Adoption of Mobile Pedigree as an Anticounterfeiting Technology for Pharmaceuticals in Developing Countries

Completed Research

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Abstract

One major challenge facing the pharmaceutical industry is counterfeiting, which is more prevalent in developing countries. Combating counterfeiting requires various technological approaches, and the most hailed technologies, including RFID-based ePedigrees, are too expensive for developing economies. However, mobile pedigree, which utilizes mobile phones and SMS communication, is a highly affordable, readily available, and user-friendly alternative technological approach. This research seeks to explore factors that influence the adoption of the mobile pedigree in the pharmaceutical industry in developing countries and offers a case study of four companies in Ghana using the Technology-Organization-Environmental (TOE) framework. The findings establish influencing factors as relative advantage, complexity, and compatibility; strategic direction and management support; pressures from partners, competitors, associations, and regulator; and legal framework and counterfeiting threat. These factors provide guidelines for research, practice, and policy, while the study could be extended to include consumer views, other industry types and developing countries.

Keywords

Adoption, mobile pedigree, anticounterfeiting, pharmaceuticals, counterfeit, developing countries.

Introduction

The Pharmaceutical industry is an essential part of the healthcare delivery system of every economy; consequently, challenges within the industry have a direct negative impact on healthcare outcomes (Aigbogun et al. 2014). Meanwhile the Pharmaceutical supply chain is very complex having unique characteristics and subject to varying regulations, which makes its management and control quite difficult and open to a lot of challenges (Yousefi and Alibabaei 2015). Counterfeiting is one of the major challenges in the pharmaceutical industry, and it is a growing trend in developing countries because it is lucrative and difficult to control (Kraiselburd and Yadav 2012; Tremblay 2013). According to Wyld (2008), estimations indicate that 7% of the global pharmaceutical market is counterfeit, while 50% of the counterfeiting occurs in developing countries in Africa and Asia. As a developing African country, Ghana is no exception to this struggle with counterfeiting, and there are reports of counterfeited and substandard antimalarial medications in retail pharmaceutical outlets in Ghana (El-Duah and Ofori-Kwakye 2012). Moreover, a more recent study confirms the presence of counterfeit and/or substandard antimalarial medications in Ghana (Aminu and Gwarzo 2017). Substandard medicines are medicines that have failed to pass set quality measurements and standards (El-Duah and Ofori-Kwakye 2012). This could be the result of poor storage and adverse conditions or could be intentional on the part of manufacturers attempting to reduce costs. Counterfeit (falsified) medicines, on the other hand, are deliberately and fraudulently produced by

companies to mimic genuine products (Sammons and Choonara 2017). Counterfeit and/or substandard medicine is a widespread problem in developing, low-income, and lower middle-income countries (Sammons and Choonara 2017). Developing countries are low- and middle-income countries or economies with low gross national per-capita income (Nielsen 2011).

According to Yousefi and Alibabaei (2015), the challenges of the pharmaceutical supply chain can be managed and controlled effectively with the use of information technologies. Moreover, the highly recommended approaches for alleviating the menace of pharmaceutical counterfeiting are through the use of technology, and there are a variety of technologies available, including product authentication technologies and 'track and trace' technologies or combinations of the two (Bansal et al. 2012). One technological approach that is hailed in alleviating counterfeiting is the use of Radio-Frequency-Identification (RFID) track-and-trace systems, also known as ePedigrees (Wyld 2008). However, RFID systems are too expensive and complicated for developing countries (Gogo and Garmire 2009). Another emerging technological approach that is gaining attention in the pharmaceutical industry for anticounterfeiting and product authentication is the use of mobile phones (Gogo and Garmire 2009; Soumya et al. 2012). Mobile phones have varied network options, are readily available, highly affordable, user friendly, and can transmit and receive information instantly and wirelessly via SMS. Mobile phone and/or smartphone usage has increased tremendously in the developing world (Poushter 2016), and its application for anticounterfeiting of pharmaceuticals would be especially useful in developing countries that do not have the capacity to implement sophisticated (RFID) Traceability Systems.

The use of mobile phones for product authentication and anticounterfeiting is described as mobile pedigree in this study. Mobile pedigree is a prospective technology for anticounterfeiting efforts in developing countries, and it can be used alongside other anticounterfeit technologies and approaches to yield more robust systems (Bansal et al. 2012). Despite the potential of mobile pedigree for anticounterfeiting, there are currently only three options available worldwide: mPedigree, PharmaSecure, and Sproxil (Ebenezer 2012). Though mPedigree was developed in Ghana (mPedigree 2019), its use as an anticounterfeit technology for pharmaceuticals is not widespread in Ghana. It is somewhat popular in Nigeria, Kenya, and India, where few studies on the mobile pedigree and pharmaceutical anticounterfeiting have been completed (Ebenezer 2012; Justine and Ilomuanya 2016). This necessitates a study on mobile pedigree adoption and non-adoption in Ghana's pharmaceutical industry. Existing studies on the adoption or use of traceability and anticounterfeit technologies are dominated by studies on RFID technologies (Aminu and Gwarzo 2017; Basole and Nowark 2016; Irani et al. 2010; Kang and Lee 2013; Pan et al. 2013). Meanwhile, most studies on traceability systems are related to logistics and the retail industry rather than the pharmaceutical industry (Bansal et al. 2012; Basole and Nowark 2016; Mattevi and Jones 2016). Furthermore, most studies on the adoption and use of traceability systems have been conducted in advanced countries while only a few have been completed in developing countries (Basole and Nowark 2016; Ebenezer 2012). Finally, despite mPedigree's origination in Ghana, there is no specific study on the mobile pedigree for pharmaceuticals in Ghana. It is, therefore, imperative to study the adoption of the mobile pedigree in the pharmaceutical industry of Ghana, a developing country.

This study seeks to examine the adoption of the mobile pedigree as an anticounterfeit and product authentication technology for the pharmaceutical industry in Ghana. The study will explore the mechanisms that enable or inhibit the adoption and use of the mobile pedigree. To address this purpose the following questions will be considered:

- What technological factors influence the adoption of the mobile pedigree?
- What organizational factors influence the adoption of the mobile pedigree?
- What environmental factors influence the adoption of the mobile pedigree?

In the pharmaceutical industry, the adoption and utilization of anticounterfeit and traceability systems usually occurs at the initial stages of the supply chain with manufacturers and importers, so this study is limited to pharmaceutical manufacturers and importers in Ghana. The study uses the Technology-Organization-Environment (TOE) model as the research framework, and it is organized into six sections: introduction; review of mobile pedigree technologies; research framework; research setting, cases, methods, and analysis; findings; and conclusions and recommendation for future research.

The Mobile Pedigree System

Mobile pedigree utilizes mobile telephones and short message service (SMS) to send product-specific serial codes to a centralized system where they can be matched to confirm product authenticity and provide instant feedback to the sender (Justine and Ilomuanya 2016). The serial codes, concealed under a scratch panel and attached to the product package, are verified only once by the end user or consumer. Current mobile pedigrees include mPedigree, PharmaSecure, and Sproxil.

mPedigree was developed in Ghana in 2007, and it is now being used in other developing countries such as Nigeria, Kenya, and India for product authentication and counterfeit detection of pharmaceuticals and other products such as textiles (Qiang et al. 2011; ur Rehman 2011). Its labels or scratch panels are referred to as "goldkeys" (Goldkeys 2018; mPedigree 2019). For pharmaceutical mobile pedigree authentication, branded medicines from manufacturers and importers are approved and registered in a central database. Pharmaceuticals are then verified or authenticated by submitting the code via SMS, and confirmation is sent to the requester's phone almost immediately (Goldkeys 2018; mPedigree 2019). mPedigree has high potential for monitoring counterfeiting, especially for pharmaceuticals; however, it does not offer the complete track-and-trace functionality that can be achieved with RFID traceability (Afarikumah 2014; Oyetunde and Ilozumba 2013). The main competitive advantage is the mobile pedigree's viability in developing economies where mobile phones are widely used and sophisticated technologies are scarce. The major challenge with the mobile pedigree, mPedigree specifically, is that it is the ultimate consumer who must verify the product; the fake product can change hands through the supply chain without detection. Also, multiple messaging of same serial code is possible but can be monitored by restricting multiple verifications of the same code or following up with consumers to trace the source of a fake product. Another setback for the mobile pedigree is its dependence on the GSM platform, which is not positioned to adapt alongside future data-driven technological developments.

PharmaSecure, based in USA and India, was also founded in 2007, but it is restricted solely to pharmaceutical products. Like mPedigree, it relies on consumer-based verification. With a presence in over 40 countries, it also offers a premier service to the pharmaceutical companies by giving them valuable information about consumer behavior and trends (PharmaSecure 2018). Sproxil was also founded in the USA in 2009 but operates mainly in developing countries in Africa and Asia. Its principle of operation is the same as mPedigree and PharmaSecure; however, in addition to mobile SMS verification, it also allows online verification (Sproxil 2019).

Research Framework and Model

The conceptual model for this study is based on the TOE model, an organizational-level theory that explains the three different elements of a firm's context and how they influence decisions in innovation and technology adoption (Baker 2011; Oliveira and Martins 2011; Tornatzky and Fleischer, 1990).

Tornatzky and Klein (1982) indicate that relative advantage, compatibility, and complexity are the main factors that affect the adoption of technology, and these factors, in addition to cost of technology as emphasized by Zhu et al. (2006), are considered in this study. Relative advantage reflects the extent to which the mobile pedigree is perceived to be beneficial to the organization. Compatibility, however, assesses the extent to which the mobile pedigree is consistent with and fits the pharmaceutical product and supply chain processes and activities. Complexity is the degree to which the mobile pedigree is perceived to be comparatively difficult to understand and use by the pharmaceutical industry. Finally, cost evaluates the extent to which the mobile pedigree places an additional financial burden on the pharmaceutical industry.

The organizational factors considered in this study are firm size, management support, and technology competence. Firm size assesses the company's capacity to utilize a mobile pedigree, as bigger firms are more prone to adopt innovative technologies (Zona et al. 2012; Zhu et al. 2006). Management support, is the extent to which management provides the resources and strategic direction necessary for the implementation of the mobile pedigree (Jeyaraj et al. 2006). Technological competence indicates the level of information technology sophistication and expertise within the pharmaceutical company; a firm is more likely to use information systems (IS) if it has higher technological sophistication and expertise (Bendoly et al. 2007).

The environmental context refers to the external context within which the organization thrives in terms of the industry, competition, regulation, social and economic conditions (Depietro et al. 1990). DiMaggio and Powell (1983) suggest that the institutional environment offers rule-like social norms and expectations that influence organizational practices, operations, structures, and behaviors. Such pressures affect the innovation intentions of organizations and are categorized into normative pressure, coercive pressure, and mimetic pressure (DiMaggio and Powell 1983). Furthermore, the availability of consultants or technology suppliers and service providers also influence technology adoption (Rees et al. 1984). For this study, we consider the influence of partners, competitors, associations, the regulator, and technology providers.

The variables for this study are expressed in the TOE model in Figure 1.

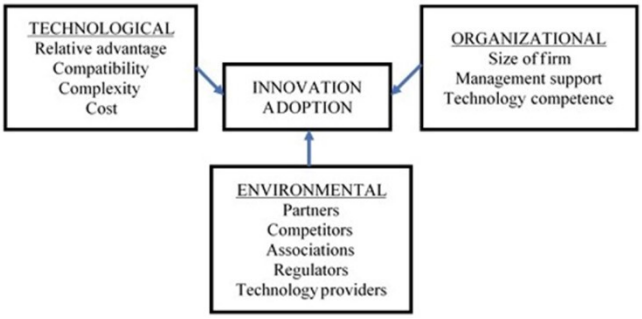

Figure 1. Technology-Organization-Environmental Model (Tornatzky and Fleischer 1990)

Methodology

Research Settings and Cases selection

Using an exploratory approach, we used qualitative methodology to conduct a multiple case study from a critical realist perspective (Creswell 2013). We implemented methodological triangulation, and the initial questionnaire was followed by an interview to increase confidence in the interpretation. Mixed method approaches involving interviews, survey techniques and sometimes focus group discussions are commonly used and recommended for social research that involve technologies (Snelson 2016)

The study involved four (4) purposely selected pharmaceutical companies in Ghana: two adopters and two non-adopters of the mobile pedigree system. By targeting both adopters and non-adopters, this study obtained a broader perspective of the factors contributing to the adoption or non-adoption of the mobile pedigree. Information obtained from the developer and implementer of the mobile Pedigree system (mPedigree), the Pharmaceutical Importers and Wholesalers Association of Ghana and the Pharmaceutical Manufacturers Association of Ghana, indicated that all the pharmaceutical manufacturers and importers in the country had knowledge of the mobile pedigree system as it was introduced to them at various fora and meetings. There were 30 manufacturing companies and 250 importing companies, of which 45 of the importing companies import their own brands of pharmaceuticals. The manufacturers and importers of their own brands (75 companies in all) were encouraged by the developer and implementer of the mobile pedigree to try the system for free before full adoption, but only 8 (10.7%) of the companies agreed and tried. Of the 30 manufacturers, only 3 (10%) tried the system while only 1 (3.3%) fully adopted and used the system. Whereas, of the 45 importers of their own brands, only 5 (11%) tried the system while only 1 (2.2%) fully adopted and used the system. Therefore, with respect to those that tried the system, out of the 8 companies, 2 (25%) fully adopted and used the system while 6 (75%) did not adopt. All the 2 companies that fully adopted (100%) and 2 of the 6 that did not adopt (33%) were involved in the study. Using all the adopting companies and one-third of the non-adopting companies out of the 8 companies that tried the system confirms that the sample size used for the study is good and representative for qualitative explorative study (Marshal 1996). The selected adopters were MM Ltd. (a manufacturer) and PP Ltd. (an importer of own brand), and the selected non-adopters were ADM Ltd. (a manufacturer) and KAI Ltd. (a manufacturer and importer of own brand). The names of the companies were abbreviated to obscure their identity. The importers of their own brands of pharmaceuticals were targeted because importing one's own brand was considered equivalent to outsourcing the manufacturing and also such companies are responsible for protecting consumers against counterfeiting of the products. Other organizations involved

in the study were the Food and Drugs Authority (FDA)—the regulator of the pharmaceutical industry in Ghana—and the two main associations to which the companies belong: The Pharmaceutical Importers and Wholesalers Association of Ghana (PIWAG) and the Pharmaceutical Manufacturers Association of Ghana (PMAG). The developer and implementer of the mobile pedigree technology, mPedigree Ltd., was also involved. The developer of the mPedigree system remains involved in the operation of the mobile pedigree system after implementation, as they handle the production and sale of the scratch panels and manage the backend server for authentication.

Research Methods and Analysis

The research method involved questionnaires and interviews based on the research questions and framework. The questionnaire was first administered to managers of the pharmaceutical companies; after receiving the managers' responses, interviews were conducted. The managers of the companies were targeted because the adoption decision was a strategic decision that necessarily involved management. Therefore, these individuals were in the best position to express the stance of the organization with respect to the adoption of a new technology. Officials of the FDA, the PIWAG, and the PMAG were interviewed to explore their views on the mobile pedigree and its adoption by the pharmaceutical industry. Finally, the mobile pedigree developers were interviewed to gather their experiences and observations in factors influencing the adoption of the system.

The interviews for the case studies were recorded and transcribed. Notes were also taken during the interviews and were compared with the questionnaire responses and the recordings to obtain a clearer understanding and implication of the responses. The data was categorized according to its relevance to the different respondents and to the research questions. Draft reports were reviewed with the interviewees to resolve any discrepancies. The approach for data analysis for this research involved the following: referencing research questions, condensing data, identifying entities, describing interacting events, identifying possible causal mechanisms, matching patterns, building explanations, cross-case synthesizing, and drawing conclusion. These approaches were chosen based on a combination of techniques drawn from the works of Easton (2010), Miles et al. (2013), and Yin (2014) and were expected to result in reasonable evidence of factors influencing the adoption of the mobile pedigree.

Findings and Discussions

Findings

In exploring the technological factors that influence the adoption of the mobile pedigree, the companies emphasized innovativeness, ease of use, availability and affordability of mobile phones, and familiarity with and popularity of serialized scratch labels and SMS as factors that enhanced the adoption of the system. The adopting companies emphasized the advantages and benefits of the technology including an increase in sales, consumer confidence in the brand, feedback from consumers about product usage and, above all, a database of consumers for possible marketing, promotional and educational campaigns. With respect to challenges of the mobile pedigree technology, the adopting companies did not have any serious complaints. The adopting manufacturer noted that adding labels requires additional time; the adopting importer, on the other hand, did not experience this increase in time, since the foreign manufacturer handled the addition of the labels at no additional cost. Each label costs between 0.05 and 1.00 cent (USD 0.005 to USD 0.01) based on quantity volumes. For the adopters, the cost of the labels themselves was insignificant in the cost of the product when high volumes were involved and did not significantly impact the price of products. The non-adopters, however, expressed potential challenges in the addition of labels, noting implications for additional production activity and cost. The adopters affirmed that the scratch panel did not have any negative effect on product package presentation and did not show signs of wear with regular handling. The developer also indicated that significant time and effort was put into research and development to ensure the continuous improvement of the labels. The developer further demonstrated the tamper-proof nature of the sticker labels and the ease of scratching to reveal the serials without defacing the product and indicated that there is an option to have the scratch panels integrated in the main product label. The adopting companies also confirmed the scratch panel labels were compatible and complementary with other anticounterfeit and authentication features like holograms and barcodes. The developer mentioned that they are currently working on challenges in the congestion of the mobile network that can sometimes cause

a delay in authentication feedback via SMS; negotiations are ongoing with telecommunication companies to provide priority switching for their short code channels in the network to avoid these delays. The developer admitted a further challenge is that not all parts of the country have mobile network service, hence authentication cannot be achieved from certain areas. However, while they do not have control over network service, they emphasized that if demand increased, they would consider the option of using satellite communication for the system.

For organizational factors, the adopting companies considered the adoption of the mobile pedigree as a strategic decision and direction backed by the full support and involvement of management. The adopting companies were smaller than the non-adopting companies, with less than 20 employees and no more than 3 distributing outlets; whereas the non-adopting companies had more than 100 employees and over 10 distributing outlets. Though they had been given access to a portal for their own reporting and analytics, the adopting companies did not have full time IT personnel and depended on the developer and implementer of the system for reporting and analytics. The adopting companies indicated that the developer providing support services encouraged them to continue using the mobile pedigree technology. On the other hand, the non-adopting companies had full-time IT professional staff. Interestingly the adopting companies do not use any manufacturing or enterprise resource planning systems in their operations and management, and they do not have elaborate computer systems and network. The non-adopting companies, however, use elaborate Enterprise systems to handle their operations and management. The level staff and management computer literacy was average for all the companies. PP Ltd. emphasized that the mobile pedigree technology provides a competitive advantage for its product, which is why management fully supports its use; MM Ltd. expressed similar sentiments. Managers of both adopting companies ensure the successful operation of the mPedigree system by monitoring the purchase of the scratch panels and matching ordered quantities with production quantities.

To assess environmental factors that influenced the adoption of the mobile pedigree we researched the influence of partners, competitors, associations, and the regulator. From the adopting companies' perspective, trade partners (suppliers and customers), competitors, associations, and the regulator did not influence the adoption decision in any way. They also did not have knowledge of any competitors or pharmaceutical companies using the product before their adoption decision. They confirmed that their adoption decision was purely an independent, strategic decision. However, when asked if they would have been influenced if their competitors were using the technology, they responded affirmatively. They also indicated they would have complied if their partners, associations, or the regulator had impressed on them to adopt. The non-adopting companies expressed similar sentiments. When reminded that other companies were already using the system, the non-adopters remarked that those companies were not their competitors and that their own products were not threatened by counterfeiting. Though the adopting companies were satisfied with the mobile pedigree, each was only using it for the protection of a single product. The managing director of PP Ltd. explained this discrepancy as follows:

"We are using the mPedigree to protect that single product because it is our flagship product and since its competing product was faked, we needed to act proactively, even though our own product had not yet been faked. The mPedigree was therefore introduced to forestall any possible faking in the future".

The manager of MM Ltd., on the other hand, indicated the following:

"We suspected that our most popular product was being faked, when we received complaints of poor outcomes from consumers and also sampled some faked ones from the market. We therefore had to opt for the mobile pedigree, for that single product, to prevent further counterfeiting and increase public confidence".

Both adopting companies, however, were not concerned about protecting their other products because they did not foresee a counterfeiting threat to those products.

Interviewing the associations also revealed that they do not promote, encourage, or require the use of anticounterfeit systems or technologies among their members. However, the regulator indicated that, though they do not require pharmaceutical companies to use anticounterfeit technologies, they sometimes encourage and recommend it to companies. According to the regulator, currently there are no legal requirements for the use of anticounterfeit technologies like the mobile pedigree by pharmaceutical companies. While the regulator, associations and the developer all agreed that such legal framework for the use of anticounterfeiting technologies would help in both preventing and detecting counterfeiting the

adopters and non-adopters also confirmed their compliance if such laws existed. The regulator and associations further believed that the mobile pedigree is basically an authentication and brand protection technology and since the responsibility of protecting brands lies with the companies themselves, they did not see the need to enforce its use. However, the developer envisioned enforcement because they have had similar experiences in other countries and jurisdictions. According to the adopters the support and involvement of the developer greatly encouraged their adoption and use of the mobile pedigree.

Discussion

The research model anticipated technological factors such as relative advantage and good compatibility would enhance the adoption of the system while higher technological complexity and cost burden would inhibit adoption (Baker 2011; Tornatzky and Fleischer 1990; Zhu et al. 2006). These effects were confirmed in the study, since the relative advantage (expressed as perceived benefits), lower complexity (expressed in ease of use), high compatibility, and lower cost enhanced the adoption of the system. Due to low income levels, lower cost is a significant factor for developing countries (Nielsen 2011). Mobile phones are common devices that are very easy to use, and the scratch-label panels with a serial for SMS verification are similar to the scratch voucher panels used by the telecommunication companies and method for loading credits to mobile phones. Therefore, consumers are already familiar with the technological side of mobile pedigree. The adopters did not express any serious challenges and confirmed the system's ease of use. This ease of use is reflected in less complexity, which is expected to enhance adoption (Jie et al. 2013). The non-adopter's expression of potential challenges with the technology are, therefore, a mere perception that does not reflect reality. The developers have ensured through extensive research and development that the mobile pedigree technology does not have many problems. The developer noted challenges as network congestion and lack of network service, yet these challenges do not directly affect the adopting companies, but rather the consumers who request verification. The relative advantage included consumer confidence in the product, an increase in sales, consumer feedback, and the opportunity for promotional campaigns. Compatibility was also expressed by the adopters in the form of the scratch panels not having any negative effect on the product or its packaging. To the adopters, the cost of the pedigree per product was negligible compared to the price of the product itself, which encouraged adoption.

The findings also show that organizational factors that influenced adoption of the mobile pedigree were mainly management's strategic direction, involvement and support. According to the research model, higher technological competence and the size of the firm were also expected to enhance adoption (Depietro et al. 1990; Zona et al. 2012; Zhu et al. 2006). However, the study showed that the adopting companies were smaller in size and had lower technological competency compared to the non-adopting companies. The organization's capacity to handle technology (Jeyaraj et al. 2006) did not affect the adoption of the mobile pedigree technology, likely because the technology is quite simple and easy to use. Bendoly et al. (2007) assert that a firm is very likely to use IS systems to achieve strategic objectives if the firm is more technologically sophisticated and has higher expertise. However, irrespective of the lack of expertise and technological sophistication, strategic objectives were being achieved with the adoption of the technology Damanpour (1992), also affirm that technology or innovation type does not affect the positive correlation of firm size and innovation adoption. However, this observation does not hold true for this study, as the smaller firms rather adopted the technology. Technological sophistication, expertise and size of organisations influencing adoption of technology therefore does not hold if the technology is very simple and easy to use.

The research model predicted environmental factors that influenced the adoption would include partners, competitors, associations, and the regulator. Though the current decision by the adopting companies was not based on any influence from any of the stakeholders, they admit they would have been influenced if such pressure existed. The non-adopters also indicated they could be influenced by external pressure, which confirms the theoretical framework (DiMaggio and Powell 1983). The non-adopters' argument that the current adopters were not their competitors suggests that the non-adopters would adopt if any of their competitors opted to use the technology. This shows that competition is a key factor that influences the adoption of technology (Jie et al. 2013). The admission by both adopters and non-adopters that they would have complied if there were laws to use anticounterfeit technologies, suggest that legal framework or regulation is important for enforcing the adoption of technology Therefore, influence by partners, competitors, associations, regulators and legal framework are important environmental factors in the adoption of the mobile pedigree technology in the pharmaceutical industry which confirm the research

model and theoretical framework (Rees et al. 1984). However, in absence of these factors, adoption still occurred, and the adopters' main drive for adoption were their own strategic direction. Interestingly, each of the two adopting companies were using the mobile pedigree technology for one product only out of several products. This confirms that the technology was only being used for products that have the potential of being counterfeited, implying that the companies had to be proactive to forestall counterfeiting of their product. Meanwhile, the non-adopting companies who had the opportunity to try the mobile pedigree did not adopt and use because they were not concerned with an imminent threat of counterfeiting. Same reason could be assigned for the stance taken by majority of the manufacturers and importers of their own brands, not to go for the trial offered by the developer and implementer. This suggests that another main factor in the adoption of the mobile pedigree is a perceived threat of counterfeiting. Furthermore, the support and involvement of technology developers and implementers also enhanced the adoption.

The factors influencing adoption based on the findings of the study slightly differed from those determined from the theoretical framework of the TOE research model. These factors and differences are represented in the modified TOE model framework in Figure 2.

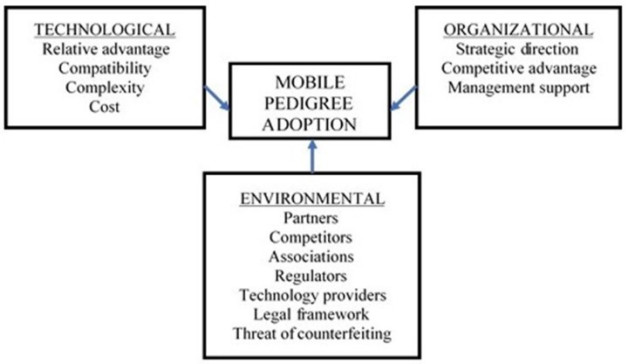

Figure 2. The Modified Technology-Organization-Environmental Model. Mobile Pedigree Adoption Model (Author's Own)

Conclusions and Recommendations

This research sought to explore the factors (technological, organizational, and environmental) that influence the adoption of the mobile pedigree in the pharmaceutical industry of developing countries through a case study in Ghana. The technological factors included relative advantage (perceived benefits), compatibility (convenience), and complexity (ease of use). The organizational factors were comprised of strategic direction, competitive advantage, and management support. The environmental factors included pressures from partners, competitors, associations, and the regulator as well as a legal framework, the threat of counterfeiting, and the presence of technology support.

By identifying the factors that influence the adoption of the mobile pedigree, this study contribute to research while providing guidelines and constructs for studying the adoption of simple technologies such as mobile pedigrees for industries in developing countries. The study also contributes towards practice by providing guidelines for organizations considering the mobile pedigree as an anticounterfeit technology, as it provides insight into its benefits, ease of use, competitive advantage, and strategic direction for pharmaceutical companies. The study further contributes to policy as it clearly shows that associations and regulators of the pharmaceutical industry can influence the adoption of a mobile pedigree through a legal framework and set regulations for anticounterfeiting. In addition, if the mobile pedigree itself is introduced and enforced by the regulator, it will go a long way in minimizing the menace of counterfeiting in the pharmaceutical supply chain of developing countries.

As this is the first study on the mobile pedigree in Ghana, it is particularly important; however, it is invariably prone to some limitations. First, it covered only four pharmaceutical companies in Ghana, with only two adopters and users of the mPedigree system. Future research may consider quantitative study covering a larger number of pharmaceutical companies and developing countries to ascertain the veracity of the factors as variables that influence the adoption of the system. Future study may also consider the adoption or assimilation of the mobile pedigree across a broad range of developing countries and for other

industries and products such as foods, beverages, cosmetics and fabrics. Other future research may also consider the assessment of the views of users and consumers of the pharmaceutical products utilizing the mobile pedigree.

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