

Applying Systems Thinking Concepts for the Analysis of Digital Excise Stamp Transformation in Indonesia

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ABSTRACT

The increasing complexity of illicit trade and excise violations has become a major challenge for governments in protecting state revenue and ensuring product legality. In Indonesia, excise violations involving tobacco and alcoholic products have continued to increase, with cases rising from 12,045 in 2021 to 21,915 in 2024, resulting in significant potential revenue losses. Digital excise stamp transformation is considered a strategic solution to improve traceability, transparency, compliance, and monitoring effectiveness. However, its implementation involves complex interactions among technological adoption, system security, industry readiness, institutional capacity, and enforcement mechanisms. This study aims to analyze the dynamics of digital excise stamp transformation in Indonesia and identify strategic intervention points for sustainable implementation using a systems thinking approach. The research employed a qualitative systems thinking method consisting of a Systematic Literature Review (SLR), conceptual model development, causal loop diagram (CLD) construction, model verification and validation through Focus Group Discussions (FGDs), and system archetype analysis. The results revealed three main feedback structures: two reinforcing loops related to user experience investment and security investment, and one balancing loop associated with enforcement effectiveness and institutional operational burden. The analysis identified several systemic challenges, including limits to growth, fixes that fail, and growth underinvestment archetypes. The study concludes that successful digital excise stamp implementation requires integrated policies focusing on technology adoption, security enhancement, institutional capacity development, and risk-based enforcement strategies to ensure long-term sustainability and optimize government revenue protection.

INTRODUCTION

Excise stamps serve as proof of excise duty payment and as instruments for ensuring the authenticity and legality of products in circulation. Known by various terms, such as excise stamps, duty stamps, tax seals, and banderoles, excise stamps are among the most widely used instruments by governments worldwide to protect state revenue derived from excise duties. They function not only as evidence of fiscal compliance but also as a deterrent against the circulation of illegal products, including smuggled and counterfeit goods (Sudan, 2015).

Based on data from the Directorate General of Customs and Excise of the Republic of Indonesia, excise violations in Indonesia, particularly those involving tobacco and alcoholic

products, increased between 2021 and 2024. In 2021, there were 12,045 recorded excise violation cases, and this number continued to increase annually, reaching 21,915 cases in 2024. This increase also contributed to greater potential state revenue losses. Data from 2021 showed that state losses due to excise violations amounted to IDR 511.69 billion, increasing to IDR 1.478 trillion in 2024.

With the advancement of digital technologies and the increasing complexity of excise supply chains, digital transformation of excise stamps has become a strategic solution to improve product traceability, authenticity verification, data integrity, and monitoring efficiency. Research by August (2023) found that many participants perceived the implementation of an electronic excise stamp system in Arusha City, Tanzania, as contributing to improved accuracy and transparency in excise tax collection. Similarly, Sulanda et al. (2024) concluded that electronic excise stamps are effective tools for supporting accurate excise reporting by taxpayers. Electronic excise stamps contribute directly to improving reporting accuracy, increasing compliance, simplifying payment processes, and strengthening monitoring capabilities. The success of digital transformation depends heavily on accelerating the adoption of digital excise stamps among manufacturers and related industry stakeholders. Accelerated adoption is essential because delayed implementation increases the risk of non-compliance and the circulation of illegal products. Furthermore, broader adoption supports monitoring efficiency, real-time data integration, and industry preparedness for increasingly complex digital regulatory requirements.

Indonesia faces similar challenges in managing excise supervision, particularly in controlling violations involving tobacco and alcoholic products. Data from the Directorate General of Customs and Excise of the Republic of Indonesia indicate that excise violations increased significantly between 2021 and 2024. In 2021, there were 12,045 recorded excise violation cases, while the number increased to 21,915 cases in 2024. This escalation also contributed to rising state revenue losses, increasing from approximately IDR 511.69 billion in 2021 to IDR 1.478 trillion in 2024. These conditions demonstrate that conventional monitoring approaches require improvement, as illegal distribution networks continue to evolve and create increasing challenges for government supervision.

The increasing number of excise violations highlights limitations in existing excise control mechanisms, particularly in ensuring product authenticity, supply chain transparency, and institutional monitoring capacity. Although excise stamps have historically supported revenue protection and product legality, conventional systems face challenges in detecting violations efficiently due to fragmented data, delayed information exchange, and reliance on manual supervision. Therefore, digital excise stamps have emerged as a strategic policy direction to enhance traceability, improve data integration, and strengthen compliance among manufacturers, distributors, and government institutions. However, implementing digital transformation in excise systems is not solely a technological challenge but involves complex interactions among policy frameworks, infrastructure readiness, industry capability, cybersecurity, institutional capacity, and user adoption.

Previous studies have demonstrated the potential benefits of digital excise stamp implementation in improving tax administration and regulatory compliance. Research by August (2023) on the implementation of electronic excise stamps in Arusha City, Tanzania, found that electronic systems improved the accuracy and transparency of excise tax collection.

Similarly, Sulanda et al. (2024) revealed that electronic excise stamps could support accurate excise reporting, increase taxpayer compliance, and simplify payment processes. Other studies have emphasized that successful digital transformation depends on technological acceptance, system security, infrastructure readiness, and stakeholder trust. These findings indicate that digital excise stamps provide significant opportunities to strengthen excise governance and improve regulatory effectiveness.

Nevertheless, previous research has primarily focused on evaluating the effectiveness of digital excise systems from technological, administrative, or compliance perspectives. Most existing studies have examined individual factors, such as system usability, tax compliance, or monitoring effectiveness, without comprehensively explaining how multiple variables interact dynamically within the excise ecosystem. The complexity of digital excise transformation involves reinforcing and balancing relationships among technology adoption, security investment, industry participation, law enforcement capacity, institutional workload, and government revenue protection. Therefore, a comprehensive analytical approach is required to understand the systemic behavior underlying digital excise transformation rather than merely evaluating isolated variables.

The research gap addressed in this study lies in the limited application of systems thinking approaches to analyze digital excise stamp transformation, particularly within the Indonesian context. Existing studies have not sufficiently explored how causal relationships among technological, institutional, and policy variables influence the long-term sustainability of digital excise implementation. Without an understanding of these system dynamics, policy interventions may focus only on short-term improvements while overlooking unintended consequences, delayed effects, and structural limitations. Systems thinking provides an opportunity to identify feedback loops, leverage points, and potential barriers that influence the long-term performance of digital excise transformation.

This research is urgent because digital transformation in excise management is closely related to state revenue optimization, regulatory effectiveness, and the prevention of illegal product circulation. The Indonesian government has strengthened its national digital transformation agenda through policies emphasizing digital infrastructure development, digital government, digital society, and digital economy advancement. In this context, excise digitalization must not only focus on technological implementation but also ensure that institutional capacity, security mechanisms, and stakeholder readiness develop simultaneously. Understanding the system structure underlying digital excise implementation is therefore essential for designing sustainable and adaptive policies.

The novelty of this research lies in integrating systems thinking concepts, causal loop diagrams (CLDs), and system archetypes to analyze digital excise stamp transformation in Indonesia. Unlike previous studies that primarily evaluate specific digitalization outcomes, this study develops a systemic model illustrating interactions among key variables influencing digital excise implementation. Through this approach, the research identifies reinforcing loops associated with user experience investment and security investment, as well as balancing mechanisms related to enforcement capacity and institutional workload. This perspective provides deeper insights into why certain policy interventions may succeed or fail over time.

The purpose of this research is to analyze the dynamics of digital excise stamp transformation in Indonesia using a systems thinking approach and to identify strategic

intervention points that support sustainable implementation. Specifically, this study aims to identify key variables influencing digital excise stamp adoption, develop a causal relationship model through causal loop diagrams, analyze system archetypes affecting implementation outcomes, and formulate policy recommendations based on identified leverage points. By achieving these objectives, the research provides a structured framework for understanding the relationship between digital technology adoption, institutional performance, and government revenue protection.

The contribution of this research is both theoretical and practical. Theoretically, this study enriches the literature on digital transformation and public sector innovation by demonstrating the application of systems thinking in analyzing complex regulatory technology systems. Practically, the findings provide policymakers, excise authorities, and related industry stakeholders with insights for developing more effective digital excise strategies that consider technological readiness, institutional capacity, and long-term sustainability. The results are expected to support evidence-based decision-making, improve excise supervision effectiveness, reduce violation risks, and strengthen Indonesia's digital governance ecosystem.

METHOD

This study employed a systems thinking approach to analyze the implementation of digital excise stamps in Indonesia. The research was conducted through five main stages: Systematic Literature Review (SLR), conceptual model development, model verification and validation, conceptual model analysis, and formulation of policy recommendations and conclusions. Secondary data were collected through an SLR of journal articles published between 2005 and 2025. The literature was obtained from databases including ScienceDirect, ResearchGate, Google Scholar, and SINTA using keywords related to digital excise stamps, digital transformation, excise revenue, and illicit trade. After applying inclusion and exclusion criteria, 33 relevant articles were selected for further analysis.

The selected literature was used to identify key variables and causal relationships influencing digital excise stamp implementation. These variables were incorporated into a conceptual model using a causal loop diagram (CLD) developed with Vensim® PLE software. The model represented positive and negative relationships among variables and provided a qualitative representation of system structures. Model verification and validation were conducted through Focus Group Discussions (FGDs) involving three experts from a security printing company in Karawang with expertise in excise stamp production, digital security technology, and public service digitalization.

The validated conceptual model was analyzed using system archetypes to identify recurring structural patterns and examine the dynamics of digital excise stamp implementation. The analysis focused on feedback loops and their implications for system performance and government revenue protection. Finally, policy recommendations were formulated based on leverage points identified within the system structure, and conclusions were drawn from the overall findings to provide insights into the role of systems thinking in supporting sustainable digital excise stamp implementation in Indonesia.

RESULTS AND DISCUSSION

After conducting a Systematic Literature Review, the information obtained from secondary data was processed into key variables involved in the implementation of digital excise stamp and determined how these variables interact and connect each other to form feedback loops. A conceptual model was then developed using a causal loop diagram. Each connection was labeled to indicate the direction and type of influence, along with the overall polarity of the loop to reflect its reinforcing or balancing loop.

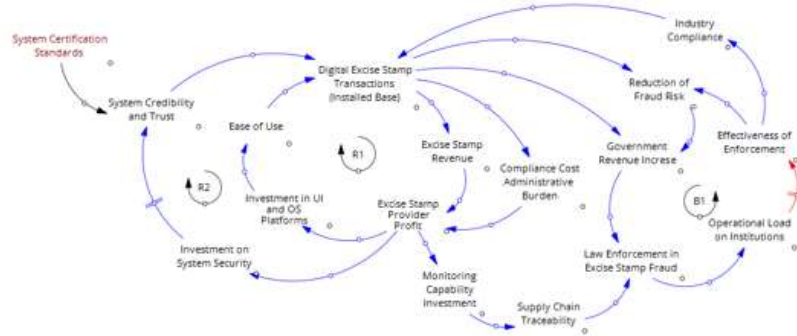


Figure 1. CLD implementation of digital excise stamp

Verification of CLD Digital Excise Stamp

In developing a system model for digital excise stamp, the verification and validation stages ensure that the policies generated from the model have a strong foundation. Based on the principles of dynamic systems modeling proposed by (Sterman, 2000), verification aims to ensure that the diagrams created are technically correct and accurately represent the logic of cause-and-effect relationships, while minimizing interpretation bias. The verification process is carried out during model development, and is summarized in the Table 3.

Based on the verification results that have been observed by the researcher in the causal loop diagram model of digital excise stamp, the results obtained show that the model has fulfilled with the criteria above, so this CLD digital excise stamp model has fulfilled the structure and can be used for further system analysis.

Table 1. CLD verification checklist

Criteria	Verification Questions	Status
Linkage Polarity (+/-)	Are all the + and – signs consistent with the system logic?	✓
Variable	Is the variable a noun, and has a clear direction of change?	✓
	Are there no variables that have double or overlapping meanings in one diagram?	✓
Loop	Is the identification of reinforcing (R) and balancing (B) correct according to the number of negative signs?	✓
	Have the R loop and B loop been identified and named?	✓
Time	Are there any signs of delay in the process that takes a long time?	✓
Ambiguity Test	Is it certain that there is no linkage that has two opposite effects in one arrow?	✓

Loop Identification of CLD Digital Excise Stamp

In the CLD model developed, there are three feedback loops in the implementation of the digital excise stamp system in Indonesia. The feedback loops consist of two reinforcing loops and one balancing loop, as explained below.

(1) User Experience Investment Incentives Loop (R1)

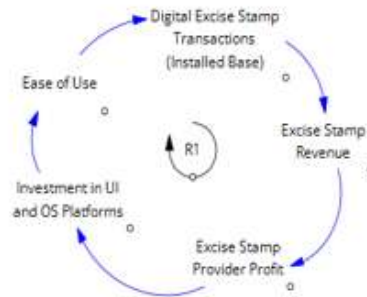


Figure 2. R1 UX investment incentives

Table 2. Variable linkage with reference (R1)

Linkage	Polarity	Reference
Digital Excise Stamp Transactions → Excise Stamp Revenue	+	After initial challenges in the first year, the volume of digitally tagged goods increased rapidly. The reduction in excise stamp violations resulted in these goods entering the formal system. The greater the number of goods entering the digital system, the higher the transaction volume processed by service providers, which impacted their profitability (Namunane, 2022).
Excise Stamp Revenue → Excise Stamp Provider Profit	+	Financial profitability (financial performance) is a key driver for sustainable investment in digital operational capabilities (digital capability) so that profits can be used to fund digital platform updates within the system (Mokgohloa et al., 2022).
Excise Stamp Provider Profit → Investment in UI/OS Platforms	+	Capital allocation (investment) focused on updating operating system infrastructure and interface design can significantly improve user perceptions of ease of use. Without continued financial investment, technology will become obsolete and difficult to operate (Mithas et al., 2005).
Investment in UI/OS Platforms → Ease of Use	+	High system quality has been empirically proven to increase user-friendliness, which triggers user satisfaction and continued usage intentions in digital transaction systems (Khayun et al., 2011).

(2) Security Investment Incentives Loop (R2)

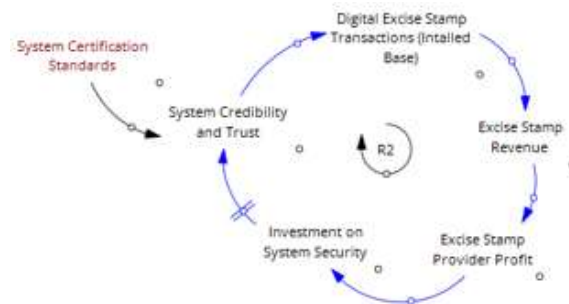


Figure 3. R2 security investment incentives

Table 3. Variable linkage with reference (R2)

Linkage	Polarity	Reference
Excise Stamp Provider Profit → Investment in System Security	+	System trust plays a major role in technology acceptance and expectations regarding electronic purchases or transactions. Therefore, building trust among users is crucial and necessary for digital success in government (Khayun et al., 2011).
Investment in System Security → System Credibility and Trust	+	
System Credibility and Trust → Digital Excise Stamp Transactions	+	System credibility is significantly influenced by taxpayers' perceptions of data security. If taxpayers feel their data is secure, compliance rates and the number of digital transactions also increase (Roida et al., 2025).
System Certification Standards → System Credibility and Trust	+	Investment in certification standards is an input variable that can strengthen the trust loop. High trust can then reduce coordination costs and increase system adoption (Nazareth et al., 2015).

The delay sign between investment and credibility indicates that investment in security does not immediately generate trust. It takes time for users or the market to recognize the system as truly secure and credible. Likewise, if a security incident, such as a data breach, occurs, rebuilding credibility will take significantly longer.

The successful implementation of a digital excise stamp system in Indonesia hinges on two pillars of investment incentives: ease of use (R1) and system security (R2). Together, these two types of investment create a reinforcing loop that drives the growth of the digital user base and optimizes service provider profits and government revenues.

(3) Effectiveness of Law Enforcement Loop (B1)



Figure 4. B1 effectiveness of law enforcement

Table 4. Variable linkage with reference (B1)

Linkage			Polarity	Reference
Digital Transactions → Government Revenue Increase	Excise Stamp		+	Several respondents in the study stated that the use of electronic excise stamps has been widely adopted and that monitoring and supervision by officials has had a significant impact on the growth of excise revenue (Kiilu et al., 2018).
Government Increase → Law Enforcement	Revenue		+	Law enforcement against excise stamp violations is more than just enforcing regulations, it acts as a preventative measure to protect future generations (Ross, 2015).
Law Enforcement Operational Institutions	Enforcement Load	→ on	+	The effectiveness of law enforcement is often hampered by institutional capacity deficits. Increased law enforcement tasks that are not matched by adequate budgets and personnel will create operational burdens (Rahman et al., 2024).
Operational Institutions → Effectiveness of Enforcement	Load on		-	Increased law enforcement efforts create pressure on institutional capacity (Stermann, 2000), where excessive operational burdens will reduce the effectiveness of supervision due to limited human resources and budget (Newsome, 2008).
Effectiveness of Enforcement → Reduction of Fraud Risk			+	When law enforcement mechanisms are ineffective, compliance levels will decline because the risk of violations is no longer properly detected (Slemrod, 2018).
Reduction of Fraud Risk → Government Revenue Increase			+	When the risk of violation is high and unreduced, the government will lose significant potential revenue (Ardana et al., 2025).

The delay sign in the relationship between the operational load in institutions and the effectiveness of law enforcement indicates that the decline in effectiveness does not occur immediately but occurs over the long term due to fatigue and limited resources which will reduce the quality of monitoring.

Loop B1 explains that government efforts to increase revenue through law enforcement can be hampered by the limits of the institutional own operational capacity. Pursuing revenue through law enforcement without increasing institutional capacity will result in increased operational costs and reduced effectiveness, ultimately increasing the risk of excisable good violations, which in turn will reduce government revenue.

Table 7 below illustrates the system dynamics influencing the operational sustainability and growth of digital excise stamp implementation in Indonesia. Identifying reinforcing and balancing loops reveals how key variables such as transaction volume, infrastructure investment, and law enforcement capacity interact to shape the overall performance of the ecosystem.

Table 5. Key variables and feedback loop structure

Loop	Type	Key Variables
R1	Reinforcing	Transactions – Excise Revenue – Provider Profit – UI/OS Investment – Ease of Use - Transactions
R2	Reinforcing	Transactions – Excise Revenue – Provider Profit – Security Investment – Credibility - Transactions

B1	Balancing	Government Revenue – Enforcement – Operational Load – Enforcement Effectiveness – Fraud Risk – Government Revenue
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Validation of CLD Digital Excise Stamp

After verification and identification, the model was validated. The validation process was conducted after the model was completed. Validation was conducted to ensure that the CLD model aligns with the reality of the actual excise tax system and is useful for policy purposes. Validation was conducted by discussing the CLD together through Focus Group Discussion to ensure that each relationship between variables was valid according to what occurs in the field and that no important causal pathways or linkage were missed. In the FGD, informants were asked to review specific feedback loops in turn. Informants discussed whether they agreed with the consolidated conceptual model. This FGD was a process of collecting primary data by developing several questions related to the system to be modeled to ensure that all understanding and information were well received and remained in line with the objectives of the system modeling.

This aimed to obtain a comprehensive perspective on the implementation of the digital excise stamp system so that the model could represent the actual situation. In addition, informants also played a role in validating the structure of the research model created by the researcher.

Based on the FGD results, after each variable and relationship were examined, there were no changes to the model. Changes occurred in the naming of the variable “Reduction of Fraud Risk” to “Reduction of Excise Stamp Violation Risk” and the variable “Law Enforcement in Excise Stamp Fraud” to “Law Enforcement in Excise Stamp Violation”. This is because as the user base or devices actively using digital excise stamp services and law enforcement increases, reductions occur not only in fraud excisable goods, but also in excisable goods without excise stamp, excisable goods misappropriated, and excisable goods mispersonalized, all of which are included in excise stamp violation cases.

Model Analysis with System Archetypes

Analysis using system archetypes from CLD is a fundamental stage in system dynamics modeling. This analysis shifts the analyst focus from simply observing the loops formed to understanding the behavioral patterns and leverage points generated by those loops over time. According to (Kim et al., 1997), viewing a given situation through the lens of different archetypes can provide various insights.

The CLD in question maps the dynamics of digital excise stamp implementation, encompassing revenue flows, law enforcement against excise stamp violations, platform investment, and institutional capacity. Each archetype is identified and described based on its structural signature, loop composition, system behavior, and strategic leverage points.

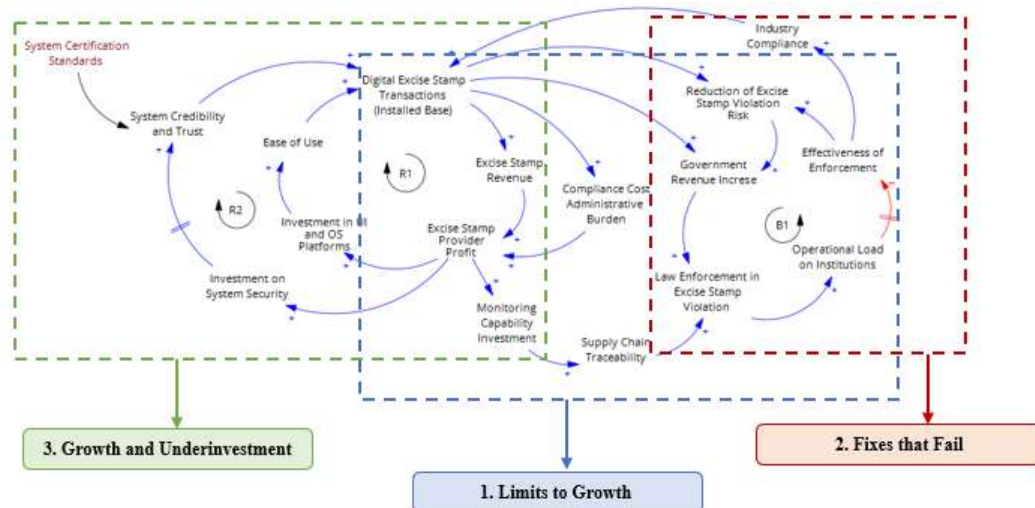


Figure 5. System archetypes of the digital excise stamp system

(4)Limits to Growth Archetype

In this archetype, sustained effort initially leads to improved performance, but the system eventually encounters limitations, causing performance to decline (Kim et al., 1998). A situation where initially satisfactory results decline or even worsen. We may try to continue pushing for continued success, but it seems that the results obtained will diminish over time with each continued effort. Performance will continue to decline even though efforts continue to increase. Initially, performance results experience rapid growth as a result of the efforts made. However, due to limiting factors, this performance growth will slow down, stagnate, and decline.

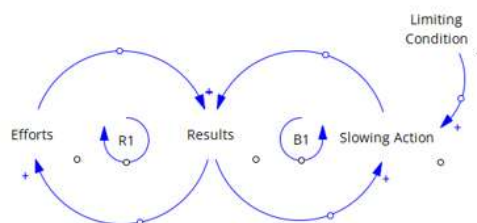


Figure 6. Generic archetype limits to growth

Limits to Growth is the most common archetype found in technology adoption systems. This archetype has a distinctive pattern: a reinforcing loop that drives growth, but as the system expands, a frequently delayed balancing loop provides resistance that progressively slows and ultimately limits growth. These systems don't fail suddenly, but rather they slow down gradually, often leaving the system unprepared because initial performance appears very promising.

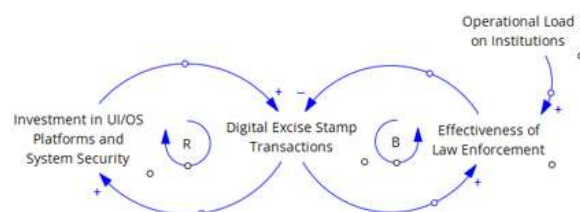


Figure 7. Archetype limits to growth digital excise stamp

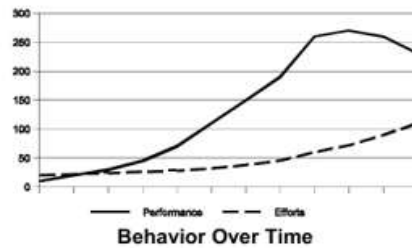


Figure 8. Generic BOT archetype limits to growth

This system exhibits a typical S-curve adoption behavior, with rapid initial growth driven by R1 and R2, followed by gradual stabilization as the resistance B1 limits growth. The delay in B1 indicates that by the time the constraint is visible, it is already firmly entrenched. If institutional capacity cannot be improved, the system could oscillate, with periods of strong adoption punctuated by instances of excise stamp violations, which could temporarily damage user confidence and revenue.

What can be done for systems with the Limits to Growth archetype is not to push harder on the reinforcing loop, but rather to strengthen its limiting conditions. In these systems, this means investing in institutional enforcement capacity before requests arise, not in response to them. This could take the form of establishing dedicated enforcement units, digital monitoring tools that reduce manual burdens, or inter-agency coordination protocols that distribute operational burdens.

(5) Fixes that Fail Archetype

Another archetype within the system is the Fixes that Fail archetype, which represents the unintended consequences of quick fixes in a system. This is based on the dominance and popularity of quick-fix measures in everyday life. There are at least two reasons for this. First, this approach generally produces results more quickly, and second, it is less expensive upfront. Of course, these proposed solutions often have unintended long-term consequences. The Fixes that File archetype depicts situations where unintended, often harmful, consequences follow good and desired actions. Often, these side effects undermine the effectiveness of the intervention, and the system reverts to its original state after a short period of time.

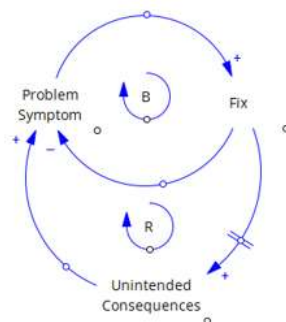


Figure 9. Generic archetype fixes that fail

The Fixes that Fail archetype describes a situation where a short-term solution to a problem produces unintended side effects that, over time, re-emerge or exacerbate the original problem. The fix is not wrong; it works, but only temporarily. But because the solution does not address the root cause of the problem, and because the side effects operate through a delayed feedback

loop, the problem keeps coming back. Those who are not observant in this pattern often conclude that they just need more of the same fix, which only deepens the cycle.

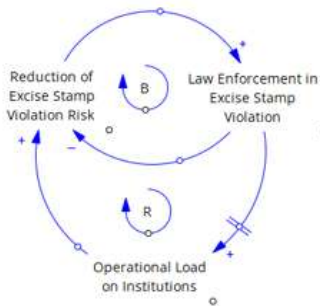


Figure 10. Archetype fixes that fail digital excise stamp

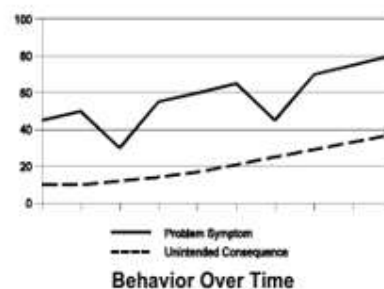


Figure 11. Generic BOT archetype fixes that fail

The delay between enforcement action and institutional overload is what makes the Fixes that Fail archetype so dangerous in a policy context. Policymakers see that if law enforcement works, excise stamp violations will decrease, and government revenues will increase, assuming the system is successful. Over an indefinite period, excise stamp violations may resurface periodically, and the instinctive response is to continue tightening enforcement, which will only further burden institutions and ultimately reduce the effectiveness of law enforcement itself. This can then become a trap, not a policy.

The leverage point for addressing the Fixes that Fail archetype is to address the fundamental solution, not just the symptoms. In this system, the root cause of the persistent risk of excise stamp violations is the incomplete implementation of the digital excise stamp system, specifically businesses and supply chains that may not yet be covered by the platform. Therefore, the fundamental solution is to accelerate widespread adoption, primarily through supply chain traceability, rather than simply increasing the intensity of law enforcement. Once this system is truly embedded throughout the value chain, the burden of legal enforcement is reduced and the cycle of institutional overload can be broken.

(6) Growth and Underinvestment Archetype

The Growth and Underinvestment archetype is a state of imbalance between increasing demand and the capacity of capital to meet that demand. In a Growth and Underinvestment situation, growth approaches a limit that can be eliminated or delayed if adequate capital investment capacity is created. However, as a result of policy or a slowdown within the system, declining demand will limit further growth. The decline in demand is then followed by an even worse reduction in capital investment capacity.

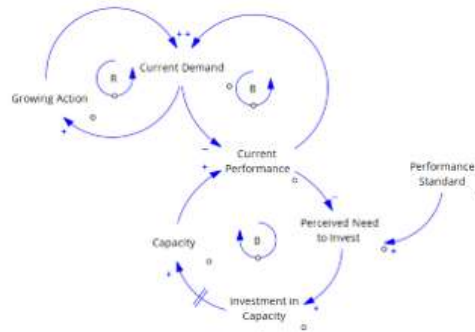


Figure 12. Generic archetype growth and underinvestment

The Growth and Underinvestment archetype is a variation of the Limits to Growth archetype with a unique pattern, its limiting constraints being partly self-inflicted. The system grows, but investment in the infrastructure necessary to sustain that growth lags behind. As a result, performance standards can decline, and this declining performance can actually weaken the growth it is designed to support. The system creates its own limits by failing to adequately invest in the capacity needed to sustain it.

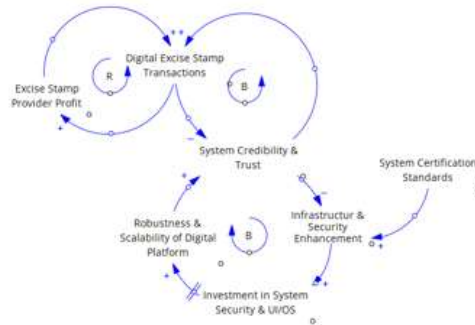


Figure 13. Archetype growth and underinvestment digital excise stamp

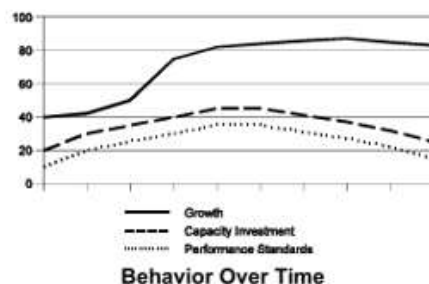


Figure 14. Generic BOT archetype growth and underinvestment

This archetype is not fully reflected in the CLD digital excise stamp, but its structural pattern is evident in the R2 loop. This loop relies heavily on two investment decisions: investments in the UI/OS platforms, and investments in system security. Both are endogenous in this model because they are driven by profit and transaction growth, not external commitments. The risk is that as the installed base grows, the investment required to maintain the systems credibility and trustworthiness grows nonlinearly. More users mean more potential attack surfaces, resulting in greater platform load. If investments in the UI, OS, and security do not increase proportionately, ease of use will stagnate and system credibility will diminish. The

R2 loop will weaken, not because of external constraints, but because the system fails to invest in its own performance standards.

This archetype is marked as “implicit” in the model because the CLD does not explicitly model performance standards or the gap between actual and desired performance, both of which are structural requirements of the Growth and Underinvestment archetype. To confirm this archetype, a variable as a performance standard is required in the CLD.

If this archetype is confirmed, the key is to establish a clear investment commitment from the outset. This means that system development shouldn’t be simply delayed until problems arise, but rather planned well in advance before the workload increases. This can be realized in the form of a service agreement between the government and the digital excise stamp provider, which requires maintaining system quality standards as a condition of its operational permit.

Policy is an action taken by decision-makers to address problems and control systems. Based on analysis using system archetypes, policy recommendation are carried out by identifying the underlying structure of the problem so that the solution is not merely temporary but also able to address the root cause. In the context of the excise stamp digitalization system, policy recommendation is based on identifying the feedback loops that most influence the systems sustainability. Policy recommendation is carried out by mapping interventions to the underlying structure of the problem identified through three main archetypes: Limits to Growth, Fixes that Fail, and Growth and Underinvestment. Figure 17 below is a CLD model that has been given with policy.

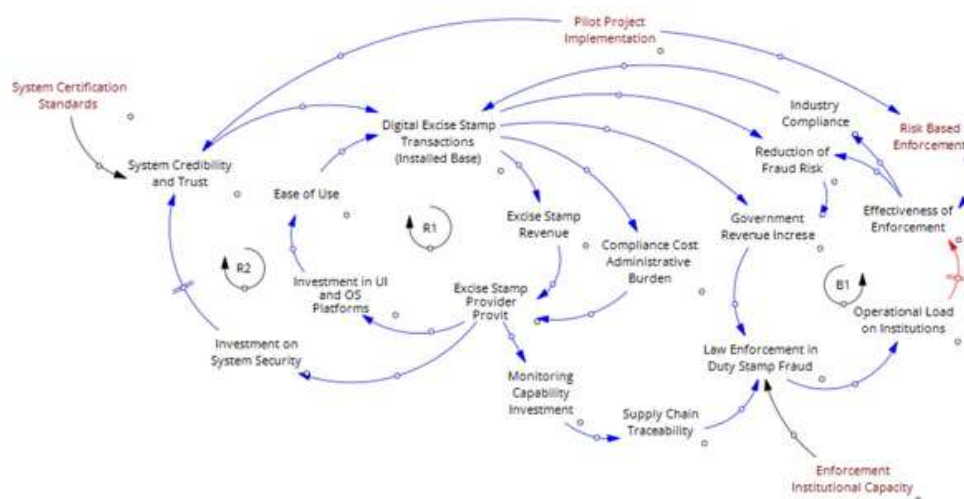


Figure 15. CLD with policy interventions for digital excise stamp system

Implementation of Pilot Project and Risk Based Enforcement

From a public policy perspective, a pilot project is a small scale initial implementation scheme systematically designed to test feasibility, costs, and potential challenges before a program is implemented on a full scale. Through this approach, organizations can collect accurate empirical data to adjust strategies, thereby avoiding systemic failures that involve large costs in the bigger implementation stage (Teijlingen et al., 2001). According to (Hassan, 2011) the main function of a pilot project is not only as a technical test, but also serves as a means to build stakeholder trust through initial evidence of success (proof of concept).

In an analysis using an archetype system, the Limits to Growth archetype indicates that the growth of system effectiveness will stall when it encounters limitations in human resources and infrastructure. To address this phenomenon, policy interventions should not focus on encouraging stronger growth, as this would only further strengthen resistance, but rather on anticipating and managing these limiting factors.

The Limits to Growth archetype can be managed through pilot project and risk based enforcement policies. Pilot project implementation acts as an early detection mechanism to identify potential systemic barriers before transaction growth reaches a national scale, while risk based enforcement policies are designed to delay the emergence of limiting factors by optimizing resource allocation in the most critical areas. In addition to anticipate action, this policy can also improve the readiness of human resources and technological infrastructure before facing large data loads.

In the CLD structure in Figure 17, the pilot project aims not only to scale up the system (R1 and R2) but also to detect the point at which the system begins to slow down due to operational load (B1). The success of a pilot project is measured by its ability to generate growth in the reinforcing loop while ensuring the load in the balancing loop remains within the institution capacity. Pilot projects enable organizations to learn in a controlled environment. The knowledge gained minimizes system delays, allowing the system time to adapt. This policy interacts with both the reinforcing loop and the balancing loop. Within the reinforcing loop, pilot project implementation can increase system credibility and trust. This trust encourages investment in system security, which in turn strengthens the systems credibility. Within the balancing loop, pilot project implementation can encourage risk based enforcement. Pilot project implementation provides real world data to adjust risk variables, so that when full enforcement is implemented, resources are already focused on violations with the highest risk profiles (Hijriani et al., 2026).

The risk based enforcement policy aims to map and allocate limited law enforcement resources to areas with the highest risk of violations. This policy is expected to increase the effectiveness of law enforcement due to more targeted actions, while reducing the operational load on institutions by redirecting resources to address larger excise stamp violations, thereby maintaining balance in the B1 loop.

Several countries have implemented or are currently implementing pilot projects and using a risk based enforcement approach in their excise stamp systems, particularly in the transformation to a digital excise stamp system. Table 8 below lists some countries and their implementation contexts

Table 6. Global implementation on risk based enforcement characteristics in digital excise stamp system

Source	Year	Digital Excise Stamp System	Forms of Risk Based Enforcement	Characteristics
National Bureau for Revenue Bahrain	2023	Digital Stamp Scheme	Targeting illegal distribution	Products without a stamp will be immediately prosecuted
General Tax Authority Qatar	2022	Digital Tax Stamp (Tobacco)	Distribution screening based on compliance	Continuous enforcement from

						imports to the domestic market
SICPA	2022	SICPATRACE®		Data-driven enforcement intelligence	&	Monitoring end-to-end supply chain and risk analytics
Kenya Revenue Authority	2021	Excise Management System (EGMS)	Goods	Real-time analysis monitoring priorities	data for	Production and distribution non-compliance detection
Tanzania Revenue Authority	2021	Digital Stamp System	Excise	Targeted enforcement based on risk nodes		Focus on high-risk supply chains
Uganda Revenue Authority	2020	Digital Tax Stamp (DTS)		Production and distribution data are used for risk profiling		Focus on detecting under reporting & targeting high-risk producers

Implementation of Enforcement Institutional Capacity

This policy aims to strengthen the institutional foundation to mitigate the impact of the operational load on institutions. By increasing institutional capacity, the system is expected to mitigate the unintended consequences of intensive law enforcement activities, thereby supporting the sustainable reduction of excise stamp violation risk.

In an analysis using the archetype system, the Fixes that Fail archetype demonstrates that law enforcement policies are often only temporary solutions (quick fixes) that will trigger unintended consequences in the form of an overload of work on institutions. Policies used should be oriented towards fundamental solutions, and if short term solutions must be used, include mitigation strategies to manage unintended consequences. The enforcement institutional capacity policy serves as a fundamental intervention that can break this negative cycle, so that efforts to reduce the risk of violations do not end in future institutional operational paralysis.

Several research have shown that weaknesses in law enforcement are often rooted in a lack of institutional capacity, both in terms of human resources and infrastructure. In a research (Rahman et al., 2024), institutional capacity deficits (including lack of personnel and cost) can directly hamper the ability of law enforcement institutions to carry out their duties comprehensively. This low capacity leads to inconsistent law implementation. Enforcement institutional capacity has a positive effect on the law enforcement policy in excise stamp violation, which can be implemented through: adequate human resources, either in the form of a number of personnel capable of covering a wide area of monitoring or by establishing a specific institution such as a task force to improve law enforcement against excise stamp violations, provision of adequate infrastructure and technological capacity, availability of funds for field operations and investigations, and good inter-institutional synergy between organizations involved in the digital excise stamp system.

Implementation of System Certification Standards

As a control instrument within the Growth and Underinvestment archetype, this policy establishes quality thresholds for system administrators. This standard ensures that investments in UI/OS and system security are proactively made to maintain system credibility and trust,

thereby preventing performance degradation as digital transaction volumes continue to increase.

The policy recommendation within this archetype involves establishing rigid, non-negotiable performance standards. The system certification standard policy serves as a safeguard against the Growth and Underinvestment archetype, as it warns of the risk of declining performance standards as system load increases to avoid investment costs. Implementing a system certification standard ensures that investments in security and UI/OS systems are no longer optional or dependent solely on residual profits. This policy must ensure that investments in security and UI/OS systems are proactively made based on growth targets. This policy requires system capacity to grow ahead of the demand curve, thus maintaining system credibility and trustworthiness and preventing performance degradation that can break the digital transaction growth loop and prevent a decrease in user experience when platform load increases non-linearly. By establishing system certification standards as a benchmark, the policy ensures that transaction growth does not exceed the systems capabilities. In digital based systems, certification often focuses on data security and privacy, which directly impacts trust. According to (Adam et al., 2024), third-party certification labels (such as data security certifications) can increase perceptions of trustworthiness. An interesting finding is that certification is most effective in increasing trust when initial trust in the system is low or untested. Certification can be a key catalyst for building credibility in new systems like digital excise stamps during their initial implementation.

Overall, the integration of these policies marks a strategic shift from a reactive approach to symptomatic problems to a proactive approach focused on strengthening the systems fundamental structure. By mitigating risks through pilot project implementation, optimizing resources through risk based enforcement, strengthening institutional foundations through enforcement of institutional capacity, and maintaining standards through system certification standards, the organization is expected to ensure that excise stamp digitization not only achieves short term revenue targets but also maintains resilience to long term growth dynamics. This archetype based approach ensures that every policy intervention is directed at strengthening the growth loop while minimizing the emergence of systemic barriers that could hinder the sustainability of the digital transformation of excise stamp in Indonesia.

CONCLUSION

This research successfully developed a qualitative model of digital excise stamp implementation in Indonesia using a causal loop diagram (CLD) to illustrate causal relationships among key variables. The model identified three feedback loops, consisting of two reinforcing loops—User Experience Investment Incentives (R1) and Security Investment Incentives (R2)—and one balancing loop, namely Law Enforcement Effectiveness (B1). Through a systems thinking approach and system archetype analysis, three dominant archetypes were identified: Limits to Growth, which highlights resource and infrastructure constraints as potential barriers to effective digitalization; Fixes that Fail, which demonstrates that intensive enforcement without corresponding institutional strengthening may provide only temporary solutions while increasing future operational burdens; and Growth and Underinvestment, which reveals the risk of declining system credibility when investments in security and user interface systems fail to keep pace with transaction growth.

The findings indicate that successful implementation of digital excise stamps requires integrated policy measures, including risk mitigation through pilot projects, resource optimization through risk-based enforcement, institutional capacity strengthening, and the establishment of certification standards to ensure long-term system sustainability. Furthermore, the identified archetypes provide a foundation for future quantitative modeling using stock-and-flow diagrams, enabling simulations of key variables such as excise violation rates, government revenue fluctuations, and stakeholder compliance levels. Although exploratory in nature, this study provides valuable insights for policymakers and researchers and can serve as a basis for future policy simulations and more comprehensive investigations into digital excise stamp transformation in Indonesia.

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