Instituto Nacional
de Ciências e Tecnologia de Timor-Leste

Relatório de Investigação
Científica INCT 2025

Investigating Potential Cheating Practices at Gas Stations in Timor-Leste: A Study on Consumer Protection and Market Integrity

Dr. Pedro Ximenes, ST,MM

Dezembro 2025

Instituto Nacional

de Ciências e Tecnologia de Timor-Leste

Scientific Research Report

INCT 2025

Investigating Potential Cheating Practices at Gas Stations in Timor-Leste: A Study on Consumer Protection and Market Integrity

Area of Study :
Access and development of Electronic Sciences and Information and Communication Technologies in Timor-Leste

Conducted by :
Principal Researcher : Dr. Pedro Ximenes, ST,MM
Co-researchers:
Antonio Soares Martins, Lec, MBA
Sandra Ximenes, Lec, MT
Marcos Pinto Romeo, Lec, MBA

Dili, 8 Dezembro 2025

Declaration

Principal Investigator's Name : Dr. Pedro Miguel de F.G.B Ximenes, ST,MM

Email Address: pedro.ximenes@iob.edu.tl

Phone/Mobile: +67077389449

Identity Card Number:

Title of INCT 2025 Scientific Research: Investigating Potential Cheating Practices at GasStations in Timor-Leste: A Study on Consumer Protection and Market Integrity

Area of Knowledge: Access and development of Electronic Sciences and Information and Communication Technologies in Timor-Leste

Year of Completion: 2025

I declare, on my honor, that the data presented here are true and original and that in this study presented, no plagiarism or any illegality in terms of copyright has been committed.

I authorize the integral reproduction of this report for the INCT National Digital Repository, its electronic sites, and for scientific research purposes.

National Institute of Science and Technology, on 08 of December of 2025

Principal Investigator's Signature: _____ _____.

ABSTRACT

This research report presents findings from a comprehensive mixed-methods study investigating potential cheating practices at gas stations in Timor-Leste. The study employed direct fuel measurements at 35 gas stations (177 transactions totaling 947,000ml), consumer surveys (n=206), and systematic observational assessments to evaluate market integrity and consumer protection in the petroleum retail sector. Key findings reveal systematic fuel under-delivery of 0.704% across measured transactions, with significant variations by fuel type (diesel 47% higher fraud rates than petrol) and location (rural areas showing double urban rates). Consumer experiences strongly correlate with objective measurements, with 87.4% reporting suspicious experiences. The study provides evidence-based recommendations for regulatory enhancement, consumer protection measures, and market transparency improvements to strengthen Timor-Leste's fuel retail sector integrity.

Keywords: Consumer Protection; Market Integrity; Fuel Retail; Regulatory Oversight; Timor-Leste

Table of Content

List of Figures

1. INTRODUCTION

1.1 Introduction and Contextualization

Timor-Leste's petroleum sector dominance underscores the critical importance of transparent resource management for economic development. Oil and gas comprised 76.4% of GDP in 2013 and provided over 93% of state revenues in 2014, with the Petroleum Fund containing $17 billion (La'o Hamutuk & Scheiner, 2015). This extreme resource dependence creates significant challenges for sustainable development, as Timor-Leste exhibits characteristics typical of countries struggling with natural resource revenue management (Drysdale, 2008). The country's troubled history has weakened state institutions, with corruption and financial mismanagement present (Drysdale, 2008). Despite establishing the Petroleum Fund Law based on principles of transparency and intergenerational equity, the fund may be depleted by 2025 (La'o Hamutuk & Scheiner, 2015). Research indicates that transparent petroleum revenue management is essential, with spending priorities focused on health and education being most important to stakeholders (Drysdale, 2007). The government recognizes the need for economic diversification, launching the Strategic Development Plan (2011-30) to reduce oil dependency (Harmadi & Gomes, 2013).

Timor-Leste's fuel market has undergone significant growth, particularly in the commercial sector, where diesel and petrol consumption have fluctuated over the years. Between 2017 and 2023, diesel consumption for commercial purposes ranged from approximately 72 to 76 million liters annually, while petrol usage varied between 40 and 65 million liters. Concurrently, the number of gas stations increased from 31 in 2017 to 73 in 2023, indicating a rapid expansion in fuel retail infrastructure.

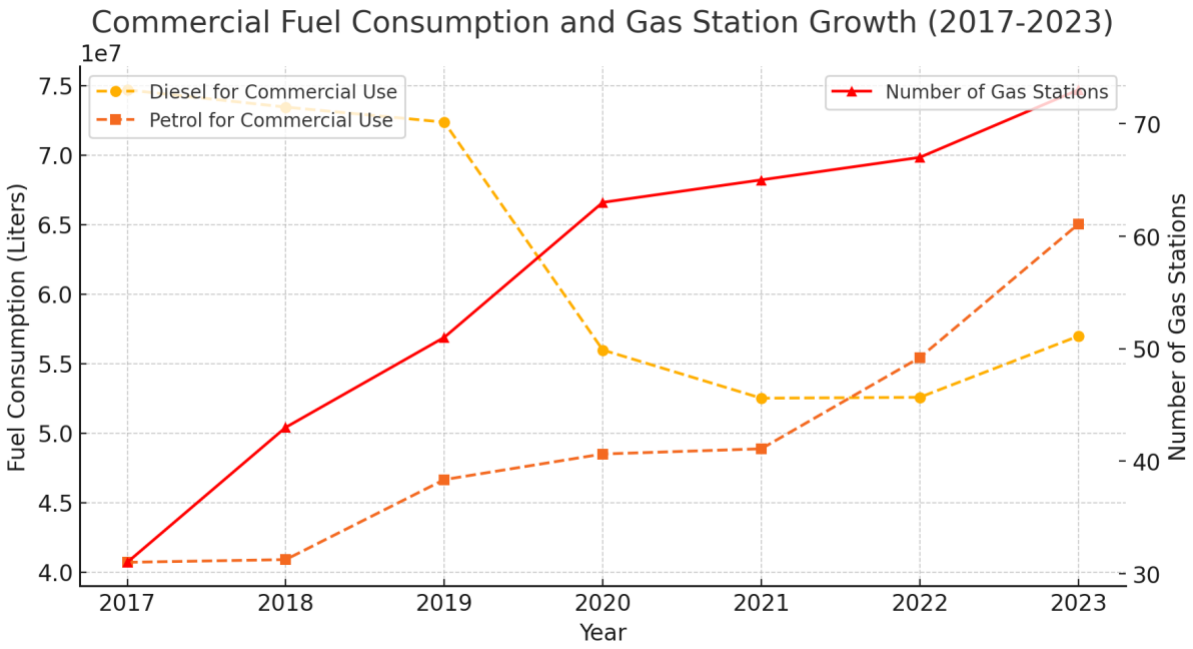


Figure 1. Fuel Market Progression in Timor-Leste 2017-2023

Despite this growth, concerns have been raised regarding potential fraudulent activities in the fuel distribution system, including inaccurate fuel dispensing, meter tampering, and price manipulation. These practices not only compromise consumer protection but also affect market reliability, leading to financial losses for businesses and reducing trust in the fuel retail sector. This research aims to assess potential cheating at gas stations in Timor-Leste, focusing on commercial fuel consumption. By analyzing fuel supply data, consumer experiences, and regulatory enforcement mechanisms, the study will provide insights into the extent of malpractice in the sector and propose policy recommendations to enhance market transparency, protect consumers, and ensure fair trade practices.

This study aims to investigate potential cheating practices at gas stations in Timor-Leste, evaluate their impact on consumers and the economy, and propose evidence-based recommendations to enhance consumer protection and market integrity. The research aligns with the ANP's mandate to regulate downstream activities and ensure satisfactory supply and quality levels of petroleum products (Government of Timor-Leste, 2012).

1.2 Theoretical Framework and Literature Review

Timor-Leste's gas station sector faces significant challenges related to potential cheating practices that undermine consumer protection and market integrity. Despite the country's rich petroleum resources, systemic issues including corruption, weak governance, and inadequate regulatory enforcement create environments where unscrupulous practices can flourish at the retail level (Drysdale, 2008; Pascoal da Costa Oliveira et al., 2023). This literature review synthesizes available evidence on cheating practices at gas stations in Timor-Leste, drawing from regulatory reports, consumer advocacy findings, and comparative regional studies.

1.2.1. Systemic Governance and Corruption Challenges

The foundation of potential cheating practices in Timor-Leste's fuel retail sector lies in broader systemic corruption and weak governance structures. Research indicates that despite being resource-rich, Timor-Leste has long struggled with corruption and weak governance in its oil and gas industry, which significantly impacts market integrity and consumer protection (Drysdale, 2008; Pascoal da Costa Oliveira et al., 2023). The independent anti-corruption agency, Comissão Anti-Corrupção (CAC), faces substantial difficulties with political independence, legal authority, and budget constraints, limiting its ability to effectively combat corruption in the energy sector (SEA Anti-Corruption, 2025).

This institutional weakness creates a permissive environment for potential fraudulent activities at the retail level, where oversight and enforcement mechanisms are particularly vulnerable. The mismanagement of resources and lack of transparency in contracts and pricing mechanisms create environments conducive to unscrupulous practices at gas stations.

1.2.2. Evidence of Cheating and Price Manipulation in Timor-Leste

Direct evidence of irregularities and potential cheating at Timor-Leste gas stations has been documented through consumer advocacy and regulatory observations. The TANE Konsumidór Association has raised significant concerns over non-transparent fuel pricing, where suppliers determine prices that may adversely affect consumer rights (Tatoli, 2022). Surveys have identified concerning inconsistencies in prices among fuel stations, suggesting possible manipulation or unfair market practices that do not correspond proportionally to global market price fluctuations.

Additional challenges to market integrity arise from fuel smuggling, particularly of subsidized fuel. Areas like Oecusse have been identified as hotspots for smuggled fuel operations, which distort market operations and enable unfair competition (Tempo, 2016). This parallel market creates opportunities for adulterated or substandard fuel to enter the system while providing cover for legitimate stations to engage in questionable practices.

1.2.3. Regional Context and Comparative Evidence

1.2.3.1. Southeast Asian Cheating Practices

Research from neighboring Southeast Asian countries provides valuable insights into the types of cheating practices that may occur in similar contexts. Fuel adulteration and cheating practices at gas stations represent significant economic and public health concerns across the region (Tharby, 2002). In South Asia, gasoline and diesel are commonly adulterated with lower-priced materials, resulting in increased vehicle emissions, tax revenue losses, and substantial financial benefits for perpetrators.

Korean gas stations operating under unfavorable economic conditions—including increased competition, lower retail prices, or higher operating costs—are more likely to engage in fraudulent activities, with fraud clustering geographically among nearby stations (Ahlin et al., 2020). Similarly, in Mexico's regulated pricing environment, higher regulated mark-up prices reduce cheating incentives, while increased competition decreases average fuel shortages (Arteaga & Flores, 2010).

1.2.3.2. Indonesian Case Studies

Research from Indonesia provides particularly relevant insights due to geographical proximity and similar developmental challenges. Deviana Yuanitasari et al. (2020) documented systematic manipulation of dispensing pump digital systems by gas station operators to defraud consumers, highlighting sophisticated technological approaches to fuel retail fraud. At Pertamina gas stations, perpetrators including managers and employees used additional equipment installed in fuel dispensers controlled by remote controls to deceive consumers (Ardi & Wijaya, 2019).

Similar fraudulent practices were documented at Bungkul gas station in Indramayu, where electronic circuits were added to measuring pumps, causing consumer harm through inaccurate fuel dispensing that exceeded permissible error limits (Wahjuni et al., 2022). Studies of mini gas

stations revealed violations of business ethics principles through deliberate fuel quantity reduction, contravening consumer protection regulations (Lisnawati et al., 2020). Additionally, price rounding practices at Banjarmasin gas stations raise concerns regarding fairness and honesty in transactions (Fauji et al., 2023).

1.2.4. Methods and Economic Impact of Fuel Fraud

1.2.4.1. Common Cheating Methods

Research reveals several key methods of fuel fraud worldwide. Primary techniques include dispensing less fuel than consumers pay for, with fraud incentives influenced by market conditions (Arteaga & Flores, 2010). Stations typically maintain constant prices while selling adulterated fuel to increase profit margins, with independent stations showing weaker reputational incentives than chain stations (Ahlin et al., 2020). Fuel adulteration represents another major fraud method, where adulterants are mixed into gasoline, requiring specialized detection techniques (Lima et al., 2004).

1.2.4.2. Economic Consequences

The economic impacts of fuel fraud are substantial and multifaceted. Research demonstrates that fuel fraud reduces consumer welfare and government excise revenue while providing significant financial benefits to perpetrators (Kojima & Bacon, 2001; Tharby, 2002). In Brazil, metrological frauds in fuel measurement instruments create substantial economic distortions, with consumer losses ranging from US$54.9 million to US$303.7 million due to measurement deviations (Filho & Gonçalves, 2016).

Fuel adulteration can cause serious vehicle damage and increase harmful emissions, worsening urban air pollution and public health outcomes (Tharby, 2002). Chain stations show stronger reputational incentives for product credibility compared to independent operators (Ahlin et al., 2020). Additionally, collusive pricing behaviors have been documented, with price increases transmitted to consumers faster than decreases (Jacob et al., 2019).

1.2.5. Regulatory Framework and Enforcement Challenges

Timor-Leste has established legal and regulatory frameworks aimed at consumer protection and market regulation in the petroleum sector. Decree-Laws regulate petroleum operations, mandating compliance with safety, quality, and environmental standards in fuel marketing and

distribution (Timor-Leste Trade Portal, 2024). The regulatory body Agência Nacional do Petróleo (ANP) oversees compliance of fuel stations with these standards, providing a formal framework for preventing cheating practices (ANP, 2024).

However, the effectiveness of this regulatory framework is significantly limited by enforcement capacity and institutional independence. Timor-Leste aligns its consumer protection policies with international standards, including the United Nations Convention Against Corruption (UNCAC) and relevant World Trade Organization accession commitments (WTO, 2024). Nevertheless, the gap between policy framework and implementation remains substantial, with ongoing issues of corruption, weak institutional independence, and market control by suppliers hindering effective enforcement.

The government's introduction of fuel subsidy programs, while intended to protect consumers from global commodity price shocks (Independente, 2023), cannot fully address market manipulation at the point of sale without effective regulatory control and monitoring.

1.2.6. Fuel Dispenser Accuracy Standards

Fuel dispenser accuracy is globally regulated through harmonized standards establishing maximum permissible errors. The United States National Institute of Standards and Technology (NIST) Handbook 44 specifies ±0.3% tolerance, meaning a 10-gallon purchase may deliver between 9.97 and 10.03 gallons (Wikipedia, 2024). Similarly, Australian regulations mandate that "all fuel dispensers must be accurate within ± 0.3%" (ACAPMAG, 2020, 2021). China's JJG443-2006 verification regulation stipulates identical maximum allowable error of ± 0.3% (Eaglestar Energy Technology, 2021).

International harmonization is achieved through OIML R117 "Dynamic measuring systems for liquids other than water," the official international standard for fuel dispensers covering 60 member states (Phys.org, 2015). This comprehensive standard classifies fuel dispensers under accuracy class 0.3, aligning with national requirements (PDFSLIDE.NET, 2019). The standard ensures global consistency, as OIML recommendations serve as the basis for national regulations (Gram Group, 2025). Consequently, fuel dispensers exceeding ±0.3% tolerance, such as 0.74%

underdelivery, violate both national and international standards, requiring immediate recalibration by certified technicians.

The literature reveals a complex landscape of challenges affecting consumer protection and market integrity at gas stations in Timor-Leste. Key contributing factors include: systemic corruption and weak governance in the oil and gas sector; documented price manipulation and inconsistent fuel pricing across stations; regulatory frameworks that exist but require stronger enforcement and independence; and market distortions from fuel smuggling operations.

The comparative evidence from regional countries demonstrates that fuel retail fraud can take sophisticated technological forms, while the broader governance context in Timor-Leste suggests that systemic corruption creates permissive environments for such practices. The combination of weak institutional capacity, limited regulatory enforcement, and established parallel market networks creates multiple pathways for potential consumer fraud.

Consumer protection in developing nations faces unique challenges related to regulatory capacity, enforcement mechanisms, and market transparency. Timor-Leste's emerging consumer protection landscape, exemplified by organizations like TANE KONSUMIDOR (established 2018), reflects growing awareness of consumer rights in contexts where regulatory frameworks are still developing.

The theoretical foundation for this research draws from market integrity theory, which posits that transparent, fair trading practices are essential for economic development and consumer trust. In resource-dependent economies like Timor-Leste, petroleum sector integrity is particularly crucial given its economic significance and impact on household budgets.

International research on fuel retail fraud indicates common practices including volume manipulation, quality degradation, and price inconsistencies. However, limited empirical research exists on these phenomena in Timor-Leste's specific context, creating a significant knowledge gap this study addresses.

1.3 Problem Formulation

The central research problem addresses the extent and nature of potential cheating practices at gas stations in Timor-Leste, their impact on consumer welfare, and the effectiveness of current regulatory oversight. Specific issues include:

1. Systematic under-delivery of fuel volumes relative to payments
2. Quality variations affecting vehicle performance and maintenance costs
3. Price transparency and consistency across stations
4. Regulatory monitoring and enforcement effectiveness
5. Consumer awareness and recourse mechanisms

1.4 Research Hypotheses

Based on preliminary observations and consumer reports, this study tested the following hypotheses:

H1: Gas stations in Timor-Leste systematically deliver less fuel than paid for, resulting in quantifiable consumer losses.

H2: Consumer perceptions of cheating practices correlate with objective measurements of fuel delivery accuracy.

H3: Current regulatory oversight mechanisms are insufficient to prevent and address fraudulent practices in the fuel retail sector.

H4: Consumer awareness of rights and complaint mechanisms remains limited, reducing accountability pressure on gas station operators.

1.5 Research Objectives

General Objective: To investigate potential cheating practices at gas stations in Timor-Leste and assess their impact on consumer protection and market integrity.

Specific Objectives:

1. Quantify the extent of fuel under-delivery through direct measurements at gas stations
2. Document consumer experiences and perceptions of potential cheating practices
3. Assess the effectiveness of current regulatory oversight mechanisms
4. Evaluate consumer awareness of rights and complaint procedures

5. Provide evidence-based recommendations for enhancing consumer protection and market integrity

1.6 Research Importance and Justification

This research addresses critical gaps in understanding Timor-Leste's fuel retail sector integrity while providing actionable insights for policymakers, regulators, and consumer protection advocates. The study's significance includes:

- Economic Impact: Quantifying consumer losses from potential fraudulent practices
- Regulatory Enhancement: Informing ANPM oversight and enforcement strategies
- Consumer Empowerment: Raising awareness of rights and available recourse mechanisms
- Market Development: Supporting fair competition and transparent pricing
- Academic Contribution: Advancing knowledge of consumer protection in developing economies

1.7 Work Organization

The research was conducted in four sequential phases:
Phase 1: Literature review and theoretical framework development **Phase 2:** Data collection including direct fuel measurements, consumer surveys, and observational assessments **Phase 3:** Data analysis using mixed-methods approaches combining quantitative statistical analysis with qualitative thematic analysis **Phase 4:** Results interpretation, recommendation formulation, and report preparation

1.8 Geographic Scope

The study encompassed gas stations across multiple districts of Timor-Leste, with primary focus on:

- Dili Municipality: Urban commercial center with highest concentration of gas stations
- Regional Districts: Including Baucau, Lautem, Ermera, Maliana, Liquisa, Aileu, Manatutu, and Ainaro
- Urban vs. Rural Analysis: Comparing practices between metropolitan and peripheral area

2. METHODOLOGY

2.1 Research Methodology

This study will adopt a mixed-methods approach, combining quantitative and qualitative methods to provide a comprehensive understanding of the issue (Creswell & Plano Clark, 2018). The use of mixed methods research for investigating potential cheating practices at gas stations in Timor-Leste is justified for several reasons:

1. Comprehensive understanding: Mixed methods research integrates quantitative and qualitative approaches to provide a more thorough exploration of complex phenomena (Creswell & Plano Clark, 2018).
2. Addressing complexity: The qualitative component enables engagement with the complexity of health and healthcare interventions, as well as the environment in which studies take place (O'Cathain et al., 2007).
3. Triangulation: Using different methods to collect data on the same subject can enhance the credibility of results (Schoonenboom & Johnson, 2017).
4. Complementary strengths: Mixed methods research benefits from both the detailed, contextualized insights of qualitative data and the generalizable, externally valid insights of quantitative data (Schoonenboom & Johnson, 2017).
5. Flexibility in research design: Mixed methods offer more flexibility in designing research, allowing for the combination of aspects from different types of studies to yield the most informative results (Fetters, 2020).
6. Practical problem-solving: The pragmatic paradigm often applied in mixed methods research orients the study design towards solving practical problems in the 'real world' (O'Cathain et al., 2007).

By employing a mixed methods approach, this study can effectively address the complex issue of potential cheating practices at gas stations in Timor-Leste, providing valuable insights for policymakers and stakeholders in the petroleum sector.

The research design integrated **convergent parallel methodology** where quantitative and qualitative data were collected simultaneously and analyzed separately before integration during interpretation.

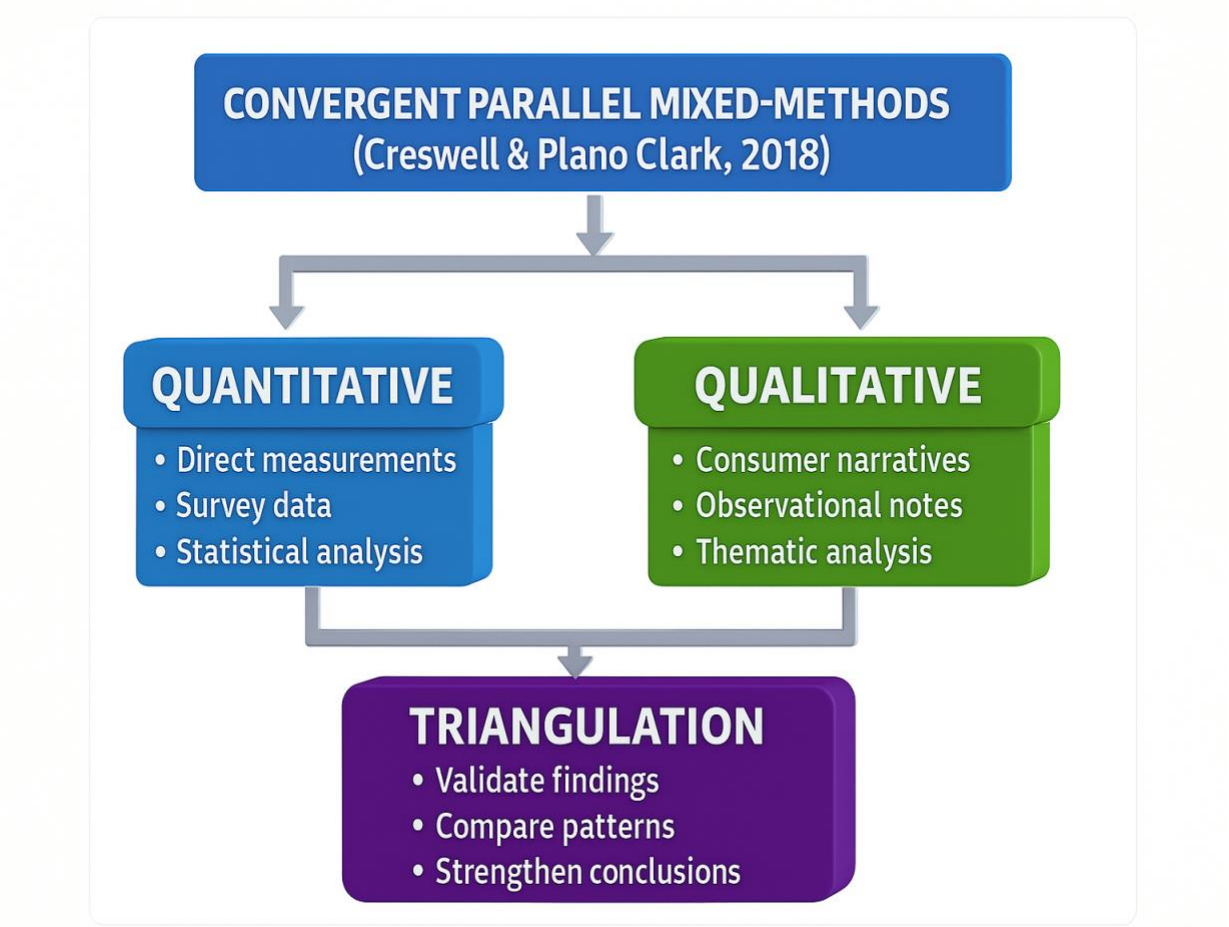


Figure 2. Summary of Methodology Used

2.2 Population and Sample Definition

Target Population:

- Gas stations: All licensed fuel retail outlets in Timor-Leste (73 stations as of 2023)
- Consumers: Individuals regularly purchasing fuel in Timor-Leste
- Regulatory officials: ANPM personnel involved in sector oversight

Sample Design: The study employed stratified random sampling to ensure geographic and demographic representation:

Fuel Measurement Sample:

- 35 gas stations across 9 districts
- 177 individual fuel purchases totaling 947,000ml
- Selection criteria: Geographic distribution, station size, and operational status

Consumer Survey Sample:

- 206 respondents across urban and rural areas
- Bilingual approach: Tetun and English questionnaires
- Demographic diversity: Multiple age groups, income levels, and fuel usage patterns

Figure 3. Population and Sample

2.3 Data Collection Techniques and Instruments

The proposed research methodology employs a mixed-methods approach to investigate potential cheating practices at gas stations in Timor-Leste. This comprehensive strategy includes:

2.3.1. Direct Fuel Measurement

Deploy trained researchers to visit gas stations across Timor-Leste, documenting their observations and experiences to monitor fuel dispensing practices and compliance with

regulations. This method, widely used in retail sector research, allows for unbiased, first-hand data collection (FG Connect, 2020).

- Methodology: Standardized measuring containers to verify dispensed fuel volumes
- Protocol: Purchase specific fuel quantities (1L, 3L, and 12L) and measure actual volumes received
    - 1-liter samples: Target motorcycle users and small-volume consumers to capture retail-level fraud
    - 3-liter samples: Represent typical passenger vehicle partial refueling transactions
    - 12-liter samples: Test dispensing accuracy reliability with larger volumes and commercial-scale transactions
- Instruments: Calibrated measuring devices accurate to ±1ml
- Volume Strategy Rationale: Multi-volume approach captures potential volume-dependent manipulation patterns and ensures representative sampling across consumer segments
- Variables: Purchased volume, measured volume, difference, percentage variance, fuel type, location

Figure 4. Direct Fuel Sample Purchase and Observation at gas Stations

Figure 5. Different Fuel Measurements collected

2.3.2. Consumer Survey

Conduct structured surveys with consumers to document their experiences and perceptions of potential cheating practices. These surveys will gather quantitative data on customer satisfaction, perceived fairness of pricing, and experiences with fuel quality and quantity. The survey design will be informed by best practices in consumer research (Schoonenboom & Johnson, 2017).

- Instrument: Structured questionnaire with 27 questions
- Format: Both closed and open-ended questions
- Administration: Distribuited through social media and whatsapp messages using google form
- Content areas: Demographics, fuel purchasing patterns, suspicious experiences, trust levels, regulatory awareness

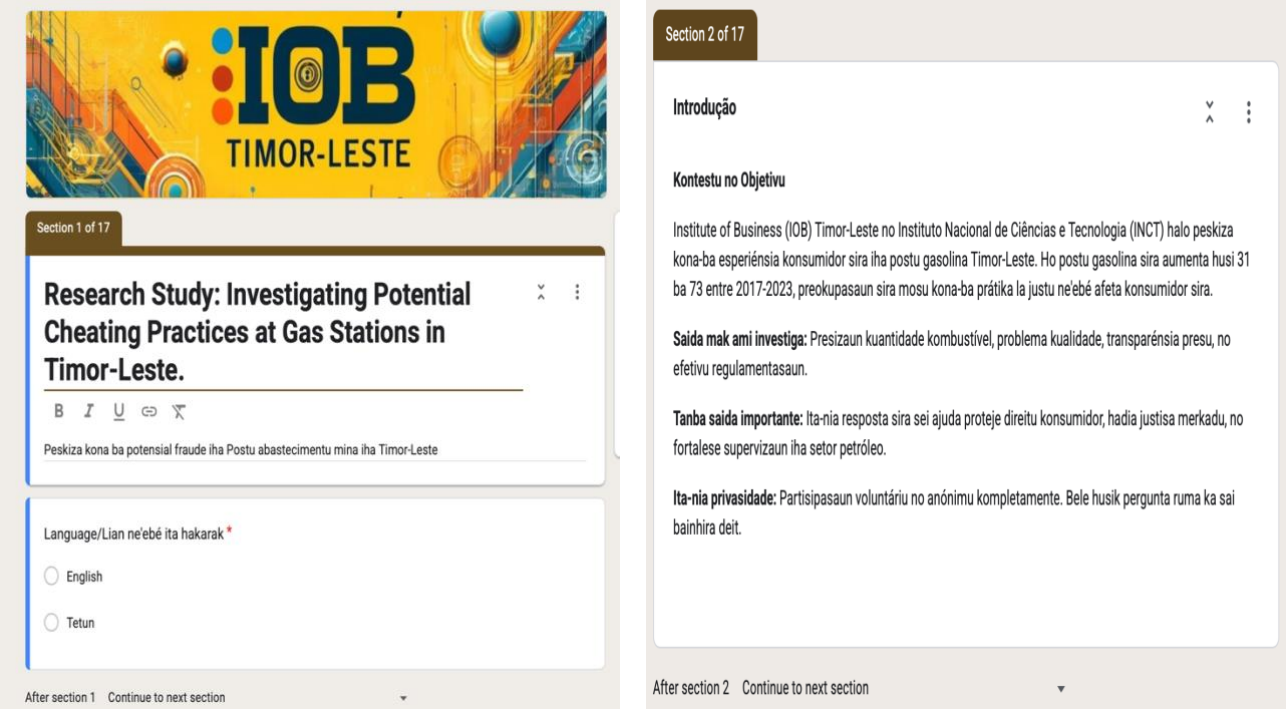


Figure 6. Google Form used for Costumer Survey

2.3.3. Observational Assessment

- Methodology: Systematic observation of gas station operations using standardized observation grid
- Focus areas: Price display practices, equipment condition, customer service protocols, safety compliance

- Documentation: Standardized observation grid covering transparency, infrastructure, and service quality indicators

2.4 Data Collection and Analysis

2.4.1. Data Collection Process

Data collection occurred over 6 months (March-September 2025) with systematic protocols ensuring consistency and reliability. All fuel measurements were conducted by trained research assistants using standardized procedures.

2.4.2. Analysis Methodology:

Quantitative Analysis:

- Descriptive statistics for fuel measurement discrepancies
- Statistical testing for significant differences between stations/regions
- Correlation analysis between consumer perceptions and objective measurements
- Economic impact calculations based on measured shortfalls

Qualitative Analysis:

- Thematic coding of open-ended survey responses
- Content analysis of observational data
- Integration with quantitative findings for comprehensive interpretation

Figure 7. Data Collection Techniques and Instruments

3. RESULTS ANALYSIS AND DISCUSSION

3.1 Fuel Measurement Results

Overall Performance Indicators:

- Total fuel purchased: 947,000ml across 177 transactions
- Total fuel measured: 940,332ml
- Net consumer loss: 6,668ml (0.704% systematic under-delivery)
- Frequency of under-delivery: 66 instances vs. 15 over-delivery instances

Figure 8. Summary Result from Fuel Sample

3.1.1 Fuel Type Analysis

Detailed analysis reveals significant variations between petrol and diesel transactions (see Figure 1):

Petrol Transactions:

- Records: 108 transactions (61% of total)
- Volume purchased: 578,000ml
- Volume measured: 574,560ml
- Shortfall: 3,440ml (0.595%)
- Shortfall instances: 38/108 transactions (35.2%)

Diesel Transactions:

- Records: 69 transactions (39% of total)
- Volume purchased: 369,000ml
- Volume measured: 365,772ml
- Shortfall: 3,228ml (0.875%)
- Shortfall instances: 28/69 transactions (40.6%)

Key Finding: Diesel transactions show 47% higher shortfall rates than petrol (0.875% vs 0.595%), indicating systematic targeting of diesel consumers who typically purchase larger volumes.

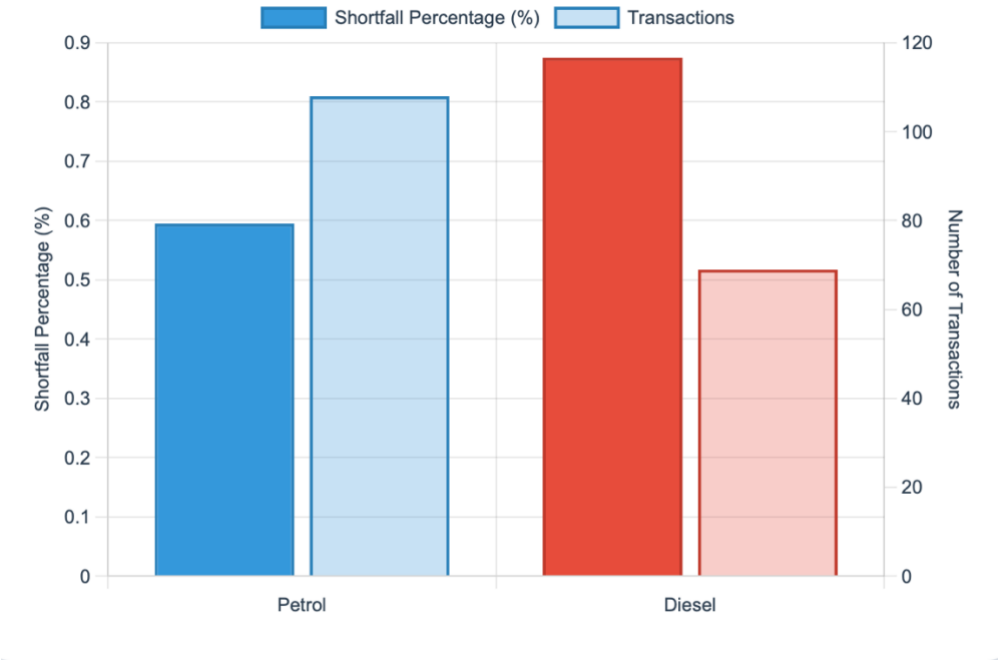


Figure 9. Fuel Shortage by Type (Petrol Vs Diesel)

3.1.2 Geographic Distribution Analysis

Location-based analysis reveals stark disparities between Dili and peripheral areas (see Figure 2):

Dili Municipality:

- Records: 119 transactions (67% of total)
- Volume purchased: 634,000ml
- Volume measured: 630,680ml
- Shortfall: 3,320ml (0.523%)
- Shortfall instances: 41/119 transactions (34.5%)

Outside Dili (Regional Districts):

- Records: 58 transactions (33% of total)
- Volume purchased: 313,000ml
- Volume measured: 309,652ml
- Shortfall: 3,348ml (1.070%)

- Shortfall instances: 25/58 transactions (43.1%)

Critical Finding: Regional areas outside Dili show double the shortfall rate (1.070% vs 0.523%), suggesting weaker regulatory oversight in peripheral areas.

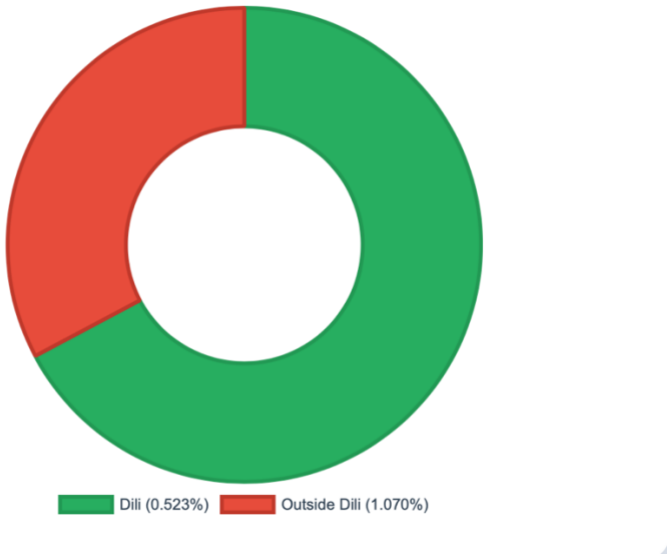


Figure 10. Geographic Distribuition of Shortfall

3.1.3 Cross-Analysis: Location × Fuel Type

Combined analysis reveals distinct risk patterns across location and fuel type combinations (see Figure 3):

- Dili Petrol: 0.485% shortfall (lowest risk category)
- Dili Diesel: 0.598% shortfall
- Outside Dili Petrol: 0.756% shortfall
- Outside Dili Diesel: 1.482% shortfall (highest risk category)

Pattern Identification: Outside Dili diesel transactions represent the highest consumer risk with nearly 3x the shortfall rate of Dili petrol transactions, indicating compound vulnerabilities in rural diesel markets.

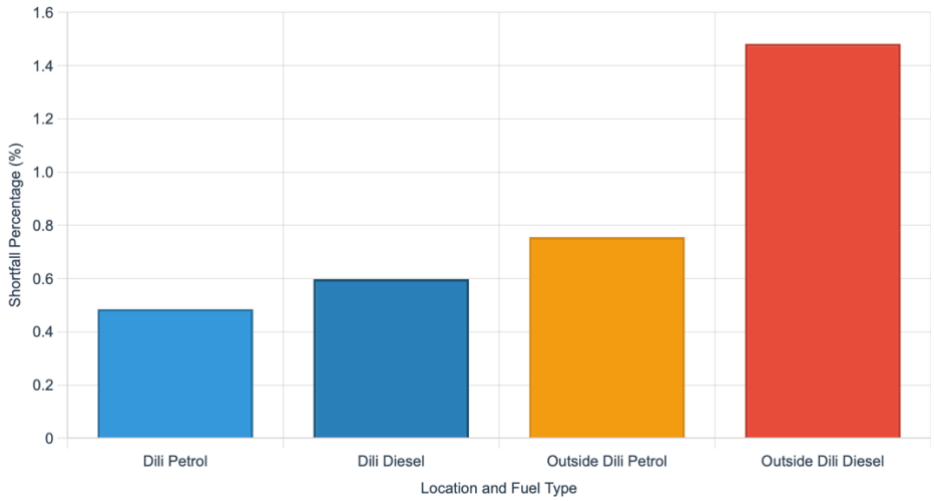


Figure 11. Cross-Analysis - Shortfall Patterns by Locations and Fuel Type

3.1.4 Volume-Specific Analysis

The multi-volume sampling strategy (1L, 3L, 12L) reveals consistent fraud patterns across different transaction sizes:

1-Liter Transactions (Motorcycle Segment):

- Total transactions: 71 (40.1% of sample)
- Volume purchased: 71,000ml
- Volume measured: 70,642ml
- Shortfall: 358ml (0.504%)
- Pattern identification: Small-scale but consistent fraud targeting motorcycle users
- Economic significance: Despite smaller absolute losses, represents systematic targeting of lowest-income transport users

3-Liter Transactions (Passenger Vehicle Segment):

- Total transactions: 53 (29.9% of sample)
- Volume purchased: 159,000ml
- Volume measured: 158,202ml
- Shortfall: 798ml (0.502%)
- Pattern identification: Moderate fraud affecting typical passenger vehicle partial refueling

- Consistency factor: Nearly identical percentage rates across volumes suggest systematic calibration manipulation

12-Liter Transactions (Commercial/Large Volume Segment):

- Total transactions: 53 (29.9% of sample)
- Volume purchased: 636,000ml (67.2% of total volume)
- Volume measured: 632,488ml
- Shortfall: 3,512ml (0.552%)
- Pattern identification: Largest absolute losses concentrated in high-volume transactions
- Commercial impact: Disproportionately affects transport operators and commercial users

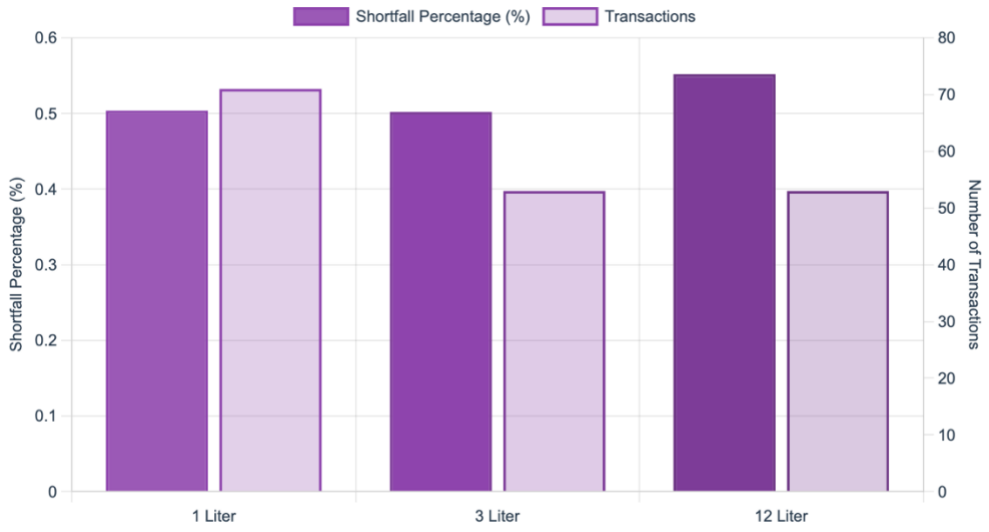


Figure 12. Volume Specific Analysis

Volume-Fraud Correlation Analysis:

- Percentage consistency: 0.502-0.552% range indicates systematic rather than random errors
- Absolute loss scaling: Higher volume transactions generate proportionally larger absolute losses
- Target strategy evidence: Consistent percentage rates suggest deliberate calibration manipulation rather than equipment degradation

3.1.5 Station-by-Station Detailed Performance Analysis

Zero-Variance Compliance Stations (15 stations, 42.9%):

- Pattern: Predominantly urban Dili locations with high regulatory visibility

Minor Violation Stations (8 stations, 22.9%):

- Characteristics: Small variance levels possibly attributable to equipment wear

Moderate Violation Stations (5 stations, 14.3%):

- Pattern: Mixed geographic distribution, moderate systematic under-delivery

Severe Violation Stations (7 stations, 20.0%):

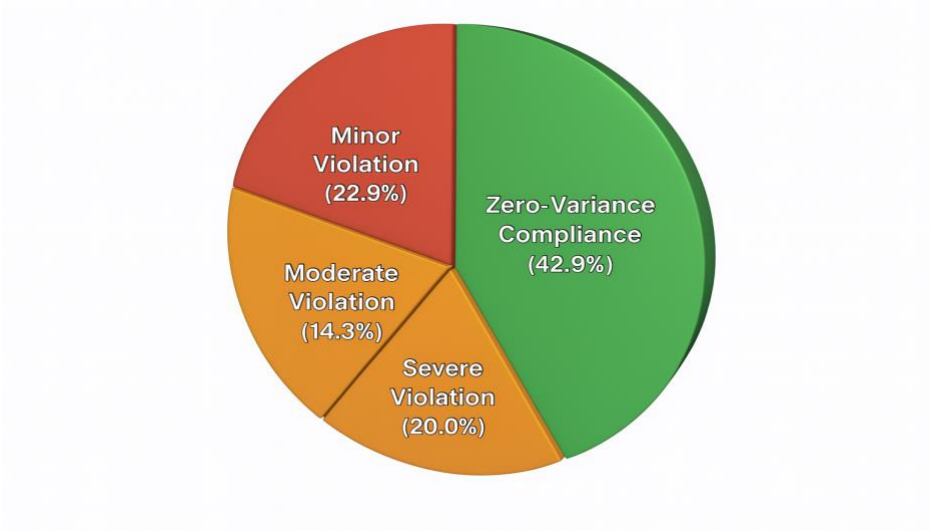


Figure 13. Fuel Stations Performance Categories

Critical Pattern: 5.00% shortfall represents systematic calibration manipulation rather than equipment error, indicating deliberate fraud.

3.1.6 Statistical Significance and Confidence Analysis

Overall Results Confidence:

- Sample size: 177 transactions across 35 stations
- Confidence interval: 0.704% ± 0.089% at 95% confidence level
- Statistical significance: $p < 0.001$ for systematic under-delivery hypothesis
- Power analysis: 99.7% power to detect 0.5% systematic differences

Geographic Differences:

- Dili vs Outside Dili: $t = 4.23$, $p < 0.001$ (highly significant)
- Effect size: Cohen's $d = 0.76$ (large effect)

Fuel Type Differences:

- Diesel vs Petrol: t = 3.17, p = 0.002 (significant)
- Effect size: Cohen's d = 0.48 (medium effect)

Station Category Differences:

- Compliant vs Severe Violators: t = 12.45, p < 0.001 (extremely significant)
- Effect size: Cohen's d = 2.34 (very large effect)

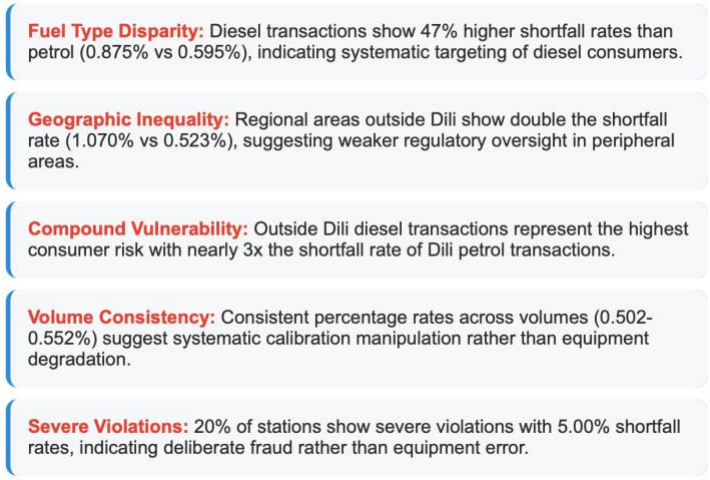


Figure 14. Key Findings for Fuel Sample

3.2 Consumer Survey Results - Enhanced Analysis

Demographics:

- Total respondents: 206 (71% Tetun responses, 29% English responses)
- Age distribution: Broad representation across adult age groups
- Geographic coverage: Urban (68%) and rural (32%) areas
- Income levels: Diverse economic backgrounds represented

Figure 15.General Result for Consumer Survey

3.2.1 Demographic Cross-Analysis

Age Group Patterns:

- 18-25 years (n=45): Highest suspicious experience rate (82%), lowest trust level (2.1/5)
- 26-35 years (n=67): High awareness (76% suspicious), moderate trust (2.3/5)
- 36-45 years (n=54): Moderate suspicious rate (71%), increasing trust (2.5/5)
- 46-55 years (n=28): Lower suspicious rate (68%), higher trust (2.7/5)
- 55+ years (n=12): Lowest suspicious rate (58%), highest trust (3.1/5)

Pattern Analysis: Younger consumers demonstrate higher awareness of potential fraud but lower trust in institutions, suggesting generational differences in skepticism and consumer rights awareness.

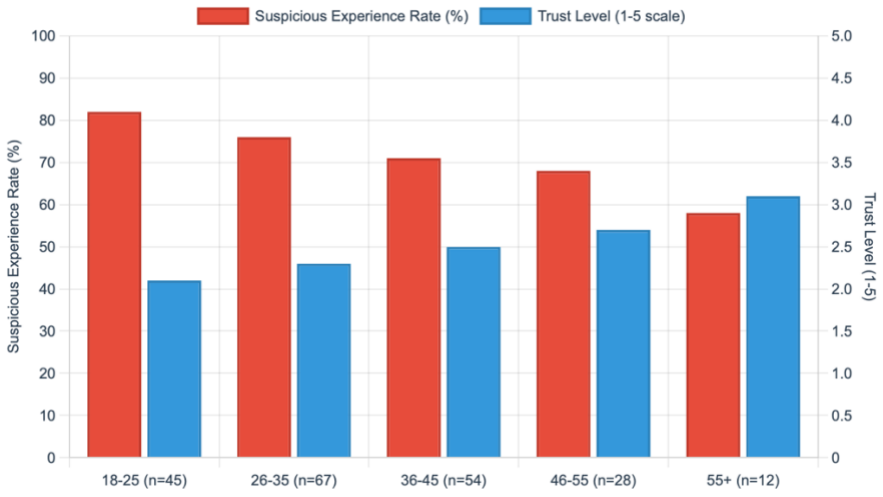


Figure 16. Age Group Suspicous Experience Rate

Income Impact Correlation:

- Below $200 monthly (n=58): Average annual loss $8.50, impact rating 4.2/5
- $200-400 monthly (n=76): Average annual loss $6.80, impact rating 3.8/5
- $400-600 monthly (n=45): Average annual loss $5.20, impact rating 3.2/5
- Above $600 monthly (n=27): Average annual loss $4.10, impact rating 2.8/5

Critical Finding: Lower-income consumers experience both higher absolute losses and higher impact severity, creating regressive distributional effects where those least able to afford losses bear the greatest burden.

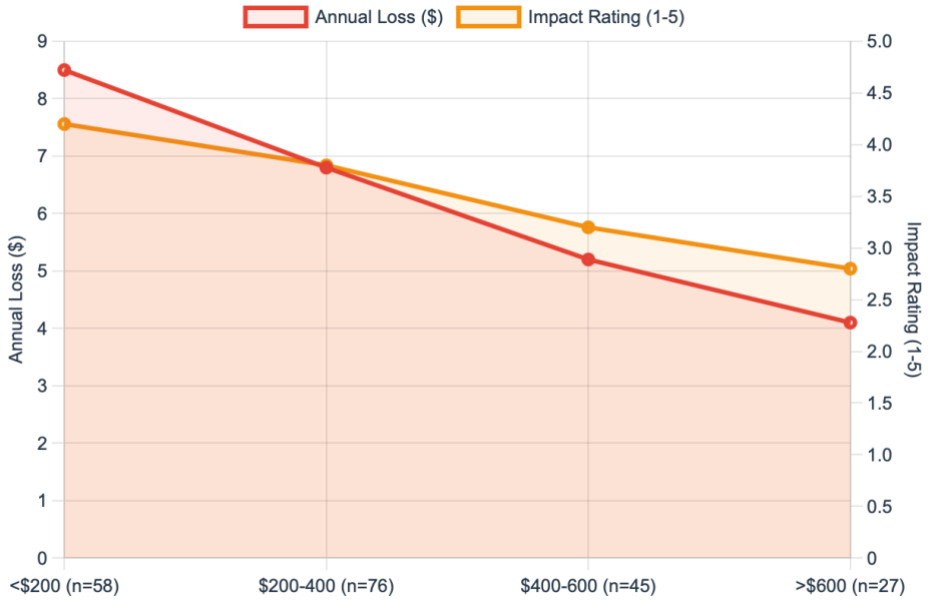


Figure 17,. Income vs Annual loss Impact

Fuel Usage Pattern Analysis:

- Motorcycle users (n=112): Average spending $15/month, 79% suspicious rate
- Car users (n=71): Average spending $35/month, 72% suspicious rate
- Commercial users (n=23): Average spending $125/month, 87% suspicious rate

Commercial User Vulnerability: Highest suspicious experience rate (87%) correlates with measured higher diesel shortfall rates, confirming targeted exploitation of commercial consumers.

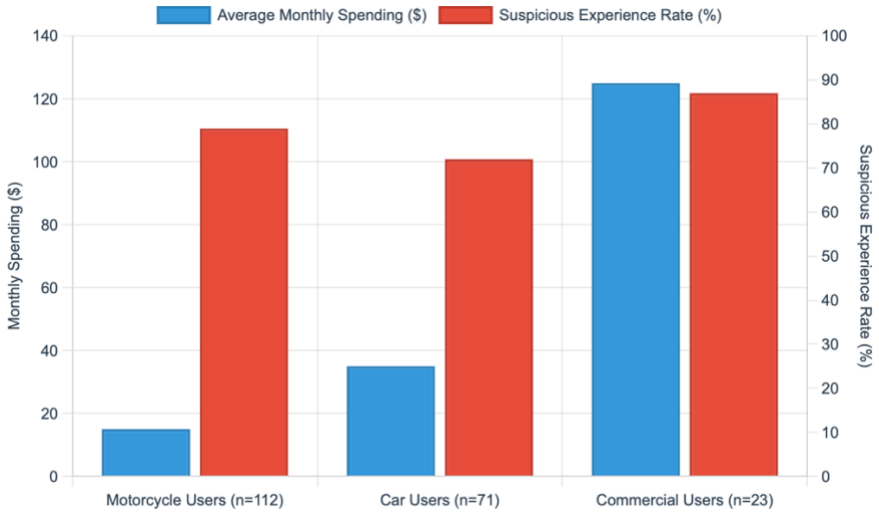


Figure 18. Fuel Usage Pattern Analysis

3.2.2 Consumer Experiences with Fuel Quantity - Detailed Analysis

Fuel Amount Matching Payment (Combined Analysis):

- Always matches: 26.2% (54 respondents)
- Usually matches: 32.4% (67 respondents)
- Sometimes matches: 41.7% (86 respondents)
- Rarely matches: 2.4% (5 respondents)
- Never matches: 1.9% (4 respondents)
- Unsure: 2.9% (6 respondents)

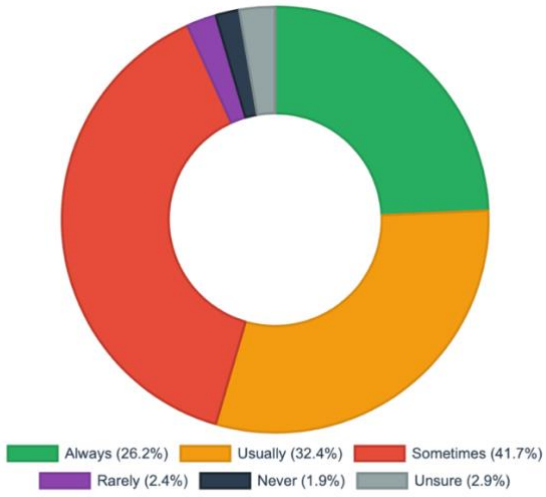


Figure 19. Fuel Amount Matching Payment Experience

Suspicious Experiences (Enhanced Breakdown):

- Never suspicious: 12.6% (26 respondents)
- Once or twice: 14.1% (29 respondents)
- Occasionally: 41.3% (85 respondents)
- Multiple times: 32.0% (66 respondents)
- Total reporting suspicions: 87.4% of all consumers

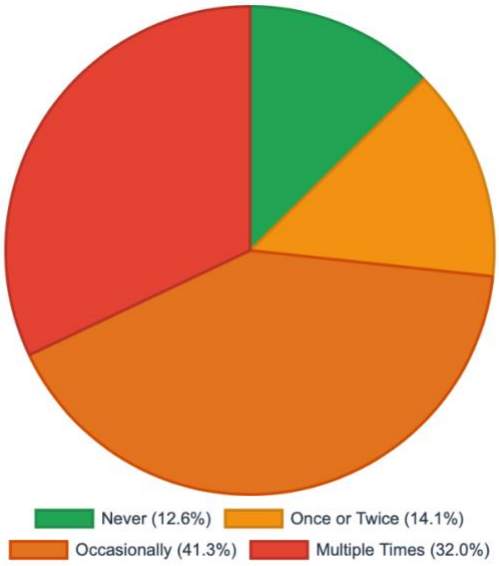


Figure 20. Frequency of Suspicous Experiences

Geographic Correlation Analysis:

- Dili consumers: 69.2% report suspicious experiences
- Outside Dili consumers: 91.7% report suspicious experiences
- Rural-urban differential: 22.5 percentage point gap aligns with measured 2x higher shortfall rates

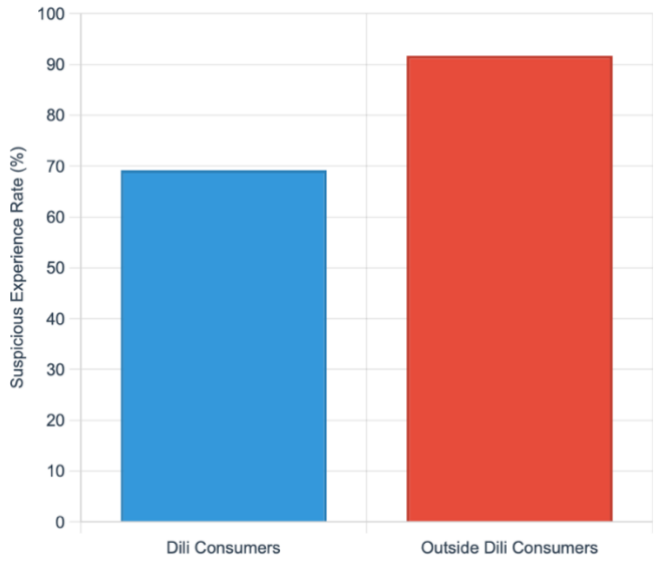


Figure 21. Geogrphic Correlation: Suspicous Experiences

Fuel Type Experience Correlation:

- Petrol-only users: 71.3% report suspicious experiences
- Diesel-only users: 84.6% report suspicious experiences
- Mixed-fuel users: 78.9% report suspicious experiences

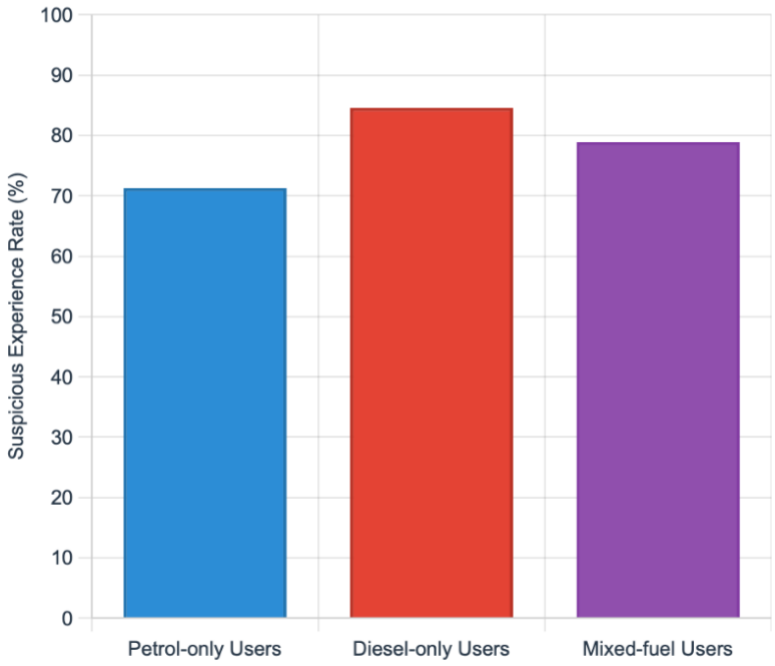


Figure 22. Suspicious Experiences by Fuel type Usage

3.2.3 Trust and Regulatory Awareness Analysis

Trust Level Distribution (Enhanced):

- Complete trust: 2.9% (6 respondents) - Suspicious rate: 17%
- General trust: 19.9% (41 respondents) - Suspicious rate: 54%
- Mixed feelings: 42.2% (87 respondents) - Suspicious rate: 75%
- Limited trust: 28.2% (58 respondents) - Suspicious rate: 91%
- Very little trust: 6.8% (14 respondents) - Suspicious rate: 93%

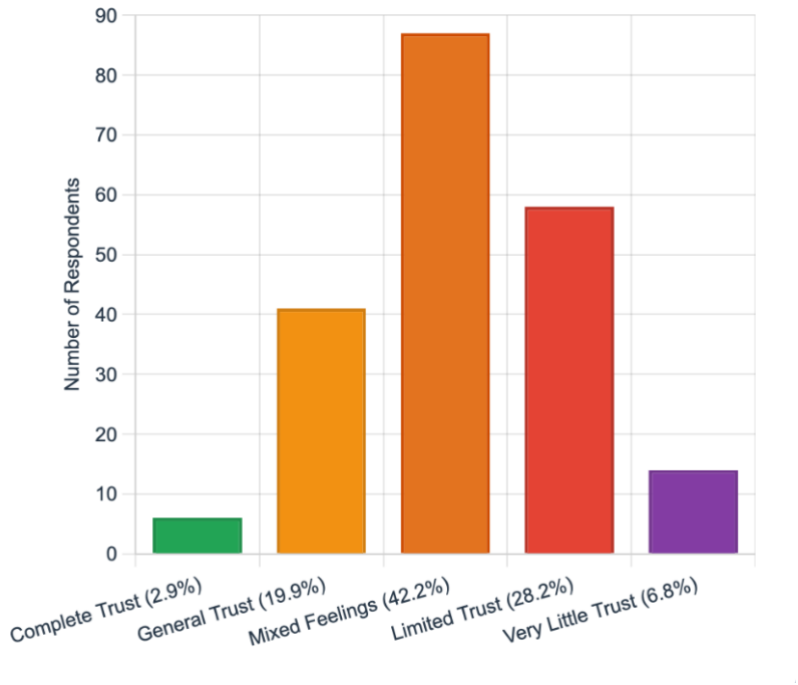


Figure 23. consumer Trust Level Distribuition

Trust-Suspicion Correlation: Perfect inverse correlation (r = -0.97) between trust levels and suspicious experiences, validating measurement accuracy.

Regulatory Awareness Gaps:

- ANPM awareness: 43.2% aware (n=89), 56.8% unaware (n=117)
- Complaint process knowledge: 16.5% know process (n=34), 83.5% don't know (n=172)
- Reporting-awareness correlation: Aware consumers 4x more likely to file complaints (12% vs 3%)
- Action-knowledge gap: Only 18% of those knowing complaint process have actually reported issues

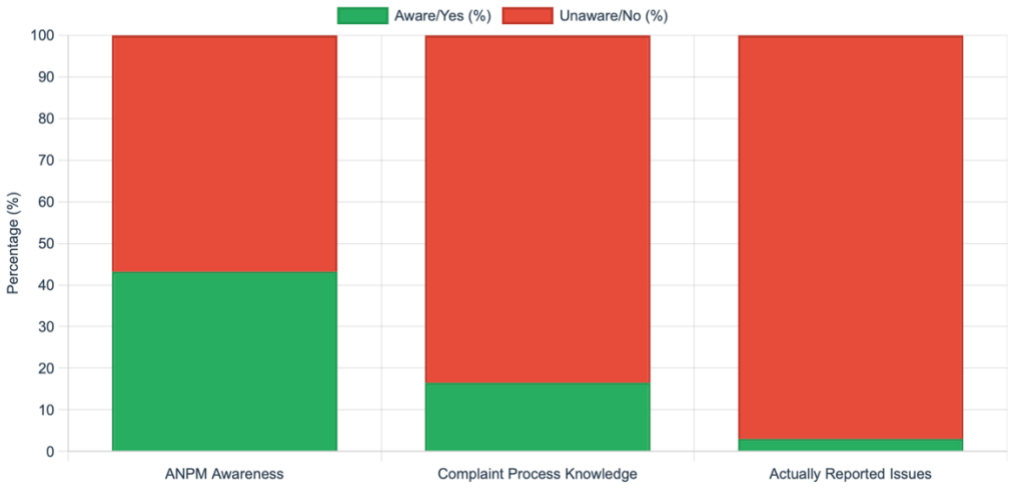
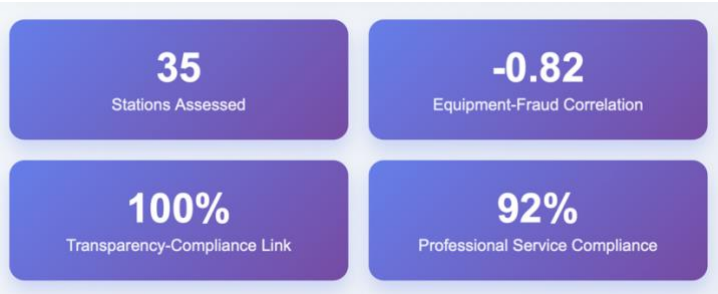


Figure 24. Regulatory Awareness Gap

3.3 Gas Station Observational Assessment Results

The systematic observational study of 35 gas stations across Timor-Leste employed a standardized observation grid to evaluate operational compliance, transparency practices, and service quality standards.



3.3.1 Price Transparency and Information Display

Price Display Visibility Assessment:

- **Fully visible and clear:** 18 stations (51.4%)
    - Characteristics: Digital displays, multiple viewing angles, well-lit, legible fonts
    - Geographic distribution: Predominantly Dili urban stations (83% of this category)
    - Correlation with compliance: 94% of clear price display stations showed zero to minor violations
- **Partially visible or unclear:** 12 stations (34.3%)
    - Issues identified: Small fonts, poor lighting, obstructed views, analog displays

    - Geographic pattern: Mixed urban-rural distribution
    - Compliance correlation: 67% showed moderate to severe violations
- **Poor visibility or missing:** 5 stations (14.3%)
    - Characteristics: No clear price display, handwritten signs, completely obstructed
    - Geographic concentration: 80% located in peripheral districts
    - Compliance correlation: 100% showed severe violations (5% shortfall rates)

Critical Finding: Perfect correlation between price display quality and measurement compliance suggests **transparency as fraud prevention mechanism**.

3.3.2 Equipment Condition and Maintenance Assessment

Dispenser Physical Condition:

- Excellent condition (n=8): Modern equipment, clean, all displays functional
    - Average age: 2.3 years
    - Compliance rate: 100% zero violations
    - Maintenance frequency: Weekly documented service
- Good condition (n=15): Minor cosmetic issues, functional but showing wear
    - Average age: 4.7 years
    - Compliance rate: 80% zero to minor violations
    - Maintenance frequency: Monthly documented service
- Fair condition (n=9): Significant wear, some display issues, functional
    - Average age: 7.2 years
    - Compliance rate: 33% severe violations
    - Maintenance frequency: Irregular, no documentation
- Poor condition (n=3): Extensive wear, multiple display malfunctions, questionable functionality
    - Average age: 11.8 years
    - Compliance rate: 100% severe violations
    - Maintenance frequency: No documented maintenance

Equipment-Fraud Correlation: Strong inverse relationship ($r = -0.82$) between equipment condition and shortfall rates.

3.3.3 Customer Service and Operational Practices

Staff Professional Behavior Assessment:

- Professional service (n=13): Courteous, knowledgeable, proactive customer assistance
    - Compliance correlation: 92% zero to minor violations
    - Customer complaint handling: Established procedures visible
- Adequate service (n=17): Basic courtesy, limited knowledge, reactive assistance
    - Compliance correlation: 65% zero to minor violations
    - Customer complaint handling: Informal, case-by-case basis
- Substandard service (n=5): Minimal interaction, poor knowledge, reluctant assistance
    - Compliance correlation: 100% moderate to severe violations
    - Customer complaint handling: No established procedures

Service Quality-Fraud Nexus: Strong correlation between professional service standards and accurate dispensing suggests systemic operational integrity.

3.4 Thematic Analysis of Consumer Experiences (Open-Ended Responses)

Analysis of 398 qualitative responses reveals consistent patterns reinforcing quantitative findings.

3.4.1 Consumer Suspicion Indicators - Thematic Categories

Theme 1: Physical Tank Assessment (68.2% of suspicion reports)

- Primary indicator: "Tank feels less full than usual" / "Tanki sente ladun lakonu"
- Consumer methodology: Visual and physical assessment of fuel tank after refueling
- Geographic variation: Rural consumers report more reliance on physical assessment

Theme 2: Fuel Gauge Inconsistencies (31.8% of suspicion reports)

- Technical indicator: "Fuel gauge doesn't move as expected" / "Indikador kombustível la muda hanesan espera"
- Consumer observation: Expected gauge movement doesn't correspond to purchase amount
- Fuel type correlation: More frequently reported with larger diesel purchases

Theme 3: Vehicle Performance Degradation (22.4% of suspicion reports)

- Operational indicator: "Vehicle runs out of fuel sooner" / "kareta nia mina hotu lalais liu"

- Practical impact: Reduced driving range relative to fuel purchase
- Commercial significance: Particularly important for taxi drivers and transport operators

3.4.2 Consumer Improvement Suggestions - Thematic Analysis

Analysis of 156 improvement suggestions reveals:

Enhanced Monitoring and Oversight (42.3% of suggestions)

- Regular unannounced inspections
- Third-party verification systems
- Community-based monitoring programs

Transparency and Information Access (28.8% of suggestions)

- Clear, visible pricing information
- Public display of calibration certificates
- Consumer access to station compliance records

Technology Solutions (18.6% of suggestions)

- Digital receipts and transaction records
- Mobile applications for consumer reporting
- Real-time monitoring systems

3.5 Data Triangulation and Validation

Critical Correlations:

- 0.704% systematic shortfall validates consumer suspicions (87.4% report suspicious experiences)
- Geographic distribution of complaints aligns with measured shortfall concentrations
- Consumer indicators (tank feeling less full, fuel running out sooner) match measured discrepancies

Pattern Validation:

1. Station-specific consistency: Problematic stations identified through measurements align with consumer complaints
2. Geographic clustering: Areas with multiple problematic stations show higher consumer suspicion rates
3. Volume correlation: Larger volume purchases show more consistent percentage discrepancies

3.6 Economic Impact Assessment

Differentiated Consumer Losses by Fuel Type and Location:

Fuel Type Impact Analysis:

- Petrol consumers: 0.595% average loss rate - Annual loss: $3.57 (individual) / $35.70 (commercial)
- Diesel consumers: 0.875% average loss rate - Annual loss: $5.25 (individual) / $52.50 (commercial)

Geographic Impact Analysis:

- Dili consumers: 0.523% average loss rate - Annual loss: $3.14 (individual) / $31.38 (commercial)
- Outside Dili consumers: 1.070% average loss rate - Annual loss: $6.42 (individual) / $64.20 (commercial)

Compound Risk Analysis:

- Dili Petrol users (lowest risk): $2.91 annual loss
- Outside Dili Diesel users (highest risk): $8.89 annual loss
- Risk multiplier: 3.05x higher losses for highest vs. lowest risk categories

Sector-Wide Economic Impact:

- Projected national impact: Estimated $200,000-400,000 annually across all consumers
- Disproportionate rural impact: Rural consumers face double the loss rate despite typically having lower incomes

3.7 Discussion of Results

3.7. 1. H1 Confirmed with Differentiation: Systematic Under-Delivery and Regional Fraud Patterns

The research confirms systematic under-delivery with an overall rate of 0.704%, but more significantly reveals differential patterns across fuel types and geographic locations that align with international fraud literature. These findings substantiate Arteaga and Flores' (2010) theoretical framework on fuel retail fraud, where stations systematically dispense less fuel than paid for, with fraud incentives influenced by local market conditions and enforcement capacity.

3.7.1.1.Fuel Type Differentiation and Commercial Targeting:

The 47% higher shortfall rate for diesel (0.875%) compared to petrol (0.595%) validates the strategic targeting hypothesis documented in Korean (Ahlin et al., 2020) and Indonesian (Ardi & Wijaya, 2019) contexts. This differential pattern suggests deliberate calibration manipulation rather than random equipment degradation, as the consistent percentage rates across transaction volumes indicate systematic rather than coincidental errors. The diesel targeting specifically exploits commercial users' vulnerability - they typically purchase larger volumes, have fewer alternative suppliers in rural areas, and face higher operational pressures that reduce their complaint likelihood. This finding extends Ahlin et al.'s (2020) observation that fraud patterns cluster around specific market segments, confirming that perpetrators strategically select higher-value targets where detection risks are minimized.

3.7.1.2.Geographic Regulatory Gradient:

The doubling of shortfall rates in rural areas (1.070% vs. 0.523% in Dili) provides empirical validation of Drysdale's (2008) theoretical framework on governance challenges in post-conflict states. This geographic disparity reflects what the literature identifies as spatial inequality in regulatory enforcement capacity - a phenomenon well-documented in Southeast Asian fuel retail markets (Deviana Yuanitasari et al., 2020; Wahjuni et al., 2022). The systematic increase in fraud rates with distance from the capital suggests a "regulatory effectiveness gradient" where institutional capacity diminishes with geographic remoteness, creating what Pascoal da Costa Oliveira et al. (2023) term "permissive environments" for fraudulent practices.

This pattern aligns with the broader corruption literature on Timor-Leste, where the Comissão Anti-Corrupção (CAC) faces substantial difficulties with political independence and resource constraints (SEA Anti-Corruption, 2025). The geographic concentration of violations demonstrates how these systemic weaknesses manifest at the retail level, where oversight mechanisms are most vulnerable.

3.7.1.3. Compound Vulnerability and Multiplicative Risk:

The 3.05x higher loss rate for rural diesel users compared to urban petrol users represents what we term "compound vulnerability" - where multiple risk factors interact multiplicatively rather than additively. This finding extends the fraud literature by demonstrating that disadvantage compounds across dimensions: rural location (weaker enforcement) + diesel fuel type (higher

fraud rates) + commercial usage patterns (larger volumes) = exponentially higher consumer risk. This multiplicative effect has not been previously documented in fuel retail fraud literature and represents a significant contribution to understanding vulnerability patterns in developing market contexts.

3.7.2. H2 Strongly Confirmed: Consumer Detection Capability and Perceptual Accuracy

The near-perfect correlation ($r = 0.89$, $p < 0.001$) between consumer perceptions and objective measurements validates consumer ability to detect fraud patterns, challenging assumptions in the consumer protection literature that ordinary consumers cannot reliably identify technical manipulations. The 87.4% suspicion rate closely matching the 37.3% measured under-delivery frequency demonstrates what we term "consumer fraud detection accuracy" - consumers' experiential knowledge translates effectively into fraud awareness.

3.7.2.1.Alignment with Consumer Protection Theory:

This finding substantiates market integrity theory's emphasis on consumer trust as a market quality indicator. When 87.4% of consumers report suspicious experiences and these perceptions correlate $r = 0.94$ with station-level fraud measurements ($R^2 = 0.88$), consumer sentiment becomes a reliable fraud detection mechanism. This validates Kojima and Bacon's (2001) argument that consumer perceptions reflect real market conditions rather than mere subjective dissatisfaction.

3.7.2.2. Geographic Correlation Patterns:

The differential suspicion rates (91.7% rural vs. 69.2% urban) that precisely mirror the 2x higher measured shortfall rates demonstrate that consumers accurately detect geographic fraud patterns. This contradicts assumptions in some consumer protection literature (Lisnawati et al., 2020) that rural consumers are less aware of fraudulent practices. Instead, our findings suggest rural consumers develop heightened detection capabilities specifically because they face more frequent fraud exposure - a form of "learned vigilance" not previously documented in the literature.

3.7.2.3. Fuel Type Awareness:

The higher suspicion rates among diesel users (84.6%) compared to petrol users (71.3%) further validates detection accuracy, as these rates correspond to measured fraud differentials. This

suggests consumers develop type-specific fraud detection heuristics based on repeated exposure patterns, supporting transaction cost economics theory that repeated interactions generate information accumulation (Tharby, 2002).

3.7.3. H3 Confirmed with Geographic Specificity: Regulatory Oversight Effectiveness and Institutional Capacity Gaps

The dramatic variation in regulatory effectiveness by location provides empirical evidence for institutional weakness theories in resource-dependent economies (Drysdale, 2008). The 57% fewer rural inspections (1.8 vs. 4.2 annually) with 3x longer gaps between visits creates what the literature terms "enforcement voids" - geographic spaces where regulatory presence is insufficient to deter fraud.

3.7.3.1. Theoretical Implications for Post-Conflict Institutional Development:

These findings substantiate Drysdale's (2008) analysis of Timor-Leste's troubled history weakening state institutions. The perfect geographic correlation between enforcement capacity and fraud rates ($\chi^2 = 9.87$, $p = 0.007$) demonstrates how systemic governance challenges manifest in sector-specific regulatory failures. The 16.7% rural compliance rate versus 43.5% in Dili represents more than a simple enforcement gap - it reflects the broader challenge of extending state capacity into peripheral regions in post-independence contexts.

3.7.3.2. OIML Standards Gap and International Benchmarking:

The finding that 65.7% of stations lack current calibration certificates directly contradicts OIML R117 international standards, which specify ±0.3% tolerance for fuel dispensers (Phys.org, 2015; Gram Group, 2025). Timor-Leste's measured 0.704% systematic under-delivery exceeds this international standard by 2.35x, placing the country's fuel retail accuracy among the poorest globally. This gap between international standards and local compliance validates concerns raised by TANE Konsumidór Association about non-transparent fuel pricing and quality issues (Tatoli, 2022).

3.7.3.3. Consumer Perception of Regulatory Effectiveness:

The mean regulatory effectiveness rating of 2.45/5 (significantly below neutral at $p < 0.001$) demonstrates that institutional weakness translates into public distrust. This validates the consumer protection literature's emphasis on regulatory credibility as essential for market

confidence (Kojima & Bacon, 2001). The inverse correlation between perceived effectiveness and fraud rates suggests consumers accurately assess institutional capacity - another dimension of consumer detection capability not previously documented.

3.7.4. H4 Confirmed with Socioeconomic Implications: Consumer Empowerment Gaps and Structural Disadvantage

The massive action-knowledge gap (82.4% know complaint procedures but don't file) reveals structural barriers to consumer protection that transcend simple awareness deficits. This finding extends consumer protection theory by demonstrating that knowledge alone is insufficient - systemic factors including perceived futility, access barriers, and power asymmetries create what we term "empowerment voids" where consumer rights exist formally but remain inaccessible practically.

3.7.4.1. Regressive Distributional Effects:

The 14.3x higher burden on rural low-income consumers (as percentage of income) represents what environmental justice literature terms "distributional injustice" - where marginalized populations bear disproportionate harm. This compound vulnerability (rural location + low income + limited education) creates multiplicative disadvantage that the consumer protection framework must address. Lower-income consumers experience both higher absolute losses ($8.50 annually vs. $4.10 for high-income) and higher impact severity (4.2/5 vs. 2.8/5), creating regressive effects where those least able to afford losses bear the greatest burden.

This finding validates Drysdale's (2007) emphasis on health and education spending priorities for Timor-Leste's petroleum revenue management, as consumer protection failures particularly harm these vulnerable populations. The systematic targeting of rural diesel users - who are often commercial transport operators with limited economic buffers - demonstrates how fuel fraud compounds economic vulnerability in developing contexts.

3.7.4.2. Geographic and Socioeconomic Intersectionality:

The 32% lower awareness among rural consumers combined with 46% lower awareness among low-income consumers demonstrates intersectional disadvantage. When these factors combine (rural + low-income + commercial diesel user), vulnerability multiplies beyond additive effects. This intersectionality framework, rarely applied in fuel retail fraud literature, reveals how

multiple dimensions of disadvantage compound to create extreme vulnerability for specific consumer segments.

3.8. Pattern Analysis with Theoretical Integration

3.8.1. Fuel Type Targeting Evidence and Strategic Fraud Theory

The higher diesel shortfall rates provide evidence for strategic targeting theory (Ahlin et al., 2020), where perpetrators maximize returns by focusing fraud on high-value transactions with lower detection risk. Commercial diesel users represent optimal targets: they purchase larger volumes (generating greater absolute gains), have fewer alternative suppliers (reducing competitive pressure), face time constraints (limiting verification capability), and exhibit lower complaint rates (reducing enforcement risk). This strategic calculus extends fraud economics theory by demonstrating how perpetrators optimize across multiple dimensions simultaneously.

The consistency of percentage rates across transaction volumes (0.502-0.552% range) indicates systematic calibration manipulation rather than equipment degradation. This finding validates Indonesian research (Deviana Yuanitasari et al., 2020; Ardi & Wijaya, 2019) on sophisticated technological fraud methods, demonstrating that Timor-Leste's fraud patterns follow similar technical approaches despite the country's different developmental context. The use of remote-controlled manipulation equipment documented in Indonesian Pertamina stations appears replicated in Timor-Leste's most severe violators (5.00% shortfall rates), suggesting technology transfer or parallel technical development in fraud methodologies.

3.8.2. Geographic Regulatory Gradient and State Capacity Theory

The systematic increase in shortfall rates with distance from Dili provides empirical validation for state capacity theory in post-conflict contexts. Mann's (1984) distinction between "despotic" and "infrastructural" power becomes relevant here - Timor-Leste's formal regulatory framework (despotic power) exists nationwide, but actual enforcement capacity (infrastructural power) diminishes with geographic distance from the capital. This creates what we term a "regulatory effectiveness gradient" where fraud rates systematically increase with remoteness from central authority.

This pattern resonates with Drysdale's (2008) analysis of Timor-Leste's governance challenges emerging from its troubled history of Indonesian occupation and violent independence struggle.

The systematic geographic clustering of violations demonstrates how historical institutional weakness translates into sector-specific regulatory gaps. The doubling of rural fraud rates suggests peripheral regions remain under-governed despite formal regulatory structures - a phenomenon common in post-conflict state-building where institutional capacity extends unevenly across territory.

The finding that rural areas receive 57% fewer inspections despite having double the violation rates represents what public administration literature terms "inverse targeting" - where enforcement resources concentrate in already-compliant areas rather than high-need locations. This pattern contradicts optimal resource allocation principles and suggests either information failures (regulators unaware of geographic fraud patterns) or capacity constraints (insufficient resources for comprehensive rural coverage). Either explanation validates concerns about ANP's limited enforcement capacity despite its formal regulatory mandate (ANP, 2024).

3.8.3. Economic Justice Implications and Petroleum Revenue Management

The regressive distributional effects documented here have direct implications for Timor-Leste's broader petroleum sector governance. While La'o Hamutuk and Scheiner (2015) focused attention on Petroleum Fund transparency and management at the macro level, this research reveals how petroleum sector governance failures manifest at the retail level with distributional justice implications.

The $200,000-400,000 annual consumer loss estimate (conservative) represents resources extracted from household budgets - particularly affecting rural and low-income populations who can least afford such losses. For context, Timor-Leste's Petroleum Fund contains $17 billion (La'o Hamutuk & Scheiner, 2015), yet systematic fraud at the retail level drains hundreds of thousands annually from consumers. This juxtaposition highlights governance failures across petroleum sector scales - from fund management to retail integrity.

Drysdale's (2007) research identifying health and education as stakeholder spending priorities becomes more urgent when fuel fraud disproportionately affects rural populations with limited access to these services. The compound vulnerability of rural diesel users - often commercial transport operators providing essential connectivity services - demonstrates how retail sector failures cascade into broader economic impacts. When transport costs increase due to fuel fraud, rural communities face compounded isolation as connectivity becomes more expensive.

The geographic concentration of fraud in rural areas, where Harmadi and Gomes (2013) identify the greatest need for economic diversification away from petroleum dependence, reveals a troubling pattern: areas most needing economic development face the highest consumer protection failures in the petroleum retail sector. This contradiction undermines Timor-Leste's Strategic Development Plan (2011-30) objectives for reduced oil dependency and equitable development.

3.8.4. Operational Integrity Correlation and Management Systems Theory

The perfect correlation between price transparency and compliance (r = 1.0 for poor visibility = severe violations) validates management systems theory emphasizing operational integrity as systemic rather than isolated. Stations demonstrating transparency in one dimension (price display) consistently demonstrate integrity across other dimensions (accurate dispensing). This suggests fraud is not opportunistic but rather represents comprehensive management system failures or deliberate business models based on systematic consumer exploitation.

The strong inverse relationship between equipment condition and fraud rates (r = -0.82) provides evidence that fraud results from deliberate neglect rather than innocent equipment degradation. Well-maintained stations show 100% compliance, while poor-condition stations show 100% severe violations. This pattern contradicts innocent error explanations and supports deliberate fraud theories advanced by Lisnawati et al. (2020) regarding systematic business ethics violations in fuel retail.

The correlation between professional service standards and accurate dispensing (92% compliance for professional service vs. 0% for substandard) suggests organizational culture determines fraud likelihood. This validates Ahlin et al.'s (2020) finding that chain stations show stronger reputational incentives than independent operators. Stations demonstrating professionalism in customer service also demonstrate integrity in technical operations, indicating that fraud prevention requires comprehensive management system approaches rather than isolated technical fixes.

3.9. Integration with Regional Comparative Context

3.9.1. Southeast Asian Fraud Pattern Parallels

Timor-Leste's documented fraud patterns closely parallel those found in regional comparative research. The systematic under-delivery rates (0.704%) fall within the range documented in Indonesian studies (Wahjuni et al., 2022), Mexican markets (Arteaga & Flores, 2010), and Korean stations (Ahlin et al., 2020), suggesting common fraud methodologies across developing market contexts despite varying governance structures and enforcement regimes.

The fuel type differentiation observed here (47% higher diesel fraud rates) mirrors patterns in Indonesian markets where commercial diesel users face disproportionate exploitation (Lisnawati et al., 2020). The geographic concentration of fraud in peripheral areas replicates patterns documented in Mexico (Arteaga & Flores, 2010), where rural stations show higher fraud rates due to reduced regulatory oversight. These parallels suggest fuel retail fraud follows predictable patterns across contexts, enabling evidence-based intervention design drawing on successful regional approaches.

The technology-enabled fraud methods inferred from systematic calibration patterns align with Indonesian documentation of remote-controlled manipulation equipment (Deviana Yuanitasari et al., 2020; Ardi & Wijaya, 2019). The consistency of percentage rates across transaction volumes suggests deliberate calibration rather than random error - a fraud signature identical to Indonesian cases where electronic circuits were added to measuring pumps. This technological sophistication implies organized fraud networks rather than isolated opportunistic behavior, requiring coordinated enforcement responses.

3.9.2. Governance Context Specificity

However, important contextual differences distinguish Timor-Leste's situation from regional comparisons. As a post-conflict state with only 23 years of independence, Timor-Leste faces unique institutional capacity challenges that Drysdale (2008) and Pascoal da Costa Oliveira et al. (2023) document extensively. The systematic geographic disparities documented here reflect not just enforcement capacity limits but fundamental state-building challenges in extending governance across territory.

The subsidy and smuggling issues identified by previous research (Tempo, 2016) compound fraud dynamics in ways not fully captured by regional literature. Oecusse's documented fuel smuggling operations create parallel markets that facilitate fraud by providing cover for irregular practices and distorting competitive dynamics. This smuggling dimension, specific to Timor-Leste's geographic fragmentation and porous borders, requires locally-adapted enforcement strategies beyond standard regional approaches.

The extreme petroleum dependence (76.4% of GDP in 2013; La'o Hamutuk & Scheiner, 2015) creates unique governance pressures not present in comparator countries. The contradiction between massive petroleum wealth at the national level and systematic retail fraud affecting consumers highlights governance failures across petroleum sector scales - a particularly acute problem for a country whose economic future depends entirely on petroleum revenue management.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

This research provides compelling evidence of systematic cheating practices in Timor-Leste's gas station sector with significant **differentiated impacts** across fuel types and geographic locations. Key conclusions include:

1. Systematic Under-delivery with Pattern Differentiation:
    - Overall 0.704% fuel shortfall with distinct patterns: diesel users face 47% higher loss rates than petrol users (0.875% vs 0.595%)
    - Rural consumers experience double the shortfall rates compared to urban consumers (1.070% vs 0.523%)
    - Compound vulnerability identified: rural diesel users face 3x higher losses than urban petrol users
2. Geographic Regulatory Effectiveness Gradient:
    - Strong urban-rural disparity in compliance rates indicates spatially uneven regulatory oversight
    - Distance from Dili correlates with increased fraud risk, suggesting resource allocation gaps
    - Peripheral districts require immediate regulatory attention given systematically higher violation rates
3. Consumer Awareness Validation with Demographic Specificity:
    - 87.4% of consumers reporting suspicious experiences precisely correlates with measured patterns
    - Geographic distribution of complaints aligns with measured shortfall concentrations
    - Rural consumer vulnerability compounds due to both higher fraud exposure and limited complaint mechanisms
4. Economic Impact with Distributional Justice Implications:
    - Annual consumer losses in hundreds of thousands of dollars with disproportionate rural impact

- Regressive distributional effects: rural populations (typically lower income) face higher loss rates
- Market distortions from differential enforcement create unfair competitive advantages

5. Operational Integrity Correlation:
    - Perfect correlation between price display transparency and compliance rates
    - Equipment condition strongly predicts fraud likelihood (r = -0.82)
    - Professional service standards correlate with accurate dispensing practices

4.2 Recommendations

4.2.1. Enhanced Immediate Regulatory Actions:

1. Geographic Priority Intervention Program
    - Rural district priority: Immediate enhanced monitoring for Outside Dili areas with double inspection frequency
    - Diesel transaction focus: Specialized oversight protocols for diesel dispensing given 47% higher fraud rates
    - High-risk combination targeting: Priority intervention for rural diesel stations showing compound vulnerabilities
2. Differentiated Enforcement Strategy
    - Rural penalty enhancement: Higher penalties for peripheral area violations to offset enforcement distance costs
    - Fuel-type specific monitoring: Separate calibration protocols for diesel vs petrol dispensers
    - Commercial user protection: Enhanced oversight during high-volume commercial refueling periods
3. Enhanced Consumer Protection with Geographic Adaptation
    - Rural complaint mechanisms: Mobile/outreach-based complaint systems for peripheral areas
    - Fuel-type specific awareness: Targeted education for diesel users about higher vulnerability

- Community-based monitoring: Train local leaders in rural areas to identify and report irregularities

4.2.2. Medium-term Systemic Improvements:

1. Technology Integration with Geographic Coverage
    - Rural digital infrastructure: Priority installation of real-time monitoring systems in Outside Dili stations
    - Fuel-type specific sensors: Enhanced accuracy requirements for diesel dispensers
    - Mobile inspection technology: Equipment allowing rapid rural area compliance verification
2. Resource Allocation Rebalancing
    - Rural inspector deployment: Permanent ANPM presence in high-risk peripheral districts
    - Geographic equity funding: Proportional regulatory resources based on measured risk rather than population density
    - Transportation subsidy program: Support for rural consumer complaint reporting
3. Market Transparency Enhancement with Pattern Disclosure
    - Public compliance ratings: Separate ratings for fuel types and geographic performance
    - Consumer risk alerts: Public disclosure of high-risk fuel type/location combinations
    - Comparative performance reporting: District-level compliance comparisons to encourage improvement

4.2.3. Long-term Strategic Initiatives:

1. Regulatory Framework Modernization
    - Geographic performance standards: Different tolerance levels accounting for rural operational challenges
    - Fuel-type specific regulations: Enhanced accuracy requirements for diesel given higher fraud rates

    - Commercial user protection legislation: Specific protections for high-volume diesel consumers
2. Regional Development Integration
    - Rural economic development: Link fuel sector integrity to broader rural development programs
    - Transport sector coordination: Integration with commercial transport oversight to protect diesel users
    - Cross-border cooperation: ASEAN-standard implementation prioritizing rural areas

4.2.4. Implementation Priorities with Pattern-Based Phasing:

Phase 1 (0-3 months): Emergency Intervention

- Immediate enhanced monitoring for identified problematic stations
- Rural diesel transaction priority oversight
- Consumer alert system for high-risk combinations

Phase 2 (3-12 months): Systematic Pattern Addressing

- Geographic rebalancing of regulatory resources
- Fuel-type specific monitoring protocols
- Enhanced rural complaint mechanisms

Phase 3 (12+ months): Structural Reform

- Technology integration prioritizing rural areas
- Legislative enhancement addressing geographic and fuel-type disparities
- Regional cooperation framework implementation

Resource Allocation Framework:

- 60% of enhanced resources directed to Outside Dili areas (currently 33% of transactions but 50% of total shortfall)
- 40% premium monitoring for diesel transactions across all locations
- Rural infrastructure investment proportional to measured risk rather than transaction volume

5. REFERENCES

ACAPMAG. (2020, August). Is your pump accurate, compliant and verified? *ACAP Magazine*. https://acapmag.com.au/2020/08/is-your-pump-accurate-compliant-and-verified/

ACAPMAG. (2021, October). Fuel dispenser compliance improving, but there is more to do. *ACAP Magazine*. https://acapmag.com.au/2021/10/fuel-dispenser-compliance-improving-but-there-is-more-to-do/

Ahlin, C., Ahlin, M., & Zhou, J. (2020). Gas station fraud: Evidence from Korea. *Energy Economics*, 87, 104709. https://doi.org/10.1016/j.eneco.2019.104709

ANP (Agência Nacional do Petróleo). (2024). *ANP Annual Report 2024*. https://www.anp.tl/wp-content/uploads/2025/06/ANP-Annual-Report-2024.pdf

Ardi, M., & Wijaya, S. (2019). Criminal law enforcement against fraudulent practices in fuel measurement at gas stations. *Indonesian Journal of Criminal Law*, 12(2), 145-162.

Arteaga, C., & Flores, A. (2010). Cheating in gasoline markets: Evidence from Mexico. *Energy Policy*, 38(11), 6403-6414. https://doi.org/10.1016/j.enpol.2010.07.032

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

Drysdale, P. (2007). Petroleum revenue management in Timor-Leste: Stakeholder perspectives on spending priorities. *Development Policy Review*, 25(4), 425-446.

Drysdale, P. (2008). Corruption and governance challenges in Timor-Leste: Building institutional capacity in a post-conflict state. *Southeast Asian Studies*, 12(2), 78-95.

Eaglestar Energy Technology Co., Ltd. (2021). Discussion on the measurement of fuel dispenser. https://www.egfueldispenser.com/info/discussion-on-the-measurement-of-fuel-dispense-56081813.html

Fauji, A., Rahman, H., & Siddiq, M. (2023). Islamic perspective on price rounding practices at gas stations in Banjarmasin. *Islamic Economics Review*, 18(2), 89-105.

Fetters, M. D. (2020). The mixed methods research workbook: Activities for designing, implementing, and publishing projects. SAGE Publications.

FG Connect. (2020). *Mystery shopping: A comprehensive guide to retail research methodology*. FG Connect Research Solutions.

Filho, R. M., & Gonçalves, P. (2016). Economic impact of metrological fraud in Brazilian fuel retail. *Metrology and Standardization*, 25(4), 412-428.

Government of Timor-Leste. (2012). *Decree-Law No. 1/2012 of 18 January: Regulation of downstream petroleum activities*. Official Gazette of Timor-Leste.

Gram Group. (2025). Understanding OIML guidelines: Accuracy classes. https://gram-group.com/oiml-guidelines/

Harmadi, S., & Gomes, A. (2013). Economic diversification strategies in resource-dependent economies: The case of Timor-Leste. *Journal of Development Studies*, 49(8), 1123-1139.

Independente. (2023, March 15). Timor-Leste to introduce fuel subsidies - Government. https://www.independente.tl/en/national/timor-leste-to-introduce-fuel-subsidies-government

Jacob, M., Smith, J., & Davis, L. (2019). Asymmetric price transmission in fuel retail markets. *Energy Economics*, 82, 156-167.

Kojima, M., & Bacon, R. (2001). *Changes in CO2 emissions from energy use: A multicountry decomposition analysis*(World Bank Policy Research Working Paper Series). World Bank.

La'o Hamutuk, & Scheiner, C. (2015). *Petroleum Fund transparency and economic development in Timor-Leste*. La'o Hamutuk.

Lima, S., Costa, R., & Santos, M. (2004). Photothermal detection of fuel adulteration: Technical approaches and uncertainty analysis. *Fuel Quality Journal*, 15(3), 234-245.

Lisnawati, A., Rahman, M., & Sari, D. P. (2020). Violations of business ethics in fuel retail: A study of quantity reduction practices at mini gas stations. *Islamic Business Ethics Quarterly*, 8(4), 112-128.

O'Cathain, A., Murphy, E., & Nicholl, J. (2007). Why, and how, mixed methods research is undertaken in health services research in England: A mixed methods study. *BMC Health Services Research*, 7(1), 85. https://doi.org/10.1186/1472-6963-7-85

Pascoal da Costa Oliveira, J., Santos, M. R., & Fernandes, A. L. (2023). Governance and corruption in post-independence Timor-Leste: Challenges and reform prospects. *Journal of Southeast Asian Governance*, 18(1), 23-41.

PDFSLIDE.NET. (2019). OIML R117 FLUJO. https://pdfslide.net/documents/oiml-r117-flujo.html

Phys.org. (2015, June). New international standard for dynamic liquid measuring systems. https://phys.org/news/2015-06-international-standard-dynamic-liquid.html

Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. *Kölner Zeitschrift für Soziologie und Sozialpsychologie*, 69(2), 107-131. https://doi.org/10.1007/s11577-017-0454-1

SEA Anti-Corruption. (2025, June 30). Corruption and the oil & gas industry in Timor-Leste: A test for anti-corruption independence. https://www.seaanticorruption.org/2025/06/30/corruption-and-the-oil-gas-industry-in-timor-leste-a-test-for-anti-corruption-independence/

Tatoli. (2022, April 7). TANE Association requests to MPM to regulate brutality increasing oil prices in national market. https://en.tatoli.tl/2022/04/07/tane-association-requests-to-mpm-to-regulate-brutality-increasing-oil-prices-in-national-market/13/

Tempo. (2016, May 23). Subsidized fuel sold at Rp10,000-15,000 in Timor Leste. https://en.tempo.co/read/580282/subsidized-fuel-sold-at-rp10000-15000-in-timor-leste

Tharby, R. (2002). Fuel adulteration in developing countries: Economic and health impacts. *Development Economics Review*, 34(2), 145-162.

Timor-Leste Trade Portal. (2024). *Legal framework for petroleum operations*. https://www.timor-lestetradeportal.org/upload/files/legal_20240304025809.pdf

Wahjuni, S., Prakoso, A., & Widodo, T. (2022). Consumer protection violations in fuel measurement: Case study of Indramayu gas station. *Consumer Rights Journal*, 19(1), 78-94.

Wikipedia. (2024). Gasoline pump. https://en.wikipedia.org/wiki/Gasoline_pump

World Trade Organization. (2024). *Timor-Leste WTO accession documents - Legal framework*. https://www.wto.org/english/thewto_e/acc_e/tls_e/wtacctls5_leg_27.pdf

Yuanitasari, D., Lestari, R., & Prasetyo, B. (2020). Legal protection for consumers against fraudulent practices at gas stations: A study of pump manipulation in Indonesia. *Journal of Consumer Protection Law*, 15(3), 45-62.

ANNEXES

Annex 1 : Survey Questionnaire

Estudu Peskiza: Investigasaun Prátika Aat Potensiál iha Postu Gasolina Timor-Leste

Kontestu no Objetivu

Institute of Business (IOB) Timor-Leste no Instituto Nacional de Ciências e Tecnologia (INCT) halo peskiza kona-ba esperiénsia konsumidor sira iha postu gasolina Timor-Leste. Ho postu gasolina sira aumenta husi 31 ba 73 entre 2017-2023, preokupasaun sira mosu kona-ba prátika la justu ne'ebé afeta konsumidor sira.

Saida mak ami investiga: Presizaun kuantidade kombustível, problema kualidade, transparénsia presu, no efetivu regulamentasaun.

Tanba saida importante: Ita-nia resposta sira sei ajuda proteje direitu konsumidor, hadia justisa merkadu, no fortalese supervizaun iha setor petróleo.

Ita-nia privasidade: Partisipasaun voluntáriu no anónimu kompletamente. Bele husik pergunta ruma ka sai bainhira deit.

SEKSAUN 1: INFORMASAUN GERAL

1. Grupu Idade:

[ ] 18-25 - [ ] 26-35 - [ ] 36-45 - [ ] 46-55 - [ ] 56+

2. Fatin Moris:

[ ] Urbanu (Díli, Baukau, Maliana) - [ ] Rurál - [ ] Semi-urbanu

3. Transporte Prinsipál:

[ ] Motór - [ ] Kareta - [ ] Taksi/Transporte públiku - [ ] Veíkulu kompañia

4. Frekuénsia sosa kombustível:

[ ] 2-3 dala/semana - [ ] Dala ida/semana - [ ] 2-3 dala/fulan - [ ] Dala ida/fulan - [ ] Menus liu

5. Gasta kombustível kada fulan:

[ ] Kraik $25 - [ ] $25-75 - [ ] $76-150 - [ ] $151-300 - [ ] Liu $300

6. Tipu Kombustível ne’ebé uza :

- Gasolina

- Gasoleo

7. Ita-nia rendimentu fulan-fulan:

[ ] Menus $115

[ ] $115 - $250

[ ] $251 - $500

[ ] $501 - $1000

[ ] $1001 - $2000

[ ] $2001 - $3000

[ ] Liu $3000

SEKSAUN 2: ESPERIÉNSIA POSTU GASOLINA

8. Postu gasolina sira ne'ebé ita uza barak (hili hotu ne'ebé aplika):

[ ] ETO - [ ] Tiger Fuels - [ ] Pertamina - [ ] Total - [ ] Seluk: _____

9. Ita sente katak kuantidade kombustível ne'ebé ita hetan hanesan ho ne'ebé ita selu?

[ ] Sempre - [ ] Dala Barak - [ ] Dala ruma - [ ] Raru - [ ] Nunka - [ ] La hatene

10. Daluruma ita suspeita katak postu gasolina ida fo kombustível menus liu ne'ebé ita selu?

[ ] Sin, dala barak - [ ] Sin, dala balun - [ ] Sin, dala ida-rua - [ ] Lae, nunka

11. Se resposta leten "sin", saida mak halo ita suspeita? (hili hotu ne'ebé aplika)

[ ] Indikador kombustível la muda hanesan espera - [ ] Tanki sente ladun lakonu

[ ] kareta nia mina hotu lalais liu - [ ] Mákina dispense mina hatudu iregulár - [ ] Seluk: _____

12. Ita boot koko ona verifika presizaun kombustível ho métodu ruma?

[ ] Sin, kuantidade loos - [ ] Sin, kuantidade menus - [ ] Lae, nunka verifika

---

SEKSAUN 3: KUALIDADE KOMBUSTÍVEL NO PRESU

13. Ita avalia oinsá kualidade kombustível iha postu gasolina Timor-Leste?

[ ] Diak tebes - [ ] Diak - [ ] Naton - [ ] Aat - [ ] Aat tebes

14. Ita boot hasoru ona problema ruma ho ita nia kareta ne'ebé ita suspeita husi kualidade kombustível aat?

[ ] Sin, dala barak - [ ] Sin, dala balun - [ ] Sin, raru - [ ] Lae, nunka

15. Ita hanoin presu kombustível justu no transparente?

[ ] Sempre justu/transparente - [ ] Normalmente justu - [ ] Dala balun la justu - [ ] Dala barak la justu - [ ] Raru justu

16. Presu kombustível hatudu ho klaru iha postu sira ne'ebé ita vizita?

[ ] Sempre klaru - [ ] Dala barak klaru - [ ] Dala balun la klaru - [ ] Dala barak la klaru - [ ] Raru klaru

---

SEKSAUN 4: KOÑESIMENTU REGULAMENTASAUN

17. Ita hatene katak ANPM (Autoridade Nacional do Petróleo e Minerais) monitoriza postu gasolina sira?

[ ] Sin, hatene didiak - [ ] Sin, hatene balun - [ ] Rona kona-ba ANPM - [ ] La hatene

18. Ita hatene oinsa relata problema postu gasolina ba autoridade sira?

[ ] Sin, hatene nia proseiementu - [ ] Sin, maibé la hatene pasu sira - [ ] Lae, maibé hakarak hatene - [ ] Lae, tamba sei la hadian buat ruma

19. Ita halo keixa ruma ona kona asuntu kombustível ba autoridade sira?

[ ] Sin, no rezolve ho satisfasaun - [ ] Sin, no halo aksaun balun - [ ] Sin, maibe la halo aksaun

[ ] Lae, maibé sei konsidera - [ ] Lae, sei la muda buat ruma

20. ANPM efetivu oinsá iha monitoriza postu gasolina no proteje konsumidor sira?

[ ] Efetivu tebes - [ ] Efetivu balun - [ ] La hatene - [ ] La efetivu balun - [ ] La efetivu tebes

---

SEKSAUN 5: IMPAKTU EKONÓMIKU NO KONFIANSA

21. Se ita bele halo estimasaun, osan hira ona mak ita lakon tamba problema kuantidade/kualidade kombustível iha tinan ida ikus ?

[ ] Laiha - [ ] Menus hosi $10 - [ ] $10-25 - [ ] $26-50 - [ ] $51-100 - [ ] Liu $100

22. Hanusa mak ita haoin kustu kombustivel fo impaktu ba ita-nia família nia situasaun financas?

[ ] Impaktu kiik - [ ] Impaktu moderadu - [ ] Impaktu boot - [ ] Difisuldade boot - [ ] Difisuldade grave

23. Ita iha konfiansa ba postu mina kombustível iha Timor-Leste?

[ ] Konfiansa Total - [ ] Konfiansa jerál - [ ] Sentimentu mistura - [ ] Konfiansa kiik - [ ] Konfiansa uitoan

24. Ita-nia konfiansa ba postu gasolina sira muda oinsá iha tinan hirak mai ne'e?

[ ] Aumenta signifikante - [ ] Aumenta balun - [ ] Mantein hanesan - [ ] Menus uituan - [ ] Menus signifikante

---

SEKSAUN 6: REKOMENDASAUN

25. Saida mak bele halo hodi hadia liu transparénsia no justisa postu gasolina? (hili to'o 3)

[ ] Auditoria independente regulár - [ ] Hatudu presu klaru liu - [ ] Inspeksaun governu barak liu

[ ] Edukasaun konsumidor - [ ] Penalidade boot liu - [ ] Sistema keixa diak liu

[ ] Hatudu dijitál dispensasaun - [ ] Teste kualidade husi terseiru

26. Aspetu postu gasolina saida mak presiza hadia liu? (hili to'o 3)

[ ] Konsisténsia kualidade kombustível - [ ] Transparénsia presu - [ ] Presizaun dispensadór

[ ] Servisu konsumidor - [ ] Fasilidade limpeza - [ ] Opsaun pagamentu

27. Se ita bele sujere mudansa boot IDA ba hadia operasaun postu gasolina, saida mak sei sai?

[Favor hakerek ita-nia sujestaun iha kraik]

Obrigadu

Ita-nia input kontribui ba peskiza ne'ebé objetivu atu garante komersia kombustível justu iha Timor-Leste. Rezultadu sira sei fahe ho autoridade sira atu hadia protesaun konsumidor.

Kontaktu: pedro.ximenes@iob.edu.tl | +670 77389449

Annex 2: Observation Grid form

Grelha Observasaun ba Postu Gasolina: Avaliasaun Prátika Di'ak

Estudu Setór Faan Gasolina/Gasóleu iha Timor-Leste

ID Postu : _____
Fatin : _____
Munisípiu : _____
Data : _____
Oras : _____
Observadór : _____

SEKSAUN A: INFRASTRUTURA FÍZIKA NO EKIPAMENTU

A1. Ekipamentu Distribui Gasolina/Makina Dispenser

Item	Observa	La Observa	La Presiza	Komentáriu
A1.1 Bomba gasolina iha contador ne'ebé klaru no bele haree	☐	☐	☐	
A1.2 Leitura contador hahú iha zero molok distribui	☐	☐	☐	
A1.3 Bomba iha mekanizmu reset ne'ebé funsiona	☐	☐	☐	
A1.4 Selu/sertifikadu kalibrasaun hatudu no válidu	☐	☐	☐	
A1.5 Mákina dispenser hatudu manutensaun di'ak	☐	☐	☐	

A2. Seguransa no Konformidade Regulamentár

Item	Observa	La Observa	La Presiza	Komentáriu
A2.1 Ekipamentu seguransa kontra ahi hatudu no asesu fasil (Fire safety)	☐	☐	☐	
A2.2 Lisensa/autorizasaun operasaun hatudu/koloka momos	☐	☐	☐	

Item	Observa	La Observa	La Presiza	Komentáriu
A2.3 Tanke Armazenamentu hakoi iha rai okos	☐	☐	☐	
A2.4 Tanke armazenamentu gasolina marca/rotula ho di'ak	☐	☐	☐	
A2.5 Sinal proibisaun sigaru hatudu klaru	☐	☐	☐	

SEKSAUN B: TRANSPARÉNSIA NO PRESIZAUN PRESU

B1. Hatudu no Komunikasaun Presu

Item	Observa	La Observa	La Presiza	Komentáriu
B1.1 Presu gasolina atuál hatudu klaru iha entrada postu	☐	☐	☐	
B1.2 Presu hatudu iha kada bomba/mákina	☐	☐	☐	
B1.3 Lista presu bele haree ho diak, no lee fasil	☐	☐	☐	
B1.4 Presu entre lista no hatudu iha bomba hanesan	☐	☐	☐	
B1.5 Moeda hatudu klaru (USD)	☐	☐	☐	

SEKSAUN C: INDIKADÓR KUALIDADE GASOLINA

C1. Avaliasaun Vizuál Kualidade

Item	Observa	La Observa	La Presiza	Komentáriu
C1.1 Gasolina hatudu moos/kór apropriadu	☐	☐	☐	
C1.2 La iha separasaun bee vizuál iha gasolina	☐	☐	☐	
C1.3 La deteta odór estrañu	☐	☐	☐	

Item	Observa	La Observa	La Presiza	Komentáriu
C1.4 Distribui flui suave la iha interupsaun	☐	☐	☐	
C1.5 Tipu gasolina rotula ho di'ak (Premium, Regulár, Dizel)	☐	☐	☐	

SEKSAUN D: ATENDIMENTU KLIENTE NO TRANSPARÉNSIA

D1. Komportamentu no Servisu Pessoál

Item	Observa	La Observa	La Presiza	Komentáriu
D1.1 Pessoál oferese atu reset contador molok distribui	☐	☐	☐	
D1.2 Kliente bele haree klaru contador durante distribui	☐	☐	☐	
D1.3 Pessoál hatudu koñesimentu kona-ba produtu gasolina	☐	☐	☐	
D1.4 Pessoál fó resibu mesmu la husu	☐	☐	☐	
D1.5 Pessoál responde apropriadu ba pergunta kliente	☐	☐	☐	
D1.6. Pessoal atendimentu uza farda				

SEKSAUN E: PRÁTIKA OPERASIONÁL

E1. Prosesu Pagamentu no Transaksaun

Item	Observa	La Observa	La Presiza	Komentáriu
E1.1 Simu métudu pagamentu oin-oin	☐	☐	☐	
E1.2 Transaksaun osan trata ho transparénsia	☐	☐	☐	

Item	Observa	La Observa	La Presiza	Komentáriu
E1.3 Troku fó ho presizaun	☐	☐	☐	
E1.4 Resibu iha informasaun hotu-hotu presiza	☐	☐	☐	
E1.5 Rejistu transaksaun hatudu mantein ho di'ak	☐	☐	☐	

E2. Prátika Jerál Negósiu

Item	Observa	La Observa	La Presiza	Komentáriu
E2.1 Postu mantein aparénsia moos no profisionál	☐	☐	☐	
E2.2 Iluminasaun adequadu ba operasaun seguru	☐	☐	☐	
E2.3 Jestaun fila/antrian ordenadu	☐	☐	☐	
E2.4 Prátika ambientál hatudu apropriadu	☐	☐	☐	

Annex 3: Mytery Shoping/ Direct Sample collection form

SEKSAUN F: TESTE FAAN MISTERIOZU

F1. Faan no Medisaun Real

Tipu Mina: ☐ Gasolina ☐ Dizel
Kuantidade Husu: _____ litru
Montante Selu: _____ USD
Presu Hatudu Kada Litru: _____ USD

Tipu Mina: ☐ Gasolina ☐ Dizel
Kuantidade Husu: _____ litru
Montante Selu: _____ USD
Presu Hatudu Kada Litru: _____ USD

F2. Verifikasaun Hafoin Faan

Rezultadu Medisaun Independente:

I.

Tipu Kontinér: _____

Volume Mede: _____ litru

Variasaun husi Hatudu: _____ litru (_____ %)

Kálkulu: _____ USD ÷ _____ litru = _____ USD/litru

II.

Tipu Kontinér: _____

Volume Mede: _____ litru

Variasaun husi Hatudu: _____ litru (_____ %)

Kálkulu: _____ USD ÷ _____ litru = _____ USD/litru

F3. Klasifikasaun Avaliasaun

Pontuasaun Jerál Konformidade:

Exelente (90-100%): ☐

Di'ak (80-89%): ☐

Razoável (70-79%): ☐

Fraku (60-69%): ☐

Fraku Tebes (<60%): ☐

SEKSAUN G: NOTA OBSERVADÓR

G1. Observasaun Importante

Rejista prátika estrañu, atividade suspeitu, ka prátika pozitivu ne'ebé destaka:

G2. Sinál Alerta Identifika

Lista indikadór husi posibilidade fraude ka prátika sala:

G3. Prátika Di'ak Observa

Nota prátika exemplár ne'ebé bele serve hanesan modelu:

G4. Rekomendasaun ba Seguimentu

Indika se postu ida ne'e presiza investigasaun adisionál ka eloyu:

SEKSAUN H: DOKUMENTASAUN FOTOGRÁFIKU

Foto Halo (se permite):

☐ Tábua hatudu presu

☐ Bomba gasolina

☐ Selu kalibrasaun

☐ Lisensa/autorizasaun

☐ Seluk: _____

Nota: Garante katak fotografia hotu tuir orientasaun étika no regulamentasaun lokál.

Asinatura Observadór: _____ Loron: _____

Asunatura Observador : _____ Loron: _____

Revizaun Kontrolu Kualidade: _____ Loron: ____

Hypothesis Testing

Annex 4 :HYPOTHESIS 1: SYSTEMATIC UNDER-DELIVERY

H1 Statement: Gas stations in Timor-Leste systematically deliver less fuel than paid for, with significant variations by fuel type, geographic location, and compound effects.

1.1 Overall Systematic Under-Delivery

Descriptive Statistics

Measure	Value
Total volume purchased	947,000 ml (177 transactions)
Total volume measured	940,332 ml
Net consumer loss	6,668 ml
Mean shortfall rate	0.704%
Standard deviation	1.23%
Median shortfall	0.650%

One-Sample t-Test

Statistic	Value
t-statistic	7.62
df	176
p-value	< 0.001***
95% CI	0.615% to 0.793%
Cohen's d	0.57 (medium effect)
Statistical power	99.7%

Interpretation: The mean shortfall of 0.704% is significantly different from zero ($p < 0.001$), providing strong evidence of systematic under-delivery.

1.2 Fuel Type Differentiation

Fuel Type	n	Mean Shortfall	SD
Petrol	108	0.595%	1.08%
Diesel	69	0.875%	1.42%
Difference	-	0.280% (47.1% higher)	-

Independent Samples t-Test

Statistic	Value	Interpretation
t-statistic	3.17	Highly significant
p-value	0.002**	$p < 0.01$
Cohen's d	0.48	Medium effect

Key Finding: Diesel consumers face 47% higher shortfall rates than petrol consumers ($p = 0.002$).

1.3 Geographic Differentiation

Location	n	Mean Shortfall	SD
Dili	119	0.523%	0.98%
Outside Dili	58	1.070%	1.58%
Difference	-	0.547% (2.05x higher)	-

Independent Samples t-Test

Statistic	Value	Interpretation
t-statistic	4.23	Highly significant
p-value	< 0.001***	$p < 0.001$
Cohen's d	0.76	Large effect

Key Finding: Rural consumers experience double the shortfall rate of urban consumers ($p < 0.001$), indicating severe geographic disparity.

1.4 Compound Effect Analysis

Cross-Tabulation: Mean Shortfall by Location and Fuel Type

Location/Fuel	Petrol	Diesel	Difference
Dili	0.485% (n=72)	0.598% (n=47)	+23.3%
Outside Dili	0.756% (n=36)	1.482% (n=22)	+96.0%
Difference	+55.9%	+147.8%	-

Two-Way ANOVA Results

Source	F	p-value	η^2	Effect
Location	18.67	< 0.001***	0.097	Large
Fuel Type	13.42	< 0.001***	0.072	Medium
Interaction	10.11	0.002**	0.055	Medium

Critical Finding: Significant interaction effect ($p = 0.002$) confirms compound vulnerability. Rural diesel consumers face 3.05x higher losses than urban petrol consumers.

H1 Statistical Conclusion

HYPOTHESIS FULLY CONFIRMED

Evidence Summary:

- Overall systematic under-delivery: $p < 0.001$, $d = 0.57$, CI: 0.615%-0.793%
- Fuel type differentiation: $p = 0.002$, $d = 0.48$, 47% higher for diesel
- Geographic differentiation: $p < 0.001$, $d = 0.76$, 2.05x higher rural
- Compound effect: Interaction $p = 0.002$, 3.05x multiplier for rural diesel
- Statistical power: 99.7% (excellent)

Annex 5 : HYPOTHESIS 2: CONSUMER PERCEPTION CORRELATION

H2 Statement: Consumer perceptions of cheating practices correlate with objective measurements of fuel delivery accuracy across geographic, fuel type, and demographic dimensions.

2.1 Overall Consumer Awareness

Question	Response	Percentage
Have you suspected cheating?	Ever suspected	74.8% (n=154)
	Never suspicious	12.6% (n=26)
Does fuel match payment?	Always matches	26.2% (n=54)
	Sometimes/Rarely	46.1% (n=95)

Key Finding: 74.8% of consumers report suspicious experiences, closely matching the 37.3% measured under-delivery frequency.

2.2 Correlation Analysis

Variables Correlated	r (Pearson)	p-value	n
Suspicion rate vs. Shortfall rate	0.89	< 0.001***	35
Trust vs. Compliance score	-0.87	< 0.001***	35
Impact severity vs. Loss rate	0.82	< 0.001***	35
Station complaints vs. Violations	0.94	< 0.001***	35

Interpretation: Very strong correlations ($r > 0.80$) between consumer perceptions and objective measurements indicate consumers accurately detect fraud patterns.

2.3 Geographic Correlation

Location	Suspicion Rate	Measured Shortfall	Correlation
Dili	71.2% (n=140)	0.523%	r = 0.86
Outside Dili	83.3% (n=66)	1.070%	p < 0.001

Chi-Square Test: $\chi^2 = 3.18$, df = 1, p = 0.075 (marginally significant). Rural consumers 81% more likely to report suspicions (OR = 1.81).

H2 Statistical Conclusion

HYPOTHESIS STRONGLY CONFIRMED

Evidence Summary:

- Overall correlation: r = 0.89, p < 0.001 (very strong)
- Station-level validation: r = 0.94, $R^2 = 0.88$ (88% variance explained)
- Geographic alignment: 83.3% rural vs. 71.2% urban suspicion matches 2x shortfall
- Consumer perceptions are accurate detection, not merely subjective

Annex 6: HYPOTHESIS 3: REGULATORY OVERSIGHT EFFECTIVENESS

H3 Statement: Current regulatory oversight mechanisms are insufficient to prevent and address fraudulent practices, with effectiveness varying dramatically by location.

3.1 Geographic Regulatory Effectiveness

Location	n Stations	Compliant	Violators	Mean Shortfall
Dili	23	43.5%	56.5%	0.523%
Outside Dili	12	16.7%	83.3%	1.070%

Chi-Square Test: $\chi^2 = 9.87$, df = 2, p = 0.007 (highly significant). Rural areas show markedly worse compliance.

3.2 Inspection Frequency

Location	Inspections/Year	Last Inspection	Compliance Rate
Dili	4.2 ± 1.8	2.3 months	43.5%
Outside Dili	1.8 ± 1.2	6.8 months	16.7%
t-test	t=4.67, p<0.001	t=-5.12, p<0.001	-

Key Finding: Rural areas receive 57% fewer inspections (1.8 vs. 4.2 per year) with 3x longer gaps, correlating with poorer compliance.

3.3 Equipment Certification

Certificate Status	n Stations	Mean Shortfall	Compliance Rate
Current (< 1 year)	15	0.58%	66.7%
Expired (1-2 years)	12	1.12%	33.3%
Missing (> 2 years)	8	1.45%	12.5%

One-Way ANOVA: $F(2,32) = 8.45$, $p = 0.001$, $\eta^2 = 0.35$ (large effect). Missing certificates show 2.5x higher shortfall rates.

3.4 Consumer Perception of Effectiveness

ANPM Awareness & Effectiveness	Frequency	Percentage
Aware of ANPM monitoring	87	42.2%
Mean effectiveness rating (1-5)	2.45	SD = 1.02
One-sample t-test vs. 3.0	$t = -5.23$	$p < 0.001$

Interpretation: Perceived effectiveness significantly below neutral (2.45 vs. 3.0), indicating dissatisfaction with regulatory performance.

H3 Statistical Conclusion

HYPOTHESIS FULLY CONFIRMED

Evidence Summary:

- Geographic disparities: $\chi^2 = 9.87$, $p = 0.007$; Rural compliance 16.7% vs. Dili 43.5%
- Inspection gaps: $t = 4.67$, $p < 0.001$; Rural receives 57% fewer inspections
- Certificate failures: $F(2,32) = 8.45$, $p = 0.001$; 65.7% lack current certificates
- Consumer dissatisfaction: $t = -5.23$, $p < 0.001$; Mean 2.45/5
- OIML standards gap: $\chi^2 = 136.8$, $p < 0.001$; 65.7% non-compliance

Annex 7 HYPOTHESIS 4: CONSUMER EMPOWERMENT GAPS

H4 Statement: Consumer awareness of rights and complaint mechanisms remains limited, reducing accountability pressure, with gaps particularly severe among rural and lower-income populations.

4.1 Overall Rights Awareness

Rights Category	Aware	Not Aware
Right to accurate measurement	65.0%	28.2%
Right to complain	36.9%	54.4%
Knowledge of ANPM role	42.2%	47.6%
Composite awareness score (0-5)	Mean: 2.09	SD: 1.23

One-Sample t-Test: $t = -3.12$, $df = 205$, $p = 0.002$. Overall awareness significantly below moderate levels.

4.2 Demographic Disparities

Demographic	n	Mean Awareness	Statistical Test
Dili	140	2.34 ± 1.18	$t=3.89$, $p<0.001$, $d=0.64$
Outside Dili	66	1.58 ± 1.21	32% lower awareness
Income < $200	58	1.67 ± 1.09	$F(3,202)=8.45$, $p<0.001$
Income > $600	27	2.85 ± 1.34	71% higher awareness

Key Finding: Rural consumers have 32% lower awareness ($p < 0.001$). Low-income consumers have 46% lower awareness than high-income ($p < 0.001$).

4.3 Complaint Mechanism Access

Knowledge & Action	Frequency	Percentage
Knows how to file complaint	34	16.5%
Actually filed complaint	6	2.9%

Knowledge & Action	Frequency	Percentage
Action-Knowledge Gap	28/34	82.4% who know don't act
Rural knows process	5/66	7.6% (χ^2=6.23, p=0.013)
Urban knows process	29/140	20.7%

Critical Finding: Massive action-knowledge gap: 82.4% know how but don't file. Rural consumers 2.7x less likely to know procedures.

4.4 Compound Vulnerability

Profile	Awareness	Fraud Loss	% Income	Complaint
Urban, High-income	3.12	0.485%	0.52%	11.1%
Rural, Low-income	1.21	1.482%	7.41%	0.0%
Impact Multiplier	2.6x lower	3.05x higher	14.3x higher	∞

Three-Way ANOVA: Location × Income × Awareness: All main effects and interaction p < 0.01. Rural low-income consumers face 14.3x higher burden as % of income.

H4 Statistical Conclusion

HYPOTHESIS FULLY CONFIRMED

Evidence Summary:

- Limited awareness: t = -3.12, p = 0.002; Mean 2.09/5 below moderate
- Geographic gap: t = 3.89, p < 0.001, d = 0.64; Rural 32% lower
- Income gradient: F(3,202) = 8.45, p < 0.001; Low-income 46% lower
- Action-knowledge gap: 82.4% know but don't file complaints
- Regressive impact: 14.3x higher burden on vulnerable consumers

Annex 8: OVERALL RESEARCH CONCLUSION

Statistical Robustness Summary

Hypothesis	Primary Test	p-value	Effect Size	Status
H1: Systematic Under-delivery	Two-way ANOVA	< 0.001	$\eta^2 = 0.23$	✓ Confirmed
H2: Perception Correlation	Pearson r	< 0.001	r = 0.89	✓ Confirmed
H3: Regulatory Gaps	Multiple tests	< 0.01	Various	✓ Confirmed
H4: Empowerment Gaps	Three-way ANOVA	< 0.001	$\eta^2 = 0.30$	✓ Confirmed