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Stress-Testing of liquidity risk in TARGET2

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Contents

Abstract

The paper reports the outcome of the stress-testing of liquidity risk in the TARGET2 payment system, with the study having been conducted by an ad-hoc group composed of operators and overseers of TARGET2. The study aims to assess the resilience of the system, defined as the network of its participants, and the appropriateness of liquidity levels under tightened liquidity conditions. The scenarios analysed are based on extreme shocks to the value of collateral of different levels and types that lead to a decrease in the intraday credit lines available in TARGET2 and, as a result, the payment capacity of TARGET2 participants. The tool used to perform these stress tests is the TARGET2 simulator, which provides access to real transaction level data and allows simulations to be run by changing parameters, in this case the credit lines. The period under analysis is one maintenance period for the years 2008 to 2013. In general, the stress-testing indicates that the system is resilient under the stress scenarios; liquidity levels seem to be appropriate and supported by the efficient liquidity management features of TARGET2. Even in the worst simulated event of a 70% drop in all collateral value, 80-90% of TARGET2 turnover would have been settled. The scenario results take also into account that the period under analysis was characterised by unconventional monetary policy measures.

Keywords: TARGET2, stress testing, simulation, liquidity risk, principles for FMIs

JEL codes: C63, E42, E58, G01

Non-technical summary

The study object is the TARGET2 payment system, which is owned and operated by the Eurosystem. TARGET2 is the real-time gross settlement (RTGS) system of the euro. It settles payments in central bank money on a continuous and individual basis. Payments in TARGET2 are related to monetary policy operations, bank-to-bank transactions, transactions of banks on behalf of their clients, as well as the operations of all large-value net settlement systems and other financial market infrastructures handling the euro, such as securities settlement systems, central counterparties or automated clearing houses (ACHs). In terms of the value processed, TARGET2 is one of the largest payment systems in the world. In 2015, it settled on daily average EUR 1,835 billion and 343,729 transactions.

The motivation for the study originates from the regulatory requirements that TARGET2 has to adhere to, namely the CPMI-IOSCO Principles for Financial Market Infrastructures (PFMI), which led to the ECB Regulation on oversight requirements for Systemically Important Payment Systems (SIPS R). Article 8 of the Regulation requires an FMI to have the ability to include stress tests in its risk management process in order to address liquidity risk, i.e. the risk of liquidity shortages caused, for example, by deteriorations in the value of collateral. The study assesses the resilience of the TARGET2 system, which is defined as the network of its participants, and the appropriateness of liquidity levels under different overall liquidity conditions, namely the simulation assessed impacts for the years 2008 to 2013. As TARGET2 is an RTGS system, the system operator itself does not face any liquidity risk.

The scenarios analysed were based on extreme system-wide shocks to the value of collateral that led to a decrease in the intraday credit lines available in TARGET2 and thus a decrease in the payment capacity of TARGET2 participants, which is composed of positive account balances, intraday credit lines and the net result of incoming and outgoing payments. The group that performed the study had access to the granular TARGET2 transaction data as well as most intraday credit data of TARGET2 participants. Thus, the simulations are based on real payment data and, where applicable, compare the simulation results with the undisturbed benchmark simulation.

The stress test scenarios measure the impact of the shocks, which can generally be categorised as follows:

- the direct and primary impact on TARGET2 participants' intraday credit line and the ability to make payments;
- the indirect and secondary impact on other TARGET2 participants as a result of the missing, lower or delayed incoming liquidity.

Output indicators

The study looks at six output indicators and, overall, it can be concluded that the more severe the scenario, the higher the negative implications in terms of unsettled transactions, affected banks, payment delays or negative end-of-day balances – almost in a linear manner. Less intense scenarios generally lead to a milder impact, even though their magnitude is already extreme given that the shock is assumed to occur from one day to another. It should be noted that TARGET2 participants may potentially have other eligible unencumbered assets available that were not pledged at the Eurosystem and could be mobilised in times of stress and could allow a TARGET2 participant to make up in part for the credit line decrease. This could result in even higher resilience by TARGET2 in the worst simulated scenarios. On the other hand, it needs to be acknowledged that the pre-designed shocks would also lead to actions by other counterparties, especially the calling for margins in cash or collateral, which could increase the shock impact.

The results from the six output indicators are as follows:

The first indicator measures the unsettled payments that would arise in each scenario in terms of value and volume. It shows that, in the worst case events, 80-90% of the TARGET2 turnover would still have been settled. In terms of volume, the impacts are even lower. This hints at the fact that a system-wide shock would hit large-value payments in particular.

The second indicator analyses the composition of unsettled payments: the stress tests show that of all transactions in TARGET2, interbank and ancillary systems transactions are impacted in particular (on average they represent over 85% of the total unsettled value). Ancillary system payments account for 40-60% of unsettled payments. Mitigation measures that both ancillary systems and banks may have at their disposal are not considered in the stress tests, suggesting that the results in reality may be even milder. Likewise, consideration has not been given to whether the scenario would have impacts on banks or ancillary systems through channels other than TARGET2, for instance via refinancing operations or increased margin requirements. In terms of number of payments, customer payments, i.e. payments banks make on behalf of their clients, account on average for around 50% of the unsettled transactions.

The third indicator provides information on banks with unsettled payments, where the number of participants having unsettled payments increases with the severity of the shock. This also implies that some of the systemically important TARGET2 participants would be affected increasingly with the severity of the deterioration scenario and over the years. Furthermore, the cumulative distribution of unsettled values is very concentrated among a few players, whose number increases marginally with the scenarios.

The fourth indicator examines payment delays and underlines the usefulness of payment queues as a real-time indicator of liquidity problems, though caution is required as queues are, to a certain extent, a built-in feature of TARGET2 and can also result from the use of liquidity management features. The delay indicator developed increases proportionately with the severity of the scenario, though overall it is at a relatively low level. On average, the value of queued payments reaches its maximum in 2009 and decreases steadily in subsequent years.

The fifth indicator measures the number of participants that would end up with a negative end-of-day balance: the number increases the more severe the collateral deterioration. This also applies to the sum of all negative end-of-day balances.

The sixth and final indicator of the degree of collateral usage gives insights into both the usage of account overdrafts in general as well as the impact of liquidity shocks on the usage of credit lines. In the undisturbed benchmark simulation of 2013, around 18% of all payments in value terms are settled by making use of intraday credit. This hints at rather high levels of available liquidity in TARGET2. Consequently, the effect of a deterioration of these credit lines, as done in the stress testing scenarios, is linked to a certain extent to the degree of collateral usage in making payments.

Overall, the TARGET2 stress-testing indicates that the system is resilient under the stress scenarios and that liquidity levels seem to be appropriate and supported by the efficient liquidity management features of TARGET2. Even very severe liquidity shocks caused by the most extreme collateral deteriorations lead to relatively mild results.

Relation to the financial crises

As a final comment, the time span studied (namely, from 2008 to 2013) was characterised in part by unconventional monetary policy, as during this time period the financial crises impacted the European financial system. In view of TARGET2, this resulted in a large amount of central bank money. This factor has two important implications. Firstly, the results have to be viewed in the light of the large amount of liquidity in the payment system. Secondly, the results indicate that the available liquidity contributed to the resilience of TARGET2 participants to liquidity risk under the stress scenarios.

1 Introduction

This paper explains the methodology and analyses the results obtained from the stress-testing of liquidity risk in TARGET2.

TARGET2 is the euro payment system used to settle financial transactions between its participants and/or linked Financial Markets Infrastructures (FMIs), the so-called Ancillary Systems (AS), in central bank money. As an identified Eurosystem Systemically Important Payment System (SIPS), TARGET2 should comply with the ECB Regulation on oversight requirements for Systemically Important Payment Systems (SIPS R).[1] The Regulation defines oversight requirements for SIPS by implementing the CPMI-IOSCO Principles for Financial Market Infrastructures (PFMI) introduced in 2012.[2] Article 8 of the Regulation requires a FMI to have the ability to include stress tests in its risk management process in order to address liquidity risk.

Stress testing is understood as the evaluation of the FMI's performance under severe but plausible scenarios in order to assist the system operators in managing risks.

TARGET2 is a payment system that settles payments on a continuous (real-time) and individual basis (gross settlement). The system operator itself does not incur any liquidity risk: irrespective of the possible insolvency of a participant, payments will remain final and irrevocable. However, TARGET2 can be viewed as a network that interlinks participants. In this wider context, the failure of one participant to fulfil its payment obligations (at all or in time) can endanger the liquidity position of the recipient and, in turn, cause the recipient to be unable to meet its payment obligations in time.

In order to analyse such risks, this paper uses stress scenarios of liquidity shortages caused, for example, by collateral deteriorations. Sudden decreases in assets prices, i.e. collateral values, would shrink the TARGET2 intraday credit lines of TARGET2 participants and hence reduce the available payment capacity of the banks, defined as the sum of their positive account balances and intraday credit lines. Such liquidity constraints could thus impact the ability of participants to settle payment obligations in time (delayed payments) or at all (unsettled payments).

The methodology used is based on collateral shocks of different levels and types that cause a decrease in the intraday credit lines available in TARGET2 for the participants and, consequently, lead to a lower payment capacity. The aim of the exercise is to assess how settlement levels would react/deteriorate as a consequence of the shocks and to obtain an indication of the overall efficiency of the

1 See ECB (2014).

2 See BIS (2012).

system and of the resilience of liquidity buffers and liquidity management features under tight liquidity conditions.

The tool used to perform these stress tests is the TARGET2 simulator, which provides access to granular TARGET2 data and allows simulations to be run, i.e. running the real transactions under changed liquidity conditions within unchanged system functionalities.

The Eurosystem has been at the forefront of exercises of this type linked to and motivated by the PFMI: it was the first to run stress tests on a real-time gross settlement system using real transactions and participant data within replicated system functionalities.

After this introductory section, the second section of the paper provides some background information on the approach applied. The third section explains in detail the methodology used to set up and run the simulations and the scenario definition. The fourth section provides an indicator-based analysis of the results. The last section sets out the conclusions.

2 Stress testing framework

TARGET2 is the Real-Time Gross Settlement (RTGS) System owned and operated by the Eurosystem. In TARGET2, payment transactions are settled one-by-one on a continuous basis in central bank money with immediate finality and irrevocability. Therefore, all the payments in central bank money take place in TARGET2 and, in particular, payments involving Eurosystem central banks (central bank operations), money market operations, operations of other financial market infrastructures (in particular large-value net settlement systems, securities settlement systems, central counterparties or automated clearing houses handling the euro (ancillary system transactions)), as well as payments by banks (interbank payments and intragroup payments) and payments banks make on behalf of their clients (customer payments).

TARGET2 is exposed to and addresses various risks, including legal, operational or general business risks. This report focuses on liquidity risk, and TARGET2 is considered and examined with a wider definition, namely as the ensemble of the infrastructure plus its participants. It should be noted that the system operator of TARGET2 as such is not exposed to liquidity risk: TARGET2 is an RTGS System and, therefore, each transaction is settled individually in real time with finality and irrevocability. However, TARGET2 participants may face liquidity risk.

Liquidity risk is defined as the possibility that one or more participants are short of payment capacity in their TARGET2 accounts, and thus cannot execute payments in a timely manner (delayed payments) or cannot execute them at all (unsettled payments). Such delayed or unsettled payments may, in turn, harm other participants, who receive fewer payments than expected, and thus may find themselves liquidity-constrained, giving rise to potentially long chains of contagion. Liquidity stress may arise from shortages in available liquidity or from an increase in liquidity needs.

Participants' liquidity needs for making payments correspond to the sum of payments which they have to settle in TARGET2 on a given business day. Estimating those needs and matching them with the different liquidity sources is the responsibility of the participants’ liquidity management and treasury.

Liquidity stress on one or more TARGET2 participants is a situation of insufficient liquidity compared with the participants’ needs. In TARGET2, participants’ liquidity resources are:

- reserve holdings (i.e. both required minimum reserves and excess reserves including working balances),
- incoming payments,
- intraday credit provided by the central bank.

Liquidity shortages may therefore arise for three kinds of reason:[3]

1. Lack of incoming payments: participants may adopt a 'free-riding' behaviour i.e. try to postpone their own payments in an attempt to recycle incoming liquidity, rather than tapping into their own liquidity reserves.

2. Reduction in the value and/or availability of eligible collateral. This causes a reduction in TARGET2 credit lines and more difficult access to liquidity providing operations, including hampered access to the money market and/or to central bank liquidity-provision operations. It may reduce the ability to meet payment obligations by one or more participants and, in turn, may lead to lower incoming payments for other participants and a further tightening of the liquidity conditions.

3. Increase in liquidity needs (i.e. need to make more and/or higher payments than usual).

Case 1 has been discussed in the academic literature, and such behaviour was seen during the banking crisis, when banks tried to limit liquidity outflows. While there may be some isolated cases in TARGET2, these do not have relevant effects.[4] Moreover, banks can delay payments only to a certain extent. Finally, the effects of such 'free-riding' behaviour could be mitigated by existing liquidity reserves and the ability to access intraday credit. In general, delayed payments would have a larger impact on those participants with low reserves, while participants with excess reserves may buffer the impact. Intraday credit would not be impacted.

Case 2 is a very concrete possibility. Moreover, its effects on liquidity (and hence on settlement) would be very direct and potentially extreme.

Case 3 is also a concrete possibility, as specific market conditions may require additional margin payments, putting additional liquidity strain on TARGET2 participants. As in case 1, an increase in liquidity needs is more likely to negatively affect participants with low reserves, but would not affect their credit lines.

Finally, situations could emerge in which all sources of liquidity stress materialise at the same time, impacting participants on both fronts, i.e. credit lines decrease and liquidity needs increase.

The paper focuses on TARGET2 stress testing on the basis of liquidity shortages caused by collateral deteriorations, i.e. reductions in the overall available liquidity. Scenarios of operational risk as well as considerations concerning interdependencies do not fall within the scope of the analysis. In particular, the study deals only with the effects of a collateral deterioration on the intraday credit capacity, and does not address other channels affecting the availability of liquidity in TARGET2.

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[3] As mentioned above, operational risk is not considered; in other words, a normal functioning of the system is assumed.

[4] Diehl (2013) evaluates free riding in the German TARGET2 component using several indicators and finds levels of free riding that can be judged to be relatively low.

3 Methodology

The outcome of the simulations carried out using the TARGET2 simulator is determined by the input data and the replicated settlement logic of the TARGET2 system. Careful preparation of the data and the setup of the simulations are necessary conditions to guarantee the quality of the output data and the robustness of the final results.

3.1 Scenario preparation

The first step is to decide on the approach to be taken to the concrete implementation of the scenario described in section 2. Here, we assume that all euro collateral of all participants suffers a drop in value. This would be the case in a euro-area system wide shock, affecting all euro-denominated securities across the board. All TARGET2 credit lines are shrunk accordingly. In the second step, the impact for each bank has to be quantified. In the final step, the adapted credit line for each bank has to be calculated and a dataset with the new values is created.

Two types of scenarios are constructed for the system-wide shock simulations:

- in *clean cut* scenarios, all collateral is deteriorated;
- in *proportional cut* scenarios, only that collateral which consists of marketable assets is impacted.

Thus, the proportional cut scenarios provide a somewhat milder but possibly more realistic shock. In order to split marketable and non-marketable assets, information about the participants' collateral composition is needed. The database of marketable assets owned by the participants is merged with the TARGET2 credit line database[5] and the transactions database to allow them to be deteriorated in accordance with the scenario and with the percentage of marketable assets posted by the participant in question.

Three levels of severity for the scenarios are considered: 30%, 50% and 70% drops in the value of collateral. Thus, in total 36 separate one-month scenarios[6] are created.

5 For those National Central Banks (NCBs) providing credit lines in a Proprietary Home Account (PHA) with liquidity transfers to TARGET2, these liquidity transfers were used as the best available proxy for the intraday credit available (See below).

6 This refers to all combinations of 6 years, 3 levels of severity and 2 scenario types, which translates into approx. 1000 single-day simulations.

3.2 Methodological assumptions

Some aspects that go beyond the pure phenomenon of a decrease in collateral value cannot be completely replicated in the scenario generation process for the TARGET2 stress testing.

One aspect that is not included in the scenarios is the effect of the shock on parameters other than the intraday credit line. The main potential effect not taken into account here is the relationship between collateral value and refinancing operations: a decrease in the value of the collateral held with the central bank could lead to a potential decrease in the capacity of participants to participate in Eurosystem refinancing operations and could give rise to margin calls. In principle, neglecting the impact of a collateral deterioration on the refinancing operations is likely to introduce a potential source of underestimation.

A second element that is not considered is the interaction of TARGET2 with other financial market infrastructures and the reactions of these to the stress scenario. While the TARGET2 simulator is replicating the TARGET2 settlement process, the shocks are not extended to ancillary systems connected to TARGET2 nor are their behavioural reactions included in the ancillary system settlement replication. This approach can in some cases (for instance in the Ancillary System Interface settlement procedure 5 using an all-or-nothing procedure for settlement) entail an overestimation of the effects in the real world.

Thirdly, the stress-testing methodology excludes any behavioural change made by participants directly in TARGET2. Technically, all modifications to transpose the scenarios into the input data are done before the actual simulations which replicate the settlement process of TARGET2 and are limited to the deterioration of the credit lines. Thus, all the scenarios are run as static simulations in the sense that no replication of dynamic behavioural changes during the simulation is included or allowed. This *ceteris paribus* assumption in the scenario design is a typical challenge in studies based on simulations using historic data. Including behavioural change or external intervention would have required assumptions to be made and would have therefore introduced an element of subjective discretion into the scenario. In order to analyse the significance of this simplification, a limited sensitivity analysis of the stress testing outcome is performed. It uses an adjusted model where one simple behavioural pattern is integrated into the TARGET2 simulator with Agent Based Modelling (ABM). This approach allows the additional impact caused by the specific participant behaviour to be estimated. Results show that the one tested behaviour causes either no impact or a deterioration in the system level outcomes in the indicators used. Further work on developing the ABM approach to model behaviours of participants is ongoing.

Fourthly, potential participant reactions could also take place outside TARGET2 but affect the parameters in TARGET2. Of particular importance is the availability of unencumbered eligible assets for the participants. These assets could be pledged at the Eurosystem in the event of a collateral deterioration to obtain additional liquidity in order to be able to settle unsettled payment obligations. Not considering this aspect could, in turn, be a potential source of overestimation of the scenario effect.

At the same time, counterparties outside TARGET2 would probably call themselves for additional collateral, which may make up for the overestimation.

Fifthly, the treatment of credit lines provided by a few national central banks to their credit institutions via their Proprietary Home Account (PHA) is done using a proxy for those credit lines. For national components providing credit lines in a PHA with liquidity transfers to TARGET2, those liquidity transfers are assumed to be the best available proxy for the credit line of the participants. The liquidity transfers from the PHA to the TARGET2 account are identified in the transaction data and, for those participants which had their credit lines in the PHA, the value of these liquidity transfers is deteriorated by the same percentage cut that is applied for cutting the credit lines of participants which were located in countries with credit lines in TARGET2. This necessary simplification leads to less available liquidity for settlement in the stress scenario for the participants using PHA liquidity transfers compared with a direct application of the cut to their credit line. The latter are therefore “overstressed” since their available liquidity is always lower. When interpreting the results, one should therefore keep in mind that participants in countries using a PHA are facing more severe scenarios due to the necessary methodological assumptions of the scenario preparation. The national components having their credit lines in PHA are Belgium until 2009, Germany until 2013 and Austria. Of particular importance is the fact that a PHA was used for German participants but was phased out in September 2013, which led to a significant methodological break. Due to the relative importance of the German component in the overall traffic, the overstress effect for German participants could have a significant impact on the system-wide results in the periods simulated when the PHA was used. This reduces comparability of results from 2013 with respect to previous years, but at the same time allows a better comparison in the future.

Finally, the TARGET2 simulator software, which is used to replicate the settlement process of TARGET2, is known to contain simplifications compared with the software of the actual TARGET2 system. This is carefully taken into account in the design of the simulation setup in order to minimise the potential systematic error.

3.3 Simulations

The simulations are carried out using original TARGET2 data and the modified data according to the scenario.

The preparation of the data to run the simulations includes several steps, which can be divided in two phases: 1) basic data preparation and 2) scenario preparation.

The basic data preparation phase provides the input for what we call the benchmark simulation, which is intended to replicate the setup and settlement process of the actual TARGET2 system without any modification. The results of the entire analysis are presented as the difference between this benchmark simulation and the scenario simulation outcome - unless explicitly stated otherwise. Obtaining the results by comparing the simulation scenario with the benchmark scenario also addresses the above-mentioned simplifications of the simulator software, since both benchmark and scenario simulations are affected in a very similar way by these simplifications.

The scenario preparation phase provides input for the scenario simulations. The simulations are performed using the TARGET2 simulator. The TARGET2 simulator includes all transactions that were (un)settled in the actual TARGET2 system. It also includes information about participants, account balances and TARGET2 credit lines. In addition, the system allows simulations to be conducted, i.e. to let the transactions of a given day run under changed parameters, which are the stress scenarios.

The period under analysis runs from 2008[7] to 2013 and focuses on the reserve maintenance periods between October and November: it features several crisis periods, different liquidity levels and transaction patterns. As a result, our dataset corresponds to 20 to 25 business days for each year and scenario.[8] The interval chosen is the reserve maintenance period since it reasonably captures the full picture of the liquidity needs of the banks. The months of October and November are selected as they correspond to representative months in terms of average traffic levels in TARGET2, as analysis of calendar effects demonstrated.[9]

7 Note that the migration from the first generation of TARGET to TARGET2 was completed in May 2008, i.e. the first month after migration was June 2008.

8 The reserve maintenance periods included 20 days in 2009, 2010 and 2011 and 25 days in 2008, 2012 and 2013.

9 See Box “Measuring the seasonal patterns of TARGET2 payment activity” in TARGET annual report 2014.

4 Outcome of the stress-testing simulations

For all simulations, six output indicators are measured and analysed:

1. unsettled transactions by volume and value,
2. unsettled transactions by payment category,
3. number of banks having unsettled transactions,
4. payment queuing and payment delays,
5. end-of-day balances (overdrafts),
6. collateral usage.

The indicators are presented as the difference (relative or absolute) with respect to the benchmark simulation. In order to simplify the reading of the outcome, only results related to the most severe scenarios, meaning those including marketable and non-marketable assets, are presented. It should be noted that, for all indicators, the two different methods of collateral deteriorations yield largely similar results, with the shock scenarios for marketable and non-marketable assets leading to slightly more intense effects.

4.1 Simulation results

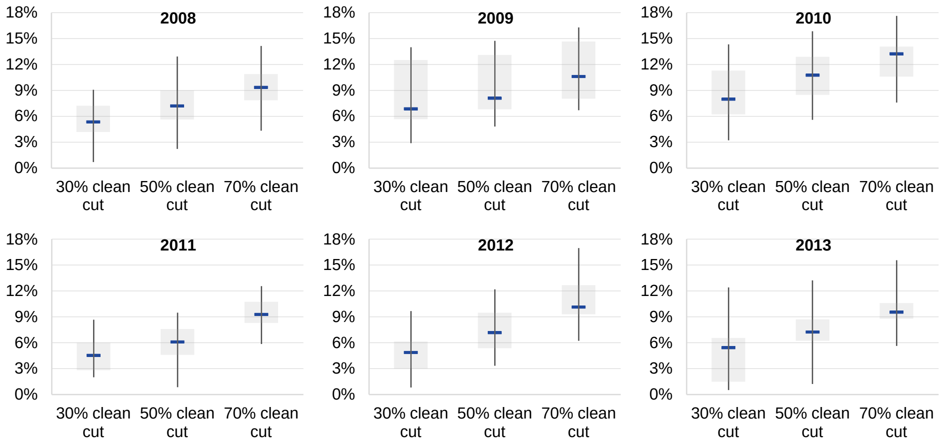
4.1.1 Unsettled Payments

The first indicator for unsettled payments captures the relative impact of the collateral deterioration scenarios on unsettled payments due to missing liquidity on the accounts of TARGET2 participants in terms of both value (EUR) and volume (number of payments).

Chart 1 shows the distribution of the value of unsettled payments (expressed as a percentage of the total daily traffic) for a given year and collateral deterioration scenario. In order to also analyse the distribution of the results across scenarios and years, box plot charts are presented below, which can be read as follows: the vertical lines represent the full distribution of results, i.e. the lower and upper ends represent the minimum and the maximum. The box indicates the 1st and 3rd quartile, thus capturing 50% of all observations, while the thick line marks the median. Lastly, the zero line for the box plots is calibrated to be equal to the benchmark scenario.

Chart 1

Unsettled payments in value



The x-axis shows the simulated clean cut scenarios, i.e. including both marketable and non-marketable assets.

A first result is that the median impact for a given scenario is relatively stable across the years, with averages of about 6%, 8%, and 10% of unsettled payments in the 30%, 50%, and 70% clean cut scenarios, respectively. This result confirms that the share of unsettled transactions increases with the severity of the collateral deterioration. Moreover, it can be concluded that the effect is more or less linear. The degree of dispersion within a scenario is also similar across the years, with the exception of 2009, where the impact of the individual days differs significantly, and 2011, where the differences between the minimum and the maximum are lower. Finally, the year that yields the most severe impact for all scenarios is 2010.

These results do not appear to be alarming. On average, the 30% shock scenario, which is already a rather severe scenario since it would imply a decrease in value of 30% across all assets posted as collateral from one day to the other, results in 6.3% unsettled payments throughout the 110 simulated days, equal to an amount of EUR 143 billion. This increases to 8.2% (EUR 184 billions) and 10.6% (EUR 238 billion) for the 50% and 70% shock scenarios, respectively. The “worst-case” is on 3 November 2010 and amounts to EUR 428 billion of unsettled transactions, representing a share of 17.3% of the total traffic.

This leads to the conclusion that:

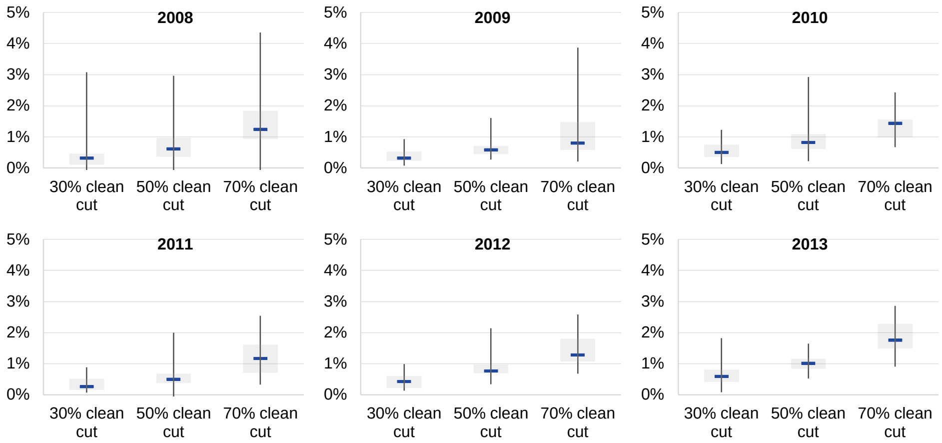
1. the overall payments capacity (i.e. sum of account balances and credit lines) of TARGET2 participants is rather high during the observed periods, and

2. the liquidity saving features of TARGET2, in particular the offsetting, may help in terms of limiting liquidity needs in stress scenarios.

Even though the volumes are less relevant from a liquidity risk viewpoint, the simulations allowed the collection of certain indicators leading to a more complete picture, as presented in Chart 2.

Chart 2

Unsettled payments in volume



The x-axis shows the simulated clean cut scenarios, i.e. including both marketable and non-marketable assets.

In terms of volume, unsettled payments in proportion appear very low compared with the value. The medians mostly remain below 0.5% for the 30% cut scenario and 1.5% for the 70% shock scenario, and the trend across years remains stable. The worst case scenario leads to 4.9% of unsettled payments (14 October 2008) corresponding to 14,800 transactions.

The fact that the impact on the volume is far smaller than on the value suggests that high-value payments, which are of greater systemic importance, are those mostly affected by the liquidity shortage.

For 2008, we observe that some days yield fewer unsettled payments under liquidity stress than in normal conditions (minimum showing negative percentages). This phenomenon is explained by the mechanics of the liquidity redistribution process within the system as a sequential process, whose effects may be amplified by the design of the netting procedures available for the settlement of the ancillary systems.

By and large, the result of a multitude of simulations for different years and scenarios is that TARGET2 is robust to a drop of collateral: even in the worst case scenario, on average 80-90% in value and more than 95% in volume of transactions would be settled. While this finding clearly highlights the high payment capacity of banks and the efficiency of the system's liquidity saving features, there are also other possible complementary explanations. In particular, the extent to which participants actually use intraday credit to make payments seems to be an important factor. Since only a small percentage of the credit lines are used to make payments in the benchmark simulations, approx. 7% on average in 2012 and 19% in 2013, TARGET2 participants' payment capacity is rather high which might also explain the rather limited impact on TARGET2, at least to some degree.

4.1.2 Categories of unsettled payments

This indicator further breaks down the overall amount of unsettled payments presented in the previous section into its components, and analyses the payment categories most impacted by the stress scenarios.

Chart 3

Composition of TARGET2 value

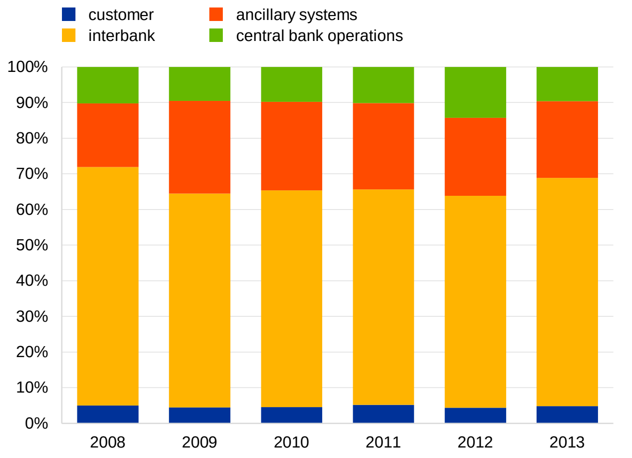


Chart 4

Composition of TARGET2 volume

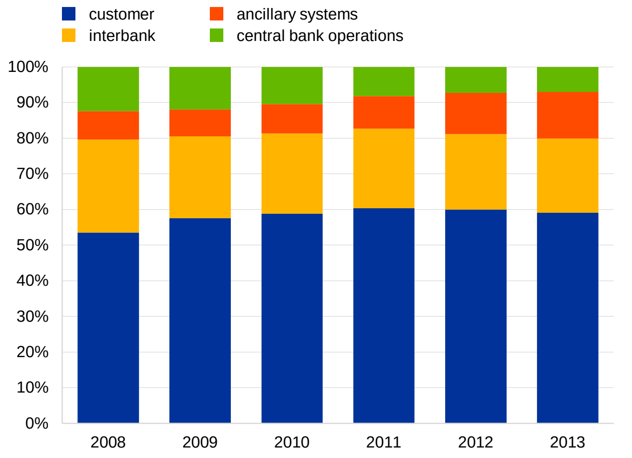


Chart 3 and Chart 4 show the average share of traffic, respectively in value and in volume, of the different payment categories[10] for the period under analysis for the unchanged input transaction data. Both charts are based on the transaction data from the TARGET2 simulator used for the simulations, i.e. not on the TARGET2 statistical framework. The main difference with respect to the production data is that some transaction types are disregarded for the simulations. At the same time, from 2009 onwards, some technical transactions were excluded from the calculations based on the statistical framework. Furthermore, in 2013 some transactions such as recourse to the deposit facility, previously included in the data for some countries, were excluded from the reporting. These transactions are, however, included in the TARGET2 simulator statistics and affect, in particular, the daily value. The value of these transactions increased in 2012 since there were higher refinancing operations with the central banks and recourse to the standing facilities, but their behaviour does not affect the results of this study.

[10] The aggregation by macro-categories includes the following statistical codes used in TARGET2 for payment types:

- Customer payments – type 1.1 (Customer payments)
- Interbank payments – types 1.2 (Interbank payments), 4.4 (technical transfers between different accounts of the same participant), and 4.5 (Commercial transfers between different accounts of the same participant)
- Ancillary systems payments – types 3.1 (Trade by trade settlement of SSS), 3.2 (Other settlement operations), 3.3 (EBA Euro1), 3.4 (CLS), 3.5 (EBA EURO1 Pre-Funding), and 4.3 (Intraday transfers with SSS)
- Central bank operations – types 2.1 (Cash operations), 2.2 (Intraday repo and similar transactions), 2.3 (Payments sent and/or received on behalf of customers), 2.4 (Inter NCB payments), and 2.5 (Other transactions)

The charts show that while interbank transactions represent over 60% of our data sample in value terms, in terms of volume almost the same percentage is composed of customer payments. It should be noted that these shares were relatively stable across the years, the only exception being the value of ancillary system transactions, which accounted for 18% of TARGET2 traffic in 2008 and 24% on average in the following years. The reason for this is that some ancillary systems migrated at a later stage to TARGET2.

Chart 5

Composition of unsettled payment by category in value

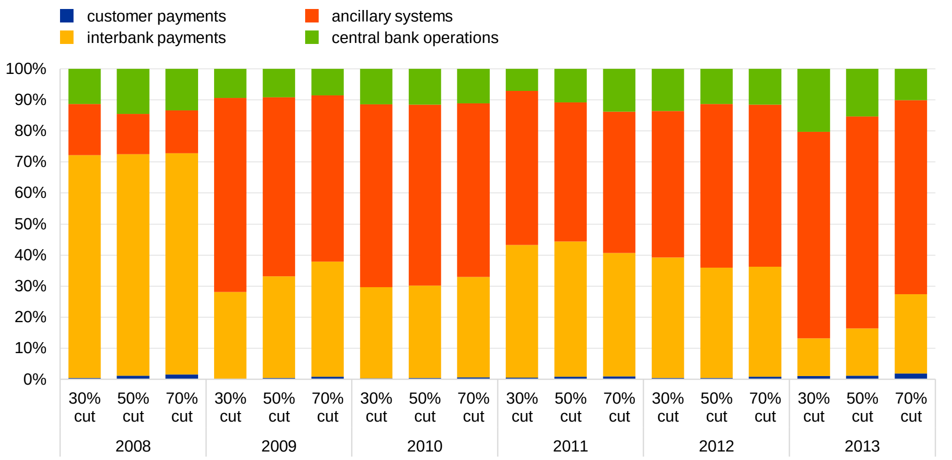


Chart 5 shows the average composition of unsettled payments[11] by category in value terms. In line with the TARGET2 traffic structure, the vast majority are represented by interbank and AS transactions, which account on average for 85 to 90% of unsettled value. This confirms the findings of the previous section that high value payments are the ones most impacted by the liquidity shocks, which are typically interbank and ancillary system transactions.

The share of unsettled ancillary system transactions is, however, out of proportion to the normal share in the TARGET2 value, representing on average more than 50% of unsettled payments from 2009 onwards.[12] This phenomenon was accentuated in 2013 due to a substantial decrease in the share of unsettled interbank payments. The reason for the high share of unsettled AS payments is the presence of the all-or-nothing settlement model that is used by some ancillary systems to settle some of their transactions.

In terms of variation across scenarios, it is difficult to identify a clear pattern. For example, while until 2010, and again in 2013, the relative share of interbank payments increases with the severity of the scenario, in 2011 and 2012 this trend seems to revert.

11 The results presented refer to the increase from the benchmark simulation as the outcome of the scenarios applied.

12 The picture for 2008 is different since, as mentioned above, the number of AS migrated to TARGET2 at that time was lower compared with the other years.

To better understand these trends, it is useful to look at the absolute value of unsettled transactions:

Chart 6

Value of unsettled payments by category

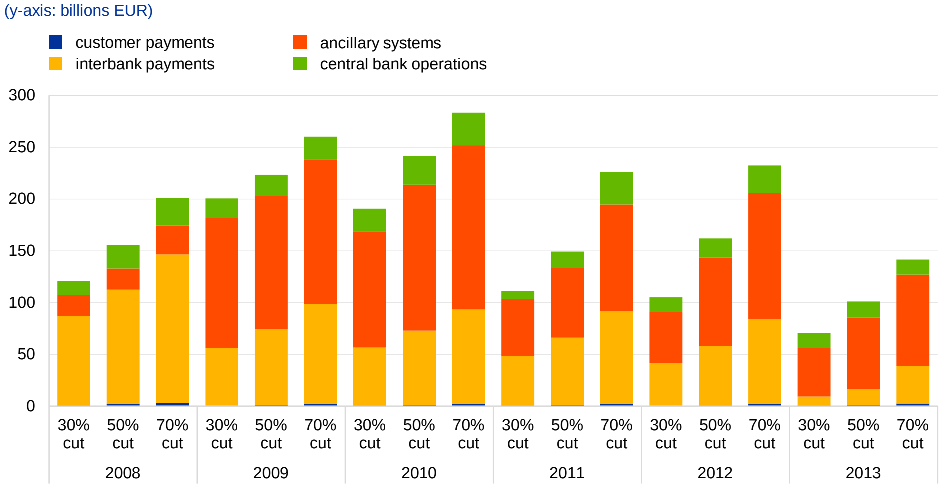
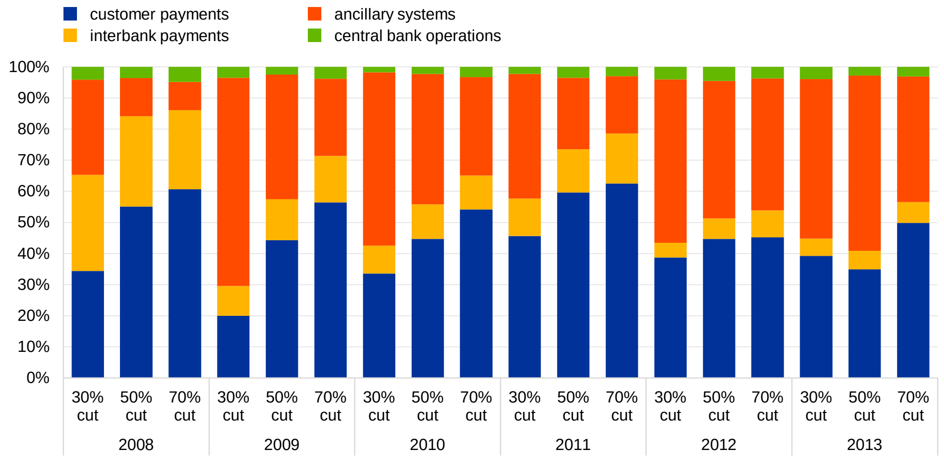


Chart 6 indicates that the value of unsettled payments is positively correlated with the severity of the scenario across all categories, and that some payment categories grow over-proportionately compared with others, leading to a decrease in the relative share of the other categories. In 2013, the value of unsettled payments is lower across all categories, and in particular for interbank payments, due to the higher level of liquidity made available by the aforementioned phasing out of the German PHA.

Chart 7

Composition of unsettled payments by category in volume

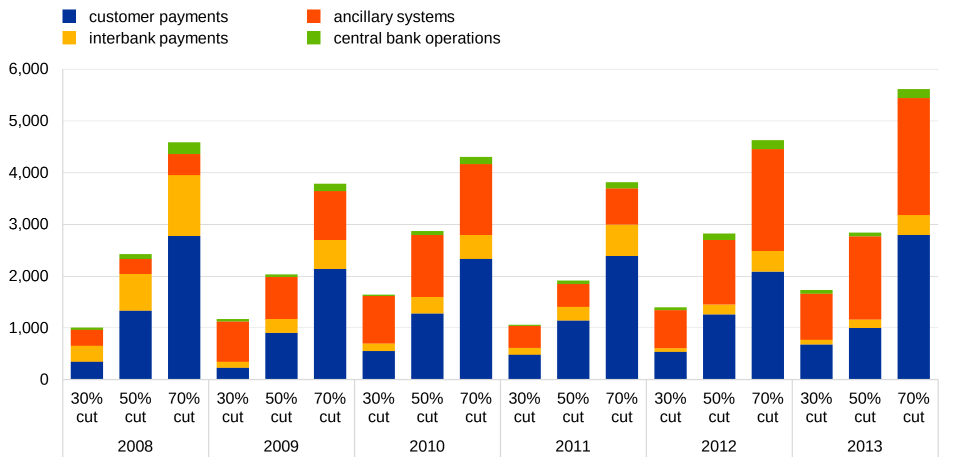


Turning to the volume of unsettled transactions by type, the picture revealed is a completely different one. Chart 7 shows that the category mainly impacted in terms of volume is customer payments, with a relative share that grows with the severity of the scenario and ranges from an average of 36% for the 30% clean cut to 55% on average for the 70% clean cut. Although this number seems quite high, the corresponding proportion for the unsettled value (as shown in Chart 5) is relatively limited, indicating that the value of the average unsettled customer payment is low. This outcome suggests that a number of participants on the receiving side do not receive the necessary liquidity to process a high number of low-value customer payments, which remain unsettled at the end of the day in the case of severe liquidity shocks. Chart 7 shows also that ancillary system payments are a strong component of the volume of unsettled transactions, however, with a relative share that decreases with the worsening of the scenario owing to the fact that the number of unsettled customer payments increases at a faster pace than that of unsettled ancillary system transactions. Furthermore, unsettled interbank payments are under-represented in volume terms relative to their share in the production system.

Finally, it is also worth mentioning that the improvement in the value settled for all categories recorded in 2013 does not materialise for the volume (Chart 8 below). On the contrary, the highest volume of unsettled transactions throughout our period is the 70% scenario in 2013, and it is mainly composed of customer and ancillary system payments.

Chart 8

Volume of unsettled payments by category



4.1.3 Institutions having unsettled payments

This indicator provides information on the number and type of participants experiencing unsettled payments as a result of the liquidity reduction due to the collateral devaluation, and on how the unsettled payments are distributed among them. The perspective taken is that of the sender. Part of the analysis is dedicated to TARGET2 critical participants.

It is worth mentioning that the indicator “number of affected institutions” must be interpreted not as an estimate of the number of defaults likely to occur after a collateral shock, but as evidence of how disordered settlement conditions spread across the TARGET2 system. Whenever an institution has at least one unsettled payment on a given day, it is considered “affected”. As explained before, there could be sending participants having unsettled payments which still maintain sufficient liquidity to settle all their outgoing obligations after the collateral devaluation: this is the case of participants involved in a failure of settlement cycles of ancillary systems operating on an all-or-nothing basis, where even a small and temporary liquidity shortage of only one participant with a debit balance may cause several senders to have unsettled payments themselves. Furthermore, it may also be the case that unsettled payments stem from temporary liquidity shortages which prevent some timed payments from being settled before the pre-set latest debit time elapses.

Chart 9

Number of participants having unsettled payments

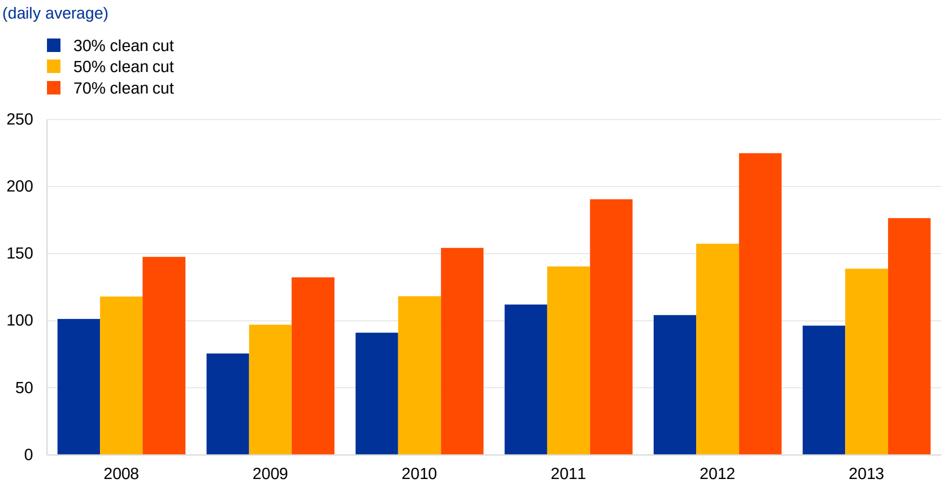


Chart 9 shows the daily average number of participants, including banks and ancillary systems, unable to send payments as a result of the liquidity shortage caused by a system-wide shock. The chart indicates that - as expected - the number of institutions affected by unsettled payments increases with the severity of the collateral deterioration. The difference between scenarios is less pronounced in 2008; such a finding is consistent with the Charts on the volume of unsettled payments, where some days had better results regardless of the collateral shock. From 2009 there is a steady increase in the number of participants having unsettled payments, with a significant reduction in 2013, which confirms that the assumptions on PHAs have been making the impact of shocks more severe. The steady increase in the number of affected participants between 2008 and 2012 is linked to the increase of participants in TARGET2: indeed, the share of affected participants with respect to total active participants is relatively stable from 2009 until 2012, with a daily average of 8-9% affected participants under the 30% shock scenario, 12% under the 50% shock and around 16% under the 70% shock scenario. In 2013, as already discussed, the share of affected participants with respect to total active participants dropped to 7%, 9% and 11% in the 30%, 50% and 70% scenarios, respectively. On average, ancillary systems represent 2.5% of the participants impacted by unsettled payments until 2011, with the value increasing to 5% in 2012 and bouncing back to 1.5% in 2013. Chart 9 shows that, on average, there are between 75 and 225 participants on a daily basis having at least one unsettled payment over the years and across the scenarios; on an annual basis, there are between 300 and 550 different participants with at least one unsettled payment across the scenarios (470 in 2013, which is the least noisy scenario). Considering that each year there are 20 to 25 simulated days, it is assumed that a certain number of participants are affected by the shock for several operational days.

Chart 10

Cumulative distribution of first 100 participants having unsettled payments

(average across years - value)

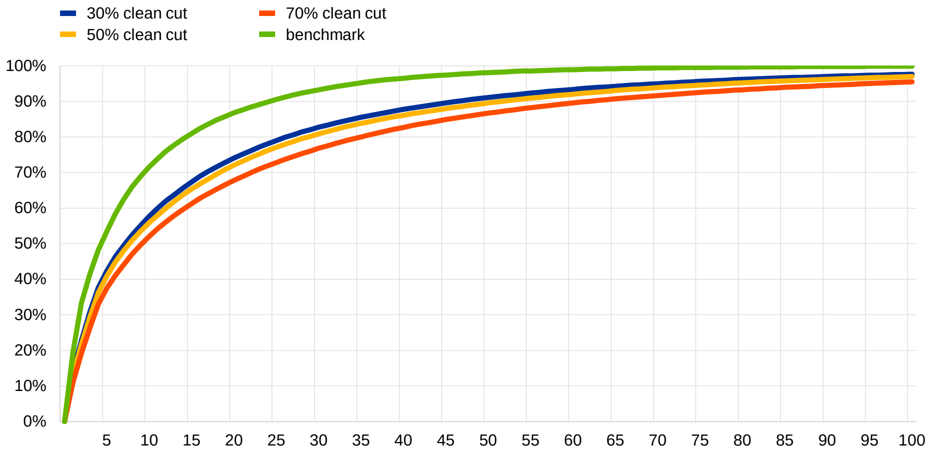


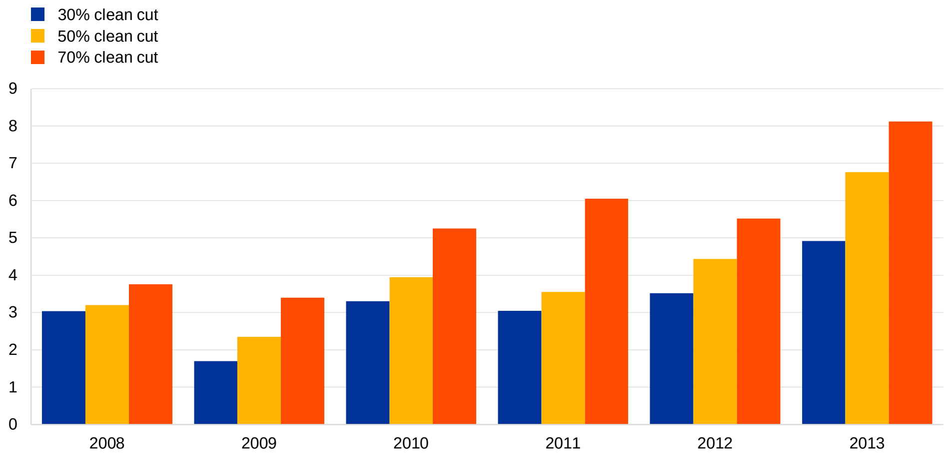
Chart 10 illustrates the average cumulative distribution of unsettled payments across years in terms of value, showing how the payments are concentrated among the "affected" participants. As the graph shows, the concentration is high as 15 participants account for almost 80% of the value of unsettled payments in the benchmark simulation and around 65% in the stressed scenarios. While indicating that with the liquidity deterioration a higher number of institutions is impacted, the graph indicates as well that a significant share of unsettled transactions is concentrated among a few participants. It is also noteworthy that, on average across years and scenarios, half of the participants affected by the shock register only one unsettled payment during the whole business day.

In line with the general picture, Chart 11 below shows that the average number of TARGET2 critical participants affected daily by unsettled payments increases with the severity of the collateral deterioration. On average, 3 or 4 critical participants, mostly the same institutions, have unsettled transactions every day over the years, with a notable exception being 2013, where the average number of affected critical participants increases to a maximum of 8 in the 70% cut scenario.

Chart 11

Critical participants having unsettled payments

(daily average)



Although the number of affected critical participants is not too high, their share of total unsettled transactions in volume and value terms can be quite significant. Critical participants account for around 15% of the value of unsettled transactions across all scenarios and years. Considering that all critical participants together generate more than 25% of the turnover in traffic (according to the definition of critical participant[13]), their share is under-represented in the total value of unsettled transactions. This finding is reassuring and suggests that most of those participants have sufficient liquidity buffers to partially shelter them from drops in liquidity levels. The share in the volume is more variable, ranging from around 5% to 30%, with around 10% in 2013, which represents the least noisy scenario due the phasing out of German PHA.

4.1.4 Payment queues and delays

This section defines and analyses the effects of stress on indicators related to payment queues and delays.[14]

The *average daily queued payment value* is defined as:

$$\frac{\sum_{i=1}^{n} totalQueuedValue_i}{n}$$

[13] Until 2014, the criterion to identify an institution as “critical participant” was: a) it should settle at least 2% in term of value of TARGET2 turnover; b) the accumulated market share of those credit institutions settling at least 2% of the value of transactions should reach at least 25% of the overall TARGET2 turnover in terms of value; c) There should be a noticeable difference (e.g. 0.1%) between the market share settled by the credit institution last-ranked as a critical participant and the top-ranked credit institution among the normal participants.

[14] See Kaliontzoglou, Mueller (2016).

Where:

- *totalQueuedValue*$_i$ is the total value of queued payments in day i
- n is the number of days within the maintenance period

The indicator for the *average queued payment volume* is defined as:

$$\frac{\sum_{i=1}^{n} totalQueuedNumber_i}{n}$$

Where:

- *totalQueuedNumber*$_i$ is the total number of queued payments in day i
- n is the number of days within the maintenance period

For both queue related indicators, all types of payments have been taken into account in their calculation. It should also be noted that the indicators consider all kinds of queued payments: those that get settled (after staying a certain time in the queue) and those that are queued but remain unsettled in the end.

The *payments delay indicator* is defined as:

$$\frac{\sum_{i=1}^{n} value_i(t_{2,i} - t_{1,i})}{\sum_{i=1}^{n} value_i(t_{3,i} - t_{1,i})} \in [0 \dots 1]$$

Where:

- $t_{1,i}$ is the time when payment i is available to be settled
- $t_{2,i}$ is the actual settlement time of the payment i (which should be equal to t_3 if the payment remains unsettled)
- $t_{3,i}$ is the end of day for the type of payment i
- value$_i$ is the value of payment i
- n is the total number of payments

The delay indicator expresses the time payments stay in the queue (if any) against the theoretical total time they could have stayed in the queue before they would become unsettled, weighted by the value of the payments. A value of zero means no delay and happens when the introduction time is the same as the settlement time ($t_{1,i} = t_{2,i}$), while a value of 1 indicates the maximum delay and happens when the payment is either settled at the end of day or remains unsettled (and therefore $t_{2,i} = t_{3,i}$). The output produced is a daily average; therefore, in the present methodology, another average for all days in the maintenance period is calculated.

Chart 12

Average daily queued payment value

(y-axis: Billions EUR)

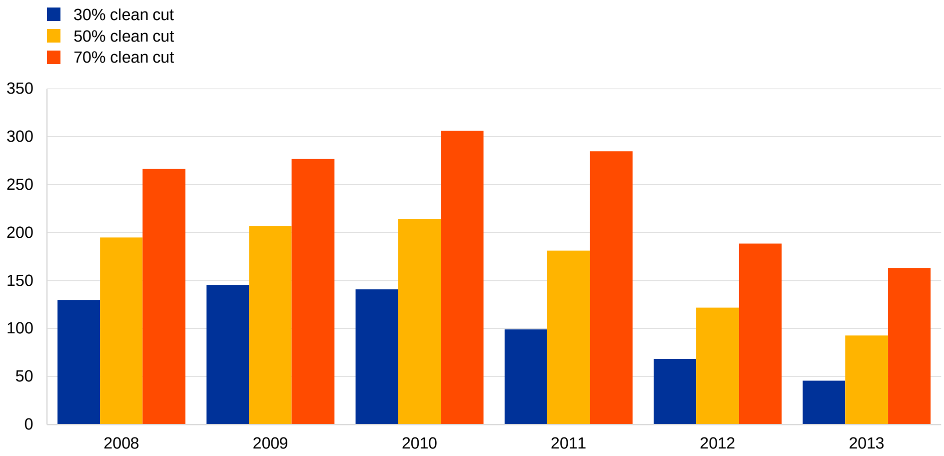


Chart 12 represents the difference of the value of queued payments between each stress scenario and the benchmark simulation.

The main observations for Chart 12 are the following:

- From 2010 onwards, there is a downward trend for the average queued value for the same level of stress.
- Across scenarios, the indicator values show a similar trend for all years, with the queued value progressively increasing as the stress increases, as one would expect. On a daily basis, the worst case corresponds to 13 October 2010 where, for the 70% cut scenario, there are an additional queued value of EUR 409 billion as a result of the stress for that particular day.
- Within a year and across scenarios, the increased value from each level of cut to the next ranges on average from 47 to 103 billion.

Overall, the average queued value as a percentage of the total value submitted to the system is significantly impacted by the collateral deterioration; for example, in 2010 it increases from around 22% in the benchmark simulation to around 36% in the 70% scenario.

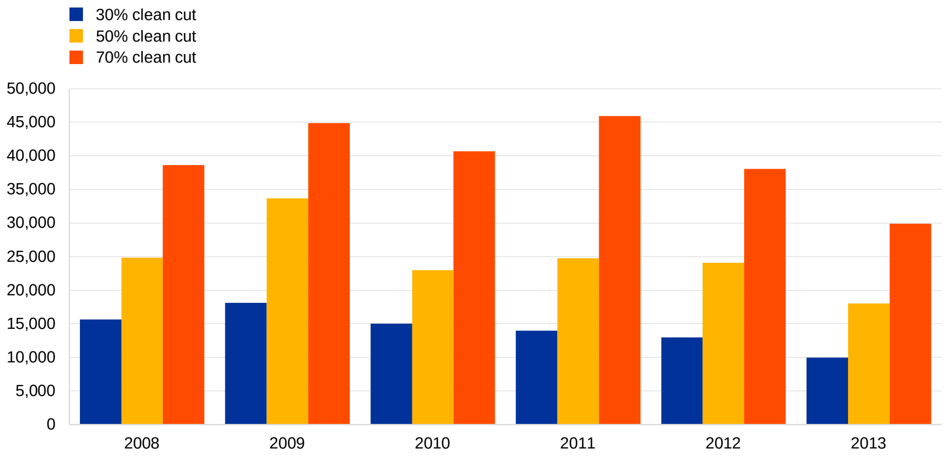
As already seen for the categories of unsettled payments, for the years 2009 to 2013 there is a high impact of the induced stress to ancillary systems, causing them to have an increased number of unsettled payments, which also implies more payments being queued. This is especially true for ancillary systems, where there is an “all-or-nothing” approach to settlement, and insufficient liquidity in the account of a single participant may cause the failure of a batch of payments in the simulation.

As with the queued value indicator, the following chart represents the difference in the number of queued payments between each stress scenario and the benchmark simulation.

Chart 13

Average daily queued payment volume

(y-axis: number of queued payments)



The main observations for Chart 13 are the following:

- As with the indicator of queued value, across scenarios the average queued volume progressively increases as the stress increases, for all years. In this case, on a daily basis, the worst case corresponds to 30 October 2009 where, for the 70% scenario, there are approximately 88,000 more queued payments as a result of the induced stress for that particular day;
- Within a year and across scenarios, the increased number of queued payments from each level of shock to the next ranges on average from 8,000 to 21,000.

The following analysis of payments delays is narrower: it focuses only on customer payments and interbank payments[15] given that they are considered more likely to remain in the queue due to insufficient liquidity. The end-of-day settlement time ($t_{3,i}$) depends on the sub-category of the payment according to the TARGET2 cut-off times: it is defined as "end-of-day trade phase 1" (currently 17.00) for customer payments and "end-of-day trade phase 2" (currently 18.00) for all other transactions.

[15] As defined in the statistical codes used in TARGET2 for payment types. The types used are 1.1 (customer payments) and 1.2 (interbank payments).

Chart 14

Payment delay indicator

(x-axis: simulated clean cut scenarios, i.e. including both marketable and non-marketable assets)

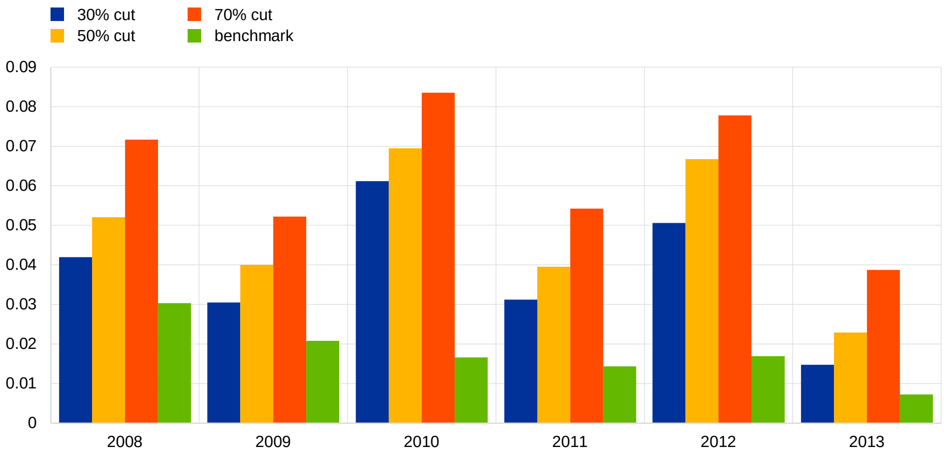


Chart 14 shows the output of the delay indicator across all years and all scenarios. The result shown is the absolute value and not the difference with respect to the benchmark. Based on a study of a delay indicator with real TARGET2 data, the delay indicator for actual TARGET2 payments (as a 22 days rolling average) is calculated to range between 0,012 and 0,03 for the years 2008-2014.

The following additional observations can also be made:

- Across the years it appears that the more severe the stress, the longer payments stay in the queue. In most cases, the indicator increases more sharply when going from no stress to the 30% cut and from the 50% to the 70% cut.
- Overall, 2010 exhibits the highest values for the delay indicator for all three types of stress simulation. 2010 also exhibits the greatest increase from the benchmark simulation in the 30% cut scenario, where the delay indicator increases by 269%.

A more in-depth analysis of the data indicates that the high 2010 values are influenced significantly by one participant with a few outgoing interbank transactions of high value (around EUR 11 billion on average). These payments constitute 1.87% of the total interbank and customer payments value of the whole system for the maintenance period. In the case of the worst stress scenario of a 70% cut, all these payments either stay significantly longer in the queues or fail to settle altogether by the end-of-day trade phase, effectively increasing that particular participant's delay indicator for outgoing payments from 0 at the benchmark (where all of those payments settle as soon as they are entered into the system) to 0.94. If that participant is excluded from the calculations, the overall TARGET2 indicator value drops from 0.083 to 0.053, which is closer to the other years. The exact same situation applies to 2012 as well, in which case excluding the same participant from the calculations decreases the indicator from 0.077 to 0.044. On the other hand, 2013 exhibits the lowest delay values. This may have been a side effect of the different way in which the German PHA payments are handled in 2013 in comparison with previous years, leading to higher overall liquidity available in the simulations.

4.1.5 Negative end-of-day balances

Next, we analyse how many participants exhibit a negative end-of-day balance in the simulated scenarios and in the benchmark scenario. In particular, the sum of the end-of-day negative balances is presented, which may provide some idea of the costs associated with it in the event of those participants having to request the use of Marginal Lending Facilities (MLF) or find liquidity in the market. Results are reported for all participants and, in addition, for TARGET2 critical participants only.

Chart 15

Average number of participants exhibiting a negative end-of-day balance

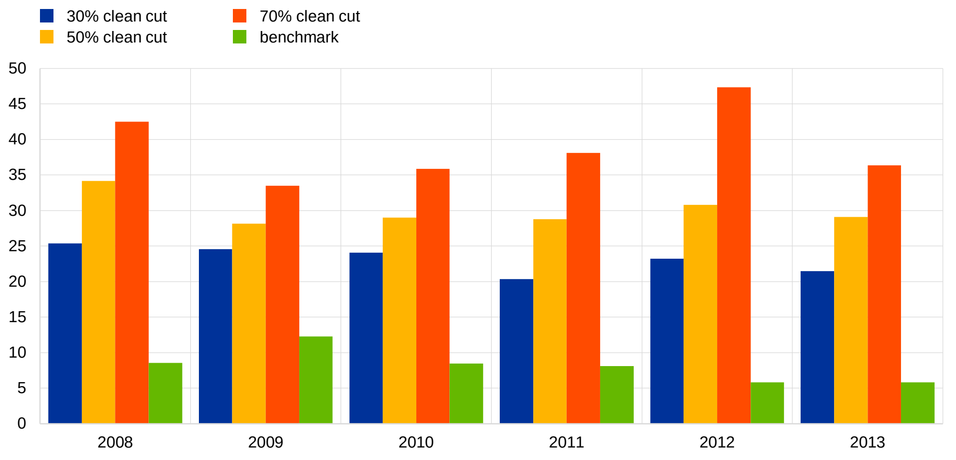


Chart 15 shows the daily average number of participants exhibiting a negative end-of-day balance. Like the other indicators, the results suggest that the number of affected participants increases with the severity of collateral deterioration. For example, while in the 30% cut scenario in 2012, 24 banks on average have a negative end-of-day balance, the 70% cut scenario leads to almost twice as many banks affected. Furthermore, the impact seems to be relatively stable across the years.

Chart 16

Average number of critical participants exhibiting a negative end-of-day balance

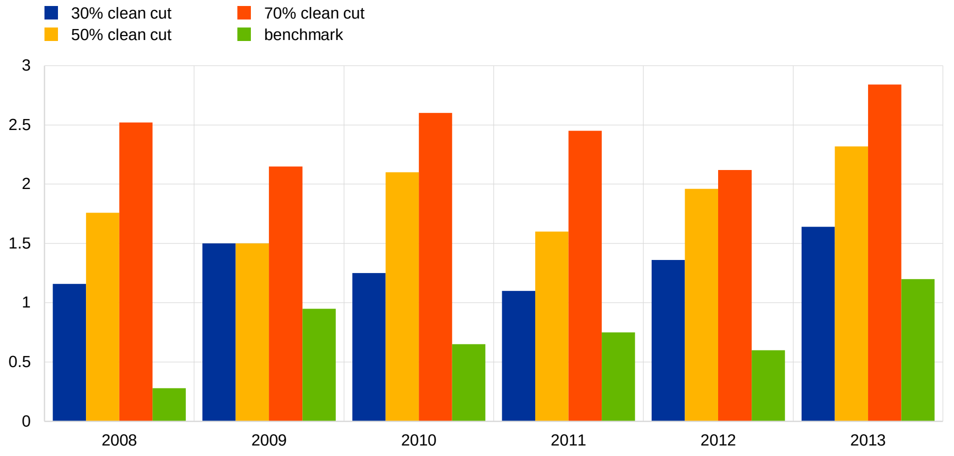
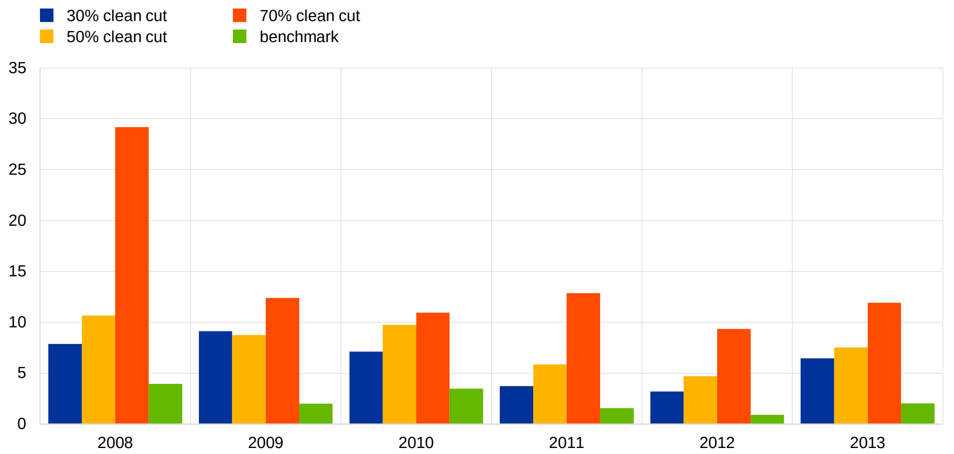


Chart 16 illustrates the average number of critical participants exhibiting a negative end-of-day balance. The general pattern is similar to the pattern for all participants. In the clean cut scenario in 2009, for example, the benchmark scenario leads on average to 0.95 critical participants with a negative end-of-day balance, while a collateral deterioration of 70% yields on average 2.15 affected critical participants (i.e. an average increase of 1.2 banks compared with the benchmark).

Chart 17

Average daily sum of negative end-of-day balances

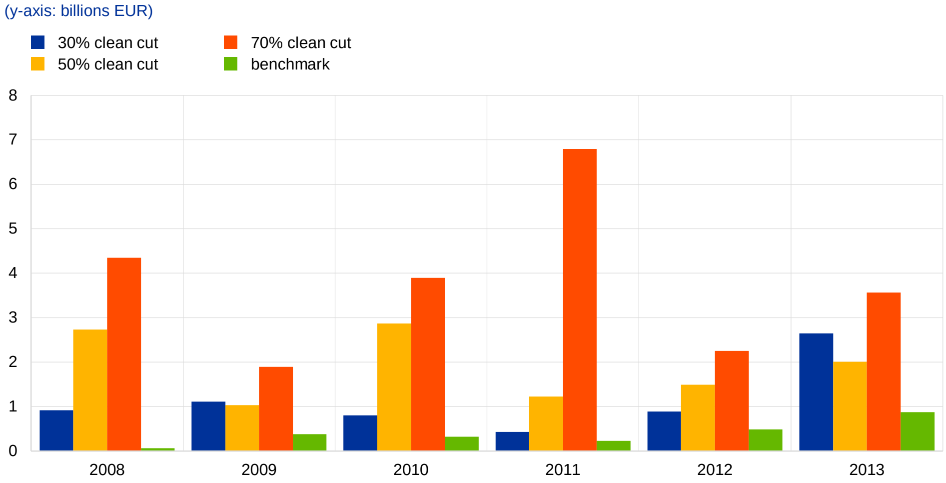
(y-axis: Billions EUR)



A breakdown by scenario of the average daily sum of the negative end-of-day balances is presented in Chart 17. It could be further translated into additional costs by multiplying the overnight MLF rate by the absolute value of the sum of the negative end-of-day balances. A striking result is that the sum of the negative end-of-day balances in 2008 for the 70% cut scenario is by far the highest. Additional effects compared with the benchmark simulation are especially pronounced for the 70% scenarios in 2008 and 2011.

Chart 18

Average daily sum of negative end-of-day balances of critical participants



Finally, the average daily sum of negative end-of-day balances of critical participants is depicted in Chart 18, which reveals that the relative impact is far more severe than that for all participants. While in the case of all participants, the increase in the sum compared with the benchmark is negligible, the collateral deterioration significantly impacts the liquidity usage of critical participants as this is much more significant. As for all participants, the years 2008 and 2011 yield the most severe effects; however, for the other years the relative impact is also quite intense. In 2012, for example, a collateral deterioration of 30%, 50%, or 70% leads to cost increases (vis-à-vis the benchmark case) of 60%, 89% and 106% respectively. Thus, in terms of additional requests for marginal lending, critical participants would be disproportionately more affected by the simulated collateral deterioration. Chart 16 shows that only around 1 to 2 critical participants per day exhibit a negative end-of-day balance on average. Thus, the sums presented in Chart 18 are concentrated among a few critical participants.

4.1.6 Collateral usage

The development of this indicator is intended to determine the volume and value of transactions that are settled by credit institutions with the use of collateral in situations of stress.

Technically, the set-up of the indicator is defined as the percentage of the number and value of transactions settled in TARGET2 where the account balance of the debited institution is lower than zero, i.e. it implies that the debited settlement bank, which is facing a lack of liquidity in its TARGET2 account, is making use of its collateral by using its credit line in TARGET2.

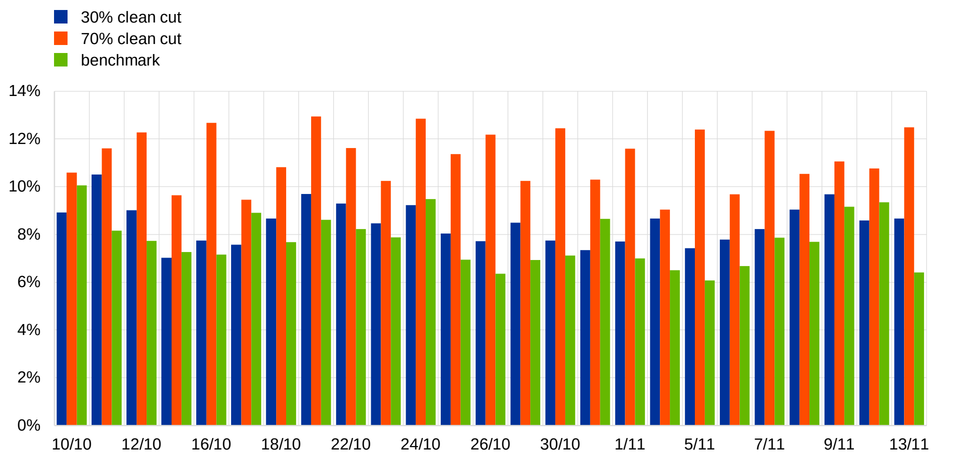
From the beginning, the results are a combination of two opposite effects. Namely, the higher the stress in the test situation:

- The lower the value of the available collateral and the fewer operations that can be settled with it. This would in turn lower the value of the indicator. Under the extreme circumstances of total deterioration of collateral, the indicator would take the value zero (by definition, no transactions can be settled through collateralisation).
- The lower the value of the liquidity available to other participants due to the fall in incoming payments which would come from their counterparties, and therefore the higher the probability that a credit institution would not be able to make its payments with its regular liquidity. As a consequence, those participants would use collateral more intensively to cover the transactions. This would, conversely, increase the value of the indicator.

The final result depends on the strength of the two opposite effects above and could lead to non-linear results. In the system-wide shock, the 2nd effect is predominant: meaning that the settlement of operations via collateralisation is more likely to happen in the stress test situations, even though collateral is scarcer. Chart 19 and Chart 20 illustrate the effects on value and volume for the scenarios in 2012.

Chart 19

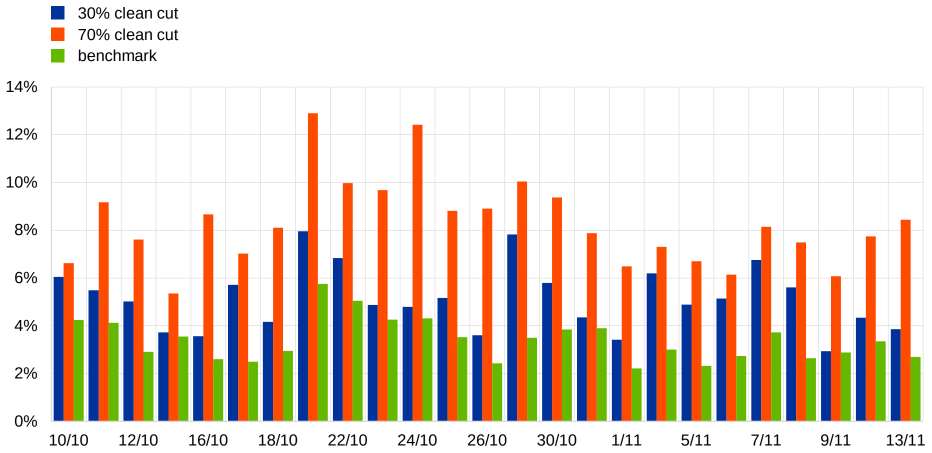
Percentage of value of operations settled with collateral in 2012 scenarios



The x-axis shows the value of payments settled using collateral for the days of the observed maintenance period in 2012 distinguishing an undisturbed simulation from the simulations of collateral price shocks of 30% and 70% respectively.

Chart 20

Percentage of volume of operations settled with collateral in 2012 scenarios



The x-axis shows the volume of payments settled using collateral for the days of the observed maintenance period in 2012 distinguishing an undisturbed simulation from the simulations of collateral price shocks of 30% and 70% respectively.

4.2 Robustness check with country scenarios

As a first robustness check, the simulations for the scenarios only affecting marketable assets confirm the results presented above, as they show throughout milder expected results in terms of the six output indicators.

As a second robustness check, in addition to the system-wide shock affecting all euro-denominated securities across the board, country-specific scenarios are simulated in order to analyse the effects of a more asymmetric shock. For the scenario creation, all eligible collateral issued by entities resident in a country (including sovereign debt) is assumed to be affected. The intraday credit line of all counterparties which hold such collateral is adjusted accordingly.

In the scenario creation, the stressed country has to be entered as a new variable in the simulation setup. This increases the number of separate independent scenarios which need to be prepared and analysed. The analysis focuses on data from two years: 2012 and 2013. Additionally, only the issuer countries accounting for the nine largest shares of the collateral posted within the Eurosystem are analysed.

Two types of scenarios are created for the country-wide shock simulations: *plain cut* and *adjusted cut* scenarios. In the plain cut scenario, only the marketable component of the collateral issued in the stressed country is affected, whereas in the adjusted cut scenario the non-marketable assets are also impacted. This means, for example, that an adjusted cut scenario with a focus on country X implies: (i) a deterioration of all collateral issued in country X and posted at the Eurosystem, independently of where these institutions are located and (ii) a cut of all non-marketable assets held in country X, i.e. it is assumed that non-marketable assets are entirely domestic. Thus, since the adjusted cut scenarios also take account of non-marketable assets, the results are more severe when compared with plain cut scenarios. Two levels of severity are considered for the country shock scenarios: total loss of value of collateral issued in a country (cut of 100%) and loss of 50% of the value of collateral. The choice of 50% is motivated by the fact that it allows direct comparability with the system-wide scenario of 50%.

Altogether, 72 scenario simulations[16] are performed for the country shock.

Since, in general, the impact of a country-wide scenario is milder than the impact of a system-wide scenario, the comforting results are confirmed and the effects shown by the indicators are generally lower and therefore not further reported in this paper. This also holds true for the 100% shock scenario where, despite its limited scope compared with the system wide scenario, the shock to the value is smaller than in the most severe system-wide scenario with a 70% cut.

The distribution of collateral by issuer country adds an important dimension to the analysis. Since domestic banks predominantly hold domestic collateral, the impact of the shock is higher on domestic banks and it increases with the degree of concentration on domestic securities. However, the main result of the country-specific analysis is again that the system is resilient under stress and liquidity levels seem to be appropriate.

[16] This refers to all combinations of 2 years, 2 levels of severity, 2 types of scenario and 9 countries, which translates into 1850 successful single day simulations.

5 Conclusion

TARGET2 stress-testing of liquidity risk shows that under the stress scenario, the resilience of TARGET2 is strong and liquidity levels seem to be appropriate and supported by the efficient liquidity management features of TARGET2. Even very severe liquidity shocks caused by the most extreme collateral deteriorations lead to rather mild results.

The analysis is based on six different output indicators and it can be concluded that, overall, the more severe the scenario, the higher the negative implications in terms of unsettled transactions, affected banks, payment delays or negative end-of-day balances – almost in a linear manner. Only few single days lead to very severe effects, and then only for the most extreme scenarios. Less intense scenarios (e.g. a 30% collateral deterioration) generally lead to a milder impact, even though the magnitude of such a shock can already be considered extreme. Not even during the past financial crisis were general drops in asset prices of about 30% from one day to the other observed. Moreover, it is worth noting that, also taking into account the potential availability of other eligible unencumbered assets not pledged at the Eurosystem, the high resilience revealed by TARGET2 in the worst simulated scenarios delivers an even more reassuring message. Nevertheless, it should be borne in mind that such scenarios would also lead to other counterparties calling for margins and additional collateral.

Across the years and scenarios analysed, even in the worst case events, 80-90% of TARGET2 turnover would have been settled. For the system-wide shock, the average daily value of unsettled transactions ranges from EUR 143 billion (30% clean cut) to EUR 238 billion (70% clean cut). This represents 6.3% to 10.6% of the TARGET2 turnover. In terms of volume, the impacts are even lower. The medians mostly remain below 0.5% for the 30% cut scenario and 1.5% for the 70% shock scenario. However, this hints at the fact that a system-wide shock would hit large-value payments in particular. The more severe the scenario, the lower the average size of the impacted payments.

When looking at the composition of the unsettled payments, the stress tests show that interbank and ancillary systems are impacted in particular, and account on average for over 85% of the total unsettled value. The most affected category is ancillary system payments representing 40-60% of unsettled payments. This observation also holds true for the country scenarios. Mitigating measures that the ancillary systems or banks may have at their disposal (such as the re-submission of files or the activation of additional collateral) are not considered in the stress tests, suggesting that the results in reality may be even milder. Likewise, consideration has not been given to whether the scenario would have impacts on banks or ancillary systems through channels other than TARGET2, for instance through refinancing operations or increased margin requirements. In terms of the number of payments, customer payment account on average for 36% for the 30% clean cut to 55% on average for the 70% clean cut of the unsettled transactions.

In terms of impact distribution, the number of participants having unsettled payments increases with the severity of collateral deterioration. This also implies that some of the TARGET2 critical participants would be affected increasingly with the severity of the deterioration scenario and over the years. Furthermore, the analysis shows that the cumulative distribution of unsettled values is very concentrated among a few players, whose number increases marginally with the scenarios.

The analysis also shows that payment queues could serve as a real-time indicator of liquidity problems, though caution is required as queues are to a certain extent a built-in feature of TARGET2 and can also result from the use of the liquidity management features. The delay indicator developed increases proportionately with the severity of the scenario, but overall it remains at a relatively low level. On average, the value of queued payments reaches its maximum in 2010 and decreases steadily in the subsequent years. In the worst-case scenario (13 October 2010), a total value of EUR 409 billion is additionally queued intraday.

The number of participants affected with a negative end-of-day balance increases with the severity of the collateral deterioration. The same applies for the sum of all negative end-of-day balances.

The indicator of the degree of collateral usage gives important insights into both the usage of overdrafts to settle payments in general and the impact of liquidity shocks on the usage of credit lines. In the undisturbed benchmark simulation of 2013, around 19% of all payments in value terms are settled making use of intraday credit. This hints at high levels of liquidity in the system in general. Consequently, the effect of a deterioration of these credit lines as done in the stress testing scenarios is linked to a certain extent to the degree of collateral usage in making payments.

As a final remark, the time span studied was characterised in part by unconventional monetary policy, which promptly reacted to the exceptional sequence of financial crises impacting the European financial system. These policies led to the injection of a large amount of central bank money into TARGET2. This factor has two important implications. Firstly, the results have to be viewed in the light of the amount of liquidity in the payment system. Secondly, the results indicate that those policies contributed to the resilience of TARGET2 participants to liquidity risk, which shows a remarkable soundness under the stress scenarios..

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Abbreviations

ABM	Agent Based Modelling
ACH	Automated Clearing House
AS	Ancillary System
FMI	Financial Market Infrastructure
MLF	Marginal Lending Facility
NCB	National Central Bank
PFMI	CPMI-IOSCO Principles for Financial Market Infrastructures
PHA	Proprietary Home Account
RTGS	Real-Time Gross Settlement
SIPS	Systemically Important Payment System
SIPS R	Systemically Important Payment System Regulation
TARGET	Trans-European Automated Real-time Gross Settlement Express Transfer System

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