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SUDDEN STOP OF CAPITAL FLOWS AND THE CONSEQUENCES FOR THE BANKING SECTOR AND THE REAL ECONOMY

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In 2013 all ECB publications feature a motif taken from the €5 banknote.

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The paper is released in order to make the research of MaRs generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the ones of the author(s) and do not necessarily reflect those of the ECB or of the ESCB.

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Abstract

The paper develops a macro-prudential liquidity stress-testing tool in order to capture the possible consequences of a capital outflow (including a run of deposits). The tool includes a feedback from the banking sector to the real economy, incorporates a link between liquidity risk and solvency risk, and is tailored for emerging market features. The stress-testing tool aims to: (i) test the capacity of the banking sector to withstand the sudden stop of capital flows, and to gauge the consequences of the liquidity stress to the solvency ratio; (ii) quantify the liquidity deficit that a central bank should accommodate; (iii) assess the impact on credit supply when the sudden stop occurs; and (iv) support the implementation of an orderly disintermediation process. The macro-prudential tool is applied on the Romanian banking sector.

Keywords: banks; systemic liquidity; stress-testing; emerging markets; macro-prudential tool;

JEL Classification: G21, F32

Contents

Non-technical summary

From a financial stability perspective, costs incurred by movements in capital flows may sometime outweigh the benefits. In order to grasp the possible consequences for the banking sector and the real economy in the event of a sudden stop of capital flows, we develop a macro-prudential liquidity stress test. Compared with the similar works provided in the literature, our approach also includes the following features: (i) puts greater emphasis on the macro-prudential pattern of the systemic liquidity shocks, by taking into account a liquidity shock affecting both the banking sector and the real economy, and by capturing the feedback effects between these sectors; and (ii) the methodology is tailored to better deal with specific issues in the banking sectors of European emerging economies.

The stress-testing tool aims to: (i) test the capacity of the banking sector to withstand sudden stops of capital flows, and to gauge the consequences of the liquidity stress to the solvency ratio; (ii) quantify the liquidity deficit that a central bank should accommodate (for both total and FX positions); (iii) assess the impact on credit supply when the sudden stop occurs; and (iv) evaluate some of the policy options.

The model uses micro data and a balance sheet approach for three sectors: banks, non-financial companies and households. The stressed scenarios consider foreign capital outflows affecting banks and non-financial companies, and a run of domestic households and companies deposits. The market characteristics for which the instrument is tailored are: low elasticity of liquidity supply from outside the financial sector, low development of local funding markets, and low marketability of banks assets.

The macro-prudential liquidity stress test consists of the following steps: (i) calculating banks positions after the initial liquidity shock; (ii) assessing banks response actions through lending activity (i.e. delivering a second-round effect of liquidity shock to the economy); (iii) computing the non-financial companies liquidity position and their response to banks decisions; (iv) quantifying the demand for money (by major currencies) and the deficit of liquidity a central bank might accommodate; and (v) computing the consequences on banks solvency. Due to the high dependence of the emerging economies on the foreign flows, the stress test is run for all major currencies within the banking sector.

If the macro-prudential tool signals that some banks would still register liquidity deficits after the usual solutions are exhausted (i.e. using the excess reserves with the central bank, obtaining liquidity against eligible collateral, not rolling over the credit lines, etc.), new instruments and policy measures should be implemented in order to cover the deficits. There are two types of policy options: (i) ex-ante solutions, targeted to the banks that could face difficulties in meeting liquidity obligations in times of stress; and (ii) ex-post conventional and unconventional solutions.

The paper has an empirical section in which we employ the macro-prudential tool for Romania. The main results suggest that the liquidity injections by the central bank and the additional FX demand on the FX market could be significant, the impact of the liquidity shock on the solvency ratios is rather limited in the short term, the supply of credit to the economy could be affected to a moderate to high degree, and the importance for the domestic economy of the companies that would not be able to pay their external creditors range from low to moderate.

1 Introduction

Small and open economies, such as those from emerging Europe, are sensitive to volume, direction and yield of capital flows, and the policy-makers from such countries should adjust their decisions to take into account the mobility of the foreign capital flows (Popa, 2011). The recent financial crisis has shown that, from a financial stability perspective, the costs delivered by capital flows may sometimes outweigh the benefits. Capital flows, besides the gains for the economy and for the financial system, behave in a pro-cyclical and volatile manner, can amplify credit boom-bust cycles, and the sudden stop of flows[1] could put systemic pressure on the financial system liquidity.

The literature identifies several types of triggers of a liquidity shock: (i) a pure liquidity shock the withdrawals are based on depositors expectations of other depositors behaviour (Diamond and Dybvig, 1983); (ii) a solvency triggered shock the depositors try to distinguish between good and bad banks in the context of asymmetric information(Allen and Gale, 1998); (iii) a funding structure shock the distribution of leverage in the financial sector and the position in the business cycles are crucial in determining the severity of crises (Acharya and Viswanathan, 2010). Understanding the correct causes of liquidity shock, though the manifestation might be similar, helps to design the right measures from the policy-maker′s point of view, as Barnhill and Schumacher (2011) also note. The central bank′s function as LOLR may be efficient in the event of a pure liquidity shock, but may be less efficient in the event of a solvency-triggered liquidity crisis. Khan and Wagner (2012) show that the characteristics of the liquidity supply (elasticity, the relative cost of raising additional liquidity) plays an important role in banks behaviour in both pre and post-crisis periods, a factor which should be taken into account when designing policy measures. The literature for evaluating the banking sector′s ability to cope with systemic liquidity shocks has gained ground over the past few years. Van den End (2012) simulates banks responses to different exogenous shocks using a macro stress-testing model. The banks liquidity position is constructed using a Liquidity Coverage Ratio approach. The results show that Basel III liquidity requirements tend to limit tail risk, by inciting banks to switch to a higher quality asset structure. Anand et al. (2011) analyses systemic risk using a network approach with three agent types: domestic banks, international finance institutions and companies. The resilience of the financial sector is measured by investigating the interconnectedness of these three agent types, the effect of asset fire sales externalities and the impact on lending to the real sector. Schmieder et al. (2012) present a new framework for system-wide balance sheet-based liquidity stress tests. The framework includes three modules assessing different aspects of liquidity risk: bank runs, maturity transformation and roll-over risks, and links arising from liquidity to solvency risk.

The liquidity stress-testing tool described in our paper was developed within the central bank of Romania[2]. It stands out from the other stress-test methodologies described in the literature, by introducing the following additional features:

(i) we place more emphasis on the macro-prudential pattern of the systemic liquidity shocks, by taking into account a liquidity shock affecting both the banking sector and the real economy, and capturing the feedback effects between these sectors. A top-down approach with micro data is put in place.

(ii) we tailor the methodology to better deal with specific issues of the banking sectors of the emerging economies. In this respect, three avenues are pursued:

(iia) greater focus on capital flights, given that such developments could incur greater risks for emerging economies as compared with developed economies. In emerging Europe, there is a

[1]For the purposes of this paper, the terms capital flight and sudden stop will be used interchangeably.

[2]The instrument was initially designed in late 2007 with the purpose of testing the resilience of the banking sector to a foreign funding shock.

high dependency on foreign funding for both the banking sector and the non-financial companies sector. The share of foreign liabilities in the total financing of banks in central and eastern European countries is around 20-25%, while the share of foreign banks assets in the overall banking sector is usually over 60%[3]. The share of external private sector debt in GDP ranges from 27% (in Poland) to over 70% (in Bulgaria)[4]. A significant part of such financing is from the parent entity, however the crisis has shown that these sources are also subject to roll-over risk. Off-balance sheet FX swap positions are also included, as they constitute material sources of liquidity in different currencies (usually, the parent institution largely supports its subsidiaries in the process of currency transformation).

(iib) we focus only on the funding liquidity channel (i.e. inability to rollover funds or to borrow additional funding without significantly increasing the cost and/or collateral requirements), instead of the market liquidity channel (i.e. the difficulty of selling assets without a substantial price discount), as emerging the European banking sector holds a lower amount of marketable securities and domestic capital markets are less developed compared to advanced economies. The emerging European banking sector′s holdings of equities vary between 0.5% of total assets (Bulgaria and Romania) to 1.6% of total assets (Czech Republic).

(iic) we incorporate the link from liquidity to solvency risk through loss and cost channels. Designing transmission channels from liquidity to solvency is constrained by certain conditions in the domestic banking sector. The lack of a fixed income market, as well as the low number of banks with ratings, puts a restraint on the funding channel to deposits and also the funding received from the central bank[5].

The stress-testing tool we describe aims to: (i) test the capacity of the banking sector to withstand sudden stops of capital flows and to gauge the consequences of the liquidity stress to the solvency ratio; (ii) quantify the liquidity deficit a central bank should accommodate (for both total and FX positions); (iii) assess the impact on the credit supply (new credit and rolling-over credit lines) when the sudden stop occurs; and (iv) evaluate the policy options.

The paper is structured as follows: the following section describes the methodology and the assumptions used, Section 3 examines the data set, Section 4 presents some of the results with a numerical example and Section 5 concludes.

2 Methodology

The model uses a balance sheet approach with three sectors: banks, non-financial companies and households. In order to test the impact of a sudden stop of capital flows, we consider different scenarios of: (i) foreign capital outflows affecting banks (including not rolling over the FX swap transactions) and companies; and (ii) some run of domestic households and companies deposits[6]. Therefore, the initial liquidity shock (first-round effects) consists of trimming (i) banks external liabilities, off-balance sheet exposures (FX swap transactions) and domestic deposits; and (ii) companies financing sources from abroad. The second shock is triggered by the banks incurring liquidity deficits. These entities would then reduce their credit activity and/or would not roll over

[3]According to ECB data; please see the ECB′s website.

[4]Based on SDDS reporting; please see the World Bank′s website on the QEDS indicator.

[5]For a different approach, see Schmieder et al. (2012). The authors use market-intensive information to infer the impact of liquidity on solvency through funding costs. Their approach assumes the existence of a direct or implied bank rating. Also, the importance of market funding in banks balance sheets is material and generates additional channels of risk (such as the potential impact of market concentration).

[6]We do not model the link between the two types of shocks under review: sudden stop of capital flows and a run of deposits.

credit lines, generating feedback effects from the real sector in order to accommodate these new constraints. If debtors are not able to fully service their debts, a further liquidity shock is sent to the banking sector, along with pressure on the solvency ratio[7]. Both first and second-round effects of the liquidity shocks are added up and different policy measures are evaluated.

The liquidity stress test consists of the following steps: (i) calculating banks liquidity positions after the initial liquidity shock; (ii) assessing banks response actions through lending activity (i.e. delivering a second-round effect of the liquidity shock to the economy); (iii) computing the non-financial companies liquidity position and their response to banks decisions; (iv) quantifying the demand for money (by major currencies) and the liquidity deficit a central bank might accommodate; and (v) computing the consequences for banks solvency.

The stress-test exercise can be conducted for different time horizons, however, the one-month horizon is better suited for our needs[8], constrained also by data availability. The shocks are calculated separately by currency (domestic and FX), and aggregated across currencies[9].

In the first step, each bank liquidity position at time t (λ_t^i) is computed as:

$$\Lambda_t^i = \sum_q A_{q,t}^i (1 - H_q) + \sum_p CFI_{p,t}^i - \sum_m CFO_{m,t}^i \tag{1}$$

where: $i = \overline{1, N}$ banks, A_q represents the stock of liquid assets and H_q the haircuts applied (Table 1 details the liquid assets that were used in the model, along with the corresponding haircuts); CFI_p represents the cash flows received by the bank from its outstanding loan repayments, and CFO_m reflects the cash outflows from new lending or due to the run of domestic deposits and parent funding withdrawals, according to the scenario under review (the initial liquidity shock).

The cash inflows/outflows are computed for customer driven flows only (deposit and credit activity). For the purpose of comparison, the items covered in the model represent around 77% of total assets (positions without central bank exposures) and around 80% of total liabilities, average values calculated on aggregate balance sheet data for the Romanian banks.

The cash inflows are derived from payments received from credits granted to companies and households. For credit lines, the initial assumption is that they are automatically rolled over. The cash inflows for each bank are computed as follows:

$$\sum_j (1 - PD_{j,t} * LGD) * DS_{j,t}^i \tag{2}$$

[7]Appendix A presents the liquidity stress-test effects on a simplified balance sheet structure for banks and non-financial companies.

[8]For three-month and higher horizons, the impact of the post-shock macroeconomic indicators (economic growth, interest rate and foreign exchange rate) must be also considered. In this latter case, new channels should be envisaged: (i) the quality of banks credit portfolios could deteriorate at a faster pace, leading to lower inflows for credit activity; and (ii) the effort in local currency of due FX liabilities could be higher in the most likely context of local currency depreciation. In addition, higher risk aversion on the part of banks would trigger a higher liquidity threshold buffer, leading to higher deleveraging consequences.

[9]The total result is not a simple sum of the currency positions, as additional effects are taken into account: if a bank registers a liquidity deficit, that bank would stop granting new loans in any currency. Also, the bank would enter the forex market to transform the liquidity from one currency (in which it has additional resources) to another currency (in which the liability is denominated). This additional demand for foreign currency would be added to total new demand on the FX swap market.

where $j = \overline{1, M}$ companies from bank's portfolio, $i = \overline{1, N}$ loans granted to company j, LGD=1[10], $PD_{j,t}$ is the default probability for the company j[11] and DS_j^i is the credit annuity of the company j for each of its loans i (the debt service for exposures with more than 90 days past due has not been included).

Table 1: The assumptions for liquid assets used are:

Assets (A_q)[12]	Haircuts (H_q)	Observations
Excess reserves held with the central bank	0%	calculated as total reserves with the central bank minus minimum required reserves[13]
Eligible securities for central bank refinancing operations	5% and 8%	5% for domestic-denominated securities and 8% for FX-denominated securities
External assets (deposits)	variable	The percentage of external deposits placed with the parent institution, part of a compensation agreement or a notification special clause
Net money market exposure	100%	There is no new borrowing between banks; the interbank markets collapses due to lack of trust between participants; all the operations will take place only with the central bank[14]

To quantify the new credit activity, we assume that banks will display two types of behaviour, based on their funding structure relative to their credit portfolio: (i) banks with a lower than average loan-to-deposit ratio (LTD) would supply new credit in a similar amount as that of the previous 12 months (no change in the business model); (ii) banks with a higher than average loan-to-deposit ratio would only lend to keep their current stock of credit unchanged (banks are no longer active in the credit market but they are maintaining their status quo). The change in banks stock of credit is described by:

$$\begin{cases} avg_{t-12<\theta\leq t}(dL_{i,\theta}), & LTD_{i,t} \leq \overline{LTD_t} \\ 0, & LTD_{i,t} > \overline{LTD_t} \end{cases} \tag{3}$$

where $i = \overline{1, N}$ banks, LTD_i is the loan-to-deposit ratio for bank i, $\overline{LTD_t}$ is the average loan-to-deposit ratio for the banking sector at time t, L is the outstanding loan portfolio, dL is the amount of new credit granted, t is the current month for which the stress test is run.

The shock of parent funding withdrawals and run of deposits (S) is calculated as:

$$S = \alpha(1 - r_{MRR}) \tag{4}$$

where: α represents the percentage that is withdrawn, r_{MRR} is the rate of minimum required reserves.

[10]We use this value for LGD, because banks would, most likely, not be able to recover the collateral over the horizon for which the test is conducted (i.e. one month), unless the collateral is highly liquid (for example bank deposits).

[11]We used the methodology from Costeiu and Neagu (2013) to calculate the default probability for each company.

In the second step, the total new credit is adjusted for the liquidity needs of the banking sector. If a bank cannot obtain sufficient resources to cover its liquidity needs resulting from the withdrawals of deposits and external funds[15], it would decide to restrain from lending.

In the third step, we assess the response of non-financial companies to banks decisions. The non-financial companies finance themselves from abroad (from foreign financial institutions and parent entities) and from domestic banks (where an important part of borrowing is for treasury purposes, under the form of revolving credit lines). The empirical literature on credit lines shows that during crises, companies typically use large parts of the undrawn amounts in order to obtain additional liquidity, putting more constraints on the financial institutions.[16]

When a company has to deal with a simultaneous shock from abroad and the domestic financial market, we consider the foreign creditor would be paid first[17]. A company that is required to pay back the credit lines would also experience a deterioration in the ability to service the debt vis-á-vis other creditors, if there are insufficient liquid assets on its balance sheet to deal with the initial shock.

A company faces the following liquidity constraint:

$$\lambda_{j,t} \geq 0 \tag{5}$$

where: $j = \overline{1, M}$ non-financial companies, and

$$\begin{aligned} \lambda_{j,t} = &\quad Deposits_{j,t} + OCF_{j,t} - STED_{j,t} \\ OCF_{j,t} = &\quad NetProfit_{j,t} + Amo_{j,t} - NI_{j,t} + dP_{j,t} + \\ &\quad STD_{j,t} - dCA_{j,t} + dIA_{j,t} \end{aligned} \tag{6}$$

Deposits are inferred from the company′s balance sheet position, OCF[18] is the operational cash flows, STED represents the short-term external debt that is not rolled over by foreign creditors, d stands for change in stock, Amo is amortisation, NI is non-cash income arising from the re-evaluation of real estate assets, P reflects provisions, STD represents short-term debt other than from banks, CA stands for current assets and IA for income in advance.

The way a bank chooses which companies are not going to be rolled over is difficult to assess. One option is to select the companies with a lower PD, on the assumption that such companies would be able to service the debt and provide liquidity for the relevant bank. The main drawback of such an option is that the bank thereby reduces its market share of good clients. The other

[15]Some banks could decide to reduce their credit activity, even if they succeed in covering the liquidity needs, owing to uncertainties regarding the future (banks are more precautionary, they are more risk averse). In order to capture this effect, the model should incorporate a threshold, higher than zero, of the liquidity position (Λ). A similar approach can be found in van den End (2012). The value of this threshold will depend on banks risk tolerance. During crisis periods, we expect to see an increase in this threshold, as banks tend to exhibit greater risk aversion, thus increasing the effect of the liquidity shock on the credit supply (this feature is not implemented in our model).

[16]During the recent international financial crisis, the Romanian banks reduced the volume of credit lines and the number of companies to which they granted loans, while companies reduced their volumes of credit drawn from such credit lines agreements (Table 1 in Appendix D).

[17]Domestic companies from emerging Europe increased their funding from abroad significantly to borrow in FX, owing to better lending conditions provided by the foreign banks (lower interest rates, larger exposures available, etc.). If a negative development were to occur, it is more probable that domestic firms would pay the external creditor first, in order not to cut off this channel of funding which has better lending conditions.

[18]We computed companies operational cash flows on a similar basis to that recommended by the IFRS.

option is to sacrifice the companies with a higher PD, however the risk there is that for those entities that are unable to service their debt, a higher increase in provisions would be applied, and therefore the liquidity problem would remain unresolved. In order to determine the scale on which a company is able to repay its debt, we compute the bilateral exposure matrix using a maximum entropy algorithm based on (Mistrulli, 2007). The results of the bilateral exposures are compiled as follows:

$$\min_{x} ln \frac{x_{j,i}}{x^0_{j,i}} \tag{7}$$

with the following restrictions:

$$\begin{cases} \sum_j x_{j,i} = min(|\Lambda_i|, \sum_j CL_{j,i}) & i = \overline{1,N} \quad banks\ with\ \Lambda_i < 0 \\ \sum_i x_{j,i} = min(\lambda_j, \sum_j CL_{j,i}) & j = \overline{1,M} \quad companies \\ x_{j,i} > 0 \end{cases} \tag{8}$$

where: $\langle x_{j,i} \rangle$, $j = \overline{1,M}$ and $i = \overline{1,N}$, is the matrix of banks/companies cross-exposures, CL represents credit lines, λ is the companies liquidity position, and $X^0 = \{x^0_{j,i}, j = \overline{1,M}, i = \overline{1,N}\}$ is the initial matrix, used as a reference.

There are two arguments underpinning the use of the maximum entropy algorithm. First, as already mentioned, there is no clear-cut assumption as to which companies will not be rolled over and how these companies will react. We can assume that the maximum entropy principle applies, in the sense that banks will request an amount proportional to the granted credit lines and companies will pay back in proportion to the received credit lines. Second, different assumptions regarding the feedback between banks and companies do not change the results significantly, because the second-round effect of the shock is much less important compared with the first-round effect.

The total amount of reimbursed credit lines is added to the banks liquidity position, while the requested but unpaid amounts are recorded as losses. The non-financial companies that are more than 90 days past due on their payments are not included, even if the credit line matures (as the probability of servicing the debt is low). In these cases, banks usually try to mitigate the loss by implementing different temporary solutions (credit restructuring, bridge loans, etc.).

In step four, we evaluate the demand for money (both in domestic and foreign currency) and the liquidity deficit that a central bank should accommodate. Owing to the high dependence of the emerging economies on foreign flows, the stress test is run for all the major currencies. Banks demand for FX currency is constrained by their available resources in local currency and is triggered by either of the following: (i) the bank has a liquidity surplus in local currency, but has a deficit in foreign currency. Moreover, if the bank does not have sufficient resources in local currency to cover the need in foreign currency, it will decide to reduce the credit activity in local currency in a similar manner as if it had a deficit in local currency; (ii) the parent bank decides not to roll over total or part of the outstanding FX swap transactions that mature within the following month (the stress-test horizon).

In step five, we compute the impact on the solvency position of the banks. The liquidity shock is transmitted to solvency position through two channels:

- credit risk channel: (i) the bank′s decision not to roll over maturing credit lines will affect the debtor′s ability to meet its payment obligations (the loss is computed as the difference between

the due amount of credit and the liquidity position of non-financial companies); and (ii) new unfavourable macroeconomic fundamentals (FX rate, interest rate, etc.) will shift upwards the probability of default in the corporate sector;

- funding cost channel: the loss resulted by summing: (i) the cost of new domestic currency funding from the central bank credit facility and/or open market operations; (ii) the cost of euro-denominated funding (such as FX swap operations).

3 Data

We use micro data for banks and non-financial companies positions. This approach has the advantage of: (i) capturing the asymmetries that exist both in the banking sector and the real economy in terms of liquidity positions and shock developments; (ii) tailoring specific scenarios (e.g. according to the country or area of the origin of the shock); and (iii) limiting model uncertainty. The main drawback of this approach is the material resources of information that need to be plugged into the model. That is the price to pay in order to capture the consequences of such shocks on the real sector and the feedback effects within the banking sector. A reduced stress-test exercise can be implemented by: (i) skipping some modules (such as the feedback on companies responses to banks decisions); or (ii) simulating the cross-exposure matrix using the Mohammad-Djafari (1991) maximum entropy approach (which does not demand an initial matrix of cross exposures, but relies on the assumptions of the probability distribution of cross exposures, similar to the methodology used by Anand et al. (2011)). For the banks, multiple databases are used: required minimum reserves for each observation period; central securities depositories to assess the eligible collateral for central bank refinancing; balance sheet information for credit institutions; and external funding (residual maturity). For the non-financial companies and households, credit information is obtained from the Central Credit Bureau. For companies credit lines, we use treasury loans as a proxy. Databases on the companies balance sheets, profit and loss statements, and long and short-term external debt positions are also used.[19]

4 Results

4.1 Scenarios tested

We run the stress-testing tool on the Romanian economy and consider two potential general scenarios (the shocks for each scenario are applied to all banks and are considered to occur simultaneously):

(i) domestic deposits run-off of 10%, short-term (i.e. up to one year) parent funding withdrawals of 25%, short-term external debt for non-financial companies that is not rolled over by 25%, banks FX swap position maturing within one month and not rolled over by 25%;

(ii) domestic deposits run-off of 20%, short-term (i.e. up to one year) parent funding withdrawals of 50%, short-term external debt for non-financial companies that is not rolled over by 50%, banks FX swap position maturing within one month and not rolled over by 50%.

The form of the shocks is motivated by the international[20] and domestic[21] episodes of liquidity drain. The design of the tool also allows us to test specific events when constructing a certain

[19] For an overview of the databases used, see Appendix B.

[20] A brief overview of the empirical literature findings and of the best practices in liquidity stress tests regarding deposit run-offs is presented in Appendix C.

[21] Between 2007 and 2011, the Romanian banks recorded net deposit withdrawals of between 1.2% and 15.3%

scenario. Establishing the exact value and the combination of shocks to be modelled in the stress-test exercise is a difficult task, particularly given the limitations of the data (liquidity shocks are low frequency and highly heterogeneous events). The stress-testing tool is also useful in supporting the implementation of an orderly disintermediation process, in that it can analyse the implications of banks decisions when a shock occurs. Most likely, this process would take place where there is a decline in foreign financing from the parent institution; while the domestic deposits would not be negatively affected (therefore, the scenarios should be tailored in this respect). The liquidity is asymmetrically allotted across banks, and this pattern persists even after the shock. Because the money market is frozen in times of stress, there would be no lending from banks with excess liquidity to banks with a deficit. The gap should be covered by the central bank, if an adequate amount of eligible collateral is in place.

4.2 Results

The main results of the stress-testing tool are: (i) the liquidity injections by the central bank can be significant, and the additional FX demand on the FX market can be significant; (ii) the impact of the liquidity shock on the solvency ratios is rather limited (based on the loss resulting over a one-month horizon after the liquidity shock), however, banks tend to be highly dependent on central bank liquidity for several months, with a greater potential impact on banks profitability (and capital) the ensuing period, especially if the interest rate rises in order to accommodate a capital outflow; (iii) the supply of credit to the economy can be affected to a moderate or high degree, even in the context of significant liquidity injections by the central bank; and (iv) some companies may not be able to pay their external creditors; the importance of these companies for the domestic economy range from low to moderate (depending on the specific stress scenario).[22]

4.3 Policy options

The shock is manageable at the aggregate level in both scenarios, but with some burden. The liquidity deficit is relatively low in the first scenario and moderate in the second[23] (Figure 1). New instruments and policy measures should be implemented in order to cover the deficits.

There are two options:

(i) ex-ante solutions, targeted to the banks that could face difficulties in meeting liquidity obligations in times of stress (e.g. early call for additional capital, improvement in loan-to-deposit ratio, increase of the outstanding amount of eligible collateral in bank′s portfolio, etc.). The magnitude of these solutions is based upon the results derived from the stress-testing tool.

(ii) ex-post solutions can be divided into two groups: conventional measures (e.g. broadening the eligible collateral, decreasing the required reserves ratio, etc.) and unconventional measures (e.g. a macro-prudential authority acting as an intermediary for an orderly asset sale of the bank with a liquidity deficit to a bank with sufficient liquidity). The main disadvantage of the

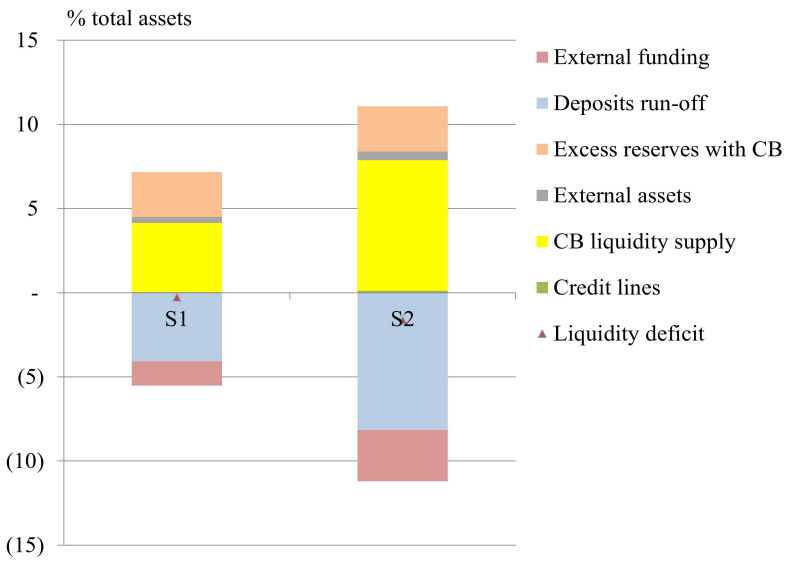
at the 25th percentile, and between 7.6% and 64.8% at the 5th percentile, depending on the counterparty and the currency (see Table 1 in Appendix C).

[22]The companies with external deficits contribute to the gross value added created by the total non-financial companies between 4% and 10%.

[23]Although the second scenario entails shocks double in size compared to those used in the first scenario, the impact on the banking sector liquidity position is not twice the magnitude, owing to various non-linear features, such as asymmetries within the banking sector (some banks might be using the entire excess reserves in both scenarios, while others might take recourse to this resource only partially or totally in the second scenario).

Another non-linear effect is that a deficit in one currency (such as the euro) can trigger a complete discontinuation of new lending for the other currencies as well.

Figure 1: The results of the stress-testing scenarios (change in total banking sector assets)



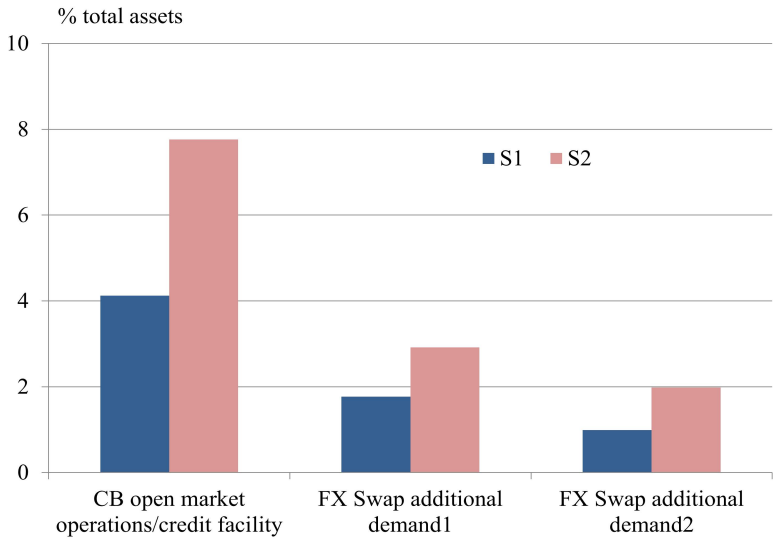
conventional measures is that it provides liquidity to the entire banking sector and is therefore not targeted to the entities most in need. Also, past experience and current simulations show that, in many cases, the effect on the banks with deficits is rather marginal. The above-mentioned unconventional measure proved to be the most efficient in our simulations, but its implementation requires some prerequisites (e.g. detailed information about banks credit portfolios, exploratory discussions with the liquid banks before the deal, if required, etc.).

It is important to run the stress test also by currency (domestic and FX) when assessing the liquidity deficit. If banks do not feel comfortable accessing the forex market owing to disequilibrium between FX demand and supply during a liquidity shortage, the overall liquidity deficit could increase considerably. Central bank interventions to provide FX swaps could be a solution, and the central bank could engage in FX swaps with other central banks in order to raise adequate liquidity buffers in foreign currencies. Moreover, in order to cope with panics during deposit runs, central banks should have adequate fiat money in their vaults, in both domestic and FX currencies.

Figure 2 displays the amounts the central bank needs to inject into the banking sector and the additional FX demand from banks resulting from the currency mismatch positions. The open market and/or credit facility amounts are determined based on banks eligible securities. Eligible securities that are currently in repo transactions (encumbered assets) are not included. The amounts injected by the central bank are significant in the second scenario, and banks largely participate in these transactions.[24] The additional demand for FX is also significant and many banks enter the FX market as buyers. Banks demand for FX is heterogeneous, as parent banks involvement in currency transformation is mixed.

[24]The assumption is that banks try to follow their business strategy, or at least retain their credit market share by using all other methods to obtain additional liquidity. Banks decide to reduce their business activity only if all other solutions prove to be insufficient.

Figure 2: Central bank interventions and banks demand for foreign currency (change in total banking sector assets)



Note: FX swap additional demand1 refers to the banks need for FX as a result of surplus liquidity in the domestic currency and a liquidity deficit in FX. FX swap additional demand2 results from the parent banks withdrawals from the FX market (the amount of withdrawals depends on the stress-test scenarios).

Depending on the scenario, the consequences of a capital outflow on lending activity range from moderate to negative material effects (Figure 3).

In the first scenario, the credit growth dynamics is nearly two-thirds of the credit growth in the no-shock scenario.[25] In the second scenario, the credit dynamics enter into negative territory. The decrease in credit is highly concentrated (three banks contribute to over 80%). If access to central bank funding (in exchange for eligible collateral) and to the forex market are adversely affected, the negative outcomes displayed above will increase accordingly.

5 Conclusions

Liquidity stress-test tools are useful instruments for macro-prudential purposes in order to assess how the overall banking sector can withstand such shocks and how these adverse developments are transmitted between the real economy and the banking sector. However, predicting the outcome of a severe capital outflow remains a challenge, owing to the different trigger events, multiple transmission channels, and the feedback responses. Capital outflows and liquidity crises can develop very quickly. That is why sound macro-prudential policies should be in place and operational. The macro-prudential tool presented here is constructed on the basis of micro data, using a balance sheet approach. It considers foreign capital outflows affecting both banks and firms, together with a run of domestic households and firms deposits. The tool aims to: (i) test the capacity of the banking sector to withstand sudden stops of capital flows and to gauge the

[25]For the baseline (non-shock scenario), we use the assumption that banks will continue to lend according to their funding position, as presented in Section 2 in which we discuss the new credit activity.

Figure 3: The impact of the liquidity shock on the new lending activity (change in outstanding loans)

consequences of the liquidity stress to the solvency ratio; (ii) quantify the liquidity deficit that a central bank should accommodate (for both total and FX positions); (iii) assess the impact on credit supply when the sudden stop occurs; and (iv) evaluate some of the policy options.

There are two types of policy measures for managing possible capital outflows. The ex-ante solutions (e.g. early call for additional capital, improvement in loan-to-deposit ratio, increase of the outstanding amount of eligible collateral in the bank′s portfolio) are able to target only those banks in need, and the implementation thereof should be performed in such a way so that the credit conditions can develop in an orderly manner. As regards the ex-post solutions, on the basis of our simulations, the most efficient solutions seems to be those that are unconventional (e.g. the macro-prudential authority acting as an intermediary for an orderly asset sale of the bank with the liquidity deficit to a bank with sufficient liquidity), however, there are some prerequisites for this. In both types of policy measures, the cooperation between the central bank and the supervisory authority is essential.

We test the macro-prudential stress-testing tool on the Romanian economy. The main results suggest that the stressed scenarios are manageable, but with some burden. The liquidity injections by the central bank and the additional FX demand on the FX market could be significant, the impact of the liquidity shock on the solvency ratios is rather limited for a one-month horizon, the supply of credit to the economy could be affected to a moderate to high degree, and the importance for the domestic economy of the companies that would not be able to pay their external creditors range from low to moderate.

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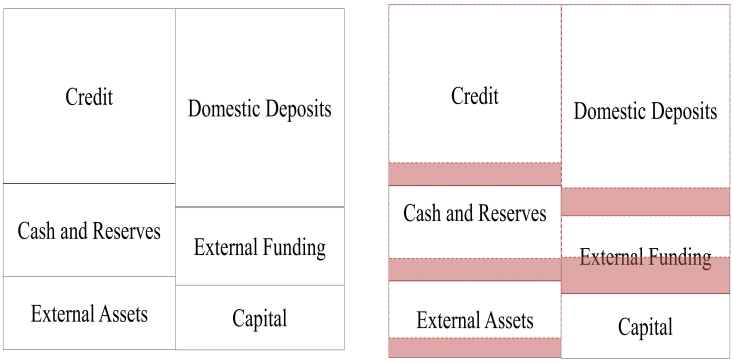
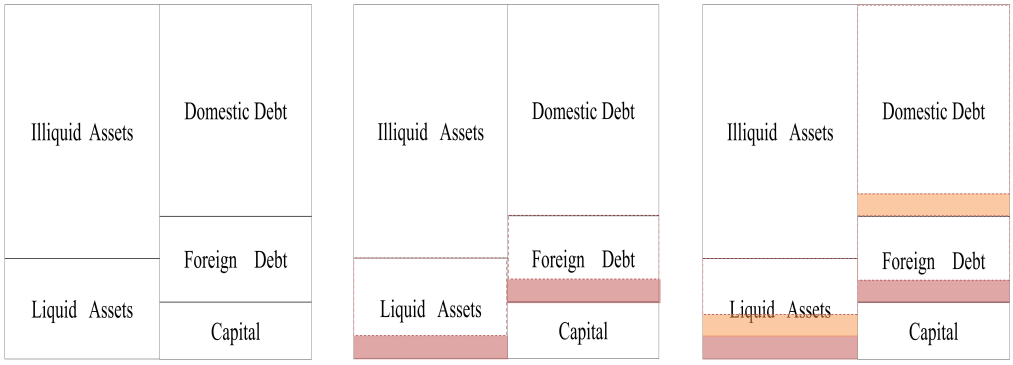
A Appendix - Stress-test impact on simplified balance sheet positions

Figure 1: Banks stress-test impact on balance sheet positions



Note: The areas marked in red reflect a decrease in the balance sheet item bordered by the dotted line after the liquidity shock.

Figure 2: Non-financial companies stress-test impact on balance sheet positions



Note: The areas marked in red (orange) designate a decrease in the balance sheet item bordered by the dotted line after the first (second) liquidity shock.

B Appendix - Data statistics and sources used in the paper

Table 1: The main data sources used in the paper (the cut-off date used is December 2011)

Data	Source	Description
a. Banks		
Minimum required reserves for each observation period	National Bank of Romania	All the banks; monthly frequency
Eligible collateral for refinancing operations	National Bank of Romania	Daily information on eligible securities registered with SaFir
Balance sheet information - foreign liabilities and assets - interbank exposures - account with the central bank - deposits of main counterparties	National Bank of Romania	All the banks; monthly frequency
External funding (residual maturity)	National Bank of Romania	Monthly data; bank-by-bank information
b. Households		
Bank credits above RON 20,000 (around EUR 5,000)	Central Credit Register	Monthly data; credit-by-credit exposures
Bank credits	Credit Bureau	Quarterly data; credit-by-credit information; database available since September 2008
c. Companies		
Financial statements	Ministry of Public Finance	All companies; semi-annual
Bank credits over RON 20,000 (around EUR 5,000)	Central Credit Register	Individual credit database
Long-term external debt - outstanding long-term external debt, scheduled inflows and outflows for each credit line	National Bank of Romania	All companies; quarterly data
Short-term external debt	National Bank of Romania	Short-term debt transactions are reported by banks as inflows and outflows

Source: Central Credit Register.

Table 2: Banks included in the stress-test exercise

	Number	Assets (% in banking system)
Banks, out of which:	37	99 %
Romanian legal entities, out of which:	30	92 %
with a majority of domestic capital	6	16 %
with a majority of foreign capital	24	75 %
Foreign branches	7	8 %

Table 3: Statistics on the balance sheet structure of the Romanian banking sector; period 2007-11; monthly values

	Mean	Median	Standard Deviation	25^{th} percentile	75^{th} percentile
Assets					
Reserves with the central bank	17.6	16.6	7.4	12.0	22.1
Eligible securities	7.5	4.3	9.7	0.6	10.8
External assets	2.5	1.1	3.6	0.4	3.1
Credit to non-financial companies	33.4	33.0	13.9	24.5	42.3
Credit to households	22.4	23.0	12.8	11.6	29.8
Liabilities					
Deposits of non-financial companies	16.6	14.2	10.9	8.9	22.7
Deposits of households	22.2	18.0	16.6	9.1	31.8
Deposits of other financial institutions	3.8	2.7	3.6	1.5	4.9
External funding	27.5	25.6	20.5	10.3	41.1

Table 4: Statistics on banks credit lines drawn by the non-financial companies; period 2007-11; monthly values

	2007-11				
	Mean	Median	Standard Deviation	25^{th} percentile	75^{th} percentile
Credit lines drawn by non-financial companies (% total outstanding loans of the non-financial companies)	50.3	49.5	21.4	34.8	61.2
Credit lines maturing in one month drawn by non-financial companies (% total credit lines drawn by non-financial companies), out of which:	9.7	8.2	7.7	4.6	12.7
- denominated in local currency (% total credit lines granted to non-financial companies maturing in one month)	54.5	53.3	30.6	29.4	81.7
- denominated in euro (% total credit lines granted to non-financial companies maturing in one month)	36.3	35.5	27.9	9.4	57.7
- denominated in other foreign currencies (% total credit lines granted to non-financial companies maturing in one month)	7.7	1.1	15.5	0	8
Number of non-financial companies with credit lines (% total number of non-financial companies with credit)	63	67	19.7	55.9	85.2
Number of non-financial companies with credit lines maturing in one month (% total number of non-financial companies with credit), out of which:	10.2	9.3	6.6	6.4	20.2
- denominated in local currency (% total non-financial companies with credit lines maturing in one month)	74.1	80.6	23.3	59.8	100
- denominated in euro (% total non-financial companies with credit lines maturing in one month)	23.2	18.8	20.3	5.8	57.5
- denominated in other foreign currencies (% total non-financial companies with credit lines maturing in one month)	4.8	1.2	11.7	0	25

C Appendix - Statistics on Romanian bank deposits

Table 1: Romanian bank deposits - monthly changes for individual banks; by counterparties and currencies; 2007-11

		Mean	Median	Standard Deviation	5^{th} percentile	25^{th} percentile
Non-financial companies	local currency	2.7	1.0	22.4	-17.2	-5.1
	euro	4.8	-0.2	36.2	-27.3	-7.6
	other foreign currencies	28.4	-0.8	715.9	-44.0	-15.3
Households	local currency	2.5	1.3	11.5	-7.6	-1.2
	euro	9	1.1	276.7	-7.6	-1.6
	other foreign currencies	6.3	-0.3	189.0	-13.1	-3.8
Domestic financial institutions	local currency	13.7	0.3	151.1	-35.2	-9.3
	euro	89.7	0.0	1357.1	-61.0	-14.6
	other foreign currencies	73.4	0.3	1031.1	-64.8	-15.3
Foreign financial institutions	local currency	23.5	0.3	249.5	-33.1	-3.1
	euro	12.8	0.4	121.3	-31.7	-3.9
	other foreign currencies	47.4	0.1	673.0	-56.4	-8.3

Source: National Bank of Romania.

The stress-test scenarios were chosen looking both at the Romanian bank deposits changes during the crisis, as well as at the international experiences and best practices. The Basel III framework (BCBS, 2013) introduces a liquidity monitoring tool (Liquidity Coverage Ratio), whereby a shock of 3% or higher for stable retail deposits, and of 10% or higher for less stable retail deposits, is recommended. Comparable results are found in a survey conducted by the European Central Bank (ECB, 2008) on 84 European banks from 25 countries. The majority of banks responses indicate that a 10% shock applied to retail deposits should be envisaged (with a few banks suggesting a 30% shock), while for interbank and other investors flows, the results are dispersed between 0% and 100%. Laeven and Valencia (2008) monitor 42 systemic banking crises from 37 countries over the period 1970-2007 and conclude that in over 62% of cases, a significant decrease in banks deposits was experienced. According to their findings, the average maximum one-month drop in the ratio of deposits to GDP is over 10%, and the largest value is over 25%.

D Appendix - Statistics on the dynamics of Romanian banks credit lines granted to non-financial companies

Table 1: Credit lines granted to and drawn by non-financial companies over the period 2007-11*

	Period 2007-11				2009/2007		2009/2008		2009/2010		2009/2011	
	Mean	Median	5%	25%	t-stat	p-value	t-stat	p-value	t-stat	p-value	t-stat	p-value
Credit lines - volumes drawn by non-financial companies (monthly changes in individual banks)	2.0	0.9	-7.3	-1.5	-3.8	0.0	-3.4	0.0	-0.1	0.4	-0.3	0.4
Credit lines - volumes granted to non-financial companies (monthly changes in individual banks)	1.8	0.7	-6.9	-1.3	-3.7	0.0	-3.9	0.0	0.0	0.5	-0.2	0.4
Number of non-financial companies with credit lines (monthly changes in individual banks)	1.5	0.0	-4.7	-1.7	-1.6	0.05	-6.5	0.0	-0.2	0.4	-1.2	0.1

* We test if the mean of the monthly change in volume of credit lines and number of companies with credit lines differs between 2009 (a year with high financial stress) and 2007, 2008, 2010 and 2011, respectively (the tests are displayed in the last eight columns of Table 1). The null hypothesis is that the mean of the monthly changes in the volume of credit lines or number of companies with credit lines is the same in 2009 compared to the other years, against the alternative hypothesis that the mean values are smaller in 2009. The results point to the conclusion that the null hypothesis is rejected when comparing 2007 and 2008 with 2009, but not when comparing 2010 and 2011 with 2009. However, the tests do not take into account the demand factors that are most probably reflected in the results for 2009, 2010 and 2011. Italic values indicate null hypothesis of equal means and is rejected at 5% significance.

Source: National Bank of Romania.