

Fevolden, Mats Bay; Smith, Lyndsie

Research Report

What Kind of Payments Settle in a Real Time Gross Settlement System?

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STAFF MEMO

What Kind of Payments Settle in a Real Time Gross Settlement System?

THE CASE OF NORGES BANK'S SETTLEMENT SYSTEM (NBO)

NO. 2 | 2018

MATS BAY FEVOLDEN
AND LYNDSIE SMITH



NORGES BANK

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THE CASE OF NORGES BANK'S SETTLEMENT SYSTEM (NBO)

Mats Bay Fevolden and Lyndsie Smith¹

Central bank settlement systems are vital for payment intermediation and have an important role in monetary policy and financial stability. Few analyses exist that explain the purpose behind the payments that are settled in these systems. In this paper we categorise payments that settle in Norges Bank's settlement system (NBO) based on their economic purpose.

Interbank lending, FX trades, and payments by households and companies were the major contributors to turnover based on value and accounted for 22, 21, and 9 percent of the turnover in NBO respectively.

Real time gross settlement system (RTGS), financial infrastructure, turnover.

1. Introduction

Most of the payments made in modern economies are transmitted electronically, such as card payments, giro payments and settlement of FX and security trades. A majority of these payments settle in a real-time gross settlement system (RTGS) operated by a central bank. As payments that settle in an RTGS have various origins, they offer central banks a glimpse into the activity in both the economy and financial markets.

Many central banks monitor activity in their RTGS and publish settlement statistics, such as the number and value of payments settled for a given time period.² To our knowledge, no analysis has yet been published that categorises payments in a RTGS according to their economic purpose. One possibility is that payments settling in a RTGS do not necessarily contain information about their purpose.³

This paper describes the procedures used to identify the economic purpose of different payments that settle in the Norwegian RTGS (Norges Bank's Settlement System, NBO). The work is made possible through information dissemination and collaboration with NBO participants and interconnected FMIs, and includes mapping data from different sources, the use of algorithms and investigating patterns in the data.

¹ We would like to thank Torbjørn Hægeland, Farooq Akram, Knut Sandal, Helle Snellingen and Bjørn Bakke for their comments. Thanks must also be made to Aleksander Bråthen for early contributions.

² The payment system survey carried out by the World Bank gives settlement statistics for RTGSs in 83 countries. The latest available report (World Bank, 2016) covers the years 2011-2015.

³ Payments settling in NBO contain: date, value, accounts to be debited and credited. We thus need additional information to categorise the original parties to the payments.

This paper is further organised as follows:

- Section 2 gives an overview of the financial infrastructure in Norway,
- Section 3 outlines the data sources and methods for mapping these data together,
- Section 4 shows the results,
- Section 5 concludes.

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2. NBO and the Norwegian financial infrastructure

Households and firms hold deposits with private banks, and use these deposits to pay for goods and services, for example. When a private individual pays for goods in a supermarket using a payment card, an obligation arises between the individual's (card issuing) bank and the bank of the supermarket. Such obligations settle in a central bank settlement system when the sending bank transfers central bank deposits to the beneficiary bank.

NBO is the ultimate settlement bank in Norway and is where most payments in Norwegian krone (NOK) eventually settle. There are millions of payments made every day that involve NOK, but only a limited number of payments settle in NBO. The value of the payments settling in NBO is, however, large. For example, NBO processed on average 1 950 payments each day in 2017, with a total value of NOK 236 billion, equivalent to 9 percent of annual mainland GDP.

Besides the government, only banks and central counterparties (CCPs) are eligible to hold an account with Norges Bank, and thereby participate in settlements in NBO. Banks settle payments in NBO on behalf of their customers, and some also on behalf of other banks and their customers (see box *Participation in NBO*). At year-end 2017, 130 banks and 3 CCPs held accounts with Norges Bank.

The payments that settle in NBO can be divided in two categories. The first category contains payments resulting from netting – usually called net settlement. Netting is the process by which multiple payments to and from each bank are summed together, and each bank either pays or receives a single net position. The second category is payments that settle on an individual basis – usually called gross settlement.

Most payments involving NOK are netted. As can be seen in Chart 2.2 in the box *Settlement in NBO* almost 10 million payments each day are netted. The number of payments settling in NBO from netting is only 270 which is roughly 6 times fewer than the 1687 settling gross. Of the NOK 236 billion settling in NBO each day in 2017, only 38 billion resulted from netting, roughly 5 times less than the 197 billion settling gross.⁴

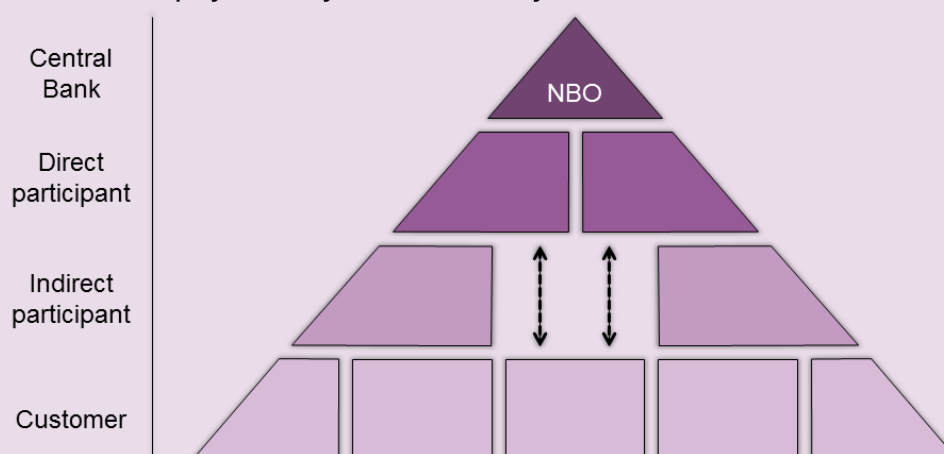
⁴ The account structure at Norges Bank makes it possible to distinguish which payments settled in NBO are the result of netting.

Participation in NBO

130 banks hold an account at Norges Bank including most Norwegian banks and some foreign banks. Settlement in NBO is concentrated – with five banks settling 90 percent of payments in 2017 (based on value).⁵ A reason for this concentration is that these five banks act as correspondent banks and settle payments on behalf of other banks. The banks that use a correspondent bank to settle payments are referred to as indirect participants and include most small Norwegian banks and many foreign banks. Although most Norwegian banks hold an account with Norges Bank, small banks hold their account for contingency purposes.

The tiered participation structure can be visualised as a hierarchy where the more critical nodes are higher up (Chart 2.1). The banks in the top tier connect their own customers, in addition to other banks and their customers, to NBO. Payments coming from indirect participants and customers rely on sufficient central bank liquidity and operational availability of the correspondent bank – the direct participant in NBO.

Chart 2.1 The payment system hierarchy



Source: Norges Bank

⁵ Based on gross payments made between banks

Settlement in NBO

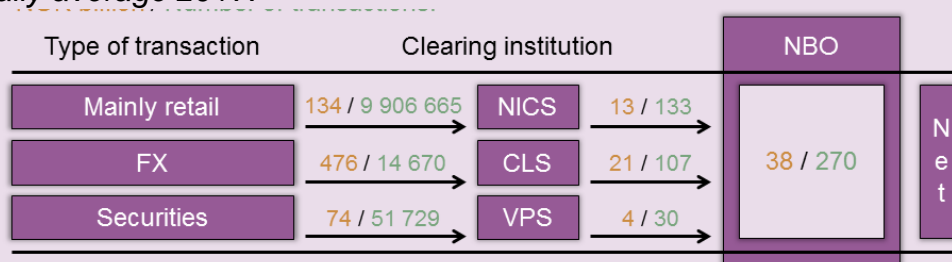
Settlement in NBO starts at 05:30 CET and closes at 16:35 CET. Banks can settle payments gross throughout opening hours, but settlement of net positions occurs only at fixed times during the day. Different types of payments are part of different multilateral netting systems (Table 1).

Table 1 Description of multilateral netting systems connected with NBO

Clearing institution	Details (as of year-end 2017)
NICS (Norwegian Interbank Clearing System)	- Mainly retail payments - 5 settlement sessions in NBO per day
VPS (Norwegian Central Securities Depository)	- Securities - 2 settlement sessions each day
CLS ⁶	- FX - Funding of net positions between 07:00 CET and 12:00 CET
CCPS ⁷	- Derivatives

Chart 2.2 shows the value (yellow) and number (green) of payments conveyed to a netting system, and the resulting net positions settled in NBO after netting. The relative values illustrate the large “netting effect”.

Chart 2.2 Net settlement in NBO. NOK billion / Number of payments. Daily average 2017.



Sources: Bits, VPS, CLS⁸, and Norges Bank

⁶ All FX trades registered with CLS settle gross in accounts that the CLS settlement members hold with CLS. CLS calculates a net position for each CLS settlement member for each currency. These net positions settle in the respective central banks whose currency is part of CLS. Funding of net positions in NOK occurs within the time interval 0700 CET – 1200 CET.

⁷ The accounts held by the CCPs: SIX x-clear, LCH Clearnet and EUROCCP are used for settlement of variation margins for example, and represent only a small fraction of the turnover in NBO and is not included in this paper for purposes of brevity and simplicity.

⁸ Any reference to CLS data herein this document is executed, anonymised and aggregated NOK swap trade data.

The economic purpose of payments subject to netting is fairly straightforward to deduce; to the securities settlement are payments that relate to trading of securities, CLS pay-ins and pay-outs relate to FX trading, and NICS netting mostly includes household and firm payments.

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The bulk of turnover in NBO, however, consists of gross payments, the deduction of the economic purpose of which is more complex. In the following section we present the methods used to categorise payments settling gross during August 2015. The month was chosen based on the accessibility of data from external institutions.

3. Data and methods for categorising gross settlements

As operator, Norges Bank keeps a record of all payments that settle in NBO. In August 2015, 1 090 payments settled gross on average each day, totalling NOK 171 billion. Information about which account was debited, which account was credited, the settlement date and the settled amount is recorded with all payments. Additional information is available for some payments which can be divided into four categories:

1. Payments with a tag indicating their purpose,
2. Payments which can be mapped with data collected from external sources,
3. Payments whose purpose can be deduced using matching algorithms,
4. Payments whose purpose can be inferred based on institutional knowledge and convention.

3.1. Tagged payments

Some payments contain information about their purpose. They include:

- Payments related to Norges Bank's liquidity management. Norges Bank holds auctions where NBO participants either can place money with or borrow from Norges Bank.⁹
- Customer payments transmitted directly to NBO, and not via NICS.¹⁰
- Payments to and from governmental entities.
- Other payments such as those related to interest on deposits banks hold with Norges Bank, and the fee for holding an account and participating in settlements in Norges Bank.

Of the 1 090 payments settling on average each day in August 2015, 507 contain such a tag. They amount to NOK 36 billion (21 percent of the gross turnover), of which NOK 21.5 billion is related to Norges Bank's liquidity management, with customer payments accounting for NOK 6.4 billion, government transfers accounting for NOK

⁹ See more details on Norges Bank's liquidity management in (Norges Bank, 2014)

¹⁰ Payments that settle in NBO are sent using the SWIFT network and SWIFT standards. The SWIFT formats used for settlement in Norges Bank are either the customer format (MT 103) or the interbank format (MT 202). Banks can send payments directly to Norges Bank or via the clearing agent NICS. Most payments are sent to Norges Bank via NICS. SWIFT payments of less than 25 NOK million sent via NICS become part of NICS net, while those above 25 NOK million are forwarded to Norges Bank where they settle gross. When NICS forwards a payment to Norges Bank, information about indirect participants is omitted, and all payments are sent using the interbank format.

8.2 billion, and other payments accounting for NOK 1.6 billion. In terms of the number of payments, the corresponding values are 12, 291, 205, and 281 respectively.

3.2. Use of external information

583 of the payments settling gross per day do not contain a tag. This amounts to NOK 135 billion, which is 79 percent of the gross turnover. At the outset, we have assumed that the non-tagged payments can be either household or firm payments (see footnote 9), relating to lending and borrowing in the money market, or settlement of FX trades. To verify these assumptions we gathered data from three different sources, the details for which are summarised in Table 3.1:

- Bits (operator/owner of NICS) provided information on payments that are sent to Norges Bank via NICS, such as whether the payment is a customer or a bank payment, and information about any indirect participants.
- 23 participants in NBO reported on their interbank lending.¹¹
- CLS provided some data on FX trades that settle in CLS.

Table 3.1 Overview of payment data from the three sources. August 2015. Daily average.

Data	Number of payments	Daily value (NOK bn.)	Source
Payments settling gross in NBO	1090	171	NBO payment registry
Data sent to Norges Bank via NICS	487	128	Bits
Interbank loan survey	11	11	23 banks
CLS settlement data	355	136	CLS

The data provided by Bits contains 487 payments per day which are mapped against the gross payments in the NBO registry. For each corresponding payment we add the details of any indirect participants. The additional data also allows us to assess whether a payment is a customer or an interbank payment. 21 additional customer payments are identified, with a value of NOK 1.6 billion.

This enriched dataset allows us to identify payments where the same bank is the sender and beneficiary - we label these payments “intrabank payments”.¹² On average 90 payments each day are intrabank payments, with a value of NOK 17 billion.

¹¹The banks reported the following information: amount lent or borrowed, counterparty, date, interest rate and amount repaid.

¹² There can be many reasons why the same bank is both the sender and beneficiary of funds. One is that banks by convention hold accounts with multiple correspondent banks and make use of these accounts to settle payments intraday. Overnight these accounts are emptied. Funds are either channeled to the central bank account (if the bank has an account with Norges Bank) or gathered in one correspondent bank account. Another reason is that a customer holds accounts with multiple branches of the same bank and transfers money between those accounts. We have not been able to distinguish between these.

The interbank loan survey of 23 banks covers redistribution of central bank deposits. The banks' part of the survey reported a daily average of 11 interbank loans with a value of NOK 11 billion.¹³

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CLS reported some FX trades that settled in CLS. The trades CLS reported are those that are either registered by the banks with CLS the day prior to settlement day, or are in-out swaps.¹⁴ On average 355 trades were reported for each settlement day that had either of these properties, totalling NOK 136 billion. This data is used together with a matching algorithm to identify swaps where one leg settles in NBO and the corresponding leg settles in CLS (see details in Section 3.3 below).

3.3. Use of matching algorithms

To this point identification of payments has been an exercise of counting tagged payments and mapping data sources with each other, which has enabled us to identify 58 percent of all gross settlements (38 percent based on value). However, there are 461 payments (NOK 105 billion) each day that remain unclassified. To proceed further we make use of matching algorithms.

As the interbank loan survey includes only Norwegian participants, the survey does not capture interbank loans to and/or from foreign banks. These loans are identified using a Furfine-filter. The Furfine-filter is applied on the NBO payment registry and identifies a pair of payments that settle on two different settlement days as an interbank loan if certain criteria are satisfied (see details in the box *The Furfine-filter*). With the Furfine-filter we identify an additional 56 interbank loans each day on average, with an average daily total value of NOK 29 billion.¹⁵

The Furfine-filter

The lack of identifiers in RTGS payments has led to the development of filters that are applied on payments recorded within a RTGS registry to identify interbank loans. Such an algorithm was first used by Furfine (Furfine, 1999) for the federal funds market and this principle has since been used extensively for other markets.

A Furfine-filter identifies a pair of payment as an interbank loan if they exhibit certain characteristics that are carefully chosen and in line with market convention. The assumptions applied are:

- The loan amount is rounded to NOK 0.1 million.
- The minimum value that a loan could be is NOK 1 million.
- The interest rate is annualised,
- The interest rate is rounded to 0.5 basis points,
- The interest rate is within ± 20 bp of the central bank rate.

¹³ Banks have an overnight deposit quota in NBO on which they earn interest at the central bank rate.

Deposits in excess of the quota earn significantly less, and thus have an incentive to redistribute deposits

¹⁴ In-out swaps are between CLS settlement members and are used to compress the funding need.

¹⁵ To verify the reliability of the Furfine algorithm, it was run on the NBO registry. The identified loans between Norwegian banks were checked against the reported loans. The type 1 and type 2 errors of the algorithm were 0 and 0.4 respectively. This is further documented in (Akram, Fevolden, & Smith, forthcoming). We have no reason to believe that the type 1 and type 2 errors for loans between foreign institutions are any different.

The data from CLS were used to identify FX swaps, where one leg of the swap settles in CLS and the other leg settles in NBO – overnight swaps and in-out swaps both share this characteristic. To identify swaps we match the CLS trade data with the interbank payments in the NBO registry using a code similar to the Furfine-filter. A payment is identified as an overnight swap if:

- the first leg settles in NBO one business day before the second leg settles in CLS,
- the value of the payment settles in NBO is the same as the payment settles in CLS, and
- the banks taking part in settlement in NBO match with the trading parties in the CLS dataset.

A payment was identified as an in-out swap if:

- the first leg settles in CLS the same business day as the second leg settles in NBO,
- the value of the payment settles in NBO is the same as the payment settles in CLS, and
- the banks taking part in settlement in NBO match with the trading parties in the CLS dataset.

We identify, on average, 93 payments related to overnight swaps settling in NBO each day and 8 in-out swaps payments. The corresponding values are NOK 19 billion and NOK 9 billion.

3.4. Inference of payment purpose

By convention banks settle customer payments that were booked at least one day in advance at exactly 06.15 CET. 21 payments settled on average each day at 06.15 with a value of NOK 1.6 billion. We classify all remaining payments that settle in NBO at 06.15 as customer payments.

A daily average of 304 payments totalling NOK 49 billion (28 percent) remains uncategorised. We are unable to state with certainty the purpose behind these payments, but we can state what they do not involve. The remaining turnover is likely not related to:

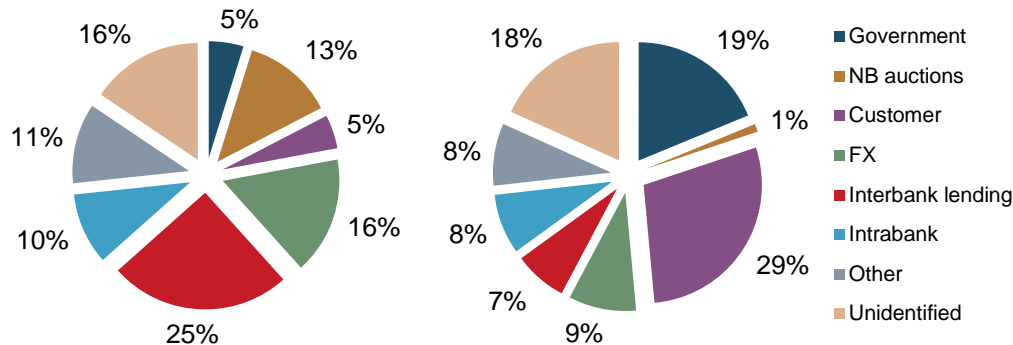
- customer payments, as they would have been on a customer format or part of the payments sent at 06.15;
- securities trading, as they would have been part of the securities settlement; or
- the settlement of FX swaps, as they would have a corresponding leg that settles in CLS.

Some of the uncategorised payments have characteristics that make it possible to infer their purpose. For example, 55 of the payments each day totalling NOK 17 billion are larger than NOK 1 million, and are rounded to millions; the same characteristics we find for interbank loans. Therefore, one likely possibility is that these payments stem from the money market and are short-term lending and borrowing of NOK. A reason why they are not captured by the Furfine-filter might be that only one leg of the loan settles in NBO and the other leg settles over correspondent bank accounts.

4. Results

Of the 1 090 payments that settled gross each day in NBO in August 2015, we are able to categorise 891 (equivalent to 82 percent). This is a considerable increase from the 508 payments (equivalent to 21 percent) we previously were able to categorise. The two charts (4.1 and 4.2) below show how settlements in NBO are categorised based on their economic purpose, value (left) and number (right).

Chart 4.1 Gross settlement in NBO. Total: NOK 171 billion. 1090 payments. . Daily average August 2015.



- 1) Share of gross payments based on value.
- 2) Share of gross payments based on number.

Sources: Bits, CLS, 23 NBO participants and Norges Bank

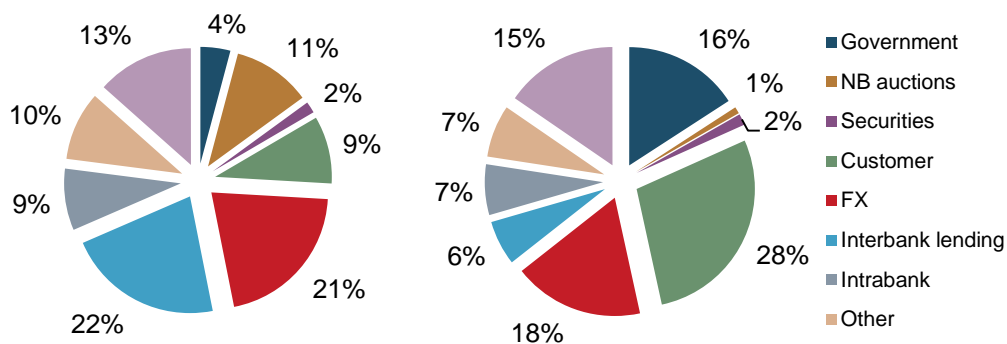
The gross turnover in NBO in August 2015 is categorised as follows:

- Payments involving the government account for 5 percent of the gross turnover based on value and 19 percent based on number.
- Payments resulting from Norges Bank liquidity management (NB auctions) are 13 (1) percent of the turnover based on value (number).
- Customer payments - from firms and households – are 5 (29) percent of the gross turnover based on value (number). These payments are the largest contributor to gross turnover based on number of payments. It follows that many of these payments are relatively small in value (32 percent are less than NOK 100 000).
- Interbank lending is the biggest contributor to liquidity usage, and are 25 (7) percent of the gross turnover based on value (number).
- FX swaps where one leg settles in CLS and the corresponding leg settles in NBO constitute 16 (9) percent of the gross turnover in NBO based on value (number).
- Intrabank payments are 10 (8) percent of the gross turnover based on value (number).
- Payments for which we can infer the purpose make up 11 (8) percent of the gross turnover based on value (number). As previously discussed, this is mostly payments which are larger than NOK 1 million and rounded to NOK 1 million – indicating that these payments are likely connected to the money market.

- 16 (18) percent of the turnover based on value (number) remains uncategorised. Most of these payments involve indirect participants.

The distribution of turnover in NBO changes slightly when net settlements are included, as can be seen in Chart 4.2. Compared with Chart 4.1, the category FX includes pay-ins and pay-outs related to the CLS FX settlements and NICS net positions are included among the customer payments. A separate category shows payments related to securities settlement.

Chart 4.2 Settlement in NBO. Total: NOK 212 billion. 1360 payments. . Daily average August 2015.



1) Share of payments based on value.

2) Share of payments based on number.

Sources: Bits, CLS, 23 NBO participants and Norges Bank

The total turnover in NBO in August 2015 is categorised as previously with the following changes:

- Including net settlement changes the proportion of turnover in NBO involving customers from 5 (29) to 9 (28) percent based on value (number).
- 2 percent of the turnover based on both value and number is attributed to net settlement of securities.
- The inclusion of CLS pay-ins and -outs alters the proportion of the turnover in NBO involving FX from 16 (9) to 21 (18) percent based on value (number).
- Only 13 (15) percent of the turnover in NBO based on value (number) remains uncategorised.

5. Conclusion

Through data dissemination and collaboration with participants and interconnected FMIs we are able to account for a much larger part of the turnover in NBO than previously. The study gives an increased understanding of gross settlements, which make up the majority of the turnover in NBO. Counting both gross and net settlements, we now can confidently identify the purpose of 79 percent of the payments. Allowing for some uncertainty and lower precision, we have made a reasonable inference for some of the remaining 21 percent, leaving only 13 percent of the turnover unexplained.

Interbank lending, FX trades, and payments involving households and companies are the major contributors to liquidity use in NBO and constitute 22 (6), 21 (18), and 9 (28) percent of the total turnover in NBO based on value (number).

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Apart from the obvious benefits of knowing the purpose behind a larger proportion of the turnover in NBO, the analyses we have performed provide additional insights. If a normal bank, correspondent bank or a part of the financial infrastructure is unable to settle payments, we will have a better idea about the kind of payments that are likely to be subject to a delay in settlement and the parts of the economy which will be affected. The analysis has also given Norges Bank better insight into the kinds of payments which are settled indirectly in NBO.

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