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Agent-Based Modelling of POS Agents' Disbursement of Nano-Credits to Nigerian Market Women: A Pathway to Financial Inclusion

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ABSTRACT

This study employed agent-based modelling to evaluate how POS agents can be optimized for disbursing nano-credits to market women in Nigeria. A simulation model was developed to capture the interactions among three key actors: Market Women (borrowers), POS Agents (lenders), and Regulatory institutions (oversight). The model included unique behavioural parameters such as transaction-based trust scoring, social collateral mechanisms, and adaptive loan pricing. The ABM framework showed that POS agents could achieve greater financial inclusion for low-income market women compared to traditional financial institutions. Liquidity recycling is likely to be efficient because repaid funds are successfully redeployed, creating a sustainable nano-credit ecosystem without external capital injections. Regulatory interventions like interest caps support liquidity mechanisms and help maintain agent viability. The study recommended a positive cycle of high loan approval and disbursement rates, high repayment, liquidity recycling, and regulatory support to sustain nano-credits and promote financial inclusion in Nigeria. It also advocated policies and initiatives that leverage POS agent networks for nano-credits within Nigeria's National Financial Inclusion Strategy (NFIS).

INTRODUCTION

Financial inclusion is a vital tool for economic development, particularly in areas such as poverty reduction, employment generation, wealth creation, and improving welfare and the overall standard of living (CBN, 2025). The World Bank (2025) describes financial inclusion as the access to and use of affordable financial products and services that meet the needs of individuals and businesses, which are delivered responsibly and sustainably. Of special importance is the fact that financial inclusion reduces the barriers for women to have access to financial services. It equips women with tools and resources to start and grow businesses, manage household finances, and invest in their futures.

In a bid to achieve significant financial inclusion, the Central Bank of Nigeria joined the global network of policymakers to commit to and sign the "Maya Declaration" in 2010, which sought to reduce financial exclusion in Nigeria to 20% by the year 2020. In line with the declaration, the Central Bank of Nigeria introduced the National Financial Inclusion Strategy in 2012, aiming to achieve adult financial inclusion of 80% with significant targets. The targets were to increase payments by 70%, savings by 60%, and Credit, Insurance, and Pensions by 40% respectively. However, long distances to access points were a huge barrier to financial inclusion. The possible solution was to implement a mechanism that would provide financial services to people over long distances (CBN, 2025).

The Central Bank of Nigeria began a campaign that targeted the financially excluded with the introduction of agent banking. This led commercial banks and FinTech Companies to introduce agent banking to meet the financial inclusion targets and serve as financial service providers. Agent Banking services refer to the delivery of financial services outside conventional bank branches, often through non-bank retail agents and using technologies such as point-of-sale (POS) terminals or mobile phones for real-time transaction processing (EFinA, 2013). Agent banking is aimed at enhancing financial inclusion, as banking agents are expected to act as delivery channels and offer financial services in a cost-effective manner (EFinA, 2017). Agent banking services are rendered by POS agents who own a retail outlet contracted by a licensed deposit-taking financial institution or a mobile money operator to provide a range of financial services to customers. Today, there are over 1.9 million POS agents scattered across Nigeria. (Consonance, 2025)

In 2013, CBN issued guidelines on agent banking and agent banking relationships to provide minimum standards and requirements for agent banking operations, enhance financial inclusion, and promote agent banking as a delivery channel for offering banking services. Recently, banking agents and other FinTech agents have rendered financial services in major areas of the country, especially in marketplaces where market women undertake their daily small business transactions. These market women may find it difficult to access credit facilities due to the nature of their small businesses, which involve perishable goods (such as vegetables, peppers, onions) and other small goods and services offered in the local market setting. Moreover, they may have no chances of accessing credits from commercial banks and microfinance banks,

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probably because of the small size of their market. They may not have the chance to visit the banks because of the processes involved, which may impede their time for businesses. Distance is another factor that they consider in getting financial services, especially the market women in rural areas and villages, where in some places "social norms and patriarchal cultures shape structures that impede women empowerment" (Chowdhury, 2025).

These scenarios present two important issues: the market women need urgent financial services, such as nano-credits, for their small business because of the frequent daily transactions; and POS agents offer financial services in marketplaces in urban and rural areas. Definitely, their nearness and familiarity in the marketplaces are admired since people would meet to transact business and would need their financial services. It is therefore pertinent to ask: with the presence of POS agents in every part of the country, especially marketplaces, how can POS agents be used to disburse nano-credits to market women to enhance financial inclusion in Nigeria?

Studies have examined the influence of POS operators/agents in promoting financial inclusion in Nigeria (Inegbedion & Akande, 2022; Bazza *et al.*, 2023; Odebola, 2023; Frank & Adewale, 2024; Abadom, 2025; and Adamu *et al.*, 2025). However, the issue of providing nano-credits through POS agents to market women to promote financial inclusion has been untouched. This presents a gap in the literature with respect to POS agents and financial inclusion. This study is probably the first of its kind, as it presents an agent-based modelling of how POS agents can disburse nano-credits to empower market women and their businesses and therefore contribute to the reduction of the financial exclusion gap in Nigeria.

Following the introduction, the study presents a review of the literature in section two. Section three presents the materials and methods. Section four presents the results and discussion, and section five concludes the study.

LITERATURE REVIEW
Systems Theory of Financial Inclusion
The systems theory of financial inclusion states that financial inclusion emerges from the interplay of economic, social, and financial systems, with each reinforcing the other. When policies or regulations modify one part of these systems, such as rules governing financial service providers, it can reshape inclusion outcomes by incentivizing fair and accessible services. This framework highlights three key advantages: it acknowledges how broader systems shape inclusion, offers a big-picture view beyond individual behaviours, and examines how different subsystems interact to drive, or hinder, financial access. Ultimately, financial inclusion both depends on and enhances the health of the systems that support it.

Special Agent Theory of Financial Inclusion
Special agent theory of financial inclusion suggests that addressing financial exclusion requires expert facilitators who understand the unique barriers faced by underserved populations, including geographic, demographic, and socioeconomic challenges. These intermediaries such as community banks, fintech firms, or specialized organizations leverage their deep knowledge of local informal financial systems to design tailored solutions that connect marginalized communities with formal services. By acting on behalf of governments or international entities without directly handling funds, they minimize conflicts of interest while ensuring clear accountability and measurable outcomes. This approach combines localized expertise with structured oversight, enabling more effective financial inclusion where traditional methods fall short.

Collaborative Intervention Theory of Financial Inclusion
The collaborative intervention theory proposes that financial inclusion requires coordinated efforts among diverse stakeholders to integrate underserved populations into formal financial systems. This approach offers several advantages: it promotes inclusive participation from various actors and provides contributors with fulfilment from supporting a socially impactful initiative. However, the theory also presents challenges - determining the ideal number of participants can be problematic, some partners may disengage, leaving others to shoulder the work, and simply increasing collaborators doesn't necessarily improve success rates. Essentially, while multi-stakeholder cooperation is valuable for financial inclusion, it requires careful management to ensure effectiveness.

In summary, the systems theory perspective highlights how POS agents operate within Nigeria's economic and social ecosystems, where their intermediation strengthens and is strengthened by formal/informal financial linkages. The special agent theory justifies POS vendors as skilled intermediaries who overcome geographic and demographic barriers through localized knowledge, acting as nano-credit distributors while mitigating principal-agent risks by not handling funds directly. The collaborative intervention theory underscores the multi-stakeholder coordination (e.g., fintech, regulators, and market associations) needed to scale POS-based nano-credit, though with challenges in optimizing partner engagement. Together, this agent-based modelling approach leverages agent networks to empower market women by addressing systemic gaps, intermediary efficiency, partnership dynamics, and financial education.

Empirical Literature Review
Abadom (2025) investigated how Point of Sale (POS) operators enhance financial access in rural Nigeria, where traditional banking services are scarce. By addressing the financial exclusion that hampers economic growth, POS operators enabled essential transactions such as deposits, withdrawals, and transfers for underserved communities. Using a mixed-methods approach, data were collected from 200 POS operators and 500 rural residents through

surveys and interviews. SPSS-based analysis revealed that POS services improve financial accessibility by reducing travel distances to banks, lowering transaction costs, stimulating local economies, and creating youth employment opportunities. However, challenges like poor network connectivity, cash shortages, high fees, security risks, and low financial literacy constrain their full potential. The author concluded that POS operators are vital for financial inclusion, and addressing these barriers is critical for maximizing their impact.

Adamu et al. (2025) examined the influence of POS transactions on banking operations and customer satisfaction in Bauchi Metropolis' deposit money banks. The study specifically analysed POS effects on service efficiency, transaction speed, revenue generation, and customer convenience, while also examining operational challenges, including transaction failures, fraud risks, and network issues. Employing a mixed-methods approach, the study gathered data through customer and operator surveys, complemented by bank official interviews. Analytical methods included both descriptive statistics and inferential analysis to evaluate POS transactions' relationship with customer satisfaction. Key findings indicated that POS systems have significantly enhanced financial accessibility, reduced banking hall congestion, and improved overall convenience. However, the study identified critical challenges such as network instability, excessive transaction fees, and fraud vulnerabilities that continue to undermine optimal customer experience and service delivery.

Frank and Adewale (2024) examined how POS terminals expand banking access, reduce financial service barriers, and stimulate economic growth in Nigeria. They thought that POS systems enable cashless transactions, mobile money services, and financial literacy initiatives as critical tools for financial inclusion. However, infrastructure gaps, security vulnerabilities, and regulatory constraints limit their broader adoption. Through primary and secondary data analysis, the research evaluated POS terminals' impact on Nigeria's unbanked populations, especially in rural areas. The findings indicated that while POS systems have significantly improved financial inclusion, greater progress requires targeted policy interventions and infrastructure investments to overcome existing challenges.

Agbor et al. (2023) examined agent banking policy implementation and its effects on financial inclusion, using a cross-sectional design with 387 purposively and accidentally selected respondents - including bank marketers, POS operators, and rural dwellers. Data collected through questionnaires were analysed using chi-square and multiple regression. The findings revealed that while POS terminals improved money transfers and cash deposits in rural areas, they did not significantly increase new bank account openings. Additionally, perceived usefulness and ease of use positively influenced POS adoption for agent banking. The study concluded that although agent banking has brought financial

services closer to rural unbanked populations, it has not substantially integrated them into the formal financial system.

Bazza et al. (2023) evaluated the impact of POS on financial inclusion, focusing on two key aspects, namely, its effect on the affordability of financial services and its role in improving access to bank transactions for unbanked individuals. The study targeted 533,418 bank customers, with a sample size of 400 determined using the Yamane formula. Data was collected through convenience sampling and analysed using multiple linear regression. The findings indicated that POS significantly enhanced financial service availability in Maiduguri. The fact that POS improves the affordability of financial services for users signifies that POS is a vital tool for promoting financial inclusion in Nigeria.

Odebola (2023) examined the operations, benefits, and challenges of Point of Sale (POS) systems in Nigeria, focusing on their role in financial inclusion and economic growth. Odebola (2023) was of the view that POS services enhance digital payments and extend banking access to underserved areas, but face operational hurdles, particularly network failures that disrupt transactions. Drawing from recent online articles, the study highlighted both the advantages for merchants and customers and the obstacles confronting operators. Ultimately, the article underscored POS as a vital financial inclusion tool, driving Nigeria's economic and financial development by bridging gaps in banking accessibility.

Inegbedion and Akande (2022) examined the connection between inclusive finance and entrepreneurship development, focusing on Point of Sale (POS) operators in Nigeria. They introduced two key innovations: the application of Khan's Measurement variables to assess financial inclusion through an FI index that evaluates banking penetration, service accessibility, and technology usage; and a financial inclusion-entrepreneurship model that supports startups and small businesses in agency banking. Using the Yamane sample size computation, 204 out of 399 distributed questionnaires were collected from POS operators and agent banks. Data analysis involved descriptive statistics and regression analysis to test hypotheses. The findings indicated that banking penetration positively influenced entrepreneurship. Access to financial products/services significantly boosted entrepreneurial activity, and usage of banking services has a strong positive relationship with entrepreneurship among Lagos POS operators.

Ogbebor (2014) explored the potential benefits, challenges, and overall prospects of agent banking in expanding financial access. Ogbebor (2014) was of the view that despite strong GDP growth in Nigeria and other African nations over the past decade, poverty levels have risen, highlighting a disconnect between economic expansion and improved living standards. This shifted focus toward poverty reduction strategies, with financial inclusion emerging as a key driver of inclusive growth. The findings affirmed that agent banking is a viable and

effective mechanism for promoting financial inclusion in Nigeria.

Summary of Literature Review: Gap and Contribution to Knowledge

Key findings from the empirical literature highlight that POS agents improved financial access by facilitating deposits, withdrawals, and transfers, reducing travel distances to banks, lowering transaction costs, and stimulating local economies. (Abadom, 2025; Adamu *et al.*, 2025; Frank & Adewale, 2024). However, challenges such as poor network connectivity, cash shortages, high fees, security risks, and low financial literacy limit their full potential (Abadom, 2025; Adamu *et al.*, 2025; Odebola, 2023). Research (Agbor *et al.*, 2023; Ogbebor, 2014) shows that while agent banking brings financial services closer to rural populations, it has not significantly increased formal bank account ownership. Inegbedion and Akande (2022) found that financial inclusion through POS services positively influences entrepreneurship, particularly in agency banking.

Despite extensive research on POS operations and financial inclusion, no study has explored the provision of nano-credits (small, short-term loans) through POS agents to empower market women, a critical segment of Nigeria's informal economy. Existing literature focuses on transactional services (deposits, withdrawals, transfers) but overlooks credit facilitation as a tool for financial inclusion. This research fills a critical gap by proposing a novel framework for leveraging POS networks beyond cash transactions, positioning them as key players in nano-credit distribution and market women's economic empowerment, ultimately contributing to reducing Nigeria's financial exclusion gap. This study is the first to introduce an agent-based modelling approach to assess how POS agents can disburse nano-credits to market women. This will enhance financial inclusion by providing accessible nano-credits to the unbanked or underbanked market women; empower small businesses by enabling market women to expand their businesses, improve their income, and reduce financial exclusion; and bridge the credit gap by addressing the unmet needs for small-scale credit facilities in Nigeria's informal sector.

MATERIALS AND METHODS

The study utilized the computational research design. The computational research design is an approach where computational tools such as algorithms, simulations, data analytics, or modelling are central to the research process. It leverages the power of computers to analyse complex systems or generate insights that may be infeasible with traditional analytical or experimental methods. The computational design tool for the study is the Agent-Based Modelling (ABM).

Agent-Based Model

Agent-based model is a computational approach that simulates real-world systems composed of interacting individual units (e.g., atoms, cells, people, institutions). The key feature of ABM is its direct representation of these units as autonomous "agents" within the model, along with their interactions. ABM focuses on explicitly modelling individual behaviours and their repeated interactions, allowing researchers to study how macro-level patterns emerge from micro-level rules. Agents follow predefined behavioural rules (simple heuristics or complex mechanisms like learning) and interact with each other and their environment over time. This method helps analyse the large-scale outcomes of theoretical assumptions about individual behaviour in dynamic, multi-agent systems. ABM is particularly useful in social and psychological research, where simulating the collective effects of individual actions can reveal insights into complex processes. No additional assumptions are imposed beyond modelling agents and their interactions (Edmonds & Ni Aodha, 2018).

The key agents for the Agent-based modelling are the Market Women, small-scale business owners that sell goods like produce, fish, spices, handcrafts and so on; the POS Agents, which comprise the Agent Bankers and Mobile Money Agents, are people that operate businesses where customers can perform financial transactions using Point of Sale (POS) terminals; and the Regulator that oversees, enforces and supervises financial services to ensure its stability, integrity and fairness.

RESULTS AND DISCUSSION

Figure 1 models and illustrates the interactions and behavioural rules of all three agents: Market Women, the POS Agents (the Agent Bankers and Mobile Money Agents), and the Regulator.

Agents Descriptions

Agents: Market Women

The first agents are the market women. They circulate information among themselves in the markets that nano-credit facilities are available through CAC-registered POS Agents. They decide whether to request nano-credits or not. Should they request nano-credits, then each of them would decide on the appropriate amount needed, depending on the nature of the business. Nano-credits range from 5,000 to 50,000, depending on available liquidity.

Agents: POS Agents

The second agents are the POS Agents. The POS Agents must be registered with the Corporate Affairs Commission (CAC). They are to consider nano-credit requests of the market women. The market women's loan requests are either rejected or accepted due to the status of the liquidity of the POS Agent and the trust score calculated by the POS Agent. They are to manage liquidity and set interest rates within the 10% to 25% range.

Agents: Regulators

The third agents are the Regulators. The Central Bank of
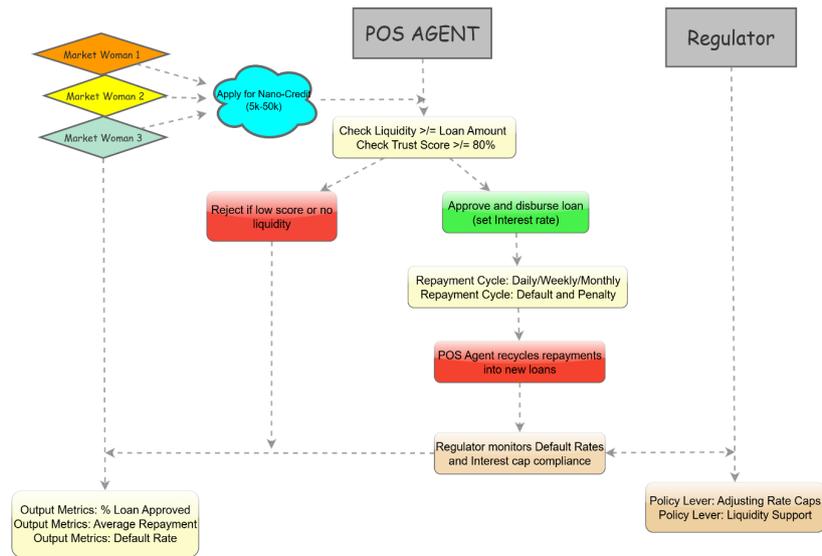
Figure 1: Agent-Based Modelling of the three agents
Source: Computed using Insight maker

Nigeria (CBN) is the apex regulator of financial activities. Regulatory duties can be delegated to other institutions for effectiveness and efficiency. The regulators are to monitor default rates and enforce interest caps to ensure the market women are not ripped off by the POS Agents with outrageous interest rates.

Decision Nodes
Decision nodes are critical points in the Agent-Based Modelling (ABM) where agents (market women, POS agents) must choose between multiple actions based on predefined rules. They determine the flow of the simulation.

Loan Approval
The predefined rules for the approval of Nano-credits for market women are checking liquidity and trust score. The POS Agent checks the liquidity of his business to ascertain if a certain amount is available for lending. The next rule is the trusting score. A simple approach is the rule-based trust scoring. Here, the POS Agents assign scores based on the observed borrower's attributes. These include the transaction history of the borrower with the POS Agent; the savings balance; membership of a lending circle, repayment history, and business longevity. Hence, the decision for the POS Agents is to reject nano-credits requests if there is no liquidity and the trust score is below 80%; otherwise, approve.

Repayment and Recycling
Another decision point is repayment and recycling. Regarding repayment, the predefined rule for market women is to consider the amount they plan to borrow, whether they can fully or partially repay within the designated timeframe, and avoid defaulting. For POS Agents, the decision is whether paid loans can

immediately replenish liquidity to support nano-credits for other borrowers (recycling) or be held as buffers. POS Agents can use real-world calibration by analysing data from microfinance banks, where repayment rates range from 75% to 90% for nano-loans, and relending rates range from 60% to 80% of the repaid funds. Therefore, if nano-credits are repaid on time, liquidity is assured, and the borrower's trust score increases; otherwise, POS Agents can impose penalties (lower trust score) if there is a default, leading to rejection of future credit applications.

Policy Levers
Policy levers are crucial at this stage. These policy levers have an impact on financial inclusion, lenders' profitability, and systemic stability. Policy levers allow regulators to influence the system by not just monitoring interest rate caps but adjusting interest rate caps and providing liquidity support. The regulators make decisions by controlling the maximum allowable interest rates that POS agents can charge. This balances affordability for market women and sustainability for lenders. The regulators also control emergency funds injected into POS Agents to prevent credit crunches.

Outputs
This last section in the ABM is the output. The output comprises the financial inclusion metrics such as access rate in terms of the percentage of nano-credits approved, the percentage of nano-credits rejected, and the percentage of nano-credits repayment defaulters. Nano-credits usage intensity is a powerful tool to know the frequency of transactions in terms of loans and savings. The financial inclusion metrics can be used as a yardstick to determine how well market women in Nigeria access and use formal financial services. It also helps to evaluate the effectiveness and efficiency of nano-credit

disbursements through POS Agents.

CONCLUSION

Nigeria's market women face acute financial exclusion due to collateral requirements and distance from formal banks. Point-of-Sale (POS) agents, with their deep penetration into informal economies, offer a promising nano-credit disbursement channel, yet their operational dynamics remain understudied. This study employed agent-based modeling to simulate nano-credit flows among three key agents: Market Women (borrowers), POS Agents (lenders), and Regulators (oversight). Findings show that higher financial inclusion rates are likely to be achieved owing to adaptive trust scoring by way of transaction history and social collateral; strong liquidity recycling and sustainable interest caps plus liquidity buffers without compromising agent viability. The implications of the ABM's link diagrams revealed a self-reinforcing virtuous cycle:

High Trust → More Loans → High Repayments → Recycling → Sustained Inclusion.

The study recommends first that the ABM should be examined to avoid the vicious cycle of high nano-credit defaults and stricter lending, as this would deter market women's access to loans. This can affect their businesses and thereby reduce the desired level of financial inclusion. Second, the virtuous cycle of high repayments and more recycling should be encouraged at all costs, as this would lead to sustainable credits and support financial inclusion in Nigeria. Third, the study advocates for policies and initiatives that focus on leveraging POS Agent networks with respect to nano-credits in Nigeria's National Financial Inclusion Strategy (NFIS).

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