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BANK SENTRAL REPUBLIK INDONESIA

Project FRIDAY: Forecasting and Anomaly Detection using Payment System Data

AI/ML Applications in Granular Payment System Data: Enhancing Macroeconomic Forecasting and Anomaly Detection in Financial Markets

on 24th Bank of Finland Seminar on Financial Market Infrastructures
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ABOUT ME AND PROJECT CONTEXT

- Fransiskus Xaverius **Tyas** Prasaja — Bank Indonesia
- Payment System Management Department
- Current work relates to payment-system operations, monitoring, and policy-oriented analysis.
- **F**o**r**ecast**i**ng and Anomaly **D**etection using P**ay**ment System Data (FRIDAY) was developed as an internal exploratory prototype.
- The presentation focuses on what we learned, not on presenting the prototype as a finalized production system.

SCOPE AND CAVEATS

An exploratory prototype, designed for learning rather than production deployment

PROTOTYPE SCOPE

- FRIDAY explores whether granular payment records can be transformed into useful and traceable analytical signals.

INTERPRETATION

- Results are indicative and application-specific; anomaly signals are not causal estimates.

INTENDED ROLE

- The prototype is designed to complement, not replace, economist, market, and payment-system expertise.
- The views presented are for discussion and do not necessarily represent the official position of Bank Indonesia.

The main contribution is practical: showing that useful economic indicators may be reconstructed from operational payment records and made traceable back to transaction-level evidence.

THE STARTING POINT: AN UNTAPPED DATA ASSET

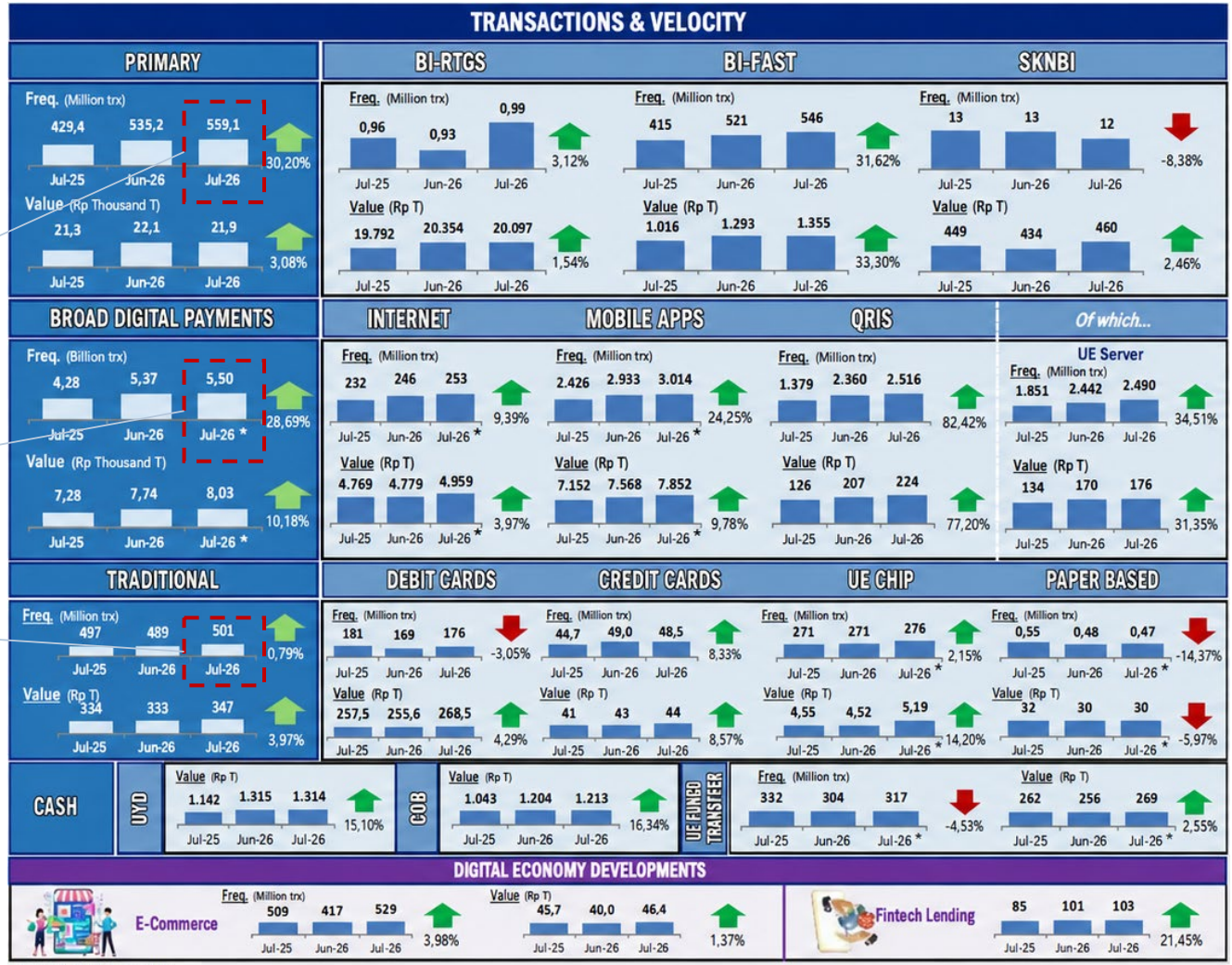
Payment systems generate operational records, and potentially useful economic signals

- Payment systems record actual transactions, not survey intentions or delayed reports.
- The data can be granular by participant, timestamp, value, and transaction type.
- In Indonesia, more than 6.5 billion payment-system transaction records per month.
- The challenge is that the most useful economic variables are often latent, not directly stored in the raw data.

>6.5bn
Transaction records per month

high frequency
timestamped operational data

near real-time
availability



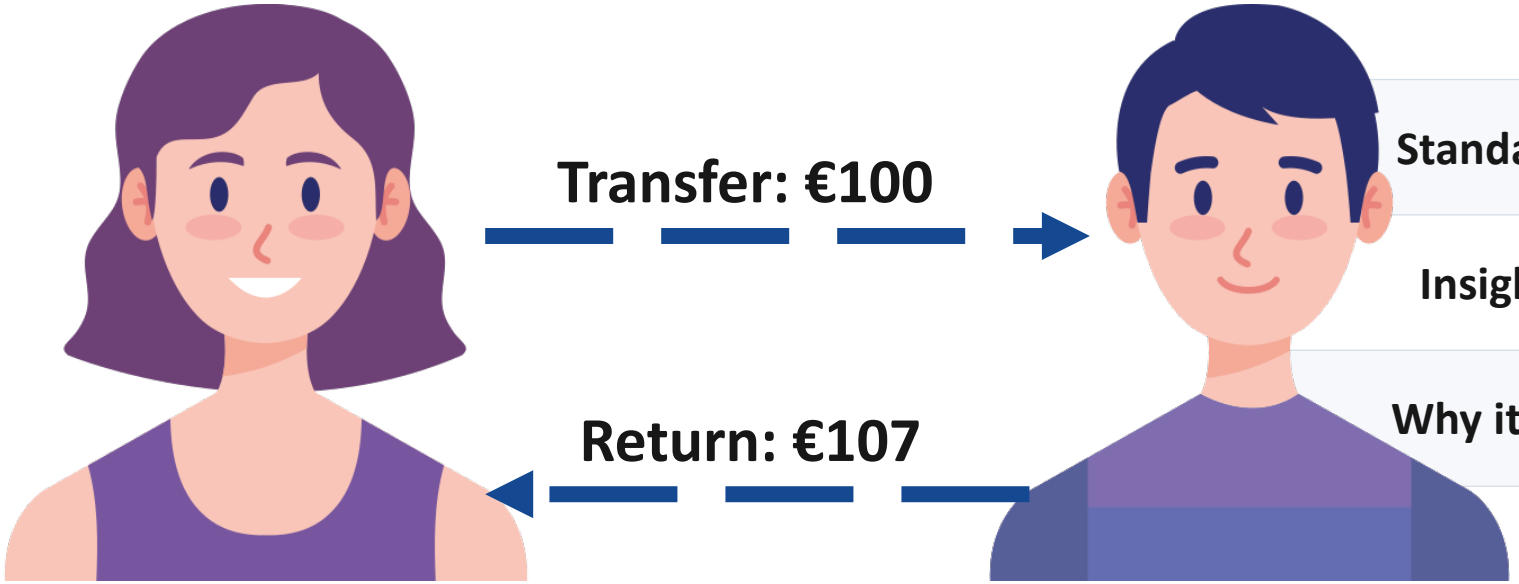
ANALYTICAL CHALLENGE

Scale alone does not produce insight. FRIDAY explores whether we can reconstruct economically meaningful variables from raw operational payment records, then use simple AI/ML methods to surface unusual patterns or forecasting signals.

FROM PAYMENT RECORDS TO ECONOMIC INSIGHT

A simple example of latent information in transaction data

- A raw payment record may only show value, sender, receiver, time, and transaction type.
- But when two related transactions are matched, they may reveal an implied rate, price, or market signal.
- The prototype starts from this simple idea and applies it at central-bank payment-system scale.



Standard view	Two payment records; value = 207
Insight view	Implied return = 7%
Why it matters	A variable can be reconstructed for monitoring

Implied return: 7%

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SOLUTIONS

We explored two ways to extract additional signals from payment-system data

Forecasting

Combine payment-system and macroeconomic variables to improve forecasting

Anomaly Detection

Reconstruct implied market variables and identify unusual transaction patterns

USE CASE 1: FORECASTING

Initial experiment suggests AI/ML can improve forecast accuracy

- FRIDAY tested selected baseline and data-driven forecasting models for payment-system analysis.
- In the prototype setting, Prophet produced MAPE of 3.8%, compared with around 22% for selected baselines.
- A careful statement is: the best-performing specification produced approximately sixfold lower MAPE in this experiment.
- Prototype result; further out-of-sample validation is needed with a documented sample, holdout design, and updated data.

EQUATION

$$SP\_Ritel_{i,t} = \gamma SP\_Ritel_{i,t-1} + \beta_0 + \beta_1 SP\_BI_{i,t} + \sum_{j=2}^{n+1}(\beta_j MacroEcon_{i,t-3}) + \sum_{k=n+2}^{m+n+1}(\beta_{kj} Control Var_{i,t-3}) + \varepsilon_{i,t}$$

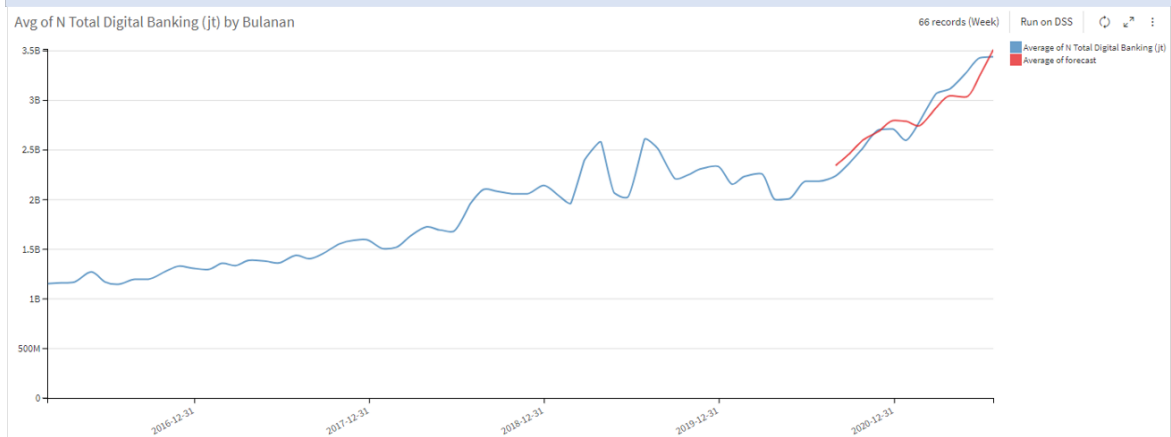
CASE STUDY: DIGITAL BANKING

VARIABLES AND FEATURES (ML)

Digital_Banking (t0) | Digital_Banking (t-1) | RTGS (t0) | Inflation (t0) | GDP (t-3) | Consumption (t-3)

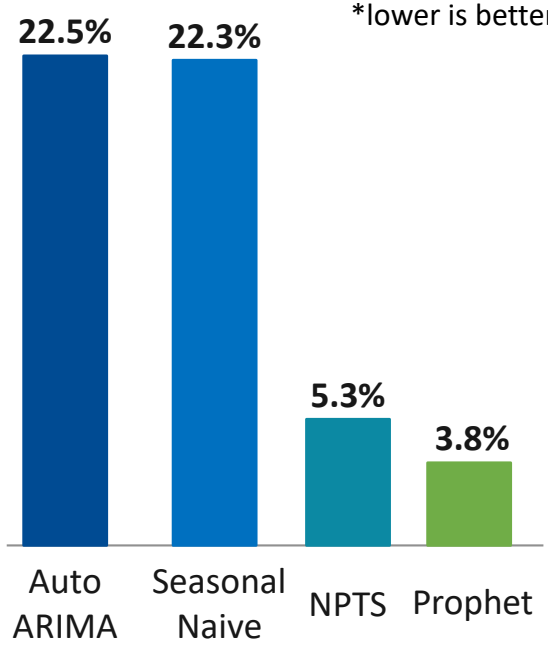
Algoritma		MAPE
Trivial identity (s3)	Uni-var	4.4%
Transformer (s3)		8.4%
MQ-CNN (s3)		99.8%
AutoARIMA (s3)		22.5%
Seasonal trend (s3)	Uni-var	11.2%
Seasonal naive (s3)	Uni-var	22.3%
Prophet (s3)		3.8%
DeepAR (s3)		30.0%
NPTS (s3)		5.3%
Simple Feed Forward (s3)	Uni-var	34.7%

Result (FB Prophet Multivariate):



PROTOTYPE FORECAST ERROR (MAPE)*

*lower is better



*) Prototype implemented using Dataiku

Interpretation: promising prototype result, but not a universal performance claim.

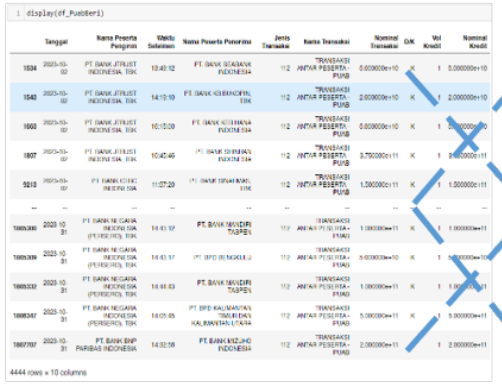
USE CASE 2: INTERBANK MONEY-MARKET SIGNALS

From payment pairs to implied rates and transaction-level anomaly flags

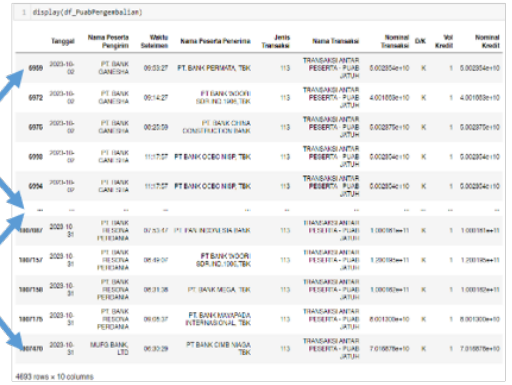
- Raw payment records do not directly contain a money-market interest rate.
- FRIDAY first matches related transactions and reconstructs an implied rate.
- Clustering is then used as an initial screen to identify transactions outside the normal range.
- The value is traceability: analysts can review the underlying transaction, participant, counterparty, time, and value.

01. Transaction Matching through Feature Engineering

H+0. Interbank Lending (TTC 112)



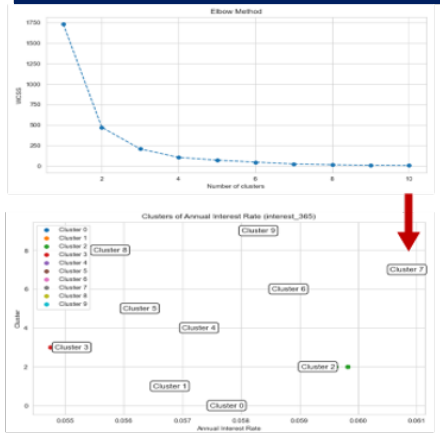
H+1. Interbank Repayment (TTC 113)

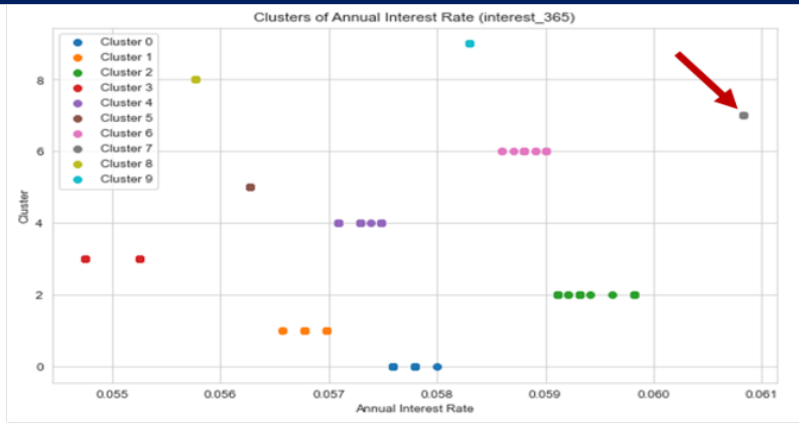


02. Interest Rate Calculation

	Tanggal	Peserta Pengirim	Waktu Setelmen	Nama Peserta Penerima	Jenis Transaksi	Nama Transaksi	Nominal Transaksi	D/K	Vol Kredit	returned_amount	interest	interest_365
1807	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	10:45:46	PT. BANK SHINHAN INDONESIA	112	TRANSAKSI ANTAR PESERTA - PUAB	3.750000e+11	K	1	3.750589e+11	0.000157	0.057285
10804	2023-10-02	PT. BANK DBS INDONESIA	15:16:27	PT. BPD KALIMANTAN TIMUR DAN KALIMANTAN UTARA	112	TRANSAKSI ANTAR PESERTA - PUAB	2.500000e+11	K	1	2.500392e+11	0.000157	0.057285
10845	2023-10-02	PT. BANK DBS INDONESIA	14:37:38	PT. BANK HIBANK INDONESIA	112	TRANSAKSI ANTAR PESERTA - PUAB	5.500000e+10	K	1	5.500856e+10	0.000156	0.056778
10846	2023-10-02	PT. BANK DBS INDONESIA	14:37:18	PT. BANK HIBANK INDONESIA	112	TRANSAKSI ANTAR PESERTA - PUAB	6.000000e+10	K	1	6.000933e+10	0.000156	0.056778

03. Clustering Method for Anomaly Detection





04. Transaction-Level Details / Granularity of Anomaly Detection Results

Tanggal	Nama Peserta Pengirim	Waktu Setelmen	Nama Peserta Penerima	Jenis Transaksi	Nama Transaksi	Nominal Transaksi	D/K	Vol Kredit	returned_amount	interest	interest_365	interest_365_cluster
2023-10-16	CONFIDENTIAL DATA	13:53:52	CONFIDENTIAL DATA	112	TRANSAKSI ANTAR PESERTA - PUAB	2.000000e+11	K	1	2.000333e+11	0.000167	0.060833	7
2023-10-16	CONFIDENTIAL DATA	13:53:53	CONFIDENTIAL DATA	112	TRANSAKSI ANTAR PESERTA - PUAB	3.000000e+11	K	1	3.000500e+11	0.000167	0.060833	7
2023-10-17	CONFIDENTIAL DATA	11:19:13	CONFIDENTIAL DATA	112	TRANSAKSI ANTAR PESERTA - PUAB	3.000000e+11	K	1	3.000500e+11	0.000167	0.060833	7

USE CASE 3: FX MARKET SIGNALS

Inferring exchange-rate distributions from selected payment records

- The same logic can be explored for FX-related payment records.
- FRIDAY reconstructs an implied exchange rate and studies the daily distribution of estimated rates.
- Outliers may provide early or complementary signals for market-monitoring discussions.
- Cautious framing: anomalies may be associated with, or precede, later price adjustment, not necessarily cause it.

1. Implied Exchange Rate Calculation

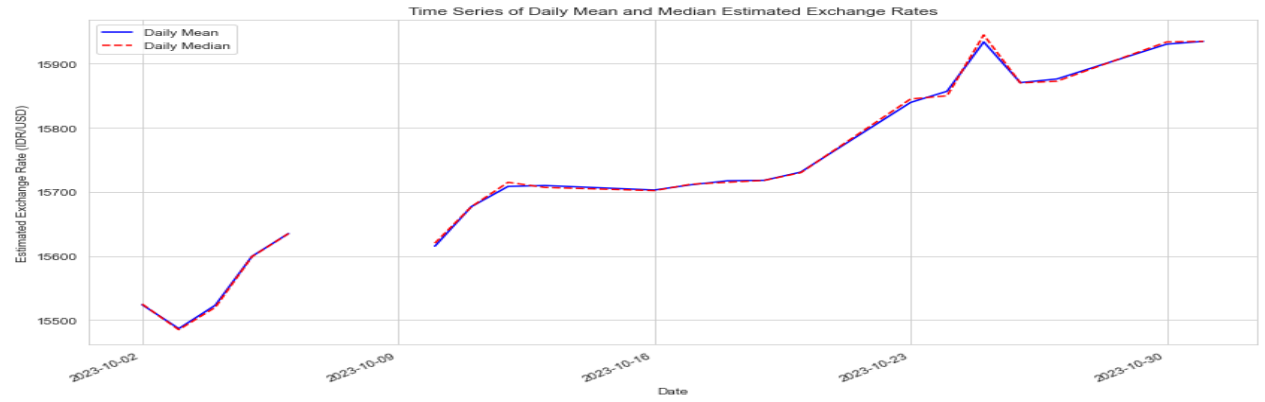
```
display(df_valas)
```

	Tanggal	Nama Peserta Pengirim	Waktu Setelmen	Nama Peserta Penerima	Jenis Transaksi	Nama Transaksi	Nominal Transaksi	D/K	Vol Kredit	Nominal Kredit
1523	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	13:36:22	PT BANK BTPN TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	3.881875e+10	K	1	3.881875e+10
1732	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	06:30:46	PT. BANK SINARMAS, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	3.105600e+10	K	1	3.105600e+10
1818	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	11:23:27	PT. BANK NEGARA INDONESIA (PERSERO), TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.552700e+10	K	1	1.552700e+10
1852	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	09:00:39	PT. BANK CENTRAL ASIA, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.552700e+10	K	1	1.552700e+10
1867	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	09:28:23	PT. BANK PERMATA, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.552700e+10	K	1	1.552700e+10
...	...	...	...	...	...	...	...	...	...	...
1809526	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	11:28:33	PT. BANK CTBC INDONESIA	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.594700e+10	K	1	1.594700e+10
1810306	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	13:17:02	PT BANK OCBC NISP, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.595000e+10	K	1	1.595000e+10
1810307	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	13:17:02	PT BANK OCBC NISP, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	3.190000e+10	K	1	3.190000e+10
1810308	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	13:17:02	PT BANK OCBC NISP, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.595000e+10	K	1	1.595000e+10
1810309	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	13:17:01	PT BANK OCBC NISP, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.595000e+10	K	1	1.595000e+10

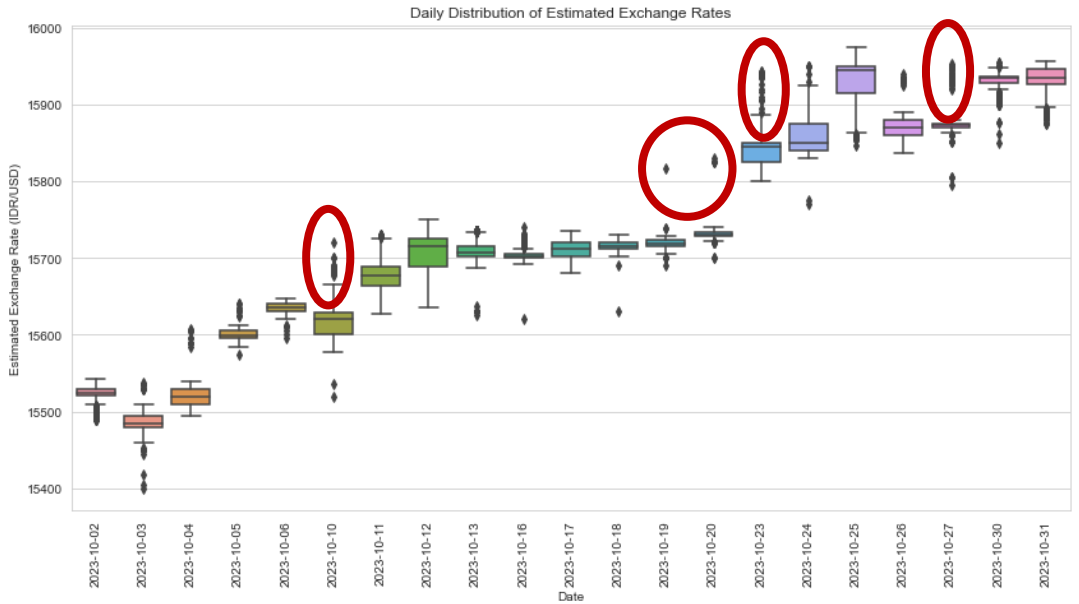
15088 rows × 10 columns

	Tanggal	Nama Peserta Pengirim	Waktu Setelmen	Nama Peserta Penerima	Jenis Transaksi	Nama Transaksi	Nominal Transaksi	D/K	Vol Kredit	Nominal Kredit	Estimated_Exchange_Rate
1732	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	06:30:46	PT. BANK SINARMAS, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	3.105600e+10	K	1	3.105600e+10	15528.0
1818	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	11:23:27	PT. BANK NEGARA INDONESIA (PERSERO), TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.552700e+10	K	1	1.552700e+10	15527.0
1852	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	09:00:39	PT. BANK CENTRAL ASIA, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.552700e+10	K	1	1.552700e+10	15527.0
1867	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	09:28:23	PT. BANK PERMATA, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.552700e+10	K	1	1.552700e+10	15527.0
1886	2023-10-02	PT. BANK JTRUST INDONESIA, TBK	09:37:18	PT. BANK PERMATA, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	3.099600e+10	K	1	3.099600e+10	15498.0
...	...	...	...	...	...	...	...	...	...	...	...
1809526	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	11:28:33	PT. BANK CTBC INDONESIA	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.594700e+10	K	1	1.594700e+10	15947.0
1810306	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	13:17:02	PT BANK OCBC NISP, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.595000e+10	K	1	1.595000e+10	15950.0
1810307	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	13:17:02	PT BANK OCBC NISP, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	3.190000e+10	K	1	3.190000e+10	15950.0
1810308	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	13:17:02	PT BANK OCBC NISP, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.595000e+10	K	1	1.595000e+10	15950.0
1810309	2023-10-31	PT. BANK NEGARA INDONESIA (PERSERO), TBK	13:17:01	PT BANK OCBC NISP, TBK	111	TRANSAKSI ANTAR PESERTA - JUAL BELI	1.595000e+10	K	1	1.595000e+10	15950.0

11627 rows × 11 columns



2. Anomaly Detection



TRACEABILITY AND VALIDATION CHECKS

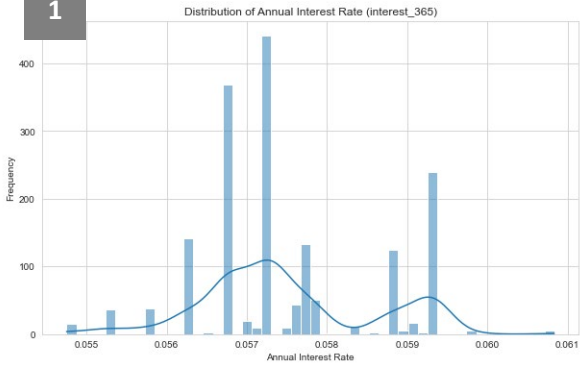
For central-bank use, a useful model should be traceable, not only accurate

- FRIDAY aims to produce outputs that analysts can review and challenge.
- An anomaly flag should be traceable to the transaction record: participant, counterparty, timestamp, value, and reconstructed variable.
- Validation checks are intended to complement, not replace, judgement from economists and payment-system experts.

CHECKS USED IN THE PROTOTYPE

1. **Histogram**
2. **Standard deviation**
3. **Quantile analysis**
4. **Internal report from Monetary and Securities Asset Management Department**
5. **Internal report from Macroprudential, Monetary, and Market Surveillance Department**

1

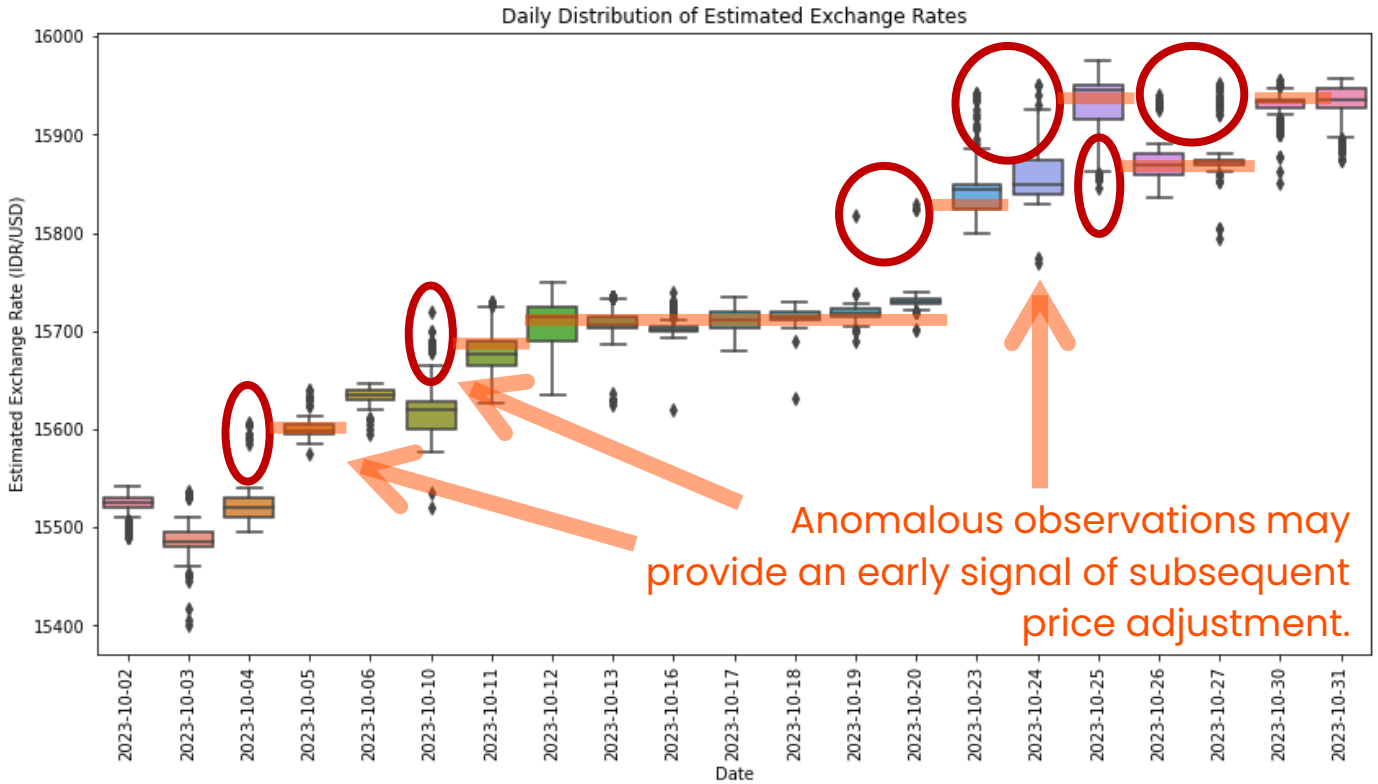


2

```
display(outliers_interest_365_StdDev)
```

	Tanggal	Nama Peserta Pengirim	Waktu Setelmen	Nama Peserta Penerima	Jenis Transaksi	Nama Transaksi	Nominal Transaksi	D/K	Vol Kredit
840425	2023-10-16	PT. BANK PANIN DUBAI SYARIAH	13:53:52	PT. PAN INDONESIA BANK	112	TRANSAKSI ANTAR PESERTA - PUAB	2.000000e+11	K	1
840426	2023-10-16	PT. BANK PANIN DUBAI SYARIAH	13:53:53	PT. PAN INDONESIA BANK	112	TRANSAKSI ANTAR PESERTA - PUAB	3.000000e+11	K	1
940243	2023-10-17	PT. BANK PANIN DUBAI SYARIAH	11:19:13	PT. PAN INDONESIA BANK	112	TRANSAKSI ANTAR PESERTA - PUAB	3.000000e+11	K	1
993368	2023-10-18	PT. BANK PANIN DUBAI SYARIAH	09:58:47	PT. PAN INDONESIA BANK	112	TRANSAKSI ANTAR PESERTA - PUAB	3.000000e+11	K	1
1081260	2023-10-19	PT. BANK PANIN DUBAI SYARIAH	10:47:25	PT. PAN INDONESIA BANK	112	TRANSAKSI ANTAR PESERTA - PUAB	2.500000e+11	K	1

Plotting (Box-Plot)



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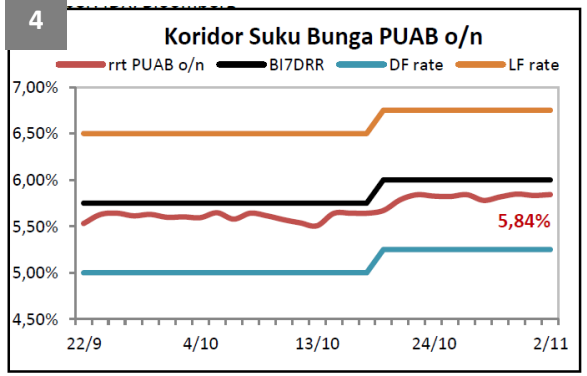

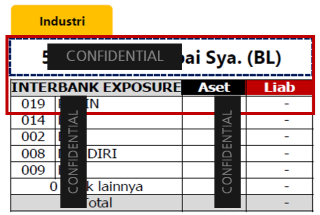

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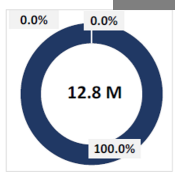

WHAT THIS COULD OFFER TO CENTRAL BANKS

The payment infrastructure as a high-frequency analytical sensor

- FRIDAY suggests a practical way to use payment-system data as an additional analytical layer.
- The potential value lies in earlier signals, transaction-level traceability, and faster analytical triage.
- Because the methods are relatively accessible, the approach may be easier to adapt across institutions.

Timeliness

Prototype analysis at H+1; potential for closer-to-real-time integration.

Granularity

Signals can be reviewed at transaction and participant level.

Analytical Relevance

Useful for oversight, money-market monitoring, FX market monitoring, and macro analysis.

Replicability

Feature engineering and accessible ML methods may be adapted by other operators.

KEY TAKEAWAYS

A practical prototype for turning operational payment data into explainable analytical signals

- Granular payment records can contain latent economic information that is not visible in standard reports.
- Simple feature engineering is often the most important part of the pipeline.
- Forecasting and anomaly detection can be useful, but results should be framed as prototype evidence.
- Explainability and validation checks are essential for central-bank use.
- A potential strength of FRIDAY is accessibility: relatively interpretable methods that may be adaptable across institutions.

Payment systems do not only settle transactions.
With appropriate governance, they may also help central banks see earlier, deeper, and more granularly.

KIITOS!
THANK YOU

Fransiskus Xaverius Tyas Prasaja
Bank Indonesia

Helsinki, 28 Aug 2026