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Mobile money innovations and health performance in sub-Saharan Africa

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Abstract

This study assesses nexuses between mobile money innovations and health performance in terms of total life expectancy in 43 countries in Sub-Saharan Africa employing data for the period 2004-2018. Four mobile money innovation dynamics are proxied with registered mobile money agents and active mobile money agents. The empirical evidence is based on quantile regressions. The findings overwhelmingly show that mobile money innovations are relevant in improving health performance or total life expectancy exclusively in bottom quantiles of the conditional distribution of total life expectancy. In other words, countries with below-median levels of total life expectancy are more susceptible to benefit from mobile money innovations compared to countries with above-median levels of total life expectancy. It follows that common or general policy measures on the linkage between mobile money innovations and health performance are unlikely to succeed unless attendant policies are contingent on initial levels of health performance and hence, tailored differently across countries with various initial levels of health performance. More policy implications are discussed.

Keywords: Mobile phones; financial inclusion; health; sub-Saharan Africa
JEL Classification: O40; G20; I10; I32; I20

1. Introduction

The motivational elements surrounding the positioning of the present study on mobile money innovations and health performance in sub-Saharan Africa (SSA) are constructed on three main foundations in the policy and scholarly literature related to the subject, namely: (i) growing poverty levels in SSA; (ii) the importance of mobile money innovations in alleviating poverty and achieving sustainable development goals (SDGs) and (iii) gaps in the extant literature on the subject. These critical motivational highlights are substantiated in the following passages in the same chronology as highlighted[1].

First, the specificity of SSA as far as poverty is concerned is premised on contemporary policy and scholarly literature which has established that the sub-region has the world's highest number of people living in absolute poverty (Asongu & Nwachukwu, 2016; Bicaba *et al*., 2017; Tchamyou, 2020). Accordingly, this narrative is consistent with Nwani and Osuji (2020) who have established that as of 2019, using the contemporary poverty line of 1.90 USD per person on a daily basis; SSA overtook the Asian region in being/becoming the region having the most important number of inhabitants on the planet living in extreme poverty. Moreover, compared to other regions of the world, the sub-region is also characterized by one of the highest rates of income inequality (Tchamyou, 2019, 2021; Asongu *et al*., 2021a). The attendant levels of income inequality are compounded, *inter alia*, by socio-economic and political exclusion. Against this background, the present study is premised on the established evidence that mobile money innovations have been documented to reduce various forms of inequality (Ngono, 2021; Kim, 2022; Awel & Yitbarek, 2022). Moreover, nine of the ten poorest countries in the world (based on the 2020 Gross National Income per capita in current USD) are in SSA, notably: Burundi (270 USD), Somalia (310 USD), Mozambique (460 USD), Madagascar (480 USD), Sierra Leone (490USD), Afghanistan (500 USD), the Central African Republic (510 USD), Liberia (530 USD), Niger (540 USD) and the Democratic Republic of Congo (550 USD).

Second, the relevance of mobile money innovations has been documented by both policy and scholarly literature to be instrumental in alleviating concerns surrounding SDGs (Asongu & Odhiambo, 2018a; Asongu & Nting, 2022; UNCDF, 2022). The narrative maintains that innovations in mobile phones are fundamental in achieving a plethora of SDGs, including, SDG3 (i.e. focused on wellbeing and health). In summary, the extant contemporary literature is consistent on the importance of instruments of financial inclusion (such as mobile money innovations) in the attainment of projected SDGs (Asongu & le Roux, 2019; Tchamyou *et al*., 2019a, 2019b; Achuo *et al*., 2021; Abdulqadir & Asongu, 2022;UNCDF, 2022). The present exposition that is focused on the nexus between mobile money innovations and health performance is also motivated by an apparent gap in the extant scholarly literature.

[1] Health performance and total life expectancy are used interchangeably throughout the study.

Third, contemporary studies upon which, the present study is based can be engaged in three main strands, notably: (i) studies on mobile money innovations; (ii) research on socio-economic inclusion and (iii) studies on health performance. These are expanded in the same chronological order in the following passages. Concerning the first steam of studies, the extant contemporary literature on mobile money innovations has fundamentally been concerned with *inter alia*: how shocks of idiosyncratic nature influence mobile money adoption (Koomson *et al*., 2021); drivers of financial technology services as well as their corresponding diffusion within the remit of corporations that are medium and small in terms of size (Coffie *et al*., 2021); the relevance of innovations in mobile money in how utility bills are paid (Awel & Yitbarek, 2022); boosters of innovations in mobile technology (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021b); the importance of inclusive finance in rural areas and households (Serbeh *et al*., 2022); digital currency mining as well as the settlement of fees related to digital mining (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021b); digital currency pricing (Schilling & Uhlig, 2019; Biais *et al*., 2020; Choi & Rocheteau, 2021) and a means of operating platforms of digital nature that is robust (Eyal & Sirer, 2014; Chiu & Koeppl, 2019; Biais *et al*., 2019; Pagnotta, 2021; Saleh, 2021).

With regard to the second stream of the third strand in this section, the extant studies on the nexus between mobile money innovations and socio-economic inclusion has been largely concerned with, among others, nexuses between self-employment, innovations in mobile money and financial institutions (Ngono, 2021); the relevance of mobile technologies in financial inclusion (Kim, 2022); nexuses among information technologies, mobile money and access to finance by women (Asongu & Odhiambo, 2018a; Osabuohien & Karakara, 2018) and variations across gender when it comes to inclusive financial avenues (Mndolwa & Alhassan, 2020).

Looking at the third stream focusing on health performance, the extant studies have been oriented towards, the nexus between education and longevity in the USA (Hansen & Strulik, 2017; Hendi, 2017), with emphasis on differences across race and sex (Olshansky *et al*., 2012); the incidence of maternal education in terms of awareness on the survival rate of children in Kenya (Mustafa & Odimegwu, 2008), corresponding finding which McTavish *et al*. (2010) have confirmed on the premise of variations between educated mothers vis-à-vis less educated mothers. Moreover, from a more African-centric view, studies have focused on the nexus between children's death and the mother's education level (Bado & Susuman, 2016; Shapiro & Tenikue, 2017; Anyamele *et al*., 2017; Aristovnik *et al*., 2020); the nexuses between immigration and child care (Immurana, 2022); the connection between changes in the environment and psychological wellbeing (Atwoli *et al*., 2022) and the nexus between longevity and education that is inclusive (Kouladoum, 2022).

Of the considered studies in the attendant literature covered in the third strand of this section, the research that is closest to this study is Kouladoum (2022) which has examined linkages between inclusive education and heath performance within the remit of life expectancy in SSA. The study has employed two main estimation approaches to conclude that inclusive education promotes life expectancy in the sampled countries, notably: the generalized method of moments (GMM) and Driscoll/Kraay technique. The main similarities between the underlying exposition and the present study are traceable to: (i) employment of life expectancy as an outcome variable and (ii) a focus on SSA. However, two elements of distinction are apparent that are worth critically engaging in order to articulate the contribution of the present study to the extant literature with specific emphasis on Kouladoum (2022). These elements of distinction are critically engaged in what follows.

The first distinctive element is the focus of the study which is on the importance of mobile money innovations in health performance instead of the nexus between inclusive education and health performance. The second distinctive feature articulates the policy relevance of the selected estimation approach. Accordingly, instead of considering estimation approaches that are contingent on the mean values of the outcome variable from which common or general policy implications are apparent, the present exposition assesses the nexuses between mobile money innovations and health performance throughout the conditional distribution of health performance. Hence, the analytical procedure is tailored such that countries with low, intermediate and high initial levels of health performance respond differently to the linkage between mobile money innovations and health performance. In essence, the policy importance of this second distinctive feature is that policies designed to assess how mobile money innovations influence health performance are not very likely to be robust unless they are contingent on initial levels of health performance and thus, tailored differently across countries with various initial conditions in health performance.

The positioning of this study also departs from a recent strand of technology in society literature which has mostly focused on *inter alia*, the application of mobile technology in evaluating and monitoring household welfare (Huq *et al*., 2020); assessing the incidence of innovation in green information technology in collaborative corporations (Jnr, 2020); the relevance of information technology in mitigating terrorism and promoting tourism (Choudhary *et al*., 2020); the impact of approaches in the dissemination of technology on agricultural technology uptake (Damba *et al*., 2020) and examining knowledge economy growth strategy within the remit of revitalizing the race between education and technology (Yeo & Lee, 2020).

As substantiated in Section 2, nexuses between poverty, mobile money innovations and improvements in health performance can be apparent when the population (especially the

fraction that is poor and excluded from formal banking services) can leverage on innovations in mobile technology such as payment and transaction mechanisms to better access and pay for health facilities and services they need. This is theoretically contextualized in Section 2 within the remit of intensive and extensive margin underpinnings.

The rest of the research is structured in the following manner. Section 2 engages the theoretical underpinnings and attendant hypothesis. The data and methodology are considered in Section 3 while the empirical results and related discussion are covered in Section 4. Section 5 concludes the study with insights into implications and future research directions.

2. Theoretical underpinnings and testable hypothesis

This section on theoretical underpinnings and testable hypothesis is engaged in three main strands, especially as it pertains to: (i) perspectives on theoretical insights; (ii) a context of the theoretical insights as understood within the remit of the present exposition and (iii) an enunciation of the hypothesis to be tested in the empirical results section of the study. These strands are covered in what follows in the same chronology as highlighted.

First, the theoretical foundation positing for the nexus between mobile money innovations and health performance is consistent with a theoretical perspective on the nexus between financial inclusion and inclusion development (Tchamyou *et al*., 2019a; Ngono, 2021), not least, because mobile money and health performance are proxies for financial inclusion and inclusion development, respectively. Thus, the theoretical insights build on the theoretical underpinnings used in the nexuses between information technology, financial inclusion and inequality in contemporary inclusive development literature (Tchamyou *et al*., 2019a). According to the theoretical narrative, financial inclusion by means of mobile money innovations can affect inclusive development outcomes through two main theories, notably: the intensive and extensive margin theories (Greenwood & Jovanovic, 1990; Tchamyou & Asongu, 2017a; Galor & Zeira, 1993; Beck *et al*., 2007; Galor & Moav, 2004; Aghion & Bolton, 2005; Asongu & Odhiambo, 2018b). According to the intensive margin theory, when more financial opportunities are provided to existing customers of financial institutions, this enables these existing customers to increase their socio-economic opportunities which include wellbeing prospects such as health externalities. On the other hand, the extensive margin theory applies when financial opportunities by means of mobile money innovations are provided to customers who did not previously have access to such financial services. These are largely clients from poorer fractions of society and hence such extensive financial opportunities provide these clients with the opportunities of improving their wellbeing which entail externalities like enhanced access to health services (Evans & Jovanovic, 1989; Black & Lynch, 1996; Holtz-Eakin *et al*., 1994; Chipote *et al*., 2014; Bae *et al*., 2012; Odhiambo, 2014; Batabyal & Chowdhury, 2015; Orji *et al*., 2015; Asongu & Odhiambo, 2019; Chiwira *et al*., 2016).

Second, in terms of contextualizing the above theoretical underpinnings within the remit of the present study focusing on the nexus between mobile money innovations and health performance, financial inclusion through mobile money innovations can benefit the population in terms of improving their access to health facilities and by extension, their life expectancy if the corresponding financial inclusion opportunities are enhanced for existing customers of financial institutions (i.e. in the intensive margin theoretical standpoint) and/or new customers of financial institutions (i.e. in the extensive margin theoretical perspective).

Third, reconciling the first-two strands of this section leads the following testable hypothesis which is considered within the remit of health performance with respect to life expectancy.

Hypothesis 1: mobile money innovations improve health performance in terms life expectancy.

3. Data and methodology

3.1 Data

The present study focuses on 43 countries in SSA using data for the period 2004-2018 which is obtained from four main sources, notably: (i) World Development Indicators (WDI) of the World Bank; (ii) the Financial Access Survey (IMF, 2020); (iii) Kouladoum (2022) from which the underlying health performance and some control variables are sourced and (iv) Ngono (2021) from which mobile money innovations variables are obtained[2]. Moreover, the choice of the sample and periodicity is conditioned on data availability constraints from the main scholarly sources (Ngono, 2021; Kouladoum, 2022).

In accordance with the elements of motivation in the introduction and the narrative on theoretical underpinnings in Section 2, the health performance outcome variable is total life expectancy. The choice of the variable is consistent with the attendant health performance literature (Hansen & Strulik, 2017; Hendi, 2017; Chen *et al*., 2021). In the light of the corresponding mobile money innovations literature (Ngono, 2021), the independent variables of interest are four main mobile money innovation dynamics, namely: (i) registered mobile money agents (registered mobile money agents per 100 000 adults and registered mobile money agents per 1000 km2) and (ii) active mobile money agents (active mobile money agents per 100 000 adults and active mobile money agents per 1000 km2).

In order to account for variable omission bias, consistent with the extant health performance and inclusive development literature, the following variables are incorporated into the conditional information set in order to account for potential drivers of total life expectancy, namely: trade in services, inflation, savings, gross domestic product (GDP) growth and education (Jakovljevic *et al*., 2016; Hendi, 2017; Shapiro & Tenikue, 2017; Hansen & Strulik, 2017; Shahraki, 2019; Aristovnik *et al*., 2020; Asongu & Odhiambo, 2020; Kouladoum, 2022). The expected signs are engaged in what follows.

First, in accordance with the extant literature (Assari, 2018; Tahir, 2020; Kouladoum, 2022), trade in services is anticipated to increase health performance in terms of life expectancy, not least because it has been established to improve health performance by Assari (2018) and Tahir (2020). Moreover, the contrary could also be apparent if the incremental income from trade services is not equally distributed across the population such that the corresponding life expectancy is enjoyed for the most part, by the wealthier fraction of the population.

[2]The 43 countries are: "Angola, Botswana, Benin, Burundi, Burkina Faso, Cameroon, Cabo Verde, Central African Republic, Comoros, Chad, Congo Republic, Côte d'Ivoire, Congo Democratic Republic, Equatorial Guinea, Gabon, Ethiopia, Ghana, Gambia, Guinea-Bissau, Guinea, Kenya, Madagascar, Lesotho, Malawi, Mauritania, Mali, Mauritius, Namibia, Mozambique, Niger, Rwanda, Nigeria, Sao Tome and Principe, Seychelles, Senegal, South Sudan, South Africa, Tanzania, Sudan, Uganda, Togo, Zambia and Zimbabwe".

Second, the effect of inflation on health performance depends on whether inflation is low/stable or high/unstable, not least, because as documented by Asongu (2013), low/stable inflation is worthwhile for economic prosperity and associated inclusive development outcomes which include health externalities such as improved life expectancy. Moreover, as also documented in a complementary strand of literature, high inflation can reflect ambiguity in an economic environment and investors have been established to prefer economic environments that are characterized by less ambiguity (Kelsey & le Roux, 2017, 2018). Consequently, the overall effect of inflation is not clear-cut because it depends on the height/level of inflation as well as corresponding inflation volatility.

Third, financial development can be proxied by savings because the fundamental mission of financial institutions is to play an intermediary role of transforming mobilized deposits or savings into credit for economic operators (Tchamyou, 2019; Alam *et al*., 2021). Hence, on the one hand, from a macroeconomic standpoint, economic operators could be provided with savings mobilized in the banking sector for investment in various economic sectors, including the health sector for the ultimate benefit of enhancing life expectancy. On the other hand, from a microeconomic perspective, the availability of household savings implies that in case of health issues, households can easily use these savings in order to have access to good health services. Furthermore, there is an underlying caveat in the perspective that, in order for the attendant savings to be relevant in consistently improving health care, *ceteris paribus*, the purchasing power of the underlying savings should be maintained (Lien *et al*., 2021; Asongu *et al*., 2021c). It follows that savings could also lead to unexpected signs when high inflation is apparent as well as when the interest rate offered by banks for savings is not high enough to hedge against the corresponding inflation.

Fourth, while it is anticipated that economic prosperity in terms of economic growth is linked to higher prospects in socio-economic development; it is also worthwhile to establish that such socio-economic development entails health sector improvement which obviously engenders health externalities such as improved life expectancy (Kunze, 2014; He & Li, 2020; Chen *et al*., 2021). It is also important to mention that in countries in which good governance practices are not apparent, the fruits of economic prosperity are not evenly distributed across the population and hence, such poor economic governance does not lead to the implementation of policies that provide public commodities such as health services to majority of the population, especially poorer segments of the population.

Fifth, education is fundamental in improving health performance because by intuition, health awareness is positively associated with education and hence, it is anticipated that education should improve life expectancy and other favorable health outcomes, in accordance with the

extant literature on the subject (Mustafa & Odimegwu, 2008; McTavish *et al*., 2010; Olshansky *et al*., 2012; Hansen & Strulik, 2017; Hendi, 2017). Moreover, the opposite effect can also be expected if inclusive education is not apparent, especially when the wealthier fraction of the population benefits more from educational services compared to the poorer strand or fractions of society.

Appendix 1, Appendix 2 and Appendix 3 respectively, show insights into the sources and definitions of the variables, the summary statistics and correlation matrix. The first is relevant in understanding the full definitions of the variables as well as original sources from which they are obtained while the second informs the study on the comparability of mean values of variables used in the empirical analysis. Moreover, the corresponding standard deviations also inform the study that reasonable estimated linkages can be derived. The correlation matrix is used to avoid concerns related to multicollinearity that can influence the expected signs of the independent and control variables.

3.2 Methodology

Motivated by the elements in the introduction, especially as it pertains to positioning the study as an extension of Kouladoum (2022), the present study adopts an empirical regression strategy that is tailored to articulate initial levels of the outcome variable. In essence, the quantile regressions estimation approach is adopted by the present study because it puts emphasis on initial levels of the outcome variable or total life expectancy. It is worthwhile to articulate that common or general policy implications are resultant from the underlying study because the estimation is based on mean values of the outcome variable. Conversely, in the present exposition, the outcome variable varies in terms of low, intermediate and high existing levels of total life expectancy, such that in various groups of countries, total life expectancy responds differently to mobile money innovation dynamics. In summary, the estimation approach or quantile regressions employed within the remit of the present exposition is tailored to assess the nexuses between mobile money innovations and health performance throughout the conditional distribution of health performance or total life expectancy.

Building on the above, the corresponding quantile regressions (QR) technique adopted in this exposition enables the investigation of the testable hypothesis while articulating on nations with various initial levels of total life expectancy. The justification for the choice of the QR technique in the light of the underlying motivational elements is consistent with contemporary and non-contemporary QR-centric literature (Billger & Goel, 2009; Tchamyou & Asongu, 2017b; Boateng *et al*., 2018).

It is also worthwhile to put emphasis on the perspective, relative to the ordinary least squares (OLS) regression procedure that is based an assumption that errors are normally distributed,

with the QR, such an assumption of normality is not apparent. It is essentially for this reason that prior to implementing the estimation approach, initial or preliminary tests such as unit root and cointegration tests are not indispensable. This narrative on the conditions for the implementation of the approach is consistent with the attendant QR-centric studies (Koenker & Bassett, 1978; Keonker & Hallock, 2001; Asongu, 2017).

Building on the underlying perspective, the θ th quantile estimator of total life expectancy is obtained by assessing the optimization problem in Equation (1), that is disclosed without subscripts in view of improving simplicity in presentation.

$$\min_{\beta \in R^k}\left[\sum_{i\in\{i:y_i\geq x_i'\beta\}}\theta\left|y_i-x_i'\beta\right|+\sum_{i\in\{i:y_i<x_i'\beta\}}(1-\theta)\left|y_i-x_i'\beta\right|\right], \quad (1)$$

where $\theta \in (0,1)$. Relative to the OLS technique that is fundamentally based on the minimization of the total sum of squared residuals, the QR approach is instead founded on maximising absolute deviations in corresponding quantiles. For example, relative to the QR technique, quantiles such as the 10th quantile (respectively, related to θ =0.10) is obtained by minimising the weighted residuals approximately. The corresponding conditional quantile of total life expectancy or y_i given x_i is:

$$Q_y(\theta / x_i) = x_i'\beta_\theta \quad (2)$$

where for the comparative θ th quantile that is modelled, parameters are estimated such that they are characterised with unique slopes. The attendant formulation is orthogonal to $E(y / x) = x_i'\beta$ for the considered OLS slope in which, parameters are for the most part, examined at the mean value of the conditional distribution of total life expectancy. For the model in Eq. (2), the outcome variable y_i is the total life expectancy indicator while x_i contains a constant term, *mobile money dynamics, trade in services, inflation, savings, gross domestic product (GDP) growth* and *education.*

4. Empirical results

The empirical findings are provided in this section in Tables 1-2. Whereas Table 1 focuses on linkages between registered mobile money agents and life expectancy, Table 2 is concerned with nexuses between active mobile money agents and life expectancy. Each of the tables is divided into two main sections. In Table 1, the left-hand side (LHS) shows findings on linkages between registered mobile money agents per 100 000 adults and life expectancy, while the right-hand side (RHS) shows nexuses between registered mobile money agents per 1000 km2 and life expectancy. Correspondingly, in Table 2, the LHS reflects results on nexuses between active mobile money agents per 100 000 adults and life expectancy, whereas the RHS shows results on nexuses between active mobile money agents per 1000 km2 and life expectancy. It is worthwhile to emphasize that the use of a multitude of independent variables of interest or mobile money innovations is a form of robustness check.

In the light of the motivational elements of the study, the lower quantiles or below-median quantile show countries in which total life expectancy is less while higher quantile or above-median quantiles illustrate countries in which total life expectancy is more. It follows that, as one move from the low quantiles to high quantiles, initial levels of life expectancy increases. This confirms our position that the nexuses between mobile money innovations and life expectancy are assessed throughout the conditional distribution of life expectancy. Another detail that is worth noting is that, compared to the OLS estimated coefficients; the QR estimates coefficients are distinct both in terms of significance and magnitude of significance. This distinction confirms the relevance of adopting the QR estimation approach in order to articulate countries with low, intermediate and high initial levels of life expectancy. The distinctive and comparative features of significance, sign and magnitude of significance of the QR estimates are discussed in what follows in the establishment of corresponding findings.

Table 1: Registered mobile money agents and total life expectancy

	Dependent variable: Total life expectancy											
	Registered mobile money agents per 100 000 adults (Oae1)						Registered mobile money agents per 1000 km2 (Oae2)					
	OLS	Q.10	Q.25	Q.50	Q.75	Q.90	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
Constant	**55.765*** (0.000)**	**62.176*** (0.000)**	**59.118*** (0.000)**	**45.474*** (0.000)**	**45.313*** (0.000)**	**47.359*** (0.000)**	**57.863*** (0.000)**	**61.734*** (0.000)**	**59.421*** (0.000)**	**46.184*** (0.000)**	**47.128*** (0.000)**	**47.517*** (0.000)**
Oae1	0.001 (0.171)	**0.003*** (0.000)**	0.002 (0.277)	-0.00002 (0.999)	0.0007 (0.634)	0.0002 (0.792)	---	---	---	---	---	---
Oae2	---	---	---	---	---	---	**0.002*** (0.000)**	**0.003*** (0.000)**	**0.003*** (0.009)**	0.001 (0.200)	0.0006 (0.413)	0.0001 (0.873)
Tradeserv	**0.181*** (0.000)**	**0.200*** (0.000)**	**0.226*** (0.000)**	**0.138*** (0.002)**	**0.096*** (0.001)**	**0.299*** (0.000)**	**0.183*** (0.000)**	**0.194*** (0.000)**	**0.209*** (0.000)**	**0.137*** (0.001)**	**0.099*** (0.001)**	**0.298*** (0.000)**
Inflation	0.076 (0.144)	**0.100*** (0.003)**	0.085 (0.400)	0.021 (0.834)	-0.020 (0.771)	-0.030 (0.532)	0.064 (0.186)	**0.089** (0.044)**	0.088 (0.360)	0.005 (0.955)	-0.029 (0.666)	-0.031 (0.550)
Savings	0.029 (0.685)	-0.017 (0.645)	0.072 (0.532)	0.140 (0.236)	0.054 (0.493)	0.083 (0.144)	0.057 (0.384)	0.015 (0.767)	0.057 (0.602)	0.144 (0.182)	0.062 (0.423)	0.082 (0.180)
GDPg	0.061 (0.753)	-0.072 (0.470)	0.127 (0.681)	-0.064 (0.838)	-0.102 (0.624)	-0.175 (0.247)	-0.019 (0.909)	0.013 (0.919)	0.109 (0.708)	-0.219 (0.444)	-0.189 (0.358)	-0.183 (0.257)
Education	0.305 (0.952)	**-12.034*** (0.000)**	**-9.695* (0.070)**	**12.145** (0.026)**	**17.788*** (0.000)**	**13.658*** (0.000)**	-2.210 (0.654)	**-11.76*** (0.000)**	**-9.464* (0.071)**	**11.901** (0.021)**	**16.103*** (0.000)**	**13.590*** (0.000)**
R^2/Pseudo R^2	0.362	0.350	0.194	0.266	0.384	0.527	0.417	0.365	0.243	0.297	0.400	0.529
Fisher	**16.27***						**25.85***					
Observations	104	104	104	104	104	104	104	104	104	104	104	104

*,**,***, respectively represent significance levels of 10%, 5% and 1%. OLS: Ordinary Least Squares. Pseudo R^2 for quantile regression and R^2 for OLS. Lower quantiles (e.g., Q 0.1) signify countrieswhere health performance is least. Oae1: Number of registered mobile money agents per 100 000 adults. Oae2: Number of registered mobile money agents per 1000 km2. Oaa1: Number of active mobile money agents per 100 000 adults. Oaa2: Number of active mobile money agents per 1000 km2. Tradeser: Trade in services. GDPg: Gross Domestic Product growth.

The following can be established from Tables 1-2: (i) registered mobile money agents improve life expectancy exclusively in the bottom quantiles of the conditional distribution of total life expectancy. It is significant in the 10th quantile of the LHS and in bottom quantiles of the RHS. (ii) Active mobile money agents enhance life expectancy for the most part in bottom quantiles of the conditional distribution of total life expectancy. This is essentially because it is significant in the 10th quantile of the LHS while in the RHS, it is also significant in bottom quantiles and the 90th quantile. However, it is important to emphasize that the significance level at the highest quintile of the RHS in Table 2 is at 10%. Hence, compared with the other significance levels that are overwhelming at 1%, it is fair to conclude that mobile money innovations overwhelmingly improve total life expectancy in countries in which initial levels of total life expectancy are below the median. In summary, the testable hypothesis is largely valid in bottom quantiles of the conditional distribution of total life expectancy.

Table 2: Active mobile money agents and total life expectancy

	Dependent variable: Total life expectancy											
	Active mobile money agents per 100 000 adults (Oaa1)						**Active mobile money agents per 1000 km2 (Oaa2)**					
	OLS	Q.10	Q.25	Q.50	Q.75	Q.90	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
Constant	**57.226*** **	**64.259*** **	**61.212*** **	**44.290*** **	**42.976*** **	**46.651*** **	**61.280*** **	**64.374*** **	**65.310*** **	**50.082*** **	**48.262*** **	**47.118*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Oaa1	-0.0006	**0.003** **	0.001	-0.003	0.0003	0.0005	---	---	---	---	---	---
	(0.793)	**(0.025)**	(0.669)	(0.402)	(0.816)	(0.464)						
Oaa2	---	---	---	---	---	---	**0.002*** **	**0.005*** **	**0.004*** **	0.001	0.0007	**0.0008***
							(0.000)	**(0.000)**	**(0.002)**	(0.324)	(0.220)	**(0.072)**
Tradeserv	**0.410*** **	**0.270*** **	**0.300***	**0.279***	**0.357*** **	**0.360*** **	**0.392*** **	**0.286*** **	**0.303*** **	**0.300** **	**0.372*** **	**0.347*** **
	(0.000)	**(0.000)**	**(0.057)**	**(0.060)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.009)**	**(0.031)**	**(0.000)**	**(0.000)**
Inflation	**0.214*** **	**0.201*** **	**0.245***	0.048	0.014	-0.001	**0.187*** **	**0.201*** **	**0.171***	0.096	-0.005	0.001
	(0.002)	**(0.000)**	**(0.067)**	(0.698)	(0.729)	(0.951)	**(0.003)**	**(0.000)**	**(0.080)**	(0.413)	(0.881)	(0.954)
Savings	-0.039	0.009	-0.074	0.122	**0.155** **	**0.126*** **	0.001	0.0008	0.068	0.110	**0.161*** **	**0.126*** **
	(0.737)	(0.888)	(0.678)	(0.469)	**(0.010)**	**(0.000)**	(0.985)	(0.987)	(0.606)	(0.494)	**(0.004)**	**(0.002)**
GDPg	0.348	-0.106	0.274	0.162	0.133	0.018	0.064	-0.135	-0.116	-0.0005	-0.087	0.031
	(0.239)	(0.572)	(0.600)	(0.741)	(0.437)	(0.846)	(0.826)	(0.137)	(0.762)	(0.999)	(0.577)	(0.784)
Education	-4.509	**-14.738*** **	-11.020	**11.835***	**13.172*** **	**11.156*** **	-8.513	**-14.649*** **	**-15.950*** **	4.976	8.395	**10.671*** **
	(0.419)	**(0.000)**	(0.130)	**(0.084)**	**(0.000)**	**(0.000)**	(0.117)	**(0.000)**	**(0.005)**	(0.457)	(0.000)	**(0.000)**

R^2/Pseudo R^2	0.355	0.368	0.204	0.231	0.396	0.549	0.422	0.454	0.292	0.249	0.411	0.553
Fisher	**5.96*** **						**13.28*** **					
Observations	65	65	65	65	65	65	65	65	65	65	65	65

*,**,***, respectively represent significance levels of 10%, 5% and 1%. OLS: Ordinary Least Squares. Pseudo R^2 for quantile regression and R^2 for OLS. Lower quantiles (e.g., Q 0.1) signify countries where health performance is least. Oaa1: Number of active mobile money agents per 100 000 adults. Oaa2: Number of active mobile money agents per 1000 km2. Tradeser: Trade in services. GDPg: Gross Domestic Product growth.

With respect to the anticipated signs from the control variables, this is in accordance with insights from the data section, especially as it pertains to expected signs that cannot be established with certainty. Hence, the anticipated signs should be understood as exploratory such that more articulation is instead placed on the significance of control variables as opposed to the anticipated signs of the control variables. This narrative is broadly in accordance with Kouladoum (2022).

With regards to the linkage between the results and the extant literature, the results are in line with extant studies that have shown the relevance of mobile money innovations in inclusive development outcomes, *inter alia*, self-employment (Ngono, 2021), financial inclusion (Kim, 2022) and access to financial services (Asongu & Odhiambo, 2018a; Osabuohien & Karakara, 2018; Mndolwa & Alhassan, 2020).

5. Concluding implications and future research directions

This study has assessed nexuses between mobile money innovations and health performance in terms of total life expectancy in 43 countries in Sub-Saharan Africa using data for the period 2004-2018. Four mobile money innovation dynamics are proxied with registered mobile money agents and active mobile money agents. The empirical evidence is based on quantile regressions. The findings overwhelmingly show that mobile money innovations are relevant in improving health performance or total life expectancy exclusively in bottom quantiles of the conditional distribution of total life expectancy. In other words, countries with below-median levels of total life expectancy are more susceptible to benefit from mobile money innovations compared to countries with above-median levels of total life expectancy. Policy implications are discussed in what follows.

First, common or general policy measures on the nexus between mobile money innovations and health performance are unlikely to succeed unless attendant policies are contingent on initial levels of health performance and hence, tailored differently across countries with various initial levels of health performance.

Second, more policy effort should be placed on countries with above median levels of life expectancy in order for the attendant countries to benefit from the importance of mobile money innovations in driving health performance in terms of life expectancy. Such policy measures could consist of increasing mobile money penetration levels in countries with above median life expectancy in order to render the incidence of mobile money innovations more significant.

Third, findings in this study also have policy relevance in the achievement of the United Nations' SDG3 which is focused on health and wellbeing. Hence, policy makers should acknowledge and consider mobile money instruments as potential channels for the improvement of health and wellbeing in view of achieving the underlying United Nations SDG.

This study obviously leaves room for further research, especially as it pertains to considering other channels through which health performance can be promoted in view of consolidating the path towards the achievement of SDG3 that is focused on health and wellbeing. Moreover, understanding why countries already benefiting from above-median levels of life expectancy are not enjoying the positive role of mobile money innovations in health performance, is also a worthwhile future research endeavour.

Appendices

Appendix1: Definitions and sources of variables

Variables	Definitions	Sources
Total life expectancy	Life expectancy at birth, total (years)	WDI (World Bank)
Registered agents 1	Number of registered mobile money agents per 100 000 adults	Financial Access Survey (2020)
Registered agents 2	Number of registered mobile money agents per 1000 km2	Financial Access Survey (2020)
Active agents 1	Number of active mobile money agents per 100 000 adults	Financial Access Survey (2020)
Active agents 2	Number of active mobile money agents per 1000 km2	Financial Access Survey (2020)
Trade in services	Trade in services (% of GDP)	WDI (World Bank)
Inflation	Inflation, consumer prices (annual %)	WDI (World Bank)
Savings	Gross savings (% of GDP)	WDI (World Bank)
GDP growth	Gross Domestic Growth (GDP) growth	WDI (World Bank)
Education	School enrollment, secondary (gross), gender parity index (GPI)	WDI (World Bank)

WDI: World Development Indicators. GDP: Gross Domestic Product.

Appendix 2: Summary Statistics

	Mean	S.D	Min	Max	Obs
Total life expectancy	58.905	6.458	42.595	75.514	645
Registered agents 1(Oae1)	237.012	314.561	0.115	2160.727	199
Registered agents 2(Oae2)	168.559	475.494	0.004	4372.031	199
Active agents 1(Oaa1)	171.339	227.829	0.000	1046.332	125
Active agents 2(Oaa2)	144.217	425.719	0.000	3141.954	125
Trade in services	17.755	15.084	2.855	114.719	560
Inflation	8.114	18.556	-8.974	379.999	625
Savings	18.462	11.965	-19.902	57.850	506
GDP growth	4.467	5.168	-46.082	37.998	637
Education	0.880	0.206	0.332	1.388	380

SD: Standard Deviation. Min: Minimum. Max: Maximum. Oae1: Number of registered mobile money agents per 100 000 adults. Oae2: Number of registered mobile money agents per 1000 km2. Oaa1: Number of active mobile money agents per 100 000 adults. Oaa2: Number of active mobile money agents per 1000 km2.

Appendix 3: correlation matrix (uniform sample size: 65)

	lifexptot	Oae1	Oae2	Oaa1	Oaa2	Tradeserv	Inflation	Savings	GDPg	Education
lifexptot	1.000									
Oae1	0.060	1.000								
Oae2	0.322	0.742	1.000							
Oaa1	0.118	0.957	0.799	1.000						
Oaa2	0.344	0.684	0.990	0.774	1.000					
Tradeserv	0.490	0.233	0.233	0.246	0.226	1.000				
Inflation	0.209	-0.072	-0.032	-0.049	-0.034	-0.065	1.000			
Savings	-0.054	-0.105	-0.201	-0.153	-0.221	-0.179	0.478	1.000		
GDPg	0.058	0.266	0.254	0.274	0.258	0.0001	-0.463	-0.409	1.000	
Education	0.064	0.102	0.260	0.171	0.276	0.348	0.234	0.145	-0.382	1.000

lifexptot: total life expectancy at birth. Oae1: Number of registered mobile money agents per 100 000 adults. Oae2: Number of registered mobile money agents per 1000 km2. Oaa1: Number of active mobile money agents per 100 000 adults. Oaa2: Number of active mobile money agents per 1000 km2. Tradeser: Trade in services. GDPg: Gross Domestic Product growth.

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