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TECHNICAL NOTE

STRESS TESTING THE BANKING SECTOR

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared by IMF staff in the context of the Financial Sector Assessment Program in Austria. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations.

CONTENTS

BOXES

ANNEXES

ANNEX TABLES

ANNEX FIGURES

Glossary

AFS	Available for sale
AQM	Austria Quarterly Model
AUB	Australian Dollar
BIC	Bayesian Information Criterion
BIS	Bank for International Settlements
BU	Bottom-Up
CAR	Capital Adequacy Ratio
CDS	Credit Default Swap
CESEE	Central Europe and South Eastern Europe
CET1	Common Equity Tier 1
CHF	Swiss Franc
CIS	Commonwealth of Independent States
CoVaR	Co-Value at Risk
CZK	Czech Koruna
EAD	Exposure at default
EBA	European Bank Authority
ECB	European Central Bank
EDF	Expected Default Frequency
IMF	International Monetary Fund
FCL	Foreign currency loan
FinStaG	Financial Market Stability Act
FSAP	Financial Sector Assessment Program
FX	Foreign Exchange
GBP	British Pound
GDP	Gross Domestic Product
G-SIFI	Global Systemically Important Financial Institution
HQLA	High quality liquid assets
iid	Independent and identically distributed
JPY	Japanese Yen
LCR	Liquidity Coverage Ratio
LGD	Loss given Default
LLPR	Loan loss provisioning rate
NII	Net interest income
NPL	Non-Performing Loan
OeNB	Oesterreichische National Bank
OIS	Overnight Index Swap
PD	Probability of Default
PLN	Polish Zloty

ROA	Return on Assets
RPV	Repayment Vehicle
RWA	Risk Weighted Assets
SD	Standard Deviation
SIFI	Systemically Important Financial Institutions
SNB	Swiss National Bank
TD	Top-Down
USD	US dollar
VaR	Value at Risk

EXECUTIVE SUMMARY

The Austrian banking system is in a recovery phase following the 2008–2009 global financial crisis. The financial crisis exerted significant pressure on Austria's financial system. Substantial liquidity and capital support was provided by the government, and three mid-sized domestic banks were fully or partly nationalized. However, Austrian banks on the whole have benefited from limited exposures to sovereign and market risks, a stable funding structure, and relatively favorable domestic macroeconomic conditions. In CESEE countries, Austrian banks have not resorted to large-scale deleveraging, notwithstanding somewhat weaker growth, recent volatility, and rising vulnerabilities, including high and rising NPLs. Crisis legacy issues have been addressed through the gradual restructuring of intervened banks.

Stress testing results suggest that Austrian banks, on aggregate, have sufficient capital buffers to withstand severe but plausible shocks from adverse macroeconomic developments. Under the most severe scenario, the estimated total capital shortfall amounts to 1 percent of GDP. The results of the solvency stress test reflect comfortable initial capital buffers built in response to the crisis, in part because of de-risking of balance sheets, and in part due to banks' recapitalization efforts through increased retained earnings. However, these results need to be interpreted with caution given asset quality—particularly in some CESEE countries—is still deteriorating and difficult to assess with full confidence. The upcoming bank asset quality reviews by the ECB should provide a more robust basis for assessing the strength of the balance sheets of Austrian banks and the policy responses that may be needed. Also the three-year stress testing horizon does not consider the repayment of state participation capital which benefited from a grandfathering clause under the Basel III phase-in transitional schedule (until 2018) or the potential implementation of a capital surcharge on domestic systemic institutions (from 2016 on). More generally, stress tests are subject to a number of methodological limitations that should be kept in mind when interpreting their results (para. 77).

The banking sector appears well positioned to meet Basel III capital requirements. On aggregate, the banking sector would comfortably pass the hurdle rates laid out by the Basel III phase-in arrangements for CET1 under the most severe scenario. Capital buffers above the minimum Tier 1 capital ratio are somewhat thinner as Austrian banks hold limited amounts of non-common equity Tier 1 qualifying capital, in the form of private preferred stock and minority interests.

Austrian banks' funding structure appears resilient across major currency buckets. Under a severe 30-day funding stress scenario, the total liquidity shortfall is estimated at only 0.1 percent of total liabilities. Liquidity stress tests show that the foreign currency liquidity position of the system has substantially improved since 2008, although some banks will have to continue their efforts regarding their CHF funding. The improvement in the liquidity position of Austrian banks can be attributed to enhanced liquidity supervision and monitoring by the OeNB and strengthened supervisory standards of banks' liquidity risk management.

The Austrian banking system is also robust to funding and contagion shocks based on network analysis. Large banking groups do not experience losses due to their strong counterbalancing capacity, as well as to the network structure of the Austrian interbank market. The impact on capital

adequacy for the whole banking system is not material and is driven primarily by fire sales rather than by rising funding costs or contagion defaults.

The risks of cross-border spillovers between Austrian and other peer banks active in the CESEE region appear contained. The results suggest that the risk that severe distress affecting the top two Austrian banks is transmitted to other banks in CESEE is not negligible, but is, on average, less that the systemic risk potentially introduced by severe distress affecting other CESEE peer banks. The analysis on inward cross-border spillovers suggests that the transmission of severity by CESEE peers to Austrian banks does not appear to be significantly different from that on other banks in the region. The analysis also provides some evidence for the need to combine a micro-prudential and macro-prudential perspective in the regulation of systemic institutions given the weak link between large European banks' individual solvency risk and their estimated contribution to systemic risk.

Table 1. Austria FSAP Update: Main Recommendations on Stress Testing

Recommendations	Priority	Timeframe [1/]
Consider assessing the impact of different regulatory ratios across CESEE jurisdictions and of potential ring-fencing of cross-border flows between foreign subsidiaries and parent banks on consolidated regulatory ratios of Austrian banks.	High	Near-term
Consider modeling credit risk in the CESEE based on insolvency data—subject to data availability—to avoid reliance on loan loss provisioning data amid asset quality concerns.	High	Medium-term
Continue developing the funding/contagion analysis by: • endogenizing fire sales and funding costs; • allowing for domino effects from cross-guarantee schemes and cross-holdings of unsecured paper; • extending the network of bilateral exposures to global banks.	High	Near-term
Consider including market risk factors, including rises in risk premia, in the satellite model for credit risk in domestic and cross-border exposures.	Medium	Immediate
Consider developing a framework to identify and measure banks' individual contribution to systemic risk for the largest Austrian banks (at the national/regional/global level) drawing on market-based approaches such as CoVaR.	Medium	Medium-term
Contribute to developing approaches to integrate solvency, liquidity, and market shocks in stress test scenario design, include second-round effects implied by the stress scenario—particularly on credit growth—and allow for the transmission of behavioral shocks.	Medium	Medium-term

[1/] "Immediate" is within one year; "near-term" is 1–3 years; "medium-term" is 3–5 years.

INTRODUCTION[1]

1. The Austrian stress testing exercise takes place during a period of gradual economic recovery following a period of financial turbulence.[2] The equity base of the Austrian banking system on the whole has strengthened, the liquidity situation has improved, and profits have firmed up following the Austrian government capital injections,[3] increased reliance on decentralized funding models, and the steady recovery of the CESEE region.[4]

2. The Austrian banking system has a commercial banking focus with net interest income as the key source of profits (Figure 1). Net interest income amounted to almost three times the income from securities holdings in 2012.[5] The breakdown of Austrian banks' securities portfolio tilts towards fixed income instruments (two thirds), followed by Treasury bills and central banks' eligible instruments (one fourth), and shares and other variable-yield securities (10 percent). Following tumbling profits in 2011, mainly driven by a step-up in securities loss provisions—including losses against participations in affiliated companies, recent developments point at a recovery of after-tax profits, in spite of the denting effects caused by the financial transaction tax introduced in 2011.[6] Return on assets has also picked-up in 2012 standing at 0.3 percent.

[1] Prepared by Laura Valderrama (MCM). The FSAP team would like to express its deep gratitude to counterparts at the Oesterreichische National Bank (OeNB) for their fruitful cooperation, close collaboration, and key inputs into this Technical Note.

[2] The 2008-09 global financial crisis exerted significant pressure on Austria's financial system leading to the full or partial nationalization of three mid-sized domestic banks.

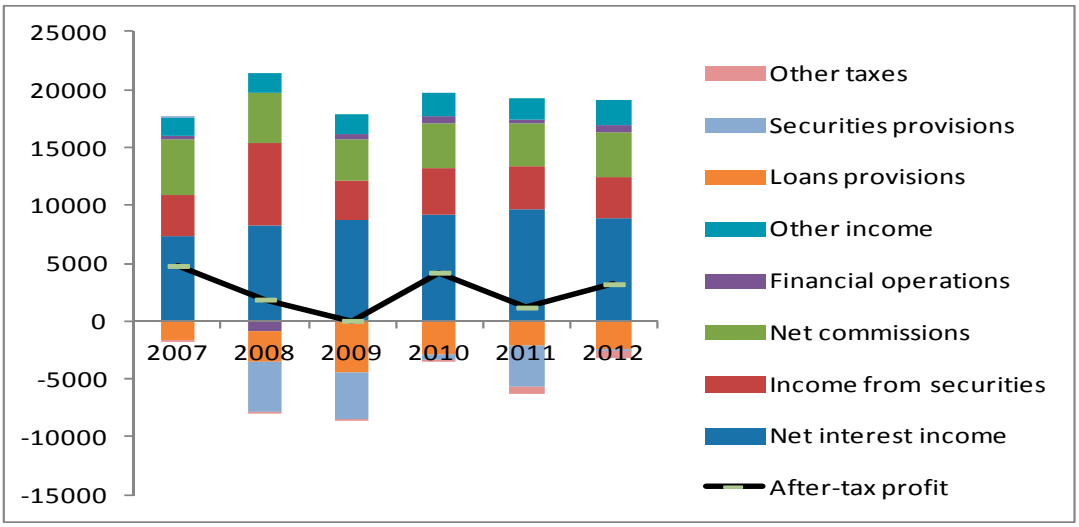
[3] In October 2008, the Financial Market Stability Act (FinStaG) authorized the recapitalization of systemically important financial institutions up to €15 billion. As of Dec 2012, €13.6 billion were utilized of which capital injections reached €5.9 billion.

[4] The acronym CESEE stands for Central Europe and South Eastern Europe. It includes new EU member states in 2004: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia; new EU member states in 2007: Bulgaria, Romania; countries in South-Eastern Europe: Albania, Bosnia and Herzegovina, Croatia, Kosovo, Macedonia, Montenegro, Serbia, Turkey; and Commonwealth of Independent States: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan.

[5] Income from securities net of provisions fell to €2.9 billion in 2008 from a pre-crisis level of €3.6 billion in 2007 and turned negative at -€0.7 billion in 2009 before picking up in 2010.

[6] Other than profit or loss taxes reached 15 percent of pre-tax profit in 2012.

Figure 1. Profit Breakdown for the Austrian Banking System
(in billion euros)



Source: OeNB and IMF staff estimates

3. The outlook assessment of expected profits is not straightforward given the diversity of activities and exposures of Austrian banks. While profit projections for the three large internationally active Austrian banks hinge on developments in the CESEE region, banks with a domestic retail focus are heavily reliant on the prospects for the Austrian economy. Each of these two groups accounts for about 45 percent of banking system assets. On the other hand, the prospects of (partially) nationalized medium-sized banks, representing about 7 percent of total assets, are mainly linked to the effectiveness of recovery and resolution plans already in train.

4. Baseline forecasts for Austria and the CESEE region show a macroeconomic upturn, albeit at a lower growth rate than before the crisis (Figure 2).[7] While Austria's macroeconomic fundamentals compare favorably with the rest of the euro area, growth remains subdued in 2013, gradually picking up in 2014–2015. The medium-term growth prospects for the CESEE region, although lower than prior to the crisis, remain stronger than those for advanced economies.[8]

5. The Austrian banking system presents a diversity of business models and corporate structures. The banking sector is comprised of more than 800 unconsolidated institutions, with total

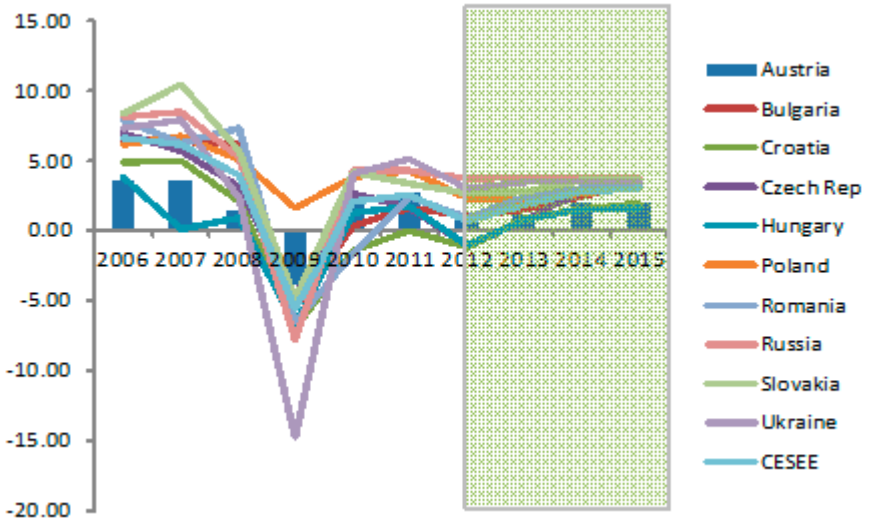
[7] The baseline forecast for the CESEE region is constructed as a BIS-weighted average of individual countries' projections as of June 2012.

[8] The WEO projections considered in the stress testing exercise are as of Oct 2012. The average annual forecast for CESEE stood at about 3 percent over 2013-2015, compared to an estimated 2 percent forecast for advanced economies and 1 percent for the euro area. The revised WEO projections published in October 2013 kept the gap between CESEE and advanced economies projections by near 1 percentage point although at a lower level. Growth projections have been reduced by an annualized 0.3 (0.4) percentage points for the CESEE region (Austria) over the stress test horizon. T.

consolidated banking sector assets amounting to about €1.1 trillion, or more than 3.5 times GDP in 2012 Q3. The three large internationally active banks account for almost half of total bank assets. The banking system can be divided into a few broad categories based on legal form and traditional business focus. These are, in order of size of assets: joint stock banks, cooperatives banks, savings banks, regional banks and other institutions (Table 1). Many Austrian banks have a multi-tier corporate structure. Cooperatives banks are owned by their depositors and include institutions that were initially set up to promote lending in industrial and agricultural sectors, for example the Volksbanken and Raiffeisen banking groups respectively.[9] Savings banks have a somewhat different structure, in which the primary banks partially own the apex institution and there is a cross-guarantee on the liabilities of the group.

Figure 2. Baseline Growth WEO Forecast as of October 2012

(in percent)



Source: WEO database.

Note: The chart shows the annual projections for real GDP growth for Austria, the most relevant CESEE countries (in terms of Austrian banks' exposure as of June 2013), and the BIS-weighted CESEE regional projections.

[9] The Volksbanken sector has a two-tier corporate structure, in which the central institution is owned by a number of local banks. The Raiffeisen sector has a three-tier structure in which the central institution is owned by regional banks, which are in turn owned by local banks.

Table 2. Financial System Structure

	December 2007				September 2012			
	Number	Assets (EUR billion)	Percent of total assets	Percent of GDP	Number	Assets (EUR billion)	Percent of total assets	Percent of GDP
Banking Sector	870	889	77	327	812	1,092	80	362
Joint stock and private banks	51	251	22	92	44	261	19	87
Savings banks	56	150	13	55	51	165	12	55
Rural credit cooperatives	558	222	19	82	523	304	22	101
Industrial credit cooperatives	69	69	6	26	65	66	5	22
State mortgage banks	11	88	8	32	11	86	6	28
Building societies	4	21	2	8	4	123	9	41
Special purpose banks	93	87	8	32	84	87	6	29
Insurance sector	50	82	7	30	50	108	8	36
Pension funds	19	13	1	5	19	16	1	5
Mutual funds	2,329	166	14	61	2,329	147	11	49
Total financial system	**3,268**	**1,149**	**100**	**423**	**3,210**	**1,363**	**100**	**452**

Source: OeNB

6. Austrian banks have sizable cross-border linkages, especially in the CESEE region, but are not significantly exposed to European peripheral countries. Direct and cross-border lending exposures amount to nearly €460 billion, of which €326 billion are to CESEE countries or under 30 percent of overall banking system assets, mainly through an extensive network of local subsidiaries.[10] This diversified regional exposure is highly concentrated in the large internationally active banks (for over 80 percent of aggregate subsidiary assets). Conversely, Austrian banks are primary lenders in CESEE countries, with market shares above one-third in Slovakia, Bosnia, Romania, Albania, and the Czech Republic. On the other hand, foreign-owned banks in Austria represent more than 25 percent of the total banking system by assets, and are dominated by one large bank and two mid-sized banks. Austrian banks' exposure to European peripheral countries fell to €31 billion from €45 billion in 2008, of which 17 percent were claims on the public sector and 24 percent claims on credit institutions in these countries.

7. Although Austrian public debt has increased significantly during the crisis, it stands below the average for advanced economies and compares favorably to other Aaa-rated peers. The public debt ratio is expected to reach a peak in 2013 at around 74 percent of GDP well below the expected 109 percent ratio for advanced economies and 95 percent for the euro area.[11] Baseline projections show that the public debt ratio will decline gradually towards pre-crisis levels of 60 percent of GDP supported by a medium-term reduction of general government debt. Government support to the banking system has been significant, including through the nationalization of three medium-sized banks. While the authorities' fiscal consolidation plans are on

[10] Total assets of foreign subsidiaries in CESEE reached €234 billion, or over 70 percent of total exposure to the region, in Sep 2012.

[11] International Monetary Fund (2013), *Fiscal Monitor*, Chapter 1 (April) (Washington: International Monetary Fund).

track, uncertainties related to the restructuring of the nationalized banks and the realization of contingent liabilities remain.[12]

8. The improvement of Austrian banks' liquidity position has been supported by the ECB's and the SNB's monetary operations, as well as by the OeNB's enhanced supervisory and regulatory requirements. Since 2008, banks have continuously improved their liquidity position across major funding currencies. The increase in liquidity buffers has been mainly facilitated by the ECB's monetary policy, the repo operations conducted by the SNB, and the swap facilities provided by the SNB and the ECB. Reflecting a recent pick-up in deposit growth at Austrian banks, their dependence on ECB financing is, however, relative low relative to their euro zone peers.[13]

9. The objective of the FSAP stress testing exercise is to assess the resilience of the Austrian banking sector to adverse macroeconomic conditions and severe stress in global funding markets. The solvency test consists of a TD test undertaken by the OeNB collaboratively with the FSAP team conducted on all 585 consolidated banks licensed in Austria. BU solvency stress tests—focusing on market and sovereign risk—were run by the five largest banks (representing about 60 percent of banking system assets).[14] A liquidity stress test covering the largest 29 banking institutions (accounting for around 80 percent of total assets), was conducted based on a range of adverse scenarios, broken-down by major currency, and with severe liquidity stress lasting for up to one year. A contagion module assessed the potential for distress in an individual banking institution to create risks to overall financial stability.

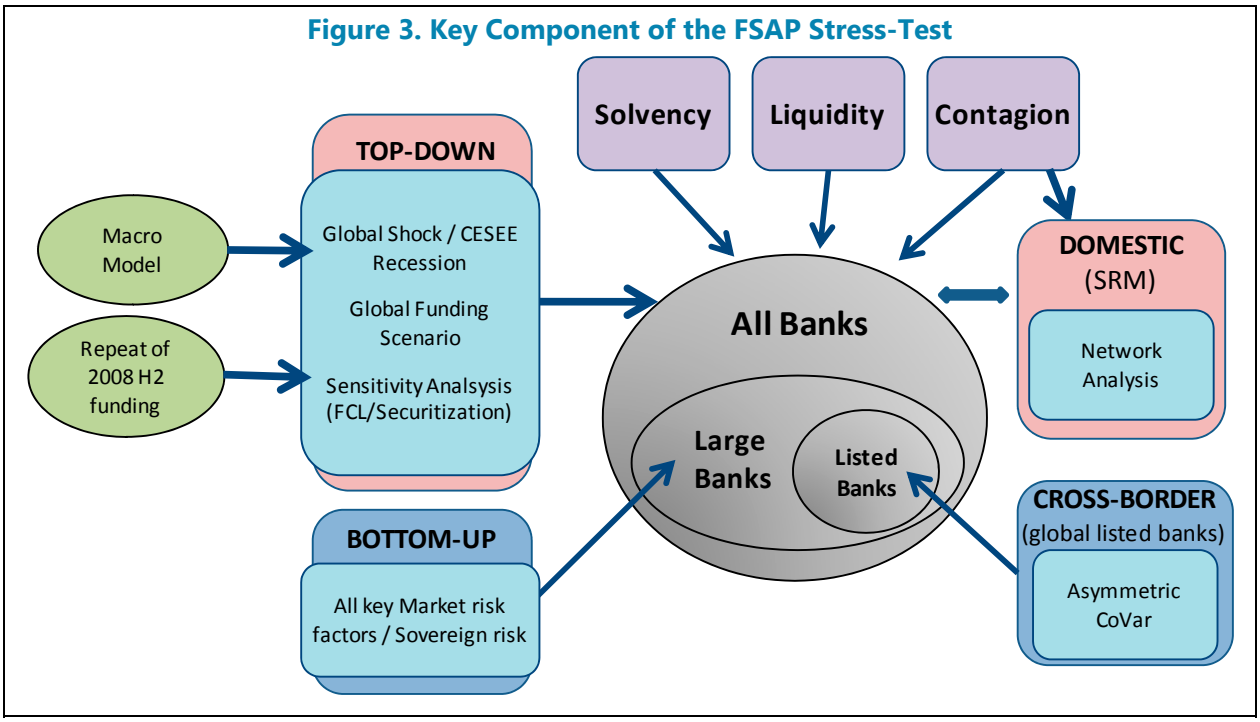
10. Major risk factors were included in the stress tests (Figure 3). To assess credit risk from cross-border exposures, country specific macroeconomic scenarios were generated for twenty-two CESEE countries besides the Austrian economy. A global funding scenario reflecting post-Lehman conditions through increased funding costs and restricted market access in FX swap markets, was used to generate solvency effects from negative funding gaps through fire sales. The potential for domino effects was assessed using a network model of the Austrian interbank market. Contagion effects through financial markets were evaluated using the CoVaR methodology.

[12] See IMF Country Report No. 13/280 for further discussion on public debt projections.

[13] Austrian banks participated in the two ECB's supplementary longer-term refinancing operations (Dec 2011, Feb 2012) with a total volume of EUR 15.7 billion, which corresponds to 1.5 percent of the total allotted volume, well below the proportionate share of Austria in the Eurosystem (3.8 percent) (OeNB Financial Stability Report 24, December 2012).

[14] The FSAP team and the Austrian authorities agreed to implement a focused BU stress test in order to avoid undue burden of banks amid expectations of concurring EU-wide EBA BU stress tests in 2013Q2. Sovereign risk was assessed using a TD approach on granular data provided by the five largest banks. Market risk was examined using a BU approach under IMF-OeNB guidance.

Figure 3. Key Component of the FSAP Stress-Test



11. This technical note is organized as follows. Section II outlines the main risk factors affecting the Austrian banking system. The solvency stress test scenarios, methodology, and results are presented in Section III. The calibration and findings of the liquidity stress tests are explained in Section IV. The interplay between liquidity and solvency effects are shown in Section V. This section also contains the contagion analysis conducted to capture the potential for cascading defaults and fire sale externalities based on network analysis. Contagion through financial markets is examined using a market-based CoVaR approach. The conclusion and main recommendations are laid out in Section VI.

KEY RISK FACTORS

12. Drawing on the FSAP team's assessment of global and domestic *key risks*, three external shocks were identified (Annex I): (i) shocks arising from a global slowdown or a resurgence of the euro area sovereign debt crisis from incomplete policy commitments, subdued private domestic demand or frontloaded fiscal consolidation in peripheral countries; (ii) spillovers from the CESEE region due to the escalation of economic imbalances or the realization of political risk in large-exposure countries, and (iii) severe funding stress in global markets including the inability to issue short-term debt or trade cross-currency swaps.

13. A complementary market-based approach was used by the FSAP team to yield insights on the main vulnerabilities affecting large banks' solvency risk (Annex II). To drill down on market-perceived vulnerabilities, the FSAP team conducted an econometric analysis on the credit risk of the largest listed banks. The analysis looked at the main determinants of major Austrian banks' solvency risk. The risk factors examined belong to three main categories: (i) Austria macro-

financial variables including revisions to market forecasts; (ii) contagion from the main sub-regions in the CESEE, i.e., New EU Member States 2004 (NMS-04), New EU Member States 2007 (NMS-07), Southeastern Europe (SEE), and the Commonwealth of Independent States (CIS).[15] To capture CESEE-specific factors, we proxy contagion by credit stress in the region which is unrelated to either domestic or global developments; and (iii) global risk factors, including changes in the state of the global economy as well as developments across asset classes from investors' portfolio reallocation under stress. The latter include estimated time-varying risk premia from the US equity and fixed income markets, namely equity premium, volatility risk premium, and term premium. The approach builds on Longstaff et al (2011) and uses monthly changes in the credit default swap (CDS) market and in Moody's KMV expected default frequencies (EDF) to provide a direct measure of changes in market perception of solvency risk. The sample covers the two most widely traded Austrian bank stocks for which CDS spreads or EDF quotes are available. All variables are expressed in monthly changes. The exact definition of the variables is contained in Annex II Table 1. For each bank we regress monthly changes in CDS spreads and EDF estimates on the set of relevant explanatory variables. The time series starts in October 2007 and ends in October 2012.[16] Results are shown in Annex II Table 2.

14. Overall, the major risk factors over the short- and medium-term affecting the stability of the Austrian banking sector are listed below:

i. *Deteriorating asset quality*. A sharp slowdown in Austria and the CESEE countries could impact significantly asset quality of banks' domestic portfolios, cross-border operations, and foreign subsidiaries' loan book.

ii. *Declining profits***.** While domestic credit growth has lost steam, a protracted growth slowdown in CESEE countries could erode significantly net interest margins. Given the high share of CESEE subsidiaries' profits in total consolidated net operating profits, a persistent depreciation of local currencies vis-à-vis the Euro could further affect banks' profitability.[17]

iii. *Credit risk from foreign currency lending*. Exchange rate volatility (e.g., CHF) or asset price declines associated to repayment vehicles loans (RPVs) could increase credit risk due to the legacy of banks' FCLs to Austrian households. The high share of FCLs in CESEE may also weigh on credit quality following a sell-off of domestic currencies. The econometric analysis points at the significance of FX developments in CESEE.

[15] The CESEE country aggregates include: NMS-04: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia; NMS-07: Bulgaria and Romania; SEE: Albania, Bosnia and Herzegovina, Croatia, Macedonia, Montenegro and Serbia; and, CIS: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.

[16] The time span is driven by the availability of EDF estimates for a major bank.

[17] CESEE subsidiaries' share in total consolidated net operating profits has fluctuated around 50 percent over 2006–2012.

iv. *Sovereign risk.* Although the risk of adverse feedback loops between Austrian banks and sovereign appears unlikely, sovereign risk perceptions have deteriorated during the financial crisis.[18] Also, lower valuations of government bonds in CESEE countries, driven by downward revisions to growth or fiscal slippages, could weigh on banks' capital positions. Rising term premia, reflecting the unwillingness of market participants to hold long-term paper despite a low short-term interest environment, could further dent securities' valuations as suggested by the econometric results.

v. *Market risk.* A widening in credit spreads on European financial institutions or corporate entities could affect banks' profitability directly through valuation effects on net open positions or indirectly through an increase in risk weights. This effect comes out significant in the econometric analysis. Also exposure to a broad-based financial market downturn affecting a wide set of risk parameters including interest rates, exchange rates, equity returns, commodities, credit spreads, and counterparty risk may erode banks' profits albeit the impact is expected to be contained given the commercial focus of the banking system.

vi. *Securitization risk.* Rapid and abrupt downgrades of structured credit products may have a non-trivial impact on capital adequacy ratios as revealed by the breadth and depth of rating downgrades observed during the global financial crisis.[19]

vii. *Funding/Rollover risk***.** Rising libor-ois spreads, dry-up of issuance in money markets, and disruptions in foreign exchange swap markets in the face of winding down of swap facilities by the SNB, may affect Austrian banks' refinancing costs or their ability to rollover maturing contracts leading to potential cascade effects through the interbank market.

viii. *Financial contagion.* The propagation of financial distress through fire sales, the interbank market or contagion from banks following similar business models may affect the solvency/liquidity position of Austrian banks as suggested by the pick-up in correlation of market performance under stress.

ix. *Regulatory changes***.** Upcoming regulatory changes including the implementation of Basel III capital requirement through the CRD IV/CRR directive[20] and the repayment of public participation capital in the context of state aid may add to the above pressures on Austrian banks.

15. Stress tests are linked to the main risks identified above. The macro stress tests cover (i),

[18] Whereas Austrian banks have benefited from a substantial sovereign support rating uplift, a potential sovereign downgrade could have balance-sheet valuation effects and impact banks' funding cost.

[19] The Global Financial Stability Report (Oct 2009) chronicles the evolution of securitization markets during the global financial crisis and offers policy proposals to restart issuance.

[20] The European CRD IV/CRR directive is expected to come into force in January 2014. Full implementation of Basel III is scheduled for January 2019. The phase-out of participation capital in the context of state aid from CET1 qualifying capital has been grandfathered until January 2018.

and (ii); sensitivity analysis assesses (iii) through (vi); liquidity stress tests examine (vii), and contagion analysis looks into (viii). The impact of regulatory changes (ix) is covered in the overall discussion on banks' capital adequacy assessment.

SOLVENCY STRESS TESTS

A. Macro Scenarios

16. Solvency stress tests were conducted for the entire Austrian banking system using supervisory and macroeconomic data as of end-2012 over the forecasting period 2013–2015. End-of-year supervisory reported data on a consolidated basis became available in May 2013.

17. A two-pronged approach to solvency stress testing was adopted:

- *Top-down tests* conducted collaboratively with the OeNB covering all 585 banks licensed in Austria, based on quarterly baseline projections generated by the Austrian Quarterly Model (AQM) for Austria.[21] Baseline forecasts for CESEE individual countries were generated by the FORCEE model developed by the OeNB.[22] These forecasts are broadly consistent with the IMF WEO forecasts for the region published in October 2012.[23]

- *"Light bottom-up" tests* conducted by the largest five banks (representing about 60 percent of banking system assets) focusing on market risk (with a comprehensive coverage of major risk factors), and sovereign risk (covering all sovereign exposures across all maturity buckets on a consolidated basis).

18. The severity of the stress test is in line, or exceeds, that of recent FSAPs as country-specific adverse scenarios were generated for twenty four countries of relevant exposure to Austrian banks.[24] Two adverse macro scenarios and one global funding stress scenario were considered (Figure 8):

[21] The AQM is a medium size macroeconomic model and consists of 107 equations and 217 variables extracted from different data sources (Schneider and Leibrecht, 2006). The model combines neoclassical long-run behavior with Keynesian short-run dynamics and is in line with the multi-country model developed jointly by the central banks of the euro system and the ECB.

[22] The FORCEE model follows a vector error correction model approach using quarterly Eurostat data over 1995–2012, using 1- to 12-steps-ahead dynamic forecasts from seemingly unrelated regressions.

[23] The forecast path for Austria is consistent, though somewhat more conservative, than the October 2012 IMF WEO forecast. Likewise, the October 2012 IMF WEO projections for CESEE countries are broadly in line with the OeNB baseline forecast. The slight downward revisions for Austria and selected CESEE countries published in April 2013 have not been incorporated into the analysis.

[24] For the Austrian economy, the 2-year cumulative growth over 2013-2014 is projected at 3.05 percent under the baseline scenario and at -2.97 percent under the adverse scenario. The magnitude of the shock generated under the stress scenario is significantly larger than that forecasted by the WEO downside scenario at 1.86 percent.

- *A global shock and intensification of the euro area economic crisis*, generating a two-standard deviation shock to Austrian GDP growth and spillover effects to the CESEE/CIS region leading to a deviation from baseline growth of one and a half standard deviation across the region.[25] The severity of the shock is applied to the aggregate CESEE region weighted by country-specific exposures of Austrian banks.

- *A severe recession in CESEE/CIS*, consisting in aggravated downturns relative to the previous scenario, bringing trend regional growth down by 1.8 standard deviations (together with a two-standard deviation shock to Austrian GDP growth).[26]

- *A global funding scenario* reflecting the acute stress conditions observed in late 2008 when the global financial crisis hit global and Austrian banks including through increased funding costs and restricted market access in FX swap markets.

19. To assess credit risk from cross-border exposures, country specific macroeconomic scenarios were generated for twenty-two CESEE countries. The OeNB solvency stress testing platform offers a high degree of granularity in the breakdown of credit exposures that allows the construction of adverse macro scenario by country of exposure. Specifically, a battery of adverse scenarios were developed for twenty-two countries[27] using a G-VAR model developed by the OeNB covering 51 countries and the euro area estimated over 1995–2012. A double-dip shock to real GDP growth from baseline growth trend is applied over the first two years with positive adjustment dynamics during the last year of the stress test horizon.

B. Modeling Approach

20. The approach to credit risk modeling as a function of macroeconomic developments differs across domestic and cross-border exposures. The exposure at default (EAD) from domestic and cross-border credit stood at 56 percent and 44 percent, respectively. Exposures to the CESEE region accounted for about 70 percent of all cross-border exposures.

[25] The SD shock is computed on year-on-year quarterly real GDP growth data over 1990Q1-2012Q4 for Austria, and from1997Q1 through 2012Q4 for all CESEE countries except for Bulgaria and Romania for which the time series begins in 2000Q1, and Bosnia & Herzegovina and Montenegro for which annual data is used starting in 1998 and 2000, respectively.

[26] Deviations from baseline growth forecasts for countries to which Austrian banks are most exposed (Croatia, Czech Republic, Poland, Slovak Republic) or with persistent economic imbalances (Hungary, Romania, Ukraine) reached about 2 SDs. The country-specific shocks are treated as idiosyncratic shocks without triggering further contagion effects on other countries.

[27] These include New Member States 2004 (NMS-04): Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia; New Member States 2007 (NMS-07): Bulgaria and Romania; South Eastern Europe (SEE): Albania, Croatia and Turkey; and Commonwealth of Independent States (CIS): Armenia, Azerbaijan, Belarus, Georgia, Kyrgyzstan, Moldova, Russia, Tajikistan, and Ukraine.

- For domestic exposures, a credit risk model links sectoral corporate probabilities of default (PD) in six Austrian corporate sectors to a wide range of observable macroeconomic variables and a latent risk factor (Box 1).

- A separate satellite model based on country specific CESEE loan loss provisioning ratios (stock and flow ratios) is calibrated to assess credit risk in cross-border operations and foreign subsidiaries.[28] Changes in provisioning ratios are used to proxy changes in PDs.

21. The stressed loss given default (LGD) is estimated separately for collateralized and uncollateralized exposures:[29]

- For real estate collateral, country-specific haircuts are estimated for CESEE countries based on the elasticity of GDP growth to house prices and the GDP growth path projections under each scenario.[30]

- For uncollateralized exposures, a country-specific LGD, capped at 45 percent for Austria, and linked to the World Bank Doing Business Statistics for CESEE countries—with the distribution truncated at 80 percent—is generated under the baseline scenario. This value is stressed through linear increments each quarter reaching a final add-on of 10 percentage points in 2015Q4 under the adverse scenario.

22. During the stress test horizon profits decline significantly mainly driven by a depreciation of host country currencies[31] and the contraction of banks' balance sheet:

- Weak macroeconomic performance in the macro stress test triggers the depreciation of local CESEE currencies relative to the Euro.

- The sustained cumulative depreciation reaches 1.5 (2.0) SD under the adverse (severe) scenario in 2013–2014, with a partial and gradual rebound assumed during the last year of the stress test horizon.[32]

- This effect is significant as CESEE subsidiaries' share in total consolidated net operating profits reached over 50 percent in 2012 Q2.[33]

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[28] A fixed effect panel estimation is combined with expert judgment drawing on local best practice and past crisis experience.

[29] Collateral information is collected at the most granular level on a creditor basis from the central credit registry.

[30] House price elasticity to GDP growth is estimated using a fixed effect panel regression and adjusted to reflect weaknesses in the housing market not captured by the model.

[31] Local CESEE currencies are assumed to depreciate vis-à-vis the Euro except for the currency pegs (Bosnia and Herzegovina, Belorussia, Latvia, and Lithuania).

[32] In line with the macro scenario, positive dynamics during 2015 trigger a rebound in market rates with FX stabilizing at 60 percent below pre-stress levels relative to the Euro. The calibration is based on the rebound of a basket of CESEE currencies experienced in the wake of financial distress.

- Operating profits decline further triggered by a drop in net interest income caused by performing loans becoming non-performing. It is assumed that all the components of operating profits decline in line with net interest income.[34]

Box 1. Overview of the OeNB's Credit Risk Model for the Austrian Economy[1/]

The endogenous variables of the credit risk model are quarterly default frequency rates over 1985-2011.[2/] The Austrian economy is divided in the following corporate sectors: construction, production, trade, transport, tourism and services. The set of explanatory variables include nineteen macroeconomic time series. For each variable, up to six quarterly lags are considered."

For each corporate sector, the number of explanatory variables is selected by applying the Forward-Stepwise Selection algorithm.[3/] For each number of regressors, the best five models are selected in terms of their explained sum of squares. Each model is estimated with an unobserved component reflecting a latent risk factor according to the following specification:

$$y_{i,t} = \beta_{0,i} + \sum_{j=1}^{k} x_{j,t}\beta_{j,i} + z_{i,t}\lambda_i + \varepsilon_{i,t}$$

$$z_{i,t} = z_{i,t-1}\phi_i + w_{i,t}$$

where y_i is the logit-transformed sectoral default frequency rate for sector i, k is the number of macroeconomic variables, x_j is the jth macroeconomic variable, z_i is the unobserved factor, and ε_i and v_i are uncorrelated error terms.

Aggregate credit risk is driven by both common variables across multiple sectors as well as by sector-specific variables. Common variables include inflation, interest rates, and credit growth; the latter enters with a negative sign suggesting that credit growth is driven mainly by productive investment projects rather than by lenient prudential standards. Sector-specific variables include, for instance, exports in the transport sector, capital investment in the trade sector, and oil prices in the construction sector.

The results suggest that a latent risk factor is only significant in small credit risk models. For credit risk models including more than seven macroeconomic variables, the evidence for a latent risk factor vanishes. This suggests that a broad macroeconomic dataset is able to capture most of the drivers of credit risk. Hence the Austrian credit risk models—given the availability of a wide set of macroeconomic data for the Austrian economy—do not have to rely on latent factors.

1/ Based on Kerbl, S. and M. Sigmund (2011).
2/ Default frequencies are estimated as the ratio of quarterly defaults to the total number of firms drawing on the *Kreditschutzverband von 1870* database.
3/ The Forward Stepwise Selection method starts with an intercept and adds the regressors which contribute most to the fitness of the model as measured by the BIC.

[33] CESEE operations generate significantly more profits than domestic operations as the share of CESEE subsidiaries in total consolidated assets stood below 25 percent in 2012Q2.

[34] Operating profits reflect the relatively more stable net income stream from banks' core business including net interest income, fees and commissions, trading income, investment in associates, other operating results, administration costs and depreciations.

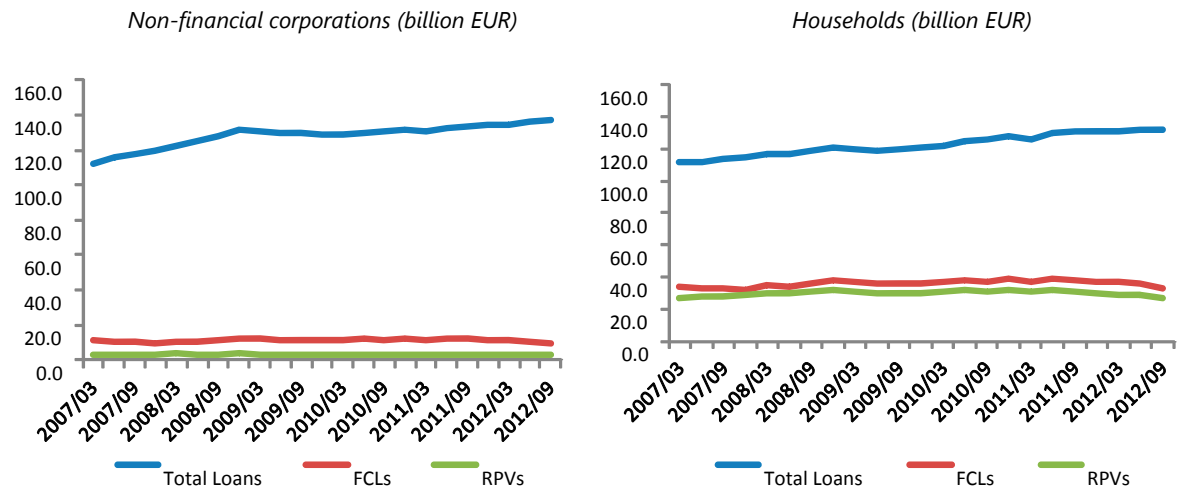
C. Sensitivity Analysis

Foreign Currency Lending

23. A sensitivity analysis on foreign currency lending was conducted to quantify the indirect credit risk from a FX shock. Foreign currency loans (FCLs) pose additional risk due to the declining ability to pay of unhedged borrowers spearheaded by the appreciation of foreign currency. The analysis was conducted separately for domestic and CESEE exposures. The methodological approach was a function of the structure of the loans and the availability of data sources.

24. The legacy of FCLs in Austria remains a concern even if new foreign currency lending has come to a halt (Figure 4).[35] As of 2012 Q3, FCLs to domestic non-banks amounted to €50.7 billion, corresponding to 15.3 percent of all domestic loans, of which € 34.6 billion were owned by households (share of 25 percent of housing loans) and € 10.0 billion by corporates (share of 7 percent of loans to non-financial corporates).

Figure 4. Breakdown of Bank Lending by Borrower



Source: OeNB

25. Given the predominant structure of domestic FCLs as bullet loans with long remaining maturities,[36] **credit risk from a FX shock was assessed using an indirect approach (Box 2)**. About 60 percent of FCLs to households and corporates are arranged as bullet loans, associated

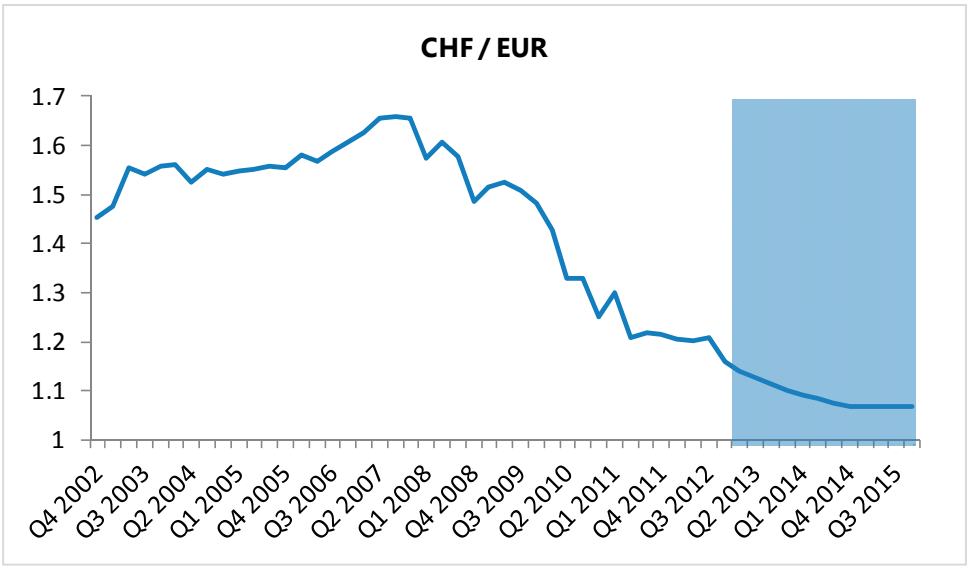
[35] Banks have refrained from new issuance of FCLs to Austrian households following the tightening of FMA Minimum Standards in January 2013 along with the previous guidelines issued in 2008 and 2010. Austria has implemented the recommendations issued by the ESRB on FCLs.

[36] As of 2012Q3, almost 80 percent of FCLs associated to a RPV showed a maturity beyond 2020.

with repayment vehicles (RPVs), with 40 percent being amortizing loans. An analysis based on loan loss provisioning data would not be reliable as bullet loans hardly show any default event. Also, mounting credit risks typically propel the conversion of FCLs into Euro loans biasing the analysis. In effect, the provisioning rate on FCLs granted to non-banks stood at 1.1 percent in 2012 Q3, less than one third of that associated to euro loans which may, however, underestimate latent credit risk which could crystallize at maturity.

26. The analysis assumes a protracted appreciation of the Swiss Franc vis-à-vis the Euro. The sensitivity analysis is conducted for Swiss Franc loans. About 90 percent of FCLs to households and corporates are denominated in Swiss Francs. We assume that the Swiss Franc appreciates by 1.5 SD over 2012Q3–2014Q4 with the nominal exchange rate climbing from 1.21 to 1.07 and stabilizing in the last year of the stress test horizon[37] (Figure 5).

Figure 5. FX Scenario for the Swiss Franc



Source: Dealogic and IMF estimates

27. In addition, bullet loans associated to RPVs are exposed to market risks that may weigh on the performance of the investing vehicle impairing borrowers' debt servicing capacity. FCLs linked to RPVs involve the risk that in case of adverse exchange rate developments or capital market underperformance the capital accumulated through the RPV may not suffice to repay the loan at maturity. RPVs are closely associated to FCLs. From the €30.0 billion bullet loans outstanding in September 2012, €25.8 billion were FCLs, of which €24.0 billion were denominated in CHF. On the other hand, 60 percent of all FCLs are linked to RPVs. The risk characteristics of RPVs vary across product categories. About three quarters of RPVs are directly linked to capital market

[37] This is equivalent to an appreciation of the Swiss Franc vis-à-vis the Euro of 13 percent over 2012Q3–2014Q4.

developments with over half of outstanding loans linked to mutual funds-based life insurance instruments.

28. A separate sensitivity test was conducted by the FSAP team to examine the potential rise in estimated projections of baseline funding gaps of RPVs under adverse market developments (Annex IV). The analysis dew on the breakdown of market sensitive investment vehicles across asset classes using tail returns of proxy distributions under the estimated annual payments implicit in the computation of current funding gaps. A combined scenario added distress from market underperformance to FX shocks. The results of this analysis should be interpreted with caution. A number of extensive assumptions had to be made to the many unknowns in the underlying data. Also these figures provide a conservative estimate as the FX shock has been included separately in the sensitivity analysis of the solvency stress test to calibrate indirect credit risk in the domestic portfolio.

Box 2. Indirect Credit Risk from FCLs in Austria

The modeling framework assumes that FCL borrowers are unhedged. An appreciation of CHF triggers an increase in the value of outstanding debt expressed in EUR by $D * \Delta FX$ (where FX is the nominal exchange rate of EUR per CHF). This leads to a rise in the debt-to-income ratio by $\frac{D}{I} * \Delta FX$ which in turn affects credit losses with an elasticity estimated at 2.5.

The increase in loan-loss provisioning rates can be approached by:

$$\Delta LLPR = -2.5 * \frac{D}{I} * \Delta FX$$

We assume a protracted appreciation of the Swiss France vis-à-vis the Euro with volatility equal to 1.5 SD. The exchange rate path is driven by the square root of t-law:

$$FX_t = FX_0 * \exp^{\left(\sqrt{t} * 1.5 * \sigma\right)}$$

Additional impairments from the equation above are distributed equally over each loan's remaining maturity. The stress test loss is the accumulated loss over the stress test horizon 2012Q4-2013Q1.

29. Credit risk from FCLs in CESEE countries was assessed drawing on impairment data broken down by currency. A 'FX boost factor' defined as the elasticity of changes in loan loss provisioning rates (LLPRs) relative to local currency loans triggered by an appreciation of the FX is applied to all FCLs in Swiss Francs.[38] The difference between the LLPR of FCL, assuming they develop like local currency loans, and that including the FX boost effect is computed as the additional losses attributed to the sensitivity test.

[38] The elasticity is the average estimate of fifteen different models that fit the excess loss provisioning rates of FCLs to changes in the FX, assuming non-linear functional forms (i.e. exponential and quadratic) and using different selection criteria to fit the curves.

30. Cross-rates between local currencies in CESEE countries and Swiss Francs are consistent with the assumptions of the stress test and the sensitivity analysis of domestic FCLs. The projection of local currency relative to the Swiss Franc assumes a compounding effect from the depreciation of local currency vis-à-vis the Euro assumed in the projection of operating profits and the depreciation of the Euro vis-à-vis the Swiss Franc envisaged in the sensitivity test.

Securitization Risk

31. Stress test on securitization positions are applied through an increase in risk weighted assets. Opacity on the underlying credit exposures and non-linear payoffs limit the use of a credit risk modeling approach to these exposures. Instead a credit risk migration matrix is assumed in line with the baseline scenario calibration of the 2011 EBA stress test exercise.

32. Migration matrices are calculated separately for medium-risk and high-risk positions (Table 3). Stressed risk weights are computed as a weighted average of the original risk weights and the migration factors. Regulatory reporting data is available on a single deal basis by product type, underlying asset and geographic distribution.

33. The impact on banks' capital ratios is twofold. First, the impact of defaulted exposures is 1,250 percent risk-weighted. Second, stressed risk weights from securitization positions are combined with those from non-securitization assets to compute risk weighted assets.

Table 3. Applied Risk Weights under the IRB Approach

Medium-Risk: Baseline RWAs (1 year migration)

(in percent)	A	B	C	D	E
AAA	10	15	23		
AAA	15	22	32		
AAA	25	33	46		
BBB	113	127	127		
BB	538	539	539		
B	1250	1250	1250		
CCC	1250	1250	1250		
CC, C, D	1250	1250	1250		

High-Risk: Baseline RWAs (1 year migration)

(in percent)	A	B	C	D	E
AAA	37	42	50	52	64
AAA	74	81	90	94	113
AAA	140	147	159	169	198
BBB	268	280	280	340	405
BB	622	623	623	677	783
B	1250	1250	1250	1250	1250
CCC	1250	1250	1250	1250	1250
CC, C, D	1250	1250	1250	1250	1250

Source: EBA 2011 stress testing exercise

Sovereign Risk

34. Sovereign risk is measured in the adverse scenario through changes in sovereign yields leading to a repricing of all affected bonds (Annex V). Holdings of government bonds in both the banking book and the trading book are repriced. The scope of sovereign includes: all central governments (but no central banks), all regional governments, and all local authorities.[39] We assume

[39] Public sector entities, multilateral development banks, and international organizations are generally excluded.

that the term structure of sovereign risk shifts upwards for all countries to which Austrian banks are exposed, including sovereign bonds held by CESEE subsidiaries to comply with local liquidity requirements. Haircuts to the banking book are applied to adjusted (marked-to-market) balance sheet values.

35. The approach allows for changes in term premia observed under market stress. In volatile conditions, investors typically require an excess yield to commit to holding a long-term bond instead of a series of shorter-term bonds. The calibration of the sovereign shock includes changes in the slope and curvature of the yield curve associated to historical stress rather than a parallel shift on spreads. When there is no available quote at a specific maturity to derive a valuation haircut, the nearby maturities' haircuts are interpolated.

36. The sovereign shock is calibrated for fifty eight countries (Annex V. Table 2):

- For fifty countries, the shock is derived from the 90th percentile of the historical distribution of annual changes of daily yields ranging between 3-month and 30-year time-to-maturity using the Bloomberg-based generic 5-year government bond yields over the period 2005–12. The change in yields is used to reprice all government bonds under a cash-flow approach matching a modified duration formula to each maturity bucket.

- For Belarus, Bulgaria, Luxembourg, Malta, and Romania, the haircut is computed using extreme returns for the most liquid outstanding international bond as of Dec 2012, given the limited time series of the generic yield curve (Annex V Table 1).[40] For Cyprus, the haircut is calibrated from the sovereign yield curve as of Dec 2012. For Estonia only international loans were outstanding at end-2012.

Market Risk

37. Market risk sensitivity analyses were run by the largest five banks as part of the "light bottom-up approach." Parameters are applied to trading book positions as of 31 December 2012. Valuation effects are reported for each risk category (interest rates, FX, etc.) individually, leaving the parameters of the other risk categories unchanged, as well as in total (changing the parameters of all risk categories at the same time).

38. Interest rates and FX rates were calibrated in consistency with the macro stress scenario (Table 5):

[40] For Romania, haircuts were computed suing the 99th percentile of the historical distribution given the short time series of historical returns under the most liquid outstanding bond.

- Volatilities of daily changes in interest rates were scaled by a factor of two and were additionally scaled over a one-year time horizon.[41] Eastern Europe interest rates were determined by an equally weighted basket of CZK and PLN.[42] Other non-emerging markets' interest rates were determined by an equally weighted basket of CHF, JPY and AUD. Other parameters in the interest rates category (Asia, volatilities) were calibrated in line with the EBA 2011 stress test.

- FX rates were defined vis-à-vis the Euro. The scenario assumes a Euro depreciation in line with the scenario used in the solvency stress test and the FCL sensitivity analysis. Emerging Markets were defined as an equally weighted basket of eight CESEE/CIS countries. Other non-emerging markets' FX rates were determined by an equally weighted basket of CHF, AUD and CAD.

- Concerning FX volatilities, the EBA 2011 calibration is considered for rates involving major currencies (i.e. non Emerging Market) as well as for rates involving at least one Emerging Market currency.

39. Other risk categories include the credit risk factors identified in the FSAP team econometric exercise. Specifically, itraxx high yield Europe, itraxx Europe crossover and itraxx senior financials were included as key risk factors in the sensitivity analysis. Parameters for these credit risk factors as well as for other market risk parameters (Equity, Funds, Commodities, Counterparty) were calibrated in line with the adverse EBA 2011 stress test scenario.

Basel III Implementation

40. Full implementation of Basel III requirements, including front-loading of phase-in capital arrangements and Basel III RWAs, would have the following estimated impact in projected regulatory ratios:

- CET1 would shed 1.4 percentage points relative to EBA CT1 capital for the whole banking system and 1.6 percentage points for the large international banks. The impact on Basel III Tier 1 would be slightly more significant at 1.7 and 2.2 percentage points for the system and the large international banks, respectively.

- The impact on the total adequacy ratio is more uncertain depending on the treatment of the €19.8 billion (€10.0 billion) long-term subordinated debt held by the banking system (large international banks) under Basel III. The effect on the CAR could range between 1.9 and 4.0 (2.3 and 4.9) percentage points for the banking system (large international banks).

[41] Volatilities are computed on absolute changes for interest rates and logarithmic changes for exchange rates in 2010–2012. Daily volatility is assumed to follow an iid process. Annual volatility is thus calculated by multiplying the estimated daily volatility by the square root of the number of trading days, i.e., 260.

[42] Given thin FX markets for these currencies, volatilities are computed based on monthly changes over 2010–2012.

- The main driver of the decline in CET1 is the phase-out of participation capital subscribed by the government in the context of state aid (€4.1 billion for the whole banking sector of which €3.0 billion was issued by the largest international banks), which is set to kick-in in January 2018.

D. Solvency Stress Test Results

41. The analysis suggests that Austrian banks benefit from sufficient capital buffers, including under most adverse circumstances (Figures 9–11). The results of the solvency stress test reflect improvement in banks' initial capital condition, in part because of de-risking of balance sheets, and in part due to banks' recapitalization efforts through increased retained earnings:

- Under the most severe macroeconomic scenario, banks representing less than 7 percent of total bank assets would fall below the regulatory threshold. The estimated aggregate capital needed to bring back the capital ratios of these banks above the regulatory minimum amounts to 0.3 percent of total bank assets, or about 1 percent of GDP.

- Yet, the thin capital buffers in some banks warrant enhanced monitoring (Figures 12–14). The percent of total bank assets under the 6–8 percent core Tier 1 capital bucket increases from about 4.5 percent under the baseline to 17 percent under the severe scenario at the end of the stress test horizon.

- Although estimated aggregate losses under the adverse scenario would hit severely large internationally active banks, they exhibit a relatively better capital position under baseline projections (Figures 15–17). For instance, the projected losses under the severe scenario would dent large banks' core Tier 1 ratio by 4.8 percentage points well above the average 2.8 percentage point losses estimated for the Austrian banking system.

42. The main driver of the decline in regulatory capital is credit risk in CESEE (Figure 6):

- The projected profit and loss effect from severe macroeconomic stress adds up to 1.5 percentage points driven by credit risk effects.

- More than two-thirds of expected losses from credit risk come from CESEE exposures while under one-fourth are originated domestically.

- Full implementation of Basel III requirements, including front-loading of phase-in capital arrangements and Basel III RWAs, would have an impact of 1.4 percentage points led by the phase-out of eligible capital.

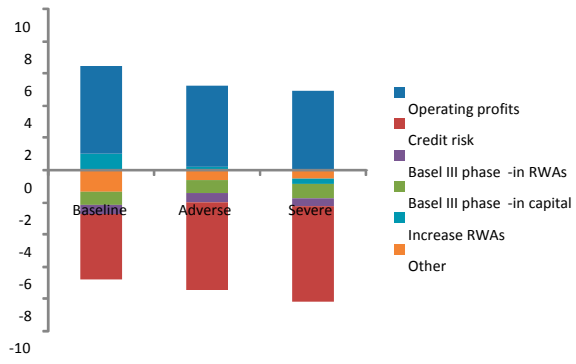
43. The large internationally-active Austrian banks would remain, on aggregate, above the regulatory hurdle even under full implementation of Basel III qualitative phase-in arrangements. Following the Supervisory Guidance issued by the OeNB and the FMA on strengthening the sustainability of the large international banks' business models in March 2012, the

top three banks have continued building capital buffers to be compliant with the full implementation of qualitative and quantitative Basel III rules for CET1 as of 2012 Q4. [43] Going forward, large international banks' projected capital ratios are above the transitional quantitative hurdle rates at end-2015, even under the most severe scenario.

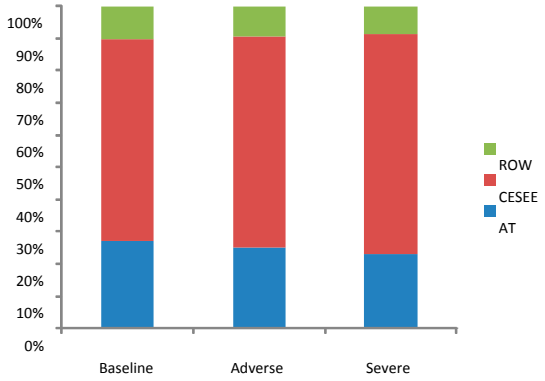
44. Sensitivity analyses, not related to the main scenarios, show a potential for some limited additional indirect credit risk losses (Figure 7). For the whole banking sector, indirect credit risk from FX appreciation in foreign currency loans, both in Austria and CESEE/CIS, add up to 35 bps in CT1 ratios. Market risk from underperformance of market instruments associated to RPVs in the stock of domestic bullet loans would contribute an additional 7 bps. The estimated impact from securitization exposure risk, at 10 bps, is not very significant.

Figure 6. Drivers of Changes in CT1 for the Whole Banking System

Breakdown by Key Driver (in percentage points of capital)



Breakdown of Credit Risk (in percent)

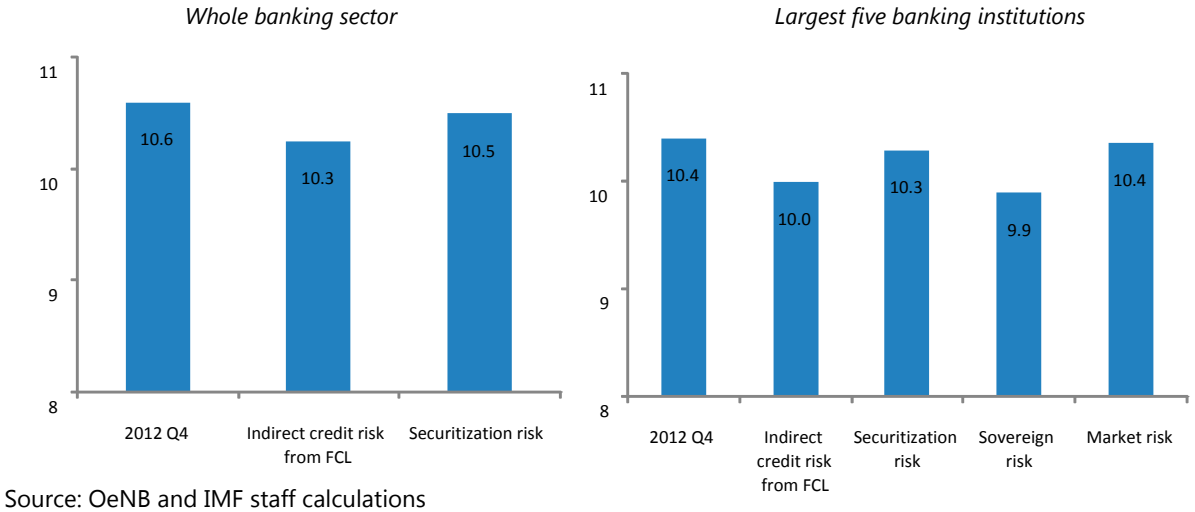


Source: OeNB and IMF staff estimates

45. For the largest five banks, the BU stress tests confirm the above results and the assessment that market risk is not a major source of vulnerability. Specifically, they suggest that credit risk from FCL appears to have greater impact on capital adequacy than the combined realization of sovereign risk and market risk. The additional credit risk from FCL would depress CT1 capital ratios for the five banks by 41 bps under the most adverse scenario. Sovereign risk is also noteworthy, but less significant, with an additional impact of 51 bps, and with the caveat that these are conservative estimates as portfolio correlations across high-yield assets (i.e., Romania, Ukraine) and safe haven bonds (i.e., Germany, Switzerland) were ignored in the analysis (leading to an overestimation of sovereign risk). On the other hand, market losses from adverse shocks on a wide range of risk factors including interest rates, FX, equity prices, commodities, high yield credit risk, and CVA are insignificant.

[43] Under the Supervisory Guidance issued in March 2012, full qualitative implementation of Basel III transitional schedule excludes the phase-out of private and state participation capital subscribed under the bank support package.

Figure 7. Sensitivity Analysis for the Solvency Stress Test



Source: OeNB and IMF staff calculations

LIQUIDITY STRESS TESTS

46. A set of TD liquidity stress tests were carried out to evaluate the Austrian banking system's liquidity exposure and its liquidity risk bearing capacity:

- The liquidity stress tests are conducted on a consolidated basis, on the largest twenty nine banks subject to the weekly cash-flow based liquidity reporting to the OeNB, which account for over 80 percent of total banking system assets.
- To ensure consistency with the solvency stress test, the liquidity stress tests are based on 2012Q4 data.
- The analysis is forward-looking. Shocks are applied to contractual as well as behavioral cash-in, cash-out flows, and shocks to the counterbalancing capacity over five maturity buckets (up to 5 days, 1m, 3m, 6m, 12m).
- Stressed haircuts are calculated on the reported collateral value after the haircut applied by the central bank on eligible collateral. Stressed haircuts are a function of the central bank where the security has been deposited due to differences in eligibility criteria applied by different central banks.
- Stress tests are conducted separately for six currency buckets (EUR, USD, CHF, GBP, JPY, other). The currency breakdown applies to cash-flows as well as to the counterbalancing capacity.

47. The liquidity stress tests cover three time horizons, five scenarios of market stress, and three approaches to the treatment of the counterbalancing capacity:

- Three time horizons are considered, i.e., 30-day, 90-day, and one-year. For each horizon, five market scenarios are developed, namely *baseline*, *market mild*, *market medium*, *market severe*, and *combined* scenario. Under the latter, an idiosyncratic shock on the rollover of retail and wholesale deposits is built in addition to a capital market shock.

- For each horizon and market scenario, three approaches to the counterbalancing capacity in terms of severity are considered:

    - Full counterbalancing capacity: including less liquid assets (BBB non-financial corporate bonds, credit claims and other pledgable assets) evaluated at baseline haircuts but excluding committed liquidity lines and liquidity injections from parent banks;

    - Increased focus on market liquidity: haircuts for less liquid assets (BBB non-financial corporate bonds, credit claims and other pledgable assets) increase to 100 percent;

    - Market liquidity: haircuts on unencumbered eligible asses deposited at the Eurosystem increase to 100 percent for securities with ratings below A- (in addition to the restriction under 'Increased focus on market liquidity').

48. Under the combined scenario, the assumption that all banks face an idiosyncratic shock at the same time means that the estimated liquidity shortfall yields a conservative estimate. It provides an estimate of the additional liquidity buffer required across the system, such that each bank would weather a substantial combined market and idiosyncratic shock. The combined scenario assumes an idiosyncratic component in the rollover rate of deposits along with a reaction function of banks' lending decisions that vary across time horizons:

- Over a 30-day horizon, expected rollover rates of wholesale deposits drop to 90 percent (95 percent) for wholesale (retail) deposits. Banks do not cut expected new loans; instead they cut their expected financial investments by 50 percent.

- The assumed rollover rate declines to 80 percent (90 percent) for wholesale (retail) deposits under a 90-day shock. Banks shed new investments by 100 percent.

- The one-year test also assumes a jump in the drawings of committed lines by households and non-financial corporates by 100 percent, a reduction of non-financial loans by 4 percent, and a drop of new unsecured loans to other banks by 100 percent.[44]

49. The calibration of the liquidity stress test draws on the assumptions built in the solvency stress test and on extensive analysis of the national and international evidence. In addition to the baseline haircuts on eligible collateral deposited at central banks, further haircuts are

[44] The calibration of banks' behavioral reaction is based on the Concerted Round of Common Liquidity Stress Test (BSCS 2010). The calibration of the reduction of new loans to households and corporates is based on the experience of the euro zone peripheral countries (excluding Greece) during the sovereign debt crisis.

applied to reflect the combined impact of market and funding stress assumed under the macroeconomic adverse scenario:

- For collateral deposited at the Eurosystem, haircuts reach up to 100 percent under the market severe scenario and 30-day horizon, depending on the issuer's rating and the asset class (Table 4);
- For foreign currency collateral, haircuts under the market severe scenario are calibrated at 10 percent (30-day) and 15 percent (90-day) due to the stricter eligible criteria used by other central banks (e.g. SNB);
- For tradable assets not deposited with central banks, additional haircuts are a function of the rating of the security.[45]

Table 4. Haircuts for Unencumbered Eligible Collateral
(in percent of collateral value after haircut)

	AC1	AC2	AC3	AC4	AC5
AAA-AA-	1	3	6	20	50
A+-A-	3	5	8	25	80
BBB+-BBB-	5	7	15	50	100

Source: OeNB.

Note: AC1 includes central government or central bank securities; AC2 other public sector entities, supranational institutions, Agencies and Jumbo-Pfandbriefe; AC3 non-financial corporate, Pfandbriefe, secured bank bonds, structured covered bonds, or multi-cedula; AC4 credit institutions and financial corporates; and AC5 asset-backed securities.

50. Also, the PD shifts for Austrian credit claims generated under the adverse scenario are embedded into the credit risk migration constructed to estimate the dry-up of liquidity:[46]

- Haircuts on non-tradable collateral, i.e., credit claims, across credit quality ratings, are linked to estimated PD shifts.[47] The haircuts increase over the horizon of the liquidity stress to reflect the deteriorating macroeconomic environment.

[45] The following haircuts are applied: 5 percent (AAA), 10 percent (AA), 15 percent (A), 50 percent (BBB), 70 percent (other pledgable assets), and 100 percent (committed lines and parent liquidity injections).

[46] For a detailed discussion of the interaction between solvency-liquidity link stress test, see Puhr and Schmitz (2013) and Feldkircher et al. (forthcoming).

[47] The satellite model for credit risk on domestic claims yields an increase of 110 percent PDs under the adverse scenario on an annual basis which implies a 11 percent shift over 30 days.

- The run-off rate of expected inflows from paper in own maturing portfolio is mapped to estimated PD shifts. The mapping is applied to non-financial corporate bonds with ratings from AAA+ to BBB- deposited at the Eurosystem and to other bonds not deposited at the central bank.

51. The results of the solvency stress test also feed markets' reaction towards banks' ability to issuance over the one-year liquidity test:

- In the first quarter, liquidity dries up for all issuers irrespective of the quality of the underlying collateral. Market uncertainty hinders investors' ability to differentiate across issuers and instruments.

- In the second quarter, banks posting high core Tier I ratios under the solvency test regain partial access to funding markets.[48] They are able to place 50 percent of their expected issuance.

52. The liquidity stress test carried out as part of the FSAP is more stringent than that implied by Basel III liquidity coverage ratio (LCR):

- Under the LCR, banks must hold sufficient liquid funds to withstand a 30-day stress scenario. Acute funding stress assumed under the FSAP liquidity stress test extends up to one-year.

- High quality liquid assets (HQLA) under the LCR are aggregated across currencies. Under the FSAP test, banks are required to hold liquid assets from which they can generate inflows to close the net funding gap in each currency and each maturity bucket.

- The FSAP test incorporates stricter assumptions on banks' forward-looking plans albeit with a less severe run-off rate for wholesale deposits. Under the market severe scenario of the FSAP test, funding markets dry-up completely for unsecured interbank funding, short-term debt, long-term secured and unsecured debt, and cross-currency swaps.[49] On the other hand, the revised LCR test assumes run-off rates of up to 40 percent (rather than 20 percent) for deposits and unsecured funding from non-retail customers.[50]

- Market funding risk captured through stressed haircuts is, on aggregate, more severe under the FSAP liquidity stress test. Haircuts on unencumbered eligible assets deposited at the Eurosystem increase to up to 100 percent for securities with ratings below A-.

[48] Banks showing core Tier 1 ratios of at least 10 percent under the most severe scenario or that increased their core Tier 1 ratio during the stress horizon by more than one percentage point, regain partial access to funding markets.

[49] The closure of FX swap markets is a particularly severe assumption for Austrian banks given their reliance on cross-currency swaps to fund their legacy portfolio of foreign currency loans.

[50] Under the original LCR standard, up to a 75 percent run-off rate was applied to deposits from non-retail customers.

53. Austrian banks' funding structure appears resilient across major currency buckets. Under a scenario comparable with that of recent European FSAPs (Table 6), assuming total closure of the unsecured interbank and FX swap markets, and with substantial haircuts in the counterbalancing capacity,[51] the total liquidity shortfall based on the cumulated counterbalancing capacity amounts to only 0.1 percent (30 day horizon), 0.3 percent (90 day horizon), and 0.2 percent (1 year scenario) of total liabilities of the twenty nine banks in the sample.[52] The improvement in the liquidity position of Austrian banks can be attributed to enhanced liquidity supervision and monitoring by the OeNB and strengthened supervisory standards of banks' liquidity risk management.

54. Moreover, OeNB's liquidity stress tests show that the foreign currency liquidity position of the system has substantially improved since 2008, amid lingering vulnerabilities in CHF funding in some banks:

- In October 2008, the FMA and OeNB stepped up their liquidity monitoring requiring banks to submit highly granular weekly liquidity reports including contractual and behavioral data by currency and maturity bucket. Weekly liquidity stress tests for monitoring purposes are regularly conducted.[53]

- Since 2008, banks have continuously improved their USD and CHF liquidity position and the stress test shows that resilience to a USD and CHF funding shocks is now high.

- For the CHF liquidity position, the results draw, however, a more nuanced picture. About half of the banks in the sample made substantial progress regarding their resilience to CHF liquidity shocks. Given the maturity structure of the CHF assets of Austrian banks and the limits to reduce the portfolio it is important that the other half further diversify funding sources across counterparties and instruments, and lengthen funding tenors.

CONTAGION ANALYSIS

55. A contagion module assessed the potential for distress in a financial firm to create risks to overall financial stability. For the simulation of the scenarios, two separate initial conditioning events (shocks) were considered:

[51] Sole focus on assets that are expected to remain liquid even under severe stress of private markets and factoring in only standard central bank open market operations.

[52] Despite the longer horizon the liquidity gap in the one year scenario is marginally lower than in the 90 day scenario due to the ability to access funding markets by the better capitalized banks and the embedded banks' behavioral reactions.

[53] The stress test horizon varies between an instantaneous shock to up to three-year depending on the risk factor that is being stressed.

- *Rising funding pressures*: A 'global funding scenario' was laid out to replicate the post-Lehman liquidity strains including a sharp rise in funding cost and credit market freezes. A bank facing a liquidity squeeze engages in fire sales to obtain liquidity. In a first step, this reaction erodes the banks' capital buffer. In a second step, the post-shock capital base is combined with a network model to simulate cascading defaults in the Austrian interbank market.

- *A drop in market value*: a repricing of market risk factors causes portfolio/credit losses pushing a bank's financial returns to the left tail of the distribution. The bank reaches its VaR returns in the market-implied value of assets.

56. The transmission of each separate initial shock from an individual bank to the broader banking sector is spread through the following channels, respectively:[54]

- *Bilateral Exposure*: counterparties with a significant exposure to the failing firm may suffer material losses resulting in their inability to satisfy their obligations thus transmitting distress to other parts of the financial system down the credit chain in the form of cascading defaults.

- *Market Contagion*: Market participants' revise their expectations on the solvency of other firms following similar business models than the firm in distress, conditional on the broader economic environment.

57. The bilateral exposure channel is captured by a funding/network analysis conducted by the OeNB drawing on Austrian banks' bilateral matrix of exposures. The stress test assesses the solvency impact of liquidity strains from fire sales and rising funding costs and the potential for indirect default cascades through the Austrian interbank market.

58. The contagion channel is examined by the FSAP team using a combined market and balance sheet-based approach. Contagion effects from Austrian banks' left tail comovement in leverage ratios and financial returns with other domestic and global banking institutions are assessed using the CoVaR methodology.

A. The Funding/Network Analysis

59. The funding/network analysis tries to address two missing links of the traditional solvency stress test. First, the solvency effects from a negative liquidity gap in banks facing funding pressures. Second, the potential for default cascades triggered by an insolvent firm on its creditors, leading in turn, to severe strains on the latter counterparties, transmitting distress throughout the entire banking sector.

[54] These channels have been highlighted by Governor Daniel K. Tarullo, "Regulating Systemic Risk," Speech, 2011 Credit Markets Symposium, North Carolina, Charlotte, March 31, 2011, Board of Governors of the Federal Reserve System, available at http://www.federalreserve.gov/newsevents/speech/tarullo20110331a.htm.

60. The one-year global funding scenario mimics the effects of the post-Lehman liquidity shock on Austrian banks. In particular:

- *New issuance:* unsecured interbank, FX swap markets and capital markets close.[55] For the very strong banks,[56] markets reopen gradually allowing up to 70 percent of banks' expected issuance after the first quarter of liquidity stress;

- *Net cash-outflows*: contingent liabilities rise triggered by a 50 percent jump in the drawings of committed lines; inflows from loans/maturing paper is banks' own portfolio decrease in line with the PD shifts estimated under the solvency test;[57]

- *Counterbalancing capacity:* liquid assets suffer from sharp price declines driving up haircuts across asset classes. For assets deposited at the central bank, Table 4 applies. For assets not deposited at the central bank, granular haircuts range between 12.25 percent (investment grade) to 80 percent (sub-investment grade).[58]

61. The cost of funding increases for both retail deposits and wholesale funding. The cost of expiring term retail funding increases by about 140 bps. For those few banks that are able to access capital markets, the cost of new issuance rises by 70 bps.[59]

62. Banks showing negative funding gaps engage in distress sales in an effort to obtain liquidity. The sudden increase in market supply of assets in a downward market drives down prices significantly. The stressed value of assets is computed on the basis of haircuts in the counterbalancing capacity. Banks that become illiquid during the stress test horizon incur asset fire losses up to the depletion of their counterbalancing capacity.

63. Domino effects are estimated using a default cascade model for the consolidated Austrian interbank market (Box 3). Cascading effects may occur when the failure of one bank causes its creditors to fail, and so on:

- The contagion mechanism is based on a network approach of interbank exposures;

[55] Repos on general collateral are, however, assumed to be rolled over.

[56] Banks' soundness is defined in terms of their performance in the solvency stress test. Banks showing a CET1 ratio of at least 10 percent under the severe scenario or increasing their CET1 by at least 1 percentage point during the stress test horizon are defined as very strong banks.

[57] Banks' behavioral reaction to mounting funding pressures include: (i) banks' cut their expected financial investments by 40 percent, and (ii) their expected new unsecured loans to other banks are reduced by 100 percent.

[58] The analysis assumes that banks cannot draw committed liquidity lines nor receive liquidity injections from their parent bank.

[59] The calibration for retail funding costs is based on the widening of deposit rates-3m Euribor spreads between 1996–2008 and 2009. The cost of capital market issuance is based on the rise in banks' issuance cost relative to the Austrian sovereign during the same period.

- Bilateral netting of intra-group exposures is allowed. The assumed LGD on net exposures is 100 percent;[60]

- A bank is considered in default when its capital adequacy ratio at the consolidated level falls below 8 percent.[61]

Box 3. Overview of Furfine's Network Model[1]

The analysis examines whether the failure of an individual institution may pose a risk to financial stability. Distress in a financial firm may cause systemic risk, when its failure triggers severe knock-on effects due to high interbank exposures. The interbank market is modeled as a network whereby each bank's financial exposures vis-à-vis other banks can serve as a potential channel of contagion through which solvency risk can spread across banks.

The examination of contagion is direct; that is, it is based on analysis of an underlying set of data that measure credit exposures bilaterally. The simulations are conducted assuming that creditor losses are realized immediately with recovery rates of 0 percent (i.e. complete loss).

The exercise tracks the lender's capacity to absorb the shock by verifying whether it has enough loss absorbing capital to cover the losses. If the generated loss is greater than its capital base, the lender will default on its own creditor counterparties, potentially unleashing a wave of defaults through a domino effect along the credit chain. The number of defaults in the default cascade provides a measure of the interconnectedness of the interbank market.

The degree of contagion for a given failure scenario depends crucially on the nature of banking relationships. In particular, the number and the capitalization of the counterparties to significant debtor banks are crucial determinants of the degree of contagion.

1/Based on Furfine (2003) 'Interbank Exposures: Quantifying the Risk of Contagion', Journal of Money, Credit and Banking 35 (1): 111–128.

64. The results suggest that the Austrian banking system is resilient to potential funding and contagion stress transmitted through creditors' exposures in the Austrian interbank market. Under the global funding scenario, large banking groups do not experience losses due to their strong counterbalancing capacity, as well as the network structure of the Austrian interbank

[60] Exposures include equity stakes and off-balance sheet items but exclude trading book positions.

[61] Contagion losses are measured at the unconsolidated level and consolidated afterwards to compute the capital adequacy ratio.

market.[62] The impact on the core Tier I ratio of the whole banking system is limited to 108 bps, and is driven primarily by banks' fire sales rather than by cost of funding effects or cascading defaults.

65. The results of the contagion analysis should be interpreted with caution. First, fire-sale assets are calibrated exogenously. The spiral effects from further declines in prices as a function of the aggregate increase in supply of assets are not modeled explicitly. Also, the mark-to-market effects from common exposures to stressed assets by banks holding similar assets are not computed. Second, domino effects are transmitted through the Austrian interbank market. Induced failures from the inability to service other debt instruments or from stress of other counterparties operating outside the Austrian interbank market are not considered. Third, contagion effects from a bear-market sentiment to banks following similar business models to the bank in distress are excluded.

B. The CoVaR Analysis

66. The CoVaR approach is complementary to the network analysis. It addresses some of the caveats outlined above. First, contagion effects are measured using equity market valuations picking up spillovers unrelated to credit exposures. Distress in an individual bank may propagate by reversing market sentiment to other firms holding the same asset classes or following similar business models. Second, financial instability transmitted through distress in global banks is captured in the analysis. For large international Austrian banks, instability is more likely to be spread from/to global counterparts, acting in the CESEE region or in global funding markets, than throughout the domestic interbank market.[63]

67. The CoVaR framework is used to assess whether individual distress could pose a material risk to financial stability. Although there is not a unique definition of financial distress, we assume that a firm is in distress when it reaches its VaR.[64] We take the approach of the US Financial Stability Oversight Council (FSOC) and characterize a financial system as stable when it is not the source of, nor amplify the impact of, shocks.[65]

68. The channel of propagation of financial distress is contagion through financial markets and changes in banks' leverage. Even in the absence of significant creditors' exposure to the distressed firm, contagion may occur if investors believe that the vulnerability of the failing firm is common across similar firms because of the type or scope of activities. The quantification of

[62] The contagion module includes all outstanding exposures but excludes potential contingent liabilities from the sectoral deposit guaranteed scheme.

[63] A vulnerability to widespread market distress may arise if Austrian banks take 'wrong-way' risk, i.e. their losses would only occur in a global/CESEE system-wide crisis, or be affected by runs or synchronized liquidity hoarding by financial institutions that serve as net providers of FX liquidity to Austrian banks and are domiciled in other jurisdictions.

[64] VaR is the most common approach to measure portfolio downward risk in risk management. Also it is used by the BSBC as a basis to compute regulatory capital requirements to absorb market risk.

[65] Financial Stability Oversight Council (2013). *A Framework to Mitigate Systemic Risk*, CRS Report for Congress.

contagion effects depends on: (i) the definition of the financial system; (ii) the economic and financial circumstances in which a firm's failure arises.

69. To assess the transmission of systemic risk through the financial system, two relevant peer groups to Austrian banks are constructed: (i) a European banking system including forty internationally active banks (Annex VI Table 1); (ii) a CESEE banking system formed by fourteen large foreign banks active in the CESEE region (Annex VI Table 2). Banks active in CESEE are defined in terms of absolute exposures—to capture systemic risk transmitted through deleveraging at distressed prices—, and in terms of the share of their CESEE operations in consolidated assets—to reflect solvency risk from macroeconomic stress in the region—(Annex VI. Figure 1). The analysis is performed on banks' market valued asset weekly returns over the period April 2005–Dec 2012.[66]

70. The potential for individual distress to unleash global financial contagion depends crucially on the broader financial environment. The key role played by economic and financial conditions in triggering and reinforcing contagion effects has come to the fore during the global financial crisis as highlighted by Tarullo (2011). To capture these effects, time-varying estimates of VaR/CoVaR dynamics are characterized using European and US financial risk factors as state variables (Annex VI Table 3).

71. The differential impact of financial state variables and banks' contribution to systemic risk measured by ΔCoVaR across European and CESEE banking systems reveals that (Annex VI Table 4):

- Among the different financial variables used as state variables, liquidity strains exhibit the strongest predictive power to forecast European and CESEE banking system tail returns. European banks' left tail returns are also affected by an uptick in equity market volatility, changes in the short-end of the yield curve, and the sovereign debt crisis.

- The effect of individual banks' distress on banking system tail returns is very significant. Asymmetries are also very noticeable. For the European banking system, the coefficient of individual negative returns on banking system returns is more than four times larger than the coefficient of positive returns, whereas for the CESEE peer group, it is over two times larger.

72. Outward cross-border spillovers to European banks active in the CESEE region appear relatively limited. The market-based CoVaR analysis identifies the rise in tail co-movement of financial institutions conditional on individual banks' distress controlling for a set of time-varying financial state variables. The results suggest that on average, the risk that severe distress affecting the top two Austrian banks is transmitted to other banks in the CESEE region is not negligible, but is less that the systemic risk potentially introduced by severe distress affecting other CESEE peer banks

[66] The starting date is determined by the listing of a large international Austrian bank.

(Annex VI Table 5).[67]

73. Inward cross-border spillovers from distress in CESEE banks differ markedly across peers. The CoVaR analysis also suggests that individual banks whose distress may have the most impact on Austrian banks are those headquartered in the CESEE region that are also active across CESEE, or those foreign banks that have the highest presence in the region (Annex VI Table 6). The severity of the distress transmitted to Austrian banks by its CESEE peers does not appear to be significantly different than is the case for other banks. Roughly the same banks that are systemic for Austrian banks are those that are similarly systemic for the peer group.

74. The analysis provides some evidence for the need to combine a micro-prudential and macro-prudential perspective in the regulation of systemic institutions. The results from the CoVaR analysis suggest that there is a weak link between individual and systemic risk. There is no correlation between banks' risk in isolation, measured by their VaR, and banks' contribution to systemic risk, measured by their ΔCoVaR. This lack of relationship applies to both the European and the CESEE banking systems (Annex VI, Figure 2). This suggests that any add-on on regulatory capital requirements designed to contain spillover effects needs to be calibrated drawing on both individual and systemic risk analysis.[68]

CONCLUSIONS AND RECOMMENDATIONS

75. Stress test results suggest that the Austrian banking system is adequately capitalized against adverse macroeconomic shocks. The support provided by the Austrian Bank Stability Package and the gradual de-risking of banks' balance sheets by selectively rebalancing portfolio exposures to the CESEE region have contributed to strengthen capital buffers. Under the most severe macroeconomic scenario, banks representing less than 7 percent of total bank assets would fall below the regulatory threshold, and the estimated aggregate capital needed to bring back the capital ratios of these banks above the regulatory minimum amounts to 0.3 percent of total bank assets, or about 1 percent of GDP.[69] The aggregate results masks, however, a certain degree of heterogeneity within and across segments, with some mid-and small-sized banks being relatively more vulnerable, particularly those with low initial risk buffers and profitability issues.

76. The banking sector appears well positioned to meet Basel III capital requirements. On aggregate, the banking sector would comfortably pass the hurdle rates laid out by the Basel III phase-in arrangements for CET1 under the most severe scenario. The front-loading of Basel III full

[67] An institution experiences severe distress when it reaches its VaR in weekly returns. Under the main specification, returns are defined as the market implied growth rate of assets. Results are robust to the characterization of banks' performance in terms of equity returns.

[68] The CRD IV/CRR directive expected to come into force in January 2014, foresees an optional 'Other SII surcharge applied flexibly by EU member states of up to 2 percent of RWAs from 2016 onwards to contain systemic risk.

[69] Solvency is assessed in according with the Austrian regulatory regime built around Basel II.5. The EBA hurdle rates are applied to compute the capital shortfall.

implementation,[70] including the total phase-in of deductions from CET1, enhanced risk-weighted assets, and a 2.5 percent capital conservation buffer, would have an impact of 1.4 percentage points on core Tier I capital, on top of 1.7 percentage point impact from projected profit and loss effects from severe macroeconomic stress. Capital buffers above the minimum Tier 1 capital ratio are somewhat thinner as Austrian banks hold limited amounts of non-common equity Tier 1 qualifying capital, in the form of private participation capital[71] and minority interests.

77. The stress test results must be interpreted with caution. Stress test results need to be interpreted with caution given asset quality—particularly in some CESEE countries—is still deteriorating and difficult to assess with full confidence. The upcoming bank asset quality reviews by the ECB should provide a more robust basis for assessing the strength of the balance sheets of Austrian banks and the policy responses that may be needed.[72] Also the three-year stress testing horizon does not consider the repayment of state participation capital.[73] It might become challenging for some individual banks to comfortably satisfy capital regulatory ratios if their profit generation capacity and ability to issue CET1 qualifying capital is severely undermined under protracted stress. Further, the potential for a capital surcharge of up to 2.0 percent of RWAs laid out by the forthcoming CRD IV/CRR on domestic systemic institutions lies outside the scope of the stress testing exercise.[74] Also stress rests results are based on Basel III regulatory minimum capital requirements as hurdle rates which may lie below the required market expected capital buffers to keep funding costs low. Other caveats include the reliance of stress testing methods on reduced-form approaches and estimated quantitative relationships that may not hold in periods of extreme stress. Finally, stress tests are based on consolidated supervisory data and, as it is typical in other FSAPs, do not allow for capital or liquidity ring-fencing measures in host countries which could constrain the free allocation of capital as well as funding relationships between foreign subsidiaries and parent Austrian banks.

78. Banks should continue building capital buffers gradually to support market confidence. The realization of a confluence of adverse events, including market expected buffers well beyond regulatory ratios, and the implementation of restrictions on cross-border transfer of capital across jurisdictions may become a source of concern in the medium term. Additional capital requirements may be imposed on Austrian banks by investors in order to ensure that they keep

[70] Basel III will be fully implemented in January 2019.

[71] Beyond the participation capital issued in the context of the Austrian Bank Stability Package released in October 2008 by the Austrian government.

[72] Before it takes full responsibility for supervising euro-zone banks in the autumn of 2014, the ECB will undertake an asset-quality review, which will scrutinize the balance-sheets of 130 big banks, including the eight largest Austrian banks.

[73] The phase-out of participation capital (private and public) subscribed in the context of state aid has been grandfathered under the Basel III phase-in transitional schedule until January 2018. The stress testing exercise nets out private capital but includes state capital.

[74] The CRD IV/CRR, expected to come into force in January 2014, empowers national authorities to set the so-called 'Other-Systemic Institution' capital surcharge of up to 2 percent from 2016 onwards.

pace with their peers, and as a result of their specific business model and comparatively large exposures to the CESEE region, where underlying asset quality is subject to significant uncertainty. These concerns may be exacerbated by an increase in financial market fragmentation across the region, including through the potential introduction of capital or liquidity ring-fencing measures in host countries, which would constrain the free allocation of capital as well as funding relationships between foreign subsidiaries and parent Austrian banks.

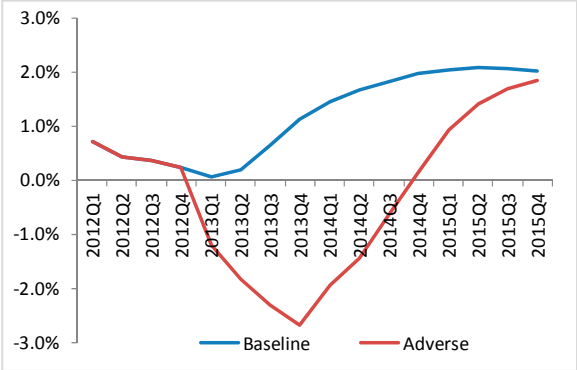
79. Banks' funding structure appears resilient to the full implementation of Basel III liquidity coverage ratio. The improvement in the liquidity position of Austrian banks can be attributed to enhanced liquidity supervision and monitoring conducted by the OeNB and strengthened supervisory standards of banks' liquidity risk management. Local liquidity supervision requirements are significantly more stringent than those agreed under the revised liquidity risk framework of Basel III, and crucially, are applied across currency buckets. Still, banks should continue lengthening funding tenors in foreign exchange to be well prepared to withstand any funding shock in global markets.

80. The Austrian banking system is also resilient to potential funding and contagion stress based on network analysis. Under a global funding scenario, large banking groups do not experience losses due to their strong counterbalancing capacity, as well as the network structure of the Austrian interbank market. The impact on the CT1 ratio of the whole banking system is limited, and is driven primarily by fire sales rather than cost of funding or contagion effects. On the other hand, the risks of cross-border spillovers between Austrian and other peer banks active in the CESEE region appear limited.

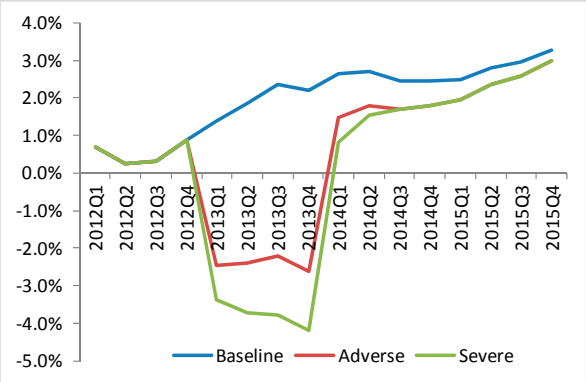
81. The contagion analysis can serve as an input in the calibration of domestic capital surcharges for domestic systemic banks. Under the CRD IV/CRR regulatory framework, the Austrian authorities will have the option to set a systemic institution capital surcharge to contain systemic risk in the domestic market. The network analysis informs how distress in a particular financial institution can be transmitted throughout the Austrian interbank market causing a broader impairment to financial stability. Contagion through market signaling or wrong-way risk can be measured using a market-based approach such as CoVaR. Both tools can serve to monitor systemic risk so that any rapidly growing activities that may pose systemic risk can be identified early and, where needed, those systemic risks addressed.

Figure 8. Macroeconomic Assumptions for real GDP growth (yoy) in Austria and CESEE
(in percent)

Austria



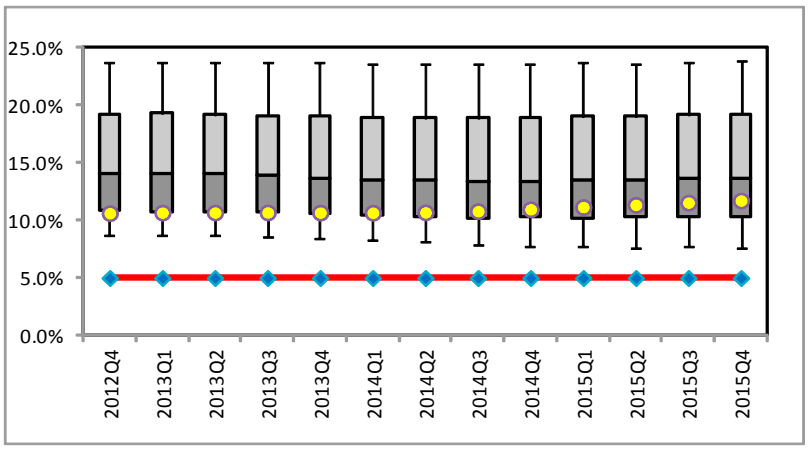
CESEE



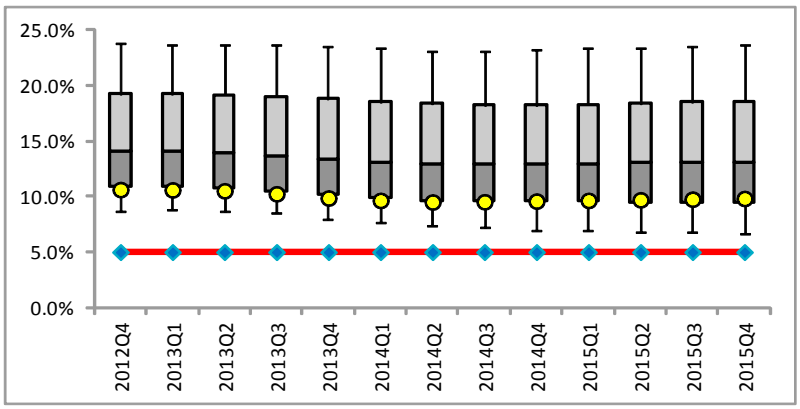
Source: OeNB
Note: CESEE projections show the June 2012 BIS-weighted country quarterly projections for twenty-three countries in Central, Eastern, South Eastern, and Commonwealth of Independent States.

Figure 9. Solvency Stress Test Results—Distribution of Core Tier I

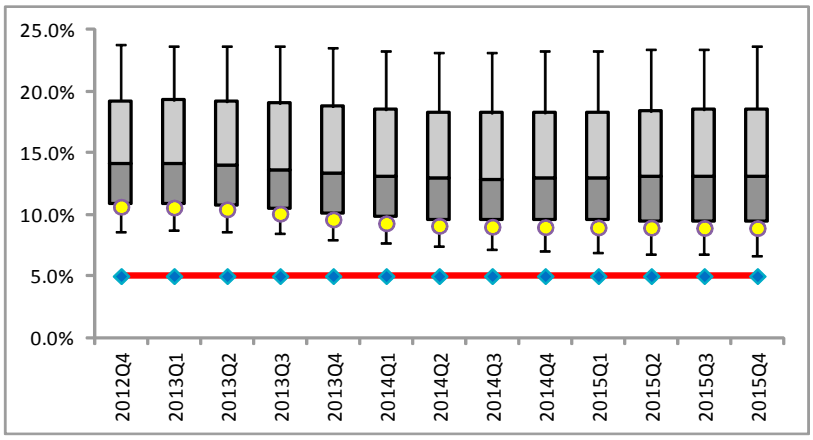
Top-Down Test: Baseline Scenario
(in percent)



Top-Down Test: Global Shock Scenario
(in percent)



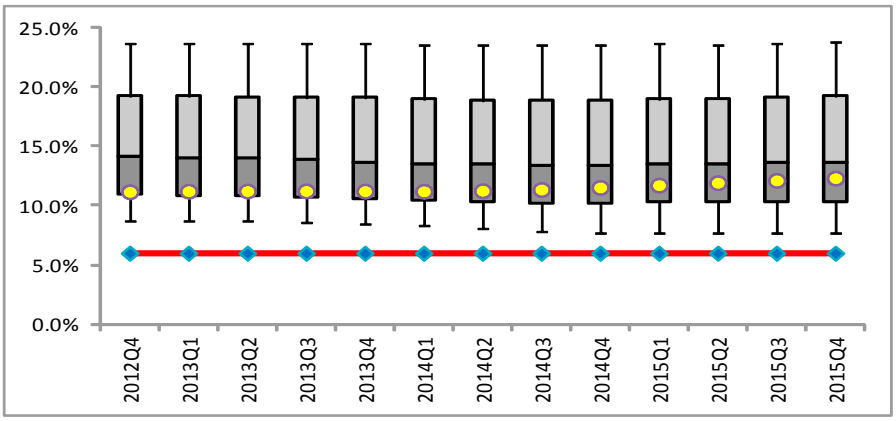
Top-Down Test: Global Shock/Recession in CESEE Scenario
(in percent)



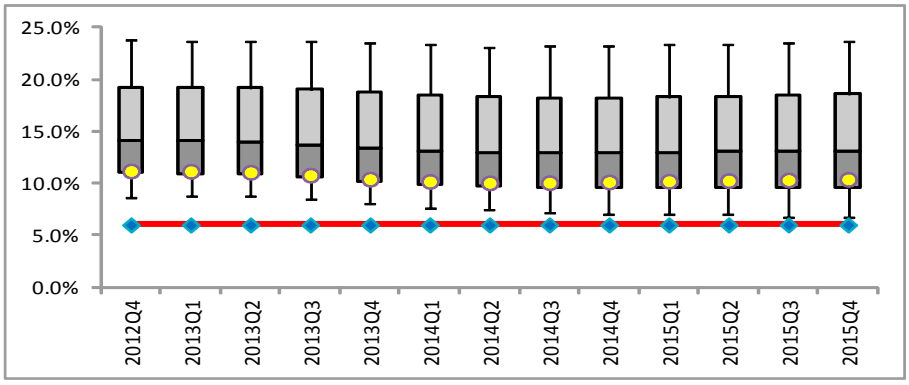
Souce: OeNB and IMF estimates. The solvency stress test is conducted over the whole banking sector on a consolidated basis. Box plots include the mean (yellow dot), the 25th and 75% percentile (shaded area), and the 10th and 90th percentiles (whiskers). The line reflects the hurdle rate.

Figure 10. Solvency Stress Test Results—Distribution of Tier I

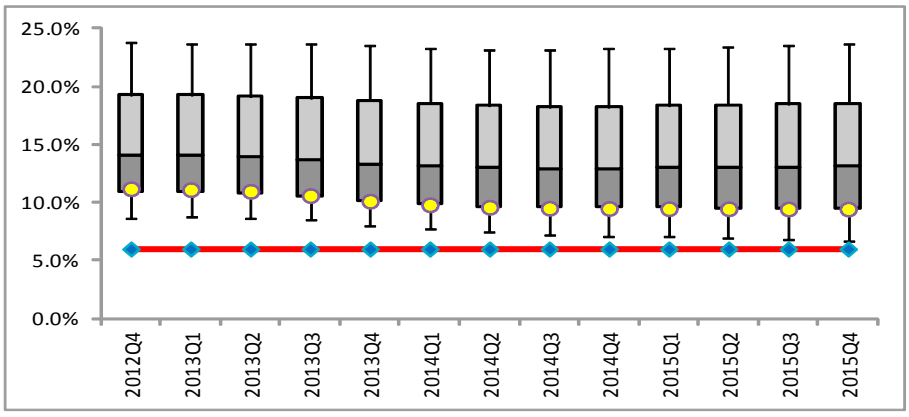
Top-Down Test: Baseline Scenario
(in percent)



Top-Down Test: Global Shock Scenario
(in percent)



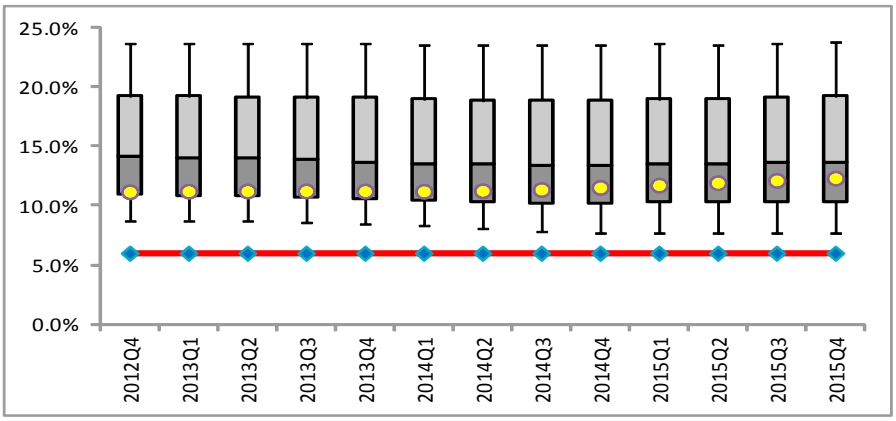
Top-Down Test: Global Shock/Recession in CESEE Scenario
(in percent)



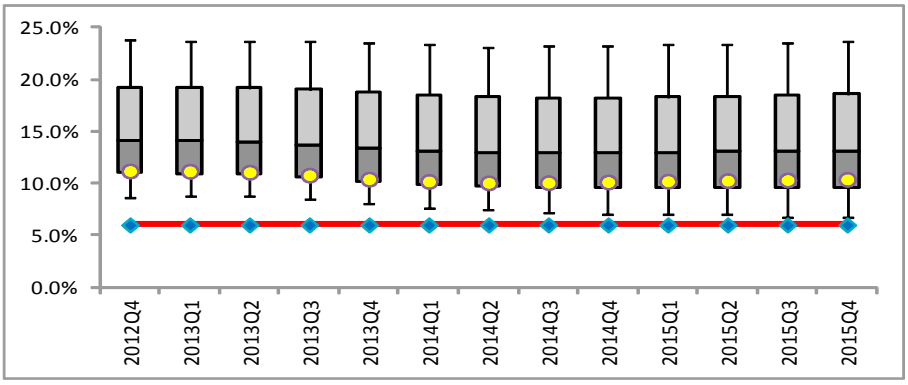
Souce: OeNB and IMF estimates. The solvency stress test is conducted over the whole banking sector on a consolidated basis. Box plots include the mean (yellow dot), the 25th and 75% percentile (shaded area), and the 10th and 90th percentiles (whiskers). The line reflects the hurdle rate.

Figure 11. Solvency Stress Test Results—Distribution of Total Capital Ratios

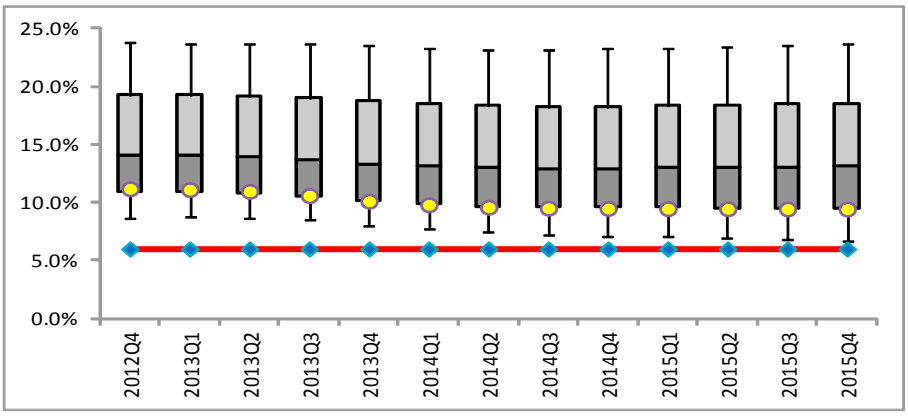
Top-Down Test: Baseline Scenario
(in percent)



Top-Down Test: Global Shock Scenario
(in percent)



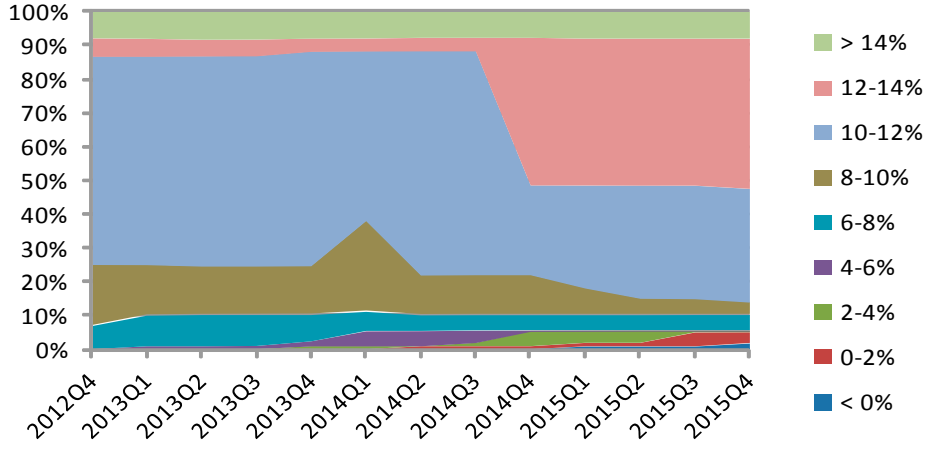
Top-Down Test: Global Shock/Recession in CESEE Scenario
(in percent)



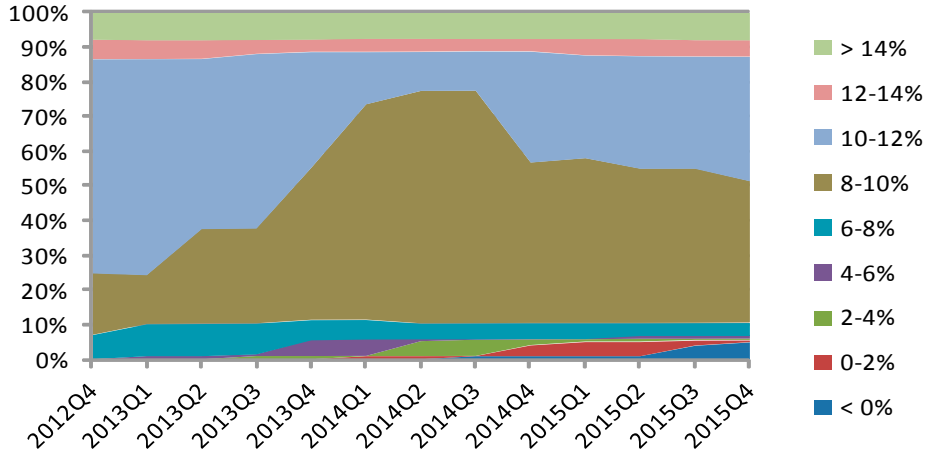
Souce: OeNB and IMF estimates. The solvency stress test is conducted over the whole banking sector on a consolidated basis. Box plots include the mean (yellow dot), the 25th and 75% percentile (shaded area), and the 10th and 90th percentiles (whiskers). The line reflects the hurdle rate.

Figure 12. Solvency Stress Test Results—CT1 Capital Buckets

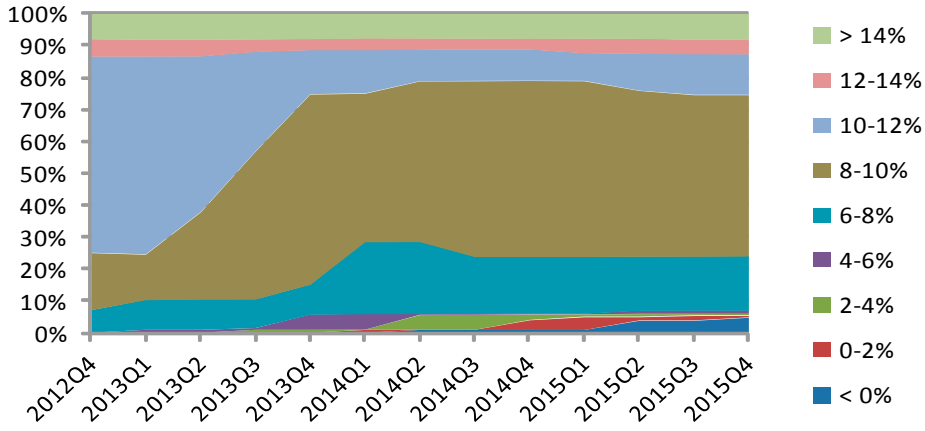
Top-Down Test: Baseline Scenario



Top-Down Test: Global Shock Scenario



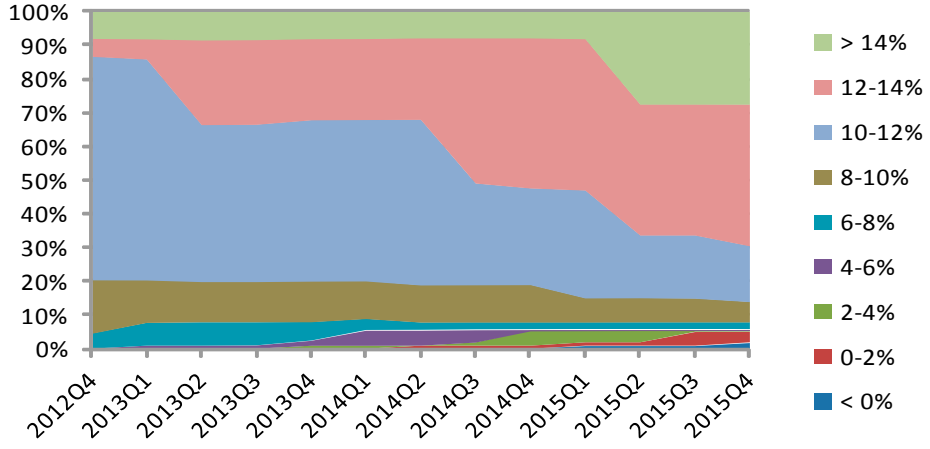
Top-Down Test: Global Shock/Recession in CESEE Scenario



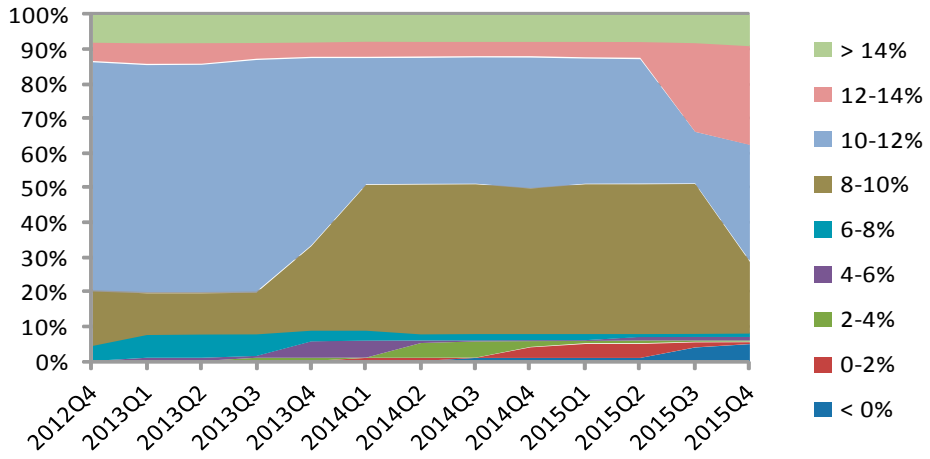
Source: OeNB

Figure 13. Solvency Stress Test Results—Tier I Capital Buckets

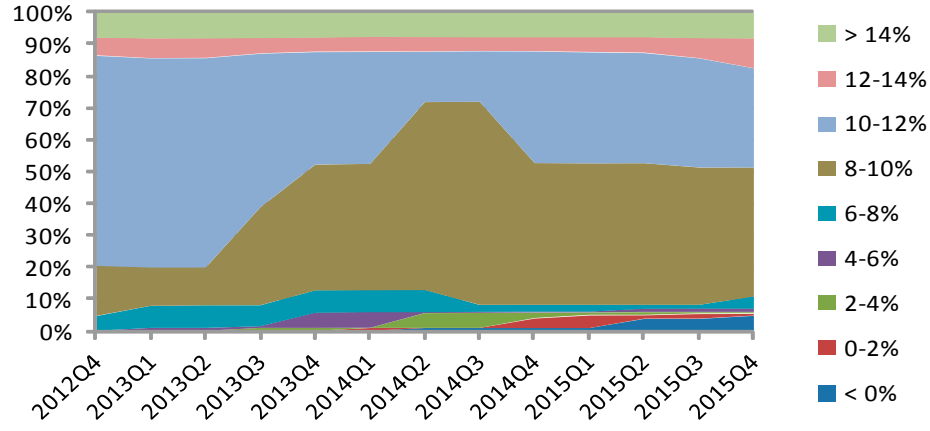
Top-Down Test: Baseline Scenario



Top-Down Test: Global Shock Scenario



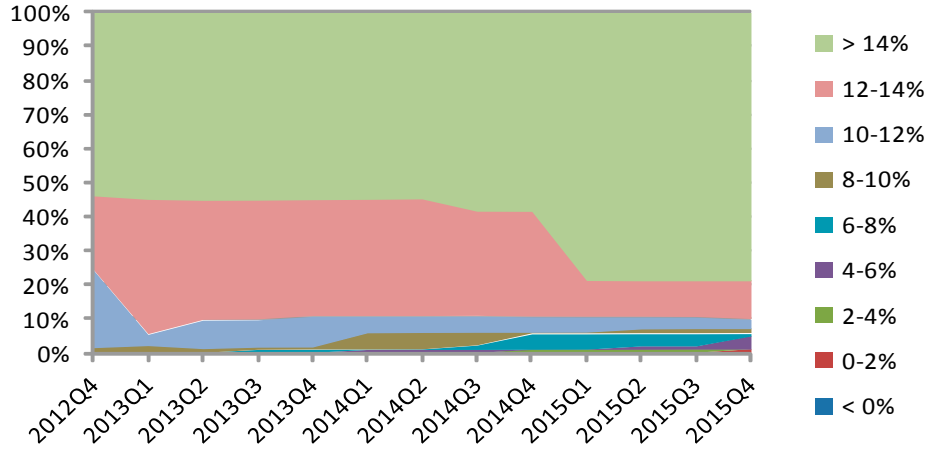
Top-Down Test: Global Shock/Recession in CESEE Scenario



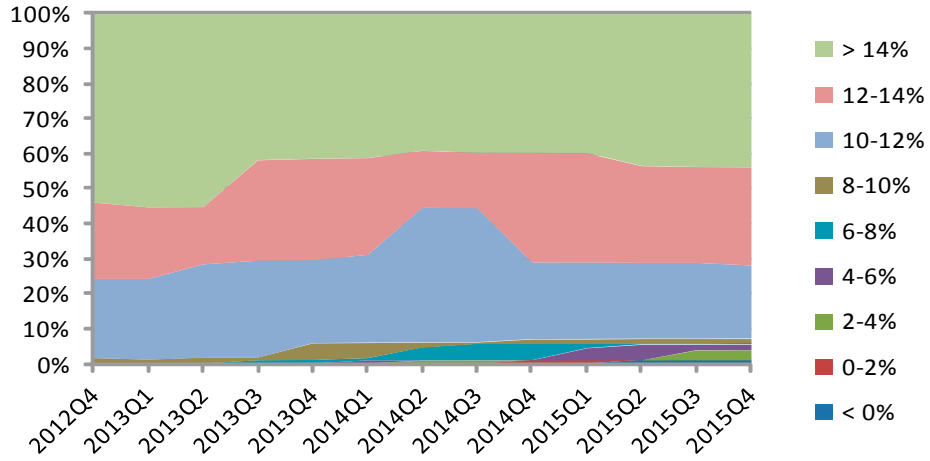
Source: OeNB

Figure 14. Solvency Stress Test Results—Total Capital Ratio Buckets

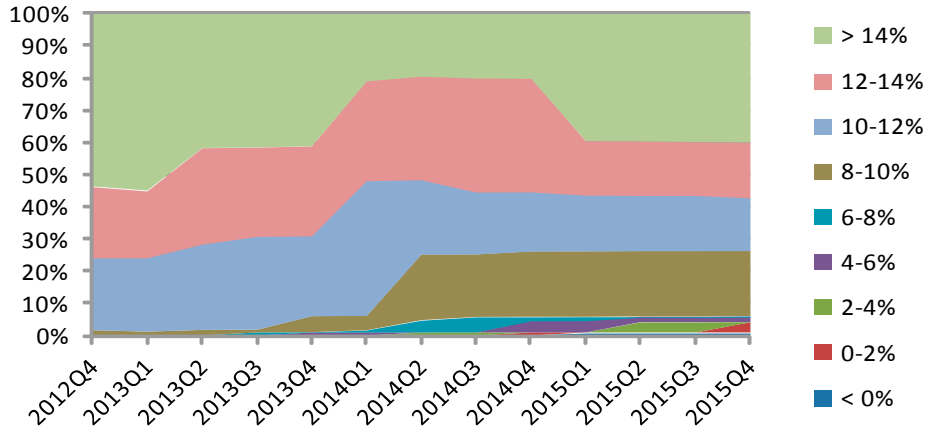
Top-Down Test: Baseline Scenario



Top-Down Test: Global Shock Scenario



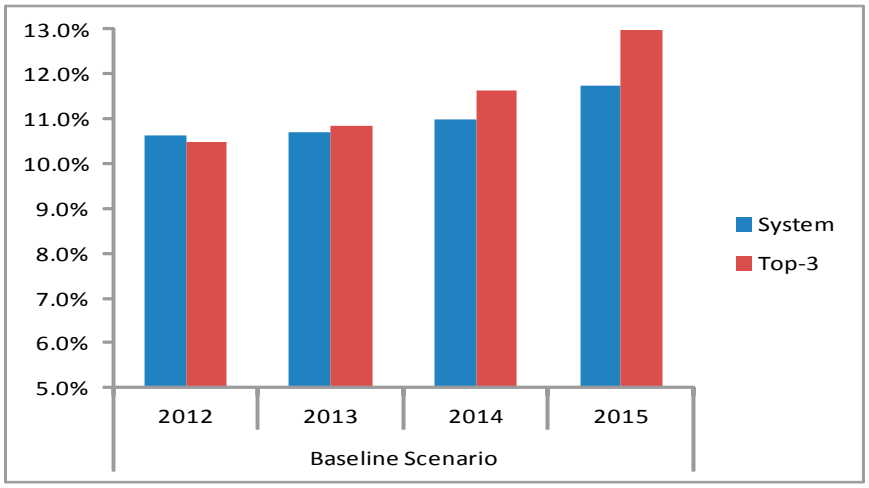
Top-Down Test: Global Shock/Recession in CESEE Scenario



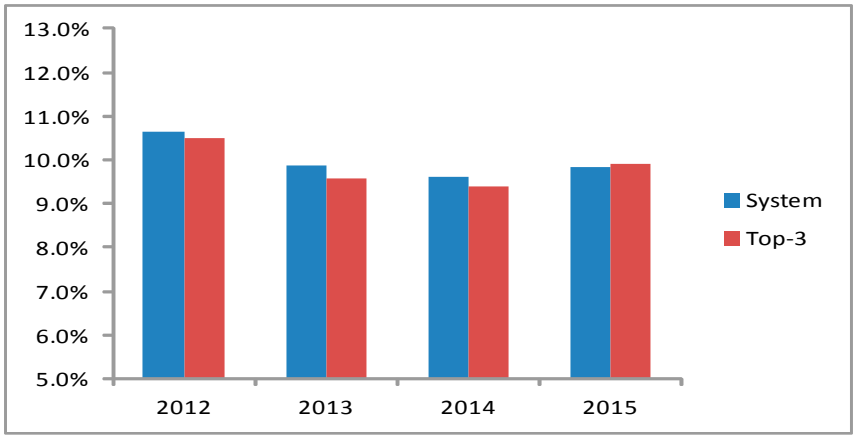
Source: OeNB

Figure 15. Weighted-Average Core Tier I Capital Ratios

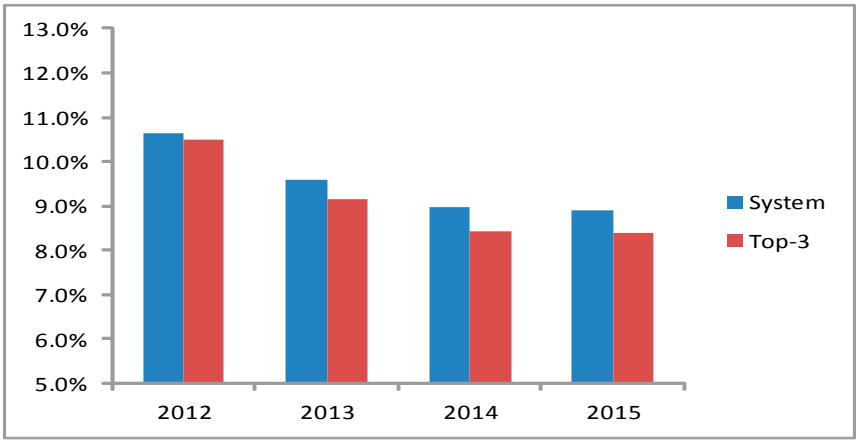
Top-Down Test: Baseline Scenario



Top-Down Test: Global Shock Scenario



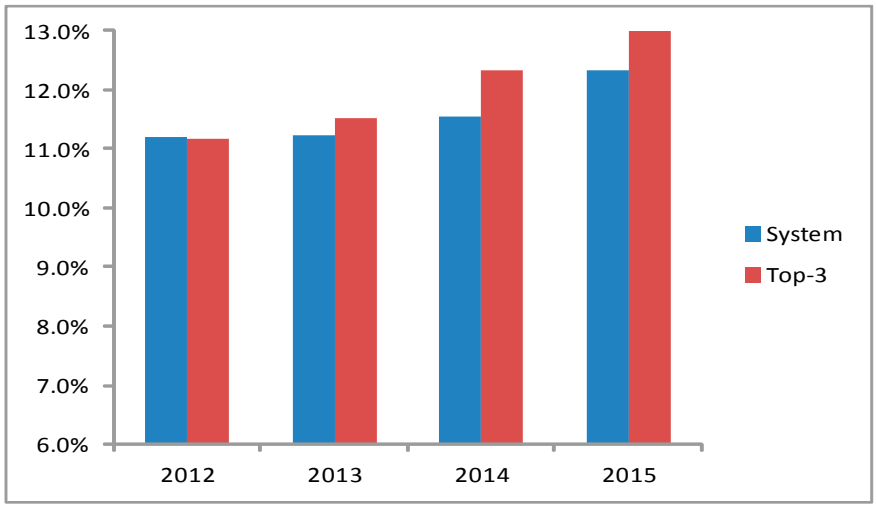
Top-Down Test: Global Shock/Recession in CESEE Scenario



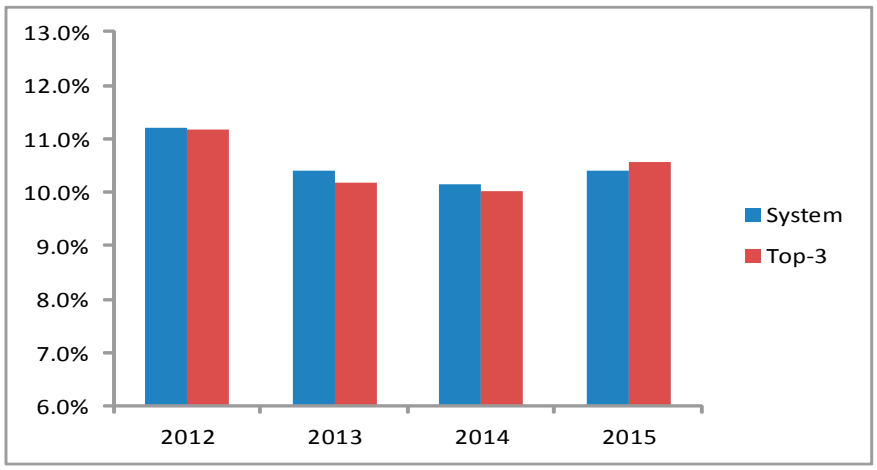
Source: OeNB

Figure 16. Weighted-Average Tier I Capital Ratios

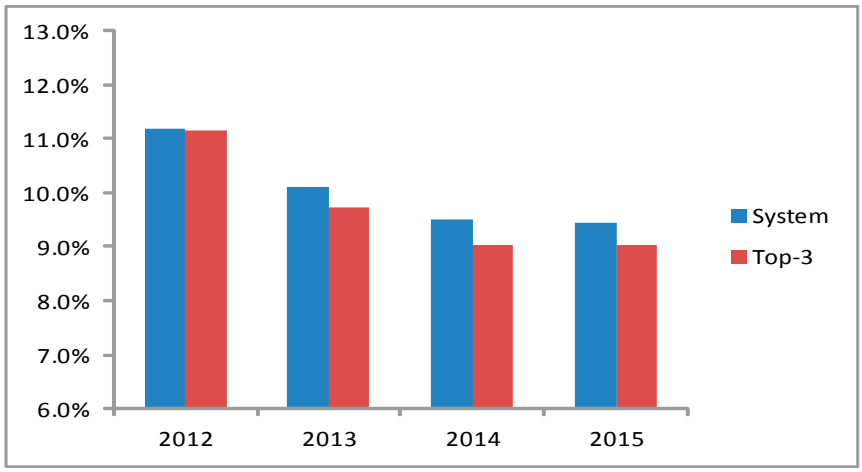
Top-Down Test: Baseline Scenario



Top-Down Test: Global Shock Scenario



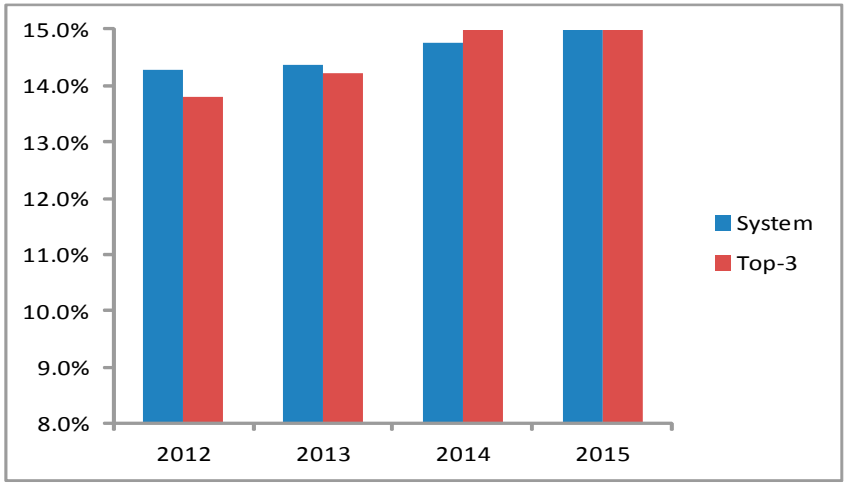
Top-Down Test: Global Shock/Recession in CESEE Scenario



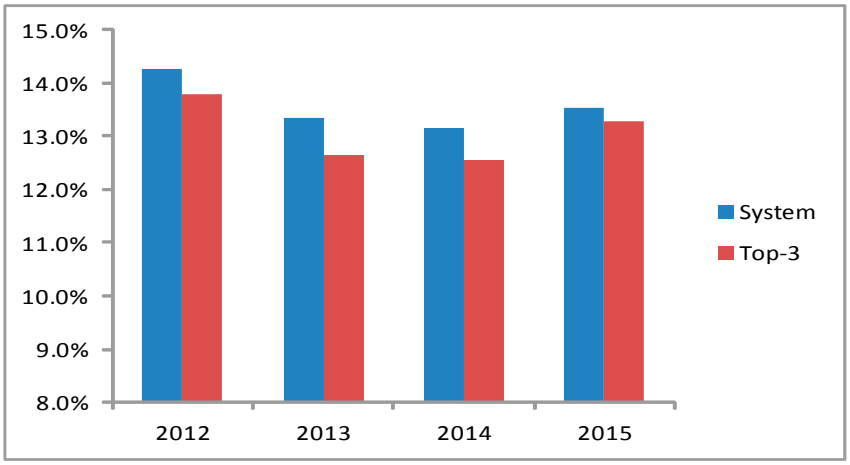
Source: OeNB

Figure 17. Weighted-Average Total Capital Ratios

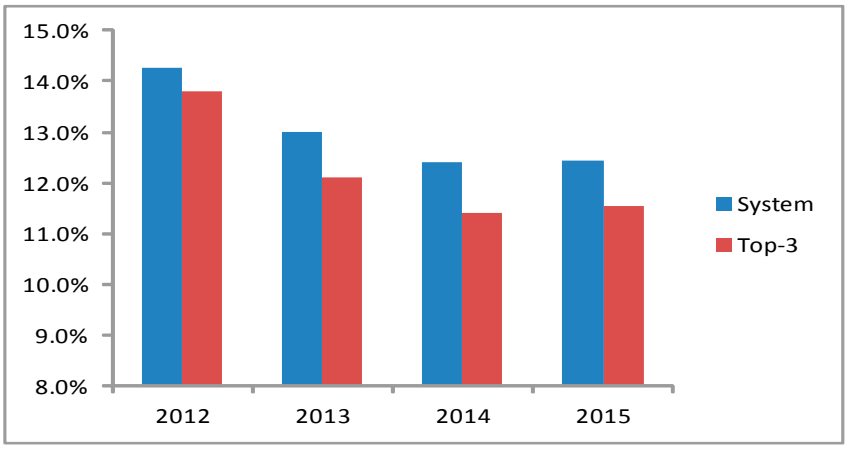
Top-Down Test: Baseline Scenario



Top-Down Test: Global Shock Scenario



Top-Down Test: Global Shock/Recession in CESEE Scenario



Source: OeNB

Table 5. Market Risk Parameters

Category	Parameter	Unit	Calibration
Interest Rates	Advanced Countries		
	USD 3M	bp	10
	USD 2Y	bp	50
	USD 10Y	bp	150
	EUR 3M	bp	30
	EUR 2Y	bp	70
	EUR 10Y	bp	130
	UK 3M	bp	20
	UK 2Y	bp	90
	UK 10Y	bp	170
	Other non-Emerging Markets 3M	bp	60
	Other non-Emerging Markets 2Y	bp	100
	Other non-Emerging Markets 10Y	bp	110
	Emerging Markets		
	Eastern Europe 3M	bp	100
	Eastern Europe 2Y	bp	110
	Eastern Europe 10Y	bp	140
	Asia 3M	bp	40
	Asia 2Y	bp	40
	Asia 10Y	bp	50
	Volatilities		
	US Volatility	%	40
	EUR Volatility	%	40
	UK Volatility	%	40
	Other non-Emerging Markets Volatility	%	70
	Emerging Markets Volatility	%	70
Foreign Exchange	FX Rates		
	USD/EUR	%	18
	JPY/EUR	%	25
	GBP/EUR	%	12
	Other non-Emerging Markets currencies/EU	%	17
	Emerging Markets currencies/EUR	%	15
	Volatilities		
	Volatilities not involving EM currencies	%	15
	Volatilities involving at least one EM currenc	%	45
	Gold/USD	%	-20
Equity	Europe (Eursostoxx 50)	%	-15
	US (S&P 500)	%	-10
	Japan (Nikkei)	%	-20
	Ems (MSCI)	%	-20
	Other non-Emerging Markets	%	-15
	Europe (Eursostoxx 50) Volatility	%	30
	US (S&P 500) Volatility	%	25
	Japan (Nikkei) Volatility	%	30
	Ems (MSCI) Volatility	%	30
	Other non-Emerging Markets Volatility	%	30
	Dividends Europe	%	-20
	Dividends US	%	-20
	Dividends Japan	%	-20
	Dividends Ems	%	-20
	Dividends non-Ems	%	-20

Table 5. Market Risk Parameters (Concluded)

Funds	Real Estate Funds	%	-10
	Hedge Funds	%	-20
	Mutual Funds	%	-2
Commodities	Brent	%	-5
	Brent Volatility	%	5
	Other commodities	%	50
	Other commodities Volatility	%	5
Credit Spreads	itrass Generic EUR	%	40
	itraxx High Yield EUR	%	100
	itraxx Senior Financials	%	110
	itraxx Subordinate Fianancials	%	100
	ABX and CMBX (ratings >=AA)	%	60
	ABX and CMBX (ratings<A)	%	60
	RBMS and CMBS Europe (ratings >=AA)	%	60
	RBMS and CMBS Europe (ratings<A)	%	40
CVA	Investmet grade counterparties	%	10
	Non-Investmet grade counterparties	%	15

Source: OeNB and 2011 EBA stress test exercise.

Table 6. Liquidity Stress Test Medium Scenario Parameters

Category	Calibration
Cash-Inflows	Complete dry-up of unsecured interbank market (100%)
	(Complete) dry-up of FX-swap market (30/90 days: 100%; 1 year: 20%)
	Issuance of long-term unsecured bonds (30/90 days: -50%; 1 year: -20%)
	Issuance of short-term unsecured paper (30/90 days: -50%; 1 year: -20%)
	Issuance of long-term covered bonds (30/90 days: -50%; 1 year: -20%)
	Issuance of short-term secured paper (30/90 days: -50%; 1 year: -20%)
	Reduction of inflows from maturing loans & form paper in own portfolio maturing (based on a link to the solvency stress test)
Cash-Outflows	30/90 day horizons: Wholesale and retail deposits (bank individual values based on conservative assessment, average across banks -2%)
	An additional idyosincratic shock reduces expected rollover rates of wholesale deposits to 90% and retail deposits to 95% over the 30 day period.
	1 year horizon: wholesale and retail outflows calibrated on peripheral Euro area experience during sovereign debt crisis (wholesale -3%, retail -2%)
	Draw down of committed lines by other banks and non-banks (+50%)
	Banks behavioural reactions are factored into the 1 year scenario (reduction of unsecured interbank loans granted -100%, reinvestment of maturing liquid assets -50%, new loans granted -3%)
Counter-balancing capacity	Haircuts on non-marketable unencumbered collateral deposited at OeNB increase to 100%
	Haircuts on collateral deposited at OeNB with rating below A- increase to 100%
	Haircuts on unsecured issuances by banks and financial corporates as well as Asset Backed Securities deposited at the OeNB increase to 100%
	Haircuts on unencumbered marketable collateral with rating from AAA to A- pledged at OeNB increase by between 100 bp (asset category 1, credit quality step 1) and 1500 bp (asset category 3 and credit quality step 2) on top of OeNB standard haircuts; other asset categories and credit quality step collateral receive 100% haircuts
	Haircuts on unencumbered collateral in USD, CHF, JPY, GBP, Other Currencies deposited at central banks (after CB haircuts) increase by additional 500 bp
	Haircuts on marketable collateral AAA to A- (not pledged at central banks) increase by 100 bp, 500 bp, and 1000 bp, respectively
	Haircuts on BBB rated (or below) non-financial corporate bonds, other marketable, pledgable (but not pledged assets) collateral, and other non-marketable pledgeable collateral (but not pledged) increase to 100%
	Haircuts on committed liquidity lines received by respective banks and liquidity injections from parent bank increase to 100%

Source: OeNB

Annex I. Risk Assessment Matrix (RAM)

Nature/ Source of Main Threats	Overall Level of Concern	
	Likelihood of Realization of Threat in the Next 1–3 Years *(high, medium or low)*	**Expected Impact on Financial Stability if Threat is Realized** *(high, medium or low)*
1. Global shock/Intensification of the Euro Area debt crisis	***Medium*** The IMF's Global Risk Assessment Matrix assigns a low/medium probability to a sharp slowdown in global growth or subdued domestic demand in the hard-hit euro zone periphery countries.	***High*** A global/euro area slowdown would decrease demand for Austrian exports and trigger a slowdown in the CESEE/CIS region, resulting in higher NPLs, lower profitability, and potential solvency pressures in some institutions. In turn, the fiscal impact of financial sector-related public liabilities may trigger adverse market dynamics. In addition, tight funding conditions could affect some Austrian banks if European banks accelerate deleveraging, hoard liquidity and cut interbank lending. Safe haven strategies by international investors may lead to sudden CHF appreciation (despite SNB interventions), heightening credit risk from FX lending to domestic borrowers. The authorities have already taken steps to promote local funding and to decrease the flow of FX lending in Austria.
2. Contagion to/from CESEE countries	***Medium*** Several large CESEE countries may be subject to severe macroeconomic and financial shocks. The highest Austrian bank exposures are to the Czech Republic, Croatia, Romania, Slovakia and Hungary. Banks also carry large exposure to foreign currency loans in host countries.	***Medium*** The Austrian banking system is a major gateway to CESEE, providing significant cross-border lending both relative to Austrian banks and to local markets. Thus, and despite ongoing shifts in country exposures, a sharp slowdown in CESEE countries would likely result in higher NPLs, lower profitability, and potential solvency problems for Austrian banks. Local currency depreciation in host countries could raise debt burdens of borrowers, also raising NPL levels for Austrian banks. Accelerated deleveraging in CESEE by Austrian

Nature/ Source of Main Threats	Overall Level of Concern	
	Likelihood of Realization of Threat in the Next 1–3 Years *(high, medium or low)*	**Expected Impact on Financial Stability if Threat is Realized** *(high, medium or low)*
		banks could fuel a negative feedback loop, possibly involving the two effects above. In turn, the fiscal impact of financial sector-related public liabilities may trigger adverse market dynamics.
3. Severe Funding Stress of Global Banks	***Medium*** Given the still fragile environment globally and in the euro area, there is a significant risk that some global banks may be hit by renewed disruption in international funding and foreign currency swap markets, reinforcing home bias shifts and tightening cross-border funding for Austrian banks.	***Medium*** Significant net cash outflows would trigger higher haircuts and unexpected margin calls on Austrian banks securities portfolios. Austrian banks may pass on rising funding costs to customers, and cut activities with high risk weights, exacerbating the credit crunch. This effect would be particularly severe for banks with negative funding gaps in USD and CHF. Liquidity support from the ECB, repo operations conducted by the SNB, and swap facilities provided by the SNB and the ECB, may mitigate funding pressures in secured and unsecured money markets. Moreover, the FX-liquidity position of the system has substantially improved since 2008 through the lengthening of tenors and diversification of counterparties.

Annex II. Identification of Key Risk Factors: A Market-Based Approach

The FSAP team conducted a market-based analysis to drill down on the main determinants of major Austrian banks' solvency risk. The risk factors examined belong to three main categories: (i) Austria macro-financial variables; (ii) contagion from the CESEE region unrelated to domestic/global developments; and (iii) global risk factors, including changes in estimated risk premia. The approach builds on Longstaff et al (2011) and uses monthly changes in the credit default swap (CDS) market and in Moody's KMV expected default frequencies (EDF) to provide a direct measure of changes in market perception of solvency risk. For each bank we regress monthly changes in CDS spreads and EDF estimates on the set of relevant explanatory variables. The time series starts in October 2007 and ends in October 2012.[75]

The first set of variables includes market revisions in macroeconomic projections for the Austrian economy. Given that most economic data releases are backward-looking, published with a lag, at low frequency, and subject to rounds of revisions, we use analysts' economic forecasts as a proxy for market expectations of Austria's economic fundamentals (GDP, industrial production, current account balance, real wages, unemployment, and sovereign CDS).

Concerns on the large exposure of Austrian banks to the CESEE region are reflected by idiosyncratic sovereign risk unexplained by systematic risk factors. Changes in sovereign spreads in the region capture market revisions in countries' economic outlook as well as valuation losses from government bond holdings by CESEE subsidiaries. In line with the OeNB modeling framework, we consider four country aggregates: New EU Member States (NMS-2004), New EU Member States 2007 (NMS-2007), Southeastern Europe (SEE), and the Commonwealth of Independent States (CIS).[76] We compute monthly changes in the sub-regional CDS weighted by consolidated BIS exposures of Austrian banks as of September 2008. To identify contagion from the CESEE region, we regress for each sub-region the monthly changes in sovereign CDS spreads on the other explanatory variables in the system—including Austria specific and global variables-, and use the orthogonal residuals as a proxy of contagion from exposure to the CESEE region.

To capture the effect of stressful financial scenarios on solvency risk we consider fluctuations in market returns and infer changes in risk premia. Market returns show the state of financial markets including the equity, fixed-income, commodities, and derivative segments. Heightened risk

[75] The time span is driven by the availability of EDF estimates for a major bank.

[76] The CESEE country aggregates include: NMS-04: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia; NMS-07: Bulgaria and Romania; SEE: Albania, Bosnia and Herzegovina, Croatia, Macedonia, Montenegro and Serbia; and, CIS: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.

aversion translates into higher risk premia demanded by global investors. Following the financial market literature, we estimate equity, volatility, and term risk premia.

The equity premium is computed as the change in the price-earnings ratio for the stock market index. We calculate changes to the equity risk premium as monthly fluctuations in the price-earnings ratio (P/E) of the S&P 100 index. Intuitively, when risk aversion (and the variance risk premium) is high, agents reallocated their portfolios from risky assets to safe haven, depressing market prices (and the P/E ratio), and increasing expected market returns.

We compute the volatility risk premium as the difference between implied and realized volatility. We replicate the analysis of Garman and Klass (1980) and construct an efficient estimator of market volatility. We use the following notation: σ^2 = variance of price change, C_0 = previous closing price, C_1 = current closing price, O_1 = current opening price, H_1 = current highest price, L_1 = current lowest price, normalized prices: $u = H_1 - O_1$, $d = L_1 - O_1$ and $c = C_1 - O_1$, and f = fraction of the day that trading is closed. The most efficient estimator is obtained by the composite ratio:

$$\hat{\sigma}_2^2 = 0.12\frac{(O_1 - C_0)^2}{f} + 0.88\frac{\hat{\sigma}_1^2}{(1-f)}$$

where $\hat{\sigma}_1^2 = 0.511(u-d)^2 - 0.019[c(u+d) - 2ud] - 0.383c^2$

We compute $\hat{\sigma}_3^2$ as a 20-day period moving average on the S&P 100 index. Our estimated volatility premium at time t is constructed as the difference between the VIX index, capturing market expectations of near-term volatility conveyed by the S&P option price, and the most efficient measure of realized volatility:

$$Vol\_prem_t = VIX_t - \hat{\sigma}_2$$

The term premium is estimated as the expected excess return on US 5 year Treasury bonds proxied by the linear combination of one through five year forward rates proposed by Cochrane and Piazzesi (2005).

We denote by $p_t^{(n)}$ the log of a n-year 1 dollar discount bond at time t. The excess total return of holding an n-year bond at time t and selling it as an n-1 bond at time t+1 is given by

$$rx_{t+1}^{(n)} = p_{t+1}^{(n-1)} - p_t^{(n)} - y_t^{(1)}$$

where $y_t^{(1)}$ denotes the log yield of an 1-year bond. CP run regressions of excess returns on 1- through 5- forward rates, where the forward rate at time t for a 1-year loan issued at time t+n-1 and repaid at time t+n is denoted by

$$f_t^{(n)} = p_t^{(n-1)} - p_t^{(n)}$$

The same linear function of forward rates forecasts holding period returns at all maturities and define a single return-forecasting factor as

$$F_t = \left(y_t^{(1)}, f_t^{(2)}, f_t^{(3)}, f_t^{(4)}, f_t^{(5)}\right)$$

We use Cochrane and Piazzesi's estimates of the loadings of the single factor on the average excess return of holding a 2- through 5-year maturity bond:

$$\frac{1}{4}\sum_{n-2}^{5} rx_{t+1}^{n} = -3.24 - 2.14 y_t^{(1)} + 0.81 f_t^{(2)} + 3.00 f_t^{(3)} + 0.80 f_t^{(4)} - 2.08 f_t^{(5)} + \bar{\varepsilon}_{t+1}$$

using one-through five-year Treasury Strips data from the fair value curve provided by Bloomberg. We proxy changes in the term premium by the change in the expected average excess return of holding a two- through five-year government bond.

The results of regressing changes in solvency risk estimates on Austrian, CESEE and global risk factors suggest that (Annex II Table 2):

- An upward revision of unemployment forecast emerges as the main Austrian macroeconomic determinant of changes in solvency risk.
- Contagion from CESEE is the most notable risk factor. The explanatory power of the regression increases significantly from 0.1 to 0.5–0.6. In terms of sub-regions, the effect is mainly driven by NMS-04 and NMS-07 with the former being associated with sharp depreciations of the Hungarian forint. A negative outlook in the SEE and CIS region prove not to be statistically significant.
- Heightened stress in European banks measured by the Itraxx Europe senior financial index, and higher credit risk in sub-investment grade European corporates tend to widen solvency risk. On the other hand, a pick-up of sovereign distress in Austria or in the GIIPS has no significant impact on Austrian banks' solvency risk consistent with the limited exposure to domestic and European peripheral countries.
- The results suggest that an increase in the term risk premium may contribute to rising credit spreads. By affecting movements in long-term rates (despite the central banks' monetary policy reaction) it may lift up banks' funding costs (direct channel) as well as credit risk of households and nonfinancial corporations (indirect channel).

Annex II. Table 1. Variable Definitions for Econometric Analysis on Risk Factors

Dependent Variable

monthly change in senior five year CDS quoted by CMA London (Bank 1) and 1-year EDF from Moody's KMV (Bank 2)

Austrian Variables

aut-return is the return of the Austrian stock market from MSCI
gdp is the montly change in annual real GDP forecast for the current year
ip is the montly change in industrial production forecast for the current year
cab is the monthly change in the current account balance forecast to GDP for the current year
w is the monthly change in real wages forecast for the current year
u is themonthly change in the unemployment rate forecast for the current year
cds_aut is the change in senior five year sovereign CDS for Austria
usd is the change in the USD to euro
chf is the change in the CHF to euro
recap is a binary variable taking the value of 1 the month it received public recapitalization.

CESEE Variables

NMS-04 is a proxy of contagion from Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia.
NMS-07 is a proxy of contagion from Bulgaria and Romania
SEE is a proxy of contagion from Croatia
CIS is a proxy of contagion from Kazakhstan, Russia and Ukraine.
forint is the change in the Hungarian forint to euro
leu is the change in the Romanian leu to euro

Global Variables

us_return is the U.S. stock market excess return computed as the monthly value-weighted return on the NYSE, AMEX, and NASDA stock indices minus the one-month US T-bill return.
ty is the change in the five-year constant maturity US Treasury rate.
liborois is the change in the 3-month LIBOR and the OIS rate on the USD
itraxx is the change in the itraxx europe senior financial index
itraxx_cross is the change in the itraxx europe crossover index covering 40 CDS on the most liquid sub-investment grade european corporate entities
itraxx_eur is the change in the itraxx europe index covering 125 CDS on investment grade european corporates
iips is the change in the weighted sovereign CDS of Ireland, Italy, Portugal and Spain
eq-prem is the change in the price-earnings ratio for the S&P 100 index
vol_prem is the difference between the VIX index and a measure of realized volatility using the Garman-Klass (1990) efficient estimator for a 20-moving window on the S&P 100 index.
term_prem is the expected excess return on US 5 year Treasury using the methodology proposed by Cochrane and Piazzesi (2005).

Annex II. Table 2. Econometric Results of Risk Factors for Solvency Stress Test

	Austrian Variables		CESEE Variables		Global Variables	
Results	Bank 1	Bank 2	Bank 1	Bank 2	Bank 1	Bank 2
market_return					0.418	-0.008
					(0.618)	(0.012)
chf	-1.374	-0.023	-1.730	-0.030	-0.093	-0.016
	(2.232)	(0.041)	(1.574)	(0.025)	(1.390)	(0.023)
gdp	-3.633	-0.126				
	(13.810)	(0.255)				
ip	2.190	0.051				
	(5.003)	(0.092)				
w	-4.108	-0.088				
	(4.042)	(0.075)				
u	-2.473	0.266	0.682	0.277**	-0.748	0.131
	(9.595)	(0.177)	(6.819)	(0.110)	(5.760)	(0.099)
cab	18.266	-0.101			10.743	0.071
	(18.889)	(0.349)			(11.675)	(0.191)
cds_aut	0.317	-0.001				
	(0.225)	(0.004)				
NMS-04			1.055***	-0.001	0.268	-0.002
			(0.323)	(0.005)	(0.365)	(0.006)
NMS-07			-0.153	0.008**	-0.090	0.009***
			(0.192)	(0.003)	(0.175)	(0.003)
SEE			0.191	-0.004	0.231	-0.000
			(0.251)	(0.004)	(0.232)	(0.004)
CIS			-0.033	0.002***	0.016	0.000
			(0.038)	(0.001)	(0.045)	(0.001)
forint					4.083***	-0.012
					(1.280)	(0.020)
leu					2.359	0.031
					(1.943)	(0.033)
libor-ois					-0.038	0.010***
					(0.157)	(0.003)
cds_iips					0.006	0.000
					(0.005)	(0.000)
recap					-25.404	-0.439
					(30.396)	(0.661)
itraxx					0.930***	0.001
					(0.214)	(0.004)
itraxx_cross					0.099**	0.004***
					(0.044)	(0.001)
itraxx_eur					-0.076	-0.004
					(0.256)	(0.004)
eq_prem					-0.066	0.001
					(1.663)	(0.030)
vol_prem					-0.113	-0.005
					(0.639)	(0.011)
term_prem					7.696	0.446**
					(11.273)	(0.177)
Constant	3.940	0.037	2.287	0.007	0.017	0.031
	(6.009)	(0.111)	(4.326)	(0.070)	(3.751)	(0.061)
Observations	60	60	60	60	60	60
R-squared	0.108	0.087	0.503	0.610	0.766	0.813

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Annex III. Stress Test Matrix (STeM) for the Banking Sector

Domain		Bottom-Up by Banks	Top-Down by OeNB with FSAP Team Inputs
Banking Sector: Solvency Risk			
1. Institutional Perimeter	Institutions included	• Five largest banks.	• All banking institutions: approx. 585 consolidated.
	Market share	• Two thirds of banking sector assets.	• 100 percent of banking sector assets.
	Data and baseline date	• Institutions' own data as of Q4 2012. • Consolidated banking group.	• Supervisory data as of Q4 2012. • Consolidated banking group.
2. Channels of Risk Propagation	Methodology	• Banks' internal models.	• OeNB Balance-sheet model.
	Satellite Models for Macro-Financial linkages	• Internal models for market risk.	• Separate satellite model for the Austrian (using insolvency data across six industry sectors) and the CESEE/CIS portfolio (using LLPR data broken down by currency), linking PDs/LGDs with macro scenarios. • Stressed PDs and LGDs. • OeNB consensus rating across banks applied to single loans. • Solvency and funding interactions included.
	Stress test horizon	• Instantaneous	• 2013–2015
3. Tail shocks	Scenario analysis		• Global Slowdown/Euro Area Debt Crisis. Deviation of 2-year accumulated growth rate of 2.0 SD for the Austrian economy and 1.5 SD for the CESEE/CIS region. Country specific projections developed for twenty-two CESEE/CIS countries. • Recession in the CESEE/CIS region. Country-specific add-on shocks are applied to seven countries raising the overall size of the shock to 1.7 SD for CESEE and 1.8 for

Domain		Bottom-Up by Banks	Top-Down by OeNB with FSAP Team Inputs
			CIS. • Global Funding Scenario (domestic currency, Eurocurrency, deposit runs, FX swap markets, market issuances) calibrated to Q3 2008.
	Sensitivity analysis	• Market risk applied to trading book positions as of Dec 2012. Valuation effects reported for a wide spectrum of stressed risk parameters. • Sovereign risk in both banking and trading book, including of CESEE subsidiaries (government, regional, and local authorities) applied to 64 countries, across all remaining maturities (3m, 6m, 1y-10y, 15y, 20y, 30y).	• Credit risk from foreign currency lending for Austrian exposures, cross-border lending, and the loan book of CESEE subsidiaries (assumption: 1.5 SD of CHF). • Funding risk for deposits and capital market issuance calibrated to 2008Q3-2009Q1. • Securitization portfolio following 2011 EBA methodology. • Market risk from underperformance of repayment vehicles and FX appreciation.
4. Risks and Buffers	Risks/factors assessed	• Market risk parameters: interest rates (23), major FX (8), equity indices (15), commodities (4), credit spreads (8), and counterparty risk (2).	• Credit losses, operating profits, funding costs, performance of repayment vehicles, sovereign risk, counterparty risk, exchange rate, taxes. • Full implementation of Basel III phase-in arrangements on aggregate CET1.
	Behavioral adjustments		• Constant balance sheet. • No asset disposals allowed • No credit growth assumed.
5. Regulatory and Market-Based Standards and Parameters	Calibration of risk parameters	• Major interest rates and FX rates jointly determined with the macro adverse scenario for consistency. • EBA's EU-wide stress test	• Stressed PDs and LGDs: • They are applied to compute both credit losses and stressed RWA calculations.

Domain		Bottom-Up by Banks	Top-Down by OeNB with FSAP Team Inputs
		2011, historical volatility, and expert judgment for the remaining risk factors.	
	Regulatory/Accounting and Market-Based Standards		• Capital definition according to EBA CT1 and Basel 2.5 RWAs. • Estimates of Basel III capital ratios (CET1, Tier 1, CAR) and RWAs for top 3, top 5, and whole banking system. • Hurdle rate: 5 percent, 6 percent, and 8 percent (CT1, T1, CAR) for whole banking system. Front-loaded CET1 ratio (7 percent) for large international banks.
6. Reporting Format for Results	Output presentation	• Dispersion of valuation losses. • Absolute and in terms of capital.	• Distribution of capital ratios. • Percentage of assets in capital buckets. • Weighted average capital ratios. • Percentage of assets that fail. Recapitalization needs.
Domain		Top-Down by OeNB in collaboration with FSAP Team	
Banking Sector: Liquidity Risk			
1. Institutional Perimeter	Institutions included	• 29 banking institutions. • All banking institutions subject to weekly cash-flow based liquidity reporting.	
	Market share	• 80 percent of banking sector assets.	
	Data and baseline date	• Supervisory data as of Q4 2012. • Consolidated banking group. • Granular data based on contractual and behavioral expected cash-flows over five maturity buckets (5 days, 1m, 3m, 6m, and 12m).	
2. Channels of Risk Propagation	Methodology	• Cash-flow-based using 6 major currency buckets. • All scenarios are based on the underlying macro-economic scenarios of the solvency stress test: (i) PD shifts feed into the counterbalancing capacity and cash inflows; (ii) feedback effects are included due to rising funding costs projected under the adverse macro scenario.	

Domain		Bottom-Up by Banks	Top-Down by OeNB with FSAP Team Inputs
3. Risks and Buffers	Risks	• Impact of solvency on liquidity via three channels: NPL impact on cash inflows via a credit risk migration matrix; capital ratios on cash outflows (funding cost and rollover rates); asset quality on counterbalancing capacity. • Funding liquidity shock. • Market liquidity shock.	
	Buffers	• Counterbalancing capacity taking into account haircuts to liquid assets. .	
4. Tail shocks	Size of the shock	• Bank run and dry up of wholesale funding markets over 45 scenarios including full/limited/restricted/closed access to money markets covering funding in domestic currency, Eurocurrency funding, FX swap markets. • Scenarios are grouped into a baseline, market mild, market medium, market severe, and combined scenario (including market and idiosyncratic shocks). • Detailed assumptions and results are reported for the mild market scenario which is consistent with recent EU FSAPs liquidity stress test scenarios. • Instantaneous outflow of funding and gradual outflow over 30-day, 90-day, and 1-year horizon.	
5. Regulatory and Market-Based Standards and Parameters	Regulatory standards	• Hurdle metrics: liquidity gap by major currency. • Definition of liquidity: local regulatory requirements. • Mapping with recent EU FSAP scenarios (stricter than revised Basel III LCR)	
6. Reporting Format for Results	Output presentation	• Percentage of assets that fail under each horizon.	
Domain		Top-Down by OeNB	Top-Down by FSAP Team
Banking Sector: Contagion Risk			
1.Institutional Perimeter	Institutions included	• Banks operating in the Austrian interbank market.	• Top listed Austrian banks and major global European banks (40) and in the CESEE (14)
	Market share	• All banking institutions: 585 consolidated.	• Ranging between 40 percent and 60 percent of banking system assets.
	Data and baseline date	• Supervisory, data as of Q4 2012. • Unconsolidated exposures	• Balance sheet, market data as of Q4 2012. • Consolidated basis.

Domain		Bottom-Up by Banks	Top-Down by OeNB with FSAP Team Inputs
		but consolidated capital ratios.	
2. Channels of Risk Propagation	Methodology	• Impact study of liquidity risk on solvency risk. • Network Analysis in the Austrian interbank market using a default cascade model.	• CoVaR framework. • Asymmetric response in episodes of deleveraging. • State variables include: a volatility index, a liquidity spread, changes in the short-end and the slope of the yield curve, changes in high-yield credit spreads, and equity market returns. • European and US financial variables considered. • Tail co-dependence assessed in (i) banks' market valued assets' growth rates, and (ii) banks' equity returns. • Individual risk computed using (i) a quantile approach, and (ii) a GARCH (1,1) framework.
3. Tail shocks	Size of the shock	• Contagion from negative funding gaps (linked to macro stress test) leading to: (i) fire sales of assets; (ii) rising funding costs; and (iii) partial closure of capital markets under a *Global Funding Scenario* replicating post-Lehman funding strains.	• 5% quantile of the conditional loss distribution. • Robustness checks applied to 1% and 2.5% of the conditional loss distribution.
4. Reporting Format for Results	Output presentation	• Capital shortfall, system wide. • Impact on regulatory capital ratios.	• Contribution to systemic risk. • Vulnerability to systemic risk. • Effect of financial state variables on tail inter-dependence. • Distribution of results for (i) a European banking system, and (ii) a CESEE banking system peer group.

Annex IV. Sensitivity Analysis of Repayment Vehicle Foreign Currency Loans

Repayment vehicle loan (RPV) exposures continue to pose a challenge to the Austrian banking system. [77]In the third quarter of 2012, 11.2 percent of net loans to the private sector were based on a repayment vehicle. Loans linked to RPVs play a greater role in lending to households than to non-financial corporations. As of September 2012, RPV loans to domestic nonbanks amounted to €30.0 billion, of which €27.3 billion (share of 20.7 percent) were granted to households and €2.7 billion (share of 2.0 percent) to non-financial corporations. By contrast to amortizing loans, the repayment of RPV loans does not take place in regular installments but at maturity (bullet loans). During the life of the loans the borrower makes a monthly payment towards a RPV. At maturity, these payments and their financial returns are used to pay back the principal of the loan.

According to the latest survey conducted in mid 2011, the total funding gap of RPVs amounted to €5.3 billion (18.2 percent). The information on the typical structure of RPVs is not available from regulatory reporting sources but derived from surveys among banks. Two such surveys were conducted in recent years: one in spring 2009 and another in autumn 2011. Both covered more than 90 percent of the outstanding volume in RPV loans of Austrian banks. In mid-2011 funding gaps of RPV loans denominated in FC and granted to domestic households and corporates amounted to €4.7 billion (with funding gaps of 20.1 percent and 18.6 percent for CHF and JPY, respectively) whereas RPV loans denominated in Euro accounted for €0.6 billion (15.6 percent funding gap).

Mutual funds-based life insurance products are at large the main contributors to RPVs funding gap. The reason is twofold. First, they account for the largest share of RPVs (54.0 percent). Second, they show the largest funding gap (21.0 percent against an average of 16.0 percent for the remaining vehicles). Its contribution to the estimated aggregate shortfall as of September 2012 (€5.5 billion) is estimated at €3.4 billion.

The sensitivity analysis of tail risk conducted by the FSAP team reveals that bullet loans 'at risk' are manageable even under extreme events. Adding an additional annual yield shock (i.e., 100 yield shock (adverse) and 200 yield shock (severe)) combined with a 1.5 SD CHF appreciation of the loan face value at maturity, the maximum funding gap would increase from an accumulated €4.2 billion to €8.6 billion. Given an average remaining maturity of 13 years, this implies an additional loss of under 1bn during the stress test horizon. These results should be interpreted with caution. A number of extensive assumptions had to be made to the many unknowns in the underlying data, mainly on the breakdown of the projected RPV value under the baseline scenario into assets already paid into the RPV, future payments into the RPV, and the assumed performance of the RPV. Also they should not be added up to the sensitivity results in FCLs as it would duplicate the effect of the FX shock.

[77] The financial crisis has put to the fore the risks facing both banks and consumers in relation to foreign currency and repayment vehicle loans. The banks ultimately bear the underfunding risk (whatever the source of the gap is—be it asset price, FX, or concentration risks.

Annex IV. Table 1. Stress Test of RPV Yield and CHF Shock by Product Category

(in million euros)

	Projected Value of RPV			Outstanding Debt		Projected Funding Gap (yield shock)			Projected Funding Gap (yield and FX shock)					
	Baseline	Adverse (100 bps)	Severe (200 bps)	Baseline	1.5 SD CHF	Baseline	Adverse (100 bps)	Severe (200 bps)	(in million euros) Baseline	Adverse	Severe	(in percent) Baseline	Adverse	Severe
Equity funds	1,046	983	924	1,254	1,388	208	271	329	342	405	464	24.6%	29.2%	33.4%
Fixed income funds	418	392	368	485	510	67	93	117	93	119	143	18.2%	23.3%	28.0%
Balanced funds	2,213	2,076	1,948	2,586	2,782	373	510	637	569	706	833	20.5%	25.4%	30.0%
Mutual funds-based life insurance	12,367	11,592	10,872	15,655	17,386	3,288	4,063	4,783	5,019	5,794	6,514	28.9%	33.3%	37.5%
Other instruments	1,180	1,107	1,039	1,503	1,663	323	396	464	483	556	624	29.0%	33.4%	37.5%
Total market sensitive	17,224	16,150	15,152	21,483	23,730	4,259	5,333	6,331	6,506	7,580	8,578	27.4%	31.9%	36.1%
Total RPVs	*23,695*			*28,983*										

Source: IMF staff calculations drawing on OeNB survey (June 2011) .

1/ 50th percentile of daily annual returns over Jan 2005 through Dec 2012 of the following proxy instruments: equity funds (Eurostoxx 50 Equity Index, fixed income funds (JPM euro EMBI global europe), balanced funds (JPMorgan Investment Funds - Global Balanced Fund in EUR), mutual funds-based life insurance (Franklin Mutual Series Fund Inc - Mutual European Fund), other instruments (average yield of the above instruments).

2/ The analysis assumes average residual maturity of 13 years as of September 2012.

3/ An accumulated CHF appreciation of 1.5 SD over 2013-2014 with a stabilizing rate thereafter, increases outstanding debt for CHF denominated loans.

Annex V. Sovereign Risk Calibration

Sovereign risk is measured in the adverse scenario through changes in sovereign yields leading to a repricing of all affected bonds. Holdings of government bonds in both the banking book and the trading book are repriced.

The scope of 'sovereign' follows the CRD IV definition in the standardized approach. It includes: all central governments (but no central banks), all regional governments, and all local authorities. Exposures classified under the IRB approach are segmented following the same breakdown.[78]

All direct and indirect sovereign exposures are stressed including those held by CESEE subsidiaries. The net direct exposure comprises gross exposures (long) net of cash short position of sovereign debt (without derivative hedges such as CDS). This is referred to as the "net direct position." The indirect sovereign exposures includes both on and off balance sheet exposures:

- Direct derivatives positions are subject to fair value adjustments based on the relevant shock (e.g., for an interest rate derivative, use the shock on interest rates) and the relevant CVA adjustments.
- Indirect exposures (those with counterparties other than the sovereign itself, i.e. CDS) are treated in a similar way, subject to fair value adjustments of the relevant shock and the CVA adjustment.

The methodological approach is as follows:

- Under stress, the term structure of sovereign risk shifts upward for all countries to which Austrian banks are exposed, including sovereign bonds held by CESEE subsidiaries to comply with local liquidity requirements.
- The approach allows changes in risk term premia associated with the excess yield that investors require to commit to holding a long-term bond instead of a series of shorter-term bonds under volatile conditions (see Annex II for estimated impact on large banks' market-implied solvency perceptions).
- The calibration of the sovereign shock on the level of spreads (parallel shift), on the slope and on the curvature of the yield curve is based on historical yields at each maturity date of the term structure, using the modified duration approach. When there is no available maturity to derive a valuation haircut, the relevant haircuts are interpolated.

[78] Public sector entities, multilateral development banks, and international organizations are generally excluded.

- The shock is calibrated for fifty eight countries. For fifty countries, the shock is derived from the 90th percentile of the historical distribution of annual changes of daily yields of Bloomberg generic 5-year government bond yields over the period 2005–12. The change in yields is used to reprice all government bonds under a cash-flow approach matching a modified duration formula to each maturity bucket.

- For Belarus, Bulgaria, Luxembourg, Malta, and Romania, the haircut is computed using extreme returns for the most liquid outstanding international bond as of Dec 2012, given the limited time series of the generic yield curve.[79] For Cyprus, the haircut is calibrated from the sovereign yield curve as of Dec 2012. For Estonia, only international loans were outstanding as of Dec 2012.

Annex V. Table 1. International Bonds for Calculation of Sovereign Haircuts
(Countries with no generic bonds)

	Belarus	Bulgaria	Romania	Luxembourg	Malta
Ticker	EI331781 Corp	EC543829 Corp	EH414868 @HVBT Corp	EH619121 Corp	EG194516 Corp
Issue Date	7/26/2010	3/22/2002	6/11/2008	11/7/2008	11/19/2001
Maturity	8/3/2015	1/15/2015	6/18/2018	12/4/2013	5/19/2013
Market	euro-dollar	private placement	euro non-dollar	eurozone	eurozone
Currency	USD	USD	EUR	EUR	EUR
Coupon	8.75	8.25	6.5	3.75	6.35

Source: Bloomberg.

Haircuts to the banking book are applied to adjusted (marked-to-market) balance sheet values. It means that banks have recognized losses or gains before the haircut itself is applied from search-for-yield or flight-to-quality dynamics. All exposures are reported before the deduction of provisions, the application of credit conversion factors, or credit risk mitigation techniques:

- For exposures valued at amortized cost, the valuation loss for each country of exposure and sovereign bucket is calculated as:

$$Valuation\ loss = amortized\ cost - market\ value + market\ value * haircut$$

- The resulting losses are distributed across the stress testing horizon.

[79] For Romania, haircuts were computed suing the 99th percentile of the historical distribution given the short time series of historical returns under the most liquid outstanding bond.

Annex V. Table 2. Sovereign Haircuts by Selected Countries of Exposure

(in percent)

	3M	6M	1Y	2Y	3Y	4Y	5Y	6Y	7Y	8Y	9Y	10Y	15Y	20Y	30Y
AT	0.28	0.56	0.82	2.18	3.17	3.68	4.48	4.33	5.16	5.25	6.64	6.24	8.19		19.25
CZ	0.28	0.56	0.49	1.01	1.70	2.18	1.77	0.90	2.78	3.45	4.82	4.84	11.09		
HU	2.00	3.00	4.00	5.00	7.42	9.78	11.50	15.00	20.79	22.50	21.00	20.70	28.03		
PL	0.28	0.56	1.63	2.52	3.11	3.54	4.02	1.55	2.41	3.82	3.18	7.28	10.04		
SK	0.28	0.56	0.63	1.77	1.50	1.50	5.10	4.00	3.81		2.00	5.25	16.90	...	
SI	0.62	0.02	0.95	6.22	4.51	11.10	10.88	16.25	14.72	21.46	24.05	19.33	41.59		
BG	0.33	0.75	1.32	2.64	3.96	5.28	6.60	8.00	9.50	11.00	12.00	13.19	19.79		
RO	0.27	0.24	1.06	2.13	3.19	4.25	5.31	6.00	7.00	8.00	9.00	10.63	15.94		
RU	0.50	0.90	1.61	2.75	5.61	3.12	4.30	4.44	5.00	6.00	7.00	7.19	8.00		
UA	2.27	4.00	5.99	8.00	11.47	11.16	19.63	21.00	22.00	22.38	25.00	27.64	30.00		
BY															
Other CIS															
HR	2.00	3.00	4.00	5.00	6.00	6.68	6.94	5.06	8.00	11.17	13.00	16.00	18.00		
TR			2.74	5.24	6.48	7.65	7.83	8.00	8.50	9.00	9.50	10.05			
Other SEE	2.00	3.00	4.00	5.00	6.00	6.68	6.94	5.06	8.00	11.17	13.00	16.00	18.00		
GR	1.16	2.49										125.29	168.69	...	293.09
IT	0.29	0.58	1.18	2.95	4.35	5.25	6.42	7.32	8.20	8.59	8.91	10.08	13.27	18.75	23.09
IE	...		2.27	7.90	12.74		23.71	20.36	16.73	26.54	28.00	30.00	33.00		
PT	0.61	1.50	4.71	16.15	26.19	28.42	37.93	42.97	47.77	52.69	54.12	47.42			87.76
ES				2.96	4.28	5.73	7.13	8.01	9.04	10.05	11.49	12.59	18.44	25.71	31.96
BE				2.80	4.17	5.09	5.20	5.81	6.28	6.49	6.91	7.13	13.26	11.36	18.83
CY			11.68	20.26	36.03				50.90						
FI	0.00	0.00	0.05	0.68	1.23	1.28	2.12	3.00	3.86	0.00	1.00	1.24	3.18		...
FR	0.29	0.57	1.12	2.19	2.94	3.54	4.28	4.67	5.05	5.26	5.54	5.92	8.59	10.34	15.08
DE	0.28	0.56	1.15	2.14	3.03	3.75	4.11	4.55	4.91	5.12	5.41	5.61	1.15	10.34	13.68
LU	0.15	0.31	0.59	2.17	3.10	3.72	4.20	4.73	5.05	5.30	5.50	5.91	6.12	11.20	14.09
MT	2.00	3.00	4.00	5.00	6.00	6.68	6.94	5.06	8.00	11.17	13.00	16.00	18.00		
NL	0.15	0.31	0.59	2.17	3.10	3.72	4.20	4.73	5.05	5.30	5.50	5.91	6.12	11.20	14.09
CH			...	0.23	0.46	0.10	0.51	0.45	0.59	1.19	1.52	1.12	3.16	3.38	4.41
GB	0.03	0.05	0.82	1.55	2.17	2.71	3.13	3.44	4.51	5.05	6.84	5.68	6.78	8.04	11.37
US	0.37	0.67	0.06	1.62	2.12	2.12	3.56	2.12		2.00	4.00	6.67	9.00	12.00	17.78
JP	0.00	0.00	0.01	0.02	0.08	0.16	0.10	0.08	0.19	0.26	0.27	0.25	1.29	2.28	5.10
Other RoW	0.37	0.67	0.06	1.62	2.12	2.12	3.56	2.12		2.00	4.00	6.67	9.00	12.00	17.78

Source: Bloomberg and IMF staff estimates.

Note: The shock is derived from the 90th percentile of the historical distribution of annual changes of daily yields of Bloomberg generic 5-year government bond yields over the period 2005–12.

For Belarus, Bulgaria, Luxembourg, Malta, and Romania, the haircut is computed using extreme returns for the most liquid outstanding international bond as of Dec 2012,

For Cyprus, the haircut is calibrated from the sovereign yield curve as of Dec 2012.

Annex VI. CoVaR Approach to Assess Contagion

The CoVaR methodology is applied to evaluate the potential for individual bank stress to propagate throughout the financial system. The channel of propagation of financial distress is contagion through financial markets and changes in banks' leverage. The quantification of contagion effects depends on: (i) the definition of the financial system; (ii) the economic and financial circumstances in which a firm's failure arises.

A bank is distressed when it reaches its VaR returns. We proxy weekly bank returns by the estimated growth rate of the market value of assets. This measure captures individual distress generated by: (i) a decline in asset prices, and/or (ii) balance sheet deleveraging. We apply the market-to-book equity ratio to transform book-valued total assets into market-valued total assets. Since balance sheet data is reported quarterly or semi-annually, we use a cubic spline interpolation to smooth accounting data to weekly frequency.

The relevant financial system is defined as the set of listed European internationally active banks. The list of banking institutions draws from the 2011 EBA stress testing exercise. Data constraints reduce the initial list to forty banks.[80] The starting date of the analysis is determined by the listing of a large Austrian bank in April 2005 and runs through Dec 2012. Balance sheet data is sourced from Bloomberg.[81] Banks' price-to-book data is extracted from Datastream as it features wider coverage than Bloomberg.

The time-series estimation of extreme returns is enhanced by using a set of macrofinancial state variables. The choice of variables is guided by their role in affecting expected returns in financial markets. We use the set of state variables sampled from the European market as common conditioning variables to characterize the time-varying conditional VaR/CoVaR dynamics of both individual banks and the financial system:[82]

- Volatility Index (VIX) of the Chicago Board Options Exchange (CBOE). This volatility measure provides a better fit than theV2X Index.[83]

[80] We add up two large Swiss banks to the 2011 EBA list and exclude non-listed banks. This brings down the initial list of banks from 90 to 56 banks. Data limitations leave out six banks for which there is no market data available as of April 2005. The realization of a negative price-to-book ratio for five banks in 2009 along with the existence of thin equity markets for another five banks reduces the final list of banks to 40 banks.

[81] The exception is Bank of Cyprus and Jyske bank for which Datastream is used as it offers a longer time series than Bloomberg.

[82] The data have been obtained from Bloomberg. The dummy variables for the global/sovereign debt crisis have been sourced from the Liikanen report.

[83] The V2X Index is based on a new methodology jointly developed by Deutsche Borse and Goldman Sachs to measure volatility in the Eurozone based on the EURO STOXX 50 Index options traded on Eurex across all maturities).

- Liquidity spread defined as the difference between the 3-month ECB repo rate and the 3-month Euro benchmark curve.
- The weekly change in the Euro benchmark 3-month rate.
- The change in the slope of the Euro benchmark yield curve defined as the yield spread between the 10-year and 2-year bonds.
- The change in the credit spread between the 10-year EMU. A corporate yield in euros and the 10-year Euro benchmark bond.
- The Eurostoxx 50 Equity Index weekly return.
- A global financial crisis dummy starting in July 2007.
- A European sovereign debt crisis dummy starting in May 2010.

The CoVaR approach measures the marginal contribution of an individual financial institution distress to the risk of the financial system. The contribution of each institution to left tail risk of the whole financial system is measured by its Δ CoVaR (Annex VI Box 1).

On the role of the macrofinancial environment to trigger extreme banking system losses, liquidity strains came to the fore as one of the key determinants (Annex VI Table 4). Among the different risk factors used as state variables, liquidity squeeze has the strongest predictive power for both European and CESEE banking systems. European banks' system returns are also affected by an uptick in implied market volatility, changes in the T-bill exhibit, and the sovereign debt crisis. These effects are not surprising. The first factor reflects investors' fear, the second factor proxies flight to quality, and the third factor captures feedback loops between banking and sovereign risk.

On the propagation of financial distress, tail system returns appear to be heavily impacted by distress in individual institutions. The coefficient related to individual returns is always significant. The median elasticity of European system returns to individual performance at the 5th quantile is 1.2 when banks are deleveraging compared to 0.3 when balance sheets are expanding. The asymmetric spread though very significant for CESEE peer banks is somewhat less pronounced.

The baseline specification consists of: (i) the asymmetric model, (ii) the definition of returns as the growth rate of market valued assets, (iii) the inclusion of European financial state variables as conditioning variables, (iv) the quantile approach to the estimation of VaR dynamics, and (v) the focus on the 95th percentile of the loss distribution.

We conduct a battery of robustness checks including: (i) the symmetric specification in the co-dependence structure of tail returns, (ii) a CoVaR analysis applied to banks' equity returns, (iii) the use of global markets developments proxied by US financial state variables, (iv) the characterization of individual VaR dynamics using a GARCH (1,1) approach on conditionally demeaned returns, and (v) the analysis of the 99th percentile of the loss distribution.

Box 4. Overview of the CoVaR Methodology

The CoVaR is defined as the maximum expected loss in the banking system for a given confidence level and time horizon, conditional on the maximum expected loss of an individual bank at a specific confidence level and time horizon. More formally, the $(1-\lambda)\%$ CoVaR of system j given the $(1-\lambda)\%$ VaR of bank *i*, denoted $CoVaR^{j|i}_{\lambda,t}$, is defined as the λ quantile of the conditional loss function:

$$\Pr\left(X^j_t \le CoVaR^{j|\Phi(X^i_t)} \middle| \Phi\left(X^i_t\right)\right) \quad (1)$$

where X^j_t and X^i_t denote system and individual bank returns.

A bank's individual contribution to systemic risk can be approximated by its Δ CoVaR:

$$\Delta CoVaR^i_{\lambda,t} = CoVaR^{j|i}_{\lambda,t} - VaR^j_{\lambda,t} \quad (2)$$

which captures how much risk bank i adds to overall systemic risk when it reaches its VaR.

For each conditioning event, we construct a different banking system to avoid spurious correlation. The banking system is defined as the weighted average returns of the remaining banks in the sample, once we exclude the bank in distress. In particular, the returns of the banking system given bank *i*'s distress are constructed as:

$$X^{S,i}_t = \sum_{j=1, j\neq i}^{n} \omega_{t,j} X^j_t, \quad \omega_{t,j} = W^j_t \left(\sum_{j=1, j\neq i}^{n} W^j_t \right)^{-1} \quad (3)$$

where X^j_t refers to the returns of the *j*-th bank and W^j_t is the book value of total assets.

The existence of risk spillovers is captured through the estimates of the $\delta_{\lambda,i}$ parameter. The left tail of the banking system can be predicted by observing the distribution of bank i's returns. The symmetric specification can be approximated by:

$$X^{S,i}_t = Z'_{t-1}\beta_\lambda + \delta_{\lambda,i} X^i_t + u_{\lambda,t} \quad (4)$$

We check for possible asymmetries in the specification. Since the interest of our analysis is clearly on the behaviour of the left tail, for which 5% VaR is expected to be a negative value, the basic specification (4) neglects an important feature of the conditioning: the final prediction is constructed on a negative value. If we factor in the reinforcing effects from credit constraints in a downward market, the model is likely to yield parameter estimates of $\delta_{\lambda,i}$ which can significantly underestimate the impact on the system of a negative shock in the balance sheet of a bank. We estimate the asymmetric specification:

$$X^{S,i}_t = Z'_{t-1}\beta_\lambda + \delta^-_{\lambda,i} X^i_t I_{\left(X^i_t<0\right)} + \delta^+_{\lambda,i} X^i_t I_{\left(X^i_t\ge 0\right)} + u_{\lambda,t} \quad (5)$$

The econometric specification of the contribution of bank *i*'s distress to the distress of the banking system is approached by:

$$\Delta CoVaR^i_{\lambda,t} = \hat{\delta}_{\lambda,i}\left(VaR^t_i(\lambda) - VaR^t_i(50\%)\right) \quad (6)$$

Annex VI. Table 1. CoVaR List of European Banking Institutions

Country	Bank	Bloomberg Ticker	Ticker
Austria	ERSTE GROUP BANK AG	EBS AV Equity	EBS
Austria	RAIFFEISEN BANK INTERNATIONA	RBI AV Equity	RBI
Belgium	KBC GROEP NV	KBC BB Equity	KBC
Cyprus	BANK OF CYPRUS PUBLIC CO LTD	BOCY CY Equity	BOCY
Denmark	DANSKE BANK A/S	DANSKE DC Equity	DANSKE
Denmark	JYSKE BANK-REG	JYSK DC Equity	JYSK
Finland	POHJOLA BANK PLC-A SHS	POH1S FH Equity	POH1S
France	BNP PARIBAS	BNP FP Equity	BNP
France	CREDIT AGRICOLE SA	ACA FP Equity	ACA
France	SOCIETE GENERALE	GLE FP Equity	GLE
Germany	COMMERZBANK AG	CBK GR Equity	CBK
Germany	DEUTSCHE BANK AG-REGISTERED	DBK GR Equity	DBK
Hungary	OTP BANK PLC	OTP HB Equity	OTP
Ireland	ALLIED IRISH BANKS PLC	ALBK ID Equity	ALBK
Ireland	BANK OF IRELAND	BKIR ID Equity	BKIR
Italy	BANCA MONTE DEI PASCHI SIENA	BMPS IM Equity	BMPS
Italy	INTESA SANPAOLO	ISP IM Equity	ISP
Italy	UNICREDIT SPA	UCG IM Equity	UCG
Italy	UBI BANCA SCPA	UBI IM Equity	UBI
Netherlands	ING GROEP NV-CVA	INGA NA Equity	INGA
Norway	DNB ASA	DNB NO Equity	DNB
Poland	PKO BANK POLSKI SA	PKO PW Equity	PKO
Portugal	BANCO BPI SA.- REG SHS	BPI PL Equity	BPI
Portugal	BANCO COMERCIAL PORTUGUES-R	BCP PL Equity	BCP
Portugal	BANCO ESPIRITO SANTO-REG	BES PL Equity	BES
Spain	BANCO BILBAO VIZCAYA ARGENTA	BBVA SM Equity	BBVA
Spain	BANCO DE SABADELL SA	SAB SM Equity	SAB
Spain	BANCO ESPANOL DE CREDITO	BTO SM Equity	BTO
Spain	BANCO POPULAR ESPANOL	POP SM Equity	POP
Spain	BANCO SANTANDER SA	SAN SM Equity	SAN
Sweden	NORDEA BANK AB	NDA SS Equity	NDA
Sweden	SKANDINAVISKA ENSKILDA BAN-A	SEBA SS Equity	SEBA
Sweden	SVENSKA HANDELSBANKEN-A SHS	SHBA SS Equity	SHBA
Sweden	SWEDBANK AB - A SHARES	SWEDA SS Equity	SWEDA
Switzerland	Credit Suisse (CS US Equity)	CSGN VX Equity	CSGN
Switzerland	UBS (UBS US Equity)	UBSN VX Equity	UBSN
United Kingdom	BARCLAYS PLC	BARC LN Equity	BARC
United Kingdom	HSBC HOLDINGS PLC	HSBA LN Equity	HSBA
United Kingdom	LLOYDS BANKING GROUP PLC	LLOY LN Equity	LLOY
United Kingdom	ROYAL BANK OF SCOTLAND GROUP	RBS LN Equity	RBS

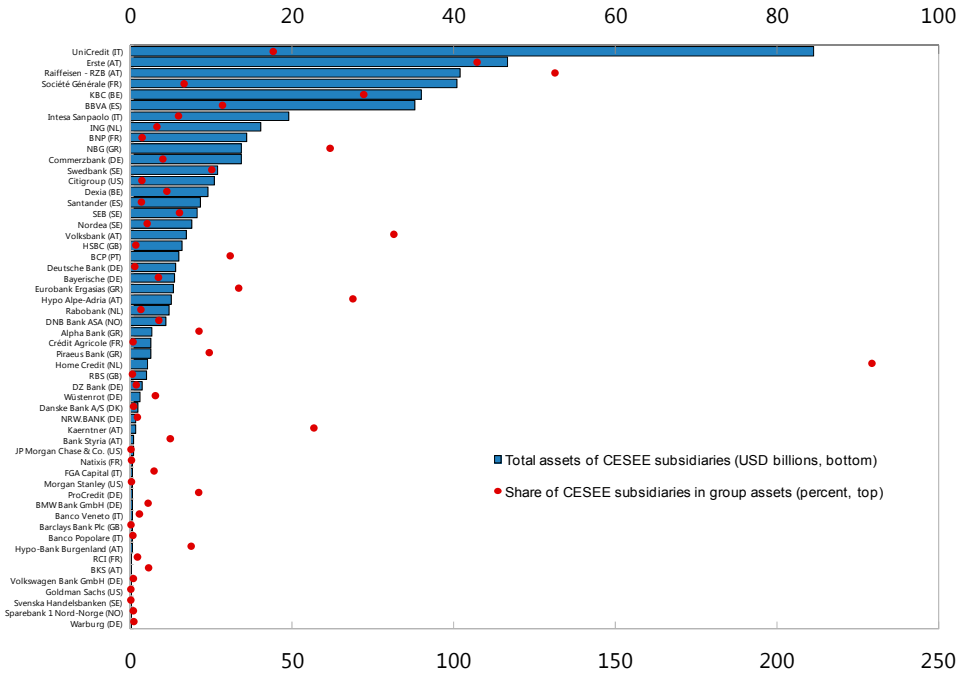
Source: Bloomberg

Annex VI. Table 2. CoVaR: List of European Banks Active in CESEE

Country	Bank	Bloomberg Ticker	Ticker
Austria	ERSTE GROUP BANK AG	EBS AV Equity	EBS
Austria	RAIFFEISEN BANK INTERNATIONA	RBI AV Equity	RBI
Belgium	KBC GROEP NV	KBC BB Equity	KBC
France	BNP PARIBAS	BNP FP Equity	BNP
France	CREDIT AGRICOLE SA	ACA FP Equity	ACA
France	SOCIETE GENERALE	GLE FP Equity	GLE
Germany	COMMERZBANK AG	CBK GR Equity	CBK
Hungary	OTP BANK PLC	OTP HB Equity	OTP
Italy	INTESA SANPAOLO	ISP IM Equity	ISP
Italy	UNICREDIT SPA	UCG IM Equity	UCG
Netherlands	ING GROEP NV-CVA	INGA NA Equity	INGA
Spain	BANCO SANTANDER SA	SAN SM Equity	SAN
Sweden	SKANDINAVISKA ENSKILDA BAN-A	SEBA SS Equity	SEBA
Sweden	SWEDBANK AB - A SHARES	SWEDA SS Equity	SWEDA

Source: Bloomberg

Annex IV. Figure 1. Foreign Banks Active in CESEE: CESEE Subsidiaries, 2011



Source: IMF, Central, Eastern and Southeastern Europe--Regional Economic Issues (April 2013).
Note: A bank is defined as foreign-owned when it has a foreign global-ultimate-owner that controls 25 percent or more of its total shares. A few small subsidiaries did not have 2011 data at the time of download.

Annex VI. Table 3. CoVaR: Summary Statistics of State Variables

European state variables

	VIX	liquidity	ch_tbill	ch_slope	_credit spreads	ch_Stoxx	crisis_global	crisis_sovereign
Mean	21.795	0.559	-0.005	0.000	0.001	-0.027	0.715	0.348
Median	19.085	0.461	0.000	-0.005	0.006	0.395	1.000	0.000
Maximum	74.260	3.579	0.918	0.356	0.332	11.518	1.000	1.000
Minimum	9.890	0.100	-1.796	-0.322	-0.608	-25.131	0.000	0.000
Std. Dev.	10.650	0.410	0.121	0.090	0.120	3.406	0.452	0.477
Skewness	1.991	2.197	-7.167	0.509	-0.734	-1.264	-0.953	0.641
Kurtosis	8.180	12.027	131.013	5.050	6.424	11.069	1.907	1.410
Observations	400	400	400	400	400	400	400	400

US state variables

	VIX	liquidity	ch_tbill	ch_slope	_credit spreads	ch_S&P	ch_LIBOR-OIS	crisis_global
Mean	21.795	0.270	-0.007	0.002	0.003	0.051	0.353	0.715
Median	19.085	0.180	0.000	-0.003	-0.006	0.275	0.164	1.000
Maximum	74.260	1.720	0.810	0.409	1.234	9.639	3.435	1.000
Minimum	9.890	-0.010	-1.590	-0.386	-0.614	-16.451	0.015	0.000
Std. Dev.	10.650	0.210	0.151	0.099	0.168	2.584	0.446	0.452
Skewness	1.991	2.581	-3.668	0.155	0.845	-1.124	3.187	-0.953
Kurtosis	8.180	12.611	42.239	5.348	10.308	9.332	16.877	1.907
Observations	400	400	400	400	400	400	400	400

Source: Bloomberg, Datastream, and IFM staff calculations.
Note. This table shows the summary statistics of European and US weekly market variables over April 2005-December 2012. The following European state variables are included: the VIX of the S&P 500 from the CBOE (as it is more significant than the VSTOXX based on the EURO STOXX 50 Index options traded on the Eurex); a liquidity spread proxied by the difference between the 3-month ECB repo rate and the 3-month Euro benchmark; the change in the Euro benchmark 3-month rate; the change in the slope of the Euro benchmark yield curve (yield spread between the 10-year and 2-year bonds); the change in the credit spread between the 10-year EMU A corporate yield in euros and the 10-year Euro benchmark bond; the Eurostoxx 50 Equity Index weekly return; a global financial crisis dummy starting on July 7, 2007, and a European sovereign debt crisis dummy starting on May 5, 2010. Likewise, the following US financial variables are considered: the VIX of the S&P 500 from the CBOE; the liquidity spread proxied by the difference between the 3-month US repo rate and the 3-month T-bill rate; the change in the 3-month US T-bill rate; the change in the slope of the US yield curve (yield spread between the 10-year and 2-year bonds); the change in the credit spread between the 10-year US Baa corporate yield and the 10-year US government bond rate; the S&P 500 Equity Index weekly return; and a global financial crisis dummy starting on July 7, 2007.

Annex VI. Table 4. Determinants of Tail Banking System Returns

	European Banks		European Banks Active in CESEE/CIS		
	Coeff	t-statistics		Coeff	t-statistics
Constant	-0.013	-1.774	Constant	-0.025	-2.850
VIX	-0.002	-5.022	VIX	0.000	-0.638
l_spread	-0.026	-2.152	l_spread	-0.033	-2.032
ch_Tbill	0.098	2.605	ch_Tbill	-0.052	-1.453
ch_slope	-0.054	-1.377	ch_slope	0.003	0.170
ch_credit	-0.015	-0.809	ch_credit	-0.021	-0.829
ret_stoxx	0.000	0.231	ret_stoxx	0.000	0.503
crisis_g	-0.015	-1.576	crisis_g	-0.015	-1.780
crisis_s	0.019	3.207	crisis_s	0.000	0.073
CoVaR(Xt<0)	1.160	15.652	CoVaR(Xt<0)	0.861	11.282
CoVaR(Xt>=0)	0.281	4.141	CoVaR(Xt>=0)	0.410	5.053
Pseudo-R2	0.613		Pseudo-R2	0.611	

Source: IFM staff calculations.
Note: The following state variables are included in the specification: the VIX of the S&P 500 from the CBOE; a liquidity spread proxied by the difference between the 3-month ECB repo rate and the 3-month Euro benchmark, the change in the Euro benchmark 3-month rate; the change in the slope of the Euro benchmark yield curve (yield spread between the 10-year and 2-year bonds); the change in the credit spread between the 10-year EMU A corporate yield in euros and the 10-year Euro benchmark bond; the Eurostoxx 50 Equity Index weekly return; a global financial crisis dummy starting on July 7, 2007, and a European sovereign debt crisis dummy starting on May 5, 2010.

Annex VI. Table 5. CoVaR: Contribution to Systemic Risk in European Banks Active in CESEE

Bank	Mean	Volatility	Median	Max	Min	Mean/Volatility	Scoring
CBK	-0.186	0.092	-0.164	-0.018	-0.679	-2.021	2
SAN	-0.170	0.075	-0.160	-0.024	-1.157	-2.267	14
ACA	-0.140	0.046	-0.141	-0.038	-0.322	-3.052	19
BNP	-0.151	0.082	-0.138	-0.011	-0.759	-1.852	22
ISP	-0.143	0.075	-0.132	-0.029	-0.968	-1.918	34
UCG	-0.138	0.064	-0.131	-0.040	-0.779	-2.150	35
INGA	-0.157	0.078	-0.130	-0.057	-0.629	-2.024	43
GLE	-0.133	0.055	-0.129	-0.019	-0.424	-2.404	57
KBC	-0.157	0.139	-0.122	0.005	-1.732	-1.127	61
RBI	-0.132	0.058	-0.121	-0.021	-0.490	-2.260	66
SEBA	-0.126	0.055	-0.115	-0.035	-0.499	-2.302	78
SWEDA	-0.117	0.058	-0.105	0.004	-0.463	-2.021	87
OTP	-0.093	0.036	-0.091	-0.002	-0.368	-2.562	90
EBS	-0.098	0.052	-0.084	-0.032	-0.381	-1.882	99

Source: IMF staff calculations.
Note: This table ranks the average weekly contribution to systemic risk of each individual bank over April 2005-December 2012. The contribution of bank i's distress to the distress of the banking system can be approximated by :

$$\Delta CoVaR^{i}_{\lambda,t} = \hat{\delta}_{\lambda,i}\left(VaR^{t}_{i}(\lambda) - VaR^{t}_{i}(50\%)\right)$$

Annex VI. Table 6. Inward Spillovers from CESEE Peer Banks

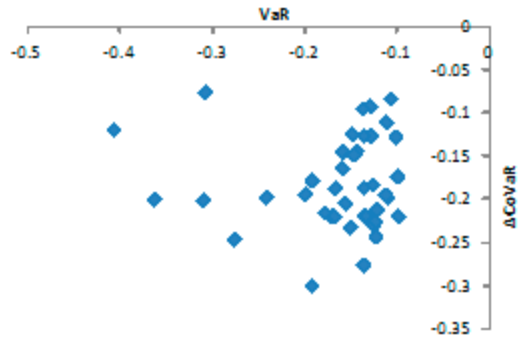
(Weekly average, in percent of market valued asset returns)

Vulnerability of Austrian banks 1/		Contribution to bilateral distress 2/	
OTP	-13.0	KBC	-11.1
KBC	-11.1	OTP	-9.1
ACA	-8.3	BNP	-7.3
GLE	-7.4	SAN	-6.7
BNP	-7.0	UCG	-6.4
SEBA	-6.4	ACA	-6.4
UCG	-6.3	GLE	-6.4
SAN	-5.7	INGA	-5.9
INGA	-4.4	SEBA	-5.8
ISP	-3.8	SEWDA	-5.8
SWEDA	-3.2	ISP	-3.9
CBK	-1.1	CBK	-1.5
Average	-6.5	Average	-6.4

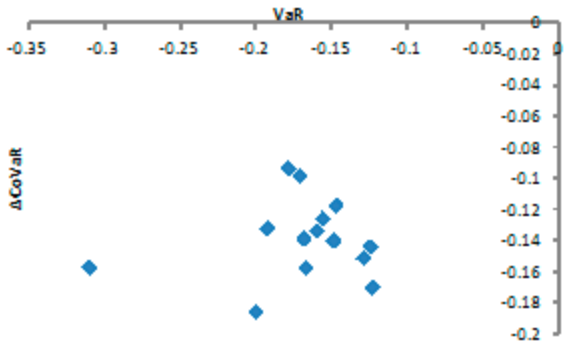
Source: IMF staff calculations.
1/ Average vulnerability of Austrian banks to CESEE peers' bilateral distress.
2/ Average bilateral contribution to distress across CESEE peers.
Note: Contribution to systemic risk is defined as the average par wise increase in distress of each vulnerable bank when the contributor bank is in distress relative to each vulnerable bank's unconditional VaR at the 5th percentile.

Annex VI. Figure 2. CoVaR: Individual vs. Systemic Risk

European Banking System



CESEE Banking System



Source: IMF staff calculations
Note: The scatter plot shows the weak link between banks' solvency risk, measured by their VaR, and their contribution to systemic risk, measured by their Δ CoVaR. Both measures are averages of weekly market valued returns over 2005-2012.

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