Robustness of Credit Risk Stress Test Results: Modelling Issues with an Application to Belgium

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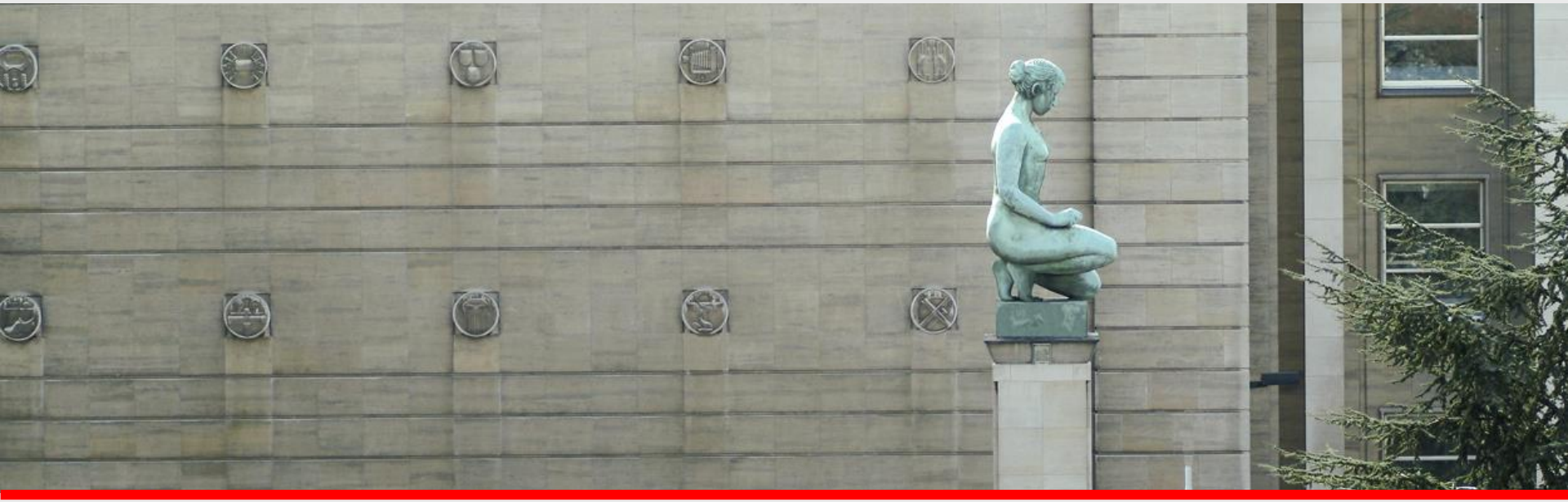

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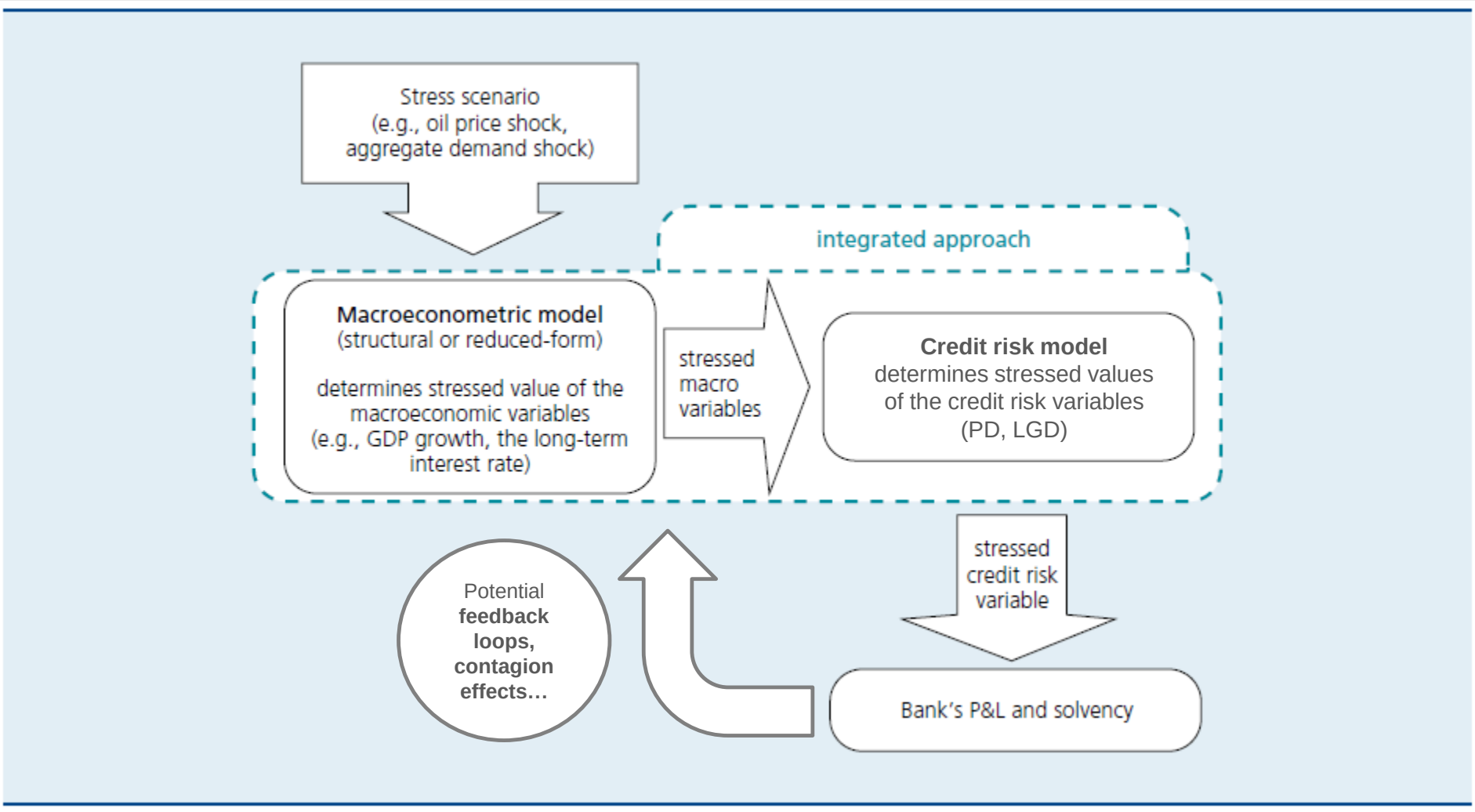
Stress testing credit risk: typical process



Source: adapted from Ferrari et al. (NBB FSR, 2011).

Paper summary

- Using data on the Belgian banking system, this paper estimates how the choices of **different PD proxies** and **levels of data aggregation** impact impairment losses hence banks' Tier 1 capital.

- In practice, these choices are often made on an ad hoc basis by banks / supervisors / academics. Yet, they appear to **matter substantially** for stress test results.

- Therefore, there might be a potential need to **harmonize stress-test methodologies** and **improve data quality and availability**.

Main contribution of paper

- **Few papers** have investigated the importance of the above-mentioned choices for stress test results.
- **Exceptions** (levels of data aggregation only):
  - **Vazquez, Tabak and Souto (JFS, 2012)** simulate the evolution of NPLs with and without exploiting a partition of credit portfolios by borrower types and economic sectors.
  - **Düllmann and Kick (FMPM, 2014)** simulate the evolution of expected losses using borrower-specific vs. sector level PD.
- **This paper**:
  - Considers not only the choice of the level of data aggregation, **but also of the PD variable** (or proxy).
  - Is based on the adverse scenario of the 2014 **EBA EU-wide stress test**.

PD variables used in practice

- **Model-based measures** (e.g. banks' internal PDs)
- **Bank accounting data** (NPL ratio => PD; LLP or FLLP ratio => PD with LGD component)
- **Default data** (e.g. default or bankruptcy rate)

The choice of the PD proxy depends on **data availability** and **practitioners' modelling choices**.

This choice matters for stress test results because of the nature of the PD variable:

- **Backward** vs. **forward-looking**
- **PIT** vs. **TTC**
- **Stock** vs. **flow**

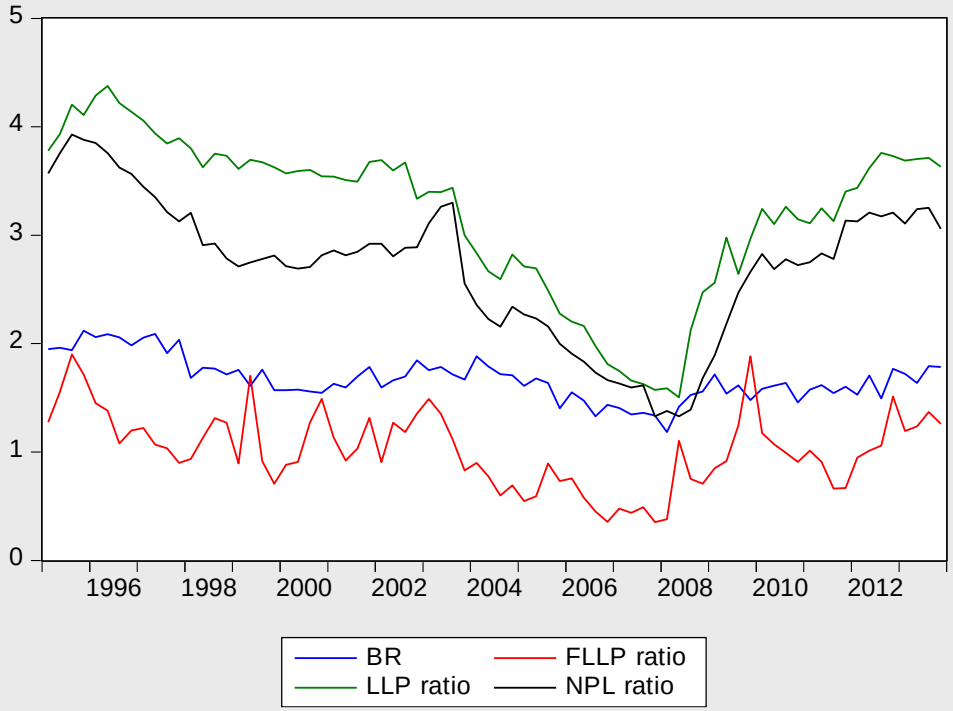
PD variables used in this paper

Variable	Definition
NPL ratio	Stock of non-performing loans / Total loans
LLP ratio	Stock of impairments / Total loans
FLLP ratio	Flow of new impairments (net of reversal) / Total loans
BR	Bankruptcy rate = number of filings for liquidation type bankruptcy (t) / number of companies in existence (t-1)

Key differences (potentially impacting stress test results):

- NPL, LLP & FLLP = **bank accounting data**; BR = **default data**
- NPL, LLP & FLLP capture the credit risk of loans to **Belgian and foreign counterparties**; BR measures credit risk of **Belgian** counterparties only
- NPL & LLP = **stock** variables; FLLP & BR = **flow** variables

Evolution of the PD variables and correlation among them (1995Q1-2013Q4)



Contemporaneous correlations:

	BR	FLLP ratio	LLP ratio	NPL ratio
BR	1.00			
FLLP ratio	0.56	1.00		
LLP ratio	0.76	0.70	1.00	
NPL ratio	0.77	0.72	0.95	1.00

Levels of data aggregation used in practice

- **Borrower level**
- **Sectoral level** (industrial, size, portfolios...)
- **Economy-wide level**

Models can also be estimated for **individuals banks** or the **whole banking sector**.

Models estimated on more granular data allow more differentiation in relationships between credit risk and the operating environment, yet are less efficient in terms of data and modelling resources.

Levels of data aggregation used in this paper (*bankruptcy rate only*)

Level	Group(s) of firms
Economy-wide	all firms (100%)
Sectoral (industrial)	manufacturing firms (7%), non-manufacturing firms (93%)
Sectoral (size)	medium/ large firms (6%), small firms (94%)
Sectoral (industrial + size)	medium/ large manufacturing firms (1%), small manufacturing firms (6%), medium/ large non-manufacturing firms (5%), small non-manufacturing firms (88%)

(% of the total population of Belgian firms in parenthesis)

Correlation among bankruptcy rates for different levels of data aggregation (1995Q1-2013Q4)

	economy-wide	manuf.	non-manuf.	medium/ large	small	medium/ large manuf.	small manuf.	medium/ large non-manuf.	small non-manuf.
economy-wide	1.00								
manuf.	0.79	1.00							
non-manuf.	0.99	0.74	1.00						
medium/ large	0.77	0.61	0.76	1.00					
small	0.99	0.79	0.99	0.72	1.00				
medium/ large manuf.	0.45	0.45	0.43	0.70	0.41	1.00			
small manuf.	0.74	0.96	0.69	0.47	0.75	0.19	1.00		
medium/ large non-manuf.	0.79	0.59	0.78	0.96	0.73	0.49	0.51	1.00	
small non-manuf.	0.99	0.73	0.99	0.72	0.99	0.42	0.69	0.73	1.00

Empirical approach

- Step 1: estimate the ADL credit risk model over 1995Q1-2013Q4:

$$C_t = \propto + \sum_{j=1}^{l} \beta_{t-j} C_{t-j} + \sum_{i=1}^{m} \sum_{j=0}^{l} \gamma_{i,t-j} M_{i,t-j} + \varepsilon_t$$

where:

$\boldsymbol{C_t}$ = credit risk variable (PD) at time *t*

$\mathbf{M_{i,t}}$ = macroeconomic variable *i* at time *t*

m = number of macroeconomic variables

l = number of lags and ε_t = error term at time *t*

in the paper:

$\boldsymbol{C_t}$ = NPL, LLP, FLLP or BR (at different levels of aggregation)

$\mathbf{M_{i,t}}$ = business survey indicator, unemployment rate (UNEMP), and long-term interest rate (OLO)

l = 1 ; all variables (except the FLLP ratio) are taken in first differences.

Step 1: credit risk model results (different PD variables)

	NPL ratio	LLP ratio	FLLP ratio	BR
Credit risk var. (t-1)	0.15 (0.12)	-0.16 (0.13)	0.58*** (0.09)	-0.55*** (0.10)
Bus. surv. indic. (t)	-0.01*** (0.00)	-0.01*** (0.00)	0.00 (0.00)	-0.00*** (0.00)
Bus. surv. indic. (t-1)	0.01** (0.00)	0.01*** (0.00)	-0.00** (0.01)	0.00*** (0.00)
UNEMP (t)	-0.05 (0.06)	0.00 (0.03)	-0.01 (0.01)	0.01 (0.01)
UNEMP (t-1)	0.03 (0.06)	0.03 (0.03)	-0.01 (0.01)	-0.00 (0.01)
OLO (t)	0.01 (0.07)	0.01 (0.03)	-0.03** (0.01)	0.02* (0.01)
OLO (t-1)	0.02 (0.06)	0.03 (0.03)	-0.02** (0.01)	-0.00 (0.01)
Constant	-0.04 (0.02)	-0.01 (0.01)	0.04*** (0.01)	-0.00 (0.00)
Observations	74	74	74	74
Adjusted R-squared	0.16	0.13	0.55	0.37

Empirical approach

Over the stress test horizon (2014Q1-2016Q4):

$$C_t = \propto + \sum_{j=1}^{l} \beta_{t-j} C_{t-j} + \sum_{i=1}^{m} \sum_{j=0}^{l} \gamma_{i,t-j} M_{i,t-j} + \varepsilon_t$$

- Step 2:
  - Obtain point estimate of C_t by multiplying $\hat{\beta}$ by lagged values of C_t and $\hat{\gamma}$ by the stressed values of $M_{i,t}$
  - Obtain the distribution of C_t by adding 100,000 random draws of ε_t
- Step 3: compute EL distribution as PD × LGD × EAD with:
  - PD = C_t distribution
  - LGD = 0.45 (NPL and BR) or 1 (LLP and FLLP)
  - EAD = Belgian banks' EAD
- Step 4: select 50th and 75th percentiles (p) of EL distribution.
  - 75th percentile accounts for model uncertainty

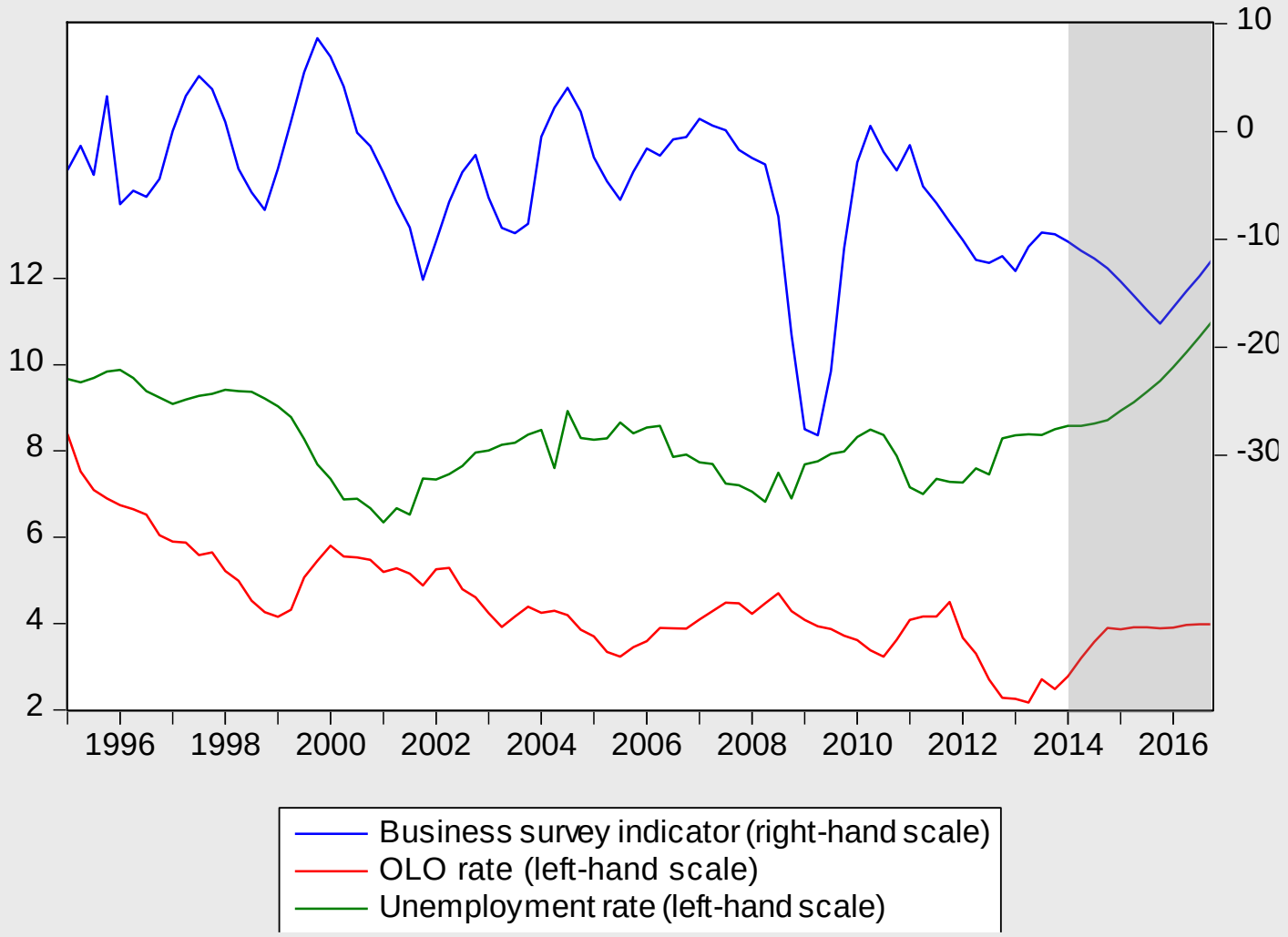
Empirical approach

- Step 5: compute stress impact on banks' balance sheet
  - Compute ΔEL(p) =
    EL(p) of Step 4 – EL of 2013Q4
  - Express ΔEL(p) in terms of Tier 1 ratio impact:

    $$Tier\ 1\ impact(p) = \frac{\Delta EL(p)}{REA}$$

    with REA = Belgian banks' REA
  - Note:
    - Different PDs => *Total* Tier 1 ratio
    - Different levels of data aggregation => *Corporate* Tier 1 ratio

Step 2: stressed macro variables (grey) for Belgium (EBA EU-wide stress test)



Step 5: Tier 1 ratio impact

Different PDs: impact on Total Tier 1 ratio

	BR	FLLP ratio	LLP ratio	NPL	**Average**	**Range**
50th percentile	-0.48pp	0.28pp	-1.25pp	-0.80pp	**-0.56pp**	**1.53pp**
75th percentile	-1.64pp	0.08pp	-2.93pp	-2.31pp	**-1.70pp**	**3.01pp**

*Different levels of aggregation: impact on Corporate Tier 1 ratio **

	Economy-wide	Industrial sector	Firm size	Industrial sector & firm size	**Average**	**Range**
50th percentile	-0.33pp	-2.63pp	-0.31pp	-2.26pp	**-1.38pp**	**2.32pp**
75th percentile	-1.10pp	-3.58pp	-1.63pp	-3.86pp	**-2.54pp**	**2.76pp**

* Corporate Tier 1 ratio = Tier 1 K for corp. exposures / REA for corp. exposures

Robustness check: use of different lags for the credit risk satellite model

Range of impacts on Total Tier 1 ratio across different PDs

	1 lag	2 lags	3 lags	4 lags
50th percentile	1.53pp	1.51pp	1.80pp	2.52pp
75th percentile	3.01pp	2.96pp	3.29pp	3.83pp

*Range of impacts on Corporate Tier 1 ratio across different levels of aggregation **

	1 lag	2 lags	3 lags	4 lags
50th percentile	2.32pp	2.49pp	2.53pp	2.65pp
75th percentile	2.76pp	2.77pp	2.55pp	2.86pp

* Corporate Tier 1 ratio = Tier 1 K for corp. exposures / REA for corp. exposures

Conclusion

- Stressed Tier 1 ratios **can differ substantially** depending on the PD variable and the level of data aggregation considered.
- Need to **better harmonize stress-test methodologies across supervisors and institutions** especially if solvency stress tests are used as a supervisory tool (e.g. for P2 decisions) or to set regulatory capital requirements (e.g. for systemically important banks).
- Need to **improve the availability and quality of the data** used for stress testing purposes.