

Payment Systems as Carbon Proxies A Novel Big Data Analytics Approach to Measure the Carbon Content of Economic Activities

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STRATEGIC ENVIRONMENT

- The global financial landscape is undergoing a fundamental transformation, driven by the recognition that climate change poses a systemic risk to financial stability. (Juhro et. al, 2024)
- The legal and institutional foundation for Bank Indonesia's role in sustainable finance has been decisively strengthened by the landmark 2023 Financial Sector Omnibus Law (P2SK Law). This legislation has fundamentally expanded BI's mandate, explicitly empowering it to develop and regulate sustainable finance.
- Climate-related data serves as a fundamental prerequisite for effective policy formulation and informed decision-making. Governments rely on climate data to develop and implement mitigation and adaptation measures, set emissions reduction targets, and track progress towards climate goals, such as those outlined in the Paris Agreement (UNFCCC, 2015).
- Current official carbon emission data, such as that provided by the Badan Pusat Statistik (Indonesia Central Bureau of Statistics), extends only to 2023, with sectoral breakdowns lagging further to 2019. This scarcity impedes comprehensive measurement of the "carbon content" of economic activities and hinders timely assessments.



RESEARCH QUESTIONS

- How can central banks leverage high-frequency payment system data to create timely indicators for monitoring climate-related economic activity and transition risks?
- How can a transaction-based carbon indicator complement current official carbon emission data to provide a more dynamic and comprehensive view of climate-related financial risks?



PAYMENTS SYSTEM AS CARBON PROXY

Data Exploration

Wholesale Payment System

RTGS transfer to carbon-intensive sectors

Retail Payment System

Credit Card Trx, QR-payment

Focus Sectors



Coal Mining



Logistics



Waste Management



Fuel Consumptions

Proxy and/or complement for carbon emission data, with:

- higher data frequency (e.g. monthly);
- firm-/household group- level, more granular analysis

The Evolving Mandate: Central Banks and Climate- Related Financial Stability

- Physical and transition risks can alter credit, market, and liquidity conditions, thereby threatening the resilience of the financial system. Central banks cannot ignore climate risks because climate change acts as an amplifier of systemic financial vulnerabilities (Wiedmann, 2021; Hansen, 2022).
- Dikau & Volz (2021) convey that 70 out of 135 central banks have a 'direct' or 'indirect' sustainability mandate, with more CB engaging in incorporating climate risk into financial stability or macro-prudential assessments, joining networks, etc. D'Orazio and Popoyan (2022) find that central banks in G20 countries are increasingly operationalizing climate goals through financial stability mandates.

Carbon Emission: Importance, Concept & Measurement

- Carbon emissions are a critical indicator of environmental and financial sustainability, increasingly integrated into the frameworks of investment risk, regulatory compliance, and economic performance. Measuring carbon emissions is central to designing effective decarbonization strategies.
- Wijerathna and Dharmarathna (2023) emphasize the role of financial institutions in either mitigating or exacerbating emissions through their lending patterns, highlighting the importance of integrating carbon footprint metrics into financial product development

AI and Big Data to Support Economic and Financial Analysis

- By processing large volumes of structured and unstructured data (eg emissions disclosures, satellite imagery) AI enables more dynamic and real-time evaluation of corporate sustainability performance.
- Adewale et al. (2023) emphasize that AI-powered financial analysis tools are supporting economic and financial analysis by enabling predictive sustainability analytics, real-time monitoring of risks, and enhanced impact measurement. This approach can be leveraged in sustainable finance file.

Prioritizing Sectoral Transition

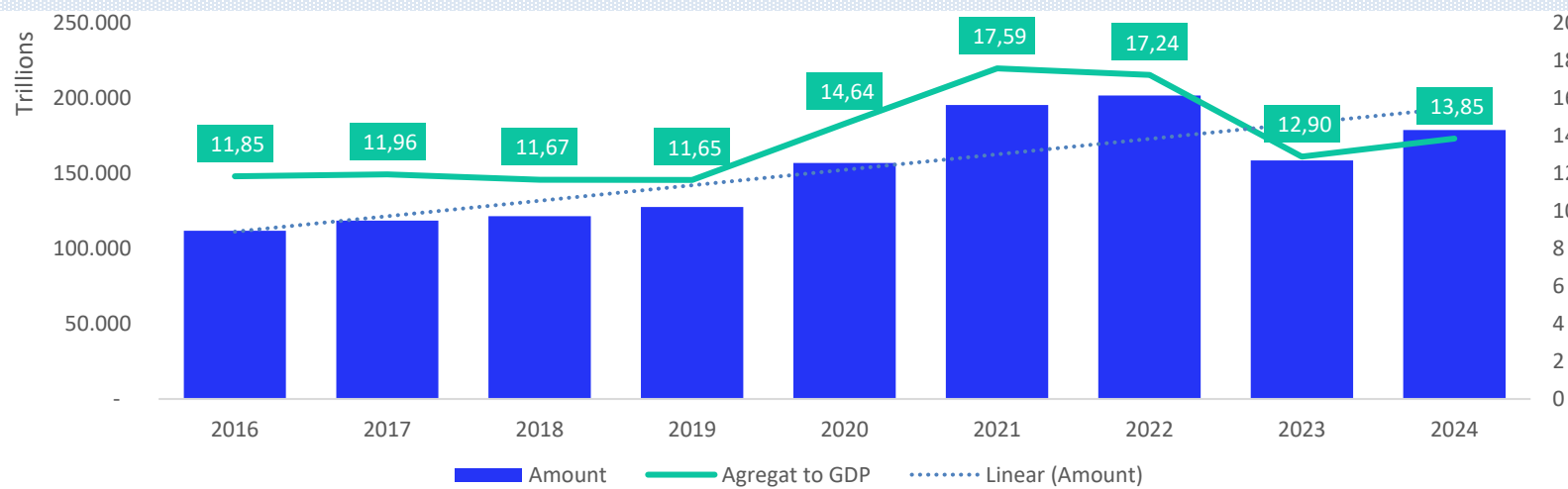
- Achieving a net-zero future requires green finance to strategically prioritize transitions in both hard-to-abate sectors (eg coal-based power, logistics, and waste management) and in household energy consumption.
- Adebayo et al. (2024) emphasize that tailored financing mechanisms such as carbon credits and green bonds are critical to incentivizing emissions reductions and technological upgrades in carbon-intensive industries. On the Household side, Sule et al. (2024) highlight the role of green mortgages, solar panel loans, and climate-focused digital banking tools in enabling sustainable home energy use



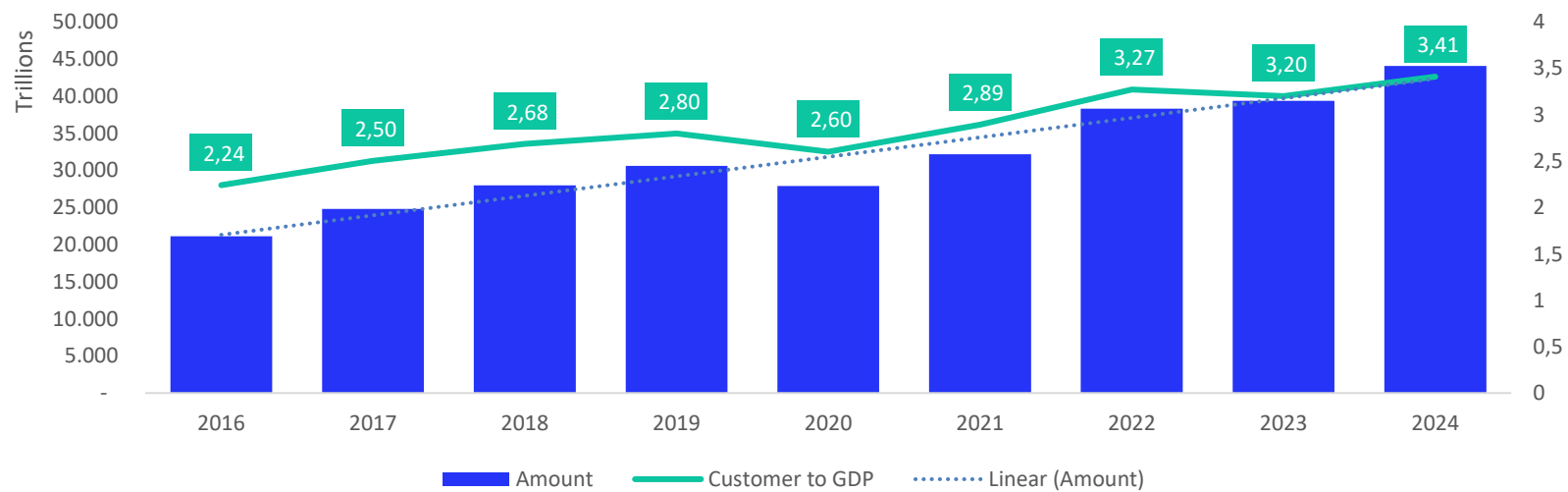
STATE OF RTGS TRANSACTION IN INDONESIA

BI-RTGS is Indonesia's **sole large-value and urgent payment system**, designated as **systemically important**. Since its launch in **2000**, it has become the **backbone** of the **High Value Payment System (HVPS)**, handling transactions above **IDR 100 million**. In **2022**, it processed settlement volumes equal to **17 times national GDP** in aggregate and **3 times GDP** in customer transactions, representing about **90% of total payment value**. As the main channel for interbank settlements in money, FX, securities, and monetary policy operations, BI-RTGS is a cornerstone of financial stability and digital payment infrastructure.

RTGS's Transaction Outlook



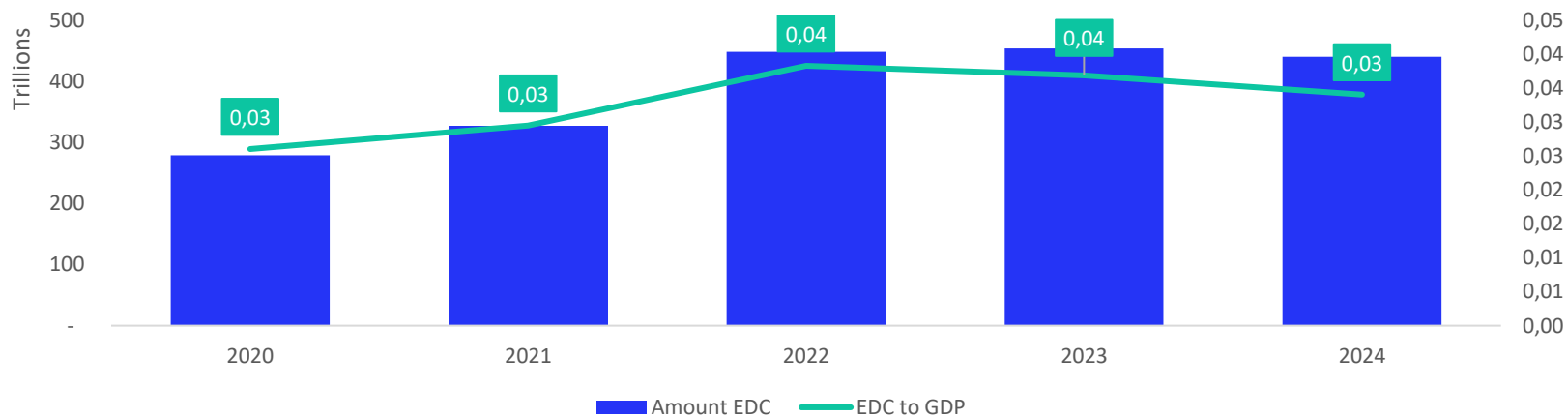
RTGS's Customer Fund Transfer Transaction



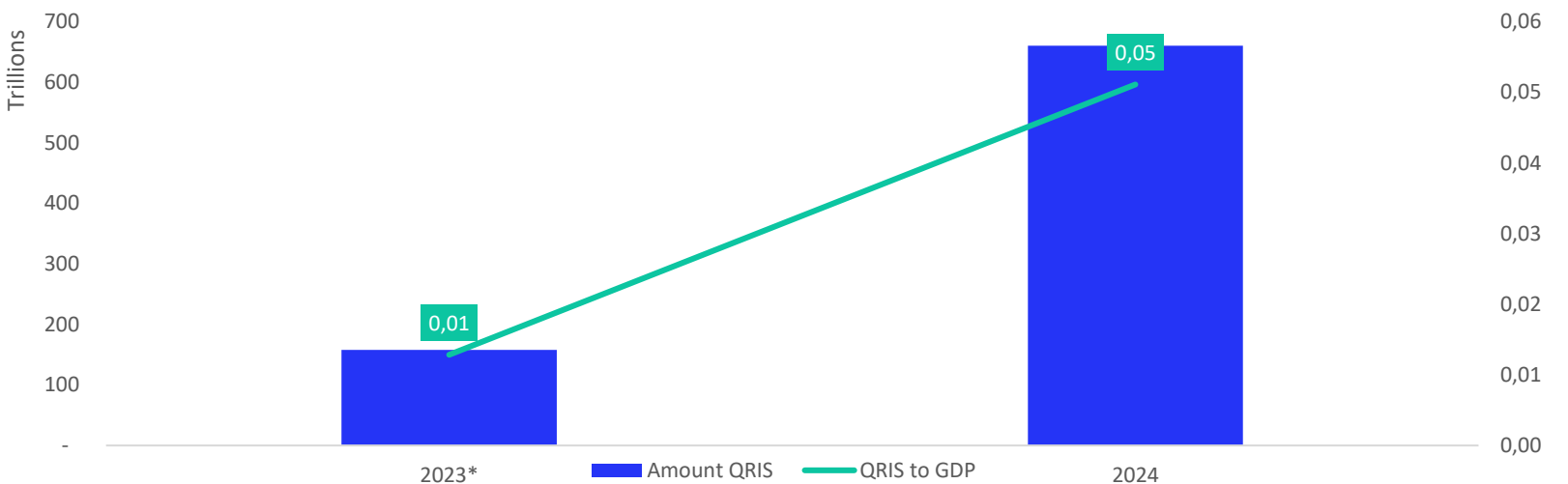
STATE OF NPG TRANSACTION IN INDONESIA

The **National Payment Gateway (GPN)** was launched by Bank Indonesia in 2017 to unify domestic retail payment transactions. Debit transactions through GPN now reach **0.04 times GDP**, while **QRIS**, introduced more recently, has grown rapidly to **0.05 times GDP**. QRIS has become the main retail payment instrument, used from **MSMEs to large merchants**, with a limit of **around IDR 10 million per transaction**, driving digitalization and financial inclusion nationwide.

Electronic Data Capture (EDC) Transaction for Purchasing



Quick Response Code Indonesian Standard (QRIS) Transaction



DATA SOURCE

Wholesale Payment

RTGS

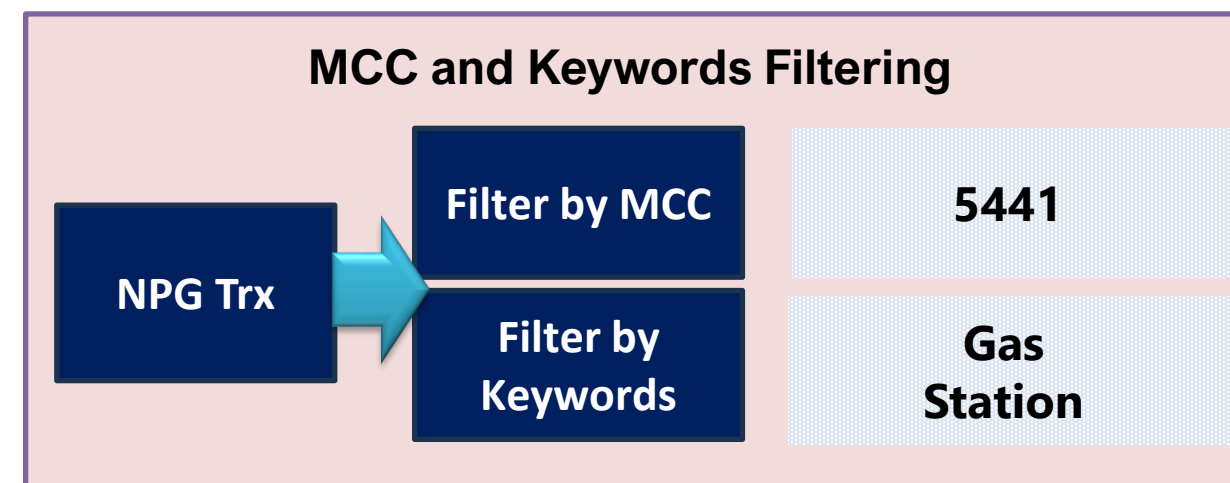
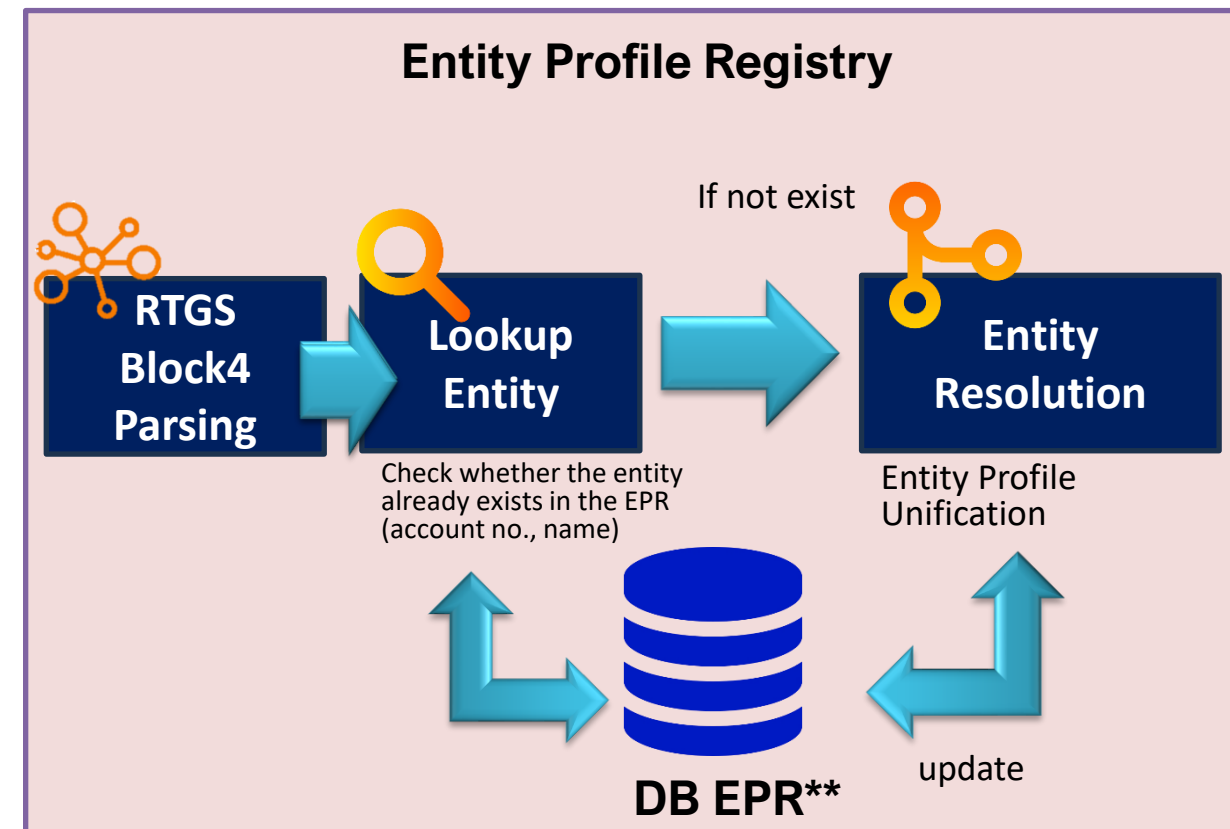
Monetary Operation
Interbank Money Market
Capital Market
Foreign Exchange Transaction
Customer Fund Transfer

Retail Payment

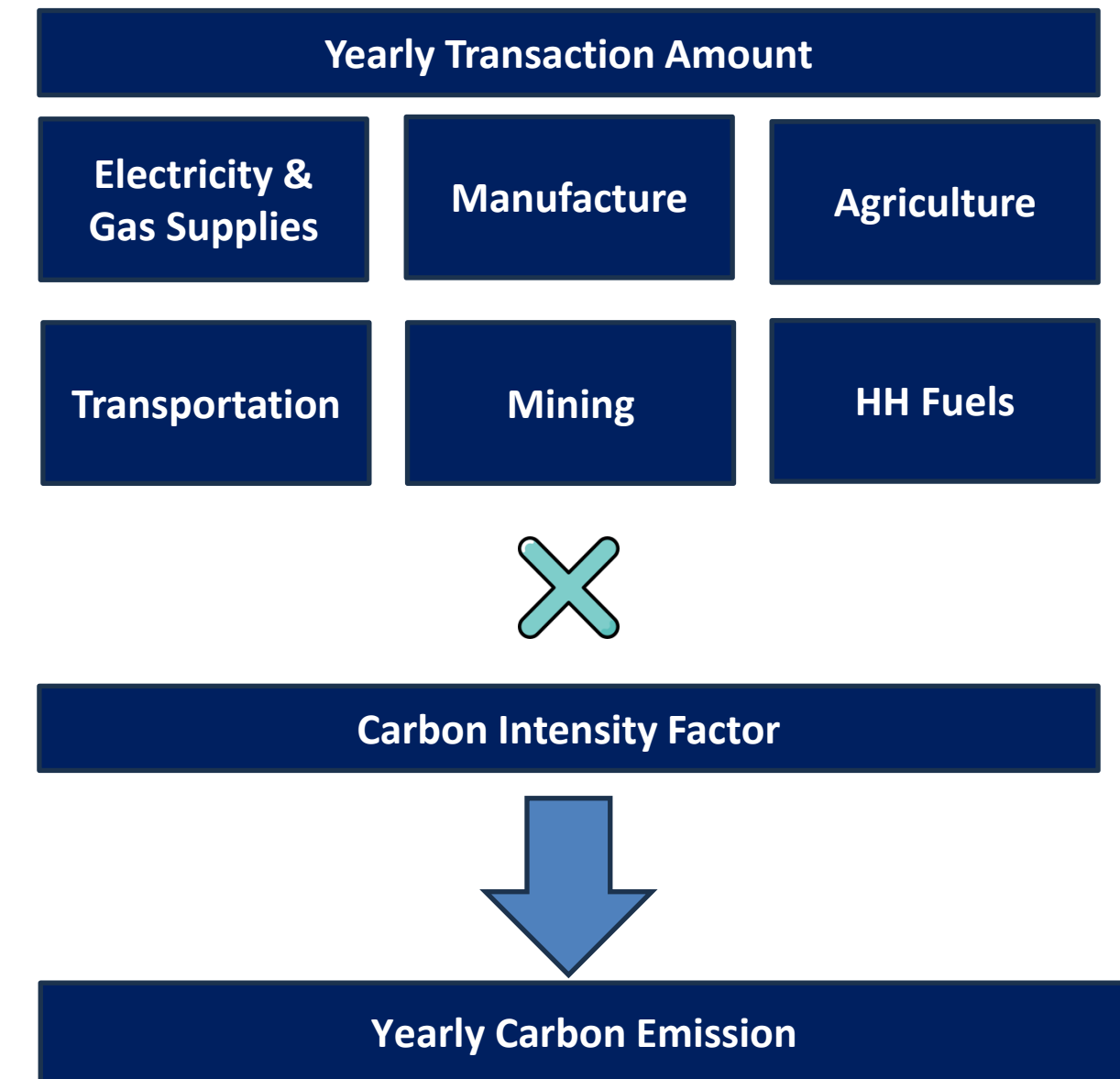
SKNBI
NPG
BI-FAST

ATM Transfer
EDC Machine
QRIS

DATA PROCESSING



CALCULATE CARBON INTENSITY FACTOR



$$CO_2e = \beta \times Transaction_in_Billions_IDR \times intercept$$

CO_2e : Carbon dioxide equivalent β : Carbon intensity factor

RESULT AND ANALYSIS

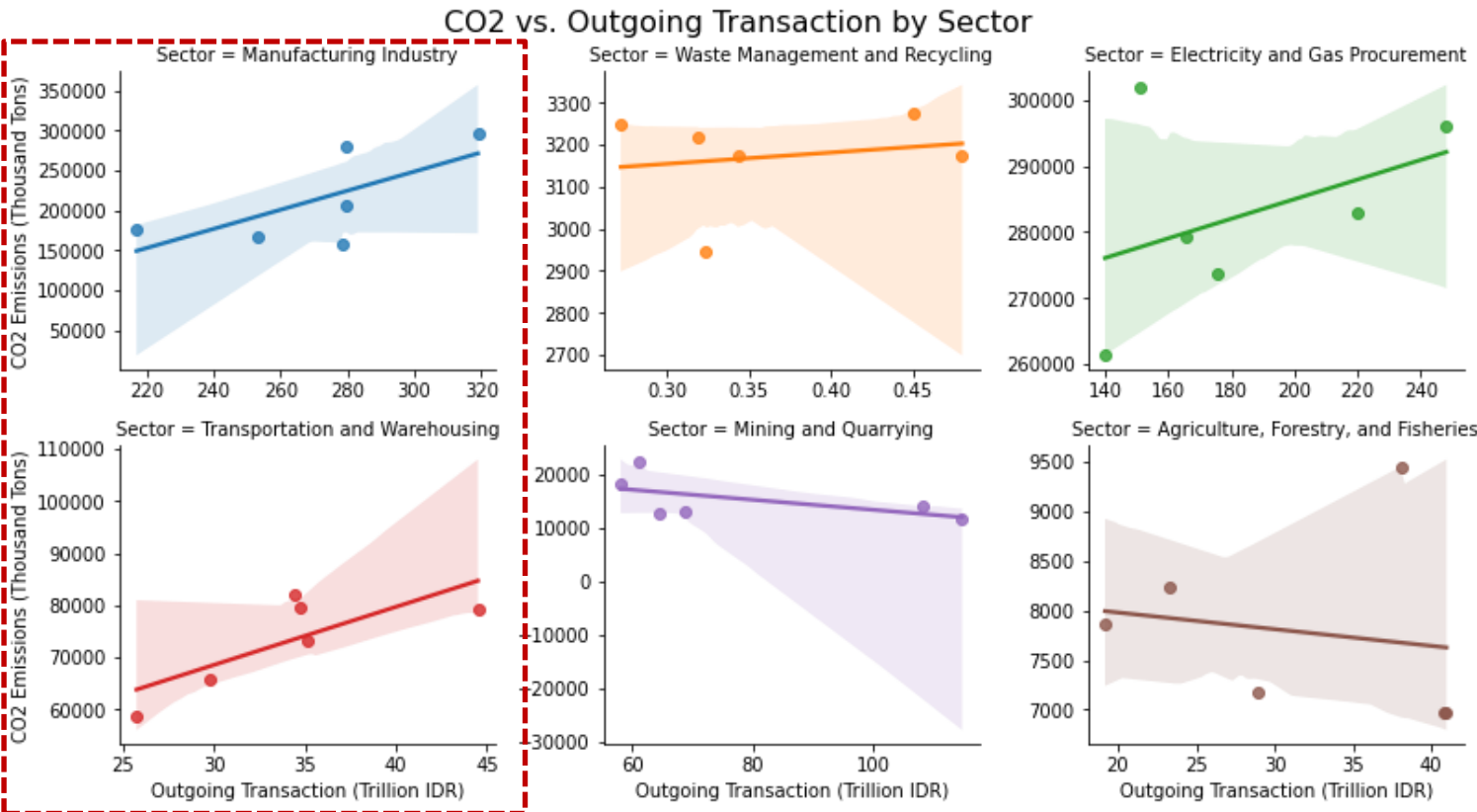
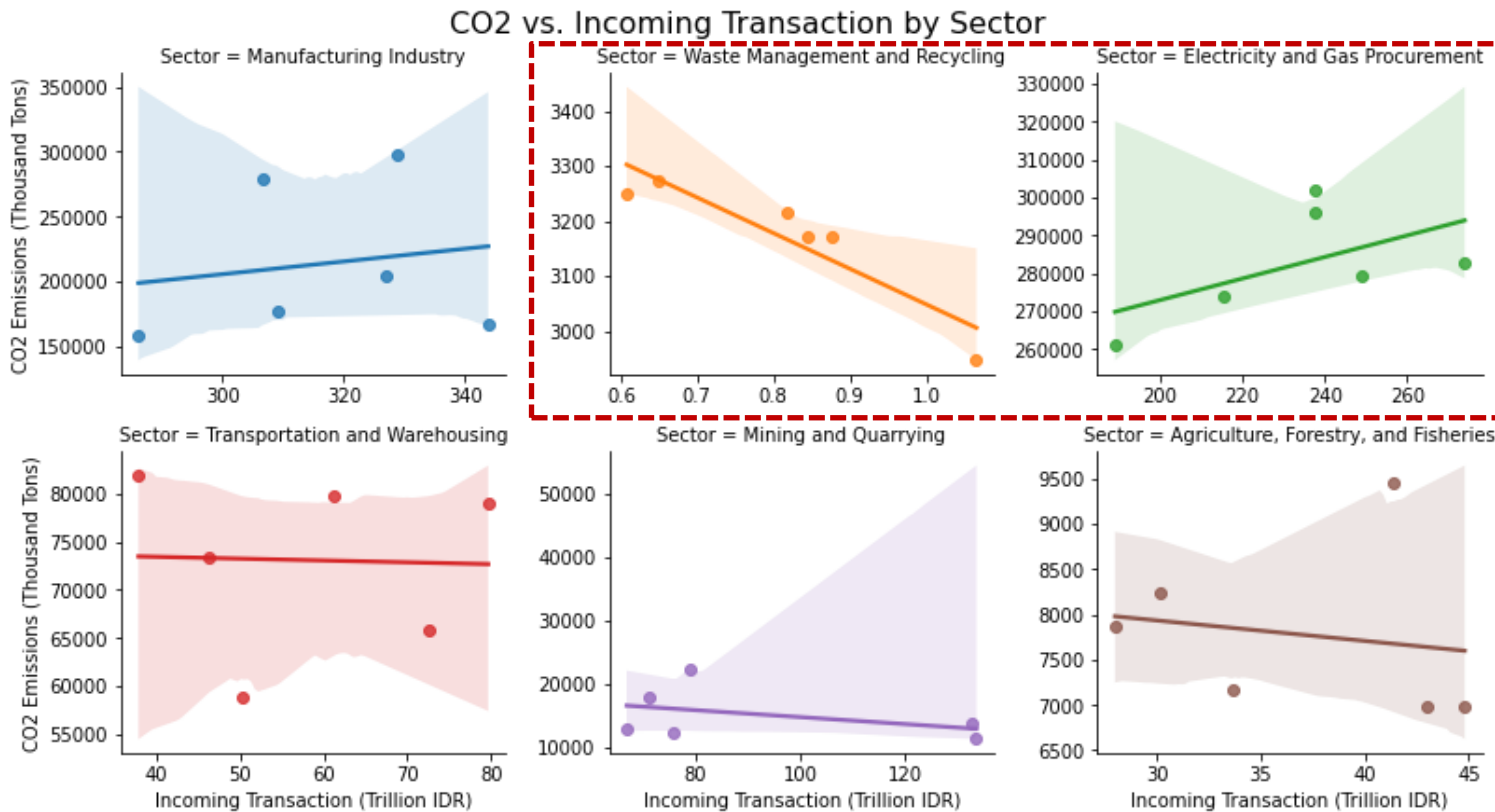


Statistical Testing for Incoming Transaction

Sektor	Observations	Correlation	R-squared	MAPE (%)	Intercept	Factor (Slope)	P-value (Slope)
Manufacturing Industry	6.00	0.17	0.03	22.97	58,859.07	489.63	0.75
Waste Management and Recycling	6.00	(0.91)	0.84	1.22	3,695.36	(646.74)	0.01
Electricity and Gas Procurement	6.00	0.56	0.31	3.57	216,103.57	284.02	0.25
Transportation and Warehousing	6.00	(0.03)	0.00	10.36	74,209.02	(19.18)	0.95
Mining and Quarrying	6.00	(0.41)	0.17	19.04	20,346.63	(54.95)	0.42
Agriculture, Forestry, and Fisheries	6.00	(0.17)	0.03	8.63	8,613.03	(22.61)	0.75

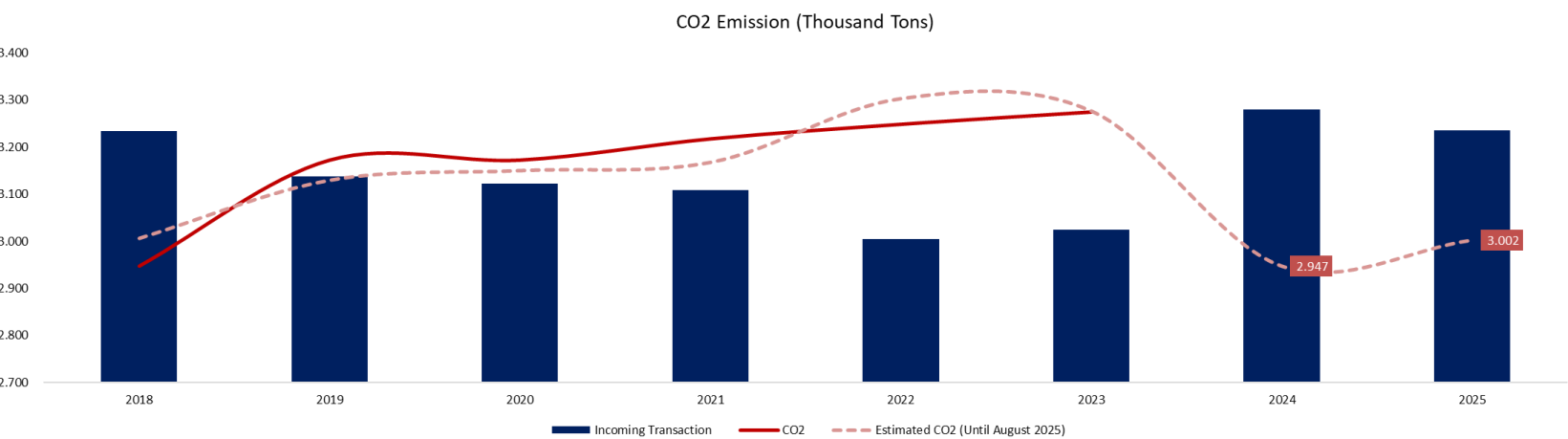
Statistical Testing for Outgoing Transaction

Sektor	Observations	Correlation	R-squared	MAPE (%)	Intercept	Factor (Slope)	P-value (Slope)
Manufacturing Industry	6	0.68	0.46	18.22	(111,096.10)	1,198.55	0.14
Waste Management and Recycling	6	0.19	0.03	2.62	3,073.77	268.39	0.72
Electricity and Gas Procurement	6	0.42	0.18	3.29	255,333.43	148.15	0.40
Transportation and Warehousing	6	0.77	0.59	6.45	35,064.07	1,115.90	0.07
Mining and Quarrying	6	(0.57)	0.32	16.67	22,679.69	(94.18)	0.24
Agriculture, Forestry, and Fisheries	6	(0.16)	0.03	8.67	8,316.20	(16.81)	0.76



Waste Management and Recycling

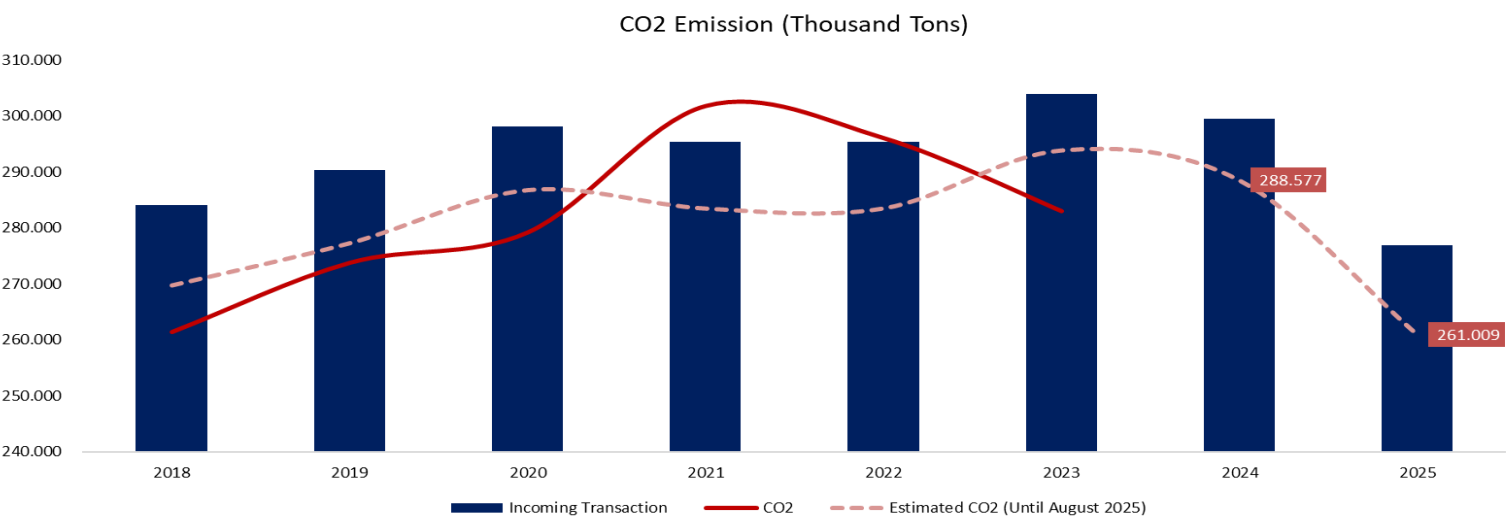
$CO_2 \text{ Emissions} = (-646.74 \times \text{Incoming Transaction Amount}) + 3,695.36$



This model suggests a negative relationship for this sector; as incoming transaction amounts increase, CO2 emissions are predicted to decrease.

Electricity and Gas Procurement

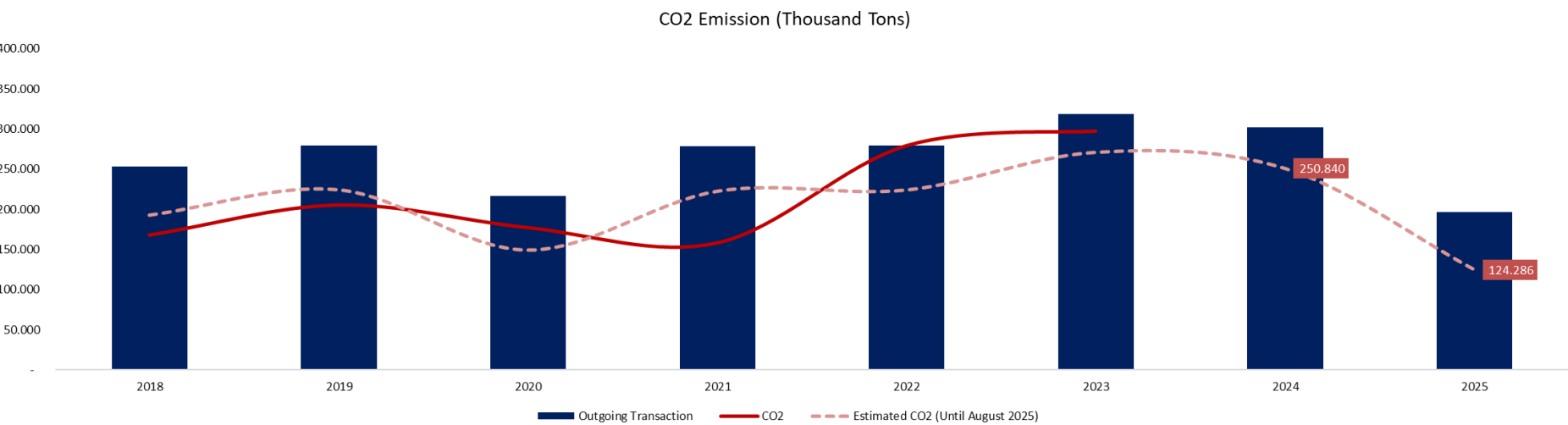
$CO_2 \text{ Emissions} = (284.02 \times \text{Incoming Transaction Amount}) + 216,103.57$



This model suggests a positive relationship; as incoming transaction amounts increase, CO2 emissions are also predicted to increase.

Manufacturing Industry

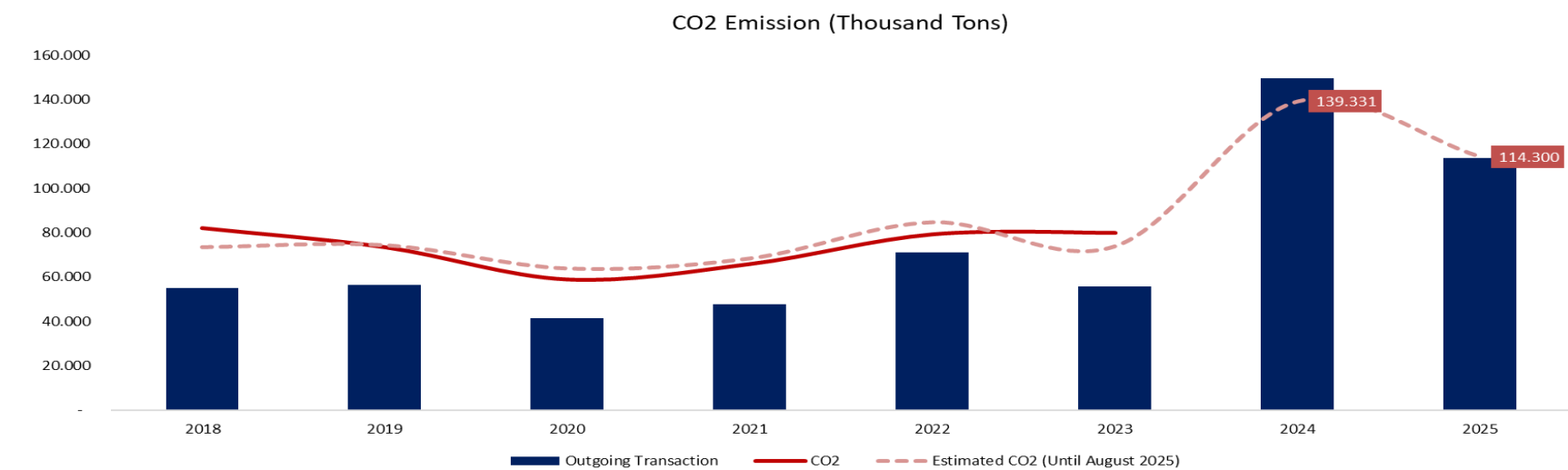
$CO_2 \text{ Emissions} = (1,198.55 \times \text{Outgoing Transaction Amount}) - 111,096.10$



This model suggests a positive relationship for this sector; as outgoing transaction amounts increase, CO2 emissions are predicted to increase.

Transportation and Warehousing

$CO_2 \text{ Emissions} = (1,115.90 \times \text{Outgoing Transaction Amount}) + 35,064.07$



This model suggests a positive relationship for this sector; as outgoing transaction amounts increase, CO2 emissions are predicted to increase.

Estimation of CO2 emission per fuel type.
Average price of 1L of gasoline since 2020 per Fuel Type

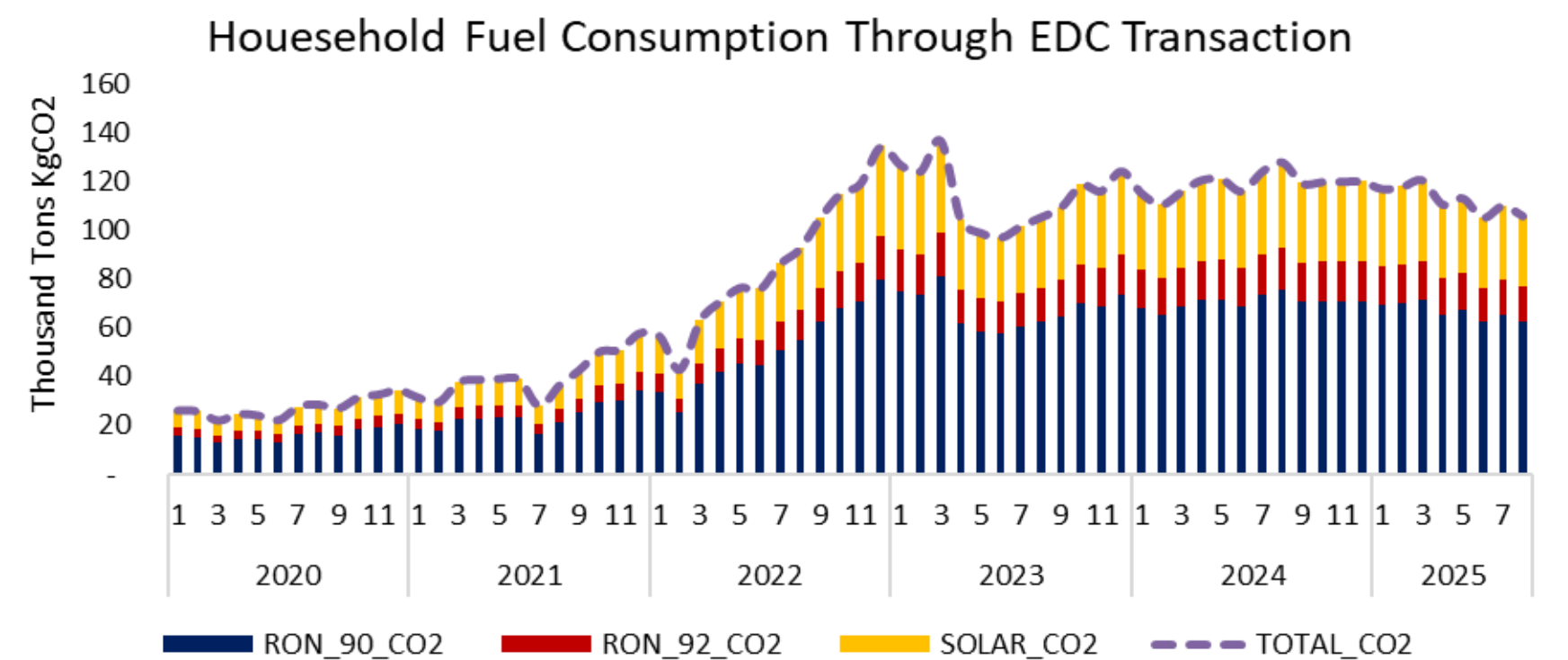
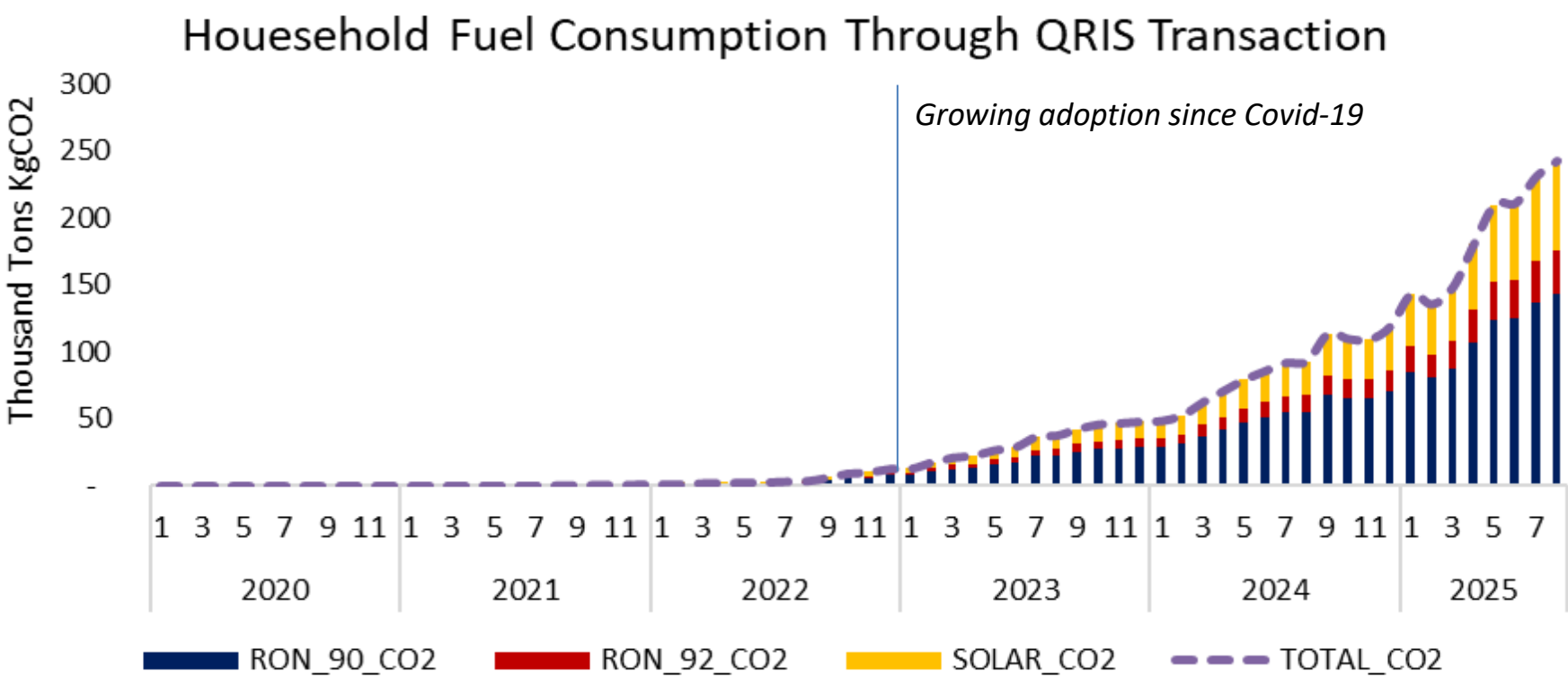
Fuel type	CO ₂ tailpipe emissions (kg/L)
Gasoline	2.29
E10 (10% ethanol + 90% gasoline)	2.21
E85 (85% ethanol + 15% gasoline)	1.61
Diesel	2.66
B5 (5% biodiesel + 95% diesel)	2.65
B20 (20% biodiesel + 80% diesel)	2.62

Source: Natural Resources Canda

Fuel Type	Average Price (Rp/L)	Weight Sales
RON 90	9050	50
RON 92	12000	15
SOLAR	6800	35

Source: Author’s synthesis from Pertamina & Ministry of Natural Resources Report

$CO_2 \text{ Emissions} = \text{Total Sales} \times \text{Weight Sales} \times \text{Average Price per Litre} \times CO_2 \text{ Emission/L}$



KEY FINDINGS:

1

For sectors such as Transportation, Manufacturing, and Electricity, the transaction amount shows a correlation with operational activity. Higher spending on inputs (such as fuel and materials) or higher income (for electricity) is linked to increased energy use, which in turn leads to higher CO2 emissions.

2

In the waste management case, increased economic activity reflects an environmental service that causes a net reduction in emissions.

3

While emissions tracked through traditional card payments appear stable, the growth in QRIS transactions still shows an uptrend in the carbon footprint of household transportation

FUTURE WORK:

1. Conduct a qualitative analysis to understand why higher incoming and outgoing transactions correlate with lower and higher emissions.
2. Confirm the interpretations by differentiating transaction purposes within each sector by breaking down sectoral interconnections, for example, the manufacturing industry and electricity supply.



Data at your
fingertips.



THANK YOU

15 September 2025

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