

# **Strategy to Accelerate QRIS Payment Adoption in Papua Province with System Dynamics Approach**

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## **Abstract**

Accelerating the adoption of digital payment systems in underdeveloped regions requires a systemic approach that considers the complex interactions between social, economic, and technological factors. This study examines strategies to promote QRIS adoption in Papua Province, employing a System Dynamics approach. By developing a Causal Loop Diagram and Stock and Flow Diagram, the research simulates the impact of various policy interventions, including community-based education, decentralized digital infrastructure development, and integration of QRIS into local economic activities. Simulation results reveal that these interventions reinforce each other in promoting the growth of users, merchants, and transaction volumes. The findings underscore the importance of context-specific, community-driven strategies in promoting digital financial inclusion in frontier regions, while providing policy insights that can be applied to similar settings across Indonesia.

## **Keywords**

QRIS, System Dynamics, Payment System, Policy Strategy.

## **1. Introduction**

The advancement of technology and digitalization has significantly accelerated the use of non-cash payment instruments. According to data from Bank Indonesia, there has been a dramatic increase in digital transactions, reflecting society's adaptation to the convenience and efficiency offered by electronic payment systems.

The development of information technology has played a crucial role in transforming Indonesia's payment system. With the rapid growth of industry and the increasing use of smartphones among the public, technology and financial companies are increasingly leveraging digital innovations, one of which is digital payment solutions. One of the most rapidly growing innovations in Indonesia's digital payment landscape is the use of Quick Response (QR) Codes payment system, which provide convenience and efficiency in conducting transactions.

The implementation of the Quick Response Code Indonesian Standard (QRIS) is a strategic initiative designed to strengthen the national digital payment ecosystem. It also serves as a key instrument in the implementation of the Indonesia Payment System Blueprint (BSPI) 2025–2030, developed by Bank Indonesia. In this context, QRIS acts as the national standard for QR code-based payments, designed to ensure interoperability and interconnectivity among payment system players—both bank and non-bank institutions, thereby enhancing efficiency, security, and convenience in digital transactions (Figure 1-Figure 3).

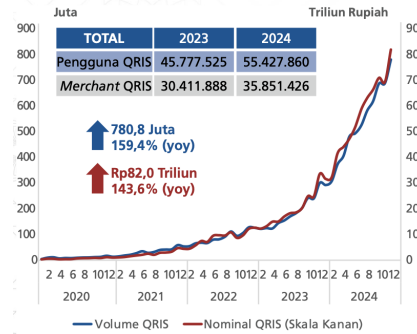


Figure 1. Number of Users, Volume, and Value of QRIS Transactions in 2024

The implementation of QRIS in Indonesia has demonstrated substantial growth throughout 2024. According to data from Bank Indonesia, the number of QRIS users reached 55,4 million, with 35,8 million registered merchants. The volume of QRIS transactions increased rapidly, rising by 159,4% year-on-year to a total of 780,8 million transactions. The transaction value also experienced significant growth, rising by 143.6% year-on-year to reach IDR 82 trillion. This growth reflects the widespread adoption and public trust in QRIS as an efficient and integrated digital payment solution in Indonesia.

However, behind this national growth, regional disparities in QRIS adoption remain, particularly in eastern Indonesia. One such area is Papua Province, which—despite showing an upward trend—still faces several challenges in achieving equitable access to and optimal utilization of QRIS. This highlights the need to investigate further the actual conditions and the urgency of developing strategies to accelerate QRIS adoption in the region.

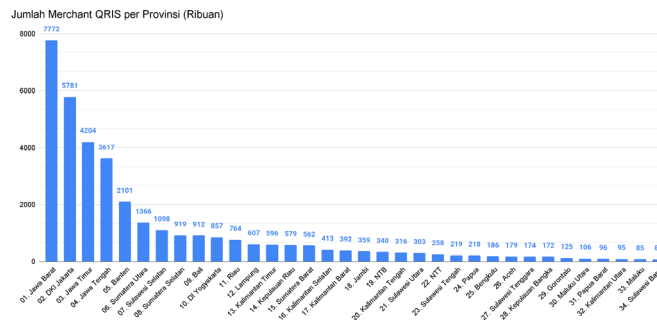


Figure 2. Number of QRIS Merchants per Province as of December 2024

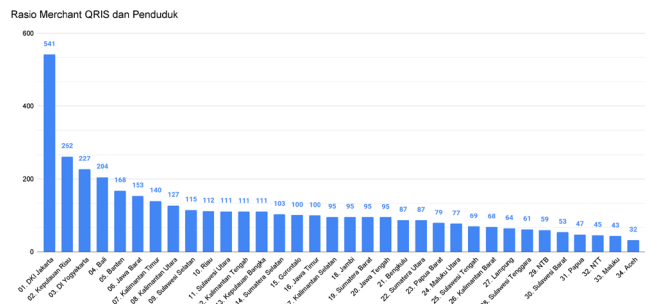


Figure 3. QRIS Merchant-to-Population Ratio as of December 2024

Although data shows that Papua ranked 24th out of 34 provinces in terms of the absolute number of QRIS merchants as of December 2024 (and thus not the lowest), selecting Papua as the focus of this study remains strategically important when analyzed in greater depth and within its specific context. With 217,571 merchants and an estimated population of around 4,6 million people (BPS, 2025a), Papua records a ratio of approximately 47 merchants per 1,000 inhabitants (Population estimates are based on pre-division figures from Badan Pusat Statistik). Although this ratio is higher than in several provinces, such as Aceh (31), Maluku (43), and East Nusa Tenggara (44), QRIS penetration in Papua remains suboptimal, particularly considering the region's geographical complexity, infrastructure limitations, and limited financial service accessibility.

## **1.1 Objectives**

The objective of this research is to analyze and develop strategies that can accelerate the adoption of the Quick Response Code Indonesian Standard (QRIS) in Papua by applying a System Dynamics approach. Specifically, this study seeks to capture and model the complex interactions among key factors that influence QRIS adoption, including user growth, merchant participation, transaction dynamics, literacy and socialization efforts, technological readiness, and supporting infrastructure. By integrating empirical data and feedback mechanisms into the model, the research aims to simulate the dynamic behavior of QRIS adoption over time and evaluate the effectiveness of alternative policy interventions. The ultimate goal is to generate evidence-based recommendations for Bank Indonesia and relevant stakeholders to design more targeted, adaptive, and sustainable strategies that not only accelerate digital payment adoption in Papua but also contribute to the broader objectives of the Indonesian Payment System Blueprint (BSPI) 2025–2030, namely financial inclusion, digital transformation, and economic equity.

## **2. Literature Review**

### **2.1 Payment System in Indonesia**

Since the early 2000s, Indonesia has increasingly adopted electronic-based payment systems. The emergence of shared ATM networks, mobile banking services, and fintech platforms has driven the digitalization of payment systems. One of the latest initiatives to improve the efficiency of digital transactions is the implementation of BI-FAST, which enables real-time interbank transactions at lower costs compared to traditional clearing systems.

One of the key innovations in Indonesia's non-cash payment system is the introduction of the Quick Response Code Indonesian Standard (QRIS). Launched by Bank Indonesia and the Indonesian Payment System Association in 2019, QRIS aims to unify the various types of QR codes issued by different payment service providers into a universal standard. With QRIS, consumers need only one application to make payments to multiple merchants, regardless of the payment provider the merchant uses. QRIS supports financial inclusion by simplifying digital payments for micro, small, and medium enterprises (MSMEs) without requiring complex infrastructure.

### **2.2 Payment System Regulations**

Regulations are fundamental to ensuring that payment systems operate securely, efficiently, and are accessible to all segments of society. The following are key regulations related to the payment system:

1. Undang-Undang Nomor 23 Tahun 1999 tentang Bank Indonesia
2. Peraturan Bank Indonesia (PBI) No.18/40/PBI/2016 tentang Penyelenggaraan Pemrosesan Transaksi Pembayaran
3. PBI No. 20/6/PBI/2018 tentang Uang Elektronik
4. PBI No. 24/1/PADG/2022 tentang QRIS
5. Blueprint Sistem Pembayaran Indonesia 2030 (BSPI 2030)

### **2.3 Quick Response Code Indonesian Standard (QRIS)**

QRIS is a national standard for QR code-based payments introduced by Bank Indonesia in 2019 to integrate various QR payment systems under a unified framework. The goal of QRIS is to improve the efficiency and inclusiveness of the digital payment system by enabling users to make transactions across platforms using a single, interoperable QR code.

Before QRIS, digital wallets such as GoPay, OVO, Dana, and ShopeePay each had their own QR codes, forcing merchants to display multiple codes to accept payments from different platforms. This created inefficiencies and posed challenges for businesses, especially MSMEs. With QRIS, all transactions can be conducted through a single standardized QR code, regardless of the consumer's chosen payment service provider.

## **2.4 System Dynamics Theory**

Systems Dynamics modeling is a methodology designed to understand dynamic problems using a feedback-based systems approach (Barlas, 1996). In complex systems, changes are not always linear; instead, they are influenced by the interaction of interrelated variables through feedback loops and time delays. Systems Dynamics views systems as entities composed of interacting elements connected by cause-and-effect relationships, stocks and flows, and time delays. This structure generates evolving system behavior over time—patterns that are often invisible using conventional analytical methods.

The System Dynamics approach also enables the exploration of policy and intervention impacts in a more systematic and simulation-based manner (Ford, 1999). It is suitable not only for large-scale systems but can also be adapted for smaller models capable of addressing large and complex issues. Pruyt (2013) emphasizes the importance of small system dynamics models for rapid learning, policy exploration, and decision-making under data and time constraints.

This methodology utilizes not only numerical data, but also qualitative insights derived from experience and formal documentation that describe system characteristics. According to Sterman (2000), in *Business Dynamics: Systems Thinking and Modeling for a Complex World*, integrating various data sources is essential for creating accurate, robust, and reliable models. Forrester (1961) in *Industrial Dynamics* also underscores that understanding system structures requires a combination of conceptual thinking (mental data), formal documentation (written data), and quantitative analysis (numerical data).

## **2.5 Strategy Theory**

Strategy is an evolving discipline designed to help organizations achieve their long-term goals in dynamic environments. Understanding strategy involves not only planning and execution but also analyzing how systems react to internal and external changes over time.

One of the most influential theories is Michael Porter's *Competitive Strategy* (1980), which outlines three generic strategies for achieving competitive advantage: Cost Leadership, Differentiation, and Focus. In contrast, Henry Mintzberg (1994) offers a more dynamic and flexible view of strategy, developing the concepts of deliberate strategy (planned) and emergent strategy (evolving naturally). Mintzberg argues that strategy cannot always be fully predicted due to the constantly changing nature of external factors.

In the context of macro policy and strategy, Donella Meadows (2008) in *Thinking in Systems* introduces the concept of leverage points—places within a system where small changes can lead to significant impacts. Additionally, Kim Warren (2008) in *Strategic Management Dynamics* connects strategy with system dynamics, emphasizing that strategy is not merely short-term planning, but a continuous process that must be monitored and adapted to environmental changes.

## **3. Methods**

This study applies the System Dynamics (SD) approach through six main stages (Figure 4). The research begins with an initial process of defining the research topic, formulating the problem, and determining the objectives. A literature review is then conducted to gather comparative study results and identify the key factors influencing the adoption of QRIS.



#### 4. Data Collection

Based on the data collection process, this study relies on secondary data obtained from Bank Indonesia Papua Province Representative Office, complemented with supporting reports and publications related to digital payment adoption. The main datasets include QRIS transaction volume and value, merchant registrations, electronic money usage, the Electronic Transaction Processing Development (ETPD) index, and records of literacy and socialization programs. These data serve as the foundation for constructing the stock–flow model and simulating adoption dynamics.

Two primary perspectives were considered in framing the data. The first perspective, or base case, assumes that adoption continues under current trends with limited intervention, reflecting the natural growth pattern of QRIS in Papua. The second perspective incorporates additional policy measures, such as intensified literacy campaigns, merchant incentives, and the introduction of an offline mode for QRIS, which are expected to accelerate adoption beyond the baseline. These perspectives enable comparisons of adoption outcomes under various strategic interventions.

#### 5. Results and Discussion

The developed System Dynamics model consists of six interrelated modules: digital literacy, QRIS users, QRIS transactions, merchants, electronic money, and cash. The digital literacy module captures the effect of education and outreach programs on public awareness and adoption. The user module represents the dynamics of consumer adoption, where understanding, trust, and accessibility drive growth. The transaction module links users and merchants to overall transaction values and volumes. In contrast, the merchant module highlights the role of incentives and activation programs in expanding the number of acceptance points. The electronic money module connects QRIS usage to the broader circulation of digital money, reinforcing the shift toward cashless payments. Finally, the cash module illustrates the substitution effect as QRIS adoption reduces reliance on cash transactions. Together, these modules provide a comprehensive representation of the adoption dynamics and feedback loops that influence the success of QRIS in Papua (Figure 6- Figure 10).

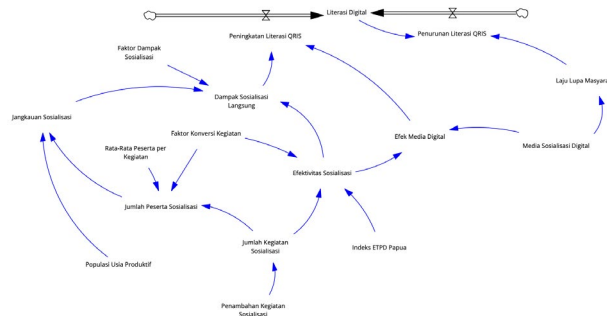


Figure 6. Digital Literacy Module SFD

Digital Literacy Module captures the impact of Bank Indonesia's outreach and education programs on QRIS adoption. Higher literacy increases public awareness, accelerates user growth, and supports sustained transaction frequency.

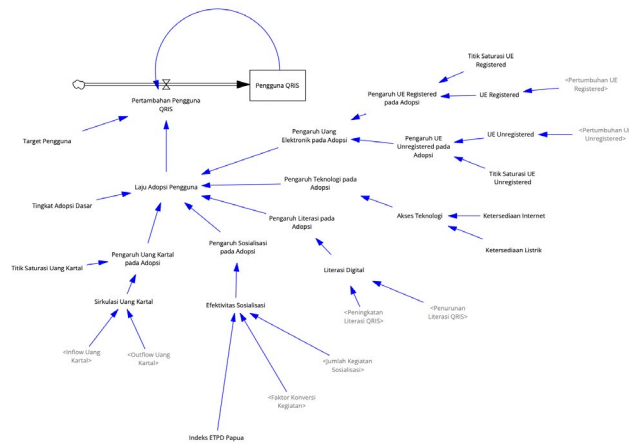


Figure 7. QRIS User Module SFD

QRIS User Module models the dynamics of QRIS adoption by consumers. It reflects how awareness, trust, and accessibility drive user growth, and how active users contribute directly to transaction volumes.

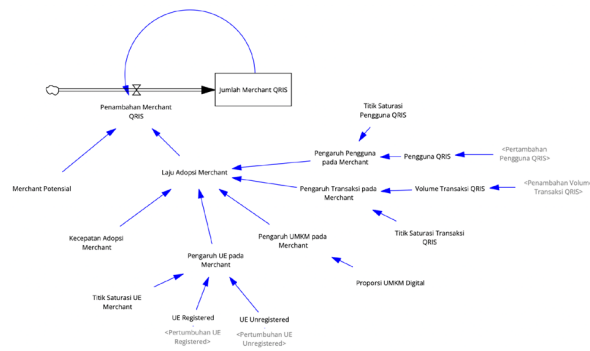


Figure 8. QRIS Merchant SFD

The QRIS Merchant Module shows the expansion of QRIS acceptance points. It highlights the role of incentives and activation programs in accelerating merchant registration, which in turn drives higher adoption and usage.

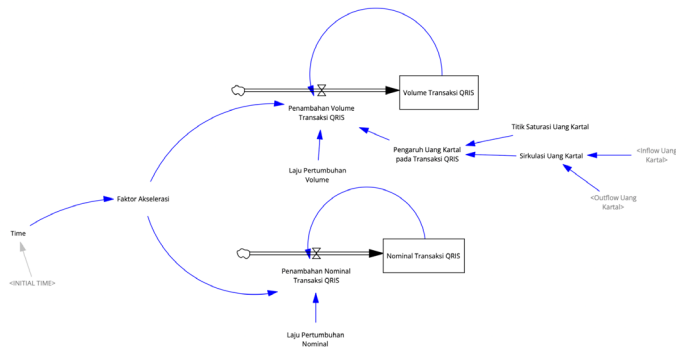


Figure 9. QRIS Transaction SFD

The QRIS Transaction Module represents the flow of transaction values and volumes generated by QRIS users. It demonstrates how the growth of adoption and merchant expansion interact to increase overall transaction activity.

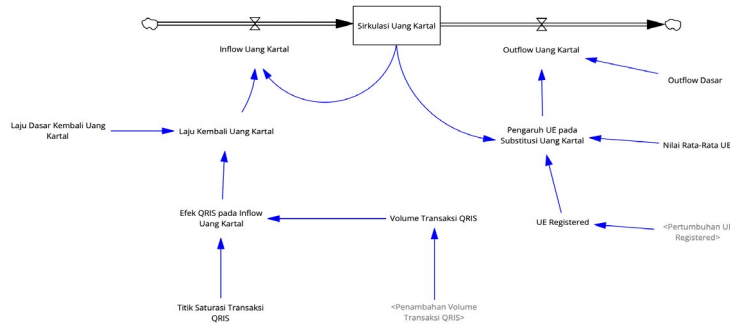


Figure 10. Cash Transaction Module SFD

The Cash Transaction Module illustrates the gradual substitution effect as QRIS adoption expands. Higher QRIS usage reduces dependence on cash transactions, aligning with national goals for a less-cash economy.

### 5.1 Numerical Results

The QRIS User variable under the Business as Usual (BAU) scenario was selected because it directly reflects the adoption dynamics and serves as the foundation for other modules, including transactions, merchants, and electronic money (Table 1). By analyzing user growth in the baseline case, the stability and accuracy of the stock–flow structure can be tested without the influence of additional policy interventions.

Table 1. QRIS User variable under the Business as Usual (BAU)

Period (Month)	QRIS User (TS: 1)	QRIS User (TS: 0,5)	QRIS User (TS: 0,25)
6	172.994	172.708	172.136
12	232.511	232.522	232.619
24	262.610	262.632	262.674
MAPE	-	0,059 %	0,189%

To ensure the reliability of the simulation, an integration error test was conducted by comparing the performance of two numerical methods: Euler and Runge-Kutta 4 (RK4). The test examined the accuracy of the model's stock–flow calculations under various step sizes. Results show that RK4 produced significantly lower integration errors compared to Euler, especially with larger step intervals. This confirms that RK4 is more suitable for capturing the non-linear dynamics of QRIS adoption in Papua, providing stable and accurate results over the simulation horizon.

Further evaluation was performed by testing different time steps (TS = 1; 0,5; and 0,25 months) for the variable QRIS Users. The outputs remained consistent across step sizes, with only minor deviations observed. For example, at month 24, the number of users was 262.610 (TS = 1), 262.632 (TS = 0,5), and 262.674 (TS = 0,25). The corresponding MAPE values relative to TS = 1; were 0,059% for TS = 0,5; and 0,189% for TS = 0,25; both far below the 10% threshold.

Additionally, model accuracy was evaluated using the Mean Absolute Percentage Error (MAPE), which measures the average deviation between simulated outputs and actual historical data. The MAPE values for key variables—such as

QRIS users, merchant registrations, and transaction volumes—were all within acceptable limits (<10%), indicating a strong fit between the model and empirical evidence. A low MAPE value suggests that the model accurately reproduces past adoption behavior, thereby increasing confidence in its ability to project future scenarios under various policy interventions.

### 5.2 Graphical Results

Figure 11 represents the integration error test for the QRIS User variable under the BAU scenario. The results demonstrate that the trajectories generated with different time steps (TS = 1; 0,5; and 0,25 months) are nearly identical, showing only minor deviations in later periods. This indicates that the model is stable and produces consistent outputs regardless of the chosen step size.

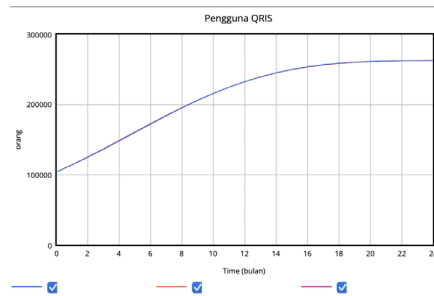


Figure 11. Integration Error Test for QRIS User Module SFD

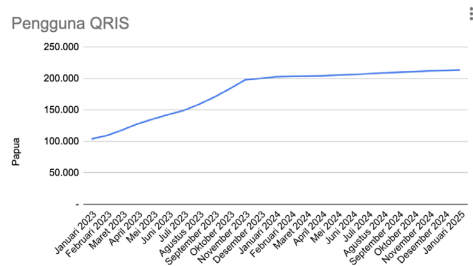


Figure 12. QRIS User Historical Data Graphics

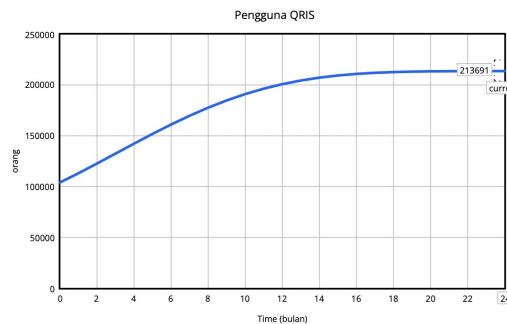


Figure 13. QRIS User BAU Scenario Graphic Results

Figure 12 and Figure 13 show the growth of QRIS users in Papua under the Business as Usual (BAU) scenario. Historical data from January 2020 to January 2023 indicate steady growth, with an acceleration in early 2022, which

served as the calibration basis for the model. The simulation over 24 months projects rapid adoption in the first year, followed by a slowdown as saturation effects emerge, with the number of users stabilizing at around 213.691. This alignment between historical trends and simulation results confirms that the model captures the dynamics of QRIS adoption. At the same time, the plateau highlights the need for policy interventions to sustain further growth.

### 5.3 Proposed Improvements

The first improvement, Social Education and Local Digital Ambassador Scenario, addresses the problem of low digital and financial literacy that significantly hinders QRIS adoption in Papua (Figure 14). Many potential users remain unfamiliar or distrustful of digital payments. By deploying local digital ambassadors, who share cultural and linguistic proximity with communities, this improvement offers a solution through targeted education and trusted socialization efforts. Based on Figure 14, this improvement accelerates early-stage adoption by improving awareness and building user confidence.

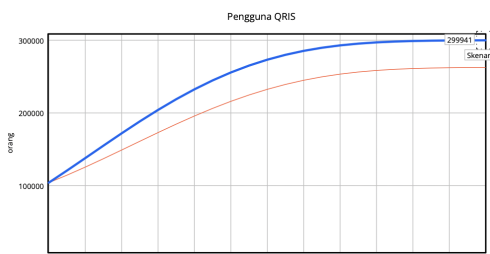


Figure 14. Social Education and Local Digital Ambassador Scenario Graphic Results

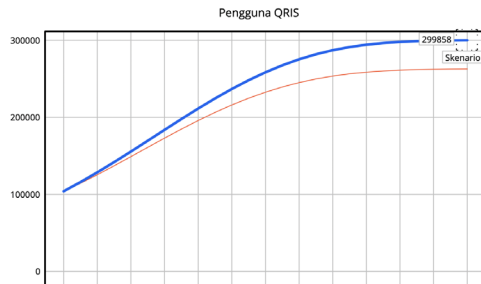


Figure 15. Village-Based Micro Digital Access Scenario Graphic Results

The second improvement, Village-Based Micro Digital Access Scenario, focuses on the structural problem of limited internet connectivity and infrastructure, particularly in remote areas. Without adequate digital access, even interested users and merchants cannot consistently adopt QRIS. The proposed solution involves establishing micro-level digital access points at the village level, supported by QRIS's offline mode and community-based facilities. Based on Figure 15, this improvement sustains adoption growth by reducing technical barriers and preventing the early saturation observed in the Business-as-Usual Scenario.

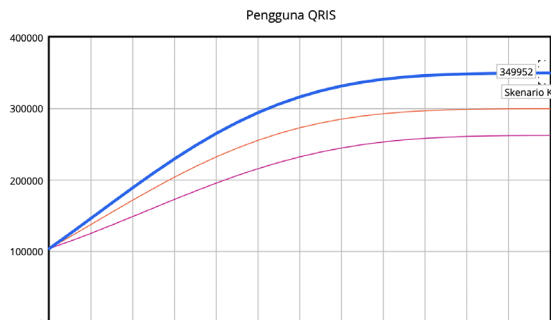


Figure 16. Combined Scenario Graphic Results

Finally, the Combined Scenario integrates both educational and infrastructural strategies to address the dual challenge of awareness gaps and digital access limitations. The problem of low literacy is mitigated simultaneously with infrastructural constraints, producing a more holistic solution. Based on Figure 16, the combined improvement yields the most substantial and sustained adoption growth, demonstrating that comprehensive strategies outperform partial approaches in expanding the long-term user base (Table 2- Table 4).

Table 2. Comparison of QRIS Users based on Scenario

Scenario	QRIS Users	Description
<i>Base Model</i>	213.691	Baseline condition reflecting current adoption trends without additional policy intervention
Social Education*	299.941	Increased adoption driven by intensified socialization programs and improved digital literacy
Micro Digital Access**	299.858	Adoption growth supported by improved access to digital infrastructure (internet, electricity, and devices)
Combined Scenario	349.952	Synergistic effect of social education and improved digital access significantly accelerates QRIS adoption

Table 3. Input Variable on Social Education\* Scenario

Variable	Value	Description
<i>Number of Digital Ambassadors</i>	57	Based on Bank Indonesia Papua’s QRIS ambassador competency program involving 57 participants in Jayapura.
Effectiveness of Social Education	0,35	The parameter is modeled as an assumption supported by digital education effectiveness frameworks. The value 0,35 is used as a baseline and tested through sensitivity analysis.
Micro Digital Access**	0,1	Interaction ratios are commonly used in diffusion and social contagion models. The value 0,1 is assumed and validated via sensitivity analysis.

Table 4. Input Variable on Micro Digital Access\*\* Scenario

Scenario	Value	Description
Initial Internet Access Points	1.705	Reported as 1.705 connected locations/points in Papua (Oct 2024–May 2025) by Komdigi/BAKTI.
Total Target Villages	1.123	Reported as 1.123 villages in Papua & West Papua targeted for electrification by PLN.
Proportion of Areas with Access	1,52	Derived (computed): 1.705 access points ÷ 1.123 target villages = 1,52 points per village.
Merchant Responsiveness Coefficient	0,50	Model as a normalized behavioral coefficient (0–1) and treat it as assumed/calibrated, then validate with sensitivity analysis.
Merchant Growth from New Access	853	Inputs come from “Initial Internet Access Points” and the responsiveness coefficient. (Data point is model-implied, not directly observed.)

Among the three improvements, the combined Scenario emerges as the most effective option. While social education with local digital ambassadors accelerates adoption in the early stages and village-based micro digital access ensures continuity despite infrastructural gaps, each alone remains limited in sustaining long-term growth. Based on Table 2, the combined improvement generates both rapid initial adoption and durable expansion over time, outperforming the

partial approaches. This result highlights that a comprehensive strategy, which simultaneously addresses literacy and access barriers, is the most suitable choice for driving inclusive and sustained QRIS adoption in Papua.

#### **5.4 Validation**

Credibility of the model is established through four complementary lenses: structural soundness, behavioral reproduction, numerical reliability, and robustness to uncertainty. First, the model boundary and equations were checked for dimensional consistency in Vensim and for conservation across stock–flow paths. A set of extreme-condition tests confirmed coherent behavior: with socialization effectiveness set to zero, adoption stalls after the initial seed; with very high access and promotion, the system approaches the potential market asymptotically rather than diverging—evidence that key feedback are correctly signed and bounded.

Second, behavioral validity was assessed by confronting the simulation with Bank Indonesia Papua historical series (2020–2023) for QRIS users, merchant counts, and transaction volumes. Calibration targeted dynamic patterns (level, trend, and curvature), no single points. Across the calibrated window, MAPE values below 10% for the three key variables indicate that the feedback structure reproduces observed adoption regularities with an acceptable level of error for policy analysis. Rolling re-fits on subperiods yield the same qualitative trajectories, suggesting that performance is not driven by overfitting to a narrow slice of data.

Third, numerical reliability was verified via an integration error test. We compared Euler and Runge–Kutta 4 under multiple step sizes and selected RK4 with a small step ( $\leq 0,25$  months) because it minimized accumulated discretization error and kept results invariant to step halving. This choice ensures stability of long-horizon simulations where slight numerical drift could otherwise bias policy comparisons.

Fourth, robustness was examined through one-way and global sensitivity analyses over plausible parameter ranges for contact rate, word-of-mouth strength, literacy effectiveness, merchant activation, and digital access. Rank-order correlations from random sampling show expected signs: early growth is most sensitive to socialization/word-of-mouth. At the same time, the long-run level is governed by access and merchant activation. Notably, no counter-intuitive tipping occurred within credible ranges; scenario rankings remained order-preserving, with the combined improvement consistently dominant.

External reasonableness was then checked by comparing shapes and magnitudes with adoption curves reported for other eastern Indonesian provinces and with diffusion-of-innovation stylized facts (rapid rise, decelerating growth, saturation). The model aligns with these patterns and reproduces the empirical responsiveness of adoption to simultaneous demand- and supply-side actions. Taken together, structural tests, historical fit, numerical checks, and sensitivity evidence support the conclusion that the model is a reliable laboratory for policy exploration. While limitations remain—e.g., partial observability of informal transactions and the assumption of homogeneous mixing within districts—the core results are qualitatively robust and suitable for evaluating the improvements analyzed in this study.

#### **6. Conclusion**

This study constructed and validated a system dynamics model to analyze the adoption of QRIS in Papua. The Business-as-Usual scenario indicated that natural diffusion processes alone would cause adoption to plateau at around 213,691 users, falling short of the region's potential market. Two policy improvements were then tested: Social Education with local digital ambassadors, which addressed low literacy and cultural trust, increased the number of users to 299,941; and Village-Based Micro Digital Access, which reduced infrastructural barriers and supported adoption in remote areas, resulted in 299,858 users. Each improvement produced positive effects yet remained limited when implemented in isolation.

The combined Scenario, which integrates both literacy-focused and infrastructure-based strategies, proved to be the most effective approach. This scenario achieved the highest adoption level, reaching 349,952 users. It generated faster initial adoption, prevented early saturation, and ensured broader long-term expansion of QRIS usage. This makes the combined Scenario the optimal solution as strategy for accelerating digital payment adoption in Papua. Beyond its local relevance, the findings also offer strategic insights for policymakers seeking to implement inclusive digital

finance under Bank Indonesia's BSPI 2030 blueprint, particularly in regions facing similar socio-economic and infrastructural challenges.

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## Biographies

**Daniel Lukita Hertanta** is an undergraduate student in the Industrial Engineering Department at Universitas Indonesia. He used this research as the basis for a thesis required to earn a bachelor's degree in engineering. Daniel Lukita Hertanta is interested in Industrial Simulation, System Dynamics, Engineering Economy, and Risk Management.

**Armand Omar Moeis** is an Assistant Professor in the Industrial Engineering Department at the University of Indonesia. He holds a Bachelor's degree from the University of Indonesia, a Master's degree from Delft University of

Technology, and a Doctoral degree from the University of Indonesia. His research expertise encompasses System Modeling, System Engineering, Industrial Simulation, System Dynamics, Advanced Modeling, and System Thinking. Armand Omar Moeis has contributed to several journal publications and conference papers.