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# Institutional Trust and Affordability on Mobile Banking Adoption in Ghana: A System Dynamic Approach

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**Abstract**

Trust between mobile applications and humans is critical for a successful adoption in our society. This study aims to investigate mobile-banking (m-banking) adoption from an institutional trust (ICT performance and Fraud) and affordable mobile broad band point of view and their impact on m-banking adoption in Ghana. In this paper, we extended the Bass diffusion model using system dynamic approach and incorporated fraud, ICT performance and affordability of m-banking services and their effects on m-banking adoption in Ghana. The model is built using system dynamic methodologies (stock and flows), validated to confirm a real-life m-banking adoption behaviour, and simulated to analyse m-banking adoption response under different scenarios. The result shows that improving ICT infrastructure development, preventing cybercrime and reducing the cost of mobile data have a positive impact on m-banking adoption. However, affordability is the primary determinant of m-banking adoption in Ghana, although it can also be enhanced through tax incentives and policy schemes related to mobile communication technologies. The model currently relies on monetary aspects of ICT infrastructure, cybercrime, and broadband data pricing. However, to enhance the model's reliability, it could be beneficial to expand its scope to include non-monetary factors and other relevant economic variables.

**Keywords:** System Dynamic, M-Banking, Adoption, Broadband data, ICT, Cybercrime and Affordability

## 1. Introduction

The study of digital trust and business ethics continues to gain importance (Luetge & Uhl, 2021) because of the rapid growth rate of information and communication technology (ICT) usage and the increasing dependency of individuals and organisation on ICT. As a result of this technological development, business environments in the financial sector have begun to employ the use of wireless internet access to support a range of innovative banking services with the aim of improving service relationships (Scornavacca & Hoehle, 2007), economic empowerment and social development. Mobile phones can now facilitate efficient allocation of resources and financial management; increasing formal savings and credits; reducing poverty rate while improving equality (Chibba, 2009).

In recent years, mobile phone handsets have become very popular, with a penetration rate approaching 100% in sub-Sahara Africa (World Bank development indicator, 2021). The COVID-19 crises have also raised peoples' interest in contactless transaction through mobile phones. Africa is comparatively advanced in digital technologies in contrast to technologies largely stemming from the industrial revolution.

The growth of mobile subscriptions is likely to increase given the growth of mobile services offered by telecommunication companies in Ghana (Narteh et al., 2017). Internet users in Ghana via computer, mobile phones etc, per the world bank development indicators account for 37.9% of the total population which is about 11.6 million as at 2019. This indicates mobile phones have gained popularity over the last years, thus, making the country a fertile ground for the use of mobile phones to execute banking services.

In Ghana, internet services providers and the banking sector believe that m-banking can help the unbanked population have access to the economic benefits of savings, credits and protection from financial shocks (Rahmann, 2016). However, it is believed that adoption is the most significant barrier to m-banking.

To demonstrate m-banking adoption, the behaviour of the institution and prices of broadband are considered necessary. Previous studies on adoption of a technology, including Davis et al. (1989), Friedman et al. (2000) and

O'Brien (2000), mention consumer decision to adopt a technology involve not only the perception about the technology but also belief about the technology environment and the cost of using the technology. System dynamics (SD) modelling is one of several tools that can help m-banking stakeholders learn and revise the technology environment, and thereby improve decision making and performance (Fisher et al., 2000).

The goal of this article is to increase our current understanding of some economic factors that influence m-banking adoption, identify the adoption patterns over time and when (or if) we can expect full adoption, using the SD approach. That is, to model the adoption of m-banking and to show the interconnection of ICT infrastructure, fraud and cost of broadband in the dynamic relationship of m-banking adoption in Ghana. We employ scenarios to demonstrate the possible applicability of the model. These scenarios do not serve as predictions of the future; rather, they enable us to envision various plausible alternative paths that might emerge (Mason, 1994). By utilizing the model, we can gain a better understanding of potential outcomes. The primary motivation for using such tools is to enhance decision-making and to better understand future changes.

### *1.1 Literature Review*

In the last decade, both accessibility and affordability to financial services has become a key strategic area for policy engagement in emerging economies. Financial inclusion is considered crucial for economic and social development and a higher quality of life. Low fees, time savings, the speed of service delivery, compatibility with personal lifestyles and the flexibility to access services anytime and anywhere (Karjaluoto et al., 2002, Black et al., 2002; Gerrard & Cunningham, 2003) have been identified as the most significant factors influencing internet banking. However, certain factors inhibit the adoption of these services, such as the complexity of the service (Black et al., 2002), perceived financial costs (Black et al., 2002), lack of awareness about electronic services (Sathye, 1999), and security risks (Sathye, 1999; Black et al., 2002).

Previous studies indicate, that factors contributing to the adoption of m-banking are related to convenience, access to the service regardless of time and place, privacy and savings in time and effort (Suoranta, 2003; Laukkanen, 2007). In spite of the advantages the use of the m-banking services has remained small. There seem to be some inhibitors that slow down the use of mobile channels in bank transactions. Previous studies indicates that, trust and financial cost inhibits the use and adoption of m-banking services (Luarn & Lin, 2005).

Although demographic characteristics help identify potential m-banking adopters, the question of why people adopt or do not adopt m-banking cannot be answered solely by socio-demographic information. Determinant factors suggested by the diffusion of innovation model, the Theory of Planned Behaviour (TPB), the Technology Acceptance Model (TAM), and other related constructs have been studied to explain (m-banking) adoption behaviours (Luo et al., 2010). As a recent example, A study in Malaysia (Rahman et al., 2024) here leverages the Unified Theory of Acceptance and Use of Technology (UTAUT) to examine Malaysian millennials' behavioural intentions toward m-banking app adoption, they found performance expectancy, effort expectancy, trust, and personal innovativeness significantly influence m-banking app adoption intentions. Osei-Assibey (2015), applied Innovation Diffusion Theory and Technological Adoption Model (TAM) to provide insight on the behavioural intention and willingness to adopt mobile money and concluded that perceived risk, education level, relative advantage and the age significantly influence their mobile money adoption. Luo et al. (2010) analysed the effects of different aspects of risk and trust on adoption of m-banking. They showed the different aspects of trust have different effects and the two factors of risk and performance have direct influence on adoption.

In order to analyse m-banking adoption in South Africa, (Brown et al., 2003) combined Diffusion of Innovations Theory and Theory of Planned Behaviour (TPB) to explain the factors influencing m-banking adoption. It identified relative advantage, trialability, and consumer banking needs, with perceived risk having a major influence on m-banking adoption. Lee and Chang, (2009) had used Delon and Mcleen (information systems success model) model, in order to survey effective factors on customers' trust and satisfaction in Korea. By adding one trust-based construct and two resource-based constructs, Luarn and Lin (2005) employed TAM and TPB to explore human behavioural intention to use m-banking. They discovered that perceived self-efficacy, financial cost, credibility, easy-of-use and usefulness had positive effects on the behavioural intention to use m-banking.

The combination of qualitative and quantitative methods highlighted in the studies mentioned above has significantly enhanced our understanding of m-banking adoption in various manners (Dutta et al., 2012). To further enrich these methods, it would be beneficial to incorporate an approach that aids policymakers in predicting the likely outcomes of their proposed interventions. Detecting the reasons for this avoidance and the reasons effective on m-banking adoption, is very important (Abbasi et al., 2016). Can we evaluate the impact on m-banking adoption in terms of both the extent and speed? While the existing methods help us understand the phenomenon and its influencing factors, they fall short of directly quantifying the effects of planned interventions. Hence it is needed

to model present structured feedbacks in m-banking adoption with a holistic, systemic and monolith point of view, so that we can make better decisions about m-banking adoption in banking.

*1.2 System Dynamic Framework*

To capture the complex cause and effect relationships among the factors involved in the adoption of m-banking in Ghana, we relied on the system dynamic (SD) representation of the Bass model provided by (Sterman, 2000). Bass (1969) drew upon theory of innovation diffusion (Rogers, 1962) to develop a predictive model that forecasted the future adoption of durable products. The model accounts for two categories of adopters: Innovators, who are generally interested in new things and are therefore the first to adopt the innovation whereas majority of adopters are imitators whose adoption decision depends on their awareness, interest, evaluation, trial, and adoption. The Bass model is better suited for our purpose because it provides a structured approach to analysing the adoption of innovations and it is based on objective data (Saeed & Xu, 2020). The Bass model has been widely used to capture the diffusion pattern of innovations in marketing (Mahajan et al., 1990) and information technology disciplines (Saeed & Xu, 2020))

By applying the Bass model within a SD framework, we could create simulations that reflect the dynamic nature of m-banking adoption in Ghana, considering factors such as ICT infrastructure, fraud, and cost of broadband data. SD was first created by J. W. Forrester at MIT in 1950. After a while, the application of this method extended to be used in other sectors including enterprises, cities, regions, nations and even the whole world (Staller, 2004; Ceresia, 2011; Tsai & Hung, 2014). SD is a mathematical language used to represent the causal structure of a system, and its basic tenet is 'structure causes behaviour'. SD is empowered to deal with non-linearity, information feedback, time delay and dynamic complexity.

The uniqueness of SD lies in its ability to connect causal structures to system behaviour in a computational format. SD compels us to explicitly represent the mechanics of diffusion by identifying relevant variables and the cause-and-effect relationships among them (Dutta et al., 2012). While various statistical methods have quantified diffusion patterns and predicted future developments, these methods often concentrate on outcome variables and/or their determinants. The strength of the SD approach is its capacity to provide a comprehensive view of the various contextual variables, their interconnections, and the resulting effects of these interactions on m-banking diffusion. By doing so, it presents a different perspective on the diffusion phenomenon—one that not only describes the observed behaviours but also allows for opportunity of altering variables to affect the observed behaviour in desirable ways.

We utilize a SD model to explore the adoption and diffusion of m-banking. The model makes the causal relationships that influence technology adoption and diffusion behaviour. This simulation approach allows m-banking stakeholder to gain insight into the causal factors influencing m-banking adoption decision making processes and thereby into the potential diffusion patterns resulting from those adoption processes.

One advantage of using SD models over more traditional models is the inclusion of feedback effects. This makes the model's output more realistic and exposes complexity that may be hidden in other modelling techniques (Fisher et al., 2000). Thus, decision makers can more easily identify the interrelationships in the environment of the model. Feedback occurs in another level as well. As managers practice with the simulation, their understanding of the environment changes. They learn from the feedback the model gives them.

## 2. Conceptual Background

The concept of institutional based trust (IBT) and affordable broadband data are first reviewed and the perspective that are relevant to the study context are delineated to examine the adoption of m-banking. Following is an explanation of why affordable broadband data and IBT are important factor in m-banking.

*Affordability* remains one of the main challenges in addressing digital inequality Yang (2009) found that high transaction cost and high set-up fees are factors that inhibit m-banking adoption. Cruz et al. (2010) also indicates that the cost of Internet access and service and perceived risk were top two barriers for adopting m-banking services. In areas where broadband data is expensive or unreliable, potential users maybe excluded from accessing m-banking services.

Although Internet access in Ghana has improved due to the growth of the telecommunication sector, affordable broadband remains out of reach for the majority of Ghanaians. Alliance 4 Affordable Internet (A4AI) latest mobile broadband pricing data shows that the cost to connect to the internet (1 GB) of mobile data in Ghana cost 5% of the Gross National Income (GNI) per capita, 3% more of the United Nation's 2% target. Its important to note many Ghanaians do not earn the official GNI per Capita of $1,829 per annum as at 2019. As a result, many Ghanaians will be reluctant to adopt m-banking if mobile broadband services remain expensive. Empirical evidence has

revealed that m-banking adoption is highly encouraged by economic factors such as advantageous transaction fees (Yang, 2009; Yu, 2012).

*Institutional based trust* is the belief that the needed structural conditions are present (e.g., the Internet) to enhance the probability of achieving a successful outcome in an endeavour like m-banking (McKnight et al., 2002). It refers to the perceptions of the institutional environment, in this case the internet. Perception of the structural characteristics of the internet, such as speed, safety and security can influence the trust to adopt m-banking (Keen et al., 2000). Technology and legal safeguards are important for the m-banking consumer. In our article, we divided IBT into two dimensions: ICT infrastructure system and Cyber Security.

*ICT infrastructure system*: this reflects Mcknights (2002) idea of situational normality, which it is defined as the believe that the environment is in proper order and success is likely because the situation is normal or favourable. That is, m-banking customer would believe that the Internet environment is appropriate, well ordered, and favourable for doing personal transaction (Osei-Assibey, 2015). High speed internet would encourage banking transaction, for instance the introduction of 5G services has been linked to the growth of internet banking in various regions (Kumar et al., 2023). Several studies have shown an effective and efficient technology-based system is dependant on the quality of technological infrastructure such as availability, connectivity, speed and reliability (Poon, 2007; Chiu et al., 2017; Pikkarainen et al., 2004).

*Cybersecurity*: M-banking operates in an automated environment and makes extensive use of an open network which can create uncertainty through fears of breach and other malicious attacks resulting in financial losses or manipulation of personal data (Laukkanen et al., 2007). Like Mcknights (2002), definition of structural assurance, meaning one believes that the structures like guarantees, regulations, promises, legal resources or other procedures are in place to promote the success of m-banking services (Shapiro, 1987). That is consumers are more likely to adopt m-banking if they perceive that there are regulations protecting their interest. Luarn and Lin (2005) argued security issues to be among the greatest concerns in the adoption of m-banking services.

Various studies have established that trust and affordability are an important factor in the adoption of a technology (Lee & Chung, 2009; Cruz et al., 2010). We focused on IBT and affordability for the following reasons. First, these 2 factors have been identified as individual factors impacting m-banking but its interconnection have been overlooked. Second, the model can help stakeholders take realistic actions and less computational complexity.

## 3. Methodology

To test the prediction, we developed a formal SD model using publicly available data (full list in the Appendix A) and the supplementary file 10 provides our model (Vensim format; Vensim 2020). Our goal was to represent and understand the behaviour exhibited by the m-banking system in the recent past (between years 2010 and 2019) as shown in figure 5. To build confidence in the model structure (Forrester & Senge, 1980; Berlas, 1996; Sterman, 2000) multiple SD model verification and validation tests were performed. We tested for structural validity to confirm if the flow and stock structure adequately represents our system (Barlas, 1996). Once the model was formulated, behaviour validity was also tested to demonstrate that the behaviour of the model is ‘close enough’ to the observed real behaviour (See Supplementary 1). Furthermore, extreme condition test which accesses the robustness of the outcome was also performed (See Supplementary 1).

### *3.1 Affordability Model*

To calculate the price of broadband data, we considered the prices as a percentage share of gross national Income (GNI) per capita (World bank development indicator, International Telecommunication union). We defined affordability as the amount of income spent on broadband data for 1 GB of mobile data. Prices of broadband data may be dependant on other factors such as production quality, demand and supply, cost of the technology and ICT experts and etc which are not included in the model.

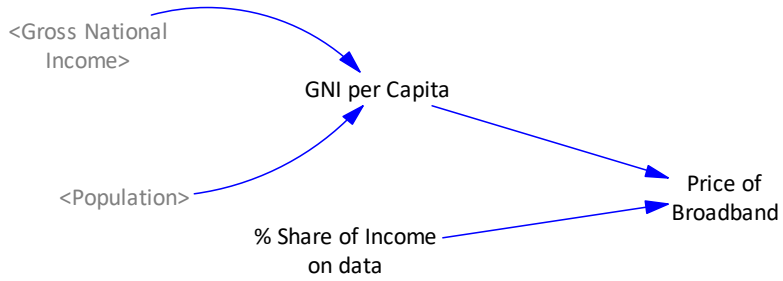


Figure 1. Overview of price of broadband data

*Note.* $P$: Price of Broadband data; $GNI_{pc}$: Gross National Income Per Capita; $\delta_p$: Share of GNI on broadband data.

$$P = GNI_{pc} \times \ \delta_p \tag{1}$$

The model describes the responding behaviour of broadband suppliers due to new conditions of demand. We assumed that broadband data suppliers may cut down prices when unit cost fall as a result of subsidies and tax incentives, and production reach capacity level because of the development of the ICT ecosystem in Ghana.

### *3.2 Institutional Model*

We assumed investments by public bodies and agencies is one of the main factors that help in achieving a sovereign and trustworthy ICT industry (European Parliament Research Service, 2017). We divided IBT into ICT performance and Cybercrime. ICT performance is based on the amount of dollars invested in ICT development and assumed more investment will increase the ICT performance hence trustworthiness of m-banking. Cybercrime is presented as the amount lost due to frauds and cyberattacks while using ICT. Hence, assumed an increase in fraud and cybercrimes will reduce trust of the technology.

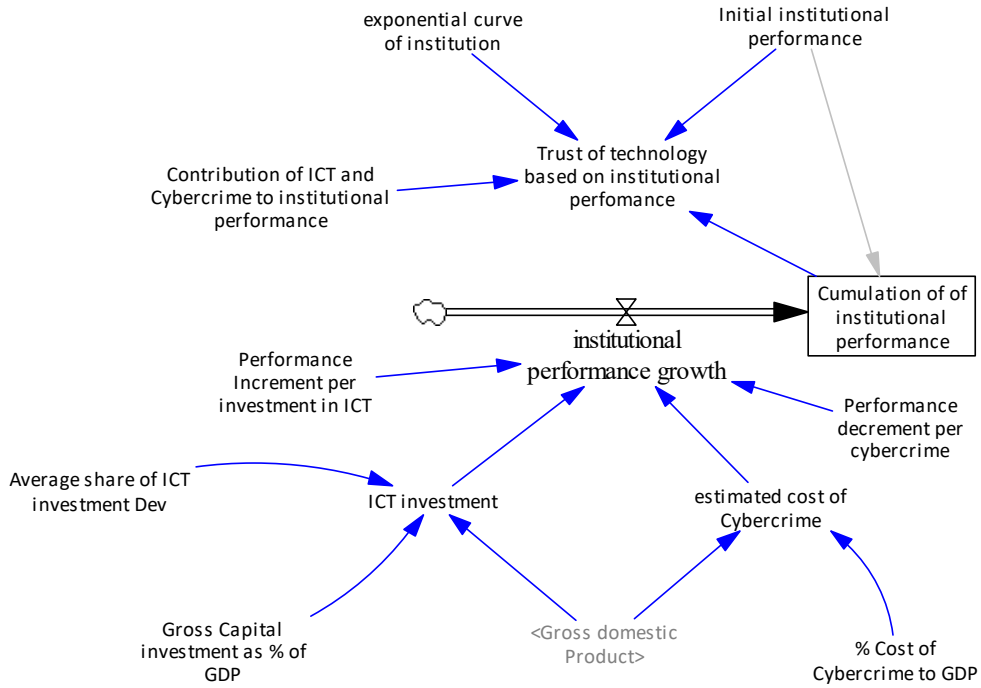


Figure 2. An overview of institutional performance

*Note.* $R_t$: Institutional performance growth; $IP$: Cumulation of institutional performance; $IP_i$: Initial institutional performance; $ICT$: ICT investment; $CA$: Estimated cost of cybercrime; $I_{ict}$: Increment of performance per ICT investment; $I_{ca}$: Decrement of performance per cybercrime; $IT$: Trust of technology based on institutional performance; $\alpha$: Institutional trust exponent curve; $\gamma$: Progress ratio; $Z$: Contribution of ICT investment and cybercrime to institutional trust.

We also considered that performance accumulation is determined by the amount of investment in ICT and the cost of cybercrime. 'Institutional performance growth' $(R_t)$ for each period depends on the difference between investment in ICT and Cybercrimes. Two exogenous variables were introduced 'Performance Increment per ICT Investment' and 'Performance decrement per cybercrime' to determine the impact of ICT investment and cybercrimes on m-banking adoption. Therefore, the rate of institutional trust is being improved by an increase in the amount of ICT investment and a decrease in cybercrimes.

$$R_t = (ICT \times I_{ict}) - (CA \times I_{ca}), \qquad \text{ICT} > \text{CA} \tag{2}$$

$$IP = IP_i + \int R_t \, .dt \tag{3}$$

For the Institutional curve formulation, we assume a similar function of the technology learning curve (Junginger et al., 2005; Kahouli-Brahmi, 2008).

$$IT = \left(\frac{IP}{IP_i}\right)^{\alpha} \times Z \tag{4}$$

Where 'Trust of technology based on institutional performance' $(IT)$ captures the effect of cybercrime and ICT investment on trust of institution. $Z$ is added to the model to differentiate between the contribution of ICT and cybercrime from the contribution of other institutional performance determinants. $\alpha$ is the institutional performance exponent curve which is calculated as

$$\alpha = \frac{\ln(1+\gamma)}{\ln 2} \tag{5}$$

$\gamma$ is the progress ratio and determines the strength of institutional performance in m-banking adoption. The exponent $\alpha$ is positive because as institutional performance increases m-banking adoption also increases.

### *3.3 Innovation Attractiveness*

As new technology diffuses into an economy and generates benefits for the users, it lowers hesitation in adopting

it (Arthur, 1989). Thus, the technology gain attractiveness among users by providing better services. As by lowering prices and enhancing the technology performance or reducing uncertainties, the technology attractiveness will increase, and as technology attractiveness increases, users tend to adopt the technology and contribute to the diffusion of the technology.

As indicated by (Mahajan & Muller, 1979) cost and price for new technologies decline over time and consequently affect the growth/ adoption of a new product. We used (Mahajan & Muller, 1979) effect of price on a product function of price elasticity (sensitivity of price) and prices at each time.

Based on the above definition, the level of attractiveness is adjusted through two different factors: prices of broadband data and institutional performance. The growth of attractiveness positively influences adoption through word-of-mouth and adoption through advertising.

The attractiveness through price is a relation between initial price of broadband data and price of broadband data each time and price elasticity (price sensitivity). This has a negative impact on attractiveness. That is a high price will deter individuals from using m-banking. Attractiveness through institutional performance changes linearly as institutional performance changes.

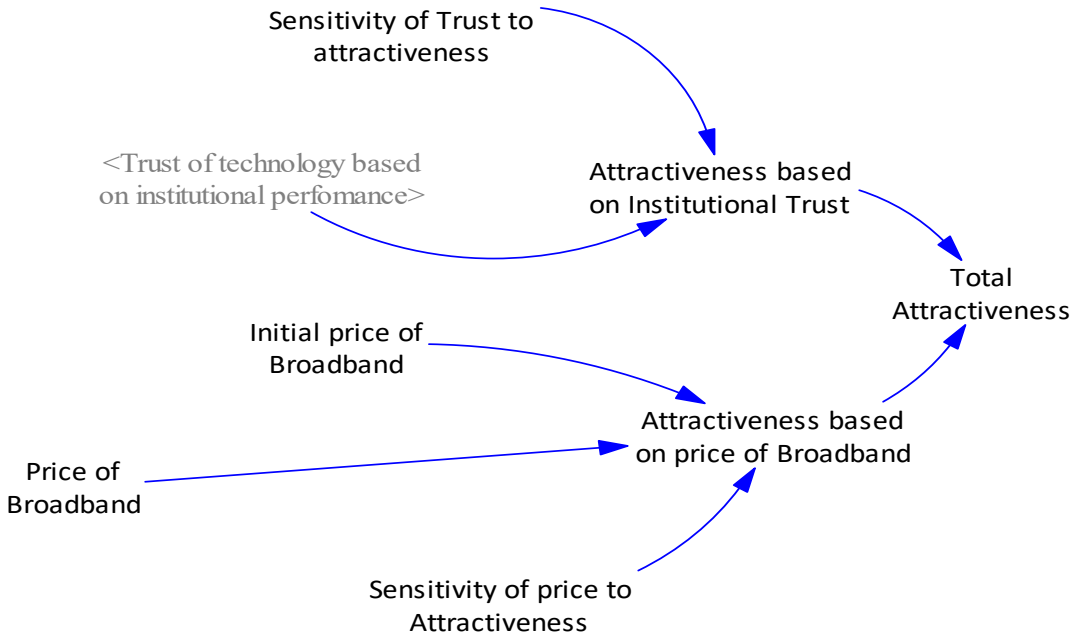


Figure 3. An overview of m-banking attractiveness based on institutional performance and price

*Note.* $AT$: Total Attractiveness; $AT_t$: Attractiveness based on institutional trust; $AT_p$: Attractiveness based on price of broadband; $S_t$: Sensitivity of trust to attractiveness; $S$: Sensitivity of price to attractiveness; $p$: Price of broadband data; $P_i$: Initial price of broadband data.

$$AT_t = IT \times S_t$$

$$AT_p = e^{(S\frac{p}{P_i})}$$

$$AT = AT_t + AT_p \quad (6)$$

Where $AT_t, AT_{p,}$ and $AT$, denote attractiveness from price reduction, attractiveness from institutional performance and total attractiveness respectively. $S_t$ is sensitivity of attractiveness to institutional performance and $S$ is the sensitivity of attractiveness to price.

*3.4 Extended Diffusion Model*

We assume that, the population with access to broadband (N), is divided into $N_p$ - the number of potential adopters (those who are not using m-banking - either they are aware or not) and $N_a$ - the number of individuals using the product. At any point in time an individual will be in either one of these states. This module is a restrictive

assumption which does not allow for repeated adoptions. In this case we assumed a fixed number of market size that is an estimated share of the population (base of Ghana population growth rate) that have access to the internet in the year 2030. After adopting the product, the adopter is removed from the group of potential adopters. Therefore, the total population is the sum of potential adopters and adopters. The modules presented here are only concerned with the timing of the initial purchase, by the definition:

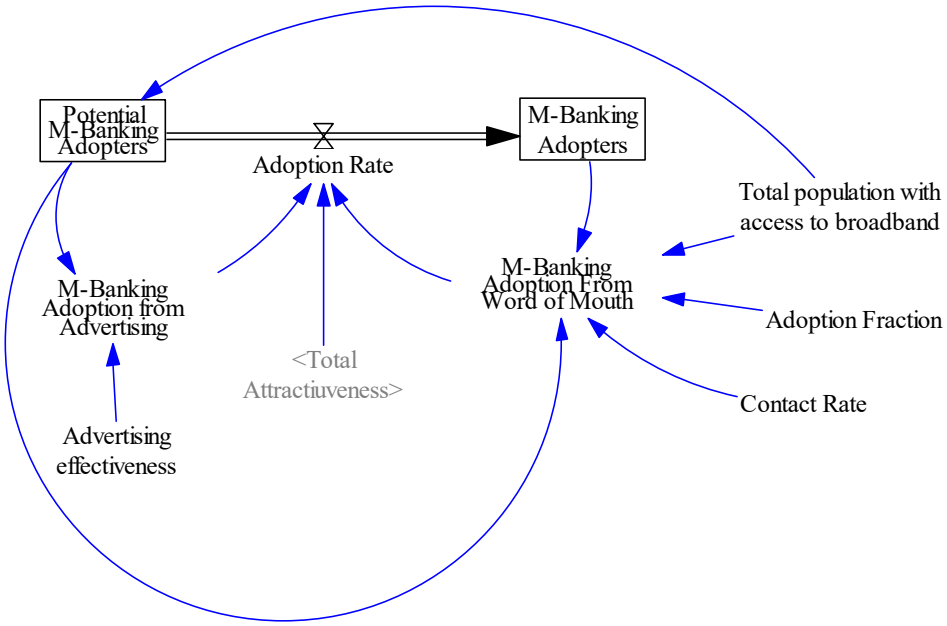


Figure 4. An overview of the extended Bass model

*Note.* $N$: Total population with access to broadband data; $N_a$: M-banking Adopters; $N_P$: Potential M-banking Adopters; $R_a$: Adoption Rate; $N_{ao}$: Initial M-banking Adopters; $WoM_\alpha$: M-banking adoption from Word-of-Mouth; $Adv_\alpha$: M-banking adopters from Advertising; $A_f$: Adoption Fraction; $R_c$: Contact Rate; $\epsilon$: Advertising Effectiveness.

$$N = N_P + N_a$$

$$N_p = \int -R_a$$

$$N_a = N_{ao} + \int R_a \tag{7}$$

Two variables – Adoption from Word of Mouth ($WoM_\alpha$) and adoption from Advertisement ($Adv_\alpha$) influence the Adoption Rate ($R_a$ ) that is the movement of customers from a potential adopter to an adopter. The imitation effect $WoM_\alpha$ is based on the information acquired from the contact with prior adopters. Early adopters of a new product interact with other less innovative members. There is also a proportion of the potential adopters who use the products independent of the influence of $WoM_\alpha$. The inducement outside $WoM_\alpha$ to purchase represents the effect of marketing e.g. advertising, media reports, promotion and others (Dodson and muller, 1978). The rate of adoption in advertisement is based on the level of awareness and familiarities (Struben and Sterman 2007). Therefore, the Adoption rate at a given time defined as

$$R_a = (WoM_\alpha + Adv_\alpha) \times (1 + AT)$$

$$WoM_\alpha = A_f \times R_c \times \frac{N_p}{N}$$

$$Adv_\alpha = N_p \times \epsilon \tag{8}$$

The Adopter's variable is increased by $R_a$ . $WoM_\alpha$ is captured as a function of contact rate $(R_c)$ between those that have adopted the new technology and those that have not. It also captures the adoption fraction $A_f$ (a constant probability of the population that takes on the new technology after exposure to it), the population using new technology and the overall population of a country. $A$ is influenced by potential adopters and advertising effectiveness constant ($\epsilon$).

Both adoption by advertising and adoption by word-of-mouth are influenced by technology attractiveness which is the summation of the institutions trust module and the affordability module and increases through economic growth, fraud reduction and infrastructure.

**4. Analysis**

The model takes decision variables: ICT (Investment in ICT as a share of total investment), cybercrime (cost of cybercrime to GDP) and affordability (share of GNI Per capita). The results of the m-banking decision model are the trajectory of m-banking adoption represented by the Bank of Ghana (BoG 2019 report) as indicated in Figure 5. The results are simulated into the future to test major scenarios that may represent economic uncertainties.

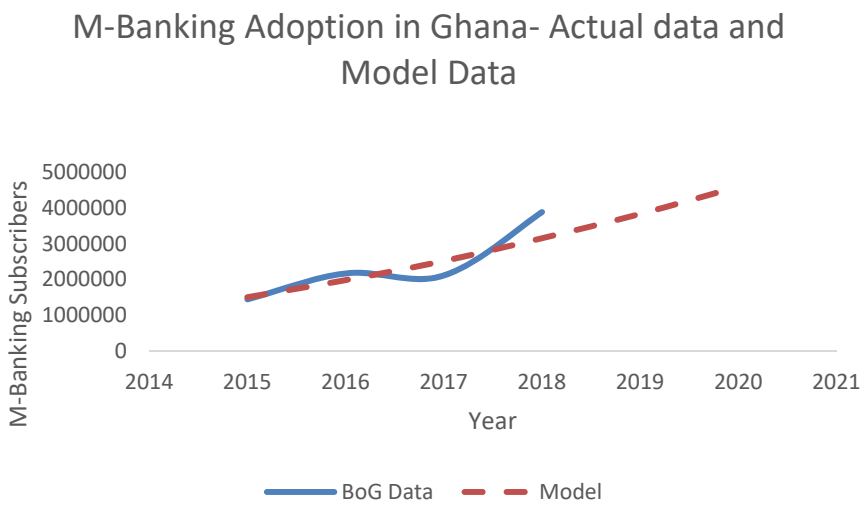


Figure 5. Simulation results behaviour of M-banking subscribers against their historical data

We calibrated the model iteratively, aiming to replicate the historical trend as shown in Figure 5. We hypothesized that by lowering prices and enhancing the technology performance or reducing uncertainties, the technology attractiveness will increase, and as technology attractiveness increase, users tend to adopt the technology and contribute to the diffusion of the technology.

Our model was simulated to forecast future trends if the government of Ghana should continue to invest in ICT at the same current rate, cost of cybercrime to GDP and cost of data should remain the same. Figure 6 shows the model simulation runs of m-banking adopters. We set a simulation time period from 2010 until 2030, wherein time 2019 represents the time period, which is the time for policy implementations. M-banking adoption is observed as the percentage of the total population using m-banking. The figure shows that without any change in Ghana's economic strategies regarding ICT, cybercrime and economic development, the percentage of the population adopting m- banking is projected to reach around 45% in 2030.

Accordingly, the adoption rate of m-banking technology creates a normal distribution curve, in which the adoption rate increases and then declines after a certain period, once the market size (percentage of the population with access to internet service) is saturated. The peak of adoption tells the magnitude and its time point.

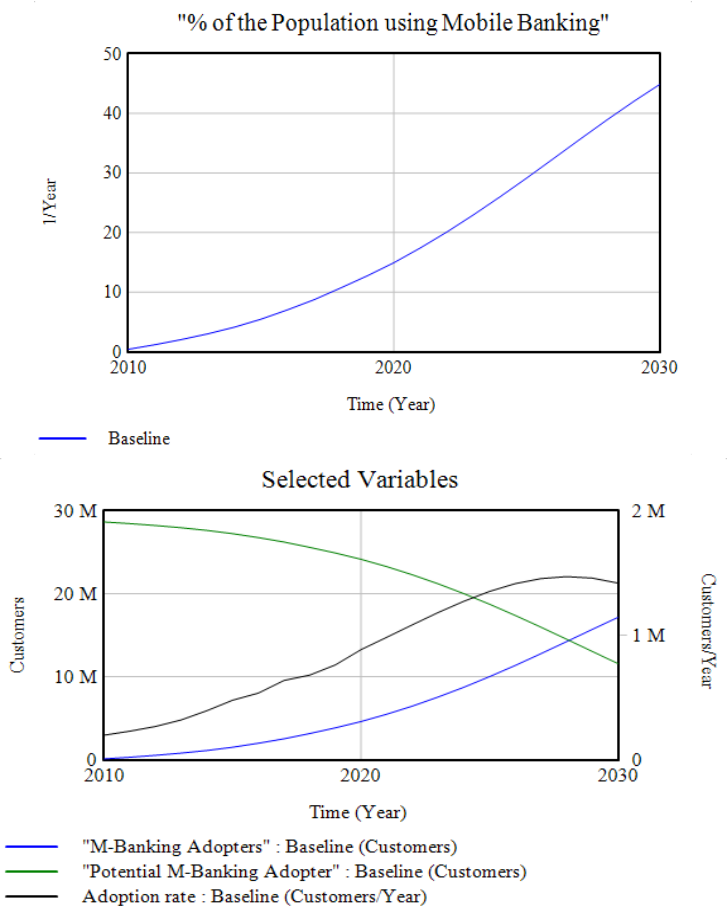


Figure 6. Reference mode under M-banking adopter, potential adopters, adoption rate and percentage of the population using M-Banking

## 5. Scenarios and Policies

Table 1 shows the scenarios that was conducted to explore the significant parameters. Scenarios are built to reflect uncertain future adoption rate by assuming alternative investment decisions (Investing in ICT and affordability) against the reference mode. We simulated these scenarios to identify their impact of m-banking adoption.

Table 1. Scenarios and Policies

| Policy Mechanism | Variables | Change |
|---|---|---|
| Optimist | · ICT | · 10% |
| | · Cybercrime | · 0.05% |
| | · Cost | · 1% |
| Reference Mode (Base) | · ICT | · 4% |
| | · Cybercrime | · 0.1% |
| | · Cost | · 3% |
| Pessimist | · ICT | · 2% |
| | · Cybercrime | · 1% |
| | · Cost | · 10% |

## 6. Results and Discussion

Using the experiment designed in Table 1 as the basis for policy and scenario analysis, Figure 8 shows the behaviour of the adoption rate under different scenarios in ICT, Cybercrime and cost of data, thus, to identify the impact of alternative policies on the adoption rate of m-banking. Based on the optimistic scenario doubling the share of investment in ICT increases the percentage of adoption in the range of 0–1% over ten-year and a 50% decrease in ICT investment reduces the adoption percentage on a range of 0–0.5%.

A reduction of the prices of broadband data from 3% to 1% of GNI per capita increase the adoption percentage by a range of 0–4%. Similarly, Increasing the cost of mobile data from 3% to 10% of GNI per capita decreases the adoption percentage by 0–4% over a ten-year period. This confirms the Research ICT Africa report that cost is the primary reason for low internet usage.

Lastly, A 50%decrease of cybercrime or an increase in cybercrime from 0.1% to 1% has no significant effect on the adoption of m-banking in Ghana. A plausible explanation for cybercrimes perceived as an inconsequential matter can be associated to the low prosecution rate and lack of cybersecurity awareness.

We also combined all the strategies, shown as the run 'oICT+oCA+oCO and pICT+pCA+pCO' for optimistic and pessimistic scenarios respectively, which indicated that investments lower than the reference mode has a negative impact on m-banking adoption whereas an investment higher than the reference mode has a positive impact on the growth of m-banking as shown in Figures 7 & 8.

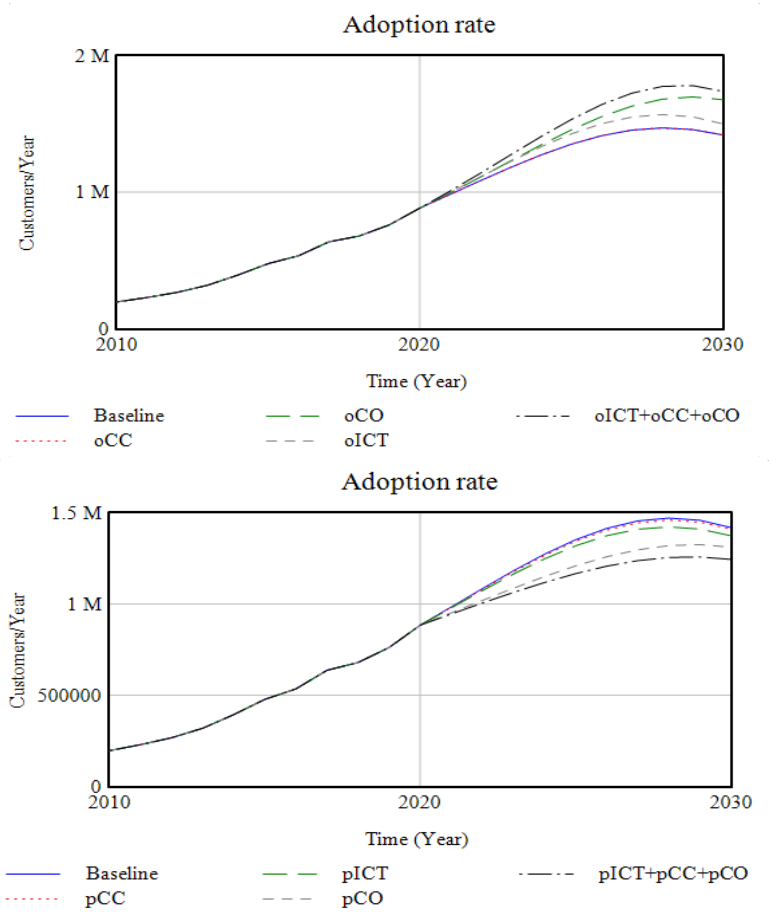


Figure 7. Adoption rate under optimist and pessimist scenarios

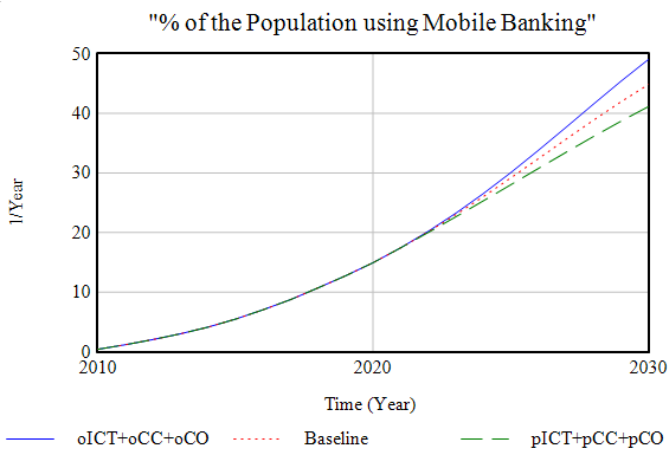


Figure 8. Simulation results of the percentage of the population using m-banking under the optimist and pessimist scenarios

## 7. Conclusion

Policy makers are faced with a dynamic, complex, and uncertain environment in which to make decisions. The factors affecting decision outcomes change over time, results may not be known at the time decisions are made, often due to the long lags existing between the time the decision was made and when the results are known.

The study explores the widely acknowledged effect of some economic factors ICT development, cybercrime and data affordability that have been found to play a significant role in the diffusion of m-banking. Not only the economic factors studied were found to be important, but so are the interdependencies among them. These economic factors were integrated in a SD modelling tool to help policy makers make decisions that lead to a faster and high m-banking adoption. The model offers several insights on how adoption of m-Banking can be accelerated.

The SD model is simulated to examine the impact of the ICT, cybercrime and data affordability on m-banking adoption. The result for the study reveals increase in ICT investments, improved cyber security and a reduction of the prices of data of m-banking service all has a positive impact on m-banking adoption. However, affordability is the main determinant of m-banking adoption in Ghana. Contrary to (Luarn and Lin, 2005) security issues are not perceived by customers to be a major obstacle to adopting m-banking.

It is important to control the diffusion process, the speed should neither be too slow nor too fast. Too slow speed will hinder the effort in solving the financial inclusion problem and faster m-banking adoption can also lead to some hidden economic trade off, human right abuse in production of mobile phones. In summary, both IBT and broadband affordability are essential in shaping the landscape of m-banking adoption. Trust in financial institutions encourages users to engage with m-banking, while affordable broadband access ensures that these services are available to a broader audience.

Although the study focuses on the relation between ICT investments, cost of cybercrime, cost of mobile data and m-banking adoption, it is important to acknowledge certain limitations. The model currently relies on monetary aspects of ICT infrastructure, cybercrime, and broadband data pricing. To improve the model's reliability, it would be advantageous to expand its scope by including non-monetary factors related to ICT infrastructure and cybercrime such as unstable electricity supply, coverage area, number of people affected by cybercrimes and other relevant economic variables. Accurately identifying and integrating all relevant economic factors is crucial for the model to serve as a dependable tool for policy analysis. Furthermore, examining the research relationships across various economic sectors would enhance the generalizability of the m-banking study in Ghana. We hope that this study offers valuable insights and lays a foundation for future research endeavours.

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## Appendix A

| Variables | Formula | Units | Source |
|---|---|---|---|
| **Auxiliary variables** | | | |
| % of the Population using Mobile Banking" | M-Banking Adopters"/Population*100 | 1/year | Evaluated based on e-conomy Africa report 2020 Google and International Finance Corporation |
| Attraction based on price of Broadband | EXP((Price of Broadband/Initial price of Broadband)*Sensitivity of price to Attraction) | Dmnl | Formula adapted from exponential price elasticity function |
| Attractiveness based on Institutional Trust | Sensitivity of Trust to attractiveness*Trust of technology based on institutional performance | Dmnl | Formula adapted from a linear elasticity demand function |
| effect of M-Banking on GDP | IF THEN ELSE(Time>2019, ("% of the Population using Mobile Banking"/100)*0.03+0.065, GDP Growth rate ) | 1/year | Formula adapted to Threshold 2021 frame work model |
| estimated cost of Cybercrime | Gross domestic Product*"% Cost of Cybercrime to GDP | Dollars | Evaluated based on Africa Cyber Security Report 2017 and GDP data from world bank development indicator |
| exponential curve of institution | LN(1.25)/LN(2) | Dmnl | Formula adopted from Stermann 2000 |
| GNI per Capita | Gross National Income/Population | Dollars/Customer | Evaluated based on GNI data and population data from the world bank development indicator |
| ICT investment | Average share of ICT investment Dev*("Gross Capital investment as % of GDP"*Gross domestic Product) | Dollars | Evaluated based on ICT investment data from the world bank development indicator |
| M-banking Adopter through Advertisement | Advertising Effectiveness*"Potential M-Banking Adopter" | Customers/Year | Formula adopted from Stermann 2000 |
| M-banking adoption through word-of-mouth | adoption fraction*Contact Rate*"Potential M-Banking Adopter"/Total population with Broadband Access*"M-Banking Adopters" | Customers/Year | Formula adopted from Stermann 2000 |
| Price of Broadband | GNI per Capita*"% Share of Income on data | Dollars/customer | Evaluated based on the ICT price basket from the International Telecommunication Union |
| Total Attractiveness | Attraction based on price of Broadband + Attractiveness based on Institutional Trust | Dmnl | - |
| Total population with Broadband Access | Estimated Population 2030*"Estimated % of Internet users 2030" | Customers | Assumption based on population data from the world bank development indicator |
| Trust of technology based on institutional performance | ((Cumulation of institutional performance/Initial institutional performance) ^exponential curve of institution)*Contribution of ICT and Cybercrime to institutional performance | Dmnl | Formula adapted from technology learning curve |

| | | | |
|---|---|---|---|
| **Constants** | | | |
| % Cost of Cybercrime to GDP | 0.001 | 1/year | Evaluated based on the Africa Cyber Security Report 2017 (Serianu) |
| Advertising Effectiveness | 0.0055 | 1/year | Calibrated in the model for M-banking Adopter to reach an average of approximately 13% by year 2019 |
| adoption fraction | 0.0045 | Dmnl | Calibrated in the model for M-banking Adopter to reach an average of approximately 13% by year 2019 |
| Average share of ICT investment for Development | 0.04 | Dmnl | Evaluated based on the national communication authority report |
| Contact Rate | 25 | 1/year | Calibrated in the model for M-banking Adopter to reach an average of approximately 13% by year 2019 |
| Contribution of ICT and Cybercrime to institutional performance | 0.3 | Dmnl | Assumption based of 2017 report of the national communication authority |
| Estimated % of Internet users 2030 | 0.75 | Dmnl | Evaluated based on Internet access data from the World bank development indicator |
| Estimated Population 2030 | 3.82E+12 | Customer | Evaluated based the population data and internet access data from the World bank development indicator |
| GDP Growth rate | 0.065 | 1/year | Evaluated based on GDP Growth rate data from the world bank development indicator |
| Initial institutional performance | 100000 | Dollars | Assumption based on Bank of Ghana report and calibrated for M-banking adoption to reach 13% by year 2019 |
| Initial price of Broadband | 150 | Dollars/customer | Evaluated based on the ICT price basket from the International Telecommunication Union |
| Performance decrement per cybercrime | 0.0001 | 1/year | Assumption based on Africa Cybersecurity report |
| Performance Increment per investment in ICT | 0.0006 | 1/year | Assumption based on 2017 report of the national communication authority |
| Population Growth rate | 0.022 | 1/year | Evaluated based on Population Growth rate data from the world bank development indicator |
| Sensitivity of price to Attraction | -3 | Dmnl | Calibrated to have a negative impact on attraction |
| Sensitivity of Trust to attractiveness | 0.4 | Dmnl | Calibrated to have a positive impact on attraction |
| **Flows** | | | |
| Adoption rate | IF THEN ELSE(Total Attractiveness=0, ("M-banking adoption through word-of-mouth"+"M-banking Adopter through Advertisement")* -0.007 , ("M-banking adoption through word-of-mouth"+"M-banking Adopter through Advertisement")* (1+Total Attractiveness) ) | Customers/Year | Formula adopted from Stermann 2000 |
| GDP Growth | Gross domestic Product*"effect of M-Banking on GDP | Dollars/year | Evaluated based on GDP data from the world bank development indicator |
| GNI Growth | Gross National Income*GNI Growth rate | Dollars/Year | Evaluated based on GNI data from the world bank development indicator |
| institutional performance growth | ICT investment*Performance Increment per investment in ICT)-(Performance decrement per cybercrime*estimated cost of Cybercrime) | Dollars | Evaluated based on data from world bank development indicator, NCA report and Africa cybersecurity report |
| Population Growth | Population*Population Growth rate | Customers/year | Evaluated based on Population data from the world bank development indicator |
| **Stocks** | | | |

| | | | |
|---|---|---|---|
| Cumulation of institutional performance | INTEG (institutional performance growth,Initial institutional performance) | Dollars | Formula adopted from Stermann 2000 |
| Gross domestic Product | INTEG (GDP Growth, 3.16631e+10) | Dollars | Evaluation based on GDP data from world bank development indicator |
| Gross National Income | INTEG (GNI Growth, 3.16631e+10) | Dollars | Evaluation based on GDP data from world bank development indicator |
| M-Banking Adopters | INTEG (Adoption rate,100000) | Customers | Formula adopted from Stermann 2000 |
| Population | INTEG (Population Growth,2.47796e+07) | Customers | Evaluated based on Population data from the world bank development indicator |
| Potential M-Banking Adopter | INTEG (-Adoption rate, Total population with Broadband Access) | Customers | Formula adopted from Stermann 2000 |
| **Tables** | | | |
| % Share of Income on data | | Dmnl | Table from the ICT price basket from the International Telecommunication Union |
| Gross Capital investment as % of GDP | | Dmnl | Table from Gross Capital investment as of GDP data from the world bank development indicator |
| GNI Growth rate | | 1/year | Table from GNI Growth rate data from the world bank development indicator |
| INITIAL TIME | 2010 | Year | The initial time for the simulation |