulations considered; left panels: only simulations with positive liquidity needs considered.

CBC haircuts

This second robustness check is aimed at testing the impact of CBC haircuts on liquidity needs in an idiosyncratic crisis. In particular, it tests how liquidity needs may vary if CBC haircuts increase as the size of the banks in distress increases. For this purpose, the baseline rule “the larger the bank, the larger the haircut” has been reversed (see Table A.16).

Table A.16

Cumulative liquidity gaps in an idiosyncratic crisis for different run-off rates

(EUR billions and percentages)

	Original			Sensitivity analysis		
Severity	Small banks	Average size	G-SIBs	Small banks	Average size	G-SIBs
Severe	1%	1.5%	3%	3%	1.5%	1%
Very severe	3%	4.5%	9%	9%	4.5%	3%

Source: ECB calculations based on COREP and FINREP data.

The results obtained by changing the CBC haircuts are closely in line with previous ones, demonstrating the robustness of the assumptions. This conclusion holds when looking at scenarios of different severity and duration, and in both absolute and relative terms, as seen in Table A.17. Thus these outcomes also show that the level of CBC haircuts is not one of the main drivers determining liquidity needs.

Table A.17

Average liquidity needs for different haircuts

(EUR billions and percentages of total assets)

		Gap 1		Gap 2		Gap 3	
		Original	Sensitivity analysis	Original	Sensitivity analysis	Original	Sensitivity analysis
Absolute (EUR billions)	Average	0.85	0.88	5.43	5.68	4.19	4.42
	Max.	64.75	64.75	183.80	186.51	157.79	160.51
Relative (% of TA)	Average	0.57%	0.59%	2.07%	2.16%	1.67%	1.75%
	Max.	17.07%	17.09%	25.95%	25.95%	21.43%	21.43%

Source: ECB calculations based on COREP and FINREP data.

A.5 Summary of past bank failures studied

Four past bank failures were studied, mainly from a liquidity perspective, and the following observations were made:

Dexia: In 2008 Dexia was a European financial services group which relied on wholesale markets to fund its growing public finance activities. Following the collapse of Lehman Brothers in September 2008, liquidity in the interbank and capital markets dried up, which left Dexia with a material short-term liquidity need.[66] In addition, the

[66] See Boudghene et al. (2010).

bank faced impairments on a large portfolio of structured credit assets, and pressures caused by the fall in the equity market.[67] On 30 September 2008, Belgium, France and Luxembourg publicly announced a capital increase of €6.4 billion for Dexia, about half of which was subscribed by the bank's key shareholders (most of them closely linked to the public sector).[68] However, this did not stop the deterioration of Dexia's liquidity position. On 9 October the same governments issued a state guarantee of new debt capped at €150 billion (later reduced €100 billion).[69] The guaranteed amounts used reached a peak of €95.8 billion in May 2009.[70] In total, the European Commission assessed the amount of liquidity aid received by Dexia at €135 billion for the State guarantees on Dexia's liabilities and the emergency liquidity assistance provided.[71] Following the next phase of the (sovereign debt) crisis (October 2011), and the negative outlook assigned by rating agencies, Dexia faced renewed problems.[72] The trust of retail customers in Belgium and Luxembourg was eroded, leading to a €7 billion outflow of deposits between the end of September and the end of October 2011.[73] An orderly restructuring plan for the Dexia group was presented on 10 October 2011, which involved divestment and placing assets in a bad bank.[74] A revised resolution plan, with a horizon set at 2021, was decided by the three governments in March 2012 and, with slight revisions, was approved by the European Commission on 28 December 2012.[75] It authorised new State aid for the Dexia group in the form a refinancing guarantee of €85 billion and a recapitalisation of €5.5 billion.[76]

Hypo Real Estate[77]: Hypo Real Estate Holding (HRE) had a business model that relied on short-term interbank funding to finance long-term wholesale investments and, like Dexia, it fell into difficulties following the collapse of Lehman Brothers in September 2008. At the end of September 2008 the German banking association tried to set up a rescue package by providing about €35 billion of liquidity to HRE, which was based on a guarantee from Germany. Eventually, HRE was nationalised and in the autumn of 2010, a public winding-up institution (FMS-WM) was established which over time took over about €210 billion of assets from HRE (approximately half of HRE's 2008 balance sheet). On 14 June 2011 Germany submitted the final version of the restructuring plan for HRE, which reorganised its business activities. On 18 July 2011 the European Commission approved German State aid for HRE consisting of capital injections of approximately €9.95 billion, guarantees of €145 billion (of which €105 billion was used)[78] and an asset transfer to FMS-WM with an aid element of about €20 billion.

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67 Ibid.

68 Ibid.

69 Ibid.

70 See Dexia (2009).

71 See Boudghene et al. (2010).

72 See European Commission (2021).

73 See Dexia (2012).

74 See Dexia (2011).

75 See European Commission (2012).

76 Ibid.

77 See Buder et al. (2011).

78 See European Commission (2010).

Banco Popular: Banco Popular Español (BPE) was a Spanish banking group with 1,600 branches which focused in particular on small and medium-sized enterprises.[79] Since 2012 the bank had carried out three capital increases totalling €5.5 billion, but it did not manage to materially wind down its €37 billion real estate exposure.[80] The deterioration of this portfolio further eroded the bank's capital.[81] Rating downgrades and significant concerns among the bank's customers followed the bank's announcement of additional provisions and year-end losses in February 2017, as well as the announcement in April 2017 that a capital increase or corporate transaction might be needed to handle any potential additional impairment of the non-performing assets portfolio.[82] This led to significant cash outflows and a severe deterioration of the bank's deposit base.[83] About €18 billion of deposits flowed out of the bank, corresponding to around 24% of the total, in the two months between the closing of its first quarter accounts in March and the intervention on 6 June 2017, when the ECB announced that Banco Popular was FOLTF.[84] In just the three days before the authorities acted, customers withdrew €6 billion.[85] Following the FOLTF decision by the ECB, the Single Resolution Board (SRB) decided that the "sale of business" tool would meet the resolution objectives and ensure financial stability.[86] Consequently, the SRB transferred all shares and capital instruments of BPE to Banco Santander for a purchase price of €1.[87] Shortly after, Banco Santander announced that it would inject €13 billion of liquidity into BPE.[88]

Bank of Cyprus and Cyprus Popular Bank: In Cyprus, the Bank of Cyprus (BoC) and Cyprus Popular Bank (CPB) dominated the banking market with a combined market share of around 80% in terms of deposits and loans in 2012.[89] Both banks had also expanded their activities abroad, particularly in Greece, and were therefore particularly exposed when the Greek crisis erupted in 2009. In December 2011, the direct loan exposure of Cypriot banks to Greece amounted to €21.8 billion, or 126% of Cypriot GDP, and the ratio of non-performing loans in their Greek loan portfolio rose to 42%.[90] In addition, the banks suffered massive losses on their holdings of Greek government bonds. Consequently, Cypriot banks suffered substantial liquidity outflows from their operations in Greece. Borrowings from the Eurosystem (regular monetary policy operations and emergency liquidity assistance) increased to a peak of €13.6 billion in September 2012, before slightly decreasing to €9.5 billion in January 2013.[91] In relative terms, the latter figure represented almost 8.5% of Cypriot banks' total liabilities.[92] Rating agencies began downgrading Cyprus, which fell below

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79 See Mesnard et al. (2017).
80 See ECB (2018).
81 Ibid.
82 Ibid.
83 Ibid.
84 See Allendesalazar (2017).
85 Ibid.
86 See Single Resolution Board (2017).
87 Ibid.
88 See Allendesalazar (2017).
89 See European Commission (2013).
90 See Hardouvelis and Gkionis (2016).
91 See European Commission (2013).
92 Ibid.

investment grade on 25 June 2012.[93] On the same day, the Cypriot authorities requested financial assistance from euro area Member States and the International Monetary Fund (IMF).[94] By now, deposit flight had soared, especially from the branches of Cypriot banks in Greece. Depending on the measurement techniques, there was a deposit outflow of about €10 to 17 billion by the time an agreement was reached with the Troika (the IMF, the ECB and the European Commission) in March 2013.[95] In March 2013, Cyprus agreed to a bail-in solution to recapitalise the largest systemic bank (BoC), while the second-largest bank (CPB) was subject to the "sale of business" tool, merging it with BoC.[96] Approximately €9 billion of Eurosystem funding accompanied the acquisition,[97] making central bank funding of CPB approximately 27% of total assets.

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93 See Hardouvelis and Gkionis (2016).

94 See European Commission (2013).

95 See Michaelides (2016).

96 Ibid.

97 See Bank of Cyprus Group (2013).

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Acknowledgements
We would like to thank Anton van der Kraaij, Fatima Pires, Sergio Nicoletti Altimari, Lev Ratnovski, Kristine Drevina , Enrico Bleve, Emmanuel Faïk, Ernest Dautovic for helpful comments and suggestions on the paper. We would also like to thank the members of the Macroprudential Policy Group and the Financial Stability Committee for useful comments on the model in earlier versions of the paper. We would finally like to thank Kristian Kjeldsen, Michael Vincent and Federico Infelise for fruitful exchanges of views on the topic. We accept full responsibility for any errors or omissions. The views expressed in this paper are our own and do not necessarily reflect those of the ECB, nor the people mentioned in these acknowledgements.

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PDF ISBN 978-92-899-4426-7, ISSN 1725-6534, doi:10.2866/48515, QB-AQ-20-013-EN-N