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BANK POLSKI

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The Current Approach to Stress-Testing and Indication of Free-Riders on Liquidity in SORBNET2 (i.e. LVPS in Poland)

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Oversight of FMIs in Poland

President of NBP performs oversight of (1.) **payment systems** and (2.) **payment schemes** and cooperates with KNF in assessing of the functioning of (3.) **securities clearing systems and securities settlement systems** and (4.) **provision of the *acquiring* services**.

On that account, NBP's prime oversight objectives are ensuring:

- **efficient and safe functioning of the payment system;**
- **compliance of the overseen services and systems functioning rules with the provisions of law.**

Fulfilling prime oversight objectives contributes to the adequate performance of NBP's significant tasks, as defined in the *Act on Narodowy Bank Polski*, i.e.:

- **organising payments;**
- **acting towards stability of the national financial system.**

Oversight of FMIs in Poland

„*Narodowy Bank Polski Payment System Oversight Policy*” was approved in October 2015 and further ammended in June 2017 and October 2019.

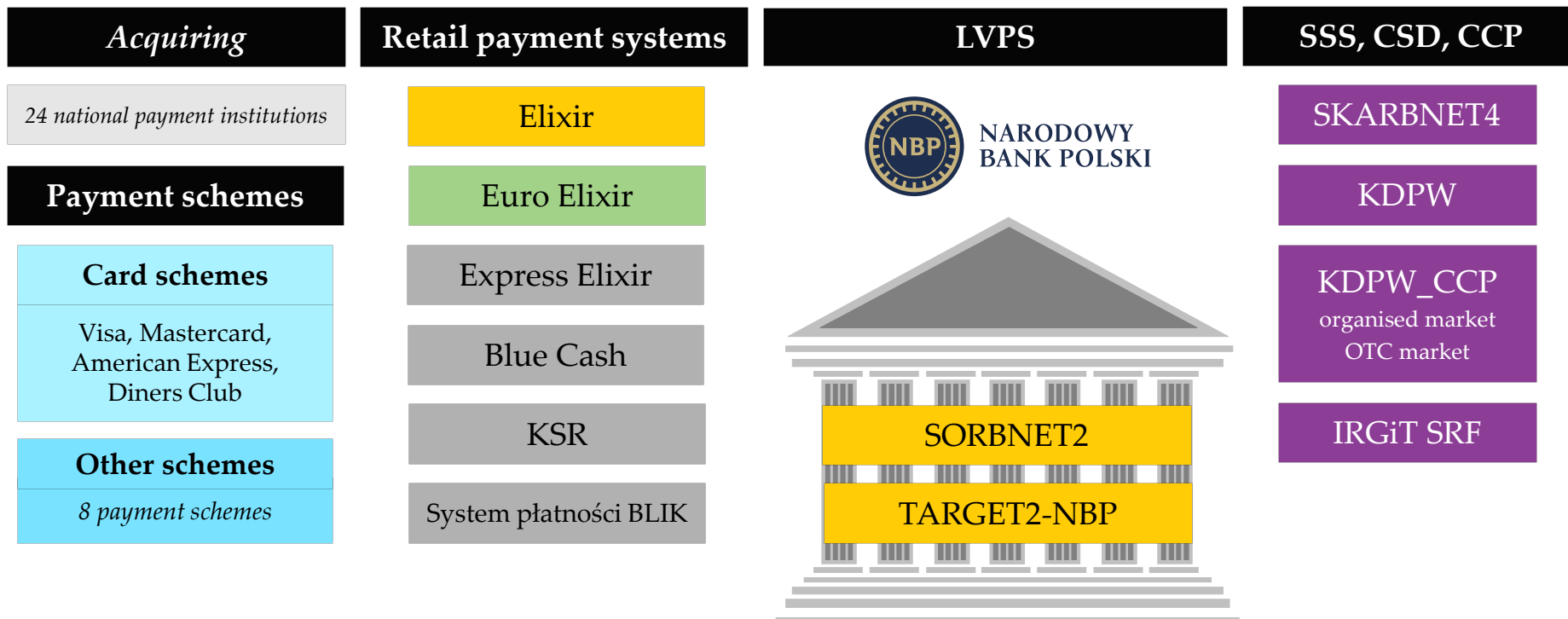
Figure 1. NBP’s oversight activities.



Source: Own elaboration.

Oversight of FMIs in Poland

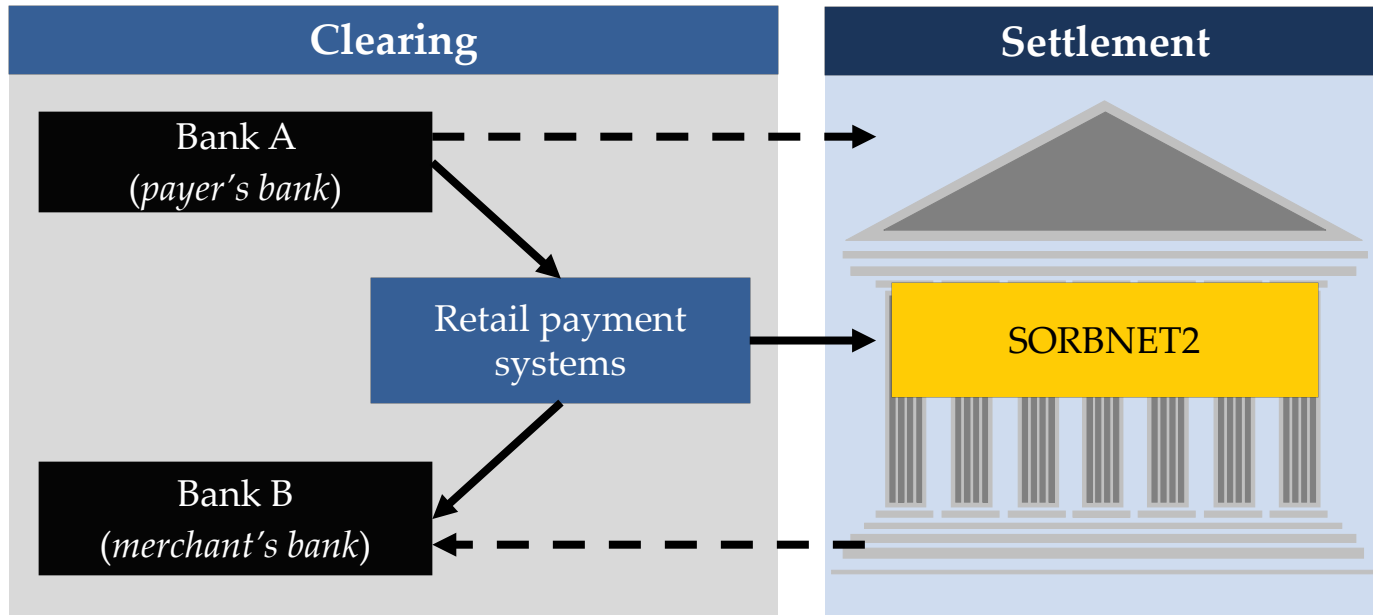
Figure 2. Payment system architecture in Poland in 2021.



Source: Own elaboration.

Oversight of FMIs in Poland

Figure 3. Typical clearing and settlement process in payment systems in Poland.



Source: Own elaboration.

Oversight of FMIs in Poland

1. *“Information on oversight”* [on a quarterly basis] reports:
 - operational availability;
 - maximum (daily, per session/hour) number of transactions;
 - average number and value of transactions;
 - information on incidents.

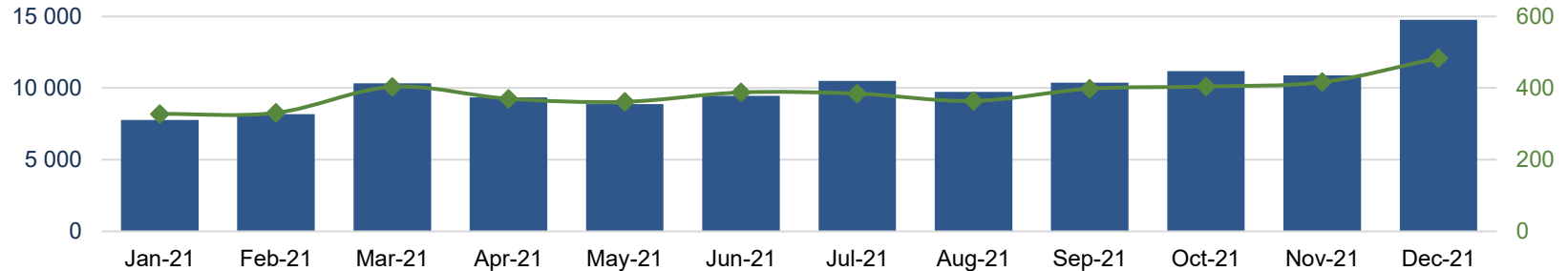
2. *“Polish payment systems oversight report”* [on annual basis] reports:
 - comprehensive quantitative data (descriptive statistics);
 - qualitative description of oversight activities and changes in systems;
 - additional information on functioning of SORBNET2 – especially in presenting:
 - *critical participants*, in accordance with the criterion of the highest value of payment orders;
 - *scenario-based liquidity stress-testing*, where detailed analyses of critical participants exposures are conducted based on relevant transactions data in order to monitor liquidity risk;
 - *free-riding on liquidity*, in order to evaluate the possibility of occurrence of payment gridlocks as an aftermath of liquidity retention;
 - *indicator-based liquidity monitoring*, to quantify possible liquidity management schemes.

SORBNET2 – system design and risk management framework

SORBNET2:

- is a systemically important LVPS owned and operated by NBP that provides services in a RTGS design for payment transactions denominated in PLN;
- allows payment orders to be settled without *netting*, i.e. on a transaction-by-transaction basis in real-time with an immediate finality in central bank money.

Figure 4. Numbers [in thousands] and values [in bln PLN] of payment orders in SORBNET2 in 2021.



Source: Own elaboration based on NBP's data.

SORBNET2 – system design and risk management framework

Payment processing:	transaction input and validation	payment routing	clearing and settlement
Risk management:	liquidity management	treasury reconciliation	liquidity monitoring

SORBNET2 risk management is concentrated primarily on supporting direct participants in their liquidity management and liquidity monitoring.

In that manner, the system provides, *inter alia*, the following liquidity management tools:

- queuing mechanism for pending payment orders;
- possibility to block funds in current accounts dedicated for settlement of ancillary systems;
- suspension of a participant;
- prioritising of transactions;
- collateralised intraday credit lines provided by NBP.

SORBNET2 – scenario-based liquidity stress-testing

At NBP, the Payment System Department performs the **scenario-based liquidity stress-testing** of **SORBNET2** by means of **BoF-PSS2**, based on the oversight responsibilities and in accordance with „*Narodowy Bank Polski Payment System Oversight Policy*”.

Scenario-based liquidity stress-testing

Idea of the exercise?

- monitoring of the safe and efficient functioning of the system;
- evaluation of liquidity risk in the system model in extreme but plausible market conditions.

For the purpose of the simulations, **SORBNET2 model's algorithms** replicate:

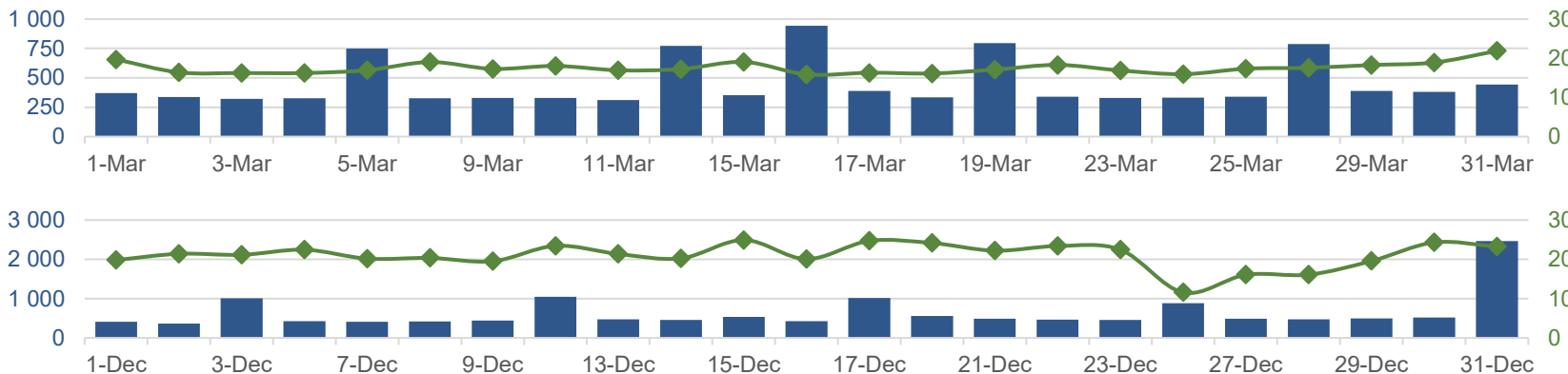
- input, processing and prioritising of payment orders;
- *first in-first out* queuing mechanism for pending payment orders;
- settlement and fund transferring procedures;
- intraday credit lines to a fixed limit.

SORBNET2 – scenario-based liquidity stress-testing

Input data?

- **time period selection** – the month, when the highest total value of payment orders in the system in the analysed interval is observed (half-year frequency).
- **(day) t** – the day within the selected month, when the average value of a payment order is the closest to the median of 90 observations of average values of payment orders in the system until that day.

Figure 5. Numbers [in thousands] and values [in bln PLN] of payment orders in SORBNET2 in March 2021 and December 2021.



Source: Own elaboration based on NBP's data.

SORBNET2 – scenario-based liquidity stress-testing

Input data? (cont'd)

- list of direct participants – at (day) t with corresponding data on:
 - payment orders (00:00:01 frequency);
 - intraday credit limits (daily frequency);
 - initial balances, including current accounts and deposit accounts (daily frequency).
- selection of banks with the highest net value of payment orders – at (day) t .

Figure 6. Percentage share in total net value of payment orders and operational links in SORBNET2 for selected participants in March 2021 and December 2021.

Mar-21	Bank	% share	Links
1.	A	12,4%	31
2.	B	11,5%	38
3.	C	10,8%	40
4.	D	10%	37
5.	E	9,6%	37

Dec-21	Bank	% share	Links
1.	A	10,5%	32
2.	B	9,6%	38
3.	C	9,4%	35
4.	D	8,8%	34
5.	E	8,2%	38

SORBNET2 – *scenario-based liquidity stress-testing*

Benchmark Scenario – non-disrupted functioning of the system model at t .

First group of scenarios – participant generating highest *net* value of payment orders at t is unable to send payment orders in the morning.

Second group of scenarios – participant generating highest *net* value of payment orders at t is unable to send payment orders in selected time intervals after 12:00:00.

Third group of scenarios – three participants generating highest *net* value of payment orders at t are unable to send 25% of value of payment orders in the morning.

Fourth group of scenarios – three participants generating highest *net* value of payment orders at t are unable to send 25% of value of payment orders in selected time intervals after 12:00:00.

Fifth group of scenarios – reduction of 25% of value of intraday credit lines in conjunction with other stress scenarios at t .

SORBNET2 – scenario-based liquidity stress-testing

Analysed interval – from January to June 2021

Scenario 4 (participant generating highest net value of payment orders at t is unable to send payment orders from 12:00:00 to 14:00:00) vs. *Benchmark Scenario*.

Scenario 5 (participant generating highest net value of payment orders at t is unable to send payment orders from 14:00:00 to 16:00:00) vs. *Benchmark Scenario*.

Results at the system level?

Both vanilla scenarios resulted in the highest percentage of theoretically not settled payment orders in the predefined settlement date (respectively: 0,7% and 1,9% of benchmark's total value of settled payment orders in the system).

Most likely it was dependant on relatively high value of theoretically blocked payment orders (respectively: 7% and 3,2% of benchmark's total value of payment orders in the system) and participant's relatively broad web of operational links with other system's participants.

SORBNET2 – scenario-based liquidity stress-testing

Analysed interval – from January to June 2021 (*cont'd*)

Scenario 14 (extended *scenario 4* – participant generating highest net value of payment orders at t is unable to send payment orders from 12:00:00 to 14:00:00 + reduction of 25% of that participant's value of intraday credit line) vs. *Benchmark Scenario*.

Scenario 15 (extended *scenario 5* – participant generating highest net value of payment orders at t is unable to send payment orders from 14:00:00 to 16:00:00 + reduction of 25% of that participant's value of intraday credit line) vs. *Benchmark Scenario*.

Results at the system level?

Similar in value of not settled payment orders in the predefined settlement date to results of both vanilla scenarios (i.e. *scenario 4* and *scenario 5*) – the effect of intraday credit line reduction remained insignificant.

All of the above, however, shall be discussed in the context of relatively low significance of the risk factors' materialisation aftermath for the analysed system model, especially, in relation to the total value of settled payment orders.

SORBNET2 model remains resistant to liquidity risk in assumed extreme but plausible market conditions.

SORBNET2 – scenario-based liquidity stress-testing

Analysed interval – from July to December 2021

Scenario 13 (extended *scenario 4* – participant generating highest net value of payment orders at t is unable to send payment orders from 12:00:00 to 14:00:00 + reduction of 25% of all participants' value of intraday credit line) vs. *Benchmark Scenario*.

Scenario 15 (extended *scenario 4* – participant generating highest net value of payment orders at t is unable to send payment orders from 12:00:00 to 14:00:00 + reduction of 25% of that participant's value of intraday credit line) vs. *Benchmark Scenario*.

Results at the system level?

In *scenario 4* the theoretical value of blocked payment orders amounted to 4,9% of benchmark's total value of settled payment orders in the system – but all payment orders were settled in the predefined settlement date.

Scenario 13 and *scenario 15* resulted in the highest percentage of theoretically not settled payment orders in the predefined settlement date (both approx. 0,1% of benchmark's total value of settled payment orders in the system).

SORBNET2 model remains resistant to liquidity risk in assumed extreme but plausible market conditions.

SORBNET2 – free-riding on liquidity and indicator-based liquidity monitoring

At NBP, the Payment System Department performs the **free-riding on liquidity** and **indicator-based liquidity monitoring** of SORBNET2 by means of **BoF-PSS2**, based on the oversight responsibilities and in accordance with „*Narodowy Bank Polski Payment System Oversight Policy*”.

Free-riding on liquidity and indicator-based liquidity monitoring

Idea of the exercise?

- monitoring of the safe and efficient functioning of the system;
- monitoring potential payment gridlocks as a result of liquidity retention;
- monitoring the liquidity indicators and quantification of participants' behaviour.

For the purpose of the simulations, **SORBNET2 model's algorithms** are set up similarly to the **scenario-based liquidity stress-testing** exercise, i.e. replicate: input, processing and prioritising of payment orders; *first in-first out* queuing mechanism for pending payment orders; settlement and fund transferring procedures; intraday credit lines to a fixed limit.

SORBNET2 – free-riding on liquidity and indicator-based liquidity monitoring

Input data?

- **time period** and (day) t are selected;
- analysis is further expanded for relevant transactional data from $t-2$ to $t+2$.
- **list of direct participants** – from $t-2$ to $t+2$, with corresponding data on: payment orders (00:00:01 frequency), intraday credit limits (daily frequency) and initial balances, including current accounts and deposit accounts (daily frequency).
- **selection of banks with the highest net value of payment orders** – from $t-2$ to $t+2$.

Figure 7. Percentage share in total net value of payment orders and operational links in SORBNET2 for selected participants in December 2021 (at time interval from $t-2$ to $t+2$).

Dec-21	Bank	$t-2$ % share	$t-1$ % share	t % share	$t+1$ % share	$t+2$ % share	Av. % share	Max. Links
1.	A	10,1%	12,8%	10,5%	4,7%	7,7%	9,2%	38
2.	B	9,2%	9,9%	9,6%	2,5%	8,9%	7,8%	41
3.	C	8,8%	9%	9,4%	4,3%	6,3%	7,1%	42
4.	D	6,8%	9,1%	8,8%	2,4%	10,1%	7,2%	41
5.	E	6,4%	7,6%	8,2%	2,5%	6,8%	6,1%	39

SORBNET2 – free-riding on liquidity and indicator-based liquidity monitoring

Free-riding on liquidity measures:

- cost-based measure;
- risk-based measure⁽¹⁾;
- time-based measures⁽²⁾.

⁽¹⁾ based on: Denbee E., Garratt R., Zimmerman P. (2012), *Methods for evaluating liquidity provision in real-time gross settlement payment systems*, in: Hellqvist M., Laine T., *Diagnostics for the financial markets – computational studies of payment system – Simulator Seminar Proceedings 2009–2011*, Scientific monographs, Bank of Finland, Helsinki

⁽²⁾ based on: Diehl M. (2013), *Measuring free riding in large-value payment systems: the case of TARGET2*, *Journal of Financial Market Infrastructures*, vol. 1, no. 3, p. 31-53

Additional liquidity monitoring indicators:

- theoretical/real lower/upper bound;
- consumed liquidity (or used own/internal liquidity);
- rigid liquidity (or used external liquidity)⁽³⁾.

⁽³⁾ based on: Koponen R., Soramäki K. (2005), *Intraday liquidity needs in a modern interbank payment system – a simulation approach*, in: Leinonen H., *Liquidity, risks and speed in payment and settlement systems: a simulation approach*, Bank of Finland Studies no. 31, Bank of Finland, Helsinki

SORBNET2 – *free-riding on liquidity and indicator-based liquidity monitoring*

Free-riding on liquidity measure:

- cost-based measure

Maximum liquidity needs – the maximum value of liquidity used by a participant to settle liabilities. Also the value of the alternative cost of held liquidity.

Minimum liquidity – the minimum value of liquidity used/delivered by a participant to the system.

Free-rider [most likely] – if the share of the value of liquidity used by a participant to settle liabilities to the total value of liquidity used by other participants to settle liabilities in the system is a higher value than the share of the maximum value of liquidity delivered by a participant to the system to the total value of maximum value of liquidity delivered by other participants to the system at the end of the business day.

Complementary: *relative net-payment indicator* – if the share of the value of absolute value of minimum liquidity to the total value of liquidity used by other participants to settle liabilities is a higher value than the share of the maximum value of liquidity delivered by a participant to the system to the value of liquidity received by a participant from the system at the end of the business day.

SORBNET2 – *free-riding on liquidity and indicator-based liquidity monitoring*

Free-riding on liquidity measure:

- risk-based measure

Average counterparty risk measure – the average value of the positive net liquidity exposure towards the system.

Free-rider [most likely] – if the share of the value of liquidity used by a participant to settle liabilities to the total value of liquidity used by other participants to cover liabilities in the system is a higher value than the share of the average value of the positive net liquidity exposure of the participant to the average value of the positive net liquidity exposure of other participants towards the system at the end of the business day.

SORBNET2 – *free-riding on liquidity and indicator-based liquidity monitoring*

Free-riding on liquidity measure:

- time-based measures

Assumption: if the *value of net liquidity exposure towards the system* is negative (especially, in the morning) the participant may be a *liquidity recycler*. Time-based measures shall prioritise no delays.

Linear early-payment indicator – the *cummulative values of net liquidity exposures towards the system at pre-specified time intervals (diminishing linearly) during the business day* based on which shares of *cummulative values of net liquidity positive/negative exposures towards the system* to half a value of *total values of net liquidity positive/negative exposures towards the system* are calculated.

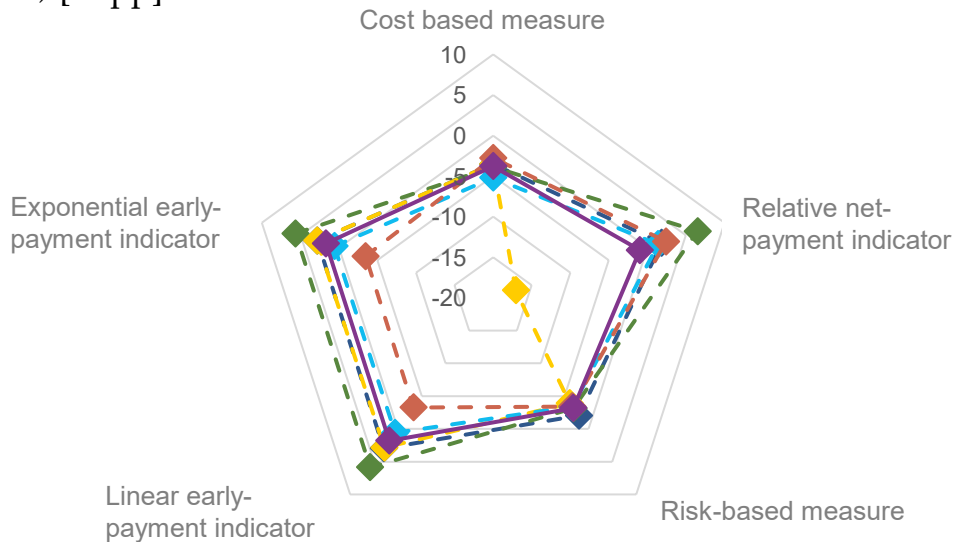
Exponential early-payment indicator – the *cummulative values of net liquidity exposures towards the system at pre-specified time intervals (diminishing exponentially) during the business day* based on which shares of *cummulative values of net liquidity positive/negative exposures towards the system* to half a value of *total values of net liquidity positive/negative exposures towards the system* are calculated.

Free-rider [most likely] – if both *linear early-payment indicator* and *exponential early-payment indicator* are negative.

SORBNET2 – free-riding on liquidity and indicator-based liquidity monitoring

Results at the system level?

Figure 8. Averaged free-riding on liquidity measures in SORBNET2 for selected participants in December 2021 (at time interval from $t-2$ to $t+2$) [in pp].



Source: Own elaboration based on NBP's data.

SORBNET2 remains resistant to identified participants' liquidity retention strategies.

SORBNET2 – free-riding on liquidity and indicator-based liquidity monitoring

Liquidity monitoring indicator:

- theoretical/real lower/upper bound

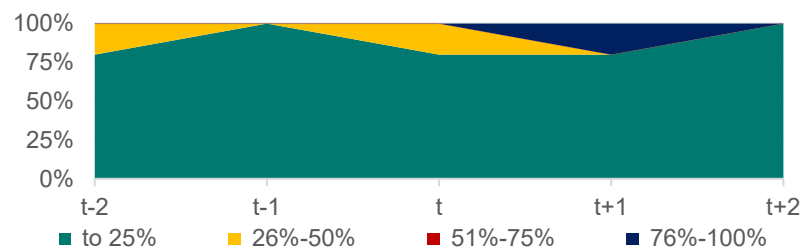
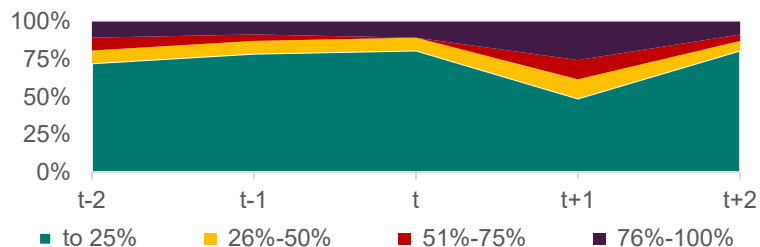
Lower bound – the minimum value of own liquidity needed for settlement of all participant’s liabilities.

Upper bound – the value of own liquidity needed for continuous settlement of all participant’s liabilities.

Results at the system level?

- information on the optimal levels of liquidity needed for settlement of all payment orders;
- information on the secured levels of liquidity.

Figure 9. „Forest fire” in SORBNET2 at system level and for selected participants in December 2021 (at time interval from $t-2$ to $t+2$).



Source: Own elaboration based on NBP’s data.

SORBNET2 – free-riding on liquidity and indicator-based liquidity monitoring

Liquidity monitoring indicator:

- consumed liquidity (or used own/internal liquidity)
- rigid liquidity (or used external liquidity)

Consumed liquidity – the measure allows to evaluate the level of coverage of own liabilities with available internal liquidity at the beginning of the business day. It may also indicate liquidity shortages.

Results at the system level?

- information on the theoretical levels of liquidity needed for settlement of participant's liabilities at the beginning of the day.

Rigid liquidity – the measure allows to evaluate the level of coverage of own liabilities with available external liquidity.

Results at the system level?

- information on if system participants needed additional liquidity for settlement of their liabilities;
- information on the theoretical levels of additional liquidity needed for settlement of participant's liabilities.

Conclusions

1. President of NBP performs oversight of (1) **payment systems** and (2) **payment schemes** and cooperates with KNF in assessing of the functioning of (3) **securities clearing systems and securities settlement systems** and (4) **provision of the *acquiring* services**.
2. From the *quantitative perspective*, oversight is mostly performed through monitoring of the functioning of systems.
3. Collected data and information is, *inter alia*, necessary to prepare:
 - “*Information on oversight*” [on a quarterly basis];
 - “*Polish payment systems oversight report*” [on annual basis].
4. Payment System Department performs scenario based stress-testing of SORBNET2 model including assumptions on:
 - inability to send payment orders by a participant generating highest *net* value of payment orders;
 - significant reduction of participants’ intraday credit lines in conjunction with other stress scenarios.
5. SORBNET2 model remains resistant to liquidity risk factors in assumed extreme but plausible market conditions.
6. Payment System Department performs free-riding on liquidity and indicator-based liquidity monitoring of SORBNET2 model where it is concluded that it remains resistant to identified participants’ liquidity retention strategies.



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