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COVID-19 and Mobile Payment Diffusion: Lessons for Future Mass Diffusion and Continual Usage

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Abstract

Covid-19 transformed mobile payment services (MPS) diffusion pattern globally. Consequently, the need to examine factors contributing to the diffusion rate of MPS in this era is substantiated. Thus, this study employs Structural Equation Model (SEM) with social media administered survey data to estimate the nexus between MPS diffusion and technological factors, non-technological factors, and environmental factors. Results suggest that although MPS diffusion increased globally, mobile payment services have the highest diffusion rate. This is because of convenience, availability, and cost. Further, technological, non-technological, and environmental factors all contribute positively to the high rate of diffusion. Environmental factors like an escalation in the Covid-19 cases, recommendations from the center for disease control positively mediates the relationship between MPS diffusion and non-technological factors. Thus, to encourage mass diffusion and continual usage of MPS during and after the pandemic, cost of usage, convenience, accessibility, and mobile-based applications should be bundled for optimized user experience.

Keywords: FinTech; Mobile Payment; Diffusion; Covid-19; Structural Equation Model.

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1 Introduction

The inability of traditional financial institutions to fully provide financial accessibility birthed Financial Technology (FinTech) services (Chen et al., 2017; Jagtiani & Lemieux, 2018). FinTech is the provision of financial products and services at an accessible, convenient, and affordable cost (Anagnostopoulos, 2018; Gai et al., 2018). Empirically, FinTech closes the financial inclusion gap, reduces poverty, and promotes economic growth (Kim, 2020; Lashitew et al., 2019). Despite these, mobile payment services (MPS) diffusion uptake globally over the past decade failed to reach the expected potential (Jagtiani & Lemieux, 2018; Yermack, 2018). This is because of both technological and non-technological factors (BenYishay et al., 2020; Honoré, 2019; Palos-Sanchez et al., 2021). Nonetheless, the mobile payment offering of FinTech is the highest in diffusion due to the ease and convenience of usage (Coffie, et al., 2020; Yermack, 2018). Per Statistica Digital

Market Outlook, the global mobile payment segment grew by 0.3% and 0.8% between 2018-2019. However, given the onset of Covid-19, growth has increased by 1.2% and 2% between 2020 and the first quarter of 2021[1]. This surmises the critical role of Covid-19 in the recent increase in MPS diffusion (Feder, 2020; Kudrati, 2020; Brown, 2020). Therefore, it creates a research gap requiring urgent empirical inquisition.

The optimism of individuals, businesses, and even countries in the first quarter of the year 2020 was dashed due to the unexpected emergence of Covid-19. Covid-19 is an infectious disease caused by a new virus. Although the main source of the Covid-19 remains a dilemma to the medical community, it spreads primarily through contact with infected persons who cough or sneeze. This presupposes that aside from directing inhaling droplets in the air, touching objects contaminated with the virus could also significantly spread the disease. According to Neeltje et al, (2020) the virus remains in aerosols for up to (3) three hours, (4) four hours on copper, up to (24) twenty-four hours on cardboard and up to (2) two to (3) three hours on plastic and stainless steel. Consequently, divergent policies are instituted to reduce the spread of the virus, China and South Korea sanitized fiat money to curtail the spread of the virus through exchanges. WHO recommends proper hand hygiene after handling banknotes (Kudrati, 2020), and urges nations to use digital payment as much as possible (Brown, 2020) to curtail the spread of the virus. This positions MPS ahead of the on-site services of traditional banks.

According to Crossman (2020), the onset of Covid-19 could propel the global FinTech industry to the next level. However, recent studies on Covid-19 and FinTech nexus fail to identify specific factors contributing to increased MPS diffusion globally (Feder, 2020; Kudrati, 2020; Brown, 2020). This creates a gap that could affect the future design, diffusion, and continual usage of MPS. Therefore, this study explores the contribution of technological, non-technological, and environmental factors to increased MPS diffusion globally. Using social media administered survey, we seek answers to the questions; can the increased MPS diffusion be explained by technological, non-technological, and environmental factors? and is the relationship between MPS diffusion and technological and non-technological factors explained by environmental factors? Results indicate that mobile payment tops the models of FinTech services diffused globally. Further, technological, non-technological factors, and environmental factors all contribute to the increased MPS diffusion globally. Finally, the recent environmental factors (Covid-19) mediate the positive relationship between MPS diffusion and non-technological factors. Therefore, the optimal design, mobile-based applications, and affordable pricing of MPS would promote future mass diffusion and continual usage.

This study is unique and significant to individuals, businesses, industry practitioners, and policymakers because; it reinforces the significant role of technology in combating the spread of infectious diseases, it supports the call for cashless economies, and challenges FinTech service providers on the development of cost-effective and accessible services for mass MPS diffusion and continual usage. The remainder of the paper is organized as; literature review, research methods, results and discussion, and conclusion.

2 Literature Review and Hypotheses formulation

2.1 FinTech

Financial technology (FinTech) revolutionized the design of financial products and services to deliver superior security, accessibility, and affordability (Gai, 2018). Currently, financing, investments, and payment solutions are readily accessible via mobile devices anywhere. FinTech services reach many

1. https://www.statista.com/outlook/dmo/fintech/digital-payments/worldwide

individuals and businesses than traditional financial services limited by infrastructural deficiencies (Jagtiani & Lemieux, 2018). Further, to resolve the infrastructural deficiencies (number of ATMs and the number of bank branches) to stay competitive, traditional financial institutions have resorted to several partnership arrangements with FinTech start-ups to provide superior financial accessibility (Drasch et al., 2018). These partnerships broaden the scope of FinTech service delivery to include individuals living in both urban and rural communities. In the wake of the Covid-19, popular non-pharmaceutical measures implemented to slow the spread include social distancing, self-isolations, and city lockdowns. This means that visiting financial institutions, markets, and other public places in many countries is prohibited. Again, previous studies suggest that money in the form of paper and coins could transmit bacteria and viruses (Angelakis, 2014; Adinortey, et al., 2011). This presupposes that the use of digital money transacted via the internet can to an extent reduce the spread of bacteria and viruses because physical contact is avoided. Further, the closure of many public places and the lockdown of cities indicate that trade must be conducted online and paid for digitally. **Figure 1** is the statistics and projection for mobile payment globally from 2017 to 2024.

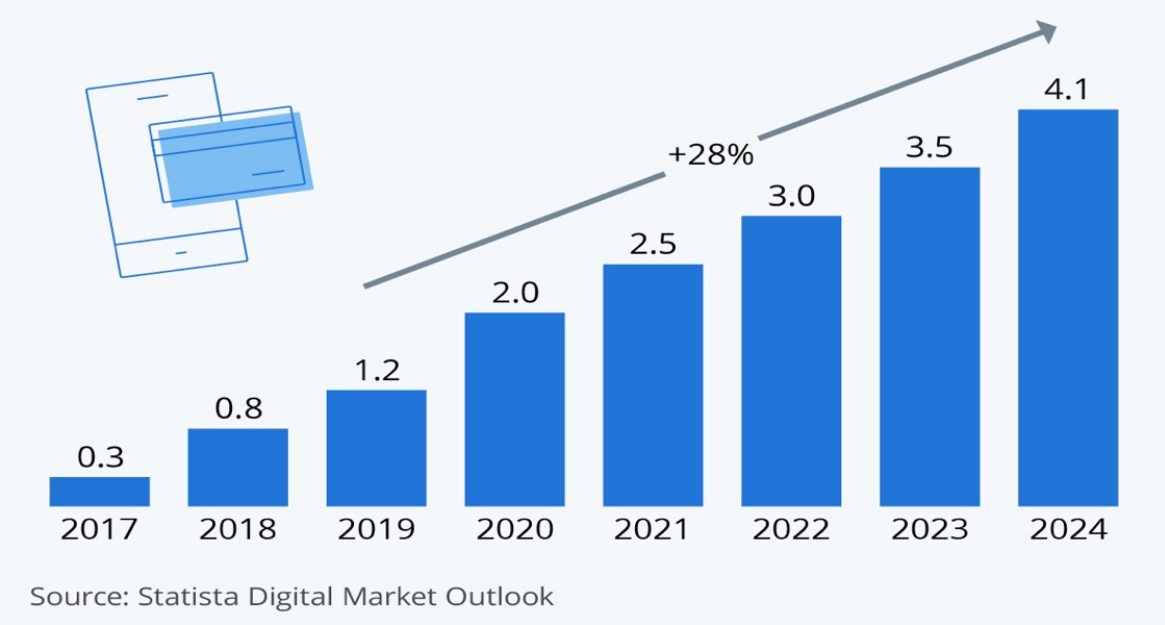

Figure 1. Mobile payment diffusion and projection (Statistica Digital Market Outlook, 2020)

2.2 Technological factors

Ligon et al. (2019) study factors contributing to low the digital payment diffusion in India and found cost of using digital payment in India is not directly related to the low diffusion. However, customers' intention to use digital payment accounts for the low diffusion. Therefore, focusing on the requirements of customers in designing digital payment services is likely to increase diffusion than simply reducing the cost. Yoo et al. (2020) study digital payment adoption and reveal that compatibility features of blockchain positively influences blockchain diffusion. However, the complexity, trialability, and observability variables of innovation diffusion theories negatively affect blockchain diffusion. Therefore, results concerning blockchain diffusion globally could resolve these challenges. Again, Daryaei et al. (2020) identify compatibility as a key determinant in diffusing blockchain in the tourism industry. Thus, given the compatibility of the proposed digital currency with existing financial technology products, digital currency diffusion could be successful. Palos-Sanchez et al. (2021) explore the approaches to digital payment diffusion and find that

privacy influences perceived utility, and that trust influences privacy and perceived ease of use, thus indirectly affecting the intention to use cryptocurrencies. Per Shahzad et al. (2018) in the study of digital payments adoption in China, perceived trustworthiness, perceived usefulness, ease of use, and intention to use are significant factors driving cryptocurrency diffusion. These outcomes confirm existing theories on innovation diffusion. Further, Almuraqab (2019) predicts the factors influencing digital currency diffusion in the UAE and finds that perceived usefulness, perceived trust, social influence, and the perceived ease of use altogether affect end-users intention to diffuse digital currency in the UAE. Zarifis et al. (2015) consider trust as a significant determining factor in the adoption of digital currency. Specifically, the type of digital currency, the platform for exchange, the mediation, and regulations are crucial factors influencing the trust of end-users. Therefore, improving the design of digital currency in these aspects would increase trust and subsequent mass diffusion. Lu et al. (2017) studies the use of digital payment in Taiwan and assert that irrespective of the potential of digital payment, security challenges continually limit diffusion, Thus, to improve diffusion, security concerns should be resolved.

Ključnikov et al. (2020) find that new technology curiosity, the level of income of prospective users, experience in the use of technology, perceived security, and expected benefits of digital currencies influences diffusion. Further, younger potential users are more likely to diffuse digital currencies than their older counterparts. Kennedyd et al (2020) identify four variables contributing to the high mobile payment diffusion in China. Although ease of use, improved infrastructure, and simplicity are significant variables, government support is paramount. Consequently, diffusion of the proposed digital currency could see mass diffusion given the right regulatory backing. Chopra and Ranjani (2020) find that the intention to use digital transactions is determined by the perceived ease of use, the cost of usage, and the influence of peers. However, the security of using the technology negatively affects diffusion if the users have trust issues concerning the transactions. Rathore et al. (2020) propose that the qualities of blockchain-like privacy, integrity, data availability and security could drive digital currency diffusion in India. Consequently, given the refined CBDC in China which promotes regulatory oversight, diffusion is likely to increase. Sun et al. (2021) employs the extended complexity theory to examine blockchain diffusion in SMEs and find that complexity, perceived risk, perceived fairness, and reward sensitivity have significant effects on the intention to use blockchain. Cong et al. (2020) find user feedback on digital currency platforms to positively drive diffusion. Further, the cost of digital currency also drives diffusion. Thus, ensuring less volatility in the proposed CBDC currency by the People's republic of China could witness mass diffusion. Saleh et al. (2020) from the Islamic perspective, behavioral intention is a key factor influencing cryptocurrency. However, the behavioral intention of users is driven by Shari'ah compliance, perceived ease of use, emotionality, perceived usefulness, and financial cost.

2.3 Non-technological factors

Valeri (2020) finds that although digital payment is perceived to be minimally understood by laypeople, the emergence of mobile payment becomes the selling point of technology. Thus, this surmises a gradual growth in the knowledge level on digital currencies which is useful for mass diffusion. Saiedi et al. (2020) study the global factors influencing digital payment diffusion and suggest that digital payment is gaining popularity because of the traditional financial system limitations. However, the potential for digital currency diffusion is superior for countries with a developed traditional financial sector. Zhu et al. (2015) assert that digital currencies have potential in China. However, legal implications should be considered in line with the regulatory framework to ensure safe diffusion. Further, mass digital currency diffusion is impossible without

the involvement of traditional financial institutions. Presthus and Malley (2017) in the evaluation of the motivations and barriers to digital payment diffusion reveal that innovation curiosity accounts for the use of digital payment for early adopters. However, late adopters are skeptical about security. Thus, the current mass non-diffusion of digital currency could be explained by the security concerns of end-users. Yao (2018) developed a framework to study central bank digital currency adoption in China and identify that the Chinese DFC ensures stability, security, regulation, and empowerment of users in the use of the digital currency. Therefore, compared with existing digital currencies, the Chinese DFC eliminates the fear of instability and security through the offer of high security for users. Sivathanu (2019) finds in the study of digital payment diffusion in India that behavioral intention to use and innovation resistance affect digital payment diffusion in India. Wu et al. (2019) propose a digital payment that supports the supervision of an auditor to reduce fear and uncertainty. This contradicts the functioning of existing digital currencies which permits anonymous transactions without the possibility of auditor mediation. Therefore, this proposed currency is capable of meeting the regulatory requirements of the Chinese Government. Lee et al. (2021) assert that the central bank digital currency is here to stay as a future currency, however, successful implementation would be influenced significantly by knowledge in technology. Consequently, individuals and countries with technology expertise have an edge concerning digital technology diffusion.

Náñez Alonso et al. (2020) suggest that the implementation of the central bank's digital currency on a global scale is far from reality because of the diverse opinions of different countries. However, the move by the Chinese government could see the potential diffusion of the currency if the backing of the population is guaranteed. Li and Huang (2021) commend the earlier effort of the People's Bank of China and investigate the prospects of digital currency. Further, they assert that the creation of digital currency by the People's Bank of China would change the financial landscape of China and this could potentially have a diverse effect on the traditional financial institutions. Shah (2017) indicates that the knowledge level of laypeople on technology is minimal. Thus, this could be a reason for the minimal digital payment diffusion. Consequently, as knowledge dissemination on digital payment expands, adoption is likely to increase over time. Arango-Arango and Suárez-Ariza (2020) present evidence that the adoption of digital payments reduces the demand for cash. Further, growth in the demand for cash is driven by economic growth and lower interest rates. Thus, the current pace of economic growth in China could propel the digital currency agenda of the government. Again, Chorzempa (2021) indicates that the early move by the People's Bank of China could become significant to the digital payment diffusion in China. The regulatory adjustment and the further development of the digital currency to meet the needs of the country are equally significant for diffusion. This is because it is perceived that the knowledge on digital currency from the layperson's view is higher in China than in other parts of the world.

Sahebi et al. (2020) purport that regulatory uncertainty, lack of knowledge, and high sustainability costs are the barriers to blockchain diffusion. So, per the regulatory certainty surrounding the proposed CBDC in China and the growth in knowledge dissemination, we expect to see mass diffusion. Werner et al. (2020) provide that organizations could become competitive if blockchain technology offers traceability and immutability of transactions. Alzahrani and Daim (2021) in the study of cryptocurrency diffusion identify economic, technical, social, and personal factors are the determining factors in cryptocurrency diffusion. Thus, cryptocurrency diffusion should not be seen from a single angle but different perspectives. Štrkolec and Hrabčák (2021) suggest issues like the correctness of records, legal status, and tax challenge digital currency diffusion. Huynh et al. (2020) found that between 2016 and 2018 the share of Canadians who were

aware of digital payment increased from 62 percent to 89 percent and those that owned Bitcoin increased from 3 percent to 5 percent. This suggests improvements in the knowledge level of people on digital currencies. Kosmarski (2020) lists key challenges and barriers to digital payment diffusion in academia as usability, security issues, legal concerns, conflict of values, and a critique of political dimensions of blockchain governance. Using text mining, Ye and Zhao (2021) disclose that majority of the public is neutral toward the proposed digital currency. Nevertheless, those with positive attitudes outnumbered those perceiving the digital currency initiative as undesirable.

2.4 Environmental Factors

While the world awaits the arrival of a vaccine, WHO and governments of countries have suggested and implemented several non-pharmaceutical measures including mass testing, quarantines, and self-isolations to effectively treat and slow the further spread of the virus. According to WHO, social distancing is the main tool to prevent the further spread of the virus. Consequently, countries across the globe have placed bans on public gatherings and activities involving a significant number of individuals. Empirical evidence suggests that the timely prohibition of public gatherings and the closure of schools, churches, and theatres had a positive effect on reducing the number of infections during the 1918 pandemic in the US (Markel et al, 2006; Hatchett et al. 2007). Again, travel bans, airport closure, and city lockdowns have been instituted to restrict the movement of individuals between cities, countries, and continents to curb the spread of the virus. According to Torres (2011), the influenza outbreak during world youth day 2008 affected pilgrims accommodated in larger halls than those in smaller groups. Although proven to be effective, the challenges presented by these measures include but are not limited to the restriction of physical trade both international and local, the accessibility to financial and other services, and possible shortage in food and water supply. Technology-enabled services provide the solution to trade, delivery, and payments. In China, cities on lockdown are sustained by digital delivery and payment systems that supply daily goods and services promptly (Chengyi, 2020). This means that individuals on lockdown can stay at home and make payments for goods and services without moving or using paper or coin money.

The declaration of Covid-19 as both pandemic and epidemic in nature resulted in the race against time to create a vaccine to halt the spread. The virus is highly contagious spreading through droplets from an infected person's cough via aerosols or contact with infected surfaces including metals, plastics, paper, and other materials (Neeltje et al, 2020). This means paper money or coins could be contaminated and aid in the spread of the virus as it changes hands. As of March 3, 2020, the fatality rate of the global Covid-19 cases stood at about 3.4% (Joseph, 2020). Consequently, scientists in different countries are working around the clock and are at various stages of vaccine development and or testing. While the development, testing, and approval of a vaccine under untested techniques is estimated to take at least between 12 to 18 months (Arnold, 2020), existing drugs identified to potentially treat the Covid-19 and non-pharmaceutical measures have been adopted globally to treat infected individuals and minimize the spread of the virus respectively. **Figure 2** is statistics of the Covid-19 cases globally from 2020 to 2021.

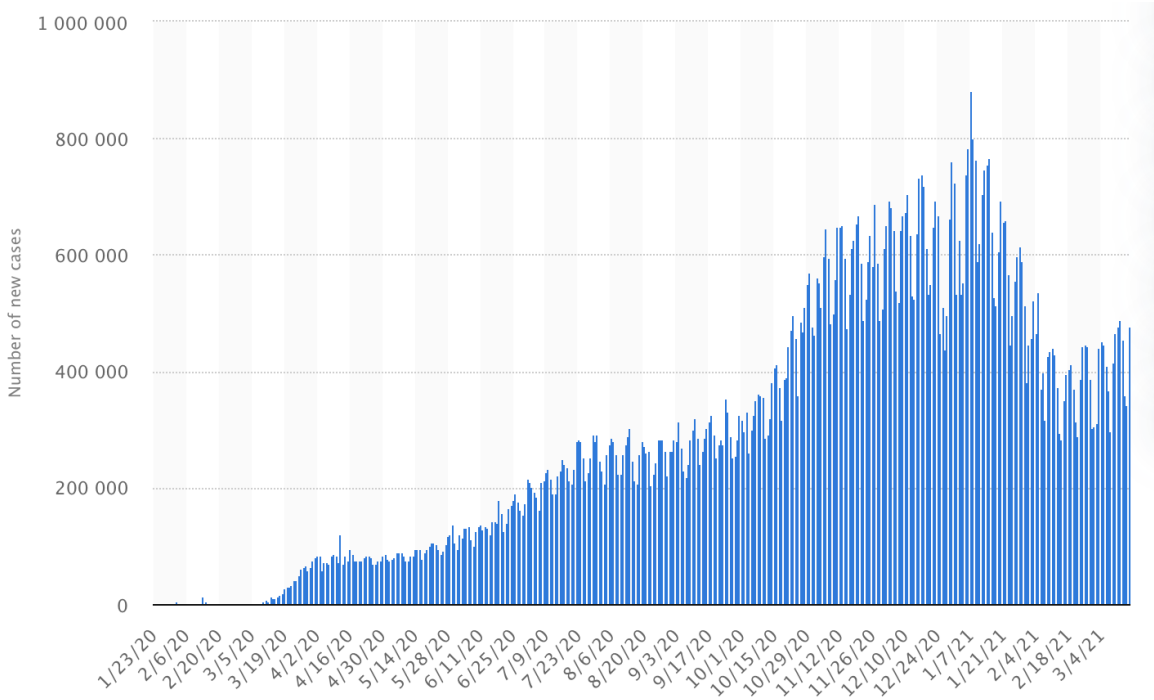

Figure 2. Covid-19 Cases 2020-2021 (Source: Statistica, 2021)

2.5 Technology diffusion theories

The study of technology or innovation diffusion at different levels is supported by different theories. Unlike technology diffusion at the firm organizational level which employs the organizational-environmental (TOE) framework (DePietro et al., 1990), technology or innovation diffusion at the individual employs the Technology Acceptance Model (TAM) which emphasizes the usefulness and perceived ease of diffusing technology (Davis, 1989), the Theory of Reasoned Actions (TRA) focuses on the user rationality in choosing to diffuse a specific technology given all possible consequences (Yousafzai et al., 2010) or the Theory of Planned Behavior (TPB) which emphasizes on the behavior of individuals given specific circumstances (Bagozzi et al., 1992). These theories together provide support for the study variables because; the technology acceptance model and the theory of reasoned actions emphasize factors like convenience, affordability, and user-friendliness which significantly affects the choice of individuals in the diffusion of any form of technology (Cong et al., 2020; Zarifis et al.,2020; Shahazad et al., 2020). Further, the theory of planned behavior also provides insight into the behavior of individuals given the existence or absence of an underlying condition. Consequently, the onset of Covid-19 and the increase in cases could also trigger the behavior of individuals towards MPS diffusion (Feder, 2020; Kudrati, 2020; Brown, 2020). Aside from these theories, the TOE provides evidence of the role of the environment in the decision to diffuse technology. Therefore, given the current environmental condition (Covid-19), there is a high likelihood that the increase in the use of mobile payment across the globe is propelled by this factor (Kudrati, 2020). Finally, the innovation diffusion theories focus mainly on the attributes of the technology or innovation in question. Therefore, using the Roger (1983) five attributes of innovation diffusion, mobile payment has a relative advantage over other forms of payment, it has minimal issues of complexity, it is compatible with several forms of transaction, it has existed for some years, and the results of using mobile money is evidence in the literature to prove it potency (Goh & Marianna, 2020). Therefore, given the current environmental conditions, individuals are likely to opt for these services ahead of card payments or physical transactions.

2.6 Hypotheses Formulation

Technology and innovation diffusion theories point to the significance of technological and non-technological factors in technology diffusion (Ključnikov et al., 2020; Ligon et al., 2019). Concerning MPS diffusion, technological factors like the cost of usage, accessibility, convenience, and ease of usage is empirically proven to affect diffusion positively (Saleh et al., 2020; Cong et al., 2020; Zarifis et al.,2020; Shahazad et al., 2020). Further, non-technological factors like knowledge level, education, and banking systems are proven to positively drive the diffusion of these services (Sahebi et al., 2020; Huynh et al., 2020). However, given the ongoing Covid-19 phenomenon, studies have identified the spike in the Covid-19 cases globally and the recommendations of the CDC to positively affect MPS diffusion (Feder 2020; Kudrati, 2020; Brown, 2020). Therefore, we theorize hypotheses H1a, H1b, and H1c to examine these relationships.

H1a: The increase in mobile payments services diffusion during Covid-19 is positively influenced by technological factors

H1b: The increase in mobile payments services diffusion during Covid-19 is positively influenced by non-technological factors

H1c: The Increase in mobile payments services diffusion during Covid-19 is positively influenced by Environmental Factors

While technological factors (cost, convenience, accessibility, and ease of use) and non-technological factors (knowledge level, banking system, and educational level) are established empirically to affect MPS diffusion (Sahebi et al., 2020; Huynh et al., 2020), we examine the role of the current environmental factors (spike in Covid-19 cases globally, and CDC recommendations) in the relationship between these factors and MPS diffusion. This is based on the recent assertion that Covid-19 and CDC recommendations increase MPS (Feder, 2020; Kudrati, 2020; Brown, 2020).

H2a: The relationship between the increase in mobile payments during Covid-19 and technological factors is positively mediated by environmental factors

H2b: The relationship between the increase in mobile payments during Covid-19 and non-technological factors is positively mediated by environmental factors

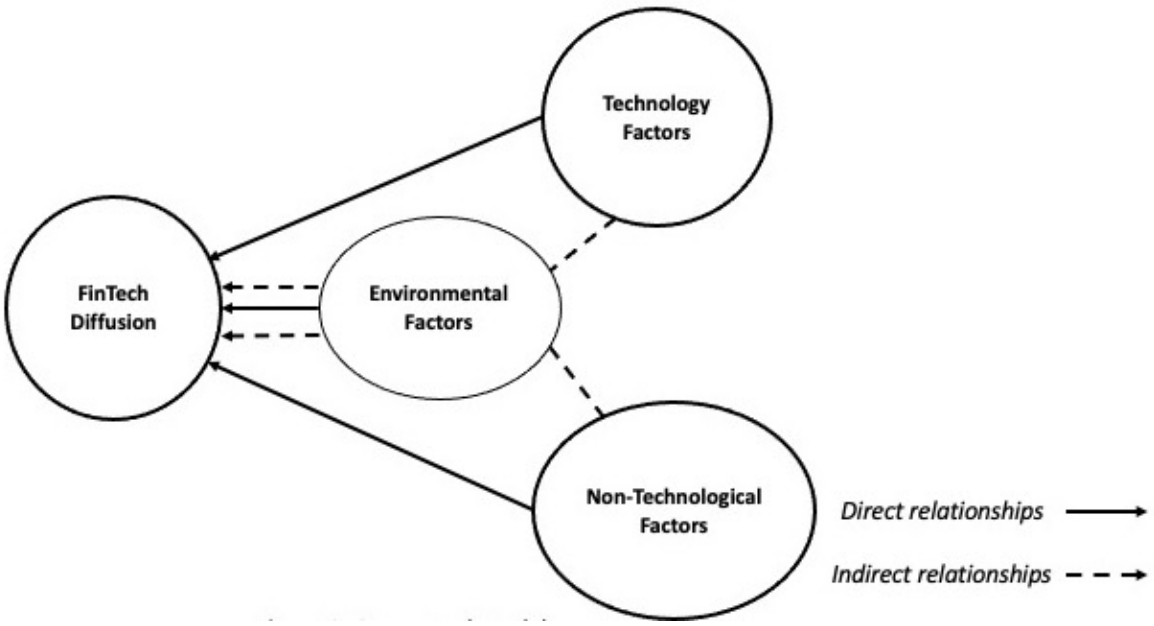

Figure 3. The Conceptual Framework

Table 1. Measurement Constructs

Constructs	Components	Items	Variable	References
FinTech Diffusion	Personal use	3	Dependent	Coffie et al.(2020); Kizza, (2013); Ligon et al. (2019)
	Business use	3		
Technology Factors	Cost	3		Saleh et al (2020); Cong et al. (2020)
	Convenience	3		Zarifis et al. (2020); Shahazad et al. (2020)
	Accessibility	3		Klju?nikov et al. (2020); Ligon et al (2019)
Non-Technological Factors	Fear of infection	3	Independent Variables	Kudrati (2020); Brown (2020)
	Participation of banks	3		Saiedi et al.(2020); Drasch et al.(2018)
	Knowledge level	3		Sahebi et al. (2020); Huynh et al. (2020)
Environmental Factors	CDC recommendations	3		Feder (2020); Kudrati (2020); Brown (2020)
	The Covid-19 cases	3		McIntosh (2020); Hall (2020)

Source: Authors Construct

3 Research Methodology

3.1 Data source and sampling procedure

The study estimates the increased MPS diffusion in the Covid 19 period, technological factors, non-technological factors, and environmental factors nexus. The study employs a quantitative approach with online social media survey data from Facebook, Instagram, and Twitter. Social media is preferred for data collection because Covid-19 MPS diffusion is a global phenomenon and social media provides the opportunity to attain data from different parts of the world. This reduces cost, increases the research scope, and saves time. Further, the study adopts the non-probability accidental sampling technique which includes participants as at when they are available and ready to respond to the survey. This method is suitable for this because it captures mostly individuals who have used FinTech services during this period and those who know the subject. Accordingly, the target population is all individuals who have used MPS during the start of the Covid-19. Therefore, due to the possibility of generating responses globally, we are unable to pre-determine the sample size of the study. To collect the data, our survey instrument consists of five (5) separate segments capturing respondents' demographic factors, MPS Diffusion (the personal and business use of mobile payments during Covid-19, the receipts, and payments using mobile payments), Technological Factors (the cost, accessibility, and convenience of using mobile payment services), Non-Technological Factors (the fear of infection, participation of banks, and knowledge level of users), and Environmental Factors (Center for Disease Control (CDC) recommendation and the total number of Covid-19 cases). See **appendix I** for the full details of the survey questionnaire. For details on the measurement constructs of the study. Further, a summary of the measurement constructs and components is presented in ***table 1***.

The data collection process had three parts; the first draft was a pre-test of the survey instrument amongst 46 Facebook users randomly to determine the suitability of the instrument.

The second stage was a follow-up test on 27 Facebook users to confirm the suitability of the improved instrument. Finally, the error-free and unambiguous questionnaire was shared via Facebook, Twitter, and Instagram. The survey was conducted between 1st March 2021, to 15th March 2021. The total response generated was 3,563. However, the data was cleaned for incomplete responses and the final responses stood at 3539. This number is attained mainly because of the duration of the data collection process and the unwillingness of individuals to participate. Nonetheless, the sample generated provides a good statistical figure for the structural equation model estimation.

3.2 Model specification

The structural equation model (SEM) is employed to estimate the nexus between the increased MPS diffusion during Covid-19, technological factors, non-technological factors, and environmental factors. Further, we estimate the mediating effect of environmental factors in the relationship between MPS diffusion, technological factors, and non-technological factors. This model is selected because it allows for the estimation of complex relationships between one or more independent variables and one or more dependent variables. This technique allows the approximation of multilevel regression models. It also helps in testing research hypotheses that contain direct and indirect observations of one or more dependent and independent variables. However, the foremost reason for employing the SEM technique in this study is to examine and validate the proposed casual model illustrated in Figure 1. Per the structural model containing four (4) variables; FD, TF, NTF, and EF, where firm FD is the response variable (Y) or the endogenous variable while TF, NTF, and EF are exogenous variables (Xs) with EF also serving as a mediating variable. Mathematically, the model is presented theoretically in a matrix form as:

$$\begin{bmatrix} y_1 \\ \dots \\ y_p \end{bmatrix} = \begin{pmatrix} 0 & \cdots & \beta_{1p} \\ \vdots & \ddots & \vdots \\ \beta_{p1} & \cdots & 0 \end{pmatrix} \begin{bmatrix} y_1 \\ \dots \\ y_p \end{bmatrix} + \begin{pmatrix} \delta_{11} & \cdots & \delta_{1q} \\ \vdots & \ddots & \vdots \\ \delta_{p1} & \cdots & \delta_{pq} \end{pmatrix} \begin{bmatrix} x_1 \\ \dots \\ x_q \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \dots \\ \varepsilon_p \end{bmatrix} \quad (1)$$

Summarily the matrix equation in Eq. (1) is reformulated as:

$$Y = BY + \Gamma X + \varepsilon \quad (2)$$

Where p represents the number of regression equations to be estimated simultaneously, p by p **B** square matrix contains the parameter coefficients of the regressors of Y variables on the other Y variables with the 0 diagonal values implying that a variable cannot cause itself. Further, the p by q Γ matrix contains coefficients of the Y's on X's whereas ε is a p by 1 vector consisting of residual terms. Per the theoretical model specified, a series of regression equations are to be estimated to assess the causal effects amid the variables employed in the study.

4 Empirical Estimation

4.1 Demographic characteristics of survey respondents

The results from the descriptive analysis revealed that most of the respondents of the survey are male with 76% compared to the female counterparts of 23.5%. This supports the active participation of the male gender in technology diffusion. Further, per the analysis, the survey respondents are mostly between the ages of 26-30 years of age at 57.3%. This is followed by those in the age bracket of 31 years or more at 27.2%. The concentration of the respondents

within the age bracket 26-30 years could suggest that FinTech products appeal mostly to the young than the old. Concerning the educational background of the survey respondents, most of the respondents had a graduate degree at 56.4%. This is followed by those with a post-graduate qualification at 31.2%. Consequently, this could mean that the level of education of individuals could affect the use of FinTech services. Finally, on the location of the respondents, the majority of the survey respondents are based in urban areas (76.4) while the remaining 23.6% are based in rural areas. This surmises that individuals in urban areas are likely to diffuse FinTech services compared to those in rural areas. See **Table 2** for the statistical details.

Table 2. Descriptive Statistics of Survey Respondents

Gender	Male	2865	76.5%
	Female	879	23.5%
Age group	18-25	584	15.5%
	26-30	2142	57.3%
	31 and above	1018	27.2%
Education	Basic	464	12.4%
	Graduate	2110	56.4%
	Post-Graduate	1170	31.2%
Location	Urban	2862	76.4%
	Rural	882	23.6%

Source: Authors Construct

4.2 Reliability and Validity Tests

To be able to estimate a robust structural equation model to examine the nexus between the MPS diffusion, technological factors, non-technological factors, and environmental factors, both reliability and validity tests are significant to determine the quality of the research instruments. Consequently, Cronbach's alpha, composite reliability, KMO and Bartlett's and, Herman's single factor tests are employed. **Table 3** depicts the results of the tests. First, we estimate the internal consistency of the research instruments with Cronbach's alpha. Following, the value conveyed for Cronbach's alpha are all above 0.7 and confirms the internal consistency of the research instrument. Further, composite reliability is employed to assess the overall scale reliability of the research instruments. The reported values above 0.8 back the reliability of the research instrument. Again, we check for the sampling adequacy of the instrument using the KMO and Bartlett's test. The result of 0.79 and a probability of 0.00 reveals the adequacy of the study sample. Lastly, the Herman single factor test is employed using the principal Axis Factoring (PAF) by loading 26 items on a single factor to investigate the issue of common method variance. The results reveal a total variance of 34.9% which is less than 50%. Consequently, common factor variance is an issue in this study. So, this provides sufficient confirmation to validate the outcome of the study.

Since the reliability of the instrument is established, the next step is to validate the instrument. Therefore, we advance to test the validity of the research instrument using the cross-loading factor and the average variance extracted (AVE). **Table 4** depicts the results of the validity test. The accepted values of the cross-loading factor must be above 0.4. Subsequently, the results illustrate that all the constructs have cross-loading values above 0.6. This substantiates that the items satisfactorily support the various constructs within the study. Further, the result of the AVE is expected to produce values above 0.5. Hence, the stated constructs show values above 0.5

Table 3. Reliability Test

Variables	Cronbach?s alpha	Composite Reliability	KMO and Bartlett?s	Herman Single Factor
FD	0.836	0.889	Value	34.9%
TF	0.780	0.830	0.79	
NTF	0.834	0.880	Probability	
EF	0.741	0.820	0.00	

Source: Authors Construct

to prove the research instrument meets both reliability and validity requirements to necessitate additional analysis. So, we continue to estimate the structural equation model.

4.3 Hypotheses Testing

The study examines the nexus between MPS diffusion in this Covid-19 period, technological factors, non-technological factors, and environmental factors using survey responses from 3744 social media users. The results of the structural equation model are illustrated in **table 5**. Per the model outcome, all the hypothesized relationships confirm positive nexuses except for hypotheses H2a which shows a negative relationship. Accordingly, the increase in MPS diffusion in the Covid era is explained by MPS technological factors. Thus, a unit improvement in the technological factors of the MPS leads to a 0.226 increase in the diffusion of FinTech at a statistically significant level of $0.000^{a.}$ Again, the increase in MPS diffusion currently is explained by non-technological factors. This is supported by a statistically significant value of 0.000^{a} to show that a unit increase in non-technological factors increases MPS diffusion by 0.324. Further, the current environmental factors prove to influence MPS diffusion in recent times. This is supported by a statistically significant level of 0.000^{a} to prove that a unit increase in the environmental factors leads to a 0.604 increase in MPS diffusion. Although technological factors, non-technological factors, and environmental factors all affect the MPS diffusion in recent times, the reported coefficient for environmental factors depicts the strongest influence. To determine if the relationship between MPS diffusion, technological and non-technological are explained by environmental factors, the results show that environmental factors negatively affect the relationship between recent MPS diffusion and technological factors. However, environmental factors positively affect the relationship between the current MPS diffusion and non-technological factors. This suggests the contribution of the Covid-19 to the recent increase in MPS diffusion. Finally, the study finds that the relationship between environmental factors and non-technological factors and technological factors show positive relationships with a coefficient of 0.575 (0.000^{a}) and 0.427 (0.000) respectively.

Note: ^{a} represents statistical significance at 0.05%

Following the testing of the study hypotheses, **Figure 4** shows the smartPLS output generated. It shows the path coefficients and the values of the adjusted R^2. Theoretically, the models show adjusted R^2 values above 0.5 to demonstrate the models explain more than 50% of the variations in the relationships projected. Accordingly, the model performs better than a zero model.

Table 4. Cross Factor Loading

Constructs	Components	FD	TF	NTF	EF
FD	FD1	.695	-.423	-.338	.075
	FD2	.807	-.301	.259	.088
	FD3	.692	-.116	.016	-.148
	FD4	.732	-.337	.232	.128
TF	ACC1	.651	.757	.104	.044
	ACC2	.692	.688	.249	-.083
	ACC3	.525	.898	.164	-.082
	CST1	.404	.695	-.192	-.258
	CST2	.559	.771	-.202	-.114
	CNV1	.472	.662	.025	.097
	CNV2	.028	.740	-.258	.070
NTF	FI1	.399	-.025	.744	-.025
	FI2	.557	.158	.797	.158
	FI3	.449	-.103	.745	-.103
	BNK1	.531	-.182	.842	-.182
	BNK2	.534	-.096	.779	-.096
	BNK3	.504	.211	.697	.211
	KNW1	.679	.082	.553	.082
	KNW2	.670	-.245	.616	-.245
	KNW3	.731	.334	.723	-.435
EF	CDC1	.767	.279	.159	.731
	CDC2	.754	-.130	.561	.762
	CDC3	.798	-.175	.312	.734
	CVC1	.513	.167	.447	.705
	CVC2	.610	-.119	.087	.710
	CVC3	.497	.040	.082	.775
Average Variance Extracted (AVE)		.567	.613	.571	.522

Table 5. Hypotheses Testing

Hypotheses	Relationships	Sign	Coefficients	P. Value	Decision
H1a	FD-TF	+	0.226	0.000a	Supported
H1b	FD-NTF	+	0.324	0.000a	Supported
H1c	FD-EF	+	0.604	0.000a	Supported
H2a	FD-EF-TF	-	-0.062	0.000a	Unsupported
H2b	FD-EF-NTF	+	0.051	0.000a	Supported
	EF-NTF	+	0.576	0.000a	Supported
	EF-TF	+	0.427	0.000a	Supported

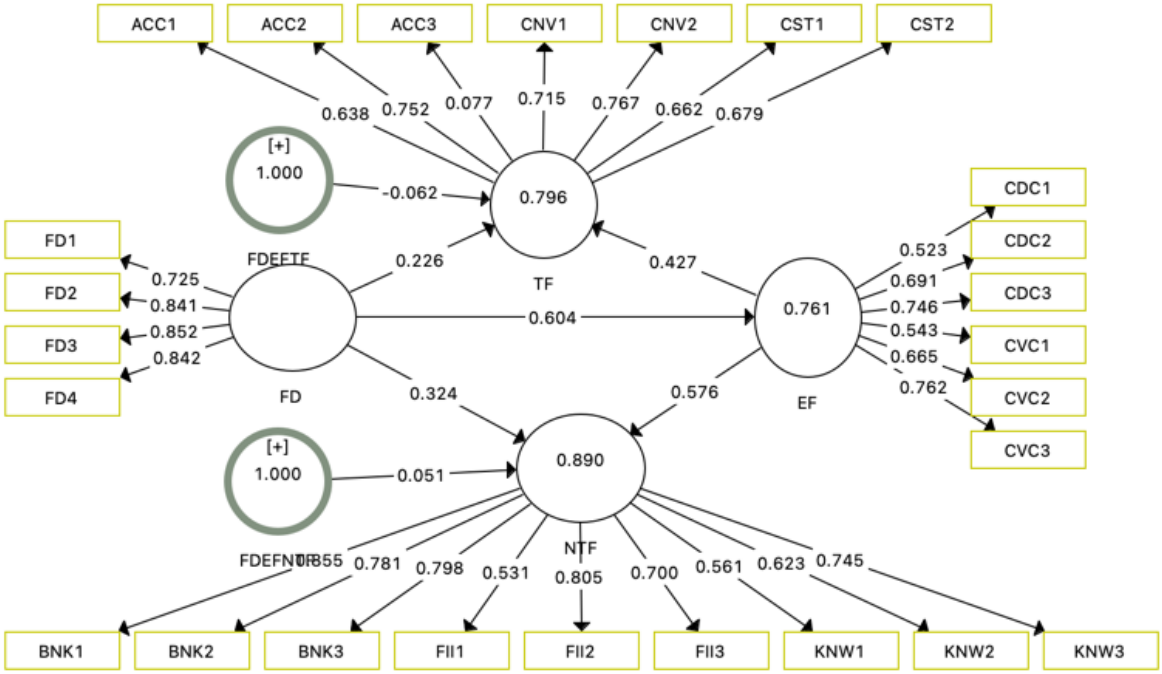

Figure 4. SmartPLS output of the model

5 Discussion and Managerial Implications

The study explores the relationships between the recent increase in MPS diffusion and technological, non-technological, and environmental factors using social media administered survey. The recent increase in MPS diffusion is contributed to by the technological factors of the MPS. This is consistent with existing literature (Ključnikov et al., 2020; Kennedyd et al., 2020; Chopra & Ranjani, 2020) to prove that the ease of use, affordability, accessibility, and convenience of technology increases diffusion. Further, this supports the TAM, TRA, and TPA theories to suggest that the specific features of innovation drive diffusion amongst individuals. Before the emergence of the Covid-19 pandemic, studies found the ease of use, affordability, and accessibility as critical factors driving the use of mobile payments (Cong et al., 2020; Zarifis et al., 2020; Shahazad et al., 2020). Thus, this provides consistency in the underlying theory. However, the current surge in diffusion could be also explained by the various measures (reduce the cost of transactions) implemented by both MPS providers and traditional banks to reduce to cost of MPS transactions during this period. Therefore, industry practitioners and policymakers should ensure that the cost of using these services is kept at an affordable minimum for future diffusion and continual usage. Further, the providers of MPS should prioritize constant improvements in the features of MPS to promote mass diffusion. Given the fact that the majority of the survey respondents were relatively younger, future designs should consider technology and aging dynamics to attract older users.

The recent increase in MPS diffusion is contributed to by non-technological factors like the participation of banks, the fear of getting infections, and the knowledge level of individuals concerning FinTech products and services. This is consistent with existing theories to show that under specific conditions, individuals' decisions to diffuse technology would increase or decrease (Sahebi et al., 2020; Huynh et al., 2020). However, given the offerings of mobile payments, industry practitioners, service providers, and policymakers should promote the use of these services beyond such conditions. Further, the literature suggests that banks and FinTech collaborations

promote MPS diffusion, therefore, the call for such collaborations is justified in this period and beyond (Coffie et al., 2020; Drasch et al., 2018). Traditional banks and MPS providers should have different levels of collaboration to improve the diffusion of these services at different levels. Again, the growth rate in the number of infections triggers fear amongst people and for that matter opt for contactless payment. This justifies the use of MPS to prevent other contagious infections (Kudrati, 2020; Brown, 2020). Further, the recent increase in MPS diffusion is contributed to by environmental factors like the spike in the number of Covid-19 cases locally and globally and the recommendations from the center for disease control (CDC) of countries. The onset of the Covid-19 significantly propelled MPS diffusion globally (Kudrati, 2020; Brown, 2020). This could become the springboard for the global mass MPS diffusion. The CDC (Kudrati, 2020) recognizes the potential of the virus to spread through the handling of banknotes and coins and thus this could also be a significant non-pharmaceutical measure to curb the spread of current and future contagious diseases. The positive relationship between the recent increase in MPS diffusion and technological features of the MPS is not mediated by the environmental factors (spikes in the Covid-19 cases and the CDC recommendations).

The positive relationship between the recent increase in MPS diffusion and non-technological factors (bank participation, the fear of infection, and the knowledge level of individuals) is positively mediated by the environmental factors (the spike in Covid-19 cases globally and CDE recommendations). This suggests that the recommendations of the CDC have generated the expected response as many endeavors to avoid contact payment to minimize the possibility of getting infected. Thus, under specific environmental conditions per the TPB and the TOE (DePietro et al., 1990; Fishbein & Ajzen, 1980; Bagozzi, 1982) individuals may choose to diffuse a specific technology. Nonetheless, the use of mobile payments should go beyond these conditions because it offers the opportunity to close the financial exclusion gap, reduce poverty, and improve economic growth (Kim, 2020; Lashitew et al., 2019). Further, this surmises that individuals have taken personal responsibility to reduce possible infection by using MPS. However, mobile payment generates the highest diffusion due to its simplicity and convenience (Yermack, 2018). Therefore, the future design of MPS should be mobile-friendly to support mass diffusion and continual usage. Finally, both the technological and non-technological factors show positive relationships with the recent environmental factors. However, the positive relationship between the environmental factors and the technological factors shows a weaker relation compared to that of the non-technological factors. This explains that the recent occurrence of Covid-19 stimulates both technological and non-technological awareness of users of MPS Therefore, this provides the avenue for MPS developers to expand their service models to satisfy the varied needs of both those in urban and rural areas.

6 Conclusion

The study examines a significant phenomenon in the circle of MPS diffusion amid the Covid-19. It estimates the contribution of technological factors, non-technological factors, and environmental factors on the increased MPS diffusion.

The increase in FinTech product and services diffusion rate globally is higher for mobile payment. The technological factors of mobile payments like the cost, convenience, accessibility, and ease of use contribute to the high diffusion rate. Particularly, the recent reduction in cost and elimination of the cost of transacting via FinTech services by services provides played a major role in the diffusion uptake. This is because although ease of use and convenience plays crucial roles in technology diffusion, the affordability element cannot be undermined. Therefore, to promote

mass diffusion and the continual usage of mobile payments beyond Covid-19, policymakers and service providers should urgently consider optimal pricing.

Non-technological factors like the participation of traditional banks, the fear of infection, and the knowledge level of individuals contribute to MPS diffusion in this Covid-19 era. This could be further explained by the fact that many customers of traditional financial institutions were afforded the optional flexibility of seamlessly accessing their funds through third-party FinTech applications. Therefore, beyond Covid-19, the collaboration between traditional financial institutions and MPS providers should be encouraged to boost mass diffusion. Further, the MPS supports the social distancing agenda of most countries in an attempt to avoid contact transactions.

The recent environmental factors (spike in Covid-19 cases globally and the recommendations of the CDC) of various countries also contribute to the recent high uptake of MPS. Although the uptake of MPS experienced steady growth in the past decade, the margin of growth between 2020-2021 indicates the real impact of Covid-19 on MPS. This is explained by the classification of contact payment as a potential channel for the spread of the virus. Previous studies have confirmed the existence of pathogens on banknotes and therefore, both countries and individuals opt for contactless payment in this period. Consequently, mobile payment can significantly reduce the spread of viruses and bacteria through the exchange of banknotes and coins.

To understand the mediating role of the environmental factors, it is established that the positive relationship between MPS diffusion and non-technological factors is mediated positively by environmental factors. This is because the recommendations of the CDC and the spike in Covid-19 cases created awareness for individuals. Further, these prompted traditional financial institutions to become flexible in the integration of their systems with MPS providers to aid seamless diffusion. Therefore, Covid-19 creates a platform that could become vital to the design and pricing of future FinTech services.

7 Limitations and Recommendations for Future Studies

While this study is timely in examining a significant phenomenon in the current diffusion trend in MPS globally, few limitations exist that could be addressed by future studies. Although these limitations do not significantly affect the current study outcome, future studies should consider time series analysis of Covid-19 cases and MPS diffusion. This would account for the deficiencies of this study concerning the effect of the passage of time on the study outcome. Again, the study employed primary data and thus future studies should consider secondary data when significantly available. The use of secondary data in the future would provide an opportunity for a standardized study across multiple countries. Further, the digital currency gained much attention in this period with a single coin topping over $ 50,000 at a point in time. Could this be Covid-19 related? Future studies should explore this nexus to understand the reasons for this price spike because currently, the same coin witnessed a sharp decline in prices after the introduction of Covid-19 vaccines globally.

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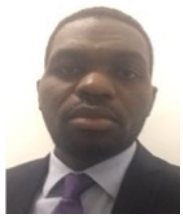

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