How to make stress tests more macroprudential

Integrating second-round effects & macro-financial feedback-loops

Stefan W. Schmitz

Macroprudential Supervision
Oesterreichische Nationalbank

IMF
Washington, D.C., Friday, 21st July, 2017

Agenda

1. **Macroprudential liquidity stress test framework**

   a. **Data requirements**

   b. **Scenario design and calibration**

   c. **Parameter uncertainty and embedded scenarios**

2. **Second round effects**

   a. **Interaction between funding liquidity and solvency**

   b. **Interaction between funding costs and solvency**

   c. **Macro-financial feedback effects**

      i. **Bank reactions to liquidity shocks**

      ii. **Bank reactions to solvency shocks**

      iii. **Dynamic balance sheet optimization and internal transfer pricing**

      iv. **Impact on loan rates**

      v. **Integration into macro-models**

Macroprudential liquidity
stress test framework

Main challenges of macroprudential liquidity stress tests

Data

Scenario design

Scenario calibration

Parameter uncertainty

Treatment of CB

Liquidity/solvency integration
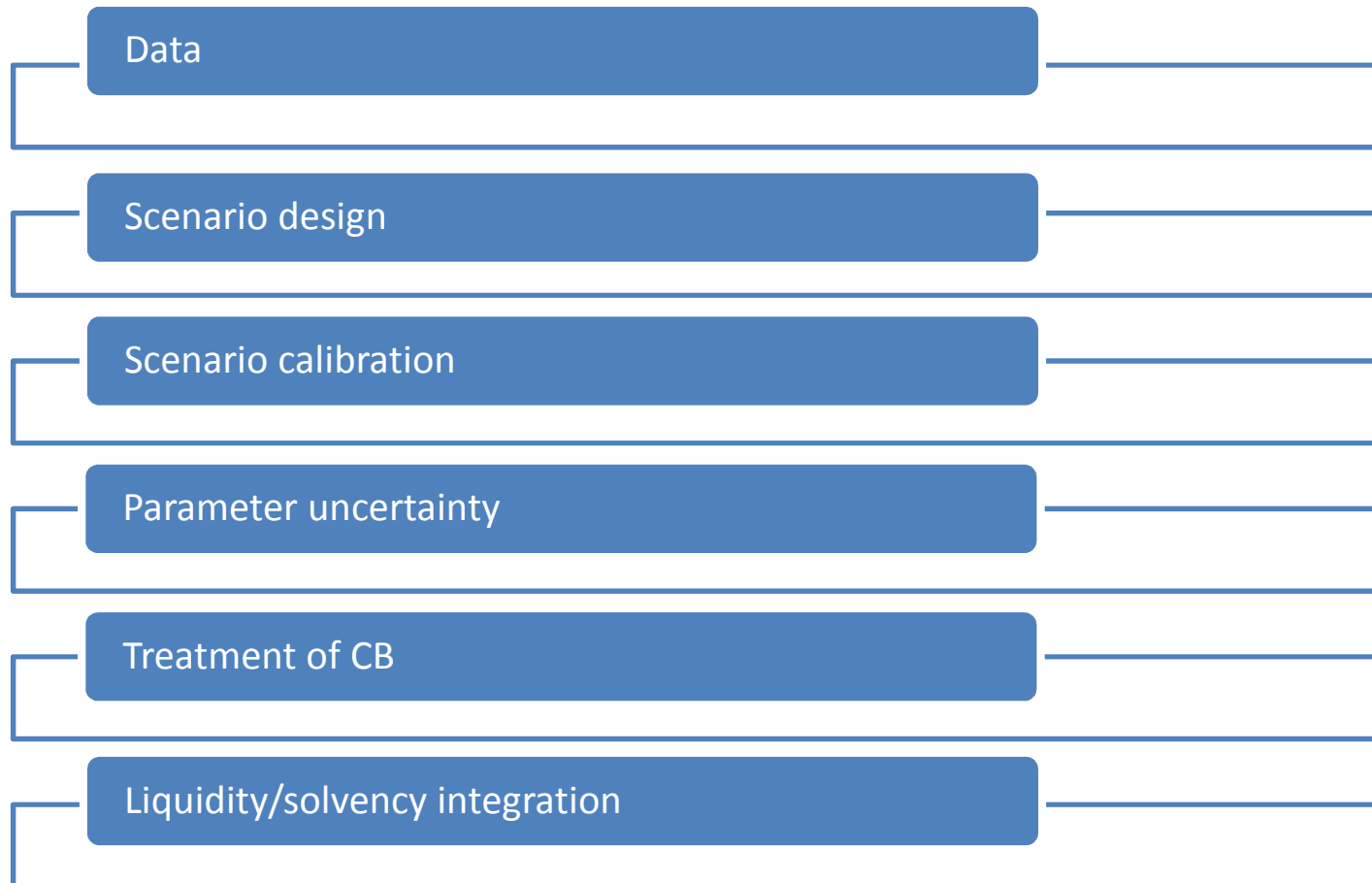
Data requirements

Contractual / behavioural maturities	Gross / net cash flows	Liquidity coverage approach / separation of liquidity risk exposure & risk bearing capacity	Stock of liquid assets / counterbalancing capacity
Single currency / multiple currencies	Frequency, cut-off date and reporting time lag	Product oriented/accounting balance sheet based versus functional items	Reporting period and bucket size (9 buckets)
	Consolidated / solo	Differentiation according to business model / comprehensive template	

Liquidity: template design crucial

Contractual & behavioural	▪ Without contractual → **results biased** ▪ Behavioural assumptions explicit → **reveal risk tolerance** ▪ Allow for **institution specifity**
Gross cash flows	▪ Allow for differentiated analysis of liquidity risk exposure → **more risk sensitive** ▪ More granular stress tests possible
Counterbalancing capacity	▪ **Consistency** across inflows/outflows counterbalancing capacity ▪ Makes implicit assumtions of stock explicit → **information gain**
Multiple currencies	▪ **Liquidity risk currency specific** ▪ Links across currencies product specific
Functional items	▪ **Common language** among li-risk managers & supervisors ▪ **Facilitates** scenario design & calibration

Liquidity: data quality – main challenges for banks and supervisors

Securities flows	▪ Security flows must be included in the counterbalancing capacity ▪ Some netting within contractual and within behavioural flows necessary ▪ Consistency with repo/reverse repo and inflows/reinvestment
Roll-over within horizon	▪ No, decision to roll/run met at the first decision point ▪ No reconsideration absent new information ▪ Exception to run-off × bucket
Counterbalancing capacity	▪ Stocks, liquidation profile, maturities and flows ▪ Consistency with inflows from paper in own portfolio & reinvestment (netting in CBC)
Loans	▪ NPLs and new loans ▪ Franchise value – different counterparties
Explanatory notes	▪ Data quality assurance & feedback to banks ▪ **Very important for successful liquidity stress test**

Scenario design

❑ Issues to consider

- Internal consistency

- Idiosyncratic and market scenarios

- Time horizon(s)

- Cross-border flow of liquidity and collateral

- Behavioural (second round) effects

- Shortening/lengthening of funding terms

- Linkages between liquidity, credit and market risk

Fundamentals

❑ Never use banks' internal evidence for calibration

    ❑ Few banks have experienced liquidity shocks

❑ Do not focus on bank characteristics alone

    ❑ Market dynamics can affect also very sound banks

❑ Evidence based calibration is most convincing

    ❑ Extensive literature surveys very helpful (I.e. BCBS 24/25)

❑ Parameter uncertainty is intrinsic

    ❑ Do not over-engineer calibration

❑ Coherent economic story key to communication

Scenario calibration

Consistency with solvency scenario

- Often contain relevant parameters (e.g. bond prices)

Econometric approach not feasible

- Low frequency/high impact events
- Data hardly available

Product & market specific

- Reporting data & academic literature

Case studies

- Bank, market & country level

Output of solvency stress test

- See discussion below

Elements of scenario calibration
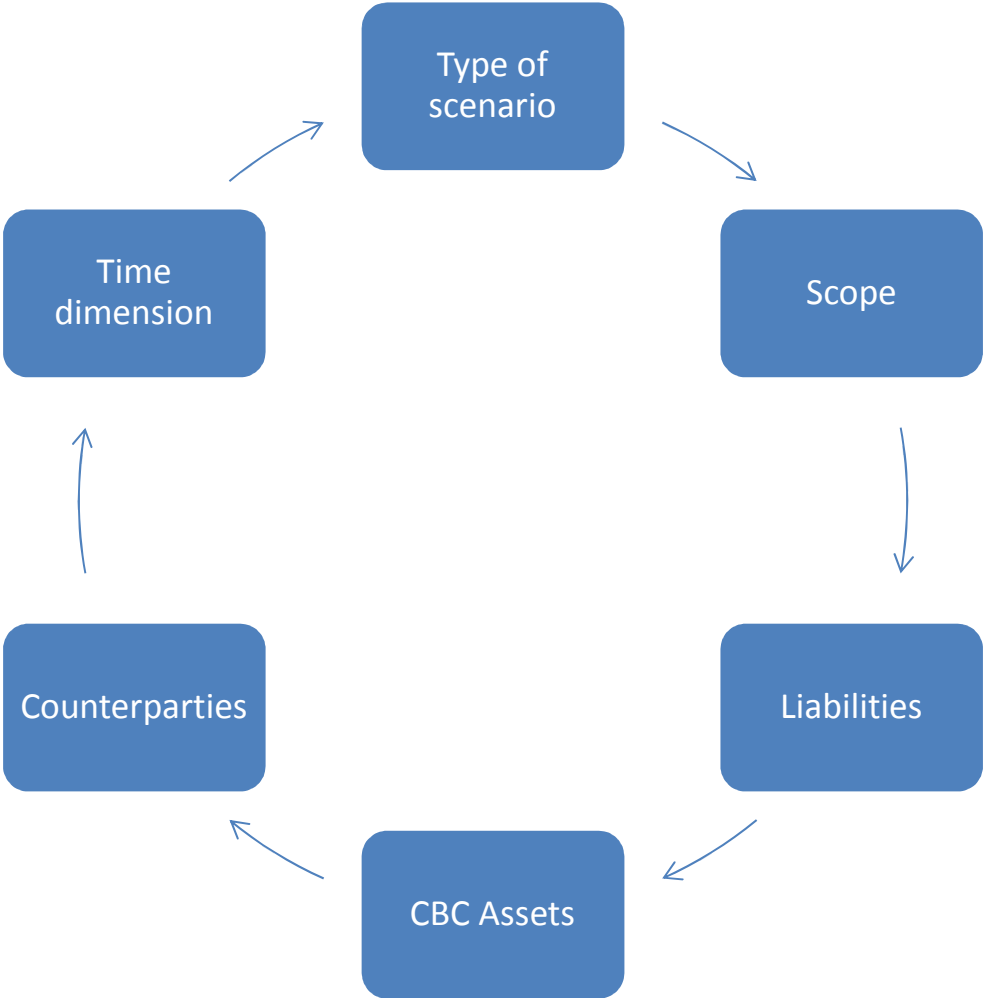
Source: ECB 2008.

Stylised facts

Complete dry-up of unsecured interbank lending

- First line of defence & consistency

Secured whole sale funding more stable than unsecured

- Repo more stable than unsecured money market
- Covered bonds versus senior benchmark
- Collateral more important for haircuts than counterparty
- Stressed haircuts capture haircut , liquidity, & price changes

Cross-border flows

- FX-risk, FX-swap market,
- Intragroup: legal risk (insolvency law, criminal law)

Maturities tend to shorten

- Different parameters across time buckets

Insured deposits more stable than uninsured

- Legal/contractual netting increases stability of deposits

Stylised facts II

Margin calls

- Increase in volatility of the underlying asset

Procyclicality of security liquidity & prices affet CBC

- HC in CBC capture changes in market liquidity, repo HC & price changes
- Assets of higher credit quality tend to be more stable
- Assets with broader & deeper markets tend to more stable
- Assets with shorter maturty have lower volatility
- Consistent calibration with repo/reverse repo
- Collateral swaps can have a strong impact on CBC

Collateral swaps can have a strong impact on CBC

- Reporting data & academic literature

Committed liquidity lines face higher drawdowns than credit lines

- SPV – interdependence with warehouse risk?
- Committed liquidity lines to the institutions – very high legal risks – 100% HC

Minimum Reserve Requirements

❑ CB money most liquid asset in the economy

    ❑ Encumbered versus unencumbered

    ❑ Encumbered for monetary policy purposes

        ❑ Minimum Reserve Requirements impose minimum demand for central bank money

        ❑ Violation costly (CB sanctions & reputation) & impedes implementation of monetary policy

        ❑ Not part of the CBC

    ❑ Unencumbered and available to absorb liquidity shocks

        ❑ Part of the CBC

Destinction between LoLR & monetary policy implementation
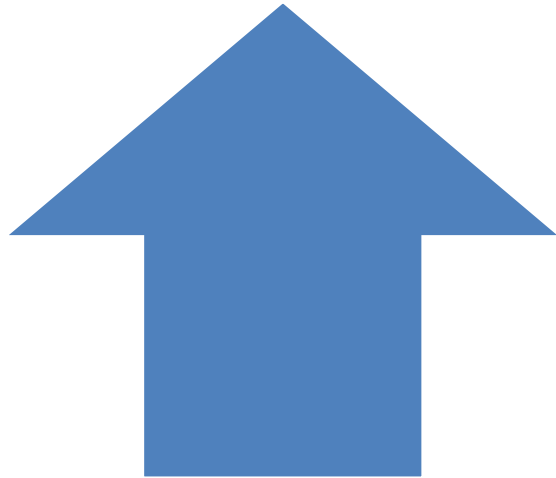
Lender of last resort

- Discretionary/extra-ordinary deviation from the standard framework of monetary policy implementation
- Liquidity provided to individual/subsample of institutions on specific terms that are not available to other market participants
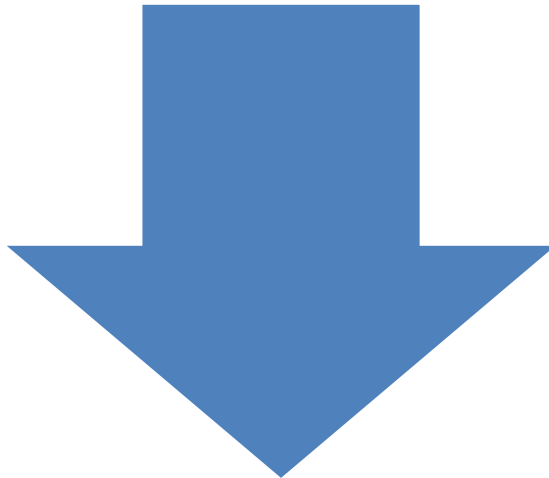
Monetary policy implementation

- Reaction to expected increase of the structural liquidity deficit at the target rate
- Always market oriented – never individual bank focused
- Can entail deviatons from standard monetary policy

LoLR: focus on markets rather than failing bank

Arguments for reliance on LoLR

- Historical experience

- Theory

    - Potential efficiency gains under restrictive assumption (e.g. prevent asset fire sale contagion)

Arguments against reliance on LoLR

- Conflicts with raison-d'être for liquidity regulation

    - Internalise externality & moral hazard & efficient allocation of liquidity & risk

    - Qualitative liquidity regulation aims at self-insurance (CEBS 2009, 2010a, BCBS 2010)

- FX liquidity (e.g. Bulgaria)

- LoLR cannot be considered in isolation (subordination, bank resolution)

- Political economy of bail-outs

    - Interference in property rights, fiscal exposure, distributional effects

- CB discretion undermined

    - Delienation of illiquidity from insolvency impossible under time pressure

    - Conflict of interest with monetary policy implementation

Potential efficiency gains can be achieved by less distortionary alternatives

Less distortionary alternatives to standard LoLR

Pricing

Charging a fee according to the liquidity risk exposure and liquidity risk bearing capacity of the bank

Objective: Internalise the externality associated with liquidity risk → banks should be indifferent between effective self-insurance and insurance by the public

Challenge: unrealistic → fair price difficult to estimate (see pricing of RCLF in AUS)

Conditionality

Automatic sanctions

Replacement of board members

Trigger for early intervention mechanism

Liquidity provision to market rather than illiquid bank

Address asset fire sale externality

assumes other market participants cannot exploit underpricing due to liquidity constraints

Original concept of the LoLR according to Thornton and Bagehot

Enables other market participants to profit from underpricing

Limits negative price effect

Conclusions: No LoLR in liquidity stress testing

Ensure sufficient liquidity risk bearing capacity

- HQLA must be composed of assets that are (extremely) highly liquid → no asset fire sale externality

Liquidity stress testing must ensure self-insurance

- No room for LoLR in liquidity stress testing
- Only standard monetary policy operations

CB operations should be treated like other repos

- Except for standard monetary policy implementation
- Consistency between the individual building blocks of liquidity stress tests

Parameter uncertainty: embedded scenarios

Severity
- Baseline/mild/severe market
- Severe combined (w idiosyncratic)

Time horizon
- Indentical: 30 and 90 days
- Specific: 1 year

CB dependence
- Market liquidity only
- Limited CB support
- Full CB liquidity insurance

27 scenarios

Severity

Time horizon

CB dependence
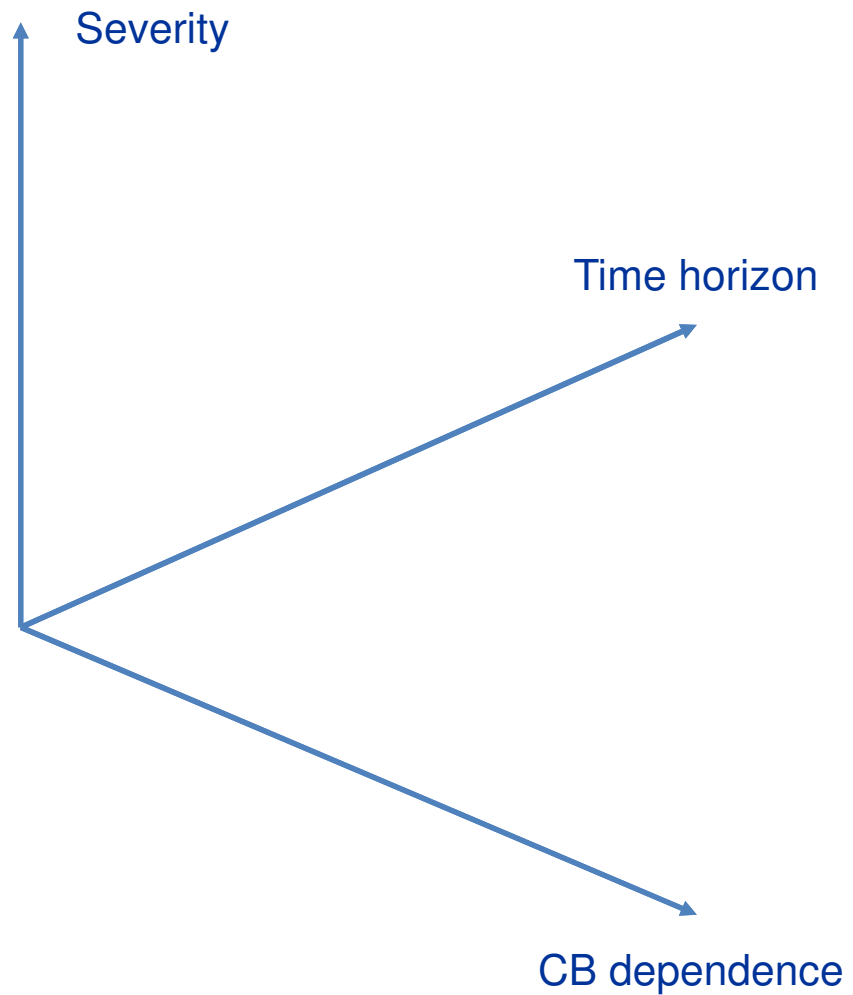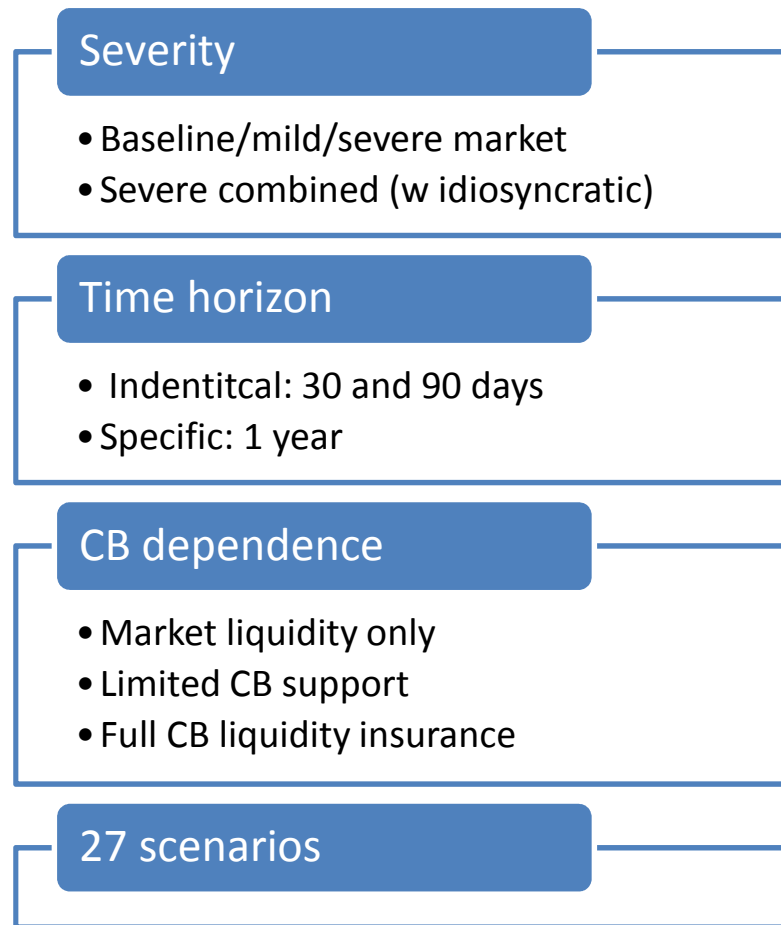
Embedded scenarios II

Cumulative severity

- Scenario 1

  - Closure of unsecured interbank markets

  - Closure of FX Swap markets

- Scenario 2

  - Reduced issuance of short term / long term debt

  - Increase in calling of credit committments

  - Mild haircuts on unencumbered collateral in CBC

- Scenario 3

  - Dry up of funding markets – no future debt issuance

  - Severe increase in calling of credit committments

  - Increased Haircuts on CBC according to the asset quality

  - Reduction in planned financial investments (mitigating)

- Scenario 4

  - Combines scenario 3 with idiosyncratic shock

  - Reduction of expected roll-over rates of wholesale and retail deposits

Reveals liquidity risk tolerance

Scenario & parameter uncertainty

Currencies

Scenario severity increases (for inflows, outflows, counter balancing capacity)

Eligibility of assets decreases

30 day Scenario

CBC Type	Baseline	Market Mild	Market Medium	Market Severe	Combined
Full CBC					
Increased focus on market liquidity					
Market liquidity					

90 day Scenario

CBC Type	Baseline	Market Mild	Market Medium	Market Severe	Combined
Full CBC					
Increased focus on market liquidity					
Market liquidity					

1 Year Scenario

CBC Type	Baseline	Market Mild	Market Medium	Market Severe	Combined
Full CBC					
Increased focus on market liquidity					
Market liquidity					

Example

Structure

- Mild & severe scenario

- Market & combined scenario (idiosyncratic & market)

- 3 & 6 months horizons

- 3 different approaches to assess counterbalancing capacity

    - Full counterbalancing capacity (with haircuts)

    - CBC without non-liquid assets not deposited at central banks

    - CBC reduced to liquid assets according to LCR

- **24 scenarios (all currencies) + 4 scenarios (USD)**

Calibration I

Cash-Outflows	Mild Market	Mild Combined	Severe Market	Severe Combined
Own issuances due	1	1	1	1
Unsecured wholesale funding due				
thereof: from non-financial corporates	0	0,06	0,10	0,20
thereof: from financial corporates	0,15	0,25	0,20	0,40
thereof: from financial institutions	1	1	1	1
thereof: from government/public entities	0	0,05	0,00	0,05
thereof: from institutional networks	0	0,06	0,05	0,10
Secured wholesale funding due				
thereof: secured by sovereign debt 0% r/w	0	0	0,20	0,20
thereof: secured by sovereign debt 20% r/w, covered bonds up to AA-, non-financial corporates)	0,05	0,05	0,60	0,60
thereof: secured by equity	0,30	0,30	0,80	1
thereof: secured by other instruments	0,50	0,50	0,80	1
Repos due with central banks	1	1	1	1
Retail (incl. SME) funding due	0	0,06	0,05	0,10
thereof: sight deposits	0	0,06	0,05	0,10
New loans granted	1	1	1	1
Outflows from derivatives	1	1	1	1
Undrawn volume of committed credit/liquidity lines to financial institutions and SPV.	0,30	0,50	0,70	0,70
Undrawn volume of committed liquidity lines to financial corporates.	0,05	0,05	0,10	0,10
Undrawn volume of committed credit/liquidity lines to retail/sme/non-financial corporates and credit lines to financial corporates	0,05	0,05	0,10	0,10
Additional outflows due to a two-notch rating downgrade	0	0	0	1
Others	1	1	1	1
Sum of Cash-Outflows				

Calibration II

Cash-Inflows	Mild Market	Mild Combined	Severe Market	Severe Combined
New own issuances (already contracted)	1	1	1	1
Unsecured wholesale funding	0	0	0	0
Secured wholesale funding	0	0	0	0
Retail funding	0	0	0	0
Loans maturing	0	0	0	0
thereof: loans to financial institutions	1	1	1	1
thereof: other	0	0	0	0
Inflows from derivatives	1	1	1	1
Paper in own portfolio maturing	1	1	1	1
Reverse repos	0	0	0	
thereof: secured by sovereign debt 0% r/w	0	0	0,20	1
thereof: secured by sovereign debt 20% r/w, covered bonds up to AA-, non-financial corporates	0,05	0,05	0,60	1
thereof: secured by equity	0,30	0,30	0,80	1
thereof: secured by other instruments	0,50	0,50	0,80	1
Volume of available credit lines from financial institutions	0	0	0	0
Others	1	1	1	1
Sum of Cash-Inflows				
Net Funding Gap				
Cumulated Net Funding Gap				

Calibration III

Counterbalancing capacity	Mild Market	Mild Combined	Severe Market	Severe Combined
Cash and central bank reserves in excess of minimum reserve requirements				
Unencumbered CB eligible collateral (deposited at central banks)				
Claims on sovereigns (PSEs or government guaranteed) 0% risk-weight under Basel II standardised approach	0,03	0,03	0,05	0,05
Claims on sovereigns (PSEs or government guaranteed) 20% risk-weight under Basel II standardised approach	0,05	0,05	0,10	0,10
Covered bonds (excl own issues, rating at least AA-)	0,05	0,05	0,08	0,08
Non-financial corporate bonds (rating at least AA-)	0,05	0,05	0,10	0,10
Other CB eligible assets (incl credit claims)	0,08	0,08	0,10	0,10
thereof: own issues	0,08	0,08	0,10	0,10
Unencumbered assets (CB eligible, but not deposited at CB)				
Claims on sovereigns (PSEs or government guaranteed) 0% risk-weight under Basel II standardised approach	0,03	0,03	0,07	0,07
Claims on sovereigns (PSEs or government guaranteed) 20% risk-weight under Basel II standardised approach	0,05	0,05	0,15	0,15
Covered bonds (excl. own issues, rating at least AA-)	0,05	0,05	0,10	0,10
Non-financial corporate bonds (rating at least AA-)	0,05	0,05	0,15	0,15
Other CB eligible assets (incl. credit claims)	0,08	0,08	0,25	0,25
thereof: own issues	0,08	0,08	0,25	0,25
Other non CB eligible, tradeable assets (incl equity)	0,60	0,60	0,80	0,80
Sum of Counterbalancing Capacity (after haircut)				
Cumulated Counterbalancing Capacity (after haircut)				

Results (example) – liquidity risk tolerance

	Three months horizon		Six months horizon	
	Mild	Severe	Mild	Severe
Market scenario	X_{11}	X_{12}	X_{13}	X_{14}
CBC without non-liquid assets not deposited at central banks	X_{21}	X_{22}	X_{23}	X_{24}
CBC reduced to liquid assets according to LCR	X_{31}	X_{32}	X_{33}	X_{34}
Combined scenario	X_{41}	X_{42}	X_{43}	X_{44}
CBC without non-liquid assets not deposited at central banks	X_{51}	X_{52}	X_{53}	X_{54}
CBC reduced to liquid assets according to LCR	X_{61}	X_{62}	X_{63}	X_{64}

X_{yz} = # of illiquid banks or US$ of li-shortfall

Interaction
solvency & funding liquidity

Austrian stress test models

Scenario Models (i.e. exogeneous shocks)

- Two separate models for Austria and „Rest of World"

Macro-2-Micro Models (i.e. risk factor distributions)

- PDs, LGDs, ratings, market risk factors, net interest income, ...

Balance Sheet Model (i.e. loss functions)

- Balance, Profit & Loss, RWAs

Feedback Models

- Interbank exposures

Cash Flow Model (i.e. maturity mismatch)

- Run-off rates and haircuts

Liquidity Stress Test

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Interlinkages solvency / funding liquidity

Solvency Stress Test	Mapping to Liquidity Stress Test
Deteriorating Capital Position	Ability to issue new CP & bonds (12M scenario)
Increase in Expected NPLs	Reduction in expected inflows from loan repayments Reduction of expected inflows from NFC bonds
Macro-driven PD Shifts	Implied rating migration of banks unencumbered collateral deposited at CB

Liquidity Stress Test	Mapping to Solvency Stress Test
Liquidity gap	Asset fire sales
Increase in Funding Costs	P&L effects

Timing / sequenzing of interaction

Complex interaction of solvency and funding liquidity

Solvency Stress Test

Liquidity Stress Test

Rating Migration

Credit Losses

Collateral Quality

Defaulted Assets

reduced pledgeability of assets

Counter Balancing Capacity

(-)

reduced inflows

Operating Result

Valuation Losses

Capital Position

Risk-weighted Assets

Solvency Position

(-)

price effect

(-)

(-)

volume effect

(+)

(+/-)

Cost of Funding

Fire Sales

(+/-)

Cash Inflows

(-)

Cash Outflows

Funding Gap

(-)

(+/-)

(-) credit spreads increase

impact on behavioural cash flows

(-)

(-) Negative impact (from a bank's point of view).
(+) Positive impact.

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Reduced pledgeability of assets

Solvency Stress Test

Liquidity Stress Test

Rating Migration

reduced pledgeability of assets

Collateral Quality

(-)

Counter Balancing Capacity

Credit Losses

reduced inflows

Operating Result

Valuation Losses

(-)

Capital Position

Risk-weighted Assets

(-)

Solvency Position

(+/-)

pact on vioural h flows (-)

Macro-to-PD impact [reduced pledgeability of assets]

- Banks' credit claims pledged at CB – decreases CBC
- Calibration: Detailed bank-level collateral data (incl. fixed/variable rate; time to maturity)
- Assume iid across PD range within credit quality steps PD impact of macro scenario shifts PDs of CCs upward
- Migration into higher credit quality steps increases haircuts (up to 100%)
- Volume weighted average across credit quality steps
- Again weighted by share of non-marketable assets in unencumbered collateral pledged at CB

(-) Negative impact (from a bank's point of view).
(+) Positive impact.

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NPL impact: reduced inflows

Solvency Stress Test

Liquidity Stress Test

Rating Migration

Credit Losses

Collateral Quality

Defaulted Assets

reduced pledgeability of assets

(-) Counter Balancing Capacity

reduced inflows

(-) Cash Inflows

Operating Result

Valuation Losses

Capital Position

Risk-weighted Assets

Solvency Position

(-) (-) (-) (+) (+/-) (+/-) (-)

NPL impact [reduced inflows]

- Expected inflows from performing loans – decreases inflows
- Calibration: Direct output of solvency stress stest
- Expected inflows from performing NFC bonds – decreases inflows
- Calibration: Assume similar distribution of exposure as in loan exposure
- Output of solvency stress test weighted by share of NFC non-loan exposure to liquid assets

impact on behavioural cash flows

(+) Positive impact.
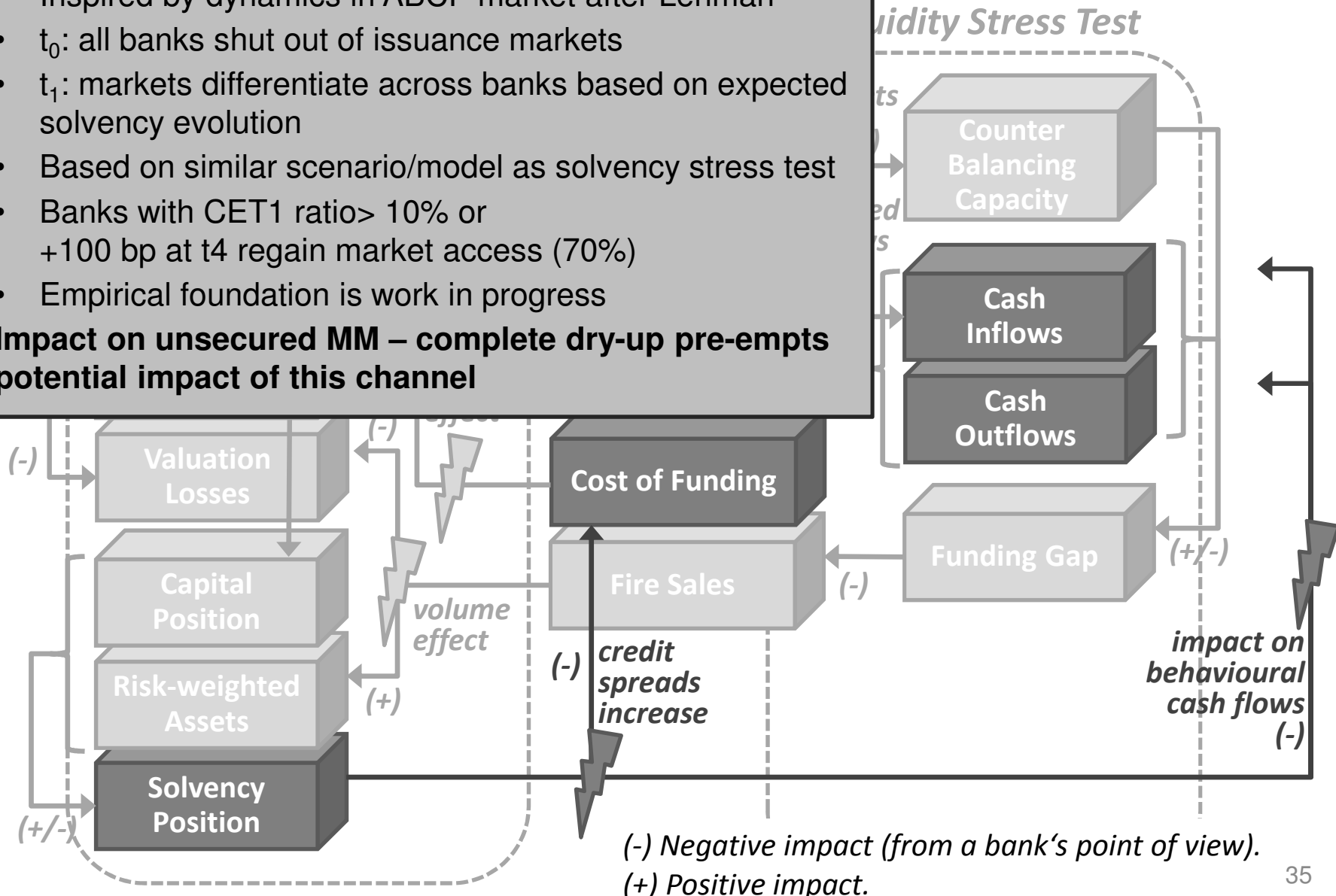
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Solvency impact on funding
[impact on behavioural cash flows]

- Inspired by dynamics in ABCP market after Lehman
- t_0: all banks shut out of issuance markets
- t_1: markets differentiate across banks based on expected solvency evolution
- Based on similar scenario/model as solvency stress test
- Banks with CET1 ratio> 10% or
  +100 bp at t4 regain market access (70%)
- Empirical foundation is work in progress

Impact on unsecured MM – complete dry-up pre-empts potential impact of this channel

...uidity Stress Test

Counter Balancing Capacity

Cash Inflows

Cash Outflows

Valuation Losses

(-)

Cost of Funding

Funding Gap

(+/-)

Capital Position

volume effect

Fire Sales

(-)

Risk-weighted Assets

(+)

(-) *credit spreads increase*

impact on behavioural cash flows
(-)

Solvency Position

(+/-)

(-) Negative impact (from a bank's point of view).
(+) Positive impact.

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Asset fire sales losses [volume effect]

- Captures common exposure to market price & market liquidity effects
- Calibration: Based on HC of liquidity stress scenario & CC migration due to solvency
- Assets: Full CBC except callable, committed credit-lines, liquidity support received from holding company (binding commitment)
- Assumption: banks sell assets proportionally to composition of CBC
- Empirical evidence inconclusive

$$ASFL_t \begin{cases} = 0, & if\ CNFG_t \leq (cash + excess\ reserves) \\ = (CBCunstressed - CBCstressed) \times \left\{ \left[\dfrac{cash + excess\ reserves + CBC_{t,stressed}}{CBC_{t,unstressed}} \right] \right\}, & otherwise \end{cases}$$

- Effect: Banks with same level of CBC but higher shares of less liquid assets face higher asset fire sale losses
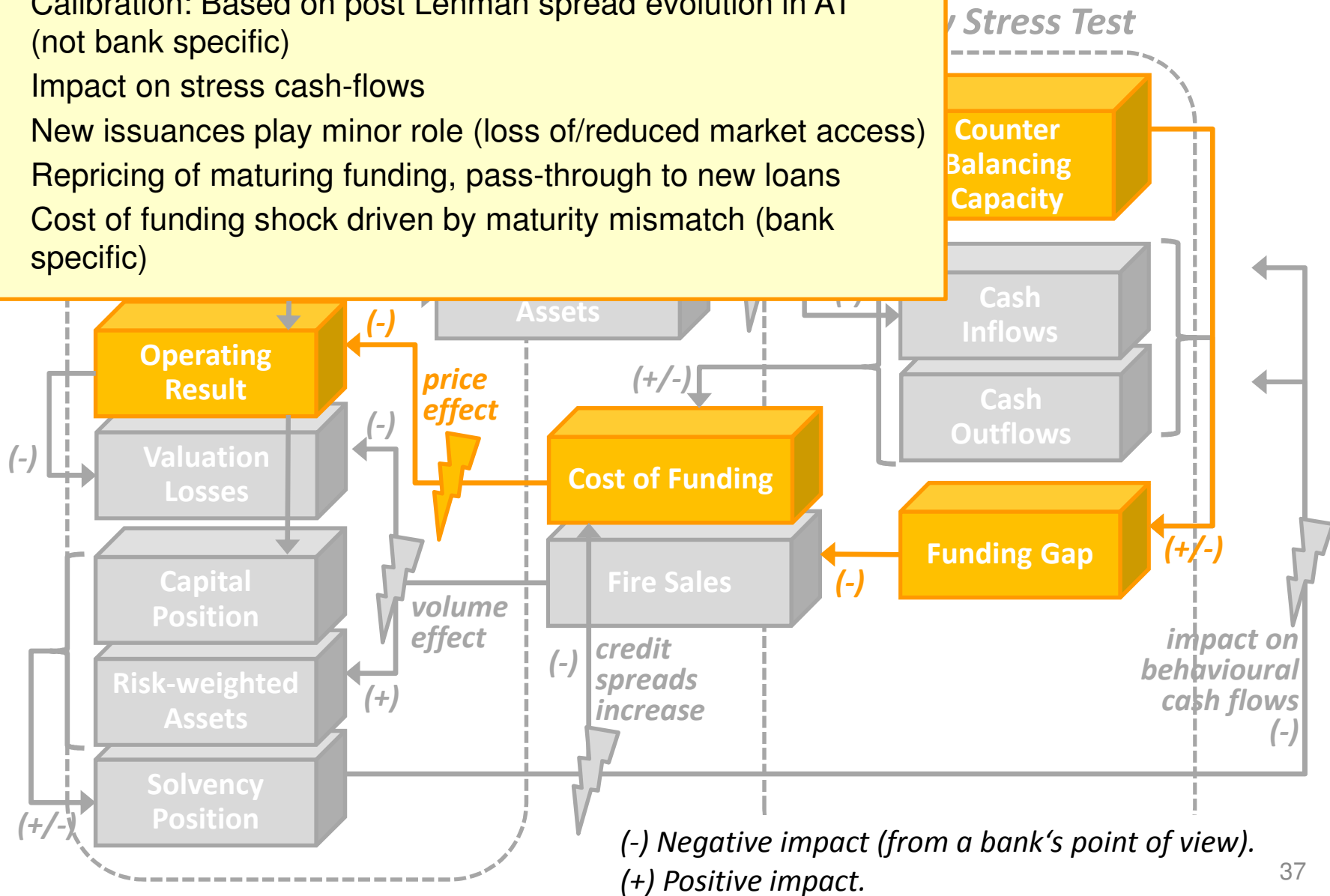- Caveats: CB treatment; static, non-behavioural; no additional fire sale loss haircuts

(-) Negative impact (from a bank's point of view).
(+) Positive impact.

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Cost of funding shock [credit spread increase – price effect]

- Increasing funding costs – impact on P&L
- Calibration: Based on post Lehman spread evolution in AT (not bank specific)
- Impact on stress cash-flows
- New issuances play minor role (loss of/reduced market access)
- Repricing of maturing funding, pass-through to new loans
- Cost of funding shock driven by maturity mismatch (bank specific)

Stress Test

Counter Balancing Capacity

Assets

Cash Inflows

Cash Outflows

Operating Result

(-)

price effect

(-)

(+/-)

Valuation Losses

Cost of Funding

Funding Gap

(-)

(+/-)

Capital Position

Fire Sales

volume effect

Risk-weighted Assets

(+)

(-) *credit spreads increase*

impact on behavioural cash flows (-)

Solvency Position

(+/-)

(-) Negative impact (from a bank's point of view).
(+) Positive impact.

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Important channels disregarded in this model

❑ Impact of solvency on access to unsecured money market

▪ Pre-empt by assumption of complete dry-up

❑ Impact of own liquidity position on supply of funds on unsecured money market & network dynamics

▪ Pre-empt by assumption of complete dry-up

❑ Contagious retail bank runs

❑ Margin calls due to rating downgrades & derivative contracts

❑ Deposit outflows due to rating downgrades

Interaction
solvency & funding costs

Introduction

- Schmitz et al. (forthcoming) studies the interdependence between bank solvency and liquidity using a fixed effect panel simultaneous equation framework approach.

- We construct a new database using supervisory data across six jurisdictions.

- Research questions:

  1. What is the magnitude of this interaction?

  2. How can this effect be used to inform stress testing practices?

Contribution to the literature

- Simultaneous equation panel approach to account for endogenous determination of solvency and funding costs.

  - Literature focuses only on the effect of solvency on funding costs - likely biased due to simultaneity & endogeneity.

- Data quality higher - unique data set compiled from regulatory agencies in 6 countries.

- Effect of solvency on funding costs larger than in the literature.

- Dynamic interaction/feedback effects captured.

Literature overview I

1. Annaert et al. (2013)

- Method: Fixed effect panel model.

- Sample: 32 listed euro area banks between 2004 and 2010.

- Results: 1ppt drop in weekly bank market-based leverage → 64 bps rise in a banks CDS spread.

2. Hasan et al. (2016)

- Method: Fixed effect panel model.

- Sample: 161 global banks from 23 countries over 2001-2011.

- Results: 1ppt increase of market-based leverage → 101 bps rise in a bank's CDS spread.

Literature overview II

3. Aymanns et al. (2016)

- Method: Fixed effect panel linear and logit regression.

- Sample: FDIC call report covering 10,000 banks over the period 1993-2013.

- Results: 5ppt drop in weekly bank market-based leverage → 20 bps rise in a banks CDS spread, but increases to 30 bps during crisis (2007).

4. Babihuga and Spaltro (2014)

- Method: Panel error correction model (PECM).

- Sample: 52 banks in 14 advanced economies over 2001-12.

- Results: 1ppt increase in bank's regulatory capital → 26 bps rise in a bank's CDS spread in the long run.

Proxy for marginal funding costs: 5-year CDS spread

- Marginal cost associated to long-term wholesale funding: If a bank is under pressure wholesale funding is the first source of funding to dry out.

- Representative of funding costs under stress: deposit insurance makes retail depositors slow to react, if at all.

- Shadow funding costs if a bank was cut of from the market: even if a bank is cut of from the wholesale market, there is still a price for CDS.

- We follow the main literature on funding costs (Aymanns et al., 2016; Babihuga and Spaltro, 2014; Annaert et al., 2013; Hasan et al., 2016, among many others).

Data

- Our data were collected in the BCBS RTF work on liquidity stress testing.

- Unbalanced panel of 54 large banks from six countries from 2004Q4 to 2013Q4: (1) 33 US, (2) six Austrian, (3) six Canadian, (4) six Dutch and (5) three Nordic banks.

- The solvency-funding cost nexus is complicated due to the challenges associated to different measures of bank solvency´and funding costs, and to the need to overcome endogeneity issues

A simultaneous equation approach

- To capture the contemporaneous realizations of bank solvency and bank funding costs, we estimate the solvency and funding equations using a two equation simultaneous panel approach with fixed effects (individual dummy).

$$
\begin{aligned}
y_{i,t,1} &= \alpha_{i,1} + \beta_0 y_{i,t,2} + \sum_{j=1}^{m} \beta_j x_{i,t,j} + \epsilon_{i,t,1} \\
y_{i,t,2} &= \alpha_{i,2} + \gamma_0 y_{i,t,1} + \sum_{j=1}^{n} \gamma_j z_{i,t,j} + \epsilon_{i,t,2}
\end{aligned}
\tag{1}
$$

- We apply two-stage, three-stage and iterated three stage least squares to estimate Eq. (1). We use all exogenous variables as instruments in each equation.

Variable selection for identification

- Solvency equation

  - Loan loss provision ratio (LLP Ratio) and country-level loan growth (Loan Growth).

  - LLP Ratio directly affect profits and solvency but not funding costs (only via counterparty risk, i.e. solvency).

  - Loan Growth directly affects banks' solvency via higher RWAs .

- Funding costs equation

  - S & P Rating, money market stress indicator (LIBOR-OIS), and sovereign CDS.

  - Ratings, money market stress, and gov funding costs (often benchmark for bank CDS spreads) directly affect funding costs but not solvency.

Results II (Regulatory solvency ratio)

	Eq.(1A) CT1	Eq.(1B) FVCDS	Eq.(2A) CT1	Eq.(2B) FVCDS
CT1		-1.048***		-1.129***
		(0.273)		(0.387)
FVCDS	-0.320***		-0.324***	
	(0.0950)		(0.0964)	
Δ CT1^2 Sign				
Δ FVCDS^2 Sign				
LLP Ratio	-1.600***		-1.593***	
	(0.346)		(0.348)	
Net Income Ratio	-0.144	-0.547**	-0.141	-0.565**
	(0.174)	(0.224)	(0.176)	(0.233)
S&P Rating (Lag1)		0.379***		0.299**
		(0.127)		(0.124)
Δ Capital			0.0784	
			(0.299)	
Gov CDS		3.707***		4.137***
		(0.613)		(0.671)
Loan Growth	0.00482		0.00510	
	(0.0404)		(0.0408)	
Libor-OIS Spread		0.492		1.707***
		(0.328)		(0.520)
VIX				-0.0642*
				(0.0370)
Crisis Dummy	3.230***	2.264***	3.260***	2.971**
	(0.180)	(0.766)	(0.185)	(1.291)
Constant	7.466***	8.123***	7.470***	9.418***
	(0.881)	(2.009)	(1.007)	(2.931)
Observations	782	782	772	772
McElroy R^2		0.805		0.801

Solvency Equation

- A 100 bps increase in the FVCDS reduces regulatory capital buffers by 32 bps.

Funding Cost Equation

- A 100 bps increase in regulatory capital ratios is associated with a decrease of our proxy for bank funding costs, CDS spreads, of about 105-130 bps.

Results II (Market based measure of solvency)

|	Eq.(1A) EDF	Eq.(1B) FVCDS	Eq.(2A) EDF	Eq.(2B) FVCDS
EDF		1.372***		1.276***
		(0.123)		(0.147)
FVCDS	0.688***		0.613***	
	(0.0556)		(0.0531)	
Δ EDF^2 Sign				
Δ FVCDS^2 Sign				
LLP Ratio	0.0554		0.194	
	(0.123)		(0.130)	
Net Income Ratio	-0.0950	0.108	-0.104	0.0292
	(0.0701)	(0.115)	(0.0758)	(0.126)
S&P Rating		0.0165		0.0839**
		(0.0328)		(0.0427)
Liquidity Risk		-0.000466		-0.000529
		(0.00140)		(0.00481)
Δ Capital			0.0187	
			(0.0497)	
Gov CDS		0.142		0.745*
		(0.301)		(0.431)
Loan Growth	-0.00656		-0.0220*	
	(0.0128)		(0.0124)	
Libor-OIS Spread	-1.810***	2.542***	-1.786***	2.452***
	(0.124)	(0.233)	(0.141)	(0.289)
VIX	0.0507***	-0.0692***	0.0529***	-0.0624***
	(0.00537)	(0.0118)	(0.00639)	(0.0151)
Crisis Dummy	-0.264***	0.355***	-0.0584	-0.146
	(0.0771)	(0.121)	(0.0997)	(0.199)
Constant	-1.032***	1.370***	-2.026***	2.892***
	(0.140)	(0.333)	(0.439)	(0.592)
Observations	905	905	733	733
McElroy R^2		0.999		0.990

Solvency Equation

- A 100 bps increase in CDS spreads is associated with an increase in the EDF by 61-69 bps.

Funding Cost Equation

- A 100bps increase in the EDF is associated with an 128-137 bps increase in the CDS spread.

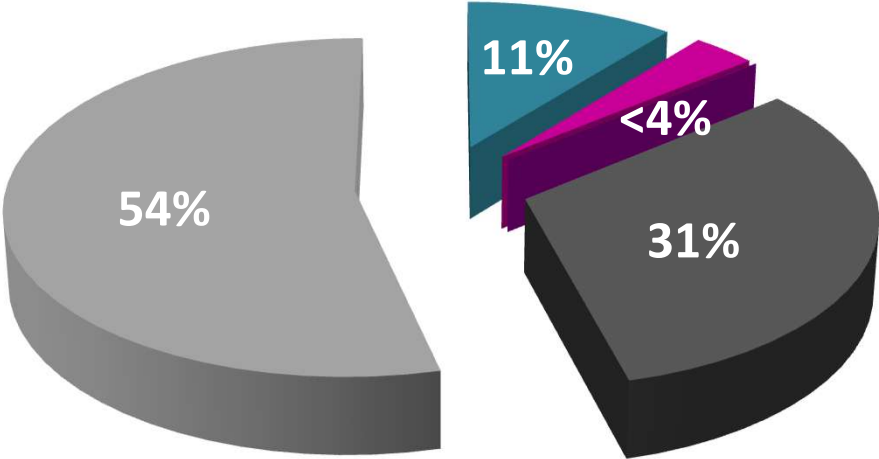# Significance of solvency/funding cost interaction

∅ Difference: 44%

- Shortcut via model: results sensitive to maturity structure & CDS sensitivity of short-term wholesale funding & risk density relative to sample average & pass-through rate
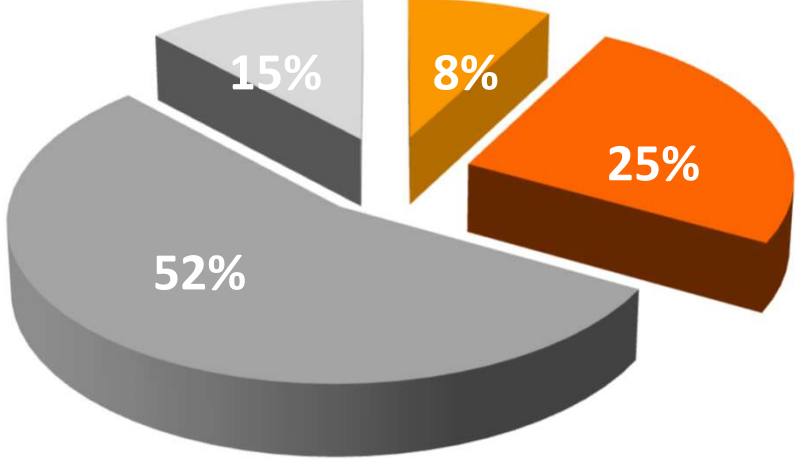- Ideally: maturity mismatch template.
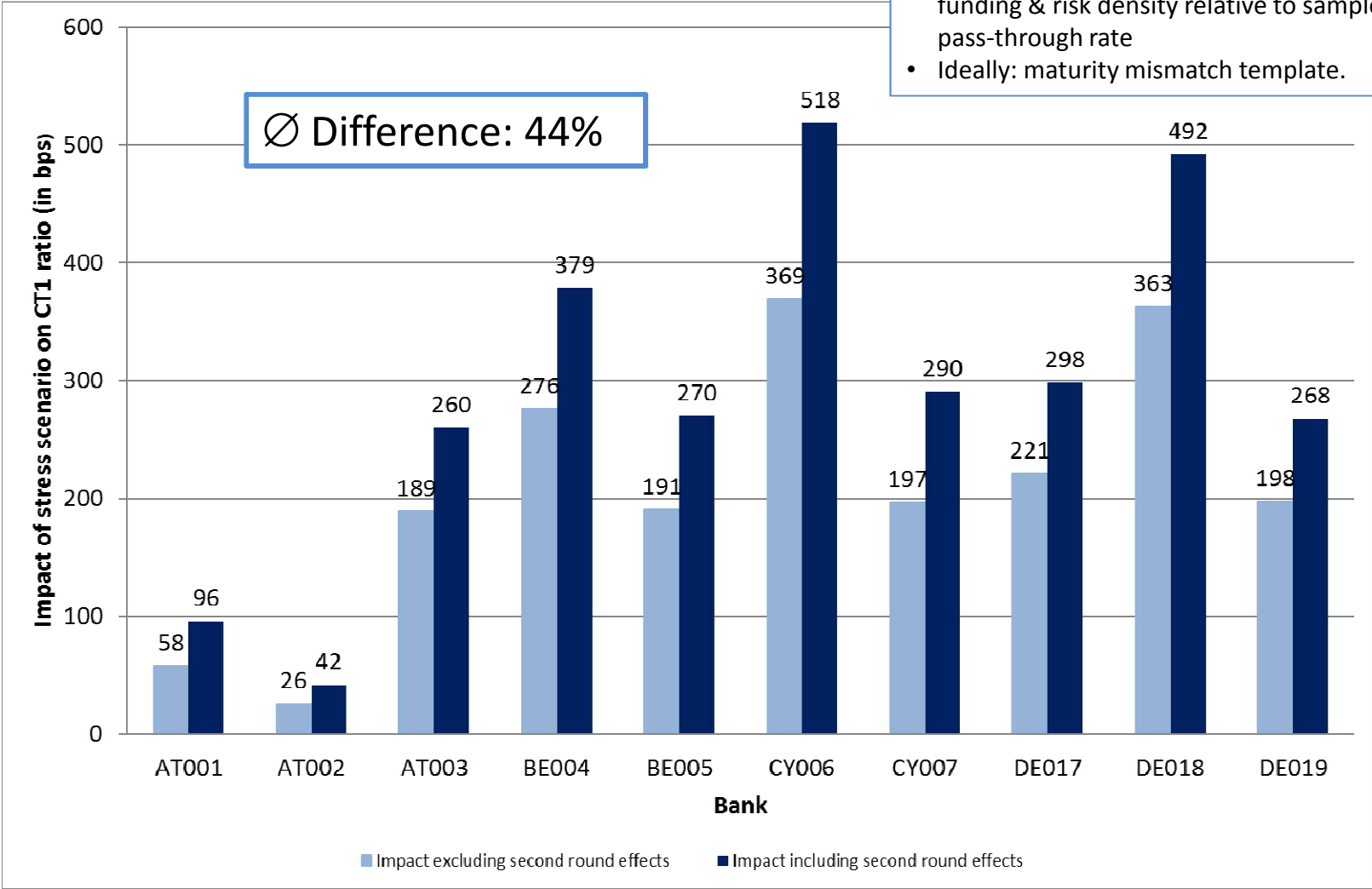
Source: Own calculations based on Schmitz et al. (forthcoming) and public EBA 2011 stress test data.

50

Significance across interaction channels

Liquidity Stress Test
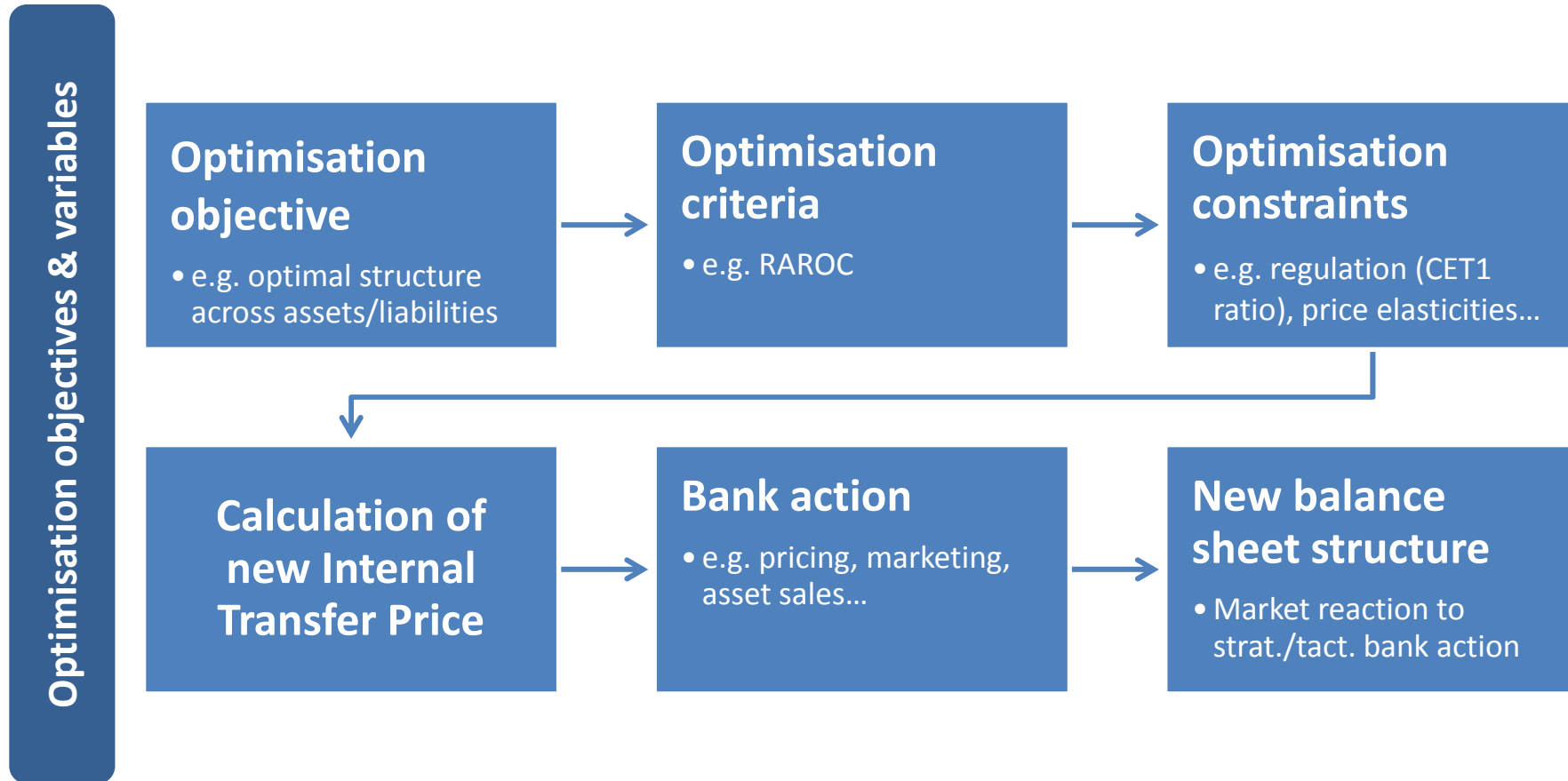*(share of total impact on cumulated counter balancing capacity)*

- ■ Rating migration impact on banks' credit claims (i.)
- ■ NPL effect on expected inflows from performing loans to non-banks (ii.)
- ■ Losses on inflows from paper in own portfolio maturing (iii.)
- ■ Market funding due to solvency position (iv.)
- ■ Other liquidity impact not associated with solvency stress

Solvency Stress Test
(share of total impact on P&L losses)

- ■ Cost of funding
- ■ Fire sale losses
- ■ Credit risk costs
- ■ Other risk costs through P&L

Feedback effects between
capital shortfalls/NPAs, lending & growth

Bank reaction to exogenous shock

Optimisation objectives & variables

Optimisation objective
- e.g. optimal structure across assets/liabilities

Optimisation criteria
- e.g. RAROC

Optimisation constraints
- e.g. regulation (CET1 ratio), price elasticities...

Calculation of new Internal Transfer Price

Bank action
- e.g. pricing, marketing, asset sales...

New balance sheet structure
- Market reaction to strat./tact. bank action

- Bank reaction to higher CET1 requirements depends on initial CET1 ratio & interaction solvency/funding cost & asset quality
- Substitution effects on loan markets

Strong increase of capitalisation since Lehman

MFI Leverage Ratios in the Euro Area and in Austria
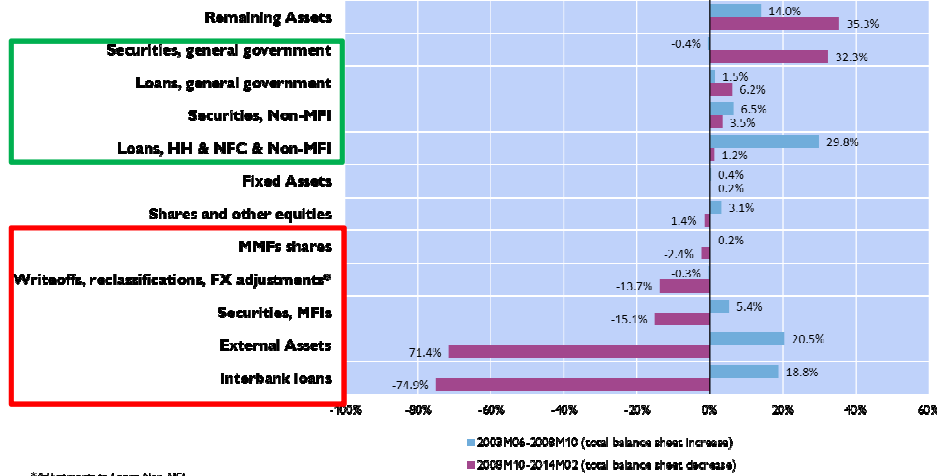
Capital in % of total assets

collapse of Lehman Brothers

— Euro area (changing composition)   — Austria

- ✓ EA: increase 5.3%-8% (Nov 2008-Feb 2014)→ contribution of higher capital: 88% (TA: 12%)

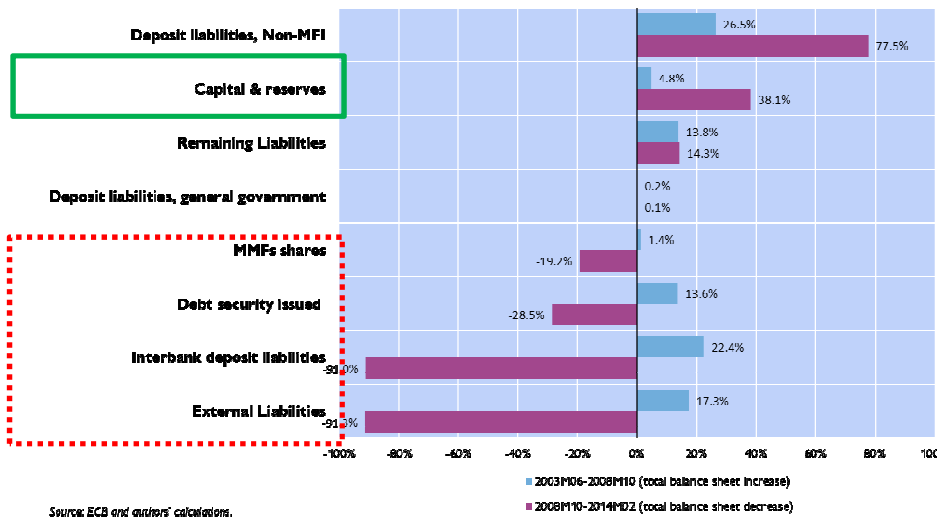- ✓ AT: increase 6.8%-10.8% (Nov 2008-Feb 2014)→ contribution of higher capital: 73% (TA: 27%)

… but deleveraging NOT by decreasing loans

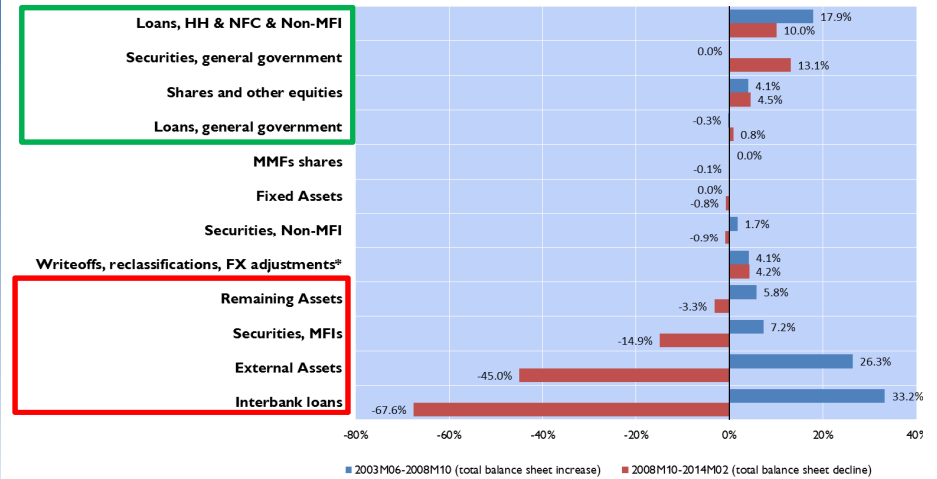## Euro area
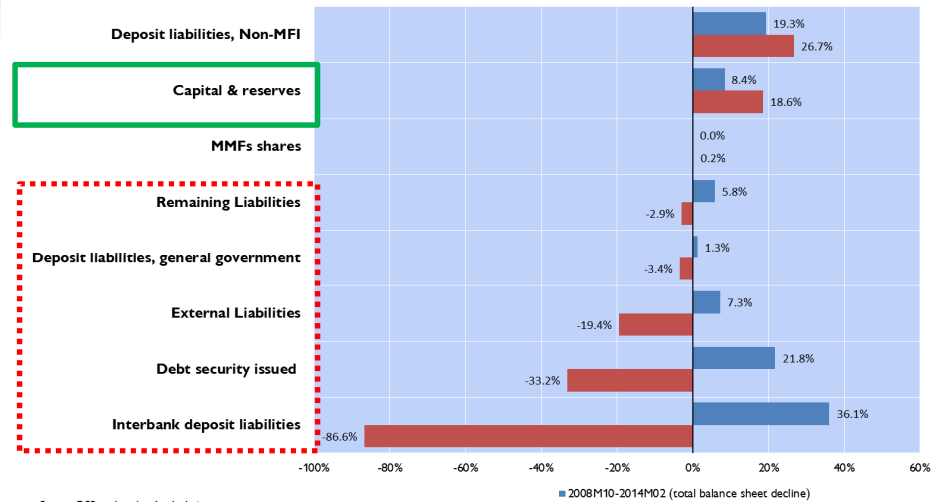

In % of total balance sheet increase/decrease

Category	2003M06-2008M10	2008M10-2014M02
Remaining Assets	14.0%	35.3%
Securities, general government	-0.4%	32.3%
Loans, general government	1.5%	6.2%
Securities, Non-MFI	6.5%	3.5%
Loans, HH & NFC & Non-MFI	29.8%	1.2%
Fixed Assets	0.4%	0.2%
Shares and other equities	3.1%	1.4%
MMFs shares	0.2%	-2.4%
Writeoffs, reclassifications, FX adjustments*	-0.3%	-13.7%
Securities, MFIs	5.4%	-15.1%
External Assets	20.5%	71.4%
Interbank loans	18.8%	-74.9%

*Adjustments to Loans Non-MFI

- 2003M06-2008M10 (total balance sheet increase)
- 2008M10-2014M02 (total balance sheet decrease)

Category	2003M06-2008M10	2008M10-2014M02
Deposit liabilities, Non-MFI	26.5%	77.5%
Capital & reserves	4.8%	38.1%
Remaining Liabilities	13.8%	14.3%
Deposit liabilities, general government	0.2%	0.1%
MMFs shares	1.4%	-19.2%
Debt security issued	13.6%	-28.5%
Interbank deposit liabilities	22.4%	-91.0%
External Liabilities	17.3%	-91.0%

Source: ECB and authors' calculations.

- 2003M06-2008M10 (total balance sheet increase)
- 2008M10-2014M02 (total balance sheet decrease)

Austria

asset categories in % of total balance sheet increase/decrease

Category	2003M06-2008M10	2008M10-2014M02
Loans, HH & NFC & Non-MFI	17.9%	10.0%
Securities, general government	0.0%	13.1%
Shares and other equities	4.1%	4.5%
Loans, general government	-0.3%	0.8%
MMFs shares	0.0%	-0.1%
Fixed Assets	0.0%	-0.8%
Securities, Non-MFI	1.7%	-0.9%
Writeoffs, reclassifications, FX adjustments*	4.1%	4.2%
Remaining Assets	5.8%	-3.3%
Securities, MFIs	7.2%	-14.9%
External Assets	26.3%	-45.0%
Interbank loans	33.2%	-67.6%

*Adjustment to loans Non-MFIs

- 2003M06-2008M10 (total balance sheet increase)
- 2008M10-2014M02 (total balance sheet decline)

Category	2008M10-2014M02 (decline)
Deposit liabilities, Non-MFI	19.3% / 26.7%
Capital & reserves	8.4% / 18.6%
MMFs shares	0.0% / 0.2%
Remaining Liabilities	5.8% / -2.9%
Deposit liabilities, general government	1.3% / -3.4%
External Liabilities	7.3% / -19.4%
Debt security issued	21.8% / -33.2%
Interbank deposit liabilities	36.1% / -86.6%

Source: ECB and authors' calculations.

- 2008M10-2014M02 (total balance sheet decline)
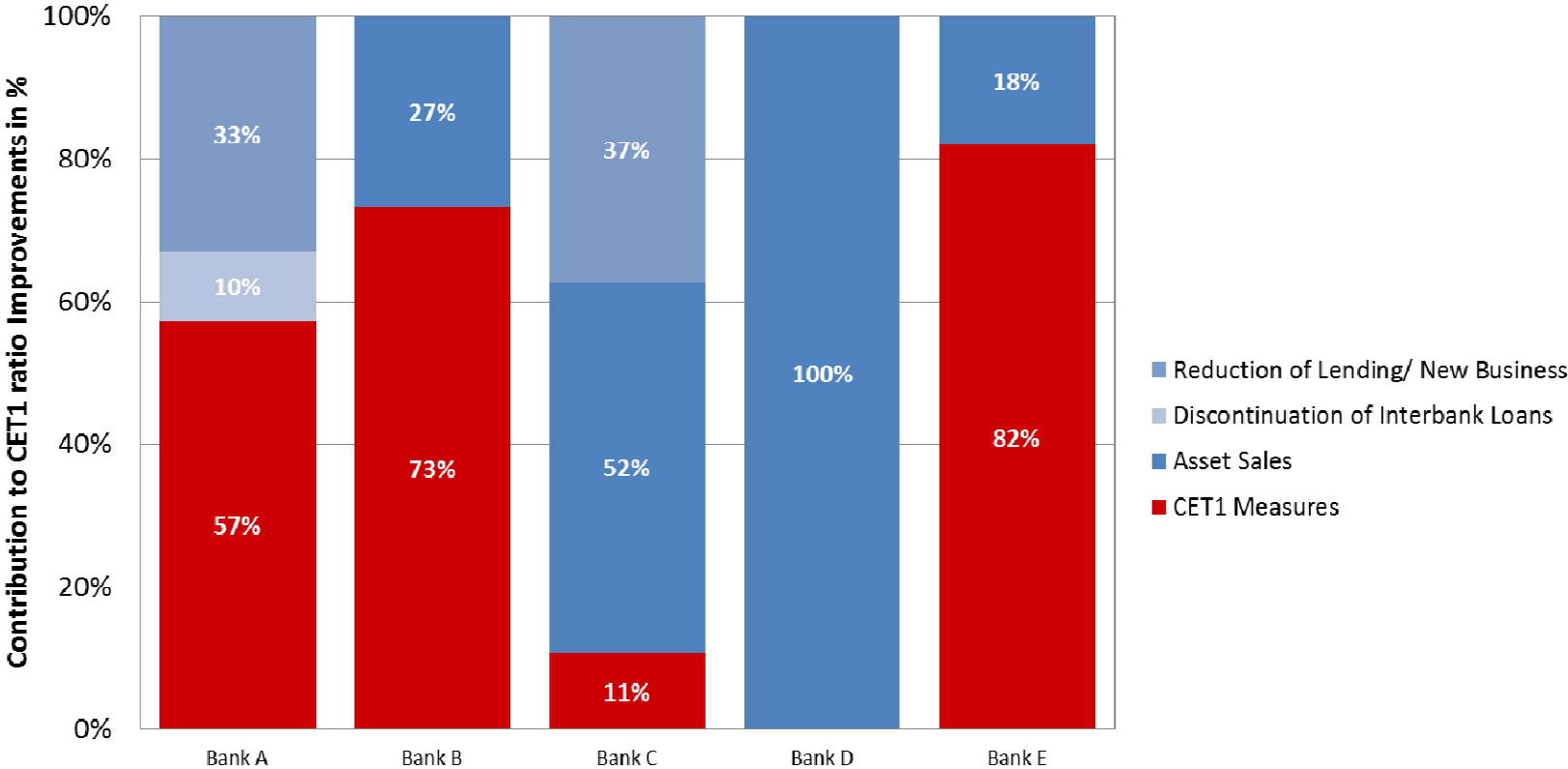
Source: Eidenberger et al. (2014) based on MFI data. Leverage ratio is defined as capital & reserves over total assets.

Austrian banks' reaction to macro shocks

LSI banks in Austria plan to increase their CET1 ratio mainly through raising CET1 capital & asset sales after macroeconomic shock (sample of 5 medium sized banks)

Source: OeNB
CET1 Measures include capital issuances, cost reductions, internal financing initiatives and realease of loan loss provisions. Data as of year end 2014 of five selected LSI banks in Austria.

BCBS RTF project

16a	If you increase your target CET1 capital ratio as a consequence of the stress test outcomes, how do plan to reach it? **Allocate contributions to reaching the new target capital ratio** again in ppts summing to 100%. [Example: You are 0.5 ppts short of your new target capital ratio. If you close the gap by retaining earnings (shortfall drops to 0.1 ppts) and reduced interbank lending, then you put 80% in "Increase capital (incl. retain earnings)" and 20% in "Reduce interbank lending".]	
	Reduce operating costs	
	Reduce interbank lending	
	Reduce trading book	
	Reduce non-core assets *(provide brief example below)*	
	Reduce NPLs (e.g. through sales)	
	Reduce participations and/or subsidiaries	
	Reduce non-financial corporate bonds	
	Reduce financial corporate bonds	
	Reduce sovereign bonds	
	Reduce securitizations and other fixed income	
	Reduce small and medium-enterprise business lending	
	Reduce other business lending	
	Reduce residential real estate lending	
	Reduce commercial real estate lending	
	Reduce loan exposure through securitization of loans	
	Reduce other assets	
	Increase capital (incl. retain earnings)	
	Close lines of business *(provide brief example below)*	
	Optimize risk weights by improving internal models (e.g. re-evaluate collateral received which reduces LGD, re-calibrate internal models)	
	Sum	**0%**

		Reduced (by x bp)	Increased (by x bp)	Stay the same
16b	If you increase your target CET1 capital ratio as a consequence of the stress test outcomes, by how much would your **internal fund transfer price** (incl. the direct and indirect costs of debt funding and the cost of capital) allocated to the asset categories below have to **decrease**, **increase** or **stay the same** (in basispoints) to keep your RoE constant per 100 basispoint CET1 capital shortfall.			
	Interbank lending			
	Trading book			
	Non-financial corporate bonds			
	Financial corporate bonds			
	Sovereign bonds			
	Small and medium-enterprise business lending			
	Other business lending			
	Residential real estate lending			
	Commercial real estate lending			
	Other *(provide brief text below)*			

BCBS RTF project – preliminary results

Increase of LR regulatory minimum: Banks combine various measures to reach their new target leverage ratio requirements. Other measures (36 per cent) and capital increases (incl. retained earnings; 25 per cent) account for the largest contributions. All other measures contribute an average of below 10 per cent. Reductions of SME business lending, residential real estate lending contribute 3 per cent, respectively, and other business lending 6 per cent. On average, 112 banks provided data for each measure.

Measures to reach a new leverage ratio target have little impact on internal transfer prices (ITP) allocated to the respective asset category. Banks report that they would keep the ITPs constant for four out of ten asset categories. For the remaining six asset categories average ITPs across respondents increase marginally by between 1 and 3 basis points. In five categories one respondent reported decreasing ITPs.

Increase of T1 target ratio after stress (test): Banks combine various measures to increase their target management Tier 1 buffer as a consequence of stress test results. Capital increases contribute 34 per cent on average across banks to increase Tier 1 buffers, the reduction of non-core assets 10 per cent, and the reduction of operating costs 9 per cent. The reduction of lending to SMEs, other business lending, residential real estate lending and commercial real estate lending contribute between 5 and 8 per cent to the overall increase of Tier 1 buffers. On average 62 banks provided data across potential measures.

Measures to increase target management Tier 1 buffer as a consequence of stress test results have little impact on the ITPs across asset categories. The ITPs for SME business lending and Other business lending increase by 6 and 5 basis points, respectively. The ITPs of residential and commercial real estate lending by 3 and 4 basis points, respectively. For all other measures the impact is between 0 and 1 basis points.

Main conclusions

• Banks combine various measures to adjust their balance-sheets to increases in regulatory minimum capital or liquidity ratios or solvency stress.

• Impact assessments that assume that banks rely only on the reduction of loans to the privat non-financial sector significantly overestimate the impact of capital/liquidity regulation or solvency shocks on loan supply.

• The price impact of measures taken is very small.

BCBS RTF project – preliminary results

Would you reduce assets or increase capital to reach your new target leverage ratio requirement?

Contribution of bank reaction to reach new target LR minimum requirement
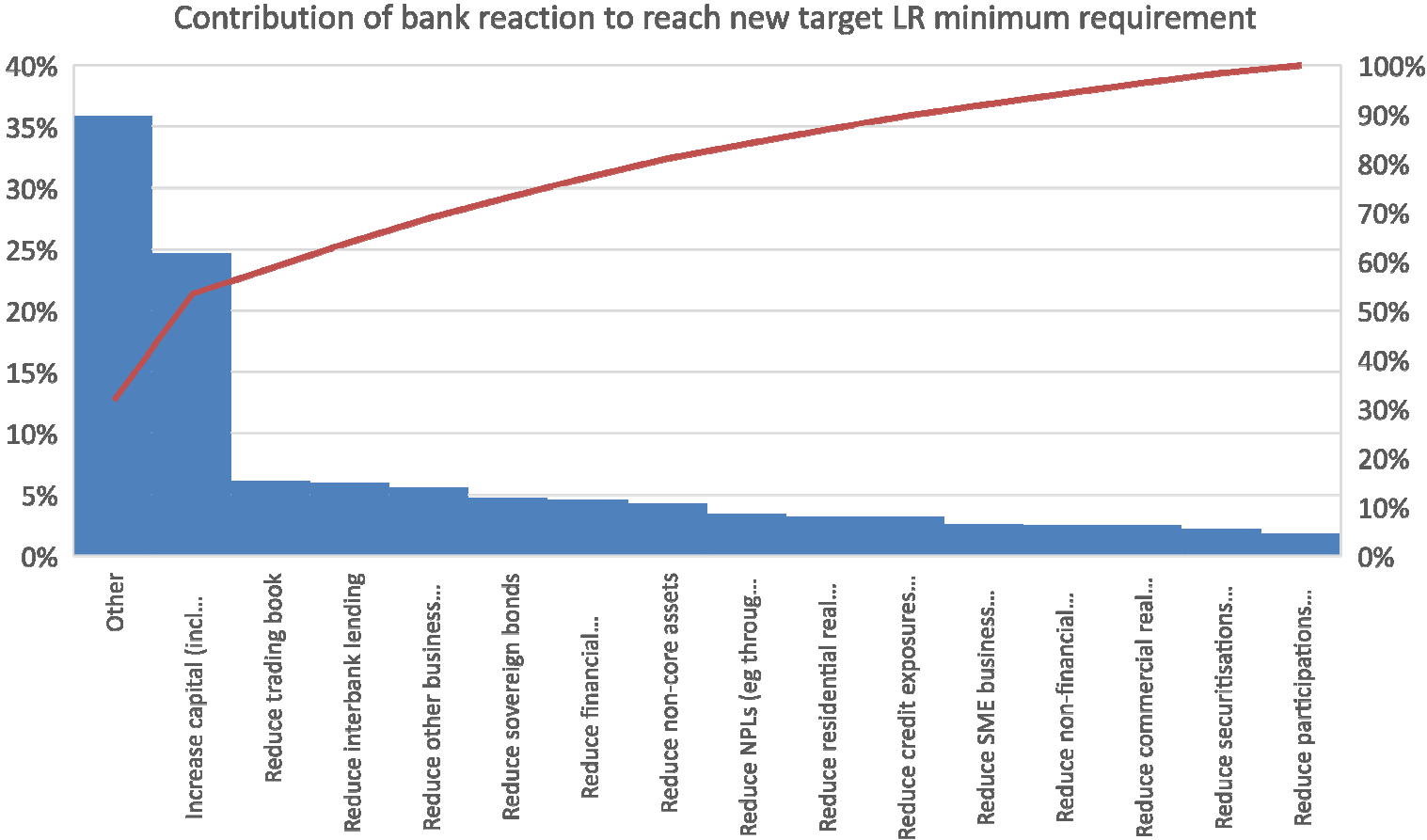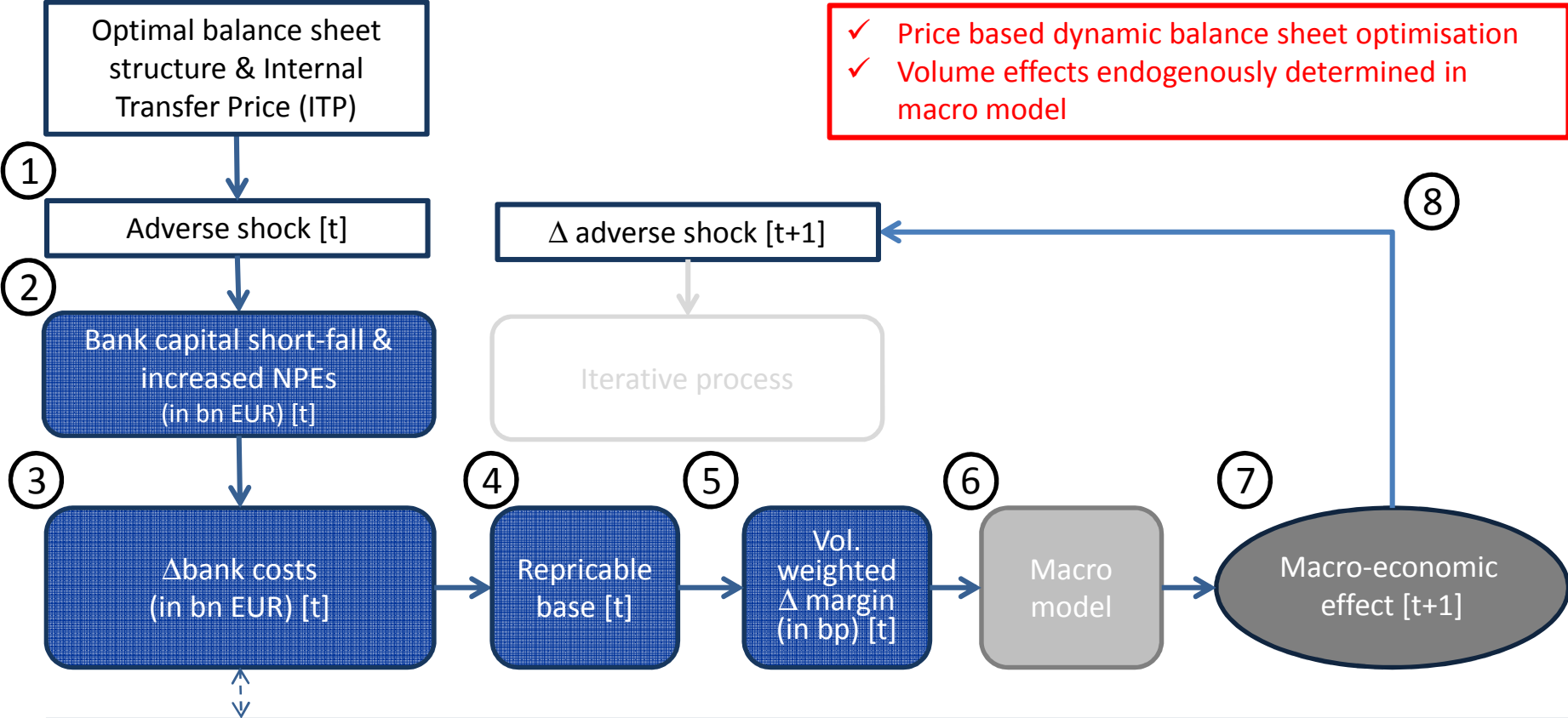
Source: QIS BCBS RTF Survey 2017

BCBS RTF project – preliminary results

Would you reduce assets or increase capital to reach your T1 target management buffer after a stress test?

Contribution of bank reaction to restore T1 target management buffer after stress tests
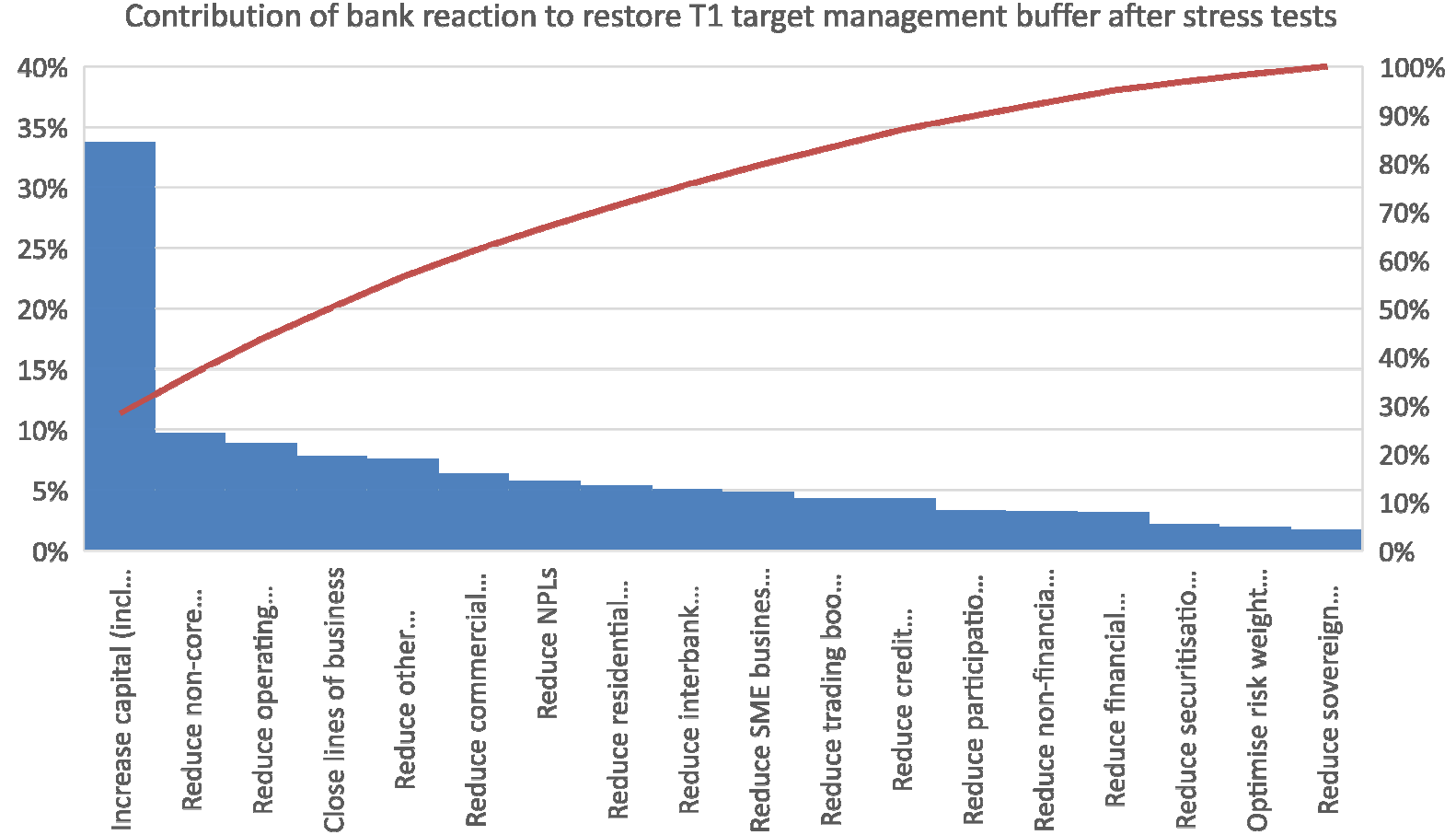
Source: QIS BCBS RTF Survey 2017

Feedback effects: capital shortfall, ITP, lending & growth

Optimal balance sheet structure & Internal Transfer Price (ITP)

- ✓ Price based dynamic balance sheet optimisation
- ✓ Volume effects endogenously determined in macro model

① Adverse shock [t]

Δ adverse shock [t+1]

② Bank capital short-fall & increased NPEs (in bn EUR) [t]

Iterative process

③ Δbank costs (in bn EUR) [t]

④ Repricable base [t]

⑤ Vol. weighted Δ margin (in bp) [t]

⑥ Macro model

⑦ Macro-economic effect [t+1]

⑧

Δbank costs include the increased shadow cost of capital $\Delta CET1 \times \left[\dfrac{RoE_{target} - (1 - tax) \times r_{Dstressed}}{(1 - tax)}\right]$, the solvency & funding cost interaction ($r_{Dstressed}$), MM and the costs of carrying higher NPEs on balance sheet...

Conclusions

Conclusions

1. Models that neglect the interactions between

- solvency and funding liquidity &

- solvency and funding costs

systemically and significantly underestimate the impact of a shock.

2. Feedback effects between the initial adverse shock, lending & growth must incorporate

- the empirics of bank reactions to stress &

- the complexities of dynamic, price based balance sheet optimisation.

- A narrow focus on the reduction of loan supply is counterfactual & overstates the feedback effect & leads to wrong policy conclusions (supervisory forebearance).

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