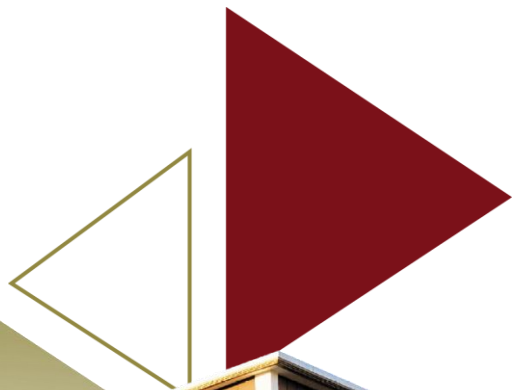


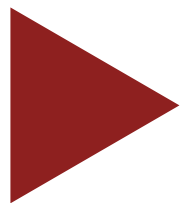


Leveraging Card Payment Data and Machine Learning to Enhance Travel Statistics and External Sector Measurement in Namibia

Sanette Schulze Struchtrup
Bank of Namibia

13th biennial conference
“Filling information gaps in central banking: effectively leveraging data and
innovative tools”

Basel, Switzerland, 20-21 August 2026



Contents



Bank of Namibia



- 01 Introduction
- 02 Statistical problem
- 03 Methodology
- 04 Trade in services results
- 05 Challenges
- 06 Conclusion

1. Introduction:

Travel Sector - Economic Significance and statistical needs



Economic Significance

Tourism drives economic growth, jobs, investment, and foreign exchange earnings.

- Average share to GDP of 6.9%.
- Average share to total employment of 7.9% (57,571)
- Tourism establishments: 17,082 (28% of all establishment)
- Share to direct investments of 2% in 2025
- Average share to foreign trade in services earnings of 40%

Travel statistical requirement

- Travel is defined as: *Goods and services acquired from an economy by non-resident travelers during visits for business or personal purposes, including health- and education-related travel.*
 - BPM6 requires the recording of business and personal travel.
 - Supplementary breakdown of travel by product group (e.g. local transport, goods etc.) is critical.



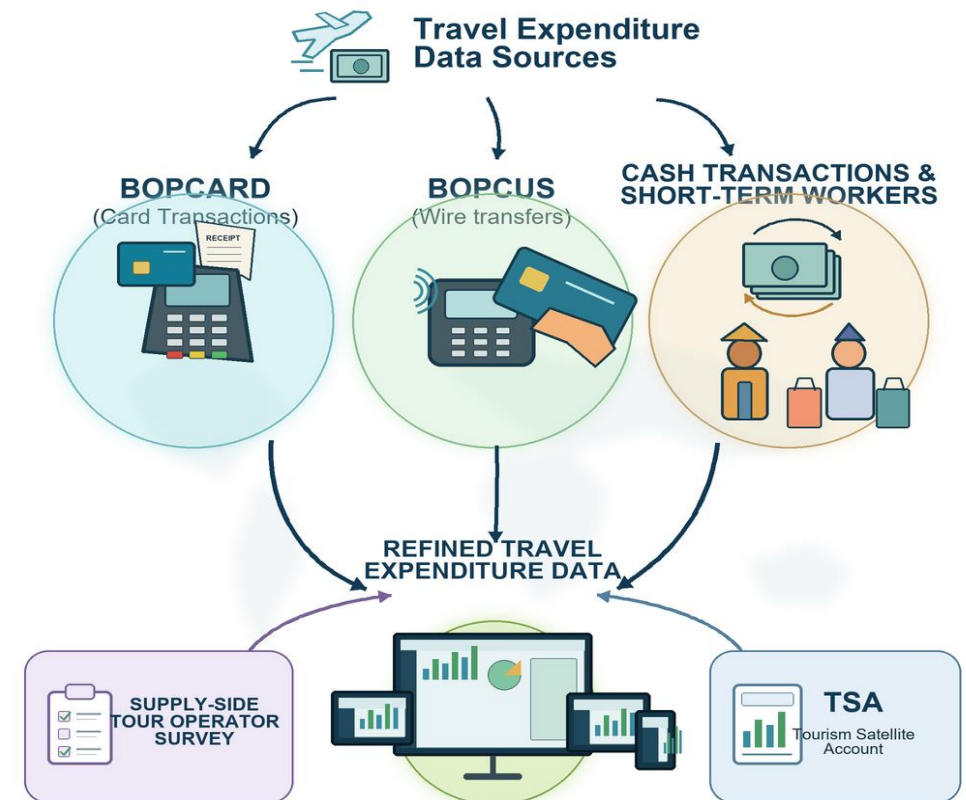
Explored the integration of card payment data and machine learning with traditional data sources to improve Namibia's travel services and external sector accounts.

2. Statistical problem

Data source

- The Bank of Namibia **Balance of Payments Customer Reporting System (BOPCUS)**, equivalent to ITRS and foreign government payment records.
 - Current sources lack detailed spending information - may not fully capture digital card payments and cash transactions
 - Bundled transactions** – making it difficult to record travel by product group as per BPM7
- Digitalisation is driving the shift toward **card-based travel payments**.
 - Provides timely and highly granular travel insights
 - Machine learning techniques enable efficient processing and classification of large this transaction datasets.
- Cash transactions persist contributing **5.9%** of total travel service credits.
- Combining these tools improves the coverage, timeliness, and detail of travel statistics required by BPM6/7**

Integrated approach



3. Leveraging machine learning techniques

Preprocessing and Feature Engineering

- Merchant names standardized (case, spacing, punctuation)
 - e.g. SHELL → SH · HE · SHE · HELL · SHELL
 - Helps match names despite typos & short forms
- Dates and values set to consistent formats
- Outliers treated

Leveraging travel workshop

- Used the Travel Workshop Working Group (**MCC-EBOPS**) correspondence list
 - Facilitated by the Deutsche Bundesbank, Banca d'Italia, and Eurostat
- Identified travel-related Merchant Category Codes (MCCs)
- 868 valid travel-related MCCs retained

Rule-based Classification

- **MCC-Merchant pair 2,036,469**
- 1,022 deterministic rules, applied sequentially
- First matching rule sets the outcome
- Determine travel verdict and assign category as per BPM6
- Unmatched pairs → passed to the ML stage

Machine Learning

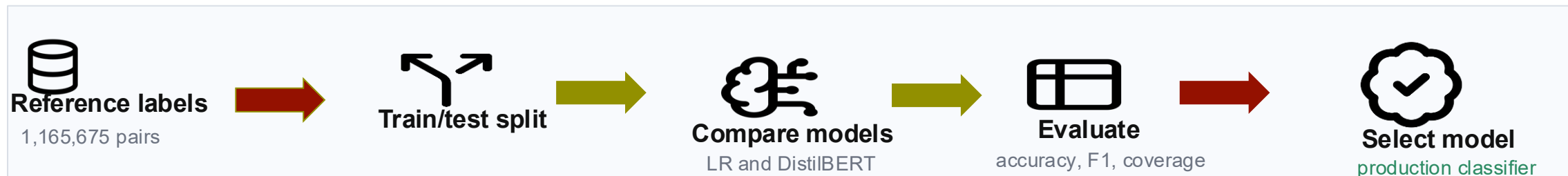
- Supervised learning on 1,165,675 rule-labelled pairs
- Two classifiers compared on one held-out test set:

Multinomial Logistic Regression

DistilBERT (transformer benchmark)

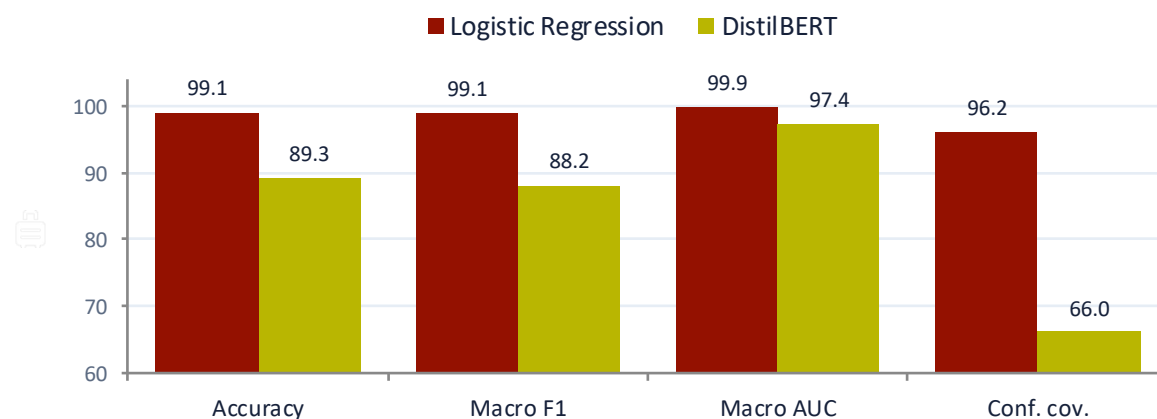
4. Model Training and Selection

Rule-labelled pairs were split 80:20 to train and evaluate two supervised classifiers.



Model	Train	Test	Accuracy	Macro F1	Macro AUC	Conf. coverage (P≥0.9)
Multinomial Logistic regression	932,540	233,135	99.12%	99.09%	99.94%	96.2%
DistilBERT	16,000	4,000	89.28%	88.19%	97.44%	66.0%

Out-of-sample model comparison (%)





PRODUCTION MODEL

99.12%

Out-of-sample accuracy · 231,083 of 233,135 pairs correct

- 96.2% confident coverage vs 66.0% (DistilBERT)
- 99.76% accuracy within the P≥0.90 band
- Trainable on the full labelled dataset

5. Integrating ITRS, surveys and Cash transaction data

1 ITRS & Card payment (credit)

- ITRS/card credit data includes 73 service-related codes.
 - Only about **4 codes** relate directly to travel services..
- **91%** of ITRS travel credits are bundled package-tour transactions.
- **TSA** and **supply-side tour operator ratios** were used to unbundle packages due to the absence of MCC and merchant information on the credit side.

2 Cash and border, seasonal, and other short-term workers

- Acquisition of goods and services by cross-border, seasonal short-term worker expenditure estimated using the remittances model (Nghinamupika et al., 2025).
- Duty-free exports and imports used to estimate goods purchased by non-residents
- Travel cash credits estimated using repatriated South African rand, allocated **90% to travel** and **10%** to personal remittances

6. Results: higher net travel and macro impact

US\$409.1m

2025 after enhancement
Net travel balance

US\$342.8m

2025 prior to enhancement
Net travel balance

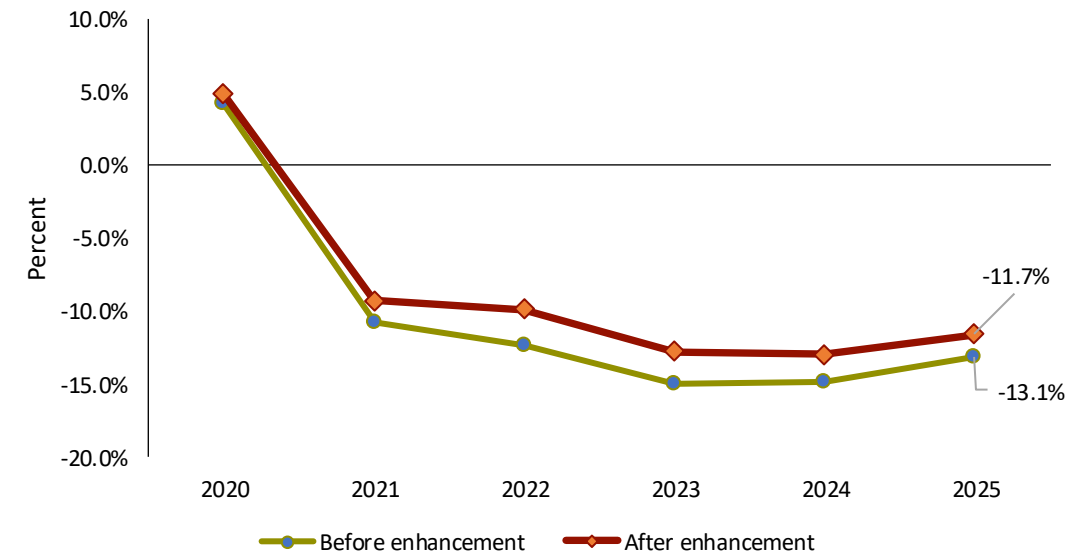
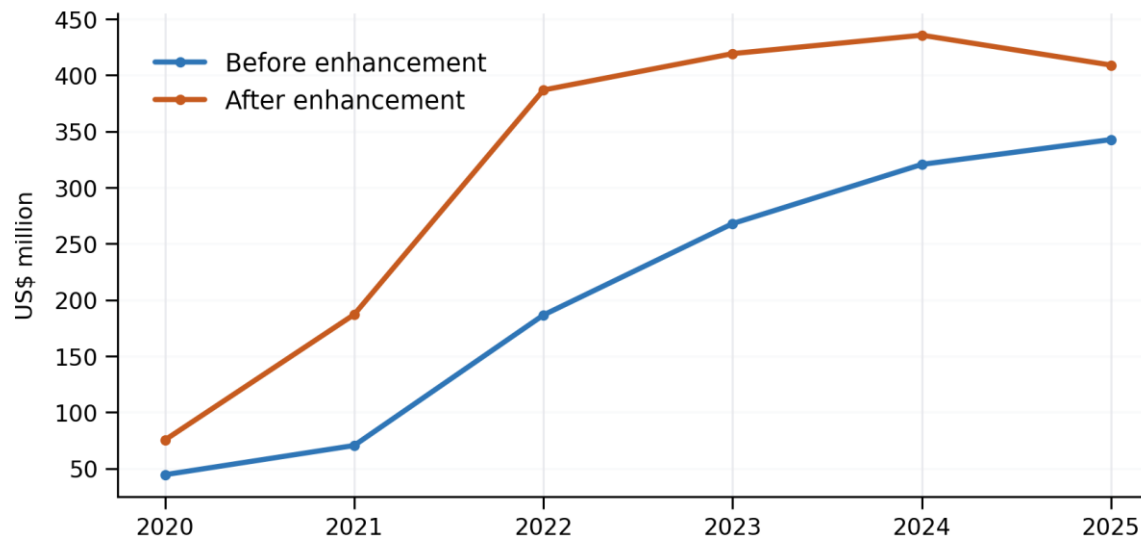
13.1% → 11.7%

Current account
Deficit as % of GDP, 2025

Granularity

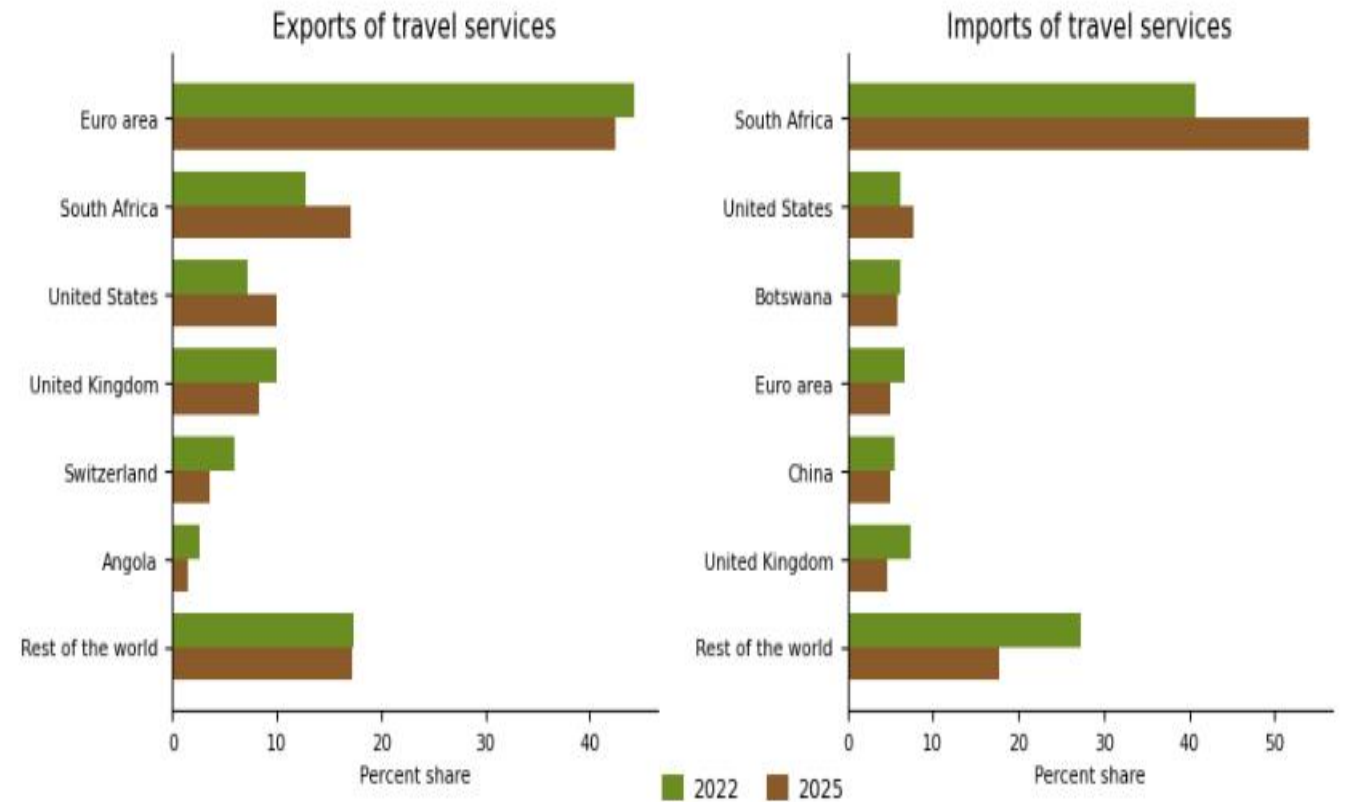
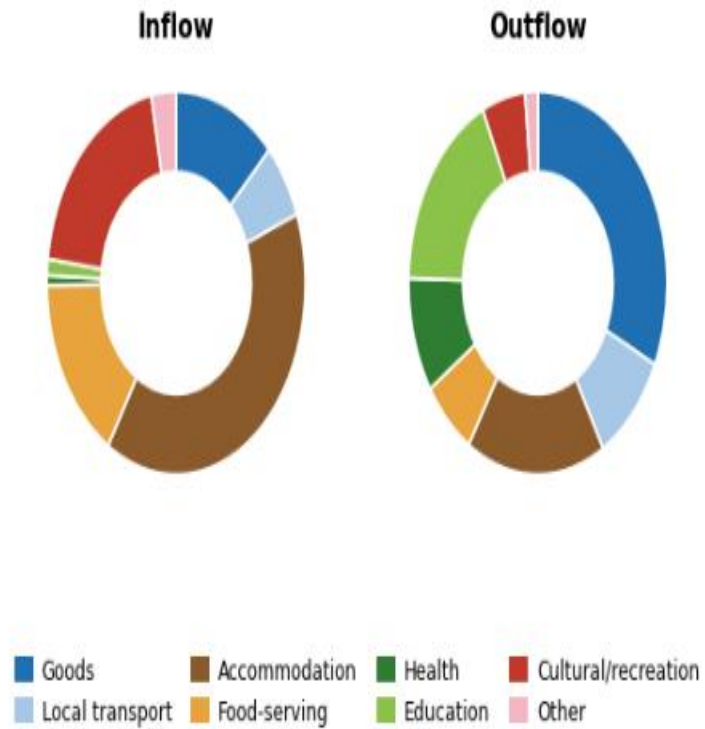
In line with geographical patterns
reported in Tourism statistics

Annual net travel balance before vs after enhancement



7. Results: Additional breakdown

Travel supplementary breakdown, percent share 2025



8. Challenges

Limitations



Remedial actions



Coverage limits

01

- Missing MCC, merchants and customer details limit machine-learning classification.
- Package-tour payments settled outside Namibia

TSA ratios and tour operator surveys used to disaggregate travel by purpose and product.

Offshore Settlement

02

- Domestic payments settled abroad by travel intermediaries may overstate travel services.

Excluded NAD-denominated transactions identified as domestic payments via foreign travel platforms.

Classification issues

03

- Domestic transactions may be misidentified as cross-border;
- payment data may not align with the accrual principle.
- limited information on the ultimate destination visited

Periodically refresh TSA ratios, package-tour survey ratios, MCC mappings and machine-learning rules.

9. Conclusion

- The objective of paper was to integrate card payment data and machine learning with traditional data sources to improve Namibia's travel statistics and external sector account
- The enhanced model produced more comprehensive travel estimates addressing the longstanding underestimation of travel services transactions.
- Card payment data, together with ITRS data, TSA expenditure structures, surveys and machine learning techniques enhances the granularity of travel statistics
- Addressing key challenges and strengthening as well as monitoring of machine-learning models are critical for full integration into official BoP statistics

THANK YOU





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INTEGRATING PAYMENT STATISTICS INTO BALANCE OF PAYMENTS SERVICES ESTIMATES: OPPORTUNITIES AND CHALLENGES

Authors: V. Amato, F. Ciccioli, M. Di Bella, V. Valletta

13th IFC Conference
20-21 August 2026

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Statistical Analysis Directorate

Disclaimer: The views expressed are those of the authors and do not necessarily reflect those of the Bank of Italy.

Italian Service BoP data sources

- CURRENT ACCOUNT

- SERVICES

- SD – Travel
 - SB – Maintenance and repair services n.i.e.
 - SF – Insurance and pension services
 - SG1 – Financial services explicitly charged and other financial services
 - SH – Charges for the use of intellectual property n.i.e.
 - SI – Telecommunications, computer, and information services
 - SJ – Other business services
 - SK – Personal, cultural, and recreational services
 - Government goods and services n.i.e.
 - SA - Manufacturing services on physical inputs owned by others
 - SC – Transport
 - SE – Construction

Travel data sources:

1. International Tourism Survey at border points (counting operation + interviews)
2. Administrative data from border authorities
3. Mobile Phone Data (MPD)
4. External benchmark

Other services data sources:

1. Direct Reporting (DR) from non-financial corporations, holding companies, and insurance firms
2. Supervisory reports from banks and other financial institutions
3. One Stop Shop (OSS) data from Italian Revenue Agency
4. Administrative data from public administration

PS DATA

PS are based on reports submitted by banks, payment institutions and electronic money institutions for supervisory and statistical purposes.
We look directly at the reports underlying PS.

ISSUING

Data on payments made **with cards issued by an Italian bank.**

Quarterly data.

Counterpart country.

Payment Modes: NR (No Remote); R (Remote) .

Reference dataset: only items with MCCs related to services, Q1 2022- Q4 2025.

PS DRAWBACKS



Missing components



Residency identification



Tour operators and Travel agencies



MCC – EBOPS mapping



Accrual principle

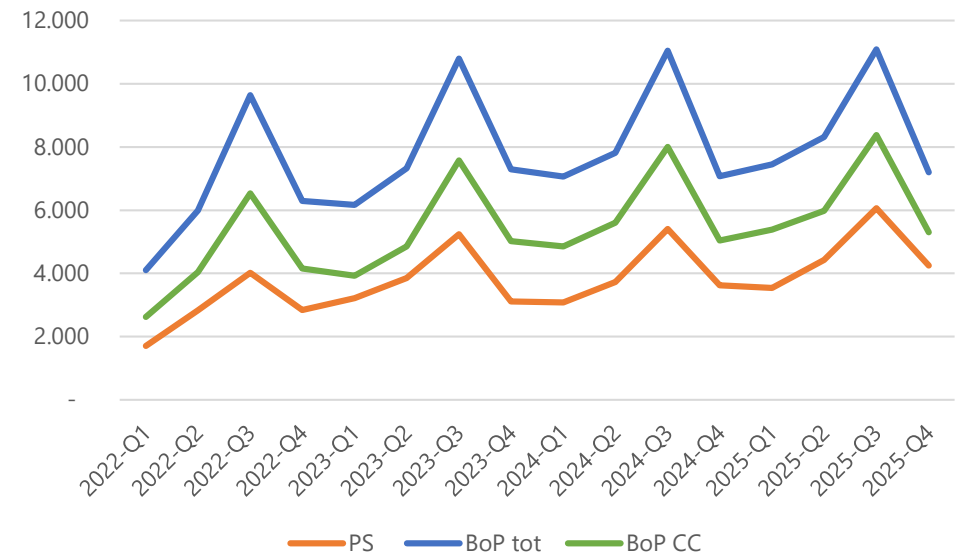
TRAVEL ITEM (1) - OVERVIEW

Comparison of Italian Travel Spending Abroad: BoP vs Payment Statistics.

- **High similarity in trends** across the two series; strong seasonality of tourism is a key factor.
- BoP total expenditure (BoP TOT) is always higher than PS as expected because:
 - Includes payment methods not in PS (cash, wire transfers).
- BoP credit card (CC) expenditures are on average 43% higher than PS.

PS alone cannot accurately estimate the total expenditure.

Quarterly comparison between the PS series and the series derived from the International Tourism Survey (Q1 2022 – Q4 2025, million euros).



Source: PS, International Tourism Survey (BI).

TRAVEL ITEM (2) - REMOTE VS NON-REMOTE

General trend: Similar for both series, except in Q3 of each year.

- Q3 = summer months → peak in in-person spending.

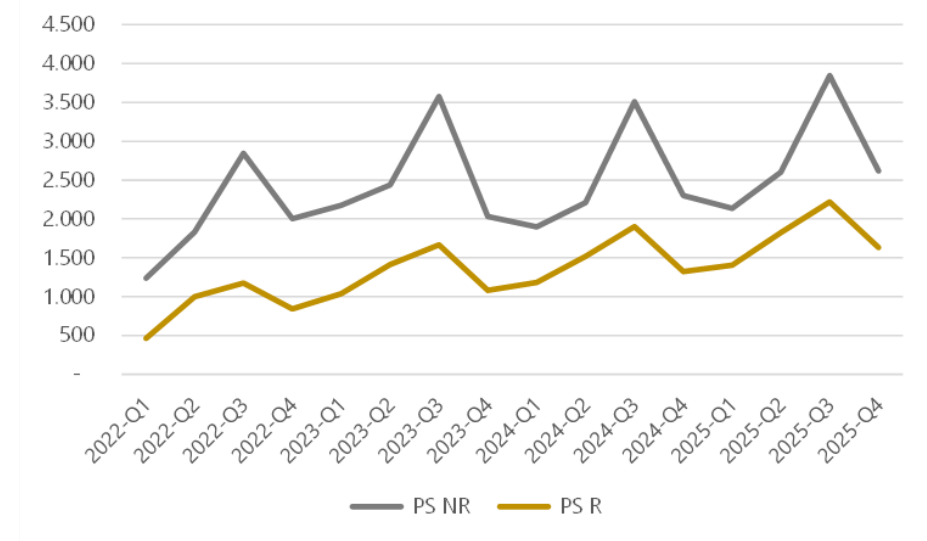
Absolute values: Remote PS < Non-Remote PS. On average, the 64% is NR.

Remote series shows a **flatter** pattern

Unexpected finding:

- Remote payments include high-value expenses (e.g., accommodation, travel agencies, tour operators).
- No strong evidence of advance bookings.

Quarterly trend of remote (R) and non-remote (NR) PS series (Q1 2022 – Q4 2025, million euros).



Source: Matrice dei conti.

TRAVEL ITEM (3) - COUNTERPART COUNTRY

**PS expenditure (PS), survey expenditure by credit card (BoP CC), percentage differences (PS/BoP CC), shares of travel-agency (TA/PS) expenditure in PS (2025).
Countries are ranked by PS expenditure.**

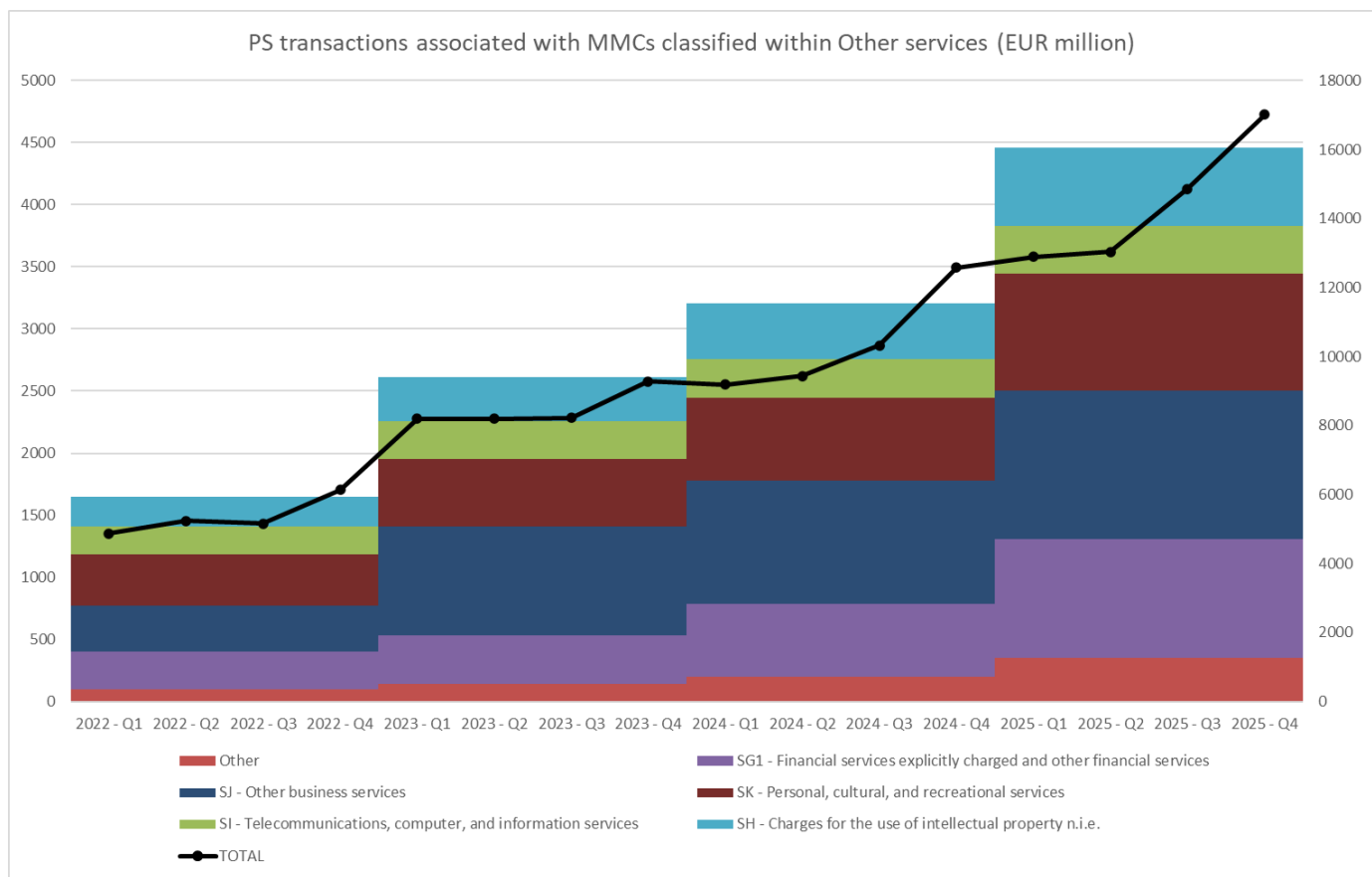
Country	PS	BoP CC	PS/BoP CC %	TA/PS %
Netherlands	3.632	419	766	59
Spain	2.325	3.090	-25	19
France	1.805	2.237	-1	11
Luxembourg	896	21	4146	45
Germany	866	1.324	-35	9
USA	860	2.647	-67	5
UK	855	1.280	-33	13
Ireland	555	203	173	34
Switzerland	514	969	-47	1
Greece	511	1.158	-56	1

Top countries account for more than 70% of PS total expenditure

Observations:

- The difference is **significantly positive** for **Luxembourg, Ireland, Netherlands** mainly due to remote transactions, whereas there is a **strong negative difference across all other countries**.
- Likely linked to **headquarters of major Digital Intermediary Platforms (DIPs)**.
- The **DIPs play a crucial role** for many MCCs and could lead to the geographic misallocation of part of the expenses.

OTHER SERVICES (1) – OVERVIEW

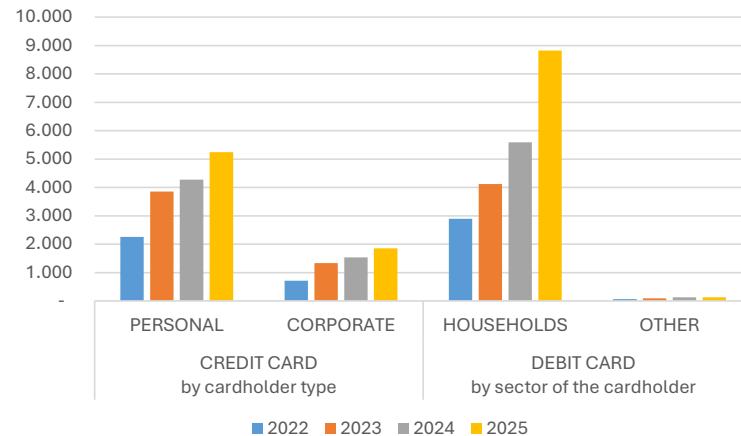


- The analysis required a **modified MCC-EBOPS conversion table**: starting from the technical notes of the Travel Workshop, with a limited number of adjustments made after internal review.
- Payment Statistics for Other services show a clear **upward trend**, but flows are highly concentrated in a few categories (SJ, SK, SG1).

OTHER SERVICES (2) – TYPE OF CARDHOLDER

Card-based Other services are dominated by personal/household transactions

Transaction values by card type and cardholder characteristics (EUR million)



Source: own calculations based on supervisory reports underlying PS.

Main implication: PS are better suited to complement household/B2C estimates than corporate services estimates

Services from corporations are mostly outside PS coverage:

Percentage distribution of payment method (average 2023-2025).

DR survey evidence	Usage %
Bank transfer	97
Credit card	1
Other/Cash	2

On average, during the period 2023-2025, 97% of payments were made by bank transfer

Bank transfers are not covered by PS.

OTHER SERVICES (3) – MCC ANALYSIS

EBOPS category	Main MCCs	Risk
SJ – Other business services	7399 and 7311 $\approx$ 75%	MCC 7399 (Business Services n.e.c) is residual.
SG1 – Financial services excluding FISIM	6012, 6051 and 6540 $\approx$ 90%	MCC 6540 (stored-value cards) may include financial operations.
SK – Personal, cultural and recreational services	7995 $\approx$ 80%	MCC 7995 (Gambling) may include personal transfers in addition to service fees.

Main findings:

- MCC conversion table is a starting point, not a classification rule.
- PS can be used after empirical adjustment factors, service/non-service splitting rules and validation against external sources.

CONCLUSIONS AND FUTURE WORK

What we learned:

1. **Payment Statistics are a valuable complementary source**
2. **For Travel, PS capture dynamics better than levels**
3. **For Other services, the main potential is household/B2C expenditure**

Future work:

- Refining the MCC-EBOPS mapping and isolating the service component
- Explore the household sector coverage in PS to ensure complete coverage of cross-border services flows.
- Analyze the acquiring side once the time series is long enough



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THANK YOU!

Marco Di Bella
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Extra slides – MCC modified table

WG ES MCC-BoP mapping available on the [ECB website](#)

MCC Code	MCC Description	BoP item (face-to-face)	BoP item (face-to-face) - Description	BoP item (card-not-present)	BoP item (card-not-present) - Description	Travel?	Notes
0763	Agricultural Cooperatives	SD	Travel	G	Goods	Yes, only F2F	SJ321 potential overlap: associations and cooperatives that provide farm management services or assistance in farming operations. Examples of such services include financial assistance, management, or complete maintenance of crops, soil preparation, planting and cultivating, aerial dusting and spraying, disease and insect control, weed control, and the harvesting of crops.

MCC	MCC Title/ MCC Description
0763	Agricultural Co-operatives
	Merchants classified with this MCC provide farm management services or engage in farming operations. Also included in this MCC are associations and cooperatives that provide assistance and services to farmers in farm management. These services include, but are not limited to financial assistance, management or complete maintenance of crops, soil preparation, planting and cultivating, aerial dusting and spraying, disease and insect control, weed control, and harvesting crops.

New proposed BoP item for card-not-present (remote) transactions: SJ322 (Services incidental to agriculture, forestry and fishing)

Extra slides – MCC modified table

WG ES MCC-BoP mapping available on the [ECB website](#)

MCC Code	MCC Description	BoP item (face-to-face)	BoP item (face-to-face) - Description	BoP item (card-not-present)	BoP item (card-not-present) - Description	Travel?	Notes
7995	Betting, including Lottery Tickets, Casino Gaming Chips, Off-Track Betting, and Wagers at Race Tracks	SD	Travel	SK24	Other personal services	Yes, only F2F	CNP - A part of gambling transactions should be allocated to personal transfers - rather than entirely as services - and recorded directly from those participating in the lottery or gambling to the winners and charities. That is, they are not recorded as transfers to or by the unit operating the gambling. The service ratio must be estimated to distinguish the service component, as payment statistics only capture flows between gamblers and the platform and provide no information on internal platform activity.

Only part of the 7995 transactions can be identified in Other personal services → a service/non-service splitting rule must be identified to distinguish between the service part and the personal transfer



Statistics on Payment by Economic Activity and Households – EPAE

An Analysis of Pix

Maurício Botelho Ribeiro

13th biennial IFC Conference

Bank for International Settlements

20-21 August 2026



Pix and The Instant Payment System (SPI)

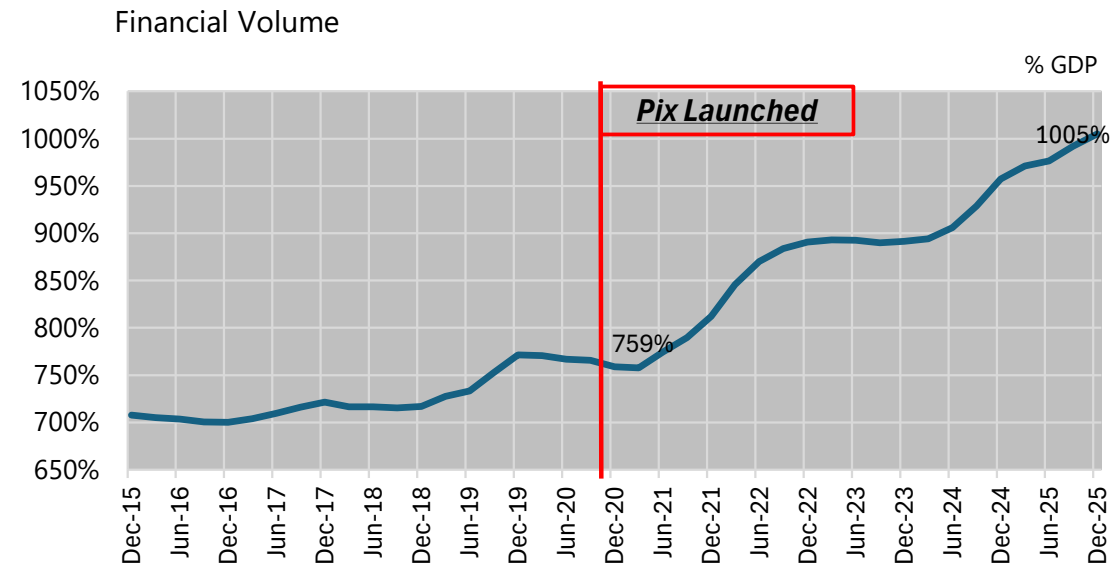
- Pix is an instant payment system developed by the Central Bank of Brazil (CBB)
 - Enables the transfer of funds between accounts within seconds, 24/7
 - So fast, convenient, and secure, and can be used through checking, savings accounts etc
 - SPI - centralized and exclusive infrastructure for the settlement of instant payments (IP), operated by the Central Bank of Brazil (CBB) – Nov/20
 - Real-Time Gross Settlement (RTGS)
 - IP Settlements – entries recorded in the IP accounts in the CBB
- No overdraft positions => No negative balances in IP accounts => Soundness of the system

EPAE Pix

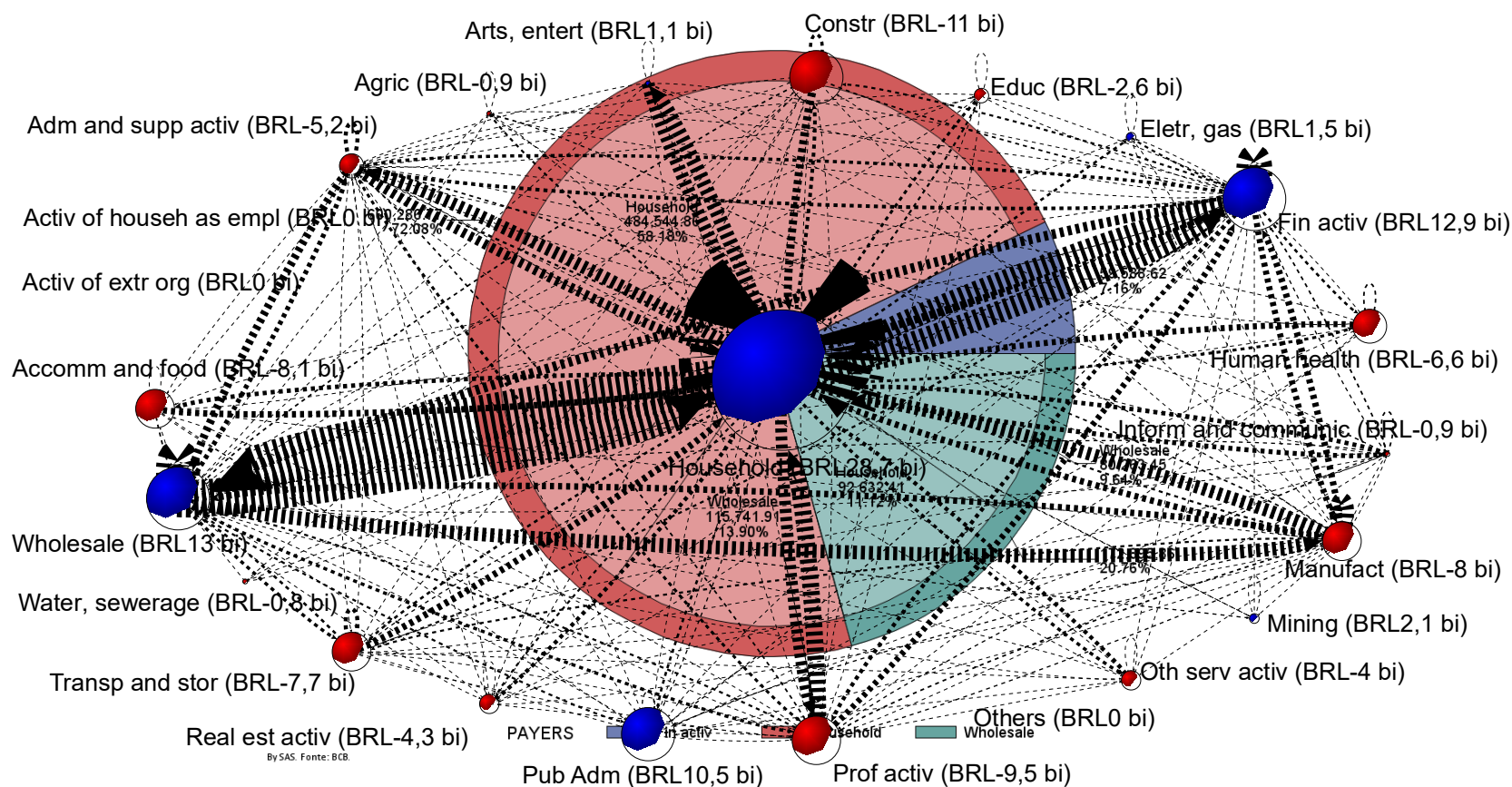
- A statistical framework designed to present transactions between payers and receivers - (F-W-T-W), disaggregated by economic activity (21- EA) and Households (HH), since Nov/20, settled through SPI
- Households and Individual Microentrepreneurs (MEIs) have not yet been identified separately
- Not between the same account holder
- Returned transactions are not considered
- "Others" include unidentified EA and amounts less than 4

Payment Instruments and Transfers, and the Evolution

- Since implementation, changes have been observed among the three main payment instruments (Pix, TED, Intrabank transfers)
- Pix has significantly influenced the financial volume of transactions conducted through all payment instruments

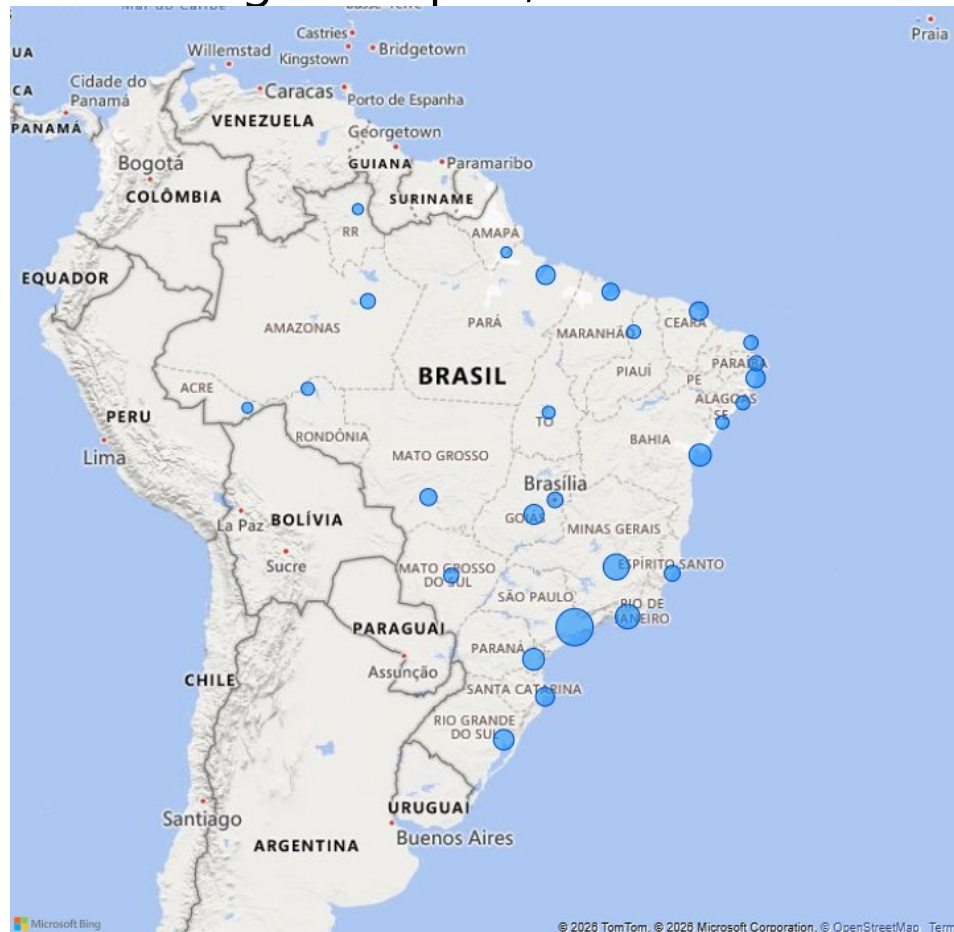


- *HH* are the main users (number of transactions and value), followed by *Wholesale and Retail*
- Both record the largest net balance between receipts and payments



Breakdown of Households – by Federative States

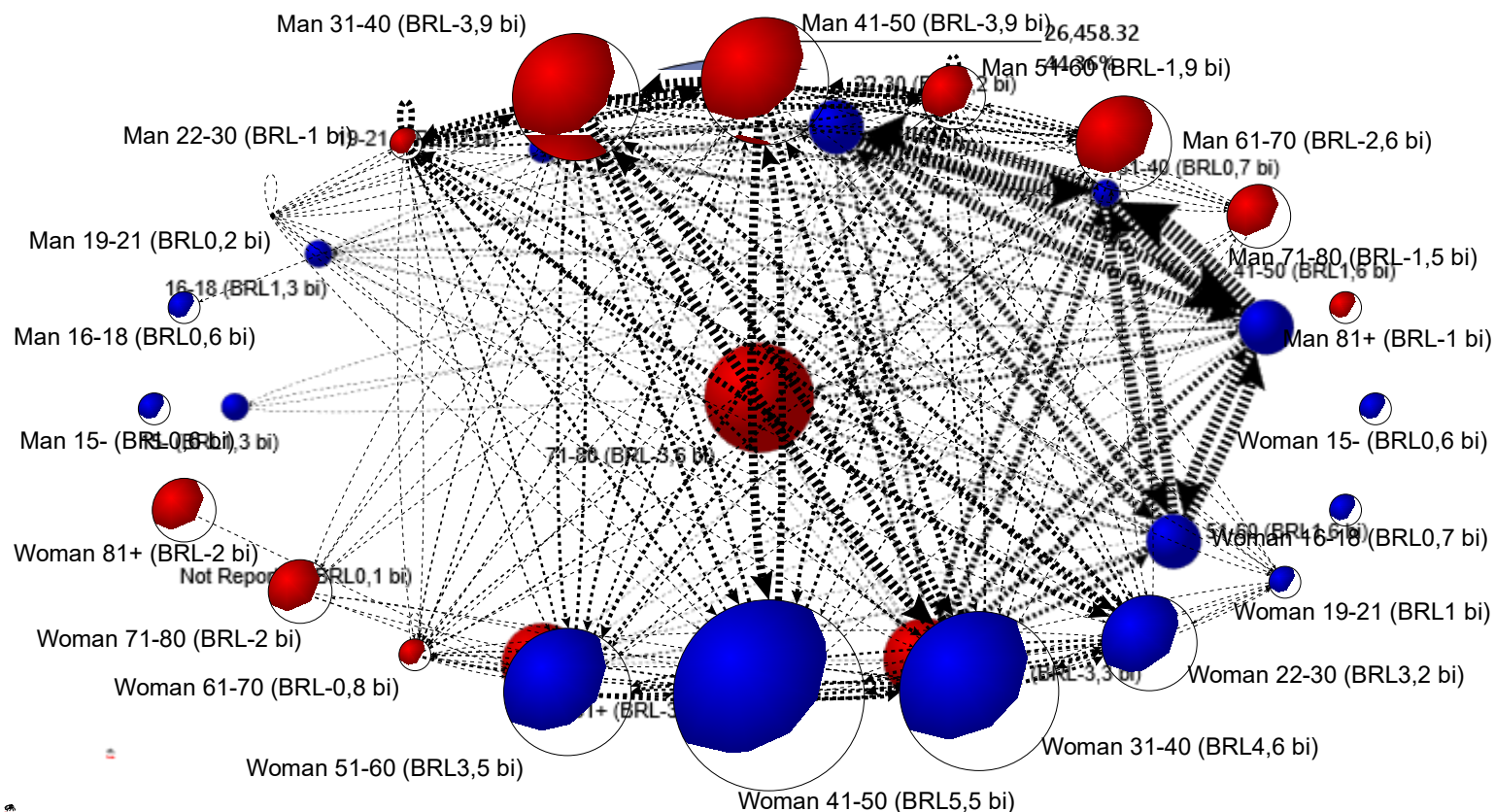
- Regional differences can be observed in the financial volume, number, and average value of Pix transactions
- Northeast region recorded the largest surplus, whereas the Southeast recorded the largest deficit



Net balance – receipts minus payments

Breakdown of Households – by Age and Gender

- Average transaction values tend to increase across age groups
- Only age groups above 60 years recorded negative net balances
- Transactions conducted between men aged 31– 40 recorded the largest total financial values
- Women aged 41–50 recorded the highest positive net balance



Next Steps

- In pipeline – Electronic Funds Transfer (TED)
- Uses an infrastructure different from that of Pix. While Pix is settled through the Instant Payment System (SPI), TED is integrated into the Reserve Transfer System (STR), which is the Central Bank of Brazil's primary settlement system
- ✓ Operates on a gross settlement basis
- ✓ Available only during limited business hours
- ✓ Does not operate on a 24/7 basis
- ✓ Traditionally used for higher-value payments

✓ **Obrigado!**

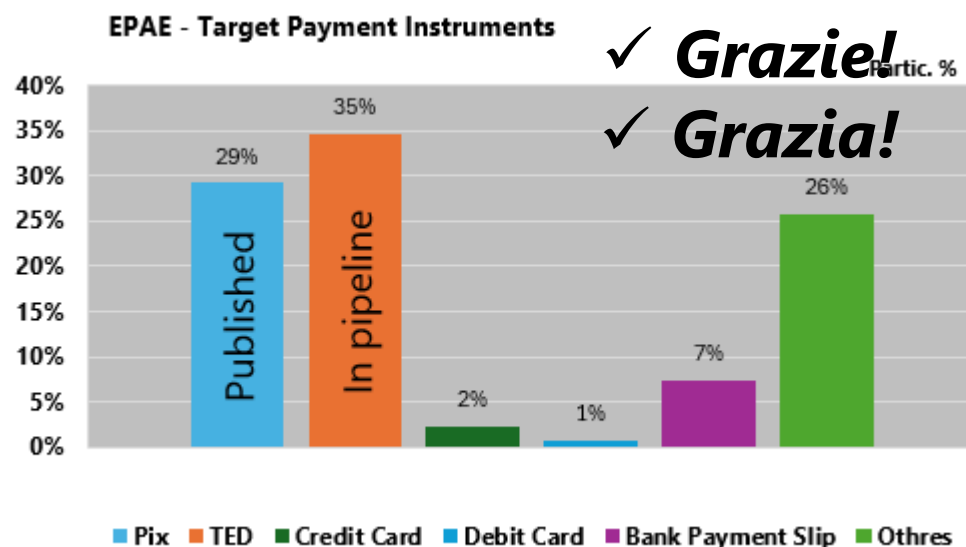
✓ **Thank you!**

✓ **Danke!**

✓ **Merci!**

✓ **Grazie!**

✓ **Grazia!**



Bridging the Data Gap

High-Frequency QRIS Payment Indicators for Nowcasting
Household Consumption in Indonesia

Muhammad Azkaenza · Maudy Halim · Jerry Y. Christi

Statistics Department · Payment System Management · Data Innovation and Digitization

The views expressed are those of the authors alone and do not necessarily reflect the official views of Bank Indonesia.



Real-time Consumption Data is Needed for In-Time Policy

Household consumption is released with a ~35-day lag, while QRIS — Indonesia's national QR payment standard — generates a daily signal. Rather than asking which model wins overall, this paper isolates QRIS's own contribution: does adding QRIS features improve a forecast, above and beyond what non-QRIS information already provides?

1

Does adding QRIS improve nowcast accuracy?

Relative to otherwise matched specifications that exclude QRIS entirely.

2

Which model wins at each horizon?

Comparing ARIMA, Bridge Equation, U-MIDAS, Elastic Net, and Random Forest.

3

At which horizon is QRIS most valuable?

Day 30, Day 60, or quarter-end — and why the answer differs by model.

4

How does the QRIS signal change with adoption?

As QRIS matures from rapid rollout to steady-state usage.

35 days

Assumed publication lag for official household-consumption data

Daily

QRIS transaction values, available in real time at every forecast origin

QRIS in Indonesia — and What This Paper Adds

One standard, every provider. Bank Indonesia developed QRIS with industry so a single merchant code can be read by apps from any licensed payment provider — replacing the fragmented, provider-specific codes merchants previously needed.

Launched August 2019, mandatory by year-end. QR-code payments were required to migrate to the QRIS standard by the end of 2019.

An incomplete but evolving lens on spending. QRIS captures only 1 payment channel (cash, cards, transfers, and direct debit are not included) and its representativeness shifts as merchant coverage and user adoption keep increasing.

Aug 2019

QRIS launched by Bank Indonesia

2,373

Daily transaction observations used
(Jan 2020 – Jun 2026)

Builds on the payment-data literature

Giannone, Reichlin & Small (2008): “jagged information edge” nowcasting.

Duarte et al. (2017); Verbaan et al. (2017); Aastveit et al. (2024): ATM/POS and debit-card data improve consumption nowcasts.

What this paper adds:

- A daily, nationwide payment indicator
- Three explicit within-quarter horizons (D30, D60, EOQ)
- A direct no-QRIS ablation to isolate incremental value
- Adoption-maturity diagnostics for a fast-evolving indicator



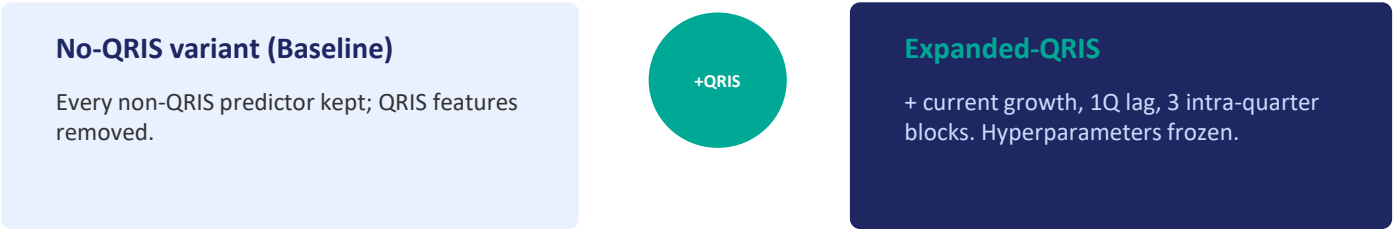
Data Sources & Evaluation Setup

DATA SOURCES

Series	Frequency	Period	N	Main transformation	Availability assumption
QRIS transaction value	Daily	2020-01-01 – 2026-06-30	2,373	Horizon-matched log YoY growth; daily averages and blocks	Available through each forecast origin
Household consumption	Quarterly	2010Q1 – 2026Q1	65	$100 \times [\ln(C_t) - \ln(C_{t-4})]$	Assumed 35-day publication lag
National inflation, YoY	Monthly	2006-01 – 2026-06	246	Latest release-aware YoY; horizon-weighted proxy	Assumed 10-day publication lag
Verified Indonesian calendar	Daily	2020-01-01 – 2026-06-30	2,373	Observed proportions of non-working, festive, and payday windows	Deterministic through forecast origin

Target: $g_t = 100 \times [\ln(C_t) - \ln(C_{t-4})]$ · QRIS growth is inflation-adjusted using only information available at each forecast origin.

FEATURE IMPACT EXPERIMENT (WITH VS. WITHOUT QRIS)



Evaluated at Day 30, Day 60, and Quarter-End — same 10 target quarters (2023Q4–2026Q1) for every model.

FORECASTING MODELS COMPARED

ARIMA	Fixed univariate anchor — never uses QRIS.
Bridge Equation	Parsimonious OLS: GDP + QRIS + calendar.
U-MIDAS	Preserves intra-quarter QRIS block timing.
Elastic Net	L1+L2 regularization for correlated predictors.
Random Forest	Randomized trees capture nonlinear interactions.

Adding QRIS Lowers RMSE in Every Comparison

12 / 12

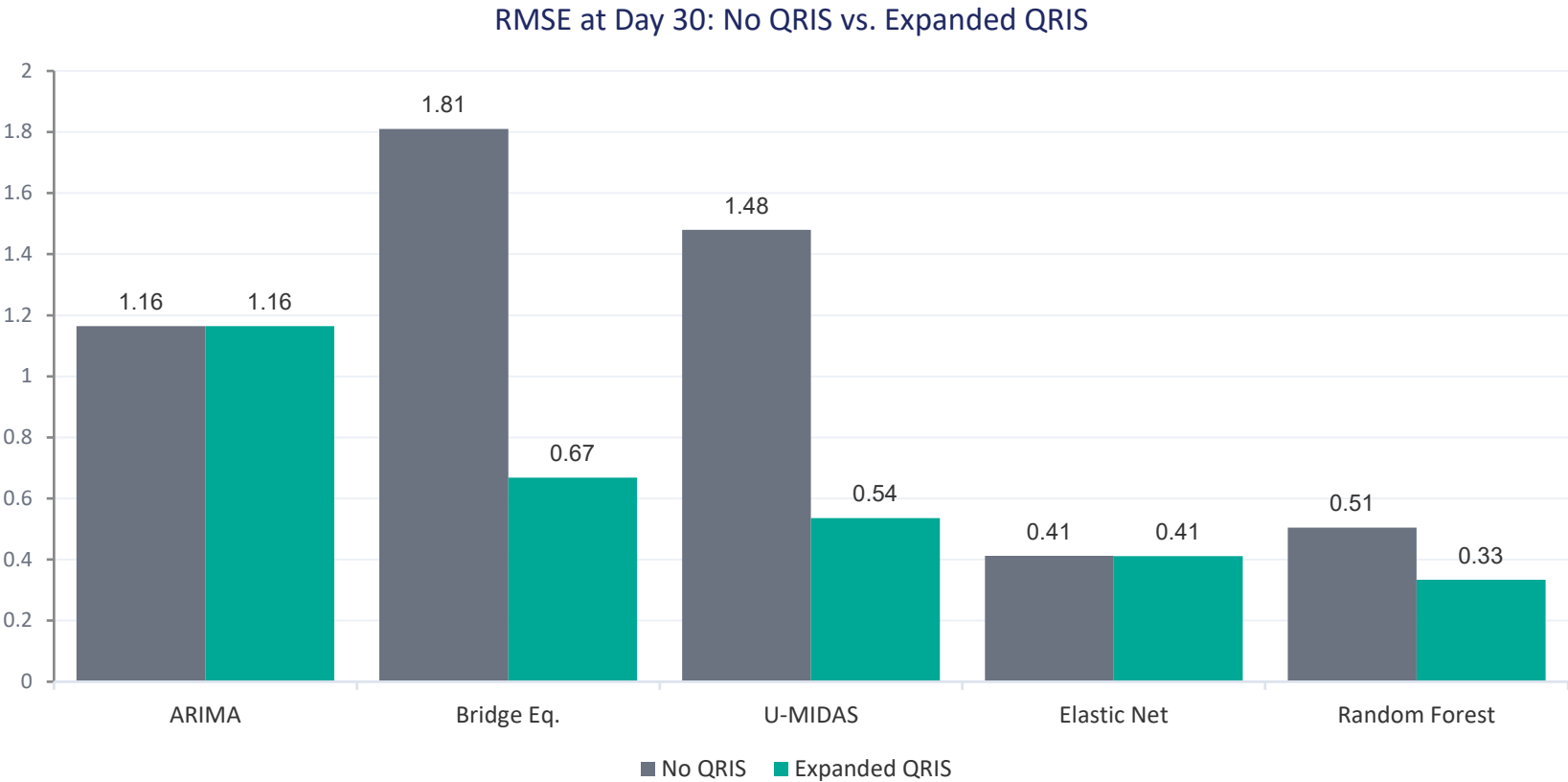
model–horizon comparisons
improve with QRIS

63.8%

largest RMSE reduction
(U-MIDAS, Day 30)

0.06%

smallest — Elastic Net, EOQ



Point estimates improve in all twelve non-ARIMA model–horizon pairs, but the size and statistical reliability of the gain vary widely by model and horizon.

Why Day 30 only? Day 30 is the horizon where t–1 GDP is typically still unpublished, so it is where a nowcast needs QRIS most — and where the gains shown here are largest and most consistently significant (Table, next slide).



Most Significant Gains Concentrate at Day 30

Model	Day 30	Day 60	EOQ
Bridge Equation	63.07%	39.44%	19.44%
U-MIDAS	63.77%	20.52%	4.76%
Elastic Net	0.30%	1.40%	0.06%
Random Forest	33.83%	14.84%	21.86%

RMSE gain:

<5%

5–20%

20–50%

≥50%

QRIS's incremental value is largest exactly where a model's non-QRIS baseline is weakest — Bridge and U-MIDAS gain most at Day 30, while Elastic Net's already-strong baseline leaves little room to improve.

Statistical significance

At Day 30:

3 of 4 models significant under both Diebold–Mariano and permutation tests (U-MIDAS $p<0.0001$, Bridge $p=0.0005$, RF $p=0.0025$).

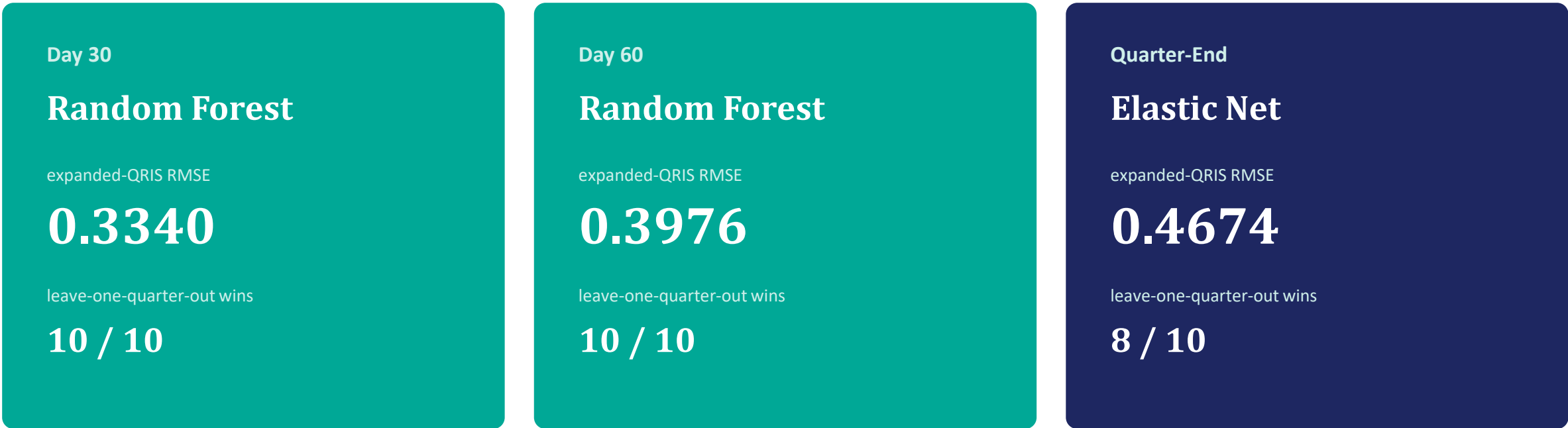
At quarter-end:

Mostly inconclusive — only Random Forest remains significant under the permutation test ($p=0.0195$); Elastic Net's 0.06% gain is indistinguishable from noise.

N = 10 target quarters limits test power.

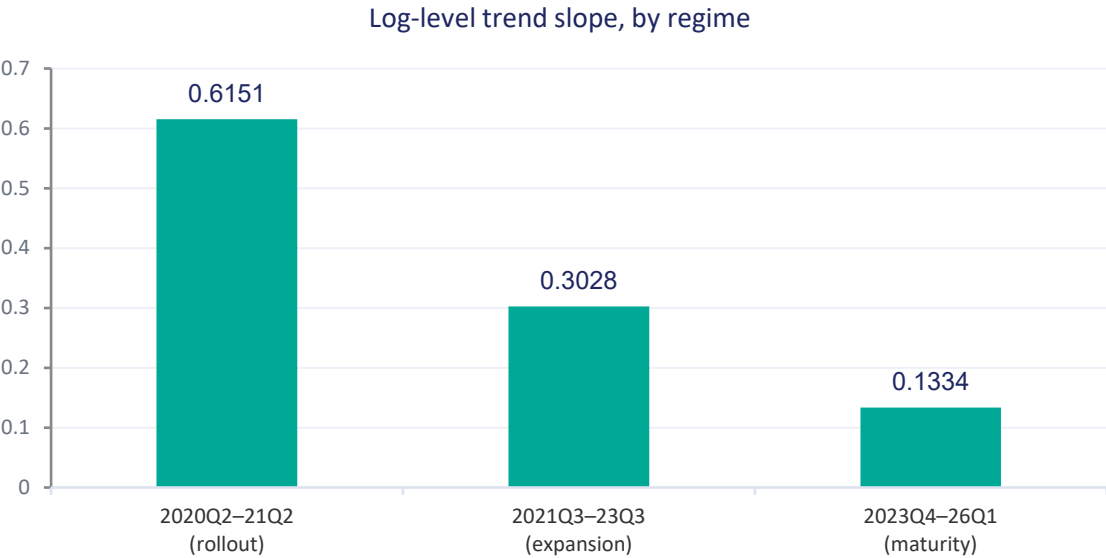


The Best Model Is Horizon-Specific

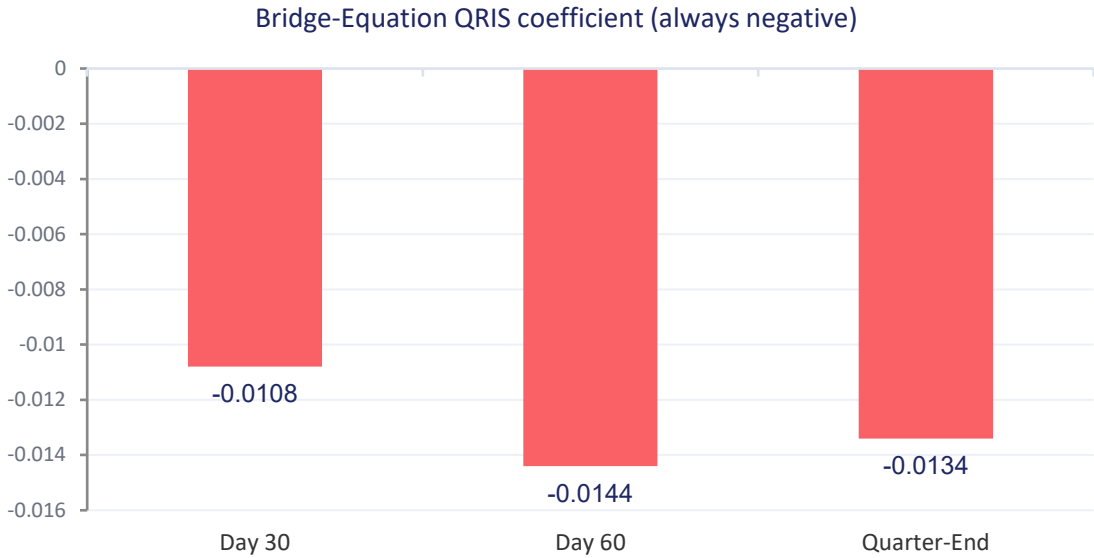


With QRIS, Random Forest has the lowest RMSE at D30 (0.3340) and D60 (0.3976), while Elastic Net is best at EOQ (0.4674). The best model is therefore horizon-specific rather than universal. Winner stability is strongest for Random Forest at the two earlier horizons. It wins every D30 and D60 leave-one-quarter-out sample, indicating that its advantage is not generated by a single target quarter.

QRIS Is Maturing — A Real, but Nonlinear, Signal



Two breaks (AICc/BIC-selected): 2021Q3 and 2023Q4. All slopes stay positive — transaction levels keep rising even as growth decelerates.



QRIS growth decelerates as adoption matures while consumption stays stable — opposing trends, not causation. Nonlinear/regularized models still extract real value because they exploit thresholds, interactions, and persistence that a single linear coefficient cannot capture.

Takeaway: an early, reliable predictive gain does not require a positive linear coefficient — especially while the indicator is still undergoing structural change.





QRIS Complements — Not Replaces — Official Statistics

No vs. expanded QRIS

Improves RMSE in all 12 non-ARIMA cells

Leave-one-quarter-out

RF wins 10/10 at D30/D60; EN wins 8/10 at EOQ

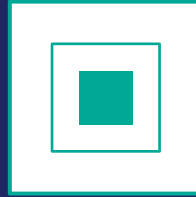
COVID / window sensitivity

Best-model identity is regime-dependent

- 1 QRIS carries genuine incremental predictive value — confirmed across all 12 comparisons, strongest and most significant at Day 30.
- 2 The gain is horizon- and model-dependent: Random Forest leads at Day 30/Day 60; Elastic Net at quarter-end. No single “best” specification.
- 3 The relationship is adoption-sensitive and nonlinear — monitoring systems should recalibrate periodically, not freeze one specification.

Next steps: longer mature-regime sample · archived release vintages · regional/MCC-level QRIS detail · production-side sector nowcasts





Thank You

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Evidence Is Strongest Where Gains Are Largest

Horizon	Model	RMSE: no QRIS	RMSE: expanded QRIS	RMSE gain	Expanded OOS R ²	Expanded directional accuracy
D30	ARIMA	1.164	1.164	0.00%	0.000	50%
D30	Bridge Equation	1.810	0.668	63.07%	0.670	70%
D30	U-MIDAS	1.480	0.536	63.77%	0.788	70%
D30	Elastic Net	0.412	0.411	0.30%	0.875	50%
D30	Random Forest	0.505	0.334	33.83%	0.918	50%
D60	ARIMA	0.921	0.921	0.00%	0.000	20%
D60	Bridge Equation	1.041	0.631	39.44%	0.532	60%
D60	U-MIDAS	0.860	0.684	20.52%	0.449	60%
D60	Elastic Net	0.476	0.470	1.40%	0.740	50%
D60	Random Forest	0.467	0.398	14.84%	0.814	70%
EOQ	ARIMA	0.921	0.921	0.00%	0.000	20%
EOQ	Bridge Equation	0.850	0.685	19.44%	0.448	60%
EOQ	U-MIDAS	0.860	0.819	4.76%	0.210	70%
EOQ	Elastic Net	0.468	0.467	0.06%	0.743	50%
EOQ	Random Forest	0.666	0.520	21.86%	0.681	60%

At Day 30

**3 of 4 models
significant**

At quarter-end

**Mostly
inconclusive**

N = 10 target quarters limits test power; one-sided Diebold–Mariano (HAC/Newey–West, small-sample corrected) and exact permutation tests are read alongside effect size and leave-one-quarter-out stability.

