OESTERREICHISCHE NATIONALBANK
EUROSYSTEM

Making stress tests more macroprudential
Integrating second-round effects

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NEW FRONTIERS ON STRESS TESTING
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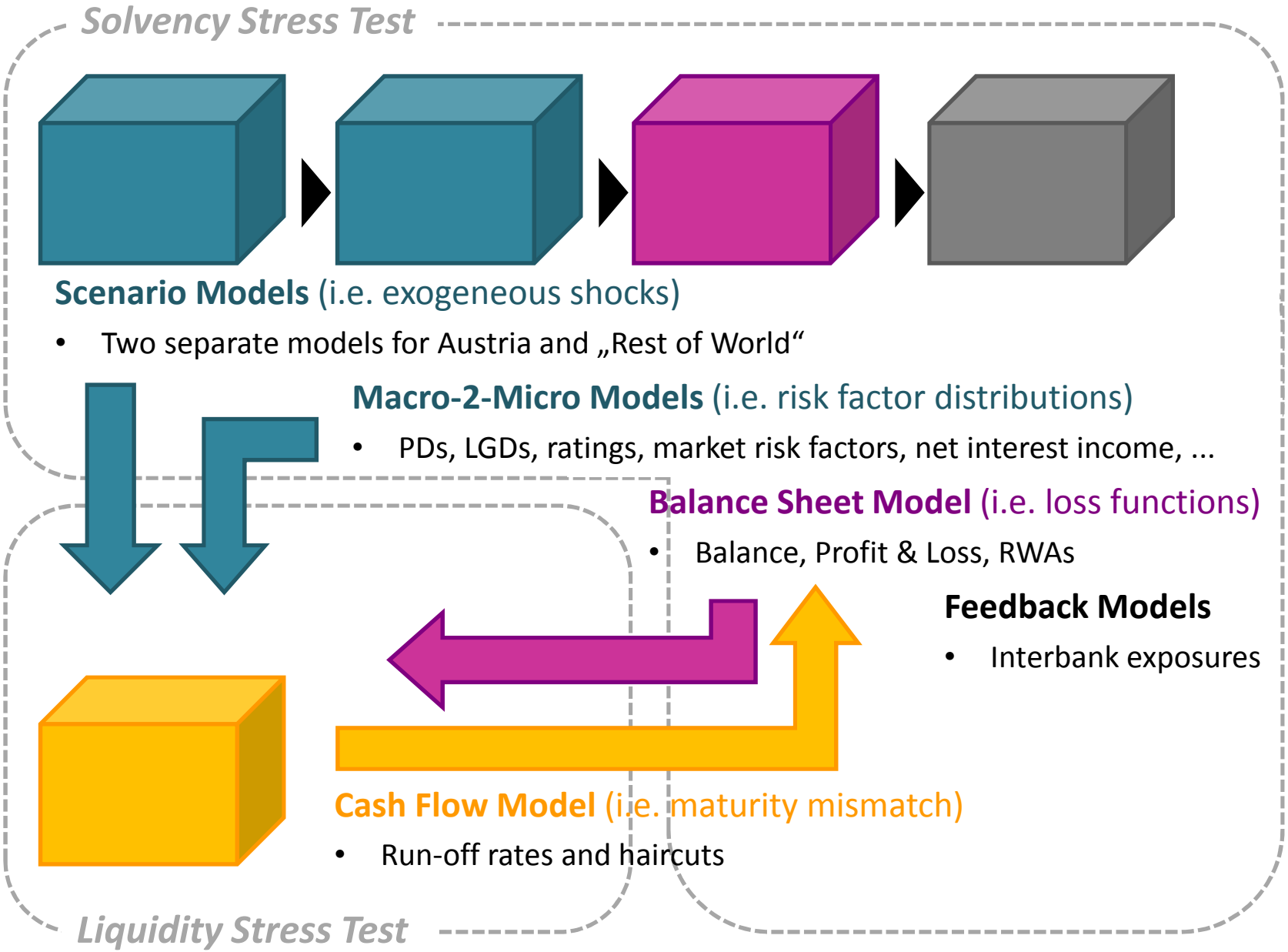
Agenda

1. Interaction solvency & funding liquidity
2. Interaction solvency & funding costs
3. Feedback effects between solvency shocks, lending & growth
4. Conclusions

Interaction
solvency & funding liquidity

Austrian stress test models



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

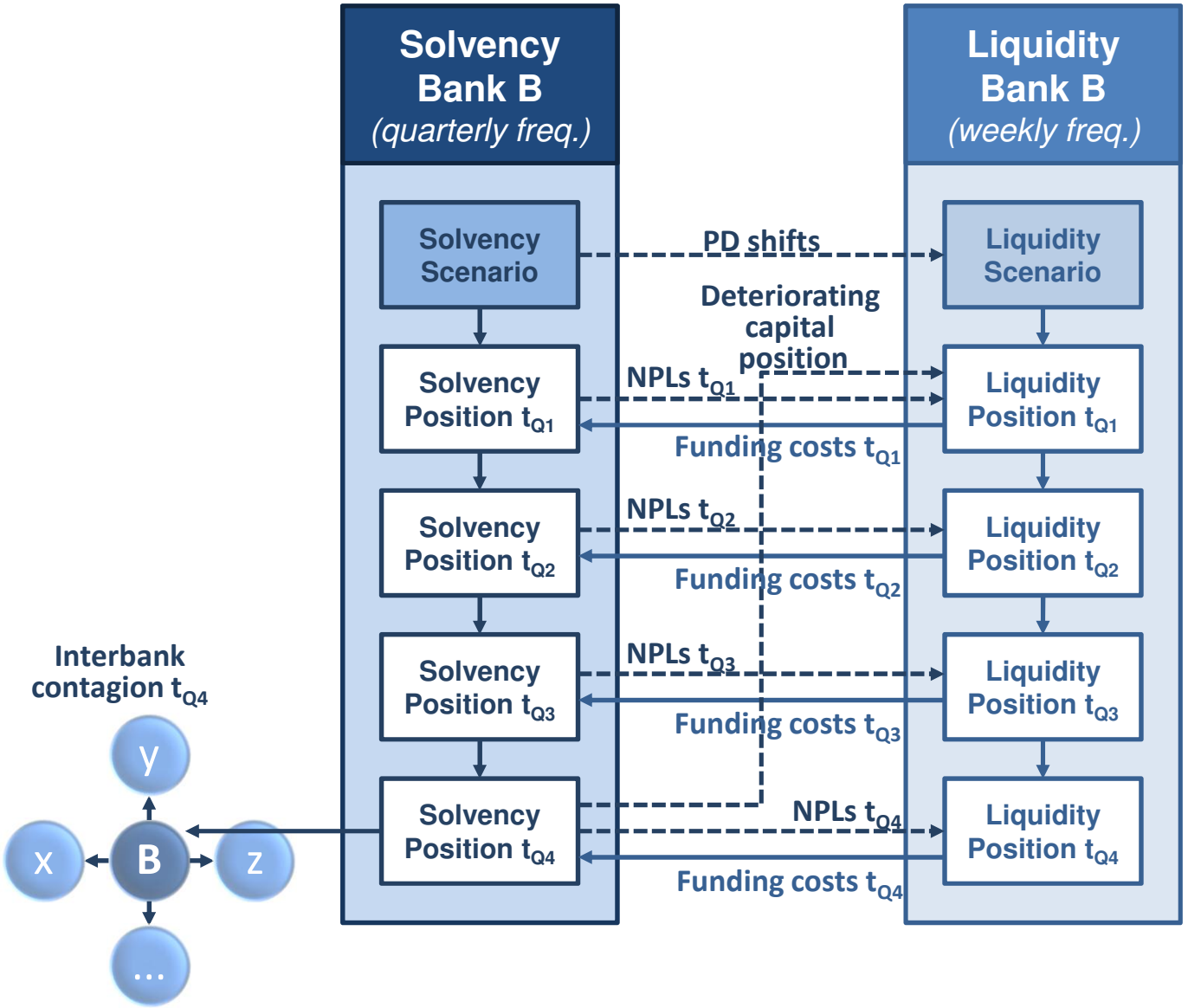
Securities flows	▪ Security flows must be included in the counterbalancing capacity ▪ Some netting within contractual and within behavioural flows necessary ▪ Consistency with repo/reverse repo and inflows/reinvestment
Roll-over within horizon	▪ No, decision to roll/run met at the first decision point ▪ 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**

Interlinkages solvency / funding liquidity

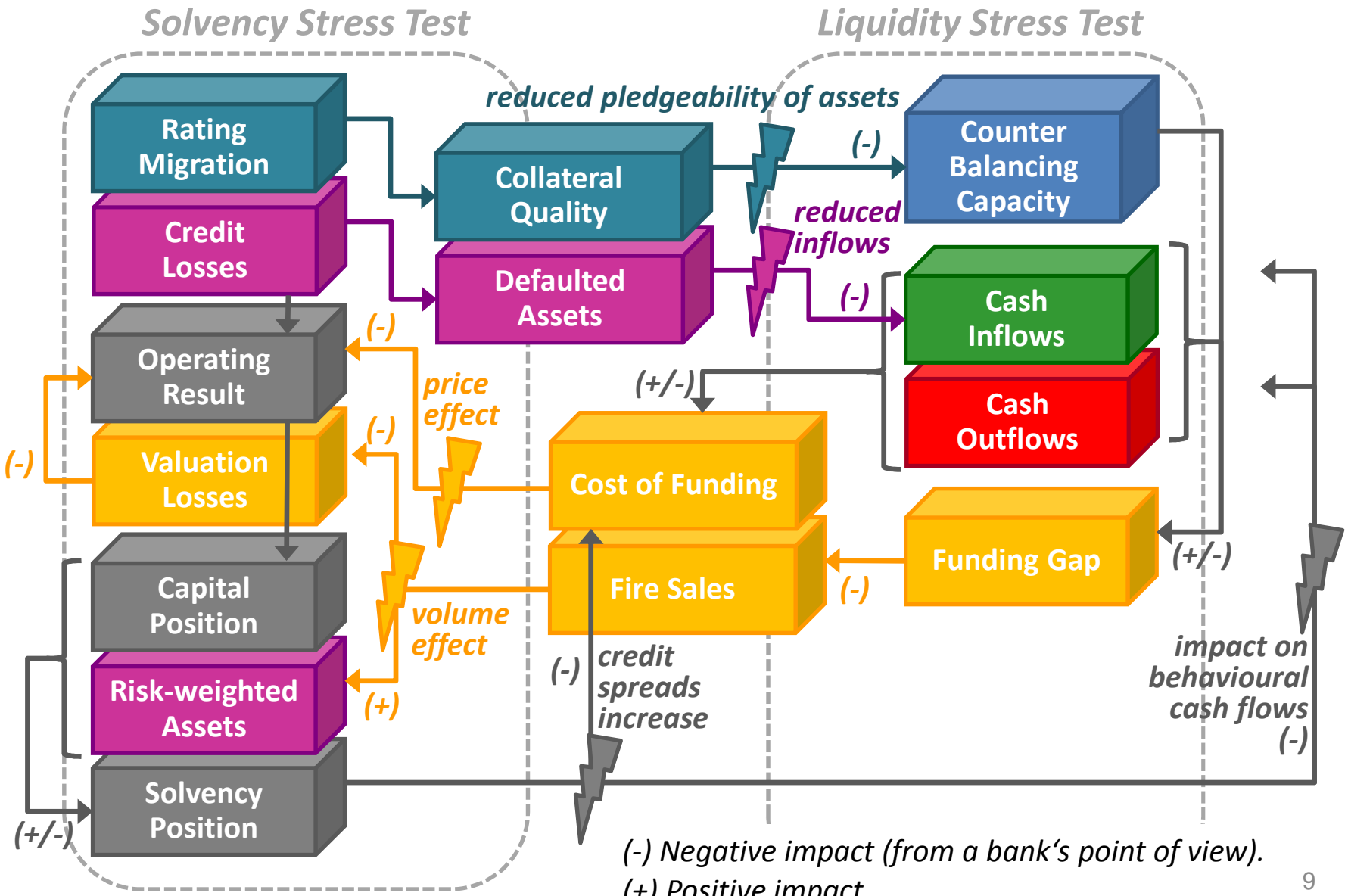
Solvency Stress Test	Mapping to Liquidity Stress Test
Deteriorating Capital Position	Ability to issue new CP & bonds (12M scenario)
Increase in Expected NPLs	Reduction in expected inflows from loan repayments Reduction of expected inflows from NFC bonds
Macro-driven PD Shifts	Implied rating migration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

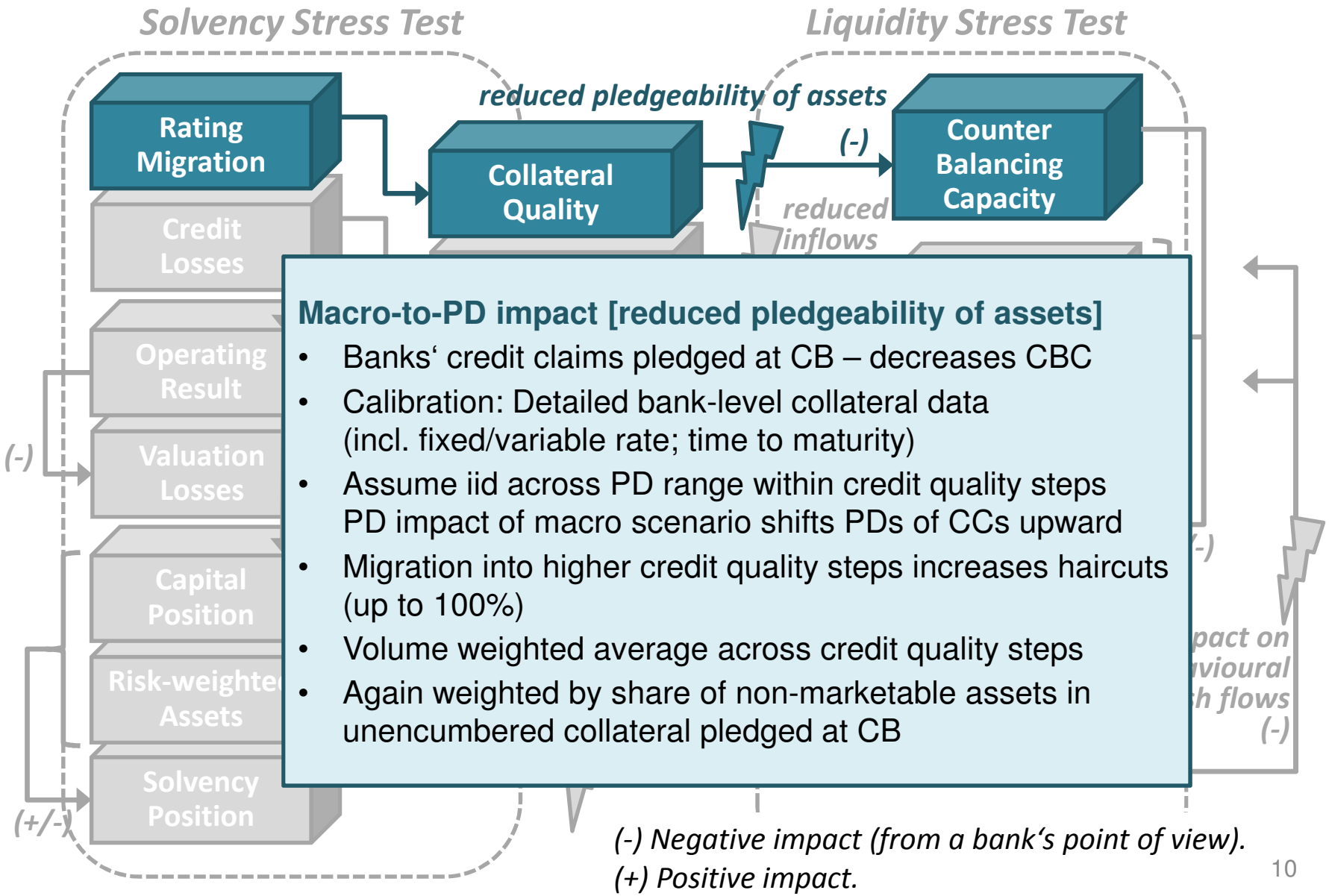


Complex interaction of solvency and funding liquidity



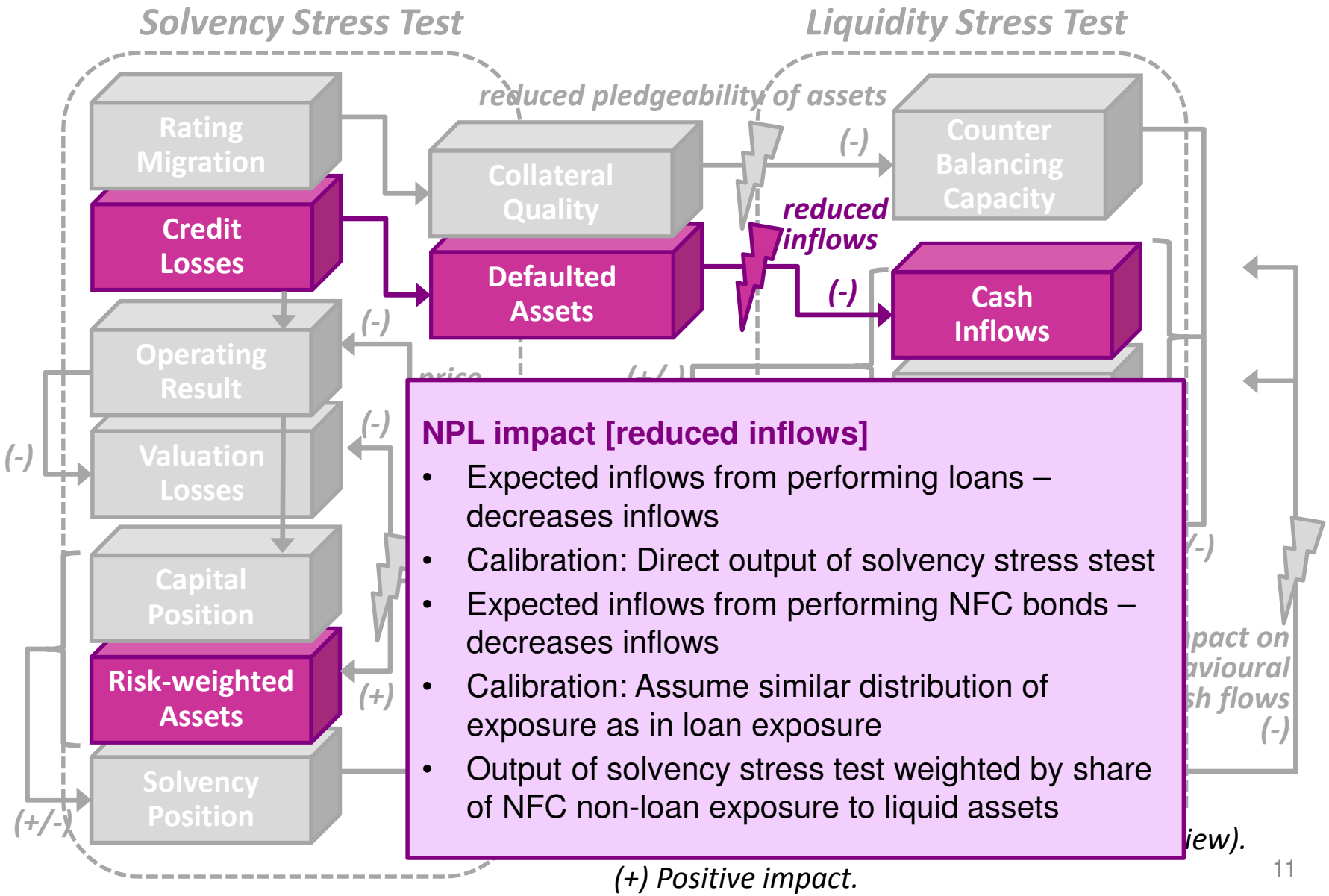
(-) Negative impact (from a bank's point of view).
(+) Positive impact.

Reduced pledgeability of assets



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

NPL impact: reduced inflows



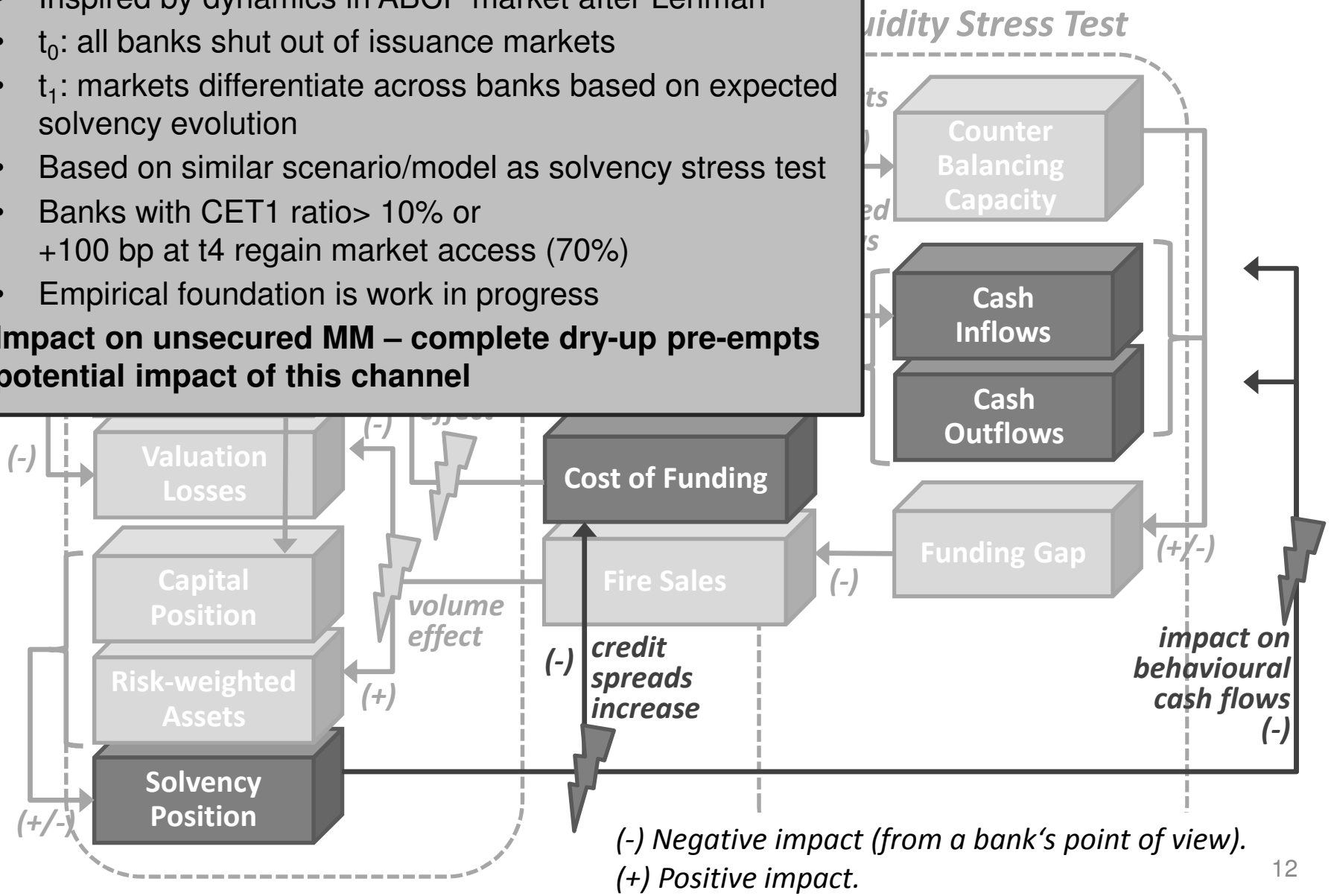
NPL impact [reduced inflows]

- 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

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



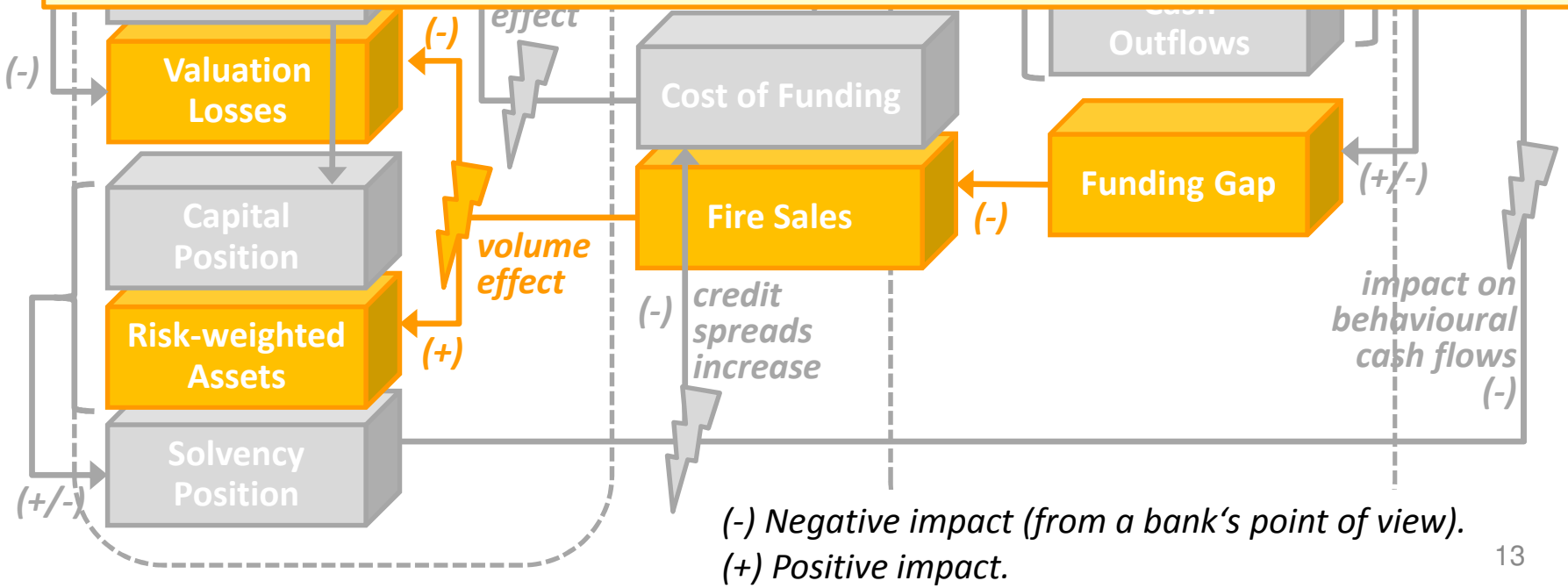
(-) Negative impact (from a bank's point of view).
(+) Positive impact.

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

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

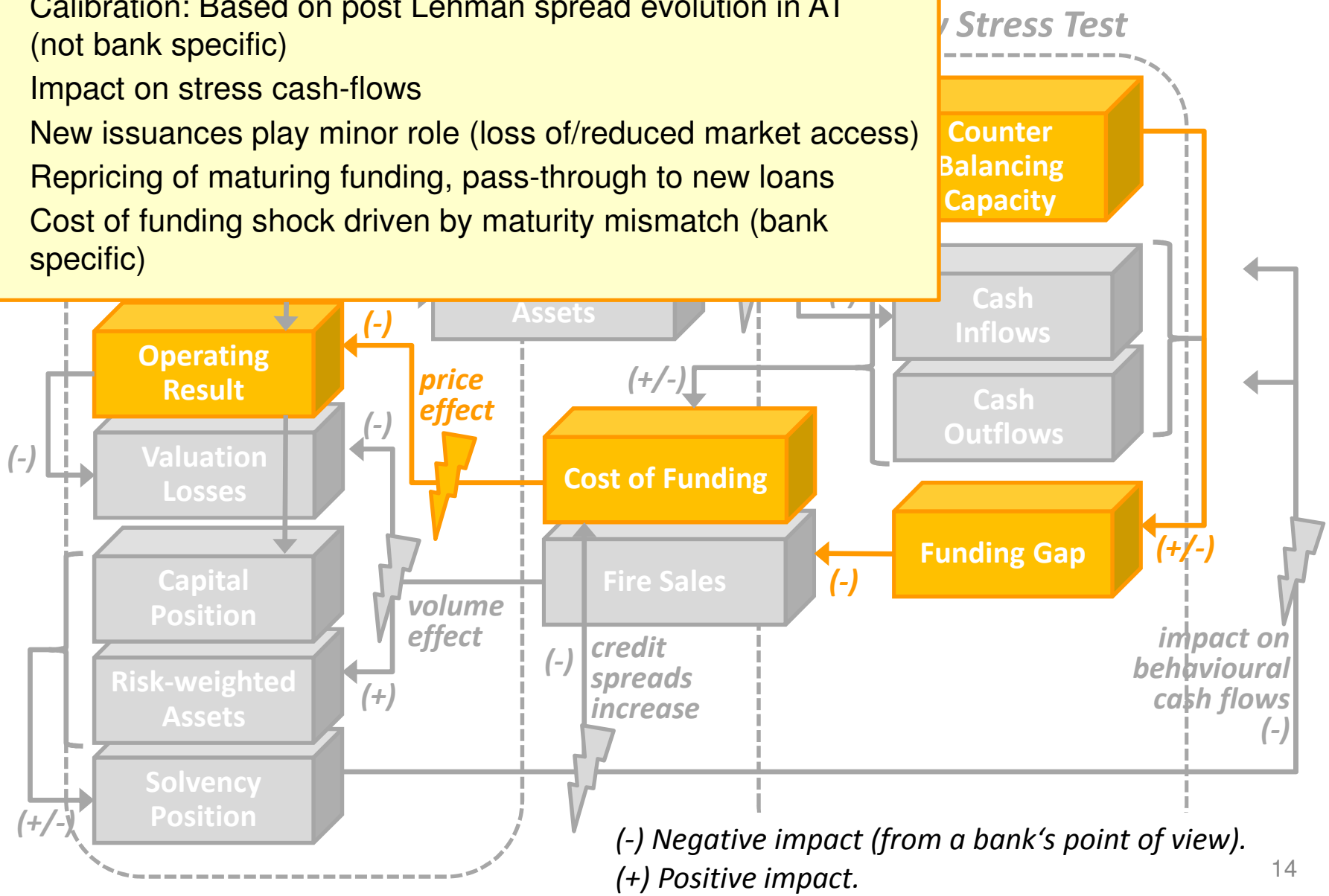
- Effect: Banks with same level of CBC but higher shares of less liquid assets face higher asset fire sale losses
- Caveats: CB treatment; static, non-behavioural; no additional fire sale loss haircuts



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

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)



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

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).

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

- 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

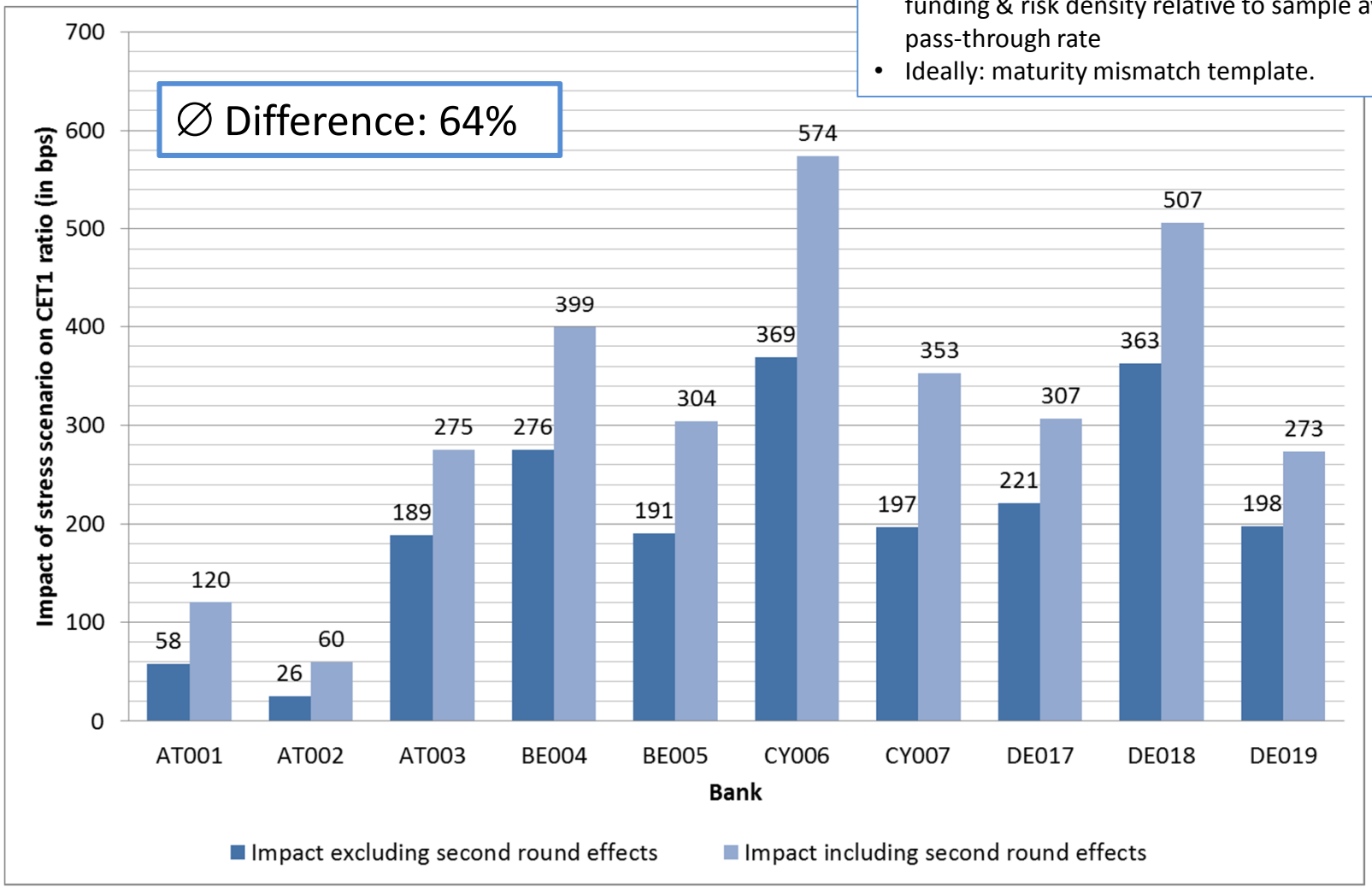
- A 100 bps increase in CDS spreads is associated with an increase in the EDF by 61-69 bps.

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

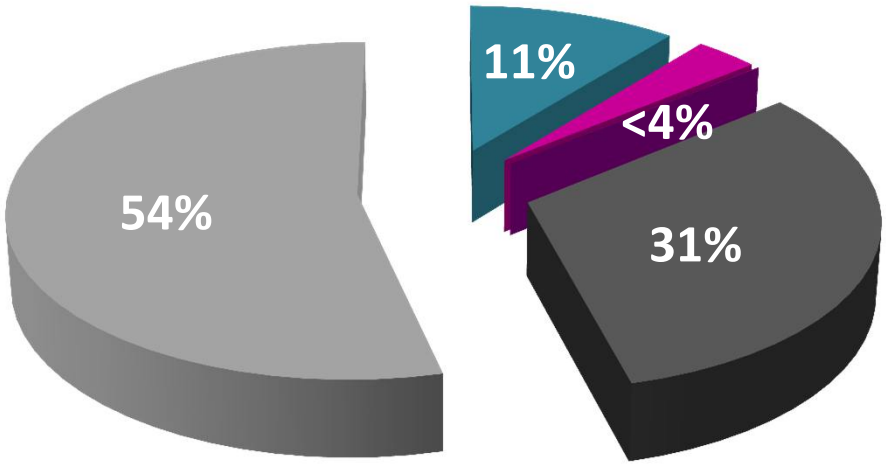
- Shortcut via model: results sensitive to maturity structure & CDS sensitivity of short-term wholesale funding & risk density relative to sample average & pass-through rate
- Ideally: maturity mismatch template.



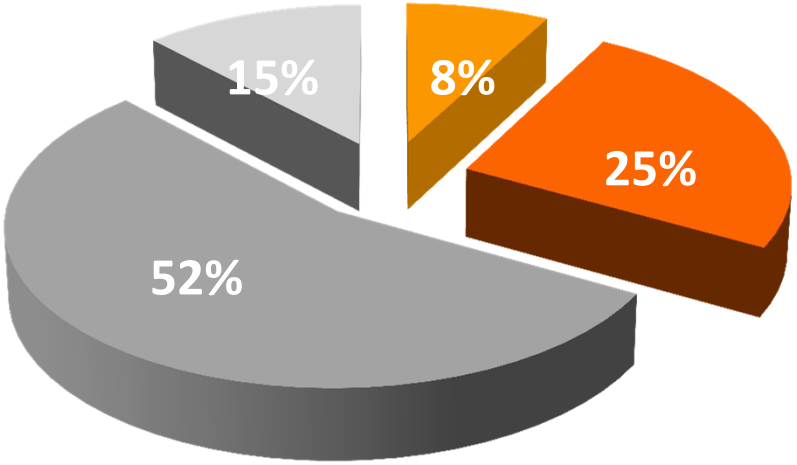
Source: Own calculations based on Schmitz et al. (forthcoming) and public EBA stress test data.

Significance across interaction channels

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



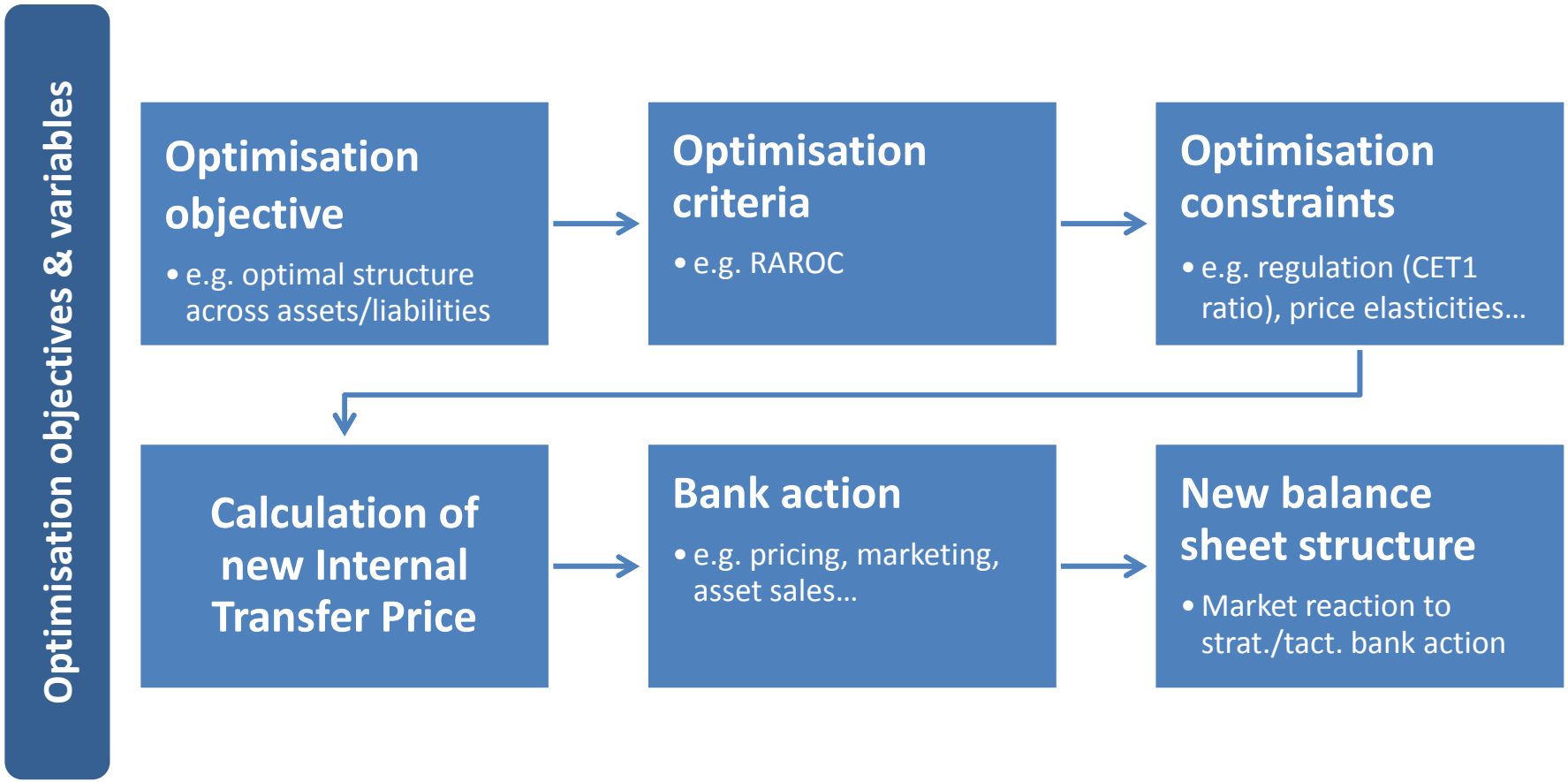
Solvency Stress Test
(share of total impact on P&L losses)



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

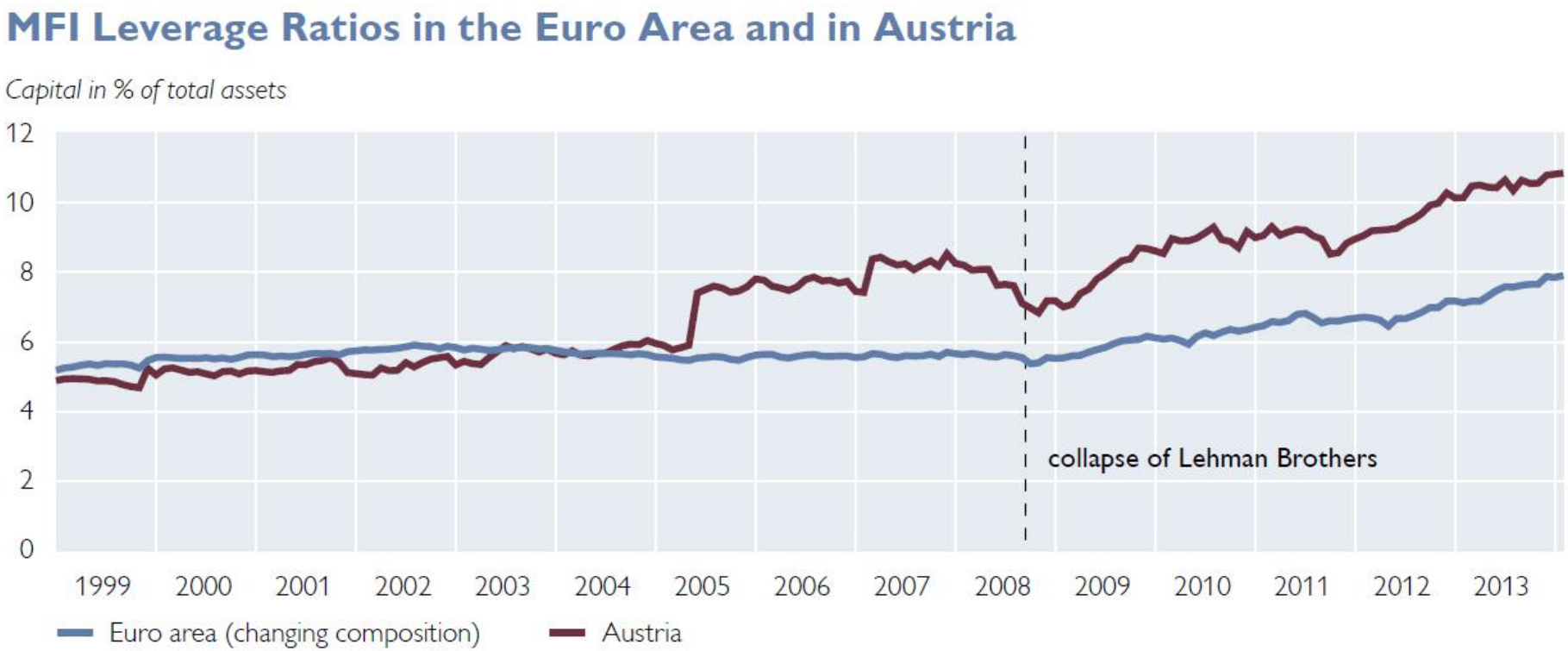
Feedback effects between capital shortfalls/NPAs, lending & growth

Bank reaction to exogenous shock



- 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

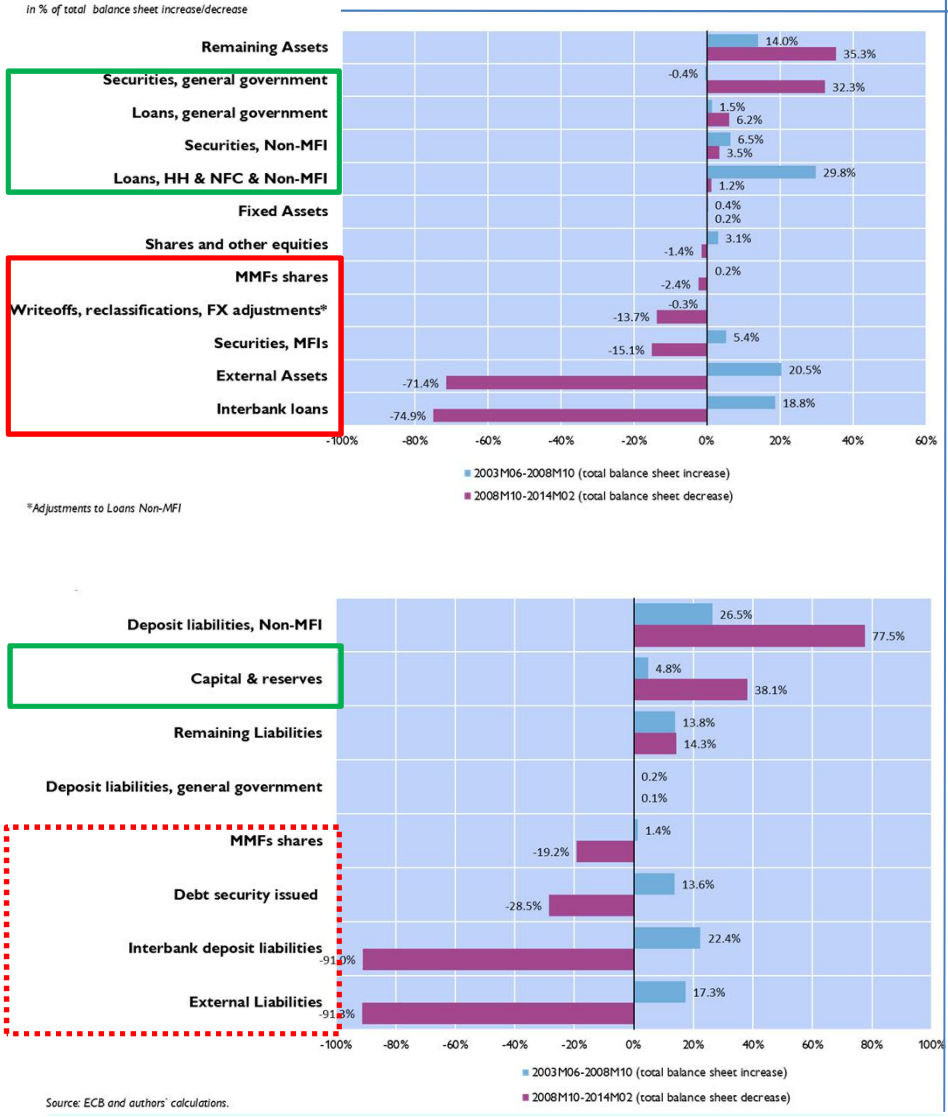


- ✓ EA: increase 5.3%-8% (Nov 2008-Feb 2014)→ contribution of higher capital: 88% (TA: 12%)
- ✓ AT: increase 6.8%-10.8% (Nov 2008-Feb 2014)→ contribution of higher capital: 73% (TA: 27%)

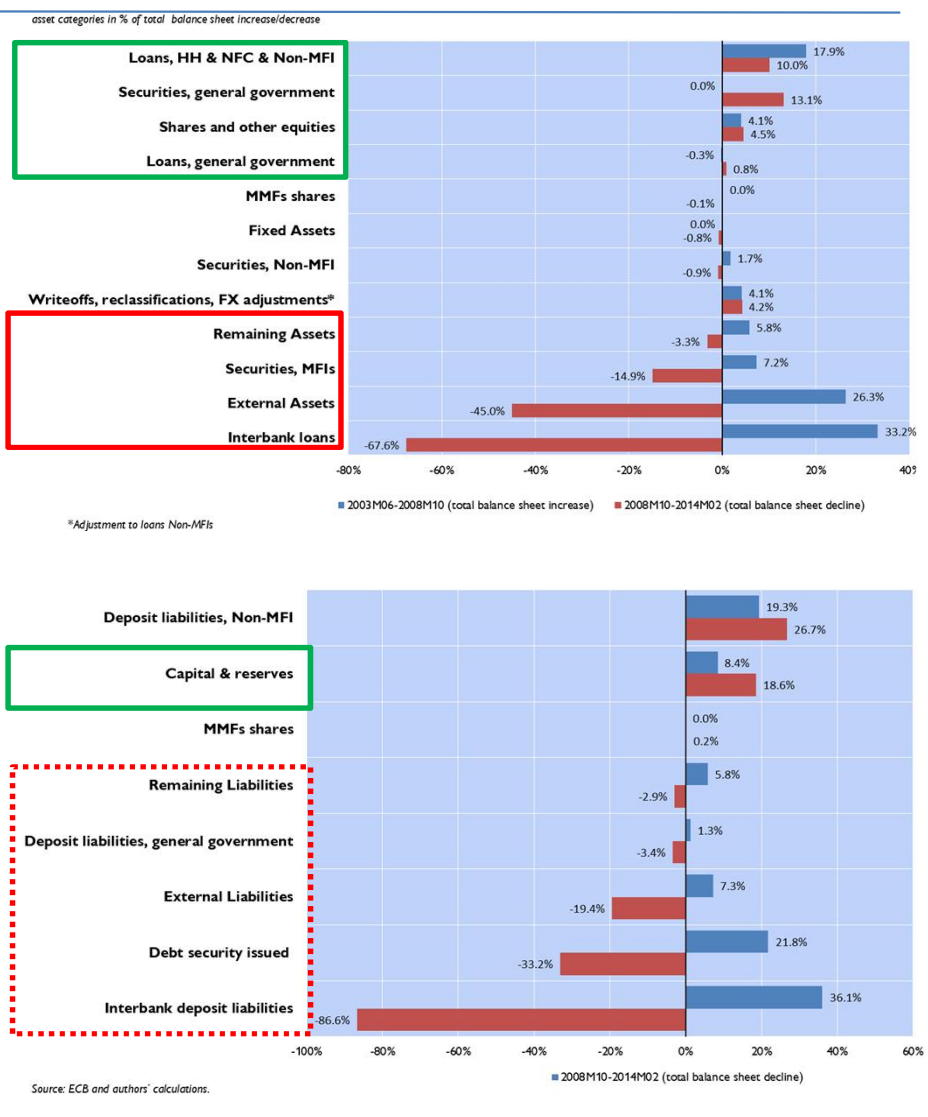
Source: Eidenberger et al. (2014) based on MFI data.
Leverage ratio is defined as capital over total assets.

… but deleveraging NOT by decreasing loans

Euro area

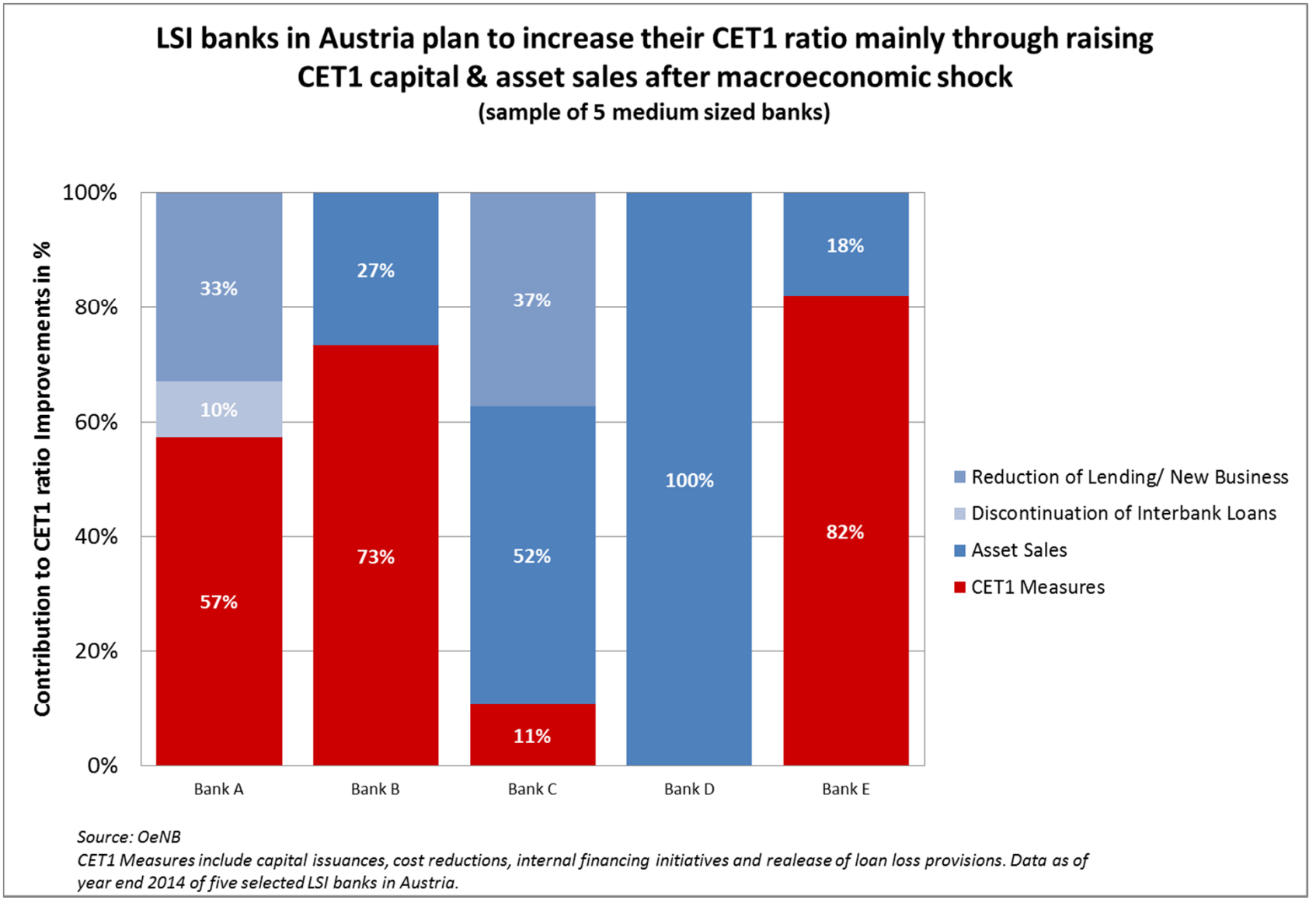


Austria



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



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.

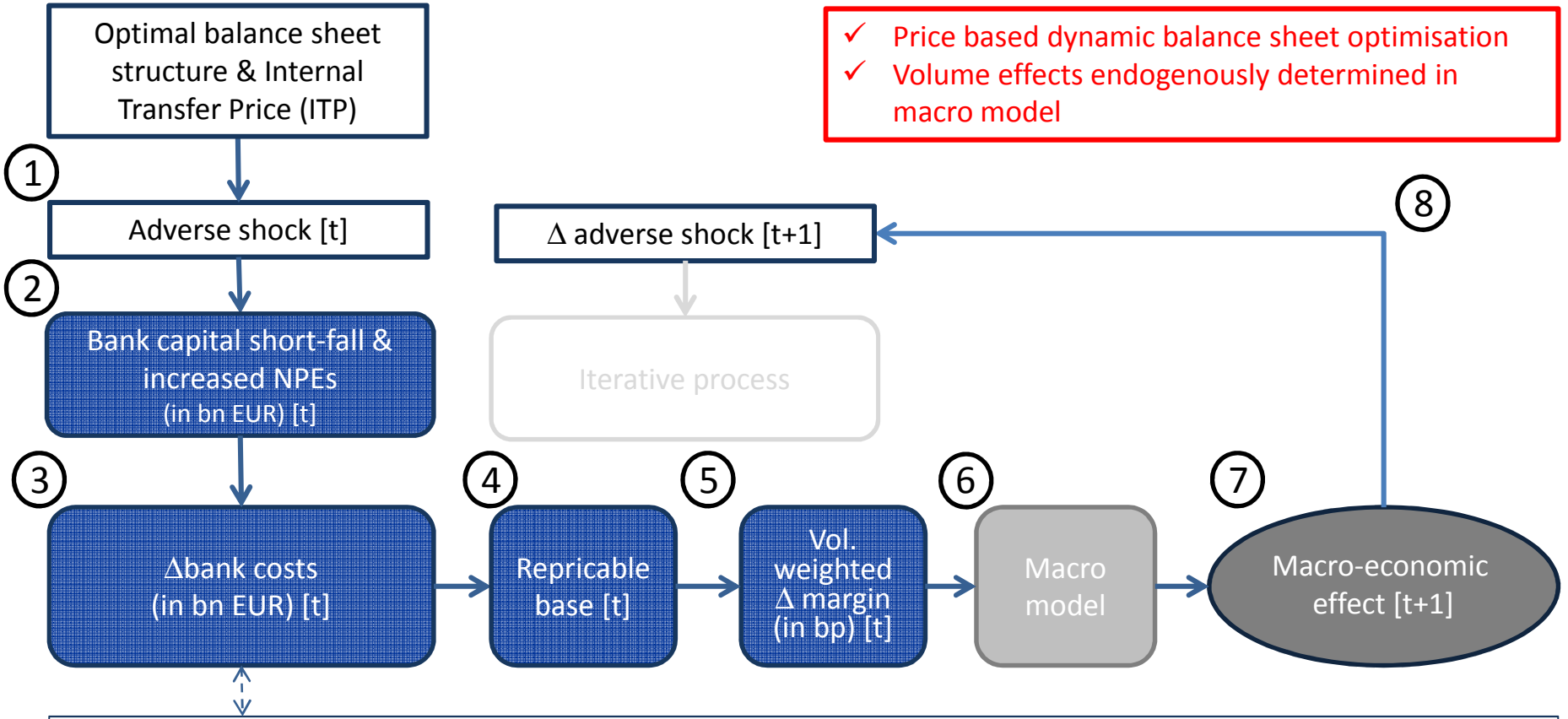
BCBS RTF project

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%**

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.	Reduced (by x bp)	Increased (by x bp)	Stay the same
	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)*			

Source:BCBS QIS.

Feedback effects: capital shortfall, ITP, lending & growth



Δbank costs include the increased shadow cost of capital $\Delta CET1 \times \left[\frac{RoE_{target} - (1-tax) \times r_{Dstressed}}{(1-tax)}\right]$, 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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