Bank Stress-Testing Lessons from Central, Eastern and Southeastern European Countries

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Summary:

This study examines the international experience of stress-testing. The sample covers stress-test practices of central banks from Central, Eastern and Southeastern European (CESEE) countries. The review is based on publicly available information, mainly from Financial Stability Reports (FSRs) in the period of their origination and up to June 2014. Having the benefit of diversity in "best stress-test practices", applied lessons are formulated on the main components of a supervisory macroprudential stress-test: preparation, execution, and publication. The first part of the process includes definition of stress-test coverage, selection of approach, and identification of risks. In the second, scenarios are designed and a methodology for quantifying shocks is created. Finally, the last phase comprises setting up a communication strategy and publication of stress test results.

Key words: Bank stress-testing, International application, CESEE region

JEL Classification: E44, E47, E50, G21

1. Introduction

art of stress-testing banks he has been around for some time. However, it was not until the global financial crisis 2007/8 that the intensity of its use increased, as well as its relevance for media and public coverage. Both the US and the EU bank regulator started conducting regular stress-tests for solvency assessments. First they were used as crisis management instruments, but then stress-tests became part of the toolkit for macroprudential supervision. Accordingly, as a response to the global financial crisis the Board of Governors of the Federal Reserve System (FED) ran in 2009 the Supervisory Capital Assessment Program for American banks and since 2011 the FED carries out an annual Comprehensive Capital Analysis and Review/Dodd-Franc Act stress-test¹. In Europe, the European Banking Authority (EBA) initiated EU-wide stress-test in 2009, 2010, 2011, and 2014². In addition, macroprudential stress-testing was established as a mandatory practice via legislation. Section 165(i) of the Dodd-Franc Act of 2010 requires the FED to run annual stress-tests. A few years later, the practice of stress-testing became part of the mandate of corresponding competent

² See https://www.eba.europa.eu/risk-analysis-and-data/eu-wide-stress-testing.

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¹ For more information - http://www.federalreserve.gov/bankinforeg/stress-tests-capital-planning.htm.

authorities (mostly central banks) in Europe with the implementation of Directive 2013/36/EU of the European Parliament and of the Council (CRD IV)³:

"The competent authorities shall carry out as appropriate but at least annually supervisory stress tests on institutions they supervise."

The vast body of literature in the field of bank stress-testing is focused on the theoretical framework and methodology design. ECB (2006) presents the main conceptual aspects of the stress-test (approach, structure and interlinkages), while Drehmann (2008) identifies key objectives and modeling choices. The theory is advanced in ECB (2013) with an emphasis on solvency analysis framework. Regarding methodology, the seminal paper of Čihák (2007) gives an introduction to the practical use of stresstesting, whereas the subsequent studies of Schmieder et al. (2011; 2012) are directed towards solvency and liquidity stress-tests. In turn, the topic of stress-test application in research papers has been covered to a lesser extent. Jobst et al. (2013) further narrow the analysis towards banking systems in developed countries. Moreover, cross-country experience is compared in the same manner by Foglia (2009), Ong and Pazarbasioglu (2013), and Schuermann (2013).

The above mentioned studies show that the topic of stress-testing practices in emerging economies, especially from Central Eastern and Southeastern Europe (CESEE), is understudied. As far as the knowledge of this author is concerned, only two studies check the box of cross-country analysis in emerging Europe. The first one by Głogowski (2009) sheds light on the stresstesting experience until 2007 of the Czech Republic, Latvia, Poland, and Slovakia. The second study of Melecky and Podpiera (2010) is currently the most comprehensive work on the matter. It expands the sample of countries to 16, broadens the stresstest research components, and extends the reference period to 2010. However, being the first of its kind, the paper delivers only an overview of cross-country stresstesting practices without providing country details and overall benchmarks. In addition, information of non-EU countries is scarce, as the predominant part of observed practices is from EU member states, especially from the Euro area.

This study builds on the existing literature of bank stress-testing by central banks in CESEE. First, it targets a sample of non-Eurozone countries. Second, this paper reviews the available public information on the stress-test practice from origination to June 2014, thus capturing its evolution and progress. Third, the growing stresstest publications in recent years provide basis for a more thorough, consistent and rigorous analysis. The main thesis of this paper is that there is a benefit in exploiting different practices of stress-testing. By taking the principle of gains in diversity, a comprehensive guidance for stress-test application can be developed. Accordingly, the goal of this study is to provide details on stress-test experiences, form common benchmarks and draw practical lessons. The cross-country analysis should be regarded neither as an attempt to calibrate a "one state of the art stress-test fits all", nor as a quality assessment of a country practice. On the contrary, this research encourages the use of stress-test information from multiple sources. As a result, this study could be beneficial to central bankers from countries with similar economies that are involved in stress-testing design or to any stress-tester in the respective region.

³ Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013, art. 100 (1).

By applying a desk-based approach of reviewing Financial Stability Reports (FSRs), the following lessons for performing a macroprudential stress-test in a CESEE context could be outlined. First, it is carried out to the domestic banking sector, in a top-down manner and addresses at least credit, market, and liquidity risk. Second, macro scenarios are designed based on the official central bank macroeconomic forecast (baseline) and on quantitative models (adverse). In the adverse scenario, the minimum assumptions include slowdown of economic activity, higher interest rates, and currency depreciation. Next, solvency and liquidity resilience is assessed via negative shocks. The former generates credit and market shock to the capital position, which is then compared to the required regulatory minimum. The latter contains a bank run, which is accompanied with a revaluation (haircut) of realized assets. In addition, the stresstest framework could be complemented with simulations on interbank contagion and concentration. During this process, expert judgment is an important element for calibrating scenarios and shocks. Finally, communication strategy is set and results are published. It should be clearly highlighted that the stress-test is a hypothetical exercise, which assumes severe but still likely to occur events and does not represent the central bank expectation for the development of the banking sector. In turn, disclosure of results consists of aggregate values at minimum with no bank-specific outcomes.

The rest of the paper proceeds as follows. Section 2 describes the sample and sets the structure for the study. Section 3 provides an overview of stress-testing practices, while Section 4 presents the Bank Stress-Testing Lessons from Central, Eastern and Southeastern European Countries

stress-test coverage and approach. Section 5 summarizes identified risks and Section 6 gives information on scenario design. Section 7 elaborates on the methodology of different stress-tests. Section 8 discusses communication strategy and presentation of results. Section 9 summarizes the lessons for stress-testing and concludes.

2. Sample selection and research method

The sample includes only non-Eurozone countries and targets the CESEE region. By applying this filter, the selection amounts to 13 countries. Further the group is divided into two core blocks – EU member states and non-EU countries. The first sub-sample consists of Bulgaria (BG), Croatia (HR), the Czech Republic (CZ), Hungary (HU), Lithuania⁴ (LT), Poland (PL), and Romania (RO). The second is composed of Albania (AL), Bosnia and Herzegovina (BiH), Kosovo (KO), FYR Macedonia (MK), Montenegro (ME), and Serbia (RS). In the sample, all macroprudential stress-tests are under the jurisdiction of the central bank.

This study employs a desk-based approach that reviews the FSRs by central banks in CESEE. The covered period starts from 2000 and ends in June 2014, which results in a total of 116 examined FSRs. In addition, further information is obtained from 15 thematic studies on stresstesting and numerous banking system assessments, annual central bank reports and macroprudential analyses. Due to the fact that there is no FSR publication in Bulgaria, the obtained evidence for the country is limited.

The current research follows the perception of IMF (2012), which regards the bank stress-test not just as a quantitative instrument, but as a whole process.

⁴ Although on 23 July 2014 the Council of the European Union approved Lithuania's request to join the Euro area on 1 January 2015, both dates are after the determined reference period of June 2014. Therefore, Lithuania remains in the sample.

Accordingly, the used definition for stresstesting is the following⁵:

"A complete stress testing exercise involves choices on the coverage of institutions, risks, and scenarios; the application of a quantitative framework to link various shock scenarios to solvency and liquidity measures; a strategy for the communication of the results; and follow-up measures, if warranted."

The analyzed information on stresstesting mirrors the pattern set by the definition: preparation, execution, publication. Therefore, the cross-country experience is extended to coverage selection, approach, identification of risks, scenario design, methodology for calibrating shocks and publication of results.

3. Overview of bank stress-testing

The practice of stress-testing has been part of the central banks' supervisory arsenal for more than a decade (Table 1). In 2000, the central bank of Hungary first started to assess the resilience of the banking sector. Since then, most of the countries implemented a stress-testing framework. By 2008, when Kosovo initiated its first stresstest, the whole sample was performing such exercises. For many countries in the sample, the Financial Sector Assessment Program (FSAP) missions of the International Monetary Fund (IMF) contributed greatly as a starting point for establishing a stress-test practice. In several cases this fact has been even pointed out explicitly (CZ, HU, LT, RO, BiH, MK). Since the introduction of stresstests as a supervisory tool, central banks followed different approaches regarding the publications of stress test results. Usually, shortly after the first year of stress-testing, the results became publicly available. For

most observations (HR, HU, PL, KO, MK) this process took a year. In Serbia, the results' publication happened during the same year of origination, while in Bulgaria stress-test results are not disclosed⁶.

In all cases, publication of stresstests appears in the FSR. With regards to differentiating the part about stress-testing into a separate section in the report, the evidence for such a practice varies. As of June 2014, a consistent segregation of stress test results in the report during the reference period could be tracked in several observations (CZ, HU, LT, AL, BiH, KO, RS). For Poland, Romania and Macedonia such separate section of the report appears occasionally, while for the rest, stress-tests are part of the banking system analyses. Publication's frequency is either annually (LT, RO, BiH, KO, MK, ME, RS) or biannually (HR, CZ, HU, PL, AL). Nevertheless, inhouse stress-tests could be run more often.

The predominant part of the sample does not include a special stress-testing section on the central bank website. Only the Czech National Bank and the Bank of Lithuania maintain specific category about stress-tests on their corresponding websites. The National Bank of Serbia discloses details on stress-testing in the financial stability indicators section.

4. Coverage and approach

In the whole sample, credit institutions subject to stress-testing are selected in a consistent way. All countries assess the domestic banking sector which puts foreign branches out of the stress-test scope. The reason behind this decision is that capital adequacy of branches is managed by the parent bank, which is supervised by the home authority. Sometimes, certain banks

⁵ International Monetary Fund, 2012. Macrofinancial Stress Testing – Principles and Practices. Monetary and Capital Markets Department, International Monetary Fund, August, p. 8.

⁶ Although stress-test results are not published in Bulgaria, general information about this practice is disclosed in the annual and semi-annual reports of the Bulgarian National Bank.

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Table 1. Stress-testing overview

| | EU | | | | | | | | Non-EU | | | | | | |
|--|------|------|------|------|------|------|------|---|--------|------|------|--------------|------|------|--|
| | BG | HR | cz | HU | LT | PL | RO | | AL | BiH | ко | МК | ME | RS | |
| Stress-testing overview | | | | | | | | _ | | | | | | | |
| Initial year of stress- testing* | 2002 | 2004 | 2002 | 2000 | n/a | 2006 | 2003 | | 2004 | 2005 | 2008 | 2003 | 2006 | 2007 | |
| Stress-testing in FSAP by IMF** | 2001 | 2001 | 2000 | 2000 | 2001 | 2000 | 2003 | | 2005 | 2005 | 2013 | 2003 | 2006 | 2005 | |
| First stress-test publication | n/a | 2005 | 2004 | 2001 | 2007 | 2007 | 2006 | | 2007 | 2007 | 2009 | 2004 | 2010 | 2007 | |
| Place of publication | n/a | FSR | FSR | FSR | FSR | FSR | FSR | | FSR | FSR | FSR | FSR (RBS) | FSR | FSR | |
| Distinct part in the report | n/a | Occ. | YES | YES | YES | NO | NO | | YES | NO | YES | Occ. | NO | YES | |
| Number of stress-test publications per year | n/a | 2 | 2 | 2 | 1 | 2 | 1 | | 2 | 1 | 1 | 1 (4) | 1 | 1 | |
| Special section on the official central bank website | NO | NO | YES | NO | YES | NO | NO | | NO | NO | NO | NO | NO | NO | |

Source: Central Banks' FSRs, RBS, and websites as of June 2014.

* Melecky and Podpiera (2010).

** Moretti et al. (2008).

fall out of the exercise due to various reasons such as: cooperative and state owned banks (PL), banks with a moratorium on their operations (LT) or banks under provisional (temporary) administration (BiH).

There are two main approaches that national authorities use when conducting stress-tests. One is the "top-down" approach, in which the central bank employs aggregated data and applies consistent methodologies and assumptions in-house. Alternatively, "bottom-up" exercise is carried out а by individual institutions using their own modeling and data infrastructure under identical scenarios. Due to the strengths and weaknesses of each approach, a combination of both is also an option. In the sample, all central banks prefer to conduct a top-down exercise. The reason possibly lies in the fact that such approach is relatively easy, uniform and consistent. Moreover, using stress-test as a supervisory tool, national authorities may not be that concerned about having less rigorous and precise results. In some cases, however, the top-down stress-test is

complemented with bottom-up information. For instance, a joint stress-test took place in the Czech Republic and Albania during 2010 and 2012, respectively. In Bulgaria, a bottom-up approach was used to assess the sensitivity of the banking sector towards market risk, while in Macedonia it is utilized for liquidity risk. The National Bank of Serbia started conducting bank stress tests by using a bottom-up approach. Melecky and Podpiera (2010) report that Polish and Montenegrin officials also implement a bottom-up exercise, but the outcome is not published.

5. Identified risks

Credit risk is deemed as the most important risk by central banks, because it has been consistently addressed, thoroughly analyzed, and continuously advanced. Market risk (both interest and exchange rate risk) is an integral part of the risk identification process, too. Only in Croatia, the interest rate risk is not concerned as a source for systemic vulnerabilities, due to

insignificant share of assets and liabilities with fixed rates. Most competent authorities include FX risk in their stress-tests. The risk of local currency depreciation is mainly against the euro (HR, CZ, HU, PL, RO, AL, MK, RS). However, being eurorized economies, Kosovo and Montenegro follow a different approach. In the former, the euro is assumed to decrease against the Swiss franc and the US dollar, while the latter applies corrections to the net USD/CHF open positions. FX risk is not addressed in Bulgaria, Lithuania and Bosnia and Herzegovina, probably due to the operation of a currency board, which pegs the local currency to the euro. A typical sovereign risk is only included in the stress-test of the Czech National Bank. Since 2012, the resilience of the corresponding banking sector is tested against losses from haircuts on EU sovereign exposures with government debt exceeding the 60% of GDP "Maastricht" criteria. In Hungary and Poland, there is evidence of sovereign risk consideration revealed in higher bond yields but it is a result from the market risk.

Liquidity risk is also covered in all countries at least once during the examined period. It has been part of the regular stress-test exercises for both EU and non-EU countries (BG, CZ, HU, LT, PL, KO, MK, ME). However, liquidity stress-testing has been mentioned rarely in Croatia, Romania, Bosnia and Herzegovina, and Serbia. Detailed liquidity stress-tests are published once or twice during the reference period (HR, BiH, RS), while Romanian officials only consider liquidity risk in 2012. The Bank of Albania addresses liquidity concerns, but public information has not been disclosed.

Additional risks are analyzed to a lesser extent or are largely present on individual basis. Contagion risk, for instance, encompasses vulnerabilities stemming from bank interconnectedness. It is characterized as the speed of transmitting financial shocks from banks' individual exposures to the system as a whole. Thus, the higher the propagation is, the more severe the shock is. The risk from interlinkages is mainly covered by EU members (BG, CZ, PL, RO). From the non-EU sample, only the National Bank of Serbia analyses bank contagion. As far as concentration risk is concerned, it is observed on 6 instances (BG, CZ, PL, KO, MK, ME). Occasionally, specific risks are incorporated by Czech and Macedonian officials. In 2010 both authorities examined risks from the Greek debt crisis and in 2012 the latter considered possible negative effects from the turmoil in the Slovenian banking system.

All in all, credit and liquidity risk are covered by the whole sample, with market risk addressed to a lesser extent. The spectrum of analyzed risks differs from country to country, but only the Czech National Bank has full risk coverage. Usually, the common practice is to combine credit risk and market risk with regards to solvency and assess liquidity risk separately. Some central banks include additional risks like contagion and concentration when analyzing the capital position, while some opt for individual treatment. In Poland, all respective risks are incorporated in a single framework.

6. Scenario design

A key element for conducting a stress-test is to generate severe but plausible scenarios. Basically there are two methods that can be employed: sensitivity (simulation) analysis and macro stress-tests. The first one aims at applying a direct isolated shock from individual variables to bank risk measures. Thus, the simulation provides information on the shock impact to the bank's overall performance and assesses how sensitive the bank's capital position is to changes in the selected financial variables one at a time. Despite its simplicity and quickness,

the method has one major drawback the lack of specifications and rationale to the underlying shock. In contrast, macro stress-tests incorporate a set of scenarios which analyzes the simultaneous move of various macroeconomic variables and their combined impact on the banks' financial conditions. It usually consists of a baseline scenario, which reflects the current state of the economy and an adverse scenario, which considers extreme, but still possible economic developments. The macro method is internally consistent and accounts for interactions between macroeconomic variables and risk measures. As such а complex quantitative modeling is required that is generally prone to model misspecifications.

In the CESEE context, sensitivity analyses are generally the predecessor for macro stress-testing, but in many cases the combination of both methods remains. The simulation of a credit shock to the loan portfolio predominantly includes quality deterioration. All non-EU countries and a few EU members assume higher nonperforming loans (NPL). The shock can be estimated via an absolute increase of risk exposures, a percentage rise, or an additional percentage point of NPL ratio. In addition, reclassification of loans to a lower quality category is commonly considered (PL, BiH, KO, MK, ME, RS). The migration analysis downgrades performing loans to categories that are typically "doubtful", "bad" or classified as "loss". Specific credit risk assumptions could also reflect a decrease in value of loan collateral (PL) and a drop of real estate prices (LT). The Czech National Bank carries out a sensitive analysis on the impact of a significant rise of EU sovereign yields. In this manner, a haircut is applied on government bonds based on their rating. The lower the sovereign rating is, the higher the haircut. For countries with the best ("AAA") rating a zero haircut is set. In terms Bank Stress-Testing Lessons from Central, Eastern and Southeastern European Countries

of market risk, the most used single-factor simulations are surge of interest rates and currency depreciation. The former shock varies from 1 to 5 p.p. and the latter could reach 20% or more.

Macro stress-testing is a prominent tool in the CESEE supervisory arsenal. As of June 2014 it has been implemented by almost all countries in the sample. Usually, officials set a 2- year period of prolonged negative shocks. In the Czech Republic the time horizon is 3 years, while a few others opt for a one-year period of stress (HR, MK, RS). According to Melecky and Podpiera (2010), there are two distinctive approaches when designing the scenarios. One is based on expert judgment, while the other on modeling. Regarding the latter, Foglia (2009) differentiates three ways for building a model: structural econometric model, vector autoregressive methods, and pure statistical approaches. In this paper, an additional combined approach is formed, which incorporates a macroeconomic model and expert judgment for fine tuning. A quick review over the CESEE experience shows that most EU members and a few non-EU countries employ models for generating macroeconomic shocks. Among them, econometric modeling is the predominant choice of central banks (CZ, HU, LT, PL, RO, RS), while autoregressive methods (HR) and pure statistical approaches (MK) are less popular. Officials from the Czech Republic, Hungary, Lithuania and Serbia follow the combined approach, as they further calibrate the scenarios with own expertise, whereas macro-scenarios based on expert judgment are more associated with non-EU countries (AL, BiH, KO), In Albania and Bosnia and Herzegovina, the process is also complemented with IMF quidance.

When it comes to the baseline scenario, it is a common practice to utilize the official central bank macroeconomic forecasts.

Alternatively, IMF projections (BiH, KO) or own knowledge (MK, RS) could be used. The adverse scenarios reflect the country idiosyncratic risks and vulnerabilities. Typically, the trigger for negative external shocks is set to come from a hypothetical prolonged EU recession, exacerbation of EU sovereign debt crisis, and turmoil in emerging markets. Three assumptions for channeling the negative shock to the macro-economy are widely made: slowdown of economic activity. currency depreciation, and rise in interest rates. The first assumption is associated with a decline in foreign demand (CZ, HU, LT, KO) and higher unemployment (CZ, HU, LT, MK), which could lead to a double-dip (W-shaped) recession in the Czech Republic and Hungary. The second one involves local currency devaluation (HR, CZ, HU, PL, RO, AL, RS) or foreign exchange rate adjustment (KO). The third one could stem from loss of confidence (CZ, HU, PL), increased risk perception (HU, LT, PL), or higher funding costs (RO). In some cases, competent authorities additionally presume negative credit growth and a drop in real estate prices. Accordingly, the predominant choice of macroeconomic variables includes real GDP growth rate, exchange rates, and interest rates (money market rates, sovereign yields, key policy rates, etc.). The detailed macroeconomic values vary on a country basis, but overall the real GDP growth rate could drop to minus 4%, depreciation rates range from 10% to 30%, and interest rates could rise on average with 3 p.p. Further variables that can be included are inflation rate, unemployment rate, wages (volume and growth), changes in residential property prices, stock prices, sovereign yields and others. Finally, officials from Croatia, Hungary, and Lithuania also assume model specifications to the adverse scenario, while the Czech National Bank keeps constant monetary policy during the stressed period with no FX interventions.

In addition, the CESEE macro scenarios,

especially those developed in EU member states, have some resemblances with the ones adopted in the EBA 2014 EU-wide stress-test. There are similarities in terms of formulating the baseline scenario, making assumptions for the adverse scenario, and selecting macro-economic variables.

7. Stress-tests

Stress-tests are performed in relation to the identified relevant risks. The most common exercise in the CESEE region is the solvency stress-test, which includes credit risk and market risk (interest rate and FX risk), if material. Liquidity stress-tests are also popular, but to a lesser extent. Other stress-tests like contagion and concentration are used individually.

7.1 Solvency stress-test

A solvency stress-test evaluates the resilience of a bank or the banking system to adverse hypothetical shocks by assessing the capital position's loss-absorbing capacity. The process incorporates credit risk models, factors, additional assumptions, market risk shock (if any), and capital measures. It could also be complemented with a reverse analysis and back-testing.

Credit risk model

credit risk model links the The development of macroeconomic indicators to banks' balance sheet. Typically, the mapping concerns the quality of the loan portfolio. For example, a slowdown of economic activity negatively impacts business corporate operations, which in turn affect the loan servicing and may lead to credit impairments for the bank. An indirect additional shock could stem from households as well. When firms are under pressure, layoffs are to be expected. Thus, vulnerabilities propagate also to the mortgage and consumer portfolios. Another channel for shock transmission could come

from a drop in real estate prices - if the value of collateral decreases then the credit becomes riskier.

CESEE countries usually apply single econometric credit model, which is internally designed. The Czech National Bank implements a set of own developed satellite models that not only incorporate credit risk, but also other elements as well. In Lithuania, a credit risk technique by Basurto and Padilla (2007) is followed, while in Kosovo the results of an IMF model are incorporated. In the credit models, the independent variable is the probability of default⁷ (HR, CZ, HU, LT), loan-loss provisions (PL, RO), or NPL ratio (AL, BiH, KO, MK, RS). Although, the NPL ratio is commonly used in non-EU countries, in Croatia the probability of default is further linked to the NPL projection. Moreover, in the Czech Republic the NPL evolution is projected from satellite models as well. For all countries, the explanatory variables come from the macro scenario. Hungarian officials add client variables when applying a household model. Additional specifications to the credit model could be made with regards to the type of loan (CZ, HU, PL) or equal treatment for different portfolios could be incorporated (BiH). Competent authorities in Albania and Kosovo assume zero credit growth. For optimizing the credit risk model, each central bank has unique techniques.

Credit risk factors

Measures for credit losses are estimated from the credit risk model. They could be based either on loan performance or on expected losses. The first one is dependent on the evolution of NPL. When projecting the path of the NPL, specific elasticity coefficients are employed as a result of the Bank Stress-Testing Lessons from Central, Eastern and Southeastern European Countries

model. For instance the elasticity between real GDP growth and NPL ratio is around 0.8 (BiH, KO, RS), which means that for every p.p. decline of aggregate output, the NPL ratio increases with 0.8 p.p. Further, based on the NPL development, loan loss provisions are extrapolated via a specific formula, regression, or expert judgment. This approach is predominantly used in the CESEE context, especially by non-EU countries.

The second measure is derived from the Basel II formula⁸:

EL=EAD * PD * LGD

Where:

EL is the expected loss;

EAD is the exposure at default, which is the outstanding amount if the borrower defaults;

PD is the probability of default;

LGD is the loss given default, which is the percentage of exposure that is not recovered.

In this framework, the EAD includes on- and off-balance sheet items, while the PD and LGD factors could be set either point-in-time or through-the-cycle⁹. at The method for calculating expected losses is adopted by officials from the Czech Republic, Hungary and Lithuania in a through-the-cycle manner. They are specified differently for a given loan portfolio (corporate, mortgage, and consumer), due to associated risks. Firms may exhibit the privilege of having an unsecured loan, while mortgage loans are backed up with substantial collateral. Moreover, consumer loans have unique credit risk characteristics. Unlike, the loan loss provisioning approach, credit risk parameters are applied to the performing part of the credit. Accordingly to risk specifics, mortgage loans have the lowest LGD. In the Czech Republic it

8 BCBS (2006).

⁷ Information for default rates typically are obtained from credit registers.

⁹ For more information on PD and LGD specifics, see Buncic and Melecky (2012).

ranges from 23% to 52%, while in Lithuania the coefficient is between 21% and 34%¹⁰. LGDs for corporate and consumer loans can reach even 70% (CZ). Hungarian officials assign 50% and 40% LGD for the corporate and retail portfolio, respectively. The given values are also in line with the theoretical country LGD benchmark¹¹. For the PD, higher estimates are attributed to retail loans, due to the stronger propensity of households to adverse economic effects. Thus, consumer and mortgage PDs are around 10% at the maximum bound (CZ, HU). As a result the overall loss rate varies from around 1% - 2% to 6% - 8%. In addition, LGD factors could be derived from a probability simulation (LT), quantitative and qualitative information (HU), or expert judgment approach (CZ). For instance, the Czech National Bank links corporate, mortgage and consumer LGD with real GDP growth rate, residential property prices, and unemployment, respectively.

Additional assumptions

Further specifications could be made with regards to balance sheet development, income projection, inclusion of "secondary effects", and exposure coverage. The predominant part of the sample employs constant balance sheet assumption, which keeps balance items static throughout the stress period. Only in the Czech Republic and Poland, a dynamic framework allowing an evolution of the balance sheet according to the scenario is implemented. The Croatian National Bank employs dynamic elements exclusively for NPL exposures and loss provisions. Among CESEE countries, it is a common practice to include net income as a first stop to shock losses. Profits can be estimated through an econometric

model (CZ, HU, PL, RO), a link to previous levels (AL, KO), or a projection of specific macroeconomic and bank variables (HR, LT, BiH). In Macedonia and Montenegro there is no indication of earnings consideration. Assumptions on dividend distribution are outlined by EU-members. It could be restricted (HU, LT), allowed (PL), or both depending on the scenario (HR, CZ). With the exception of Hungary, "secondary effects" (the supervisory reaction function from the stress-test results and its subsequent impact to the economy) are not included. Off-site balance items are incorporated or partially included in the risk exposures by several competent authorities (CZ, HU, BiH, KO, RS), but there is no evidence for the rest.

Market shock

Market shock comprises direct and indirect effect of a rise in interest rates and currency depreciation. The direct channel of increased interest rates accounts for pressures on the net interest income and revaluation of securities in the trading book. For exchange rate risk, the impact consists of losses from the foreign currency net open positions. The indirect channel refers to the credit risk. When interest rates surge, difficulties for loan repayments arise. Similarly, if the local currency devaluates, corporations and households lose value on respective profits and wages as business transactions are typically in local currency. Thus, for unhedged borrowers credit service in foreign currency deteriorates. The incorporation of market shock in the CESEE region depends on the scenario assumptions. In all cases, the market risk is considered either through a hike in interest rates, currency depreciation, or both. The direct shock is calibrated via market

 ¹⁰ A 100% LGD means that no cash flows are expected from the exposure, and a full loss is accounted.
¹¹ Country LGD is calculated as the 2004 - 2015 average from resolving solvency section of the Doing Business database, which is based on the methodology of Djankov et al. (2008). LGD for the Czech Republic, Hungary and Lithuania is 64%, 62%, and 53%, respectively.

risk factors, while the indirect shock is addressed by including market explanatory variables in the credit risk model.

Capital measures

All countries in the sample choose the capital adequacy ratio (CAR) as a measure for the capital position. In most cases the hurdle rate follows the regulatory minimum. However, Hungarian, Polish, and Romanian officials assume higher CAR level, which is based on expert judgment, official recommendation by the Polish Financial Supervision Authority, and the IMF and EU agreement in 2009, respectively. Overall, CAR hurdle rate ranges from 8% to 12%. Only in Poland the outcome indicator is complemented with a core capital ratio of 9%. Further, capital assumptions are formed on individual basis. For example, a few countries (CZ, LT) restrict capital increase during stress, while in others it is possible due to sufficient profits (HR) or announced recapitalization prior the stress-test (HU, BiH). As far as risk weighted assets (RWA) are concerned, the predominant part of the sample adjusts them for loan revaluation. The central banks of Bosnia and Herzegovina and Serbia also account for loan growth in their RWA calculations. Finally, the Czech National Bank incorporates its own modeling for RWA evolution which combines loan quality, growth and expert judgments.

Reverse stress-test and back-testing

Reverse stress-test and back-testing are valuable add-ons to the solvency framework. The former assumes a pre-defined state of the capital position (below required minimum or zero) and "pushes" selected variables until the capital threshold is breached. As a result, the most sensitive indicator for capitalization is identified. The latter verifies the level of conservativeness in the applied methodology and assumptions by comparing Bank Stress-Testing Lessons from Central, Eastern and Southeastern European Countries

the stress results with subsequent actual developments. Considering the CESEE region, central banks from the Czech Republic, Lithuania, Albania, Macedonia and Serbia perform reverse stress-testing. Back-testing is attributed only to the Czech National Bank. It confirms the conservative approach to stress-testing and calls for further improvement.

7.2 Liquidity stress-test

The concept of stress testing liquidity risk is to assess whether the stock of liquid buffers is sufficient to withstand adverse liquidity shocks. More specifically, the liquidity stress-test is performed to examine if credit institutions hold enough liquid assets and revenues to meet their obligations in time and at a reasonable cost under stressed conditions. In its framework, Brunnermeier and Pedersen (2009) distinguish two important components: funding liquidity risk and market liquidity risk. Thus, the liquidity stress-test scenario typically contains bank runs and subsequent reductions in the value (haircut) of realized assets.

Most central banks employ a horizontal sensitivity analysis, which applies a common set of approaches, scenarios and assumptions to all banks. Only in Croatia and the Czech Republic, there is a combination of idiosyncratic and market scenarios in one macro-model. Following the van den End (2008) liquidity stress-test framework, a three phase model is executed that includes the formation of a shock, bank reactions, and subsequent "secondround" effects to market conditions and risk perception. Nevertheless, both authorities adjust the model to better capture the specifics of the respective banking system. With regards to the time horizon, EU members adopt 1 month period of stress, non-EU countries - up to 5 days, and others opt for an instantaneous shock (PL, MK,

ME). The predominant part of central banks outlines the loss of clients' confidence and reputational risk as triggers for liquidity pressures. Lithuanian and Serbian officials assume concerns about the financial state of parent banks as a premise for local bank runs, while in Hungary the source could be a rating downgrade. For numerous non-EU countries a specific trigger is not indicated.

The literature on liquidity stresstesting differentiates between two types of stressed outcomes: balance-sheet based and maturity-based. The first one is static and typically includes liquid assets ratios (liquid assets to total assets/ liabilities/deposits). The second one is linked to computing a liquidity gap based on cash inflows and outflows, which are adjusted according to preset rules. Several competent authorities (HR, LT, PL, MK, RS) use balance sheet liquidity ratio, while cash flow liquidity gap is selected to a lesser extent (CZ, BiH, ME). The central banks of Hungary and Kosovo incorporate both outcomes. As far as the shock formulation is concerned, some countries draw experience from recent local or international banking crises (HR, CZ, HU, LT, RS). Nevertheless, expert judgment is exercised by all for defining the adverse liquidity parameters. Finally, central banks employ advanced quantitative tools to calibrate liquidity shocks such as specific models (HR, CZ), Monte Carlo simulations (CZ, RS), and Value-at-Risk (VAR) techniques (HU, LT, RS).

Bank runs are defined differently in all observations¹². Deposit withdrawals are specified by maturity (sight/demand and time/savings), by client (households, corporations, state), and by type (wholesale, private). Due to diverse time horizons of stress and deposit shortfall definitions, drawing a cross-country comparison on the level of adversity to the liquidity shock is unfeasible. However, certain common traits can be outlined. The outflow of total deposits ranges from 25% in 1 month (LT) to 50% in 5 days (KO)¹³. Further, available on demand funds are assigned with a higher weight than time deposits (BiH, RS). Deposit outflows by households are between 5%-10% for EU countries and 20%-40% for non-EU members, while the respective ranges for firms are 10%-15% and 20%-40%. When a distinction is made by client, usually the bigger liquidity shock is assumed from corporations. For instance, corporate outflows in Hungary and Poland are 15% and 10%, respectively. Only the central bank of Montenegro sets a 40% equal rate to households and legal persons. In turn, government deposit outflow is considered in Poland (10%), Serbia (35%), and Montenegro (100%). A separation of retail and wholesale funding is more common to EU countries. Private deposits have a runoff rate of 11% (CZ) and 20% (HR), while the outflow of interbank funding (including from parent bank) can reach up to 50%. Finally in Poland, an assumption is made about foreign liabilities. The rationale behind these observations is that in a liquidity crisis, significant outflows come from the interbank market (usually non-residents), corporations react faster to a shock than households due to the dynamic way of managing deposits, and the biggest chunk of withdrawn funds is the one that is available on demand. In addition, concentration in the liabilities is addressed from non-EU countries (KO. MK, ME) by assuming a withdrawal from largest depositors.

¹² The remark is not surprising given the unique mix of characteristics, development of intermediation, structure, and regulatory environment for each banking system.

¹³ The following figures for outflows and assets' haircuts correspond to the whole respective stress period.

Turning to the asset side, implementation of haircuts on realized instruments is attributed more to EU member states. The most considered type of security is the government bond, which is reprised in the range of 10% to 35%¹⁴. Moreover, officials in Lithuania distinguish a haircut on foreign sovereigns in the amount of 10%. Interbank claims are realized fully (LT) or at 80% (HU). From non-EU countries, information on haircuts is only available in Kosovo and Serbia with both central banks applying a 20% revaluation on liquid assets. Cash and funds with central banks have a zero haircut.

As part of the liquidity scenarios, competent authorities include additional assumptions. Even though some restrictions are not explicitly mentioned, it can be concluded that they are applied. For instance, intervention from CB and government is limited. Also, the withdrawn deposits do not return to the banking system. There is a restriction on external financing, debt rollover, wholesale funding, and the use of cash amounts attributed to the remaining deposits (minimum reserves). Assumptions on parent funding are not that coherent, as some states (HR, PL) allow it, others (CZ, HU) do not, and one use both depending on the scenario (LT). In Croatia and Montenegro, liquid assets include only cash and deposits at CB, while in Hungary and Poland there is an exchange rate shock involved, as well.

In addition, a reverse stress test can be applied for liquidity risk. It seeks to identify the maximum stress resistance of banks by increasing the risk parameters until liquidity problems are present like breach of a regulatory minimum or complete drain of liquidity. Such liquidity reverse analysis is executed by officials in Lithuania, Kosovo, and Serbia. Bank Stress-Testing Lessons from Central, Eastern and Southeastern European Countries

stress-test The examined liquidity practices of CESEE countries are in line with the assumptions and level of conservativeness prescribed by the Basel III liquidity coverage ratio (LCR) and the IMF liquidity stress-test¹⁵. For example, the selection of method, time horizon, stressed outcome, shock calibration and additional restrictions overlaps. On average, central banks employ more stringent approach towards retail deposit outflows and haircuts on government bonds, but the shock from wholesale funding is to a smaller extent when compared to the one in the LCR and the IMF hypothetical tool. Finally, there are qualitative similarities between the CESEE liquidity stress-test methodology and the corresponding surveys on best practices by ECB (2008) and BCBS (2013b).

7.3 Other stress-tests

Other commonly addressed risks in a stress-test framework are contagion and concentration. They are solvency type stress-tests, as the outcome is related to the capital position. Accordingly, both risks can be included as an add-on to the primary solvency exercise, or tested separately. Contagion stress-test is executed by the central banks in Romania, and Serbia, while concentration simulations are run in Kosovo, Macedonia, and Montenegro. Bulgaria¹⁶, the Czech Republic, and Poland include both risks in their stress analyses.

Contagion stress-test

Contagion stress-test examines the extent to which banks are sensitive to interbank negative spillovers and their ability to offset outstanding exposures visà-vis banks in default with capital. Typically, the test starts by assuming a local bank will become insolvent ("primary insolvency"),

¹⁴ A haircut of 100% means that the market has closed and the asset is illiquid.

¹⁵ BCBS (2013a) and Schmieder et al. (2012), respectively.

¹⁶ Due to the fact that stress-test results are not published in Bulgaria, further information is not available.

which will lead to a default on its interbank obligations¹⁷. Then, the expected losses are calculated to the rest of the banking system. If the impact is strong enough, other banks may become insolvent ("secondary insolvency"). At this point, a second iteration is performed to check the effect of losses from the newly defaulted banks. If more defaults are triggered, then the iterations continue until the "domino effect" stops. During the process, two features are essential: defining the exposure at default and the default event itself. The former usually is related to net interbank claims (the positive value of liabilities minus assets), but a more conservative approach could be implemented that includes only the liabilities side (deposits and loans received). The latter assumption depends strongly on the legal framework. Being a hypothetical exercise, however, deviations from the law are also possible.

All central banks follow a simulation of a pre-determined bank failure. Accordingly, expected losses are calculated as the product of EAD, LGD, and PD. When determining the risk exposure officials use the net interbank claims with the latter including both on- and off-balance items (RO, RS). The Czech National Bank applies two methods to determine the risk exposure. The first one uses the greater of value of assets and liabilities in the interbank market (worst case scenario), while the second considers the received deposits and loans. In Poland, EAD are based on net interbank claims and more conservatively on solely the interbank liabilities. Due to the fact that interbank exposures are unsecured, competent authorities apply a 100% LGD parameter. The PD could be set at 100% (CZ, PL) or linked to either capital (CZ, RS) or macroeconomic shock (RO).

Defining the default event is in general difficult, because of the acting national law on bankruptcy. The simplest way is to assume that a bank defaults when its capital becomes negative (CZ, RO, RS). In practice, however, even banks with positive capital can fail. Such peculiarity is captured in the approach of Czech and Polish officials. In this manner, the Czech National Bank not only performs a simple contagion test, but also incorporates an advanced one. In its framework, the PD increases with decreasing capital. For instance, CAR below 0% corresponds to a 100% PD, up to 5% CAR - 25% PD, up to 8% CAR - 15% PD, and so on. As a result, the iterations stop when banks' capital remains in the same bracket and so the PD is unchanged. The Polish competent authority sets the default event if CAR falls below 4%, which is indirectly based on a provision in the banking law of Poland - if the loss is bigger than half of the capital then a decision could be made for liquidation proceedings. Thus, the bankruptcy threshold is set at half of the regulatory CAR minimum (8%), in order to account for banks with high or low capital buffers above the minimum. In the end, the initial solvency of a bank could be deteriorated from the macroeconomic shock (CZ, RO).

Concentration stress-test

Stress-testing concentration risk focuses on high exposures of banks to a few borrowers or a small group of entities that could also be connected. Concentration on the asset side is generally tested by impairing the largest exposures of each bank. Although, the approach is rather straight-forward, it varies from country to country in terms of application.

¹⁷ It would be of great relevance to test contagion channels from abroad, especially from a parent bank, but availability on such information is limited.

considered authorities All use а simulation method to test for concentration. Due to the simple stress-test objective, it seems that no advanced techniques are required. In the scenario design, it is usually assumed a default of the debtor (corporation) on its debt. The capital shock is applied individually (CZ, KO, ME), or both on bank and system level (PL, MK)¹⁸. On a bank level, a bankruptcy of the largest top 1 (CZ, ME), top 3 (CZ, PL, KO), and top 5 (KO) non-financial borrowers is applied. On a banking system level, Polish officials extend the same corporate assumption. In addition, there are deviations from the common rule of corporate default. For instance, in Poland a failure of the top 3 financial (non-bank) debtors is incorporated. Czech officials also test selected sectors with including a 50% write-off for all exposures to the property developers. The National Bank of the Republic of Macedonia does not assume a default, but worsening of the credit quality towards the largest corporations.

Most central banks (PL, KO, MK) impair the defaulted exposures fully, but a lower LGD could also be applied (CZ). On one hand, the typical credit to a large corporation is unsecured due to the presumption of a high guality borrower. Thus, in stressed conditions the loss is 100%. Nevertheless, large corporations possess assets that could serve as collateral in time of default. As a result, a lower LGD is also granted. In Montenegro, the amount of debt decreases by the amount of the respective provisions. Further, the bankruptcy impairments are made on balance sheet exposures (PL, KO, MK, ME). Only the Czech National Bank adds off-balance items like commitments and guarantees. The effect to capital is predominantly direct, but in Poland the shock is softened through the operating income.

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8. Communication strategy and presentation of results

Communication is an important component of the stress-test in terms of delivering the right message. All central banks manage to convey in a clear manner to the public the main stresstest features. Either explicitly or implicitly indicated it is understood that the stress-test is a hypothetical exercise. The simulation is not a forecast for future development, but rather a "what if" type of analysis. In addition, it is suggested that the stress-test is severe enough and plausible. It simulates extreme and rare ("tail") events that are still possible to occur. In that manner, the adversity of the shock impact is outlined by referring stressed macroeconomic and bank financial values with historical observations, especially with those experienced during a financial crisis. Lastly, without a doubt it is stated that the stress-test does not represent the central bank expectations for the development of the banking sector.

As far as methodology is concerned, in all countries there is some published information but a specific technical note is available to a lesser extent. It is mostly part of the FSR as a box or an appendix (CR, LT, PL, AL, MK, RS), whereas in the Czech Republic and Hungary it is given separately. A general practice of CESEE central banks is to note in the stresstest publication if any significant changes are made in the stress-test process. Only Hungarian officials maintain the methodology relatively constant, which is a prerequisite for comparing the resilience of the banking system in time via dynamic solvency and liquidity stress-test indexes. Additional research on stress-testing is carried out in EU member states (HR, CZ, HU, PL). From them, the number of papers in the Czech Republic is superior, which contributes to the development of a robust stress-test framework that covers various risks.

¹⁸ One should note that when applying a concentration simulation at the banking system level, the largest borrowers typically have credits from multiple banks.

Disclosure of stress-test results to the public is the final part of the process. Goldstein and Sapra (2013) advocate that publication of aggregate instead of bank-specific results, is more beneficial when the goal of the stress-test is to promote financial stability. If stress-testing is used from a macro-prudential perspective as a supervisory tool, then disclosing aggregate results is in line with the objective. However, if individual results are published, they should be accompanied with extensive background and level of details, so that misinterpretation and possible spread of unwarranted panic among the public are avoided. The CESEE experience on disclosure of stress-test results is in line with the academic suggestion of Goldstein and Sapra (2013). Following the goal of macroprudential stability, all central banks publish system level results and abstain from giving bank-specific outcomes. The extent of disclosure, however, varies from country to country. The bare minimum is to exhibit aggregate values for capital ratios. Only in Albania, there is no system outcome, but rather capitalized/under-capitalized statement. а A complementary approach is to add a distribution of capital outcomes by statistical elements (HU, LT, ME) or by number of banks (HU, KO, MK, RS). The former shows post-CAR mean, minimum, maximum and percentiles, while the latter assigns the number of credit institutions to a given CAR value bracket. From the statistical distribution, individual results (lowest/highest) can be indirectly implied. Moreover, the central banks of Croatia, Kosovo and Macedonia disclose unspecified results of the worst capitalized bank. Rarely, individual values of all participants are revealed, but if so, bank names are not present. In addition, there are instances of stress-test disclosure grouped by size (HR, CZ, LT, AL, BiH), business model (HR), and ownership (RO).

With regards to capital shortfall, it is a common practice to point out the number of banks that are below the required minimum and in a few countries (HR, CZ, PL, RS) their

market share is also disclosed. Most central banks provide additional information on the capital need, which could be further referred as a percentage of GDP (CZ, KO, MK). Also, banks with negative capital, if present, are outlined as well (BiH, MK, ME, RS). In terms of liquidity stress-testing, if there is a regulatory requirement, the liquidity deficiency is provided.

Presentation of results is visualized via figures and tables but further details are unique to each country. There is one common feature, though, when disclosing aggregate CAR results among EU members (HR, CZ, HU, LT, PL) - the way of presenting the evolution of CAR before stress to CAR after shock is similar to the one adopted by EBA in the 2011 EU-wide stress-test. It includes the factors that influence the capital ratio either positively (pre-impairment income), or negatively (impairment charges, changes of RWA, etc.).

Due to the fact that the stress-test is used as a supervisory tool for assessing the resilience of the banking system against various adverse shocks, follow up measures are not present. There is no direct evidence for a link between the stress-test and subsequent policy actions or supervisory constraints. As such indicative information on compulsory capital plans, dividend and bonuses restrictions, and asset restructuring (deleveraging) is absent.

Conclusion

This study examines the stress-testing experience of central banks in the CESEE region from its origination to June 2014. It identifies the advantage of unique stress test framework in each country and therefore aims at utilizing cross-country diversities into common guidance for application. By analyzing publicly available information, mainly from FSRs, this paper outlines lessons for the main components of the macroprudential stress-test process: preparation, execution, and publication.

In the first stage, a common practice of central banks is to apply the exercise on the domestic banking sector. Competent

authorities carry out the stress-test in a top-down fashion and occasionally, it is complemented with bottom-up information. Credit and liquidity risks are identified by all countries, while market risk is addressed to a lesser extent. Other risks like interbank contagion and exposure concentration can also be included in the analysis.

In the second stage, CESEE countries apply predominantly macro stress-tests, but simulations on credit quality and market risk are also popular. Macro scenarios consist of a baseline and adverse version. The former usually utilizes the official central bank macroeconomic forecast, while the latter is based on econometric modelling. Three macroeconomic adverse assumptions stand out: recession, currency depreciation and rise in interest rates. Accordingly, the minimum set of employed macroeconomic variables includes real GDP growth rate, exchange rates, and interest rates.

Moreover, solvency stress-test typically encompasses credit shock, which is derived from loan loss provisioning or expected losses via an econometric credit risk model. Competent authorities also assume static balance sheet and net income consideration. Dynamic framework is implemented only by a few national officials. Market shock is further added in line with the scenario. For determining the capital position, a general practice is the use of capital adequacy ratio and a hurdle rate reflecting the regulatory required minimum. Liquidity stress-testing contains a bank run and subsequent revaluation (haircut) of realized assets. Stronger assumptions regard interbank financing, corporate funds and deposits on demand. In most cases, haircuts are applied on government bonds. Other simulations are also carried out. Contagion stress-test employs initial bank insolvency and if triggered subsequent "domino effect", while the concentration one assumes default of the largest borrowers. Throughout this phase, expert judgment for fine tunings and calibrations is implemented.

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In the final stage, CESEE central banks convey clearly to the public that the stress-test is a hypothetical exercise, which incorporates extreme but plausible events and does not represent the central bank expectation for the development of the banking sector. They also publish aggregate values at minimum, whereas bank-specific results are not disclosed at all.

Overall, the CESEE experience on stresstesting shows that there is no universal way for carrying out such an exercise. The benefit of having different approaches, scenarios, methodologies, techniques, and assumptions contributes to the pool of options a stresstester could have for executing a stress-test based on his needs. Given the constant interconnection between quantitative tools, qualitative information, and expert judgment, CESEE lessons affirm the notion that stresstesting is a form of "art, rather than science".

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