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THE BEHAVIOR OF THE ACTORS OF ELECTRONIC PAYMENT SYSTEMS USING BANK CARD AND MOBILE WALLET: THE CASE OF WEST AFRICA ECONOMIC AND MONETARY UNION (WAEMU)

[1]Kengne Assomo Aubin Martial

[1]Expert in electronic payment system and digital finance

Corresponding Author:
martialassomo@buenco.africa

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SUMMARY

The traditional microeconomic analysis of the behavior of direct actors (customer, merchant) and incidentally indirect actors (banks and mobile money operators) in West Africa Economic and Monetary Union (WAEMU) bank card and mobile money payment systems over the period 2019-2023, informs that the adoption of mobile money in the WAEMU is supported by a favorable equilibrium for the customer, thanks to a strong network effect and a low risk of fraud, despite a higher cost. As for the merchant, he bears a negative net charge on both payment methods, but less with mobile money, which can influence his preferences. The application of game theory to the WAEMU context shows that market equilibrium favors the adoption and acceptance of mobile money by customers and merchants, while the bank card remains a minority. In doing so, it suggests improving financial education and success rate around the bank card, reducing fees for merchants on mobile money, and continuing to watch over fraud to maintain overall trust in both systems.

KEYWORDS: *Electronic payment system, bank card, mobile money, network externalities, adoption rate, customer, merchant, market equilibrium, strategic game, financial education*

1. INTRODUCTION

Electronic payment systems (EPS) have profoundly transformed customer habits and economic interactions. The research work, both theoretical and empirical, has focused on the behavior of the different actors in these systems – customers, merchants, providers and regulators – in order to better understand the dynamics of adoption, the trade-offs between instruments, the impact of network effects and the implications for financial inclusion.

Theoretical studies on user behaviour are numerous, starting with that of Rogers (1962) and his founding model on the diffusion of technologies, including payment systems. In the 1980s, we witnessed a wave of work, notably Katz & Shapiro (1985) through the economic modeling of network externalities, followed by the work of David (1985) who highlights the technology lock-in effect. It is necessary to wait until the 2000s to witness sufficiently edifying works in the same vein as the previous ones, but especially in new perspectives, notably Bolt & Tieman (2006) who analyze the competition between payment instruments, while Gowrisankaran & Stavins (2004) highlight the impact of network effects on adoption.

On the empirical level, many researchers have distinguished themselves with their work on Adoption and Use. This is the notable case of Humphrey, Pulley & Vesala (1996), with their study on cash, scriptural currency, and electronic payments. While Rysman (2007) conducts an empirical analysis on card payment uses, Porteous (2006) studies the factors favoring the mobile money environment in Africa. As for Jack & Suri (2011), they made a kind of economic monograph on M-PESA. Donovan (2012) studies the relationship between mobile money and financial inclusion.

Besides that, numerous studies on Preferences, Security and Trust have also emerged, with Bounie & François (2006) who studied the preferences between cash, check or bank card, then Mallat (2007) focuses on the adoption of mobile payments by customers, while Ching & Hayashi (2010) dwell on the gains inherent in the use of the card in the choice of the customer. Finally, Zhou (2011) places particular emphasis on trust in mobile payment.

Moreover, and not least, a few recent studies and global data do indeed reflect the interest of the subject in question. This is how Suri & Jack (2016) studied the relationship between mobile money and poverty, while the GSMA (2019), periodically publishes a report on the state of the mobile money industry. Meanwhile, the Bank of International Settlements (2019), reports on the implications of digital innovations for retail payments.

However, the financial inclusion perspective is not left out, since Andrianaivo & Kpodar (2011) have focused on the relationship between ICT, financial inclusion and growth. Demirgüç-Kunt et al. (2015) published 'The Global Findex Database 2014'. The World Bank (2022), reported on the state of digital financial services in Africa.

As we can notice, the evolution of analytical approaches to user behaviour in electronic payment systems is moving from macroeconomic models of externalities to behavioural analyses of individual preferences. The rise of mobile money in developing countries is a major turning point, particularly for financial inclusion. The interdisciplinarity of the work, between economics, sociology and data science, offers rich analytical avenues for public policies and innovation.

The first criticism that can be formulated regarding these analyses, particularly those referring to adoption, use, preferences, security and trust, is that the behavior of the customer in relation to the use of an electronic payment instrument in addition to perceived benefits and costs, also depends on its level of financial education and the availability of the electronic payment infrastructure and that consequently, it is not possible to act on the usage rate without intervention in terms of awareness and improvement of the payment terminal or POS availability.

The second criticism is that these analyses do not make it possible to grasp the real dynamics of acceptance of an electronic payment instrument by the merchant outside the framework of pure and perfect competition, as suggested by neoclassical theory, where producers compete solely through prices; the meeting of supply and demand determines the equilibrium price.

Indeed, if the supplier (the bank or the mobile money operator) maintains commercial relationships with the customers, its income will remain dependent on the more or less volatile behavior of the latter despite service pricing efforts; such volatility is explained by the low financial education, particularly when it comes to in-store proximity payment services, in the markets, services for which a majority of customers still use cash due to ignorance of the advantages of electronic payments; those of customers who are sufficiently educated to use electronic payment terminals, or a merchant code (QR Code or digital code) for mobile payments still sometimes use cash to pay for products and services, because the acceptance ecosystem is not sufficiently developed. In contrast to its relationship with the merchant, which could be more sensitive to the cost of transactions and the increase in the volume of sales, it must be recognized that the issue of adoption is more about the quality and availability of services.

Traditional microeconomics relies on a number of assumptions that sometimes seem unrealistic. Information is supposed to be perfect, transactions have no cost and rational individuals make non- strategic decisions. If these conditions are valid, conceivable in a material economy, they no longer hold in an increasingly immaterial economy where economic interactions become more and more complex. Service activities requiring greater involvement and cooperation between providers and users, the EPS can fit into this latter immateriality framework and consequently, suggest market concerns in terms of relationships and strategic behavior of users. In this perspective, the use of game theory, which belongs to the current of the new microeconomy that has been developed from the 1970s in response to the shortcomings of the standard model, seems to us to be a framework for in-depth analysis, because taking into

account a greater number of parameters in the interactions between stakeholders and the construction of market equilibrium. At the same time, it hardly sacrifices the principle of rationality, since as Von Thadden (2004) points out very well, "we are here interested in the different forms of rational behavior in a game. By rationality, we mean the wish of an individual to maximize their payment function given what they know or believe they know about their environment."

Our objective in this paper is to examine for the WAEMU, in the period 2019-2023, the behavior of users, particularly customers and merchants, in order to better understand the forces that influence adoption (use and combined acceptance) of electronic payment instruments such as, mobile money and bank card. Our approach is as follows:

- ✧ First, we concretely apply the standard model to EPS, and show that some concerns remain in terms of asymmetric information and long-term decisions in traditional approaches, which reduces the strategic efficiency of users;
- ✧ In the second place, we are building, based on a few assumptions that we will want as realistic as possible, a model within which it is conceivable to integrate both user preferences, the costs, the network externalities as well as the level of financial education and the availability rate of the service, to give a relevant meaning to the strategic behavior of users.

The originality of our paper lies on two levels:

1. Unlike traditional approaches and empirical studies known to date, which admittedly take into account preferences, costs and network externalities, factors such as the level of financial education, the success rate for a transaction, if they were not neglected by the authors, they were only indirectly through the equation on market equilibrium. In the model we propose, these elements are explicitly taken into account.
2. Studies carried out so far have focused more on the functioning mechanisms of the system (market), but not enough on the non-cooperative game between direct actors (customer and merchant). It is precisely for these reasons that we have the humility to propose an approach more in line with their strategic requirements, then if necessary, derive their tactical and even operational concerns in the system.

We will proceed as follows. In section 4 we will explain the methodology and the results obtained, in section 5 we will debate the results in light of the assumptions made, in section 6 we will conclude.

2. METHODOLOGY AND RESULTS

2.1 DEFINITION OF RELATIONSHIPS AND MECHANISMS WITHIN THE TRADITIONAL MODEL

According to traditional microeconomic theory, in order to analyze the relationships between the actors of payment systems by bank card and mobile money, one can define utility functions for each actor and deduce the conditions of market equilibrium.

For payment instruments i {1,2}, the mathematical formulation of these utility functions is:

$$Ui=V-\alpha * (Ci * M)-\beta * (Fi * M)+\gamma * Pi \quad (1)$$

where:

- V is the intrinsic value or gross utility of the payment (constant for simplification)
- α,β,γ are the weights of transaction costs, fraud, and penetration rates respectively
- Ci * M is the direct monetary cost,
- Fi * M is the expected loss due to fraud (probability amount),
- Pi is the penetration rate (positive network effect).

The merchant receives a payment of amount M via instrument i.

Profit Π i of the merchant by transaction: $\Pi i=(COMi-CHi)$ (2)

where:

- COMi * M is the direct monetary income earned,
- CHi * M is the direct monetary charge supported.

2.1.1 EFFECT OF THE DECISIONS OF EACH ACTOR

Note that the decisions of each actor depend on the choices of others. The customer effect on merchants is manifested by the fact that if customers prefer to use instrument i, merchants must be willing to accept payments made with instrument i to attract more customers.

The effect of merchants on customers is manifested by the fact that merchants can influence the behavior of customers through discounts or incentives to use a specific payment instrument (e.g., discount for card payments).

The effect of providers (banks/mobile money operator) is manifested by the fact that the fees applied by these providers can guide the choices of merchants and customers towards a favored payment instrument.

2.1.2 MARKET EQUILIBRIUM IN THE TRADITIONAL MODEL

Following traditional microeconomic theory, the equilibrium in the market for means of payment is reached when:

- The customer chooses the instrument i that maximizes its utility Ui;
- The merchant chooses to accept instrument i if its profit $\Pi i \geq 0$ (or at least above a break-even value).

With i {1,2}, the market balances supply and demand, as long as the proportion of customers using each instrument corresponds to the observed adoption (penetration rate pi).

Either:

$$V-\alpha C1 * M-\beta F1 * M+\gamma P1 \geq V-\alpha C2 * M-\beta F2 * M+\gamma P2 \quad (3)$$

Simplification (by canceling V):

$$-\alpha C1*M-\beta F1 * M+\gamma P1 \geq -\alpha C2 * M-\beta F2 * M+\gamma P2 \quad (4)$$
$$\gamma(P1-P2) \geq \alpha M(C1-C2)+\beta M(F1-F2)$$

This implies that customer preferences, merchant costs, and supplier charges of instruments 1 and 2 must coexist in an equilibrium. In other words, the supply of transactions by customers equals the demand for transactions by merchants.

2.2 RESULTS OBTAINED WITH THE TRADITIONAL MODEL

The electronic payment system in the WAEMU space is mainly composed of two offers: Mobile Money and Bank Card. The key data published by the BCEAO (central bank of west african countries) on the situation of financial services via mobile telephony and those on interbank electronic payment systems (bank card activity) in the WAEMU from 2019 to 2023 will allow us to analyze the behavior of customers and merchants vis-à-vis these two means of payment. Furthermore, we can also understand the behavior of suppliers (bank and mobile money operator) in their pricing strategy.

2.2.1 DATA, PARAMETERS AND WEIGHT

The customer makes a payment of an average amount M (in FCFA) via a payment method i {mm,bc} (Mobile Money or Bank Card). For Mobile Money M= 12,228 FCFA, for the Bank Card M= 83,245 FCFA.

Parameter (0 to 1)	Mobile Money (mm)	Bank Card (bc)	Weight (importance) in (utility)
Transaction cost	Cmm=2.25%=0.0225	Cbc=1.35%=0.0135	α=0.2
Fraud rate[1]	Fmm=0.0016%=0.000016	Fbc=0.73%=0.0073	β=0.3
Penetration rate	Pmm=71%=0.71	Pbc=25%=0.25	γ=0.5
Charge of the merchant (fees)	CHmm=2.5%=0.025	CHbc=2.0%=0.02	
Commission earned by the merchant	COMmm=1.5%=0.015	COMbc=0%=0	

Source: BCEAO and author calculations

2.2.2 UTILITY FUNCTION OF THE CUSTOMER

The customer incurs a monetary cost proportional to the amount of the transaction, and a risk of fraud that reduces its usefulness. The customer's utility is a decreasing function of total cost (transaction cost

+ expected cost of fraud) and increasing with penetration rate (representing social utility and network effect).

V= 1 because all the parameters are normalized to the same scale (proportions), which allows a direct comparison.

UTILITY FUNCTION UI OF THE BEARER FOR INSTRUMENT I:

The calculation of utilities gives us:

MOBILE MONEY:

$$Umm=1-0.2\times0.0225-0.3\times0.000016+0.5\times0.71$$

$$=1-0.0045-0.0000048+0.355 \Longrightarrow Umm=1+0.3504952=1.3505 \quad (5)$$

BANK CARD:

$$Ubc=1-0.2\times0.0135-0.3\times0.0073+0.5\times0.25$$

$$=1-0.0027-0.00219+0.125 \Longrightarrow Ubc=1+0.12011=1.1201 \quad (6)$$

As an interpretation, the customer obtains a higher utility with Mobile Money (Umm=1.35) than with the Bank Card (Ubc=1.12), which reflects the high penetration and low fraud of mobile money, despite a slightly higher transaction cost.

2.2.3 MERCHANT'S PROFIT FUNCTION

The calculations give us:

MOBILE MONEY:

$$\Pi mm=(0.015-0.025)=-0.01 \quad (7)$$

BANK CARD:

$$\Pi bc=(0-0.02)=-0.02 \quad (8)$$

The merchant therefore loses on each transaction, but the loss is lower on mobile money.

[1] To illustrate the benefit perceived by the customer, we have opted for the risk criterion, in particular fraud. Indeed, the majority of customers are sensitive to it, just as the regulatory authority (BCEAO), which through the guarantee fund GIM- UEMOA has historically provided for a risk rate of 5% to scale the contributions to the guarantee fund. This figure does not reflect an observed fraud rate, but rather a conservative assumption to cover potential losses. for the WAEMU, a target fraud rate between 0.05% and 0.1% would be consistent with international standards while taking into account regional challenges. This rate could be adjusted according to the type of service (card vs mobile money), the level of banking, and the detection capabilities. In fact, fraud cases stood at 310,274 for a value of 1.07 billion CFA francs in the second half of 2021 compared to 635,435 frauds estimated at 1.06 billion CFA francs at the end of June 2021, a decrease of 51.17% in volume and an increase of 1.00% in value. By doing the calculation, the fraud rate is 0.73% at the end of 2021. For the present study, it is this rate that is used..

2.2.4 MARKET EQUILIBRIUM EQUATION

The customer chooses mobile money if Umm≥Ubc, whether:

$$1-\alpha Cmm * M-\beta Fmm * M+\gamma Pmm \geq 1-\alpha Cbc * M-\beta Fbc * M+\gamma Pbc \quad (9)$$

Simplification (by canceling V=1):

$$-\alpha Cmm * M-\beta Fmm * M+\gamma Pmm \geq -\alpha Cbc * M-\beta Fbc * M+\gamma Pbc$$

$$\gamma(Pmm-Pbc)\geq \alpha M(Cmm-Cbc)+\beta M(Fmm-Fbc) \quad (10)$$

Now, Umm>Ucb (1.35>1.12) so the customer prefers mobile Money.

The merchant accepts instrument i if, $\Pi i=(COMi-CHi)\geq 0 \Longrightarrow COMi\geq CHi$

In this case, for mobile money: $0.015<0.025 \Longrightarrow \Pi mm<0$

For the bank card: $0<0.02 \Longrightarrow \Pi bc<0$

The merchant incurs a loss on each transaction, which may be offset by other benefits (loyalty, increase in sales volume, etc.).

The merchant undergoes a lower burden on mobile money, which may encourage him to favor this instrument. The market therefore tends towards an equilibrium where mobile money is mostly adopted, which corresponds to the penetration rates (71%) observed in the WAEMU.

The classic microeconomic analysis certainly sheds light on the behaviors of direct actors (customer and merchant), but not enough on their gaming strategies. We think that there are still imperfections and unclarified aspects, which should be studied. This is precisely the reason why we will examine the contribution of game theory integrating new financial education parameters and the success rate for a transaction, as well as the respective weights provided, to explain the adoption factors of mobile money (mm) and the bank card (bc) in the WAEMU. The aim being to deepen understanding of the behavior of the customer and the merchant, who are the direct actors in an electronic payment transaction.

2.3 A MODEL OF ANALYSIS ACCORDING TO THE GAME THEORY

2.3.1 ASSUMPTIONS AND MATHEMATICAL FORMALIZATION OF THE MODEL THE ASSUMPTIONS ARE AS FOLLOWS:

H1: The market for electronic payment instruments in the WAEMU brings together two main players: the customer and the merchant;

H2: The customer chooses between mobile money (mm) and bank card (bc) according to its perceived usefulness, costs, risks, network effects, financial education and success rate for a transaction;

H3: The merchant accepts one or more payment methods depending on its profitability (net profit per transaction);

H4: These actors make interdependent strategic decisions in a non-cooperative game where: The decision of the customer depends on the availability and acceptance of the payment method by the merchant, as well as the intrinsic characteristics of the payment methods. The merchant's decision depends on the majority of customers' choice (network effect) and the profitability of payment methods.

Therefore, the mathematical formulation that follows for both the customer and the merchant is: For the customer, by normalizing V=1, we express the usefulness of the customer as:

$$Ui=V-\alpha Ci-\beta Fi+\gamma Pi+\theta Ei+\lambda Ri \quad (11)$$

Strategically, the customer has the possibility to choose mobile money or bank card.

For the merchant, its profit function is expressed as: $\Pi i=M * (COMi-CHi)$ (12)
Strategically, the merchant has the possibility to accept mobile money, to accept the bank card, to accept both, or to refuse either one.

2.3.2 NASH EQUILIBRIUM

The Nash equilibrium will be obtained if, on the one hand, customers mainly choose a payment instrument at the expense of the other, due to a higher utility. On the other hand if merchants accept a payment instrument despite certain constraints, but more thanks to network externality.

2.4 RESULTS OBTAINED WITH THE GAME THEORY

2.4.1 DATA, PARAMETERS AND WEIGHT

Parameter	Mobile Money (mm)	Bank Card (bc)	Weight (importance) in (utility)
Transaction cost (Ci)	2,25% (0.0225)	1,35% (0.0135)	$\alpha=0.2$
Fraud rate (Fi)	0,0016% (0.000016)	0,73% (0.0073)	$\beta=0.1$
Penetration rate (Pi)	71% (0.71)	25% (0.25)	$\gamma=0.3$
Education level (Ei)	0.7	0.6	$\theta=0.1$
Success rate (Si)	97,5% (0.975)	92,5% (0.925)	$\lambda=0.1$

BCEAO and author calculations

2.4.2 UTILITY FUNCTION OF THE CUSTOMER

We normalize V=1 and express the utility as:

$$Ui=V-\alpha Ci-\beta Fi+\gamma Pi+\theta Ei+\lambda Si \quad (13)$$

The numerical calculations give:

FOR MOBILE MONEY:

$Umm=1-0.2\times0.0225-0.1\times0.000016+0.3\times0.71+0.1\times0.7+0.1\times0.975$

$= 1 - 0.0045 - 0.0000016 + 0.213 + 0.07 + 0.0975$

$= 1 + 0.3759984$

$=1.3760$

FOR THE BANK CARD:

$Ubc=1-0.2\times0.0135-0.1\times0.0073+0.3\times0.25+0.1\times0.6+0.1\times0.925$

$=1-0.0027-0.00073+0.075+0.06+0.0925$

$=1+0.22407$

$=1.2241$

2.4.3 MERCHANT'S PROFIT FUNCTION

Reminder of net profits per transaction: $\Pi i=M * (COMi-CHi)$ (14)

For mobile money: $\Pi mm=(0.015-0.025)=-0.01$

For the bank card: $\Pi bc=(0-0.02)=-0.02$

The profit function of the merchant remains unchanged, he suffers a lower loss with mobile money.

2.4.4 EXPECTED NASH EQUILIBRIUM

The simplified matrix of strategies is below

	Merchant accepts mobile money (mm)	Merchant accepts bank card (bc)	Merchant accepts both
Customer chooses mobile money (mm)	(1.3760, -0.01)	(0, 0)	(1.3760, -0.01)
Customer chooses the bank card (bc)	(0, 0)	(1.2241, -0.02)	(1.2241, -0.02)

Gains are (customer utility, merchant profit), the customer cannot choose an unaccepted mode (utility 0) and the merchant loses less with mobile money. Customers mostly choose mobile money, because its overall utility is higher. Indeed, Umm=1.3760>Ubc=1.2241. Merchants accept mobile money despite the higher fees, as demand is very high (network externalities). Besides that, they incur fewer losses with mobile money, which explains a higher preference for accepting mobile money compared to the card.

The network effect (via Pi) reinforces the popularity of mobile money, creating a stable equilibrium where the customer chooses mobile money and the merchant accepts mobile money. However, financial education and transaction success rates play a significant role (weight 0.1 each), reinforcing the adoption of mobile money through a better level of associated education and a more favorable payment transaction success rate.

The bank card remains a niche choice, used for higher value transactions or by segments with better financial literacy.

3. DISCUSSION

A critical analysis of the adoption factors and their implication allows to understand why the customer favors the payment method with the best compromise between cost, risk of fraud and network effect. In the WAEMU, the high penetration of mobile money (Pmm=0.71) and its low fraud rate compensate for its higher transaction cost, which explains its majority adoption.

The merchant incurs a negative net charge on each transaction, but less with mobile money than with the bank card. He may be encouraged to favor mobile money, especially for small amounts, but may also prefer the bank card for larger transactions or due to other factors (security, liquidity).

Trust, education, infrastructure, which can be modeled as adaptation costs, all constitute as much as they are, barriers to adoption. Market equilibrium depends on the simultaneous satisfaction of customers (utility maximization) and merchants (profitability or cost acceptability).

4. CONCLUSION

Microeconomic modeling shows that the adoption of mobile money in the WAEMU is supported by a favorable eqilibrium for the customer, thanks to a strong network effect and a low risk of fraud, despite a higher cost. The merchant, on the other hand, bears a negative net load in both modes, but less with mobile money, which can influence their preferences.

To improve this equilibrium, policies aimed at reducing transaction costs and increasing merchant commissions, while maintaining security, are desirable to promote the adoption and sustainability of electronic payment methods in the region.

The integration of education and success factors into the utility function confirms and reinforces the dominance of mobile money in the WAEMU. Despite a higher transaction cost, mobile money benefits from a significant network effect, a low fraud rate, a better level of user education and a more favorable success rate.

Game theory shows that in this context, market equilibrium favors the adoption and acceptance of mobile money by customers and merchants, while the bank card remains a minority.

Indeed:

- ✧ The dominant strategy for customers is to use mobile money, thanks to better accessibility, strong network externalities, and sufficient financial education;
- ✧ Merchants, in front of this massive demand, are adapting their strategy by accepting mobile money despite higher fees;
- ✧ The bank card, although more attractive on the cost criterion for the customer, suffers from low technical penetration and lower externalities, which limits its adoption;
- ✧ The strategic dynamic is therefore a Nash equilibrium where mobile money dominates the market, reinforced by positive externalities and the success rate.

Therefore, to balance the market, it would be necessary to improve financial education and the success rate around the bank card, reduce fees for mobile money merchants, and continue to monitor fraud to maintain overall confidence in both systems.

The possible extensions of this game theory could concern a dynamic model with evolution of penetration rates according to cumulative choices (diffusion of innovation), a multi-stakeholder game including suppliers and regulators, or an integration of psychological costs and barriers to adoption.

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Certified in Fintech Regulation (Harvard University), Certified in Financial Development and Financial Inclusion (IMF), MBA in Management (University of Nicosia), PGD in Business Administration (University of Bradford), Master Financial Professional (American Academy of Financial Management), PGD in Banking and financial management (University of Douala).