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Exploring how mobile money adoption affects nutrition and household food security

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Abstract

This paper explores how using mobile money services affects food security and nutritional status of households in Tanzania. This study uses data obtained from three waves of the Tanzanian National Panel Surveys and the instrumental variable (IV) approach. The evidence from this paper shows that using mobile money services resulted in household's enhanced nutritional and food security status. Households' receipt of remittances is the main pathway in which using mobile money services influences the food security and nutritional outcomes among households in Tanzania.

KEYWORDS

food security, mobile money, nutrition, Tanzania

1 | INTRODUCTION

Evidence has shown that using mobile money services reduces transaction costs associated with conventional banking among households in developing countries (Aron, 2018). Other financial innovations in many developing countries that entail the use of short message service (SMS) to transfer funds have led to a decline in the transfer of funds, with significant implications for households' consumption in diverse contexts (Nan, 2019). There has been an upsurge in mobile money network operators, particularly in sub-Saharan Africa, which led to significant financial inclusion, mostly among the unbanked poor (Aron, 2018).

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There has been a growing interest among researchers and policymakers in exploring the connection between using mobile money services and households' well-being (Ajefu & Massack, 2023; Suri & Jack, 2016). For instance, Suri and Jack (2016), one of the foremost studies on mobile money, provide evidence that reveals that the adoption of M-PESA resulted in smoothing of food consumption in Kenya. This evidence is similar to the findings in Abiona and Koppensteiner (2022), which emphasizes on Tanzania. In view of the above, our study emphasizes a complementary outcome from mobile money innovation, that is, food security, a more comprehensive measure that considers food security and nutritional status of individuals and households, which can have severe implications on sustainable development. Specifically, this paper explores how using mobile money services affects households' food security and nutritional outcomes, by analysing the nationally representative panel data from a large household survey. The surveys capture the expansion of this technology and household food security indicators across space and time.

This innovation has transformed the financial sector of Tanzania, a country with a high unbanked population and an increasing rate of mobile money usage. In a certain period around 2017, 21% of the population within the age cohort 15 years (and above) have accounts with a financial institution (compared with 19% in 2014), while those having mobile money accounts in the same period were 39% (compared with 32% in 2014), and 38% of rural residents have mobile money accounts (Magwedere, 2019). The upsurge in using mobile money services occurred in the country only 8 years since mobile money had taken root in the country. This innovation in mobile money services resulted in a significant increase in financial inclusion as a result of a decrease in the transaction cost of transferring funds among individuals and households, thereby circumventing the barriers imposed by distance from the bank in many developing countries. Hence, the use of mobile services facilitates remittance receipts more cheaply, which was not the case prior to the development of mobile money services (Abiona & Koppensteiner, 2022; Riley, 2018). Nonetheless, in the year 2021, Tanzania records high food insecurity, scoring 86/100 in the index of global food security, with poor outlook in categories including food affordability (95 of 100), quality and safety (90 of 100) and natural resource and resilience (90 of 100) (The Economist, 2022).

Moreover, this study's focus on nutrition and food security is relevant for policy discussions on mobile money innovation and how it affects the quality of food intake and the security of food access by adopters of this technology (FAO, 2020). Contrarily, food security considers composite measures that are necessary to meet individuals' or households' nutritional requirements or needs (Abokyi et al., 2023). Our study contributes broadly to the evidence that explores the interplay between financial inclusion and household welfare (and particularly using mobile money services). Furthermore, we are interested in examining whether mobile money matters for household well-being in developing countries (Abiona & Koppensteiner, 2022; Ajefu & Massack, 2023; Batista & Vicente, 2023; Jack & Suri, 2014; Suri & Jack, 2016), by pitching on the effects on nutrition and food security.

There are diverse and distinct reasons why we expect that using mobile money services can have influence on households' food security and nutritional status. Pending more detailed discussion for later, one reason is that the mobile money technology eases households' transaction cost for the purchase of food items (Abiona & Koppensteiner, 2022; Ajefu & Massack, 2023; Batista & Vicente, 2023; Jack et al., 2013; Jack & Suri, 2014; Suri, 2017). A second reason, which we tested in this study, is that the technology would improve household liquidity for enhanced food purchase through remittance inflow. In the context of an altruistic society, where individuals and households provide mutual assistance to help reduce liquidity crunch, as it is for Tanzania (Comola & Fafchamps, 2014; Di Falco et al., 2019), this channel is likely to be at play. The third is other channels through which inclusion in the traditional financial system enhances household welfare, including precautionary savings and investment (Brune et al., 2016).

This paper focuses on the analysis of both dietary diversity and food security indicators, including food availability and deficit. This approach goes beyond the focus of welfare indicators as considered in other studies such as food consumption (Abiona & Koppensteiner, 2022; Batista & Vicente, 2023), to consider outcomes such as food consumption score, dietary diversity and food availability, which are important indicators for measuring food security and nutritional outcomes (Amare et al., 2021; Ickowitz et al., 2014). Our identification strategy using instrumental variables estimation relies on examining the variation in access to mobile money agents across districts (village) and

nearness of households to the agents (mobile money). These two variables are used as instruments to mitigate the endogeneity associated with using mobile money services (Abiona & Koppensteiner, 2018; Ajefu & Massack, 2023).

2 | BACKGROUND OF MOBILE MONEY INTRODUCTION

2.1 | Mobile money operators and financial inclusion in Tanzania

Before 2009, Tanzania had 58 banks and banking activities occurred mostly in urban centres and a significant number of rural inhabitants were captured in formal banking activities (World Bank, 2017). In 2011, about 17% of the population between 15 years and above had accounts in formal financial institutions, and the value increased to 21% in 2017 (World Bank, 2017). The rural area statistics mimics this outlook, with 14% of the population aged 15 and above having accounts with a formal financial institution in 2011 and 20% in 2017 (Ajefu & Massack, 2022).¹ In the same period, the global average reflects that 51% (in 2011) and 67% (in 2017) of the same population cohort had accounts with a formal financial institution, with the statistics for rural areas also reflecting higher financial inclusion relative to the Tanzanian outlook.

The launch of mobile money in Tanzania since 2009 has reached the majority of the population opening mobile accounts,² mostly because of its efficiency and low-cost associated with the transfer funds. The money mobile subscribers in Tanzania grew from less than 200 000 subscribers in 2008 to about 53.3 million accounts of registered mobile money users in 2016, with users of at least a mobile money transaction in 30 days being about 17.6 million (World Bank, 2017).³ Having a mobile money account allows for transactions across mobile money users regardless of whether the mobile money operators of the respective mobile money subscribers are the same or not. Most mobile money users require the service for remittance inflow; in 2017, 24% of the population aged 15 and above received domestic remittance using accounts in the formal financial institution, while 32% received it through their mobile accounts.

In addition, in Tanzania, about 56% of individuals are involved in borrowing funds in order to meet obligations such as consumption and social services, in which informal networks such as friends and family account for about 63%, mobile network loans account for about 17%, and credit from formal financial institutions accounts for about 7%.⁴

2.2 | The adoption of mobile services, food security and nutrition outcomes

Compared with formal financial services, using mobile money services is linked to a number of merits, which include a reduction in transaction costs, risk-sharing to cope with idiosyncratic shocks and increased savings (Abiona & Koppensteiner, 2022; Ajefu & Massack, 2023). Households' remittance transfers or receipts are the offshoot of the upsurge in mobile money services, which can have consequences on consumption, savings and borrowing, as well as household welfare (Ajefu & Massack, 2023 2016; Aker et al., 2016). However, studies have shown that using mobile money services has not always translated to increased households' investment or may have increased disinvestment, probably because of induced migration and the ease of money transfer (Batista & Vicente, 2020).

Studies have found varying effects regarding impacts on household nutrition and food consumption. For example, recent evidence of the upsurge in mobile money services across Africa highlights a positive nexus between mobile money services and food consumption (Abiona & Koppensteiner, 2022; Aker et al., 2016; Batista & Vicente, 2020; Jack & Suri, 2014), while some other studies find a lower likelihood of using mobile money services being related with spending on food and high likelihood of spending on ostentatious or luxury goods (Dunne & Kasekende, 2017). Furthermore, evidence shows that, in comparing the linkage between using mobile money services relative to non-food and food items, the findings reveal that there exist stronger effects from using mobile

money services on non-food expenditure and social contributions compared with food items (Ajefu & Massack, 2023; Munyegera & Matsumoto, 2016). The findings of this study are largely influenced by the sample composition from rural locations, where most foods consumed are from household farm production.

A number of studies unpack the mechanisms through which using mobile money relates to nutrition and food security outcomes of households, including, savings and informal insurance scheme (Jack & Suri, 2014) and increased investment and credit access (Brune et al., 2016; Naito et al., 2021). However, the extent to which mobile money innovation yields benefits to its adopters depends on diverse factors, including the gender of the user (Suri & Jack, 2016) and the educational status of the user (Gichuki & Mulu-Mutuku, 2018). These factors portray the individuals' ability to optimize the advantages associated with using mobile money services to benefit from the innovation.

3 | DATA SOURCE

The data are from the Tanzania National Panel Surveys. Three waves of data from the TNPS, which comprises 2010/11, 2012/13 and 2014/15, were used for this study. We were unable to use the 2008/2009 wave of the Tanzania National Panel Surveys because the survey does not capture households' mobile money services usage. The surveys were designed to be nationally representative and collect data on individuals, households and community-level attributes.

The dataset used in this study comprises a 3-year panel of 3291 households. From Table 1, the summary statistics reveal that the average household dietary diversity is 7.732 and the average real food expenditure is 25 561 across the three periods for the sample. In addition, the average food consumption score is 58, while 33% of households worry about enough food, 1.019 number of days, on average, households depended on foods that are less

TABLE 1 Descriptives.

Variables	Mean	Std. Dev.
Dietary diversity	7.732	1.884
Food consumption score	57.837	22.149
Total household food expenditure	25 561.360	25 533.460
Household worry about enough food (dummy)	0.331	0.470
Number of days HH relied on less preferred foods	1.019	1.934
Number of days HH limit the variety of foods eaten	0.576	1.571
Number of days HH borrowed food	0.276	1.019
Number of days HH limit meals portion	0.423	1.263
Number of days no food in household	0.157	0.739
Number of days not eaten whole day & night	0.058	0.367
HH use mobile money (dummy)	0.379	0.485
Male HH head (dummy)	0.735	0.441
Married HH head (dummy)	0.704	0.456
Age of household head	45.069	15.802
Household size	4.926	3.006
Household head education (schooling years)	0.943	0.670
HH bank account (dummy)	0.213	0.409
HH uses electricity (dummy)	0.244	0.429
Received remittances (dummy)	0.190	0.392
Number of observations	9873	

preferred, 0.576 number of days the food eaten by households are of limited varieties, 0.276 number of days households borrowed food, 0.157 number of days households have no food, and lastly, 0.058 number of days households have not eaten whole day and night. Table 2 shows descriptive statistics of household food security outcomes by mobile money users versus non-mobile money users. The average dietary diversity for households with mobile money adoption is 8.465, compared with 7.284 for households without mobile money adoption or usage.

For the food consumption score, households with mobile money adoption reported on average is 65.581, while households without mobile adoption is 53.101. Moreover, real household food expenditure on average households with mobile money adoption reported 37 747.82, while households without mobile money adoption reported 18 107.45. Considering other food security indicators reported in Table 2, there are discrepancies in descriptive statistics between households that are using mobile money services versus households that are not using mobile money services in patterns that support the hypotheses of this paper. In other words, the descriptive shows households with mobile money adopted reported better food security indicators.

4 | EMPIRICAL METHODOLOGY

This paper explores how using mobile money services affects household food and nutrition outcomes, using the model presented below:

$$Y_{ft} = \delta_i + \omega M_{ft} + \varphi X_{ft} + \sigma_i + \tau_t + \varepsilon_{ft} \quad (1)$$

Y_{ft} denotes household food security indicators and nutrition outcomes for household f at time t ,⁵ and M is a dummy variable for using mobile money services. Moreover, X_{ft} represents household covariates (regressors). In

TABLE 2 Mean difference (test) of food security indicators.

Variables	HH without mobile money	HH with mobile money	Difference
Dietary diversity	7.284	8.465	-1.181***
Food consumption score	(0.024)	(0.025)	(0.037)
	53.101	65.581	-12.480***
	(0.266)	(0.360)	(0.441)
Total food expenditure	18 107.450	37 747.820	-19 640.380***
	(239.142)	(491.694)	(491.293)
HH worry about enough food (dummy)	0.3661	0.2272	0.094***
	(0.006)	(0.007)	(0.009)
Number of days HH relied on less preferred foods	1.166	0.781	0.385***
	(0.026)	(0.026)	(0.039)
Number of days HH limit the variety of food eaten	0.624	0.4991	0.124***
	(0.021)	(0.022)	(0.032)
Number of days HH borrowed food	0.328	0.190	0.137***
Number of days HH limit meals portion	(0.014)	(0.013)	(0.021)
	0.466	0.352	0.114***
	(0.017)	(0.018)	(0.026)
Number of days no food in HH	0.190	0.101	0.088***
	(0.010)	(0.009)	(0.015)
Number of days not eaten whole day and night	0.068	0.041	0.027***
	(0.005)	(0.004)	(0.007)

Note: Standard errors are in parentheses.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

addition, Equation (1) uses district-fixed effects denoted by δ_i , household fixed effects denoted by σ_i , year fixed effects represented by τ_t and error term captured by ε_{ift} .

Following Equation (1), using mobile money services could be linked to omitted variables that are correlated with our outcome variables described in Equation (1). Considering the endogeneity of mobile money services, this paper uses instrumental variable (IV) estimation approach. This paper uses two instruments in the IV analysis, which are mobile money agents being situated or available in the districts and households' proximity to mobile money agents (Abiona & Koppensteiner, 2022; Ajefu & Massack, 2023; Riley, 2018). One plausible rationale for using the growth of mobile money network as instruments stems from the assumption of the likelihood of association or correlation between mobile money agents being situated or available in the districts and households' using mobile money services (Ajefu & Massack, 2023).

A possible source of bias in estimating the above relationship may result from mobile money agents being located or situated in districts based on observed characteristics of the districts (self-selection). For example, mobile money agents may choose to situate in districts having a higher number of wealthy individuals because of certain advantages associated with such a decision. If that is the case, there could be an association or correlation between wealth and the outcome variable under consideration, which could confound the estimate of our main regressor (mobile money services usage) in the analysis (Ajefu & Massack, 2023). However, existing evidence reveals that the spread of mobile money agents across Tanzania follows the existing airtime and sim card vendors that were in operation before the upsurge of mobile money services in Tanzania (Ajefu & Massack, 2023). Hence, the distribution of airtime and sim cards sellers does not necessarily follow defined or prevailing community or district characteristics (Ajefu & Massack, 2023; Shkaratan, 2012). The assumptions for the choice of the instruments stem from our understanding that the instruments satisfy both the relevance and exogeneity conditions.

To buttress the justification for the choice of the instruments used in the analysis, the results from first-stage regression are captured in Table A1. The results support the relevance condition, which shows an association between using mobile money and the excluded instruments. Moreover, regarding the exogeneity condition, this paper argues that having a mobile money agent situated in a district is unlikely to be related or associated with unobserved or confounding factors that could potentially influence the outcome variables (household food security outcomes) (Ajefu & Massack, 2023). In the lower rows of Table A1, the overidentification test and test for weak instrument results are captured. The result for the weak identification test satisfies a threshold value of 10 (as a rule of thumb). The test of overidentifying restrictions using Hansen J statistic reveals that the instruments are valid instruments.

5 | RESULTS

From Table 3, the findings reveal the interplay between using mobile money services and the food security indicators. The use of these outcome variables in Table 3 as food security indicators is consistent with the existing literature on food security, and it also follows Ajefu and Abiona (2020) and Ajefu et al. (2021). Based on the results in columns (1), (2) and (3), using mobile money is positively linked to the dependent variables reported in Table 3—column (1), household dietary diversity; column (2), food consumption score; and column (3), total food expenditure. From Table 4, we presented the results using indicators of food security such as binary variable, for example, if household worried about enough food or otherwise. In addition, from Table 4, we used variables such as number of days households depended on foods that are less preferred; number of days the food eaten by households are of limited varieties; households borrowed food (no. of days); households limit meal portion (no. of days); no food in the household (no. of days); and not eaten whole day and night (no. of days). The outcome variables used in the analysis follow George et al. (2020). Although most of the indicators reveal that mobile money adoption reduces food insecurity, we find statistically significant effects only for column (4) (the number of days that households borrowed food for consumption). The implication of result in column (4) speaks to the negative interplay between using mobile money services and household's borrowed (number of days).

TABLE 3 Mobile money usage and food security outcomes (OLS regression).

Variables	HDD (1)	FCS (2)	Log food expenditure (3)
Mobile money usage	0.811*** (0.054)	5.194*** (0.728)	0.565*** (0.059)
Married household head	0.454*** (0.103)	3.217*** (0.9162)	1.320*** (0.116)
HH head male	-0.355*** (0.104)	-1.409* (0.838)	-1.124*** (0.115)
Age HH head	-0.102*** (0.014)	0.017 (0.016)	-0.0001 (0.001)
Size of the household	0.063*** (0.009)	1.156*** (0.108)	0.145*** (0.011)
Household head education	0.260*** (0.037)	2.735*** (0.400)	0.258*** (0.041)
HH holds bank account	0.390*** (0.071)	6.431*** (0.855)	0.399*** (0.077)
Household uses electricity	0.580*** (0.064)	6.457*** (0.968)	0.509*** (0.072)
Household FE	✓	✓	✓
District FE	✓	✓	✓
Year FE	✓	✓	✓
R ²	0.439	0.450	0.455
Obs.	9873	9873	9873

Note: Robust standard errors are in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

The results in Table 5 are obtained using disaggregated food categories such as fruits, cereals and grains, fats and oil, nuts and pulses, roots and tubers, spices and condiments, sugar, meat/fish, vegetables and milk. Further, from columns (1) to (10), findings show using mobile money services is positively related to the disaggregated food categories being consumed. The use of the disaggregated food categories enables us to explore further aspects of food security beyond the indicators captured in Tables 3 and 4, respectively.

Considering Equation (1) above, using the main regressor (mobile money) in the OLS regression is likely to be endogenous. To mitigate such concerns, this study uses IV method. From Table 6, the IV regression method indicates a positive impact of mobile money usage on dietary diversity score and total food expenditure, respectively. The results are robust to using household income as an additional regressor in the regression. The results are captured in Table A2. This study uses additional measures of food security, which include household worried about enough food or otherwise; number of days households depended on foods that are less preferred; number of days the food eaten by households are of limited varieties; households borrowed food (no. of days); households limit meal portion (no. of days); there were no food in the household (no. of days); and not eaten whole day and night (no. of days). As reported in Table 7, the findings of this paper show a statistically significant effect only for nexus between using mobile money services and indicator of food insecurity captured by households worried about enough food reported in column (1). Table 8 presents the IV results of food categories such as cereals and grains, milk, fats/oil, nuts and pulses, roots and tubers, spices and condiments, fruits, sugar and products, vegetables, and meat and fish. The results reveal positive effects of the nexus between using mobile money services and milk, fats/oil, nuts/pulses, meat/fish, sugar, vegetables and fruits.

TABLE 4 Mobile money and food security outcomes.

Variables	=1 if household worried about enough food (1)	No. of days: household relied on less preferred food (2)	No. of days: HH limit the variety of food eaten (3)	No. of days: household borrowed food (4)	No. of days: HH limits meals portion (5)	No. of days: no food in HH (6)	No. of days: not eaten whole day and night (7)
MM usage	-0.009 (0.016)	-0.049 (0.065)	0.047 (0.058)	-0.047* (0.028)	-0.001 (0.037)	-0.033 (0.024)	-0.006 (0.011)
HH head married	-0.024 (0.020)	-0.108 (0.092)	-0.098* (0.068)	-0.086** (0.043)	-0.146*** (0.056)	-0.125*** (0.034)	-0.014 (0.013)
Male HH head	-0.077*** (0.021)	-0.129* (0.075)	-0.036 (0.066)	-0.080* (0.041)	-0.081* (0.057)	0.036 (0.032)	-0.016 (0.016)
Age HH head	0.001*** (0.000)	0.007*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.003*** (0.001)	0.001* (0.001)	0.000 (0.000)
Size of the household	0.000 (0.002)	-0.010 (0.010)	0.005 (0.007)	-0.018*** (0.003)	0.010* (0.006)	-0.005** (0.002)	-0.003** (0.001)
Household head education	-0.044*** (0.010)	-0.150*** (0.047)	-0.076*** (0.025)	-0.058*** (0.020)	-0.062** (0.028)	-0.041*** (0.013)	-0.018*** (0.007)
HH bank account	-0.106*** (0.016)	-0.314*** (0.051)	-0.157*** (0.049)	-0.107*** (0.032)	-0.135*** (0.042)	-0.059** (0.023)	-0.025* (0.013)
Household uses electricity	-0.081*** (0.015)	-0.340*** (0.059)	-0.133*** (0.050)	-0.096*** (0.033)	-0.103*** (0.037)	-0.041** (0.020)	-0.024* (0.015)
Household FE	✓	✓	✓	✓	✓	✓	✓
District FE	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓
R ²	0.364	0.359	0.343	0.348	0.350	0.339	0.343
Obs.	9873	9873	9873	9873	9873	9873	9873

Note: Robust standard errors are in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

In Tables 9 and 10, this study explores the pathways through which using mobile services is related to nutrition and food security. Consistent with studies such as Munyegera and Matsumoto (2016) and Ajefu and Massack (2023), the study identified remittance receipts being the dominant channel through which the above relationship holds.

The findings from Table 9 reveal the plausible mechanism in which using mobile money services impacts nutrition and food security outcomes. The analysis uses an instrumental variables estimation approach, and the findings indicate that using mobile money services impact positively on household remittance receipts. This result is consistent with Ajefu and Massack (2023). In column (1), we used a dummy variable for remittance receipts by the households, while column (2) captures the amounts of remittances received in the last 12 months. Both results from columns (1) and (2) reveal how using mobile money services impacts food security and nutrition outcomes by identifying remittance receipts as the pathway. This result reveals one of the mechanisms that link using mobile money services with food security and nutritional outcomes.

Further analysis was conducted using interaction terms of mobile money usage and remittance receipts. In Table 10, this study shows the coefficients of interaction terms using mobile money services and remittances and

TABLE 5 Mobile money usage and food security (disaggregated food categories) outcomes.

Variable	Cereals & grains (1)	Fats & oil (2)	Fruits (3)	Meat & fish (4)	Milk & products (5)	Nuts & pulses (6)	Roots & tubers (7)	Spices & condiments (8)	Sugar & products (9)	Vegetables (10)
Mobile money usage	0.244*** (0.053)	0.571*** (0.089)	0.268*** (0.081)	0.187* (0.101)	0.394*** (0.081)	0.197* (0.106)	0.131* (0.069)	0.587*** (0.058)	1.245*** (0.100)	0.515*** (0.062)
Control variables	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Household E	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
District FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year E	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R ²	0.338	0.486	0.389	0.538	0.411	0.382	0.400	0.404	0.459	0.375
No. of observations	9873	9873	9873	9873	9873	9873	9873	9873	9873	9873

Note: The control variables used are captured in Table 4. Robust standard errors are in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

TABLE 6 Mobile money usage and food security outcomes (IV results).

Variable	HDD (1)	FCS (2)	Log food expenditure (3)
Mobile money usage	1.845*** (0.669)	0.281 (9.642)	2.324*** (0.719)
Control variables	✓	✓	✓
Household FE	✓	✓	✓
District FE	✓	✓	✓
Year FE	✓	✓	✓
R ²	0.104	0.123	0.050
No. of observations	9873	9873	9873

Note: The control variables used are captured in Table 4. Robust standard errors are in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

TABLE 7 Mobile money usage and food security outcomes (IV results).

Variables	=1 if household worried about enough food (1)	No. of days: HH relied on less preferred food (2)	No. of days: HH limit the variety of food eaten (3)	No. of days: HH borrowed food (4)	No. of days: HH limits meals portion (5)	No. of days: no food in HH (6)	No. of days: not eaten whole day and night (7)
Mobile money usage	-0.287* (0.193)	-0.102 (0.697)	-0.338 (0.560)	-0.040 (0.328)	-0.662 (0.471)	-0.278 (0.331)	-0.030 (0.178)
Control variables	✓	✓	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓	✓	✓
District FE	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓
No. of observations	9873	9873	9873	9873	9873	9873	9873

Note: The control variables used are captured in Table 4. Robust standard errors are in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

having food security outcomes as the dependent variables. The results from columns (1) to (3) of Table 10 reveal the positive impact of remittance receipts and mobile money usage in relation to the outcome variables (food security indicators).

6 | DISCUSSIONS OF FINDINGS

The findings of this paper reveal interesting connections between using mobile money services and food security and nutritional outcomes in Tanzania. Furthermore, Tanzania is an interesting and compelling context for this study considering the spread of mobile money networks or operators such as M-PESA, Tigo and Tigo Pesa to mention a

TABLE 8 Mobile money usage and food security outcomes (disaggregated food categories)—IV results.

Variable	Cereals & grains (1)	Fats & oil (2)	Fruits (3)	Meat & fish (4)	Milk & milk products (5)	Nuts & pulses (6)	Roots & tubers (7)	Spices & condiments (8)	Sugar & products (9)	Vegetables (10)
Mobile money usage	0.006 (0.087)	0.421*** (0.148)	0.882*** (0.175)	0.225** (0.112)	-0.236 (0.171)	0.344** (0.168)	0.037 (0.184)	0.073 (0.096)	0.237* (0.140)	0.099* (0.067)
Control variables	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
District FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
No. of observations	9873	9873	9873	9873	9873	9873	9873	9873	9873	9873

Note: The control variables used are captured in Table 4. Robust standard errors are in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

TABLE 9 Exploring pathways of mobile money usage and food security outcomes—IV results.

Variable	Remittances dummy (1)	Log. Remittances (2)
Mobile money usage	0.365*** (0.138)	4.926** (2.153)
Control variables	✓	✓
Household FE	✓	✓
District FE	✓	✓
Year FE	✓	✓
No. of observations	9873	6585

Note: The control variables used are captured in Table 4. Robust standard errors are in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

TABLE 10 Exploring pathways of mobile money usage and food security outcomes—IV results.

Variable	HDD (1)	FCS (2)	Log food expenditure (3)
Mobile money usage	2.238** (1.028)	2.995 (14.682)	3.128*** (1.145)
MM*Remittance	1.117 (0.886)	7.562 (12.434)	1.827* (0.988)
Remittances	0.562* (0.362)	3.426 (5.109)	0.673* (0.391)
Control variables	✓	✓	✓
Household FE	✓	✓	✓
District FE	✓	✓	✓
Year FE	✓	✓	✓
No. of observations	9873	9873	9873

Note: The control variables used are captured in Table 4. Robust standard errors are in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

few, coinciding with food insecurity remaining a continuous problem (Wenban-Smith et al., 2016). The major outcomes of this paper show how households using mobile money services reported having enhanced or better food security and nutritional outcomes than non-users of the services. In addition, using other indicators of nutritional and food security outcomes, the evidence of the study reveals that mobile money usage is positively linked to the consumption of fats and oil, fruits, meat and fish, and milk and products.

The findings of this paper lend credence to a growing literature that explores the association between using mobile money services and household welfare (Abiona & Koppensteiner, 2022; Munyegera & Matsumoto, 2016; Suri & Jack, 2016). For instance, using M-PESA (mobile money services) can help households in the smoothing of food consumption (Suri & Jack, 2016). Similarly, Abiona and Koppensteiner (2022) show in the context of Tanzania that using mobile money services during rainfall shocks resulted in smoothing of consumption as well as maintaining investments in human capital. In light of these studies, our findings suggest that using mobile money services could be a plausible pathway for the realization of nutritional and food security outcomes in Tanzania. Regarding the mechanisms, this paper demonstrates that using mobile money services could facilitate remittance receipts among households.

7 | CONCLUSION AND POLICY IMPLICATIONS

Mobile money revolution in developing countries has given rise to financial inclusion (Abiona & Koppensteiner, 2022; Ajefu & Massack, 2023). Hence, mobile money introduction has led to a reduction in financial inclusion gaps among unbanked poor households, especially in most developing countries. Moreover, using mobile money services is associated with households' facilitation of saving, an increase in receipt of remittances, an increase in capacity to borrow and an improvement in households' insurance potential against shocks—both covariate and idiosyncratic shocks (Abiona & Koppensteiner, 2022; Ajefu & Massack, 2023; Munyegera & Matsumoto, 2016; Suri & Jack, 2016).

In light of the above, this paper examines how using mobile money services is correlated with food security among households in Tanzania. In addition, this paper explores potential pathways in the interplay between using mobile money services and nutritional and food security outcomes in Tanzania. To mitigate the endogeneity concerns that pertain with the main regressor (using mobile money services), this paper, therefore, adopts the instrumental variables approach by using two instruments—the presence and proximity of mobile money agents in the districts, respectively. From the findings of this paper carried out using OLS and instrumental variables methods, the findings reveal the positive effect of using money services on nutritional outcomes and food security indicators in Tanzania. This paper uses a few outcome variables as proxies for food security and nutritional outcomes, including disaggregated food categories such as cereals and grains, fats and oil, fruits, and roots and tubers, among others. In terms of mechanisms of effects, this paper unpacks remittance receipts as the plausible pathway in exploring the nexus between using mobile money and food security.

The results of this paper speak to the connection between financial inclusion and issues of hunger, poverty and well-being among households in developing countries, which are captured in SDG1, and SDG2, of the sustainable development goals. Therefore, programs that promote financial inclusion or using mobile money services can be a viable pathway towards achieving sustainable food security in Tanzania.

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CONFLICT OF INTEREST STATEMENT

There is no conflict of interest.

DATA AVAILABILITY STATEMENT

The dataset and the replication codes are available upon request through the corresponding author.

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ENDNOTES

¹ Global Financial Index of the World Bank.

² (Abiona & Koppensteiner, 2022; Ajefu & Massack, 2023).

³ <https://www.tralac.org/news/article/11513>.

⁴ <https://www.tralac.org/news/article/11513-1>

⁵ For the indicators of food security used in this paper, we followed studies such as Ajefu and Abiona (2020) and Ajefu et al. (2021).

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APPENDIX A

TABLE A1 First-stage regression.

Variable	
Availability MM agent district	0.077***
Proximity to MM agent	(0.011)
Household FE	-0.047***
	(0.017)
	✓
District FE	✓
Year FE	✓
<i>Weak identification test</i>	
F statistic: Cragg–Donald Wald	32.99
Critical value: Stock–Yogo weak ID test	19.93

Note: The control variables used are captured in Table 4. Robust standard errors in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.

TABLE A2 Robustness check: Mobile money usage and food security (OLS result).

Variables	HDD (1)	FCS (2)	Log food expenditure (3)
MM usage	1.800*** (0.125)	0.245 (0.511)	2.311*** (0.200)
Control variables	✓	✓	✓
Household FE	✓	✓	✓
District FE	✓	✓	✓
Year FE	✓	✓	✓

Note: The control variables used are captured in Table 4. Robust standard errors in parentheses clustered by enumeration area.

* $p < 0.10$. ** $p < 0.05$. *** $p < 0.010$.