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Household welfare in the digital age: Assessing the effect of mobile money on household consumption volatility in developing countries

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ABSTRACT

Based on a sample of 76 developing countries over 1990–2019, we assess the effect of adopting mobile money on consumption volatility using entropy balancing. We reveal that countries with mobile money exhibit lower consumption volatility. After checking the robustness of this result, we show that the key drivers of mobile money's stabilizing effect are financial inclusion and migrant remittances. Heterogeneity tests conducted indicate the sensitivity of the result to time and type of mobile money and to some structural factors, including trade openness, inflation, rural population, the rule of law, and level of development.

1. Introduction

Access to financial services plays an important role in household welfare as it provides access to business opportunities, investment, savings, consumption smoothing, and insurance against unexpected events (Demirgüç-Kunt, Honohan, & Beck, 2008; Demirguc-Kunt & Klapper, 2012). However, developing countries' financial landscape is characterized by a large number (almost half) of excluded or unbanked people, mainly due to market imperfections and urban concentration of services.

The spread of cell phones as a means of communication in the developing world has led to the emergence of mobile money as an alternative to traditional financial services. Since its introduction in the Philippines in 2001 and its success story by M-PESA in Kenya in 2007, mobile money has emerged in developing countries as the cheapest way to provide (poor) households with access to financial services on the one hand and modernize financial transactions on the other in the context of a strong preference for cash. Currently, we identify 1.21 billion accounts with nearly 740000 active accounts for a daily transaction of 2.10 billion USD. The Global System for Mobile Communications (GSMA) projection expects transactions to increase by nearly 50% by 2022, representing 3 billion USD per day.[1] Around the world, there are currently 390 mobile money services in 96 countries.[2] In 2020, the number of accounts has increased by 13%, while the volume and value of transactions have increased by 15% and 22% respectively.

The literature on mobile money explores several outcomes. For instance, Suri and Jack, 2016 analyze the long-term effects of mobile money and show a positive effect on Kenyan households by bringing 2 percent of Kenyans out of poverty. The authors explain this result by changes in financial behavior–increasing financial resilience and savings–and an efficient labor allocation resulting in a shift from agriculture to business. Focusing on rural households in Uganda, Munyegera and Matsumoto, 2016 show that mobile money adoption increases welfare–measured by real per capita consumption–of households through its ability to facilitate remittances. Related studies show that mobile money increases household consumption expenditures, food security

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[1] https://www.gsma.com/mobilemoneymetrics/#global
[2] https://www.gsma.com/sotir/

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0305-750X/

and per capita consumption (see for example Aker, Boumnijel, McClelland, & Tierney, 2016; Wieser, Bruhn, Kinzinger, Ruckteschler, & and Heitmann, 2019; Batista & Vicente, 2020). In addition, some authors show a positive effect of mobile money adoption on self-entrepreneurship, on the ability of households to get well paid jobs, receive remittances, save, invest, deal with unexpected shocks, and on firms' performance (Suri, Jack, & Stoker, 2012;Suri & Jack, 2016; Islam, Muzi, & Meza, 2018; Hamdan et al., 2019; Aggarwal, Brailovskaya, & Robinson, 2020; Batista & Vicente, 2020; De Mel, McIntosh, Sheth, & Woodruff, 2020;Donovan, 2012; Wieser et al., 2019;Kanz, Breza, & and Klapper, 2020; Moorena et al., 2020;Patnam et al., 2020; Riley, 2020;Tabetando & Matsumoto, 2020; Ahmed & Cowan, 2021; Koomson, Bukari, & Villano, 2021; Lee, Morduch, Ravindran, Shonchoy, & Zaman, 2021;Lee, Morduch, Ravindran, & Shonchoy, 2021; Suri, Bharadwaj, & Jack, 2021). Finally, some studies identify mobile money as a mechanism for business formalization, redistribution, monetary policy efficiency and the promotion of financial development (Adam & Walker, 2015; Asongu, 2015; Kipkemboi & Bahia, 2019; Mawejje & Lakuma, 2019; Jacolin, Keneck Massil, & Noah, 2021).

A part of the literature–which mainly focuses on particular countries or regions–analyzed the effect of mobile money on household consumption volatility. For example, drawing on Kenyan households Jack and Suri, 2014 show the ability of mobile money to smooth household consumption in the face of negative shocks. Riley, 2018, analyzes the counter-cyclical power of mobile money in Tanzanian villages and shows the power of households using mobile money to contain the effect of rainfall shocks on their consumption compared to households without this financial innovation. Alinaghi, 2019 replicates Jack and Suri, 2014's study on Kenyan households and supports the authors' conclusion that mobile money reduces household consumption volatility. In this paper, we test the external validity of these studies by examining the relationship between consumption volatility and mobile money by looking at cross-country results.

Capitalizing on the existing literature, we think that mobile money's effect can be transmitted through two main channels: financial inclusion and migrant remittances. The first channel, financial inclusion, is explained by two mechanisms: ex-ante and ex-post. The ex-ante mechanism arises from the ability of mobile money to provide households with appropriate financial services for business growth, welfare improvement, poverty reduction, and labor market reshaping. For example, existing literature (see Ahmad, Green, & Jiang, 2020) shows that users' mobile money transactions can be used to establish credit scores that can help them get loans to finance their investments. Consequently, privacy and control provided by mobile money limit the social pressure to share loans obtained and favors a better profit and a better capital business (Hamdan et al., 2019; Riley, 2019). The ex-post mechanism can be sourced from network effects, liquid savings opportunities instead of illiquid physical ones, micro-insurance service, and the effectiveness of aid programs in the event of shocks. For example, households with mobile money suffer less from climate shocks due to their network.[3] In addition, studies in Niger revealed that households that received aid programs during the 2009–2010 famine and food crisis through mobile money coped better with the crisis than households that received cash (Aker et al., 2016). The second channel, characterized by increased volume and frequency of migrant remittances, is also justified by the ex-ante and ex-post effect. The ex-ante effect results in the protection of productive capacity through investment in order to promote consumption smoothing and growth, while the ex-post effect is characterized by the surge in migrant remittances following an unforeseen event as an insurance or risk management tool (Combes & Ebeke, 2011).

Based on a large sample of 76 developing countries over 1990–2019 and using entropy balancing, we show that mobile money is an effective instrument to reduce consumption volatility in developing countries. This result remains robust to various tests, including alternative specifications, alternative consumption volatility measures, and alternative estimation methods. To explain this result, we highlight various transmission channels. We show that the stabilizing role of mobile money may come from its ability to increase remittances and promote financial inclusion. Subsequently, heterogeneity tests show that the effect of mobile money may depend on time length, the type of mobile money, and some structural factors, including trade openness, inflation, rural population, the rule of law, and level of development.

The rest of the paper is organized as follows: the next section presents the methodology, Section 3 presents the data and descriptive statistics, Sections 4–7 present respectively the results, the robustness, the transmission channels, the heterogeneity, and Section 8 concludes.

2. Methodology

This study analyzes the effect of mobile money adoption on consumption volatility–measured by the standard deviation of the real household consumption per capita growth rate–in mobile money countries (treatment group) compared to non-mobile money countries (control group). Mobile money adoption is far from being a random feature. It may depend on several factors, including economic performance, level of development, access to cell phones, and access to traditional financial services. These factors–which may also affect the volatility of household consumption–make mobile money adoption endogenous (not random) through the problem of selection bias. To circumvent this problem and identify the effect of mobile money, we use an impact assessment method, namely entropy balancing developed by Hainmueller, 2012. This approach is used in the economic literature including Neuenkirch and Neumeier, 2016 to assess the impact of U.S. sanctions on poverty, Balima, 2020 to assess the effect of coups d'état on the cost of debt, Balima and Sy, 2021 to evaluate the fiscal effect of IMF programs. A similar approach is adopted by Jacolin et al., 2021 to identify the effect of mobile money on informal sector, Riley, 2018 to assess the effect of mobile money on risk-sharing, and Munyegera and Matsumoto, 2016 to assess the effect of mobile money on the welfare of a panel of 846 rural Ugandan households.

The approach used in this study is based on the principle that mobile money adoption is the treatment and consumption volatility is the outcome variable. The units of observations are country-year observations. The observations with mobile money are the treatment group, and those without mobile money are the control group. The treatment effect on the treated (ATT) is defined as follows:

$$ATT = E[Y_{(1)}|T = 1] - E[Y_{(0)}|T = 1] \quad (1)$$

where $Y_{(.)}$ is the outcome variable measuring the consumption volatility. T indicates whether the observation unit is subject to mobile money adoption ($T = 1$) or not ($T = 0$). $E[Y_{(1)}|T = 1]$ the volatility of consumption during the mobile money period, $E[Y_{(0)}|T = 1]$ is the counterfactual result for countries that had adopted mobile money, i.e. the volatility of consumption in countries that had adopted mobile money if they had not.

The issue is that $E[Y_{(0)}|T = 1]$ is not observable due to the non-random nature of mobile money adoption. If this were the case,

[3] It is characterized by the ability of mobile money households to dig into their relationship to secure a source of financing in case of extreme shocks.

the ATT could easily be identified by comparing the volatility of consumption in mobile money countries with non-mobile money countries. Identifying ATT then requires a good proxy for $E[Y_{(0)}|T=1]$. To do so, we match mobile money units with non-mobile money units (after purging for some specific factors) that are as close as possible on observable characteristics that meet two criteria: correlated with mobile money adoption and consumption volatility. Under the condition that the non-mobile money units are fairly close to the mobile money units, any difference in consumption volatility is attributable to mobile money adoption. Based on these different elements, we can rewrite Eq. (1) as follows:

$$ATT = E[Y_{(1)}|T=1, X=x] - E[Y_{(0)}|T=0, X=x] \quad (2)$$

where $X=x$ is a vector of observable covariates that may affect both the decision to adopt mobile money and the volatility of consumption, $E[Y_{(1)}|T=1, X=x]$ is the consumption volatility of mobile money units, and $E[Y_{(0)}|T=0, X=x]$ is the expected consumption volatility for the synthetic control units. Estimating the ATT by the entropy balancing involves two steps. The first is to compute weights for the control group (non-treated group). These weights may satisfy pre-specified balanced constraints involving sample moments of observable characteristics (X). Following Neuenkirch and Neumeier, 2016, we choose balance constraints that impose equal covariates means between the treatment and control groups. In doing so, we want to ensure that the control group, on average, has non-treatment units that are as similar as possible to the treated units.[4] The second uses the weights from the first step in a regression analysis where consumption volatility is the dependent variable. In the second step, we control for the covariates employed in the first step. This is equivalent to including control variables in a randomized experiment and increases estimation efficiency. In addition, time- and country-specific effects are included in the second step to respectively account for time-specific effects such as the Global Financial Crisis and country-specific heterogeneity arising from, for instance, differences with regard to political, economic, and institutional environments.

Entropy balancing allows us to identify the effect of mobile money by comparing mobile money and non-mobile money countries (or units) that are similar on observable characteristics while taking care to account for country- and time-specific effects. By combining both a matching and regression approach, this method offers some advantages over several existing methods as listed by Neuenkirch and Neumeier, 2016. A particularly important advantage is that entropy balancing is nonparametric in the sense that no empirical model for either the outcome variable or selection into treatment needs to be specified. Hence, potential types of misspecification like those, for instance, regarding the functional form of the empirical model, which likely lead to biased estimates, are ruled out. Also, in contrast to regression-based analyses, treatment effects estimates based on entropy balancing do not suffer from multicollinearity, as the reweighting scheme orthogonalizes the covariates with respect to the treatment indicator.

Moreover, in contrast to other matching methods, entropy balancing ensures a high covariate balance between the treatment and control group even in small samples. With "conventional" matching methods such as, for instance, nearest-neighbor matching or propensity score matching, each treated unit–in the simplest case–is matched with the one untreated unit that is closest in terms of a metric balancing score. Accordingly, the control group is comprised of only a subset of the units that are not subject to treatment (Hainmueller, 2012; Diamond & Sekhon, 2013). In other words, with conventional matching methods, each untreated unit either receives a weight equal to 0, in the event it does not represent a best match for a treated unit or equal to 1, in the event it does represent a best match for one treated unit. However, when the number of untreated units is limited, and the number of pre-treatment characteristics is large, this procedure does not guarantee a sufficient balance of pretreatment characteristics across the treatment and control groups. This is a serious problem, as a low covariate balance may lead to biased treatment effect estimates. In contrast, with entropy balancing, the vector of weights assigned to the units not exposed to treatment is allowed to contain any non-negative values. Thus, a synthetic control group is designed that represents a virtually perfect image of the treatment group. Entropy balancing thus can be interpreted as a generalization of conventional matching approaches.[5] Also, compared to conventional matching where the control units are either discarded or matched, entropy balancing uses more flexible reweighting schemes. It reweights units with the goal of achieving balance between treated and untreated while keeping the weights as close as possible to the base weights to avoid a loss of information.

Finally, by combining a reweighting scheme with a regression analysis, entropy balancing allows us to properly address the panel structure of our data. In particular, we are able to control for both country-fixed as well as time-fixed effects in the second step of the matching approach, that is, the regression analysis. The inclusion of country-fixed effects is particularly useful in accounting for the potential unobserved heterogeneity between countries that have never adopted mobile money and those that have adopted it given that economic and political environments of these two groups of countries may differ beyond the set of covariates used in the entropy balancing approach. By including country fixed-effects, we also control for time-invariant country-specific factors that could lead to differences in consumption volatility across countries. In other words, including country-fixed effects allows us to control for country-specific characteristics that may influence mobile money adoption or shape consumption volatility in the sample countries. As stated earlier, time fixed-effects allow us to control for time-specific effects such as the Global Financial Crisis that may affect the countries in our sample. Despite the various advantages discussed in this section, it is essential to note that this approach may have some limits. Indeed, entropy balancing may fail to control potential endogeneity biases resulting from unobserved time-varying factors that may affect both mobile money and consumption volatility and the reverse causality problem that may exist between the treatment variable and the outcome variable on the one hand, and on the other hand, to successfully deal with the inertia of consumption volatility. To test the robustness of our conclusions, we complete the entropy balancing by alternative estimation methods such as Ordinary Least Squares (OLS), PSM, two-step system-GMM dynamic panel estimator.

3. Data, and descriptive statistics

3.1. Data

To assess the effect of mobile money, we use an annual panel of 76 developing countries from 1990–2019. The study focuses on developing countries as the adoption of mobile money is specific to them. In other words, no developed country has adopted this policy to date. The treatment variable, mobile money, comes from GSMA's mobile money deployment tracker.

[4] This procedure ensures that once the weights are generated, mobile money and non-mobile money countries exhibit similar trends in their outcome variable over the pre-treatment period (see Ogrokhina & Rodriguez, 2019).

[5] Hainmueller, 2012, using Monte Carlo simulations as well as empirical applications, demonstrates that entropy balancing outperforms other matching techniques, such as propensity score matching, nearest neighbor matching, and genetic matching, in terms of estimation bias and mean square error

In line with previous studies (Munyegera & Matsumoto, 2016; Riley, 2018; Jacolin et al., 2021), we measure the adoption of mobile money by a dummy variable, taking 1 if a country *i* at date *t* adopts mobile money, and 0 elsewhere. Over the study period, 23 out of 76 countries have never adopted mobile money, and the remaining 53 countries adopted it. In addition, note that no country has adopted mobile money before the sample of analysis.

Our outcome variable is consumption volatility.[6] Drawing on the literature, especially that on migrant remittances (see for instance Fatás & Mihov, 2003; Combes & Ebeke, 2011; Ding, Jiang, Li, & Wei, 2018; Mondal & Khanam, 2018; Eftimoski & Josheski, 2020), we measure consumption volatility by the standard deviation of the real household consumption per capita growth rate estimated over a 5-year moving window. We collected the real household consumption per capita growth rate from the World Development Indicators (WDI) for its estimation.

For the control variables, we select the control group of units with no mobile money that is on average as similar as possible to the treatment group of mobile money units in terms of relevant pretreatment characteristics. Following the literature on the determinants of mobile money adoption and consumption volatility, we select the following control variables: inflation, urban population growth, the labor force, real GDP per capita, and fixed telephone. We expect a negative correlation between inflation and the probability of mobile money adoption, as a healthy economic environment is a catalyst for reforms. We expect a negative correlation between the last two variables, namely real GDP per capita (a proxy of economic development) and fixed-line telephone and mobile money adoption, given that mobile money is considered to be a low-cost solution for low-income countries compared to relatively high-income countries, which would have access to a variety of payment methods, and that the deployment of mobile money services is fundamentally linked to the cell phone market's dynamism (Jacolin et al., 2021). However, we expect a positive sign for urban population growth and labor force as mobile money transactions are mainly from urban to rural areas and fulfill a need for distant payments (Buku & Meredith, 2012; Della Peruta, 2018; Eftimoski & Josheski, 2020).[7]

Finally, we assess the performance of entropy balancing. To do so, we present some descriptive statistics obtained before and after weighting used to estimate the treatment effect of mobile money adoption. Table 1 presents in columns [1] and [2] respectively the sample mean before weighting for country-year observations for the treatment group (with mobile money) and the control group (without mobile money). Column [3] of this table reports the difference in means between the two groups. The results reveal a difference between these two groups. Indeed, the mobile money countries are characterized by low inflation, low fixed-line subscriptions, low GDP per capita, high urban population growth, and a high labor force. These findings are consistent with the expected relationship between the probability of mobile money adoption and the various control variables discussed above. These differences across mobile money and non-mobile money countries demonstrate the importance of selecting an appropriate control group when computing the treatment effect of mobile money to avoid incorrectly estimated treatment effects. Table 2 shows in columns [1] and [2],[8]the sample mean after weighting between the treatment group and the synthetic group obtained by entropy balancing, and column [3] presents the difference between the two former's. The analysis of the two groups in this table reveals the effectiveness of entropy balancing as the difference shown in the previous table seems to disappear. As a result, entropy balancing allows us to construct a perfect control group closely similar to the mobile money countries in terms of the mean values of the pretreatment covariates.

Table 1
Descriptive statistics before weighting.

	[1] Mobile money	[2] No mobile money	[3]=[2-1] Diff
Lag inflation	5.163	34.66	29.497
Lag urban population growth	3.01	2.42	−0.59
Lag fixed telephone	5.992	11.54	5.548
Lag real GDP per capita (log)	7.648	7.94	0.292
Lag labor force	64.04	61.43	−2.61
Obs	449	1489	

Table 2
Descriptive statistics after weighting.

	[1] Mobile money	[2] No mobile money	[3]=[2–1] Diff
Lag inflation	5.163	5.17	0.007
Lag urban population growth	3.01	3.01	0
Lag fixed telephone	5.992	5.992	0
Lag real GDP per capita (log)	7.648	7.648	0
Lag labor force	64.04	64.04	0
Obs	449	449	
Total of weights	449	1489	

3.2. Descriptive statistics

A first look at the relationship between consumption volatility and mobile money can be revealed by exploring the unconditional correlation between these two variables. Results of the line [2] of Table D.6 in Appendix B–which present the unconditional correlation between these two variables–reveal that mobile money is negatively and significantly correlated with consumption volatility at the 1% confidence level.

Next, we look at key correlations with mobile money. First, we expect a negative correlation between financial development and mobile money, as financially developed countries would have less incentive to adopt financial services like mobile money. However, financial development can be complementary to mobile money as it may signal less restrictive investment environments that favor financial innovations like mobile money (Pelletier, Khavul, & Estrin, 2020; Jacolin et al., 2021). In line with these two arguments, the correlation between financial development and mobile money is ambiguous. Second, mobile money and remittances could be positively correlated.. Indeed, the ability to receive remittances more easily (see for instance Munyegera & Matsumoto, 2016; Riley, 2018) in case of shocks may motivate households to adopt mobile money, suggesting a positive correlation of remittances with mobile money. Finally, expect a positive correlation between mobile money and financial inclusion. Indeed, mobile money is identified as a financial innovation capable of providing households excluded from the formal financial system with basic financial services (Donovan, 2012). Results of these correlations are presented in lines [23], [24], and [41] of Table D.6 in Appendix B.

[6] For simplicity, we refer to household consumption volatility as consumption volatility.

[7] For robustness concerns, we add to these variables a large number of other potential determinants of mobile money adoption (and consumption volatility). Finally, to contain the reverse causality, we lagged these variables by one period. The definitions and sources of all variables, as well as the sample countries, are presented in Tables C.1 and C.2 (Appendix A), and the last section of Appendix B.

[8] It is important to note that time fixed effects are included in the first step model, i.e., in Tables 1 and 2, to capture common global shocks.

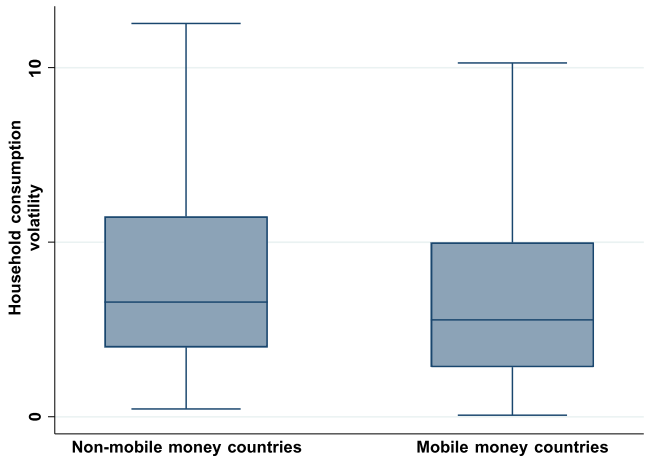

Fig. 1. Consumption volatility by mobile money adoption. *Note*: In box plots, the lower and upper hinges of each box show the 25th and 75th percentiles of the samples, the line in the box indicates the respective medians, and the end-points of whiskers mark next adjacent values.

We observe a positive correlation between financial development and mobile money. Remittances, financial inclusion, and mobile money are positively correlated, although the correlation coefficient of remittances is not statistically significant.

Next, we look at/compare consumption volatility in the treated and control countries. We explore this comparison in three ways. First, we analyze graphically some key statistics offered by Fig. 1. A closer look at this figure reveals a difference in the volatility of consumption between mobile money and non-mobile money countries. Indeed, mobile money countries exhibit a median (the middle line of the box), 25th (bottom hinge of the box), and 75th (top hinge of the box) percentiles of consumption volatility lower than non-mobile money countries. This finding is justified by the fact that the median line, bottom hinge, and top hinge of the box for mobile money countries are respectively below those of non-mobile money countries. While this figure exhibits a difference between mobile and non-mobile money countries, it cannot assess its magnitude or significance. Thus, to judge the significance of the difference between these two groups of countries, we then rely on statistics from tests of difference in means. Table 3 (Panel A), which tracks these statistics by comparing the average consumption volatility in the two groups of countries, reveals that adopting mobile money appears to reduce consumption volatility. Indeed, compared to the control group, countries using mobile money experience low volatility in consumption with a significant difference of 1 percentage point.

Third, we analyze, as Munyegera and Matsumoto, 2016, the change in average consumption volatility within countries by computing the mean of the volatility of consumption before and after mobile money adoption. The results presented in Table 3 (Panel B) show that consumption volatility decreases after mobile money adoption.[9] Compared to the results of the comparison between mobile money and non-mobile money countries, the decline in volatility from this exercise appears larger–about 1.5 versus 1 percentage points. These relationships, while not causal, provide a picture of the treatment effect of mobile money adoption and how to identify it. Indeed, due to potential secular trends, it would be misleading to estimate the effect of mobile money on consumption volatility by simply comparing consumption volatility before and after mobile money adoption. To avoid overestimating the effect of the policy, we use, as discussed above, the non-mobile money countries as a control group to estimate the counterfactual outcome. In doing so, we can control for secular trends, and separate the treatment effect (see Lagarde, 2012; Ogrokhina & Rodriguez, 2018).

Finally, we present descriptive statistics for our variable of interest, i.e., mobile money.[10] To do so, we use mobile money per population from the IMF Financial Access Survey. The results presented in Panel C of Table 3 show that the average rate of mobile money use is approximately 38%. Looking at the evolution of mobile money usage, we can observe that before 2004, the mobile money use rate was around 0.0%. However, since the period 2004–2009, we note a growing trend in the adoption of this service. Indeed, the use of mobile money increased from 9% between 2004–2009 to 21% between 2010–2014 and finally to 48% between 2015–2019.

4. Results

4.1. Mobile money and household consumption (level)

Before analyzing the effect on volatility, we briefly discuss in this section the impact of mobile money adoption on real per capita household consumption (named household consumption). The intent is to explore what is happening at the level before getting into the heart of the issue. The intuition behind this maneuver is simple: does mobile money increase household welfare by improving household consumption, or does it only stabilize consumption volatility without significantly improving household consumption? This question seems necessary given the low level of consumption of households in developing countries. Thus, a policy that stabilizes consumption without increasing its level may not improve the welfare of households in these countries. We test this intuition using entropy balancing. The results in the Table 4 below show a favorable effect of mobile money adoption on household consumption.[11] As consumption and income are related, this result signals that mobile money changes the standard of living (or welfare) of households in developing countries by possibly providing them with better incomes. As a result, mobile money prepares them for minor shocks and major shocks since adaptation and resilience to shocks seem to be positively correlated with income level. This result corroborates at the macroeconomic perspective those reported in the microeconomic literature (see for instance Munyegera & Matsumoto, 2016; Riley, 2018).

4.2. Mobile money and consumption volatility

With the synthetic controls in Table 2, we estimate the effect of mobile money adoption on consumption volatility (ATT) in developing countries using weighted least squares method. The results are reported in Table 5. Columns [1–4] present the second-stage results with no addition of the covariates used in the first stage in constructing the synthetic group. Column [1] excludes country- and time-fixed effects. Columns [2–3] include respectively country- and time-fixed effects while column [4] includes these two effects jointly. Finally, columns [5–8] repeat the exercise of columns [1–4] except for adding in each second stage regression the covariates used in the first stage, namely inflation, urban population growth, the labor force, real GDP per capita, and fixed telephone.[12] It is useful to note that including matching covariates in the second stage of entropy balancing increases the quality of the matching (as in a randomized experiment), while controlling for

[9] Non-mobile money countries are not included due to multiple adoption dates, making it difficult to assign an economically valid adoption date for them.

[10] Descriptive statistics are based on mobile money countries only, as mobile money use rate in non-mobile money countries is zero.

[11] Similar results are found using OLS regression (see column [1] of Table C.5 in Appendix B).

[12] The same approach is followed for results in Table 4.

Table 3
Consumption volatility by mobile money adoption: mean-comparison tests

	Mobile money	Non-mobile money	Diff	Ttest	P-value
Panel A: Consumption volatility	3.989	5.058	1.069	4.652	0.0000
Panel B: Mobile money adoption	Before	After	Diff	Ttest	P-value
Consumption volatility	4.500	2.992	1.509	6.660	0.0000
Panel C: Mobile money adoption	Average	<2004	2004–2009	2010–2014	2015–2019
Mobile money use	37.60	0.00	9.194	20.792	47.686

Table 4
Mobile money and household consumption

Household consumption (log)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	0.207***	0.329***	0.207***	0.329***	0.217***	0.273***	0.217***	0.273***
	(0.0494)	(0.0092)	(0.0494)	(0.0092)	(0.0312)	(0.0093)	(0.0312)	(0.0093)
Covariates in the second step	No	No	No	No	Yes	Yes	Yes	Yes
Year fixed effects in the second step	No	No	Yes	Yes	No	No	Yes	Yes
Country fixed effects in the second step	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1844	1844	1844	1844	1844	1844	1844	1844

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Refer to the following table for comments on the observations.

Table 5
Mobile money and consumption volatility

Consumption volatility	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	−1.464***	−1.658***	−1.468***	−1.663***	−1.538***	−1.153***	−1.543***	−1.157***
	(0.2397)	(0.1437)	(0.2395)	(0.1442)	(0.2370)	(0.2295)	(0.2366)	(0.2297)
Covariates in the second step	No	No	No	No	Yes	Yes	Yes	Yes
Year fixed effects in the second step	No	No	Yes	Yes	No	No	Yes	Yes
Country fixed effects in the second step	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1702	1702	1702	1702	1702	1702	1702	1702

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: The observations in this table are different from those in the previous table, mainly because the dependent (or outcome) variables in the two tables are different. While the previous table uses real per capita household consumption as a dependent variable, this one uses the standard deviation of real household consumption per capita growth rate.

country- and year-fixed effects eliminates any country- or year-specific effects.

Independent of the specification, the adoption of mobile money significantly reduces (at 1%) the volatility of consumption in our sample countries. This result ranges from −1.15 percentage points (column [6]) to −1.66 percentage points (column [4])–a robust result given the relative stability of the coefficients in the 8 specifications of the table–, with an average effect of −1.46 percentage points. In other words, mobile money adoption reduces on average consumption volatility by 1.46 percentage points in countries using mobile money compared to non-mobile money countries. This result is economically high given the sample average consumption volatility of 4.30%. By adopting mobile money, a country with average consumption volatility of 4.30% can expect to reduce its consumption volatility from 26.74% to 38.60%, or an average of 34% (one-third). Relative to the standard deviation, this result represents between 25.39% and 36,64% of the standard deviation of consumption volatility, or an average of 32.23% (one-third).

5. Robustness checks

Our estimations show that mobile money adoption significantly reduces consumption volatility in developing countries. In this section, we test the robustness of these findings. Several variables are used for this exercise. First, we alter the definition of the treatment variables excluding mobile money services provided by banks, by dropping the first year of the policy's adoption, by leading (anticipating) and lagging the adoption of the program by one period, and by defining a placebo mobile money. Second, given that countries are likely only introducing mobile money, not eliminating it, any characteristic that predicts the introduction of mobile money could be a source of endogeneity. Also, when a country introduces mobile money, it is likely that other aspects such as the institutional, political, social, or economic context also change, potentially polluting the relationship between mobile money and consumption volatility. To get around these problems and properly identify the effect of mobile money, we performed an additional alteration to the treatment variable. Following the literature, we remove all observations prior to and following the first year of mobile money adoption. Third, it is important to emphasize that using a binary variable in a cross-country study raises two major concerns, namely the inability to take into account the intensity of mobile money adoption and the manner in which mobile money is deployed.[13] To circumvent these problems, we use an alternative measure of the variable of interest, that is, the mobile money accounts per population. This continuous variable comes from the IMF's Financial Access Survey, which provides broader time coverage than the FINDEX data. Finally, three alternative definitions of the dependent variable are used to test the robustness of our results. First, we test the sensitivity of our results to the choice of the estimation window by using a standard deviation of the real household consumption per capita growth rate estimated over 4-, 3-, and 2-year moving window. Second, we estimate the volatility of con-

[13] In this sense, we can state that telecommunication operators have been more effective in the spread of mobile money than central banks and the Kenya' s example, with its more or less laissez-faire approach, provides the perfect illustration compared to several West and North African countries.

sumption using a residual approach. Finally, we perform sensitivity analysis using skewness and kurtosis instead of standard deviation.

5.1. Alternative specifications

We begin this exercise by altering our sample by excluding some countries or periods. First, we exclude the pre-2000 period because of its major economic and political changes that may affect consumption volatility. Second, we exclude former and current communist countries. This exclusion seeks to take into account the possible bias in the measurement of consumption volatility caused by the difference in the public goods distribution system between communist and non-communist developing countries (see Mondal & Khanam, 2018). Finally, we exclude countries with recently adopted mobile money because of the potential time lag between reforms and their expected effects. The results of these tests compiled in columns [1–3] of Table 11 in Appendix A show the consistency of our findings with these different specifications. Based on the mobile money and consumption volatility literature, we then test the robustness of our results using a set of additional control variables. These variables cover a wide range of characteristics that we group conceptually into four main groups: *i- economic variables*: GDP volatility per capita, commodity price shock, public investment volatility, public investment (% GDP), current expenditure (% GDP), public investment (% public expenditure), current expenditure (% public expenditure), public debt, financial openness, financial openness squared, ODA, remittances, trade openness, exchange rate, exchange rate regime; *ii- political and institutional conditions*: internal conflict, external conflict, conflict, the rule of law, investment freedom, corruption; *iii- climate considerations*: climate resilience, climate vulnerability, weather shocks; *iv- infrastructure and structural issues*: social globalization, mobile cellular, internet adoption, electricity access, electricity consumption, human capital, agricultural productivity, initial GDP per capita.[14] For the reason of reverse causality, these variables included essentially in the second stage of the estimation are all lagged by one period. Columns [4–36] of Table 11 in Appendix A, which report the results of these specifications, show their consistency with our baseline findings. In other words, adding these additional covariates does not change our results. In addition, given that any characteristics able to predict mobile money can be a source of endogeneity, we augment the variables used in the baseline first-stage model by adding these additional control variables to construct the synthetic control. The results in Panels A and B of Table 12 (columns [1–33]) in Appendix A show that adding these variables to the determinants of mobile money does not change our results. Finally, following the approaches of Tables 11 and 12, we augment our baseline model by adding additional control variables by groups. The results presented in Table 13 in Appendix A support those previously reported: mobile money reduces consumption volatility.

Third, we test the robustness of our results to the window choice in Table 14 in Appendix A. To do so, we compute the volatility of consumption over 4-, 3-, and 2-year moving window instead of a 5-year moving window. Results obtained using these three new dependent variables reveal the non-sensitivity of our conclusions to the choice of the window since our coefficients are all significant (at 1%) and close to those in Table 5.

Fourth, we use the residual approach to estimate consumption volatility. To do this, we define consumption volatility as a standard deviation (over a 5-year moving window) of the residual from a regression in which the log difference of real per capita household consumption is explained by its lag and time trend. Using entropy balancing, we estimate the effect of mobile money using our new volatility measure. Results in Table 15 in Appendix A show a negative effect of mobile money adoption on consumption volatility with coefficients close to our baseline results.

Fifth, we use an alternative database for mobile money adoption, namely the IMF Financial Access Survey (FAS). Regression results using this alternative database are presented in Table 16 in Appendix A. They show a negative and significant effect at the 1% level of mobile money adoption on consumption volatility with coefficients very close to our baseline findings. Thus, we can safely say that the use of an alternative database does not alter our results.

Sixth, we modify our treatment variable by excluding mobile money services provided by banks, removing the first year of policy adoption, and leading (lagging) mobile money adoption by one year. The results of these alternative definitions are compiled in columns [1–4] of Table 17 in Appendix A. We can conclude that altering the treatment variable does not change our results since the coefficients remain negative and statistically significant. Finally, the effect captured in this work may suffer from some problems. Indeed, mobile money adoption can lead to a change in countries' environments. In this sense, the effect captured may not be due to mobile money but to changes in institutional, political, social, or economic conditions after its adoption. Also, any other characteristic that may determine mobile money may be a source of endogeneity. To circumvent these problems, we employ a similar approach as Neuenkirch and Neumeier, 2015 by removing all observations before and after the initial year of mobile money adoption. Thus, we expect that this narrow time window characterizing our new mobile money variable should provide a more robust estimate of its effect on consumption volatility since the (generally slow-changing) institutional, political, social, and economic environment is more likely to be stable over a narrow time window. Using entropy balancing with this new variable as the treatment variable, the column [5] of Table 17 in Appendix A provides results that reinforce our baseline findings. Thus, we can conclude that it seems unlikely that the estimated effect of mobile money is due to a coincidental change in the institutional, political, social, and economic environment in the mobile money country or to any other characteristics that may predict mobile money adoption.

Seven, we perform a placebo (falsification) test in two different ways. First, we define placebo or arbitrary dates for mobile money, computed by randomly assigning mobile money episodes to countries in our sample after removing actual adoption years, i.e., those provided by the GSMA database. Second, we define a placebo date for mobile money by computing a mobile money variable that incorrectly assigns the mobile money start date before the actual start date, i. e. seven years[15] before the actual mobile money date of each country in our sample. The intuition is that if our baseline findings are due to mobile money adoption, using placebo dates should produce non-statistically significant estimated effects of mobile money adoption. Result based on entropy balancing and using placebo mobile money is presented in columns [6–7] of Table 17 in Appendix A. The non-significant effect of placebo mobile money variables on consumption volatility underscores the robustness of our findings, especially with respect to measurement error.

We conclude this section with a continuous version of the treatment variable based on the mobile money accounts per population

[14] See Appendix B where we discuss in detail the motivation behind the selection of these variables.

[15] We computed it by taking half of the year difference between the first year of mobile money adoption (2004) and the starting year of our study (1990) as, for example Balima, Combes, and Minea, 2021.

expressed in logarithm. The estimation performed by the Blundell and Bond, 1998 two-step system-GMM dynamic panel estimator to contain potential endogeneity problems shows a negative effect of mobile money on consumption volatility (column [2] of Table A.5 in Appendix A). Specifically, an increase in the logarithm of the mobile money accounts per population by one standard deviation decreases consumption volatility by 0.3 percentage points. This result shows that changing the measure of the treatment variable (from binary to continuous) does not alter the direction of our initial findings.

5.2. Alternative measure of volatility: skewness and kurtosis

Our main model relies on standard deviation to compute the volatility of consumption. In this section, we use two alternative measures of volatility, namely skewness, and kurtosis, which, unlike standard deviation, take into account the asymmetry of consumption shocks and the occurrence of extreme consumption shocks (Wolf, 2005; Cariolle & Goujon, 2015). Armed with these new measures, we evaluate the stabilizing effect of mobile money using entropy balancing. The results in columns [1] and [2] of Table A.1 in Appendix A show that adopting mobile money reduces the asymmetry of shocks and the occurrence of extreme consumption shocks by 9.68 percentage points and 8.53 percentage points respectively. Columns [3] and [4] analyze the counter-cyclical function of mobile money by evaluating its effect on negative and positive shocks. The results show that mobile money increases consumption in times of negative shocks and reduces it in times of positive shocks, thus providing a useful risk management opportunity. Finally, these results support that changing the measure of volatility does not alter our conclusions.

5.3. Alternative estimation methods

We use three methods to test the robustness of our results. This exercise aims to check if our results are influenced or biased by the choice of the estimation method. To do this, we use the Ordinary Least Squares (OLS) method, the propensity score method (PSM) developed by Rosenbaum and Rubin, 1983 and the Blundell and Bond, 1998 two-step system-GMM dynamic panel estimator.

First, we use Ordinary Least Squares (OLS). Starting with the most concise model that includes only the treatment variable as an explanatory variable, we gradually add the same control variables as those used in the baseline entropy balancing approach (see Neuenkirch & Neumeier, 2016; Balima, 2017; Ogrokhina & Rodriguez, 2019; Balima, 2020 for a similar approach). The results in columns [1] (the most concise specification) to [6] (the baseline specification) of the Table A.2 in Appendix A show that, similar to the entropy balancing approach, mobile money reduces consumption volatility independently of the specification. However, the relationship identified in the previous table may suffer from omitted variable bias. To mitigate this problem, we test the robustness of this relationship by extending our baseline specification with a set of control variables drawn from mobile money and consumption volatility literature. To do so, we use the previous four groups defined as follows: *i- economic variables*; *ii- political and institutional conditions*; *iii- climate considerations*; *iv- infrastructure and structural issues*.

To mitigate potential multicollinearity problems, we test the robustness of our findings to possible omitted variable biases by including these four groups one at a time in our baseline model. The results in Table A.3 (columns [1–4]) in Appendix A present the findings of the inclusion of economic variables, political and institutional conditions, climate considerations, and infrastructure and structural factors respectively. The conclusions show that, despite some loss of coefficients magnitude and observations compared to Table A.2 in Appendix A, our results remain consistent: mobile money reduces consumption volatility. However, because the four groups are included separately, the inclusion of economic variables, for example, allows us to mitigate the omitted variable bias from these variables, but our results can potentially suffer from omitted variable bias from the remaining three groups, namely political and institutional conditions, climate considerations, and infrastructure and structural factors. Accordingly, in column [5], we simultaneously include our four previous groups in the baseline model. The conclusions remain consistent with those reported previously despite some loss of magnitude and a larger reduction in the number of observations compared to Table A.2 (Appendix A). [16] Finally, it is important to note that the statistically significant control variables exhibit signs consistent with the literature. Thus, we notice that GDP volatility per capita, public investment volatility, public debt, and trade openness seem to increase consumption volatility while remittances, exchange rate regime, i.e., fixed exchange rate, the rule of law, internet adoption, and human capital tend to negatively influence household consumption volatility.[17] Next, we extend our robustness set by modifying the window of consumption volatility estimation, using the residual approach for consumption volatility estimation, excluding the pre-2000 period, former and current communist countries, countries that have recently adopted mobile money, using an alternative mobile money database, modifying our treatment variable, using the placebo mobile money, and using skewness and kurtosis as in the entropy balancing strategy. The results of these robustness tests, presented in Tables C.4 (columns [1–4]), C.5 (columns [2–11]), C.6 (columns [1–4]) of Appendix B, support the negative effect of mobile money on consumption volatility. However, the kurtosis coefficient is not statistically significant due to its p-value (13%) which is slightly above the 10% significance level. This result may reflect the limitations of OLS specifications to properly account for endogeneity issues in addition to the fact that a regression-based approach may suffer from restrictions on functional form and multicollinearity issues (see Neuenkirch & Neumeier, 2016). Next, we test the robustness of our results using the propensity score method, which is part of an impact analysis methods. It allows us to correct for endogeneity problems, particularly selection bias. The results in Table A.4 in Appendix A compile the estimation of the mobile money effect (ATT) using four matching methods: Nearest-Neighbor Matching, Radius Matching, Kernel Matching, and Local Linear Regression Matching. They allow us to conclude the consistency of our results to the choice of the alternative method since the ATTs are independent of the matching method used negatively and statistically significant.

We conclude this section by estimating the effect of mobile money using the Blundell and Bond, 1998 two-step system-GMM

[16] Conflict is excluded from the political and institutional conditions group (i.e. column [3] of Table A.3) because of its high correlation with internal and external conflict, 90% and 82% respectively (see Table D.6 in Appendix B). Consequently, the coefficient associated with this variable is omitted when included in the group. Similarly, because of its high correlation with real GDP per capita, i.e. 93% (see Table D.6 in Appendix B), the coefficient associated to initial GDP per capita is omitted when the variable is included in the infrastructure and structural issues group (i.e. column [4] of Table A.3). In order to include the conflict, we drop internal and external conflict in the political and institutional conditions group. Similarly, we drop real GDP per capita from the baseline model in order to include initial GDP per capita in the infrastructure and structural issues group. Finally, following column [5], we simultaneously include the full set of variables but drop those that are collinear with conflict and initial GDP per capita, i.e., internal and external conflict and real GDP per capita. The results of these modifications not presented in this paper but available on request provide conclusions in line with those previously highlighted.

[17] These associations are also supported by the correlation matrix presented in Table D.6 of Appendix B.

dynamic panel estimator. [18] This method provides us with two major opportunities. First, it allows us to include the lagged consumption volatility in the control variables. A possible justification is that the past household consumption volatility due to, for example, erosion of household assets can affect present consumption volatility. Second, this method addresses the lack of a valid external instrument for estimating the causal effect of mobile money on consumption volatility while controlling for the Nickell bias[19] that arises when estimating a dynamic panel with fixed effects. The results from this method are in column [1] of Table A.5 in Appendix A and show that mobile money adoption significantly decreases consumption volatility. More concretely, the adoption of mobile money decreases the volatility of consumption by 0.3 percentage point. In addition, results show some persistence of consumption volatility. This is signaled by a positive and significant coefficient of 0.74 for lagged consumption volatility.

Based on these different estimations, we can conclude that our results are robust to the choice of estimation method since changing the method does not qualitatively modify our conclusions.

6. Channels

6.1. Main driver of mobile money's stabilizing effect

This section tests the two identified channels by estimating mobile money's effect on financial inclusion and migrant remittances. Results presented in Table 6 below show that adopting mobile money increases financial inclusion by 5.1 percentage points and migrant remittances by 1.05 percentage points. These results validate our two main channels and show that mobile money's stabilizing effect on household consumption volatility can be driven by financial inclusion and access to external financing, particularly migrant remittances.[20]

6.2. Does mobile money mitigate the destabilizing effect of remittances?

A possible weakness of the remittances channel is its ability to destabilize consumption beyond some thresholds. In other words, remittances can increase consumption volatility above some threshold. We test this idea by estimating the effect of mobile money on six sub-samples arising from a position relative to the median level of remittances (2.14%) and considering thresholds of Chami, Hakura, and Montiel, 2009 and Combes and Ebeke, 2011. Table 7 presents the results. In contrast to expectations, mobile money's effect appears to be stronger in countries receiving higher remittances, especially in columns [1–4], while columns [5–6] tend to address the consumption volatility gap that may exist between countries receiving larger remittances and those receiving relatively lower amounts.[21] Two explanations can be mobilized for this result. First, mobile money can provide a framework for managing remittances flows to ensure consumption smoothing. Second, countries with high remittances inflows may expect volatility in consumption, so their marginal benefit from mobile money adoption may be large.

Table 6
Mobile money, financial inclusion, and remittances

	[1] Remittances (%GDP)	[2] Financial inclusion
Mobile money	1.050***	0.051***
	(0.2301)	(0.0043)
Covariates in the second step	Yes	Yes
Year fixed effects in the second step	Yes	Yes
Country fixed effects in the second step	Yes	Yes
Observations	1804	1727

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: Compared to Table 5, the observations in this table are different. This is mainly due to differences in the dependent variable in each of these tables.

7. Heterogeneity

7.1. The type of mobile money

Using the GSMA database, we disaggregate mobile money dummy into eight major transactions: international remittances, P2P transfer, bill payment, P2G transaction, G2P transaction, bulk payment, airtime top-up, and merchant payment.[22] The aim of this exercise is to test the hypothesis that consumption volatility would react differently depending on the mobile money service considered. The results in Table 8 present the conclusions of this hypothesis. With the exception of the P2G service (money transfer from individuals to the government), we find that mobile money adoption reduces consumption volatility regardless of the type of service. However, we observe some relative variations in the coefficients according to the type of mobile money, corroborating our intuition.

7.2. The effect of mobile money over time

In this section, we test whether mobile money adoption has a persistent or temporary effect. To achieve this, we estimate the effect of mobile money over five years after mobile money adoption. The results in Table 9 show that the effect of mobile money is persistent. This effect appears as soon as the mobile money is

[18] This method combines equations in levels and first differences in a system and estimated them with an extended system-GMM estimator that allows the use of lagged differences and levels of explanatory variables as instruments. Compared to the difference GMM estimator, system-GMM estimator allows introducing more instruments by adding a second equation, which should improve estimation efficiency. To tackle the problem of instrument proliferation raised by the above method (Roodman, 2009), the instrument matrix is collapsed and we limit the number of lags to three. Moreover, to avoid that the standard errors are downward-biased, we use the Windmeijer, 2005 finite-sample correction to reduce the possibility of spurious precision.

[19] See Nickell, 1981.

[20] It is important to note that additional channels can be identified. These channels include resource constraints (unemployment, working poor, poverty, inequality), sensitivity and vulnerability to shocks, human capital accumulation, institutional quality, informal sector. However, these channels are far from being independent of our two major ones. Their tests not shown in this section are in Table B.1 in Appendix A. An additional question regarding these channels may concern their potential endogeneity. If this is the case, our results would be seen as driven by these different variables rather than by mobile money itself. Although we tried to contain any potentially endogenous factors and differences that may influence our results in the robustness part of this paper, we carefully test this additional question that may emerge from these channels. To do so, we re-estimate the effect of mobile money by controlling with each of the Table B.1 variables. The results not reported in this paper and available on request show that including these variables does not undermine mobile money's negative and significant effect on consumption volatility. These results thus support the conclusion that the effect of mobile money on consumption volatility is more specific to the adoption of mobile money than to the different variables identified here as potential additional transmission channels. Finally, we replicate the results of Table B.1 and those obtained when including the additional channels as control variables, using OLS specification. The results not reported in this paper and available on request support those of entropy balancing.

[21] Combes and Ebeke, 2011 showed that countries above 5.5 percent exhibit consumption volatility reduction of 0.24 percent, compared to 1.07 percent for those below. This means that countries receiving more than 5.5 percent of GDP in remittances experience a decline in consumption volatility 4.45 times lower than those receiving below. In our analysis, this difference almost disappears with the use of mobile money since the ratio is 1.08. This result may lead to conclude that with mobile money, the relatively high level of remittances would no longer create a difference in consumption volatility between countries.

[22] See Appendix B for definitions.

Table 7
Mobile money, remittances, and consumption volatility

	[1] Remit<2.14	[2] Remit > 2.14	[3] Remit<2	[4] Remit > 2	[5] Remit<5.5	[6] Remit > 5.5
Mobile money	−0.669**	−1.057***	−0.669**	−1.059***	−1.074***	−0.990***
	(0.3010)	(0.2131)	(0.3066)	(0.1750)	(0.2252)	(0.2602)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes
County fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes
Observations	769	933	749	953	1168	534

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Columns [1] and [2] are based on the median value of remittances. Columns [3–4] and [5–6] consider respectively Chami et al., 2009 and Combes and Ebeke, 2011 thresholds. Note: No difference with observations in Table 5 when aggregating observations from each sub-sample.

Table 8
Mobile money and consumption volatility: disaggregating mobile money

Consumption volatility	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
International remittances	−0.675***							
	(0.2571)							
P2P transfer		−1.064***						
		(0.2320)						
Bill payment			−1.125***					
			(0.2283)					
P2G transaction				0.439				
				(0.2739)				
G2P transaction					−0.681**			
					(0.3010)			
Bulk payment						−1.041***		
						(0.2353)		
Airtime top up							−1.089***	
							(0.2285)	
Merchant payment								−1.101***
								(0.2309)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1702	1702	1702	1702	1702	1702	1702	1702

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: No difference with observations in Table 5.

Table 9
Mobile money and consumption volatility: mobile money effect over time

Consumption volatility	[1]	[2]	[3]	[4]	[5]	[6]
Mobile money adoption (t0)	−0.502**					
	(0.2177)					
First year after adoption (t + 1)		−0.528**				
		(0.2108)				
Second year after adoption (t + 2)			−0.676***			
			(0.2121)			
Third year after adoption (t + 3)				−0.780***		
				(0.2142)		
Fourth year after adoption (t + 4)					−0.850***	
					(0.2216)	
Five year after adoption (t + 5)						−0.917***
						(0.2237)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1312	1361	1409	1457	1502	1546

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: Compared to Table 5, observations related to the treatment variable differ. The first column constructs a new treatment variable by dropping all observations following the mobile money initiation year. Columns [2–6] consider only observations for 1, 2, 3, 4 and 5 years after the mobile money adoption year, respectively.

adopted and increases over time to approach the (average) magnitude of our baseline effect five years after adopting the policy.

7.3. The contribution of structural factors

Despite having some common characteristics, developing countries are subject to various structural differences that shape mobile money's effect on consumption volatility. Consequently, this section examines the heterogeneity effect of mobile money according to five characteristics: trade openness, inflation, rural population, the rule of law, and level of development.

First, we analyze the effectiveness of mobile money concerning trade openness, inflation, rural population, and level of development. Given their link with consumption volatility and/or financial

Table 10
Mobile money and consumption volatility: structural factors

	[1]	[2]	[3]	[4]	[5]
Mobile money	−0.852**	−2.183***	−1.262***	−2.168***	−1.278***
	(0.3745)	(0.3089)	(0.2352)	(0.4520)	(0.2413)
Mobile money*trade openness	−0.012**				
	(0.0053)				
Trade openness	0.025***				
	(0.0066)				
Mobile money*inflation		−0.194***			
		(0.0567)			
Inflation		0.048***			
		(0.0181)			
Mobile money*rural population			−0.817***		
			(0.3153)		
Rural population			0.119***		
			(0.0369)		
Mobile money*rule of law				−1.913***	
				(0.7019)	
Rule of law				−1.271*	
				(0.6713)	
Mobile money*middle income countries					0.616**
					(0.2562)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes
Observations	1692	1696	1702	1223	1702

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: The difference between columns [1–4] and Table 5 is due to differences in observations on the interaction variables.

deprivation (di & Levchenko, 2006; Donovan, 2012; Jacolin et al., 2021), we hypothesize that mobile money adoption may have a larger effect in situations characterized by high trade openness, high inflation, high rural population, and in relatively low-income countries. To test this hypothesis, we include an interaction between each of these variables and mobile money. Accordingly, a statistically significant interaction means the presence of heterogeneity. Results in columns [1], [2], [3] and [5] of Table 10 support our hypothesis. Indeed, the negative and statistically significant sign of interaction between mobile money and each of these variables, i.e., trade openness, inflation, rural population, and level of development,[23] suggests that the effect of mobile money can be amplified in situations characterized by high trade openness, high inflation, high rural population, and in relatively low-income countries.

Second, we analyze the sensitivity of our results to institutions (specifically the rule of law). The results of column [4] show a larger effect of mobile money in situations of good institutional conditions, i.e., high rule of law, thus supporting the literature on institutional quality influence on policy efficiency (Llanto & Gonzalez, 2007). [24]

8. Conclusion

This paper analyzes the effect of mobile money adoption on consumption volatility. Using a large sample of 76 developing countries over the period 1990–2019 and relying on entropy balancing, we show that countries using mobile money exhibit a lower level of consumption volatility supporting external validity of existing studies. This result is robust to various tests, including alternative specifications, alternative consumption volatility measures including skewness and kurtosis, and alternative estimation methods. Transmission channel analysis indicates that remittances and financial inclusion drive mobile's stabilizing effect. However, results reveal some heterogeneity across the type of mobile money, time, and structural factors such as trade openness, inflation, rural population, the rule of law, and level of development. Additional results highlighted in this paper show that mobile money not only stabilizes consumption in developing countries but as microeconomic literature supports the level of consumption of households in developing countries.

This study contributes, based on cross-country analysis, to the debate on the role of financial innovations (such as mobile money) on welfare and risk management (sharing) in developing countries. In this paper, we present another aspect of risk, namely consumption uncertainty measured by volatility. Demonstrating that mobile money is a welfare-enhancing tool by reducing consumption volatility (or smoothing household consumption), this paper may allow policymakers concerned with social justice and inclusive growth to consider its extension for a more equitable post-Covid-19 period.

CRediT authorship contribution statement

Ablam Estel Apeti: Conceptualization; Data curation; Formal analysis; Methodology; Software; Writing - original draft; Writing - review editing.

Declaration of Competing Interest

None

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[23] The coefficient of the level of development defined as a dummy that takes 1 if a country is classified as a middle-income country is omitted if the variable is added simultaneously with its interaction with mobile money in the model. In addition, note that trade openness, inflation, and rural population positively influence consumption volatility.

[24] Finally, note that we draw similar conclusions to those in Sections 6,7 using OLS regressions (see Tables D.1,D.2,D.3,D.4,D.5 in Appendix B).

Appendix A

Table 11
Mobile money and consumption volatility: additional control in the second stage and altering the sample

	[1] Exluding 90s	[2] Excluding former and current communist countries	[3] Excluding new mobile money countries	[4] GDP volatility per capita	[5] Public investment volatility	[6] Financial openness	[7] Financial openness squared	[8] ODA	[9] Human capital
Mobile money	−0.801***	−1.105***	−1.188***	−1.004***	−1.063***	−1.135***	−1.125***	−1.152***	−0.530***
	(0.2452)	(0.2753)	(0.2424)	(0.2369)	(0.2498)	(0.2333)	(0.2341)	(0.2425)	(0.1899)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1376	1345	1560	1655	1426	1604	1604	1547	1574
	[10] Initial GDP per capita	[11] Social globailisation	[12] Exchange rate	[13] Vulnerability	[14] Resilience	[15] Rule of law	[16] Investment freedom	[17] Exchange rate regime	[18] Trade openness
Mobile money	−1.209***	−1.072***	−1.155***	−1.070***	−0.907***	−0.921***	−0.978***	−1.140***	−1.190***
	(0.2324)	(0.2424)	(0.2302)	(0.2380)	(0.2440)	(0.2365)	(0.2022)	(0.2330)	(0.2221)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1616	1702	1702	1537	1537	1231	1564	1702	1691
	[19] Financial development	[20] Remittances	[21] Electricity access	[22] Electricity consumption	[23] Agricultural productivity	[24] Public debt	[25] Mobile cellular	[26] Corruption	[27] Internet adoption
Mobile money	−1.120***	−0.952***	−1.149***	−0.775***	−1.110***	−0.647***	−0.653**	−0.872***	−0.878***
	(0.2261)	(0.2193)	(0.2262)	(0.2260)	(0.2270)	(0.2246)	(0.2679)	(0.2363)	(0.2472)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1571	1608	1702	1205	1571	1469	1702	1231	1702
	[28] Internal conflict	[29] External conflict	[30] Conflict	[31] Weather shocks	[32] Commodity price shock	[33] Current expenditure (% GDP)	[34] Public investment (% GDP)	[35] Current expenditure (% public expenditure)	[36] Public investment (% public expenditure)
Mobile money	−0.944***	−0.927***	−1.009***	−1.039***	−0.903***	−1.076***	−1.079***	−1.068***	−1.056***
	(0.2209)	(0.2268)	(0.2288)	(0.2374)	(0.2121)	(0.2049)	(0.2445)	(0.2001)	(0.2465)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1318	1318	1318	1687	1490	1467	1562	1467	1472

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: The differences that can be observed between observations in Table 5 and those in this table (except columns [11], [12], [17], [21], [25], and [27]) are attributable to our sample's alteration, which is materialized by the exclusion of some countries or years on the one hand, and on the other hand by the number of observations of additional variables.

Table 12
Mobile money and consumption volatility: additional controls in first stage, in both second stage and first stage

	[1] GDP volatility per capita	[2] Public investment volatility	[3] Financial openness	[4] Financial openness squared	[5] ODA	[6] Human capital	[7] Initial GDP per capita	[8] Social globalisation	[9] Exchange rate	[10] Vulnerability	[11] Resilience
				Panel A: Additional controls in the first step only							
Mobile money	−0.930***	−0.800***	−1.149***	−1.134***	−1.147***	−0.476**	−0.935***	−0.365	−1.085***	−0.985***	−0.999***
	(0.2516)	(0.2450)	(0.2284)	(0.2292)	(0.2243)	(0.1921)	(0.2762)	(0.3687)	(0.2315)	(0.2447)	(0.2358)
Covariates in the second step	No	No	No	No	No	No	No	No	No	No	No
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1655	1426	1604	1604	1547	1574	1616	1702	1702	1537	1537
	[12] Rule of law	[13] Investment freedom	[14] Exchange rate regime	[15] Trade openness	[16] Financial development	[17] Remittances	[18] Electricity access	[19] Electricity consumption	[20] Agricultural productivity	[21] Public debt	[22] Mobile cellular
Mobile money	−0.834***	−0.942***	−1.098***	−1.180***	−1.040***	−0.944***	−0.986***	−0.780***	−0.832***	−0.499**	0.478
	(0.2444)	(0.2170)	(0.2108)	(0.2236)	(0.2001)	(0.2184)	(0.2249)	(0.2143)	(0.2229)	(0.2328)	(0.5880)
Covariates in the second step	No	No	No	No	No	No	No	No	No	No	No
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1231	1564	1702	1691	1571	1608	1702	1205	1571	1469	1702
	[23] Corruption	[24] Internet adoption	[25] Internal conflict	[26] External conflict	[27] Conflict	[28] Weather shocks	[29] Commodity price shock	[30] Current expenditure (% GDP)	[31] Public investment (% GDP)	[32] Current expenditure (% public expenditure)	[33] Public investment (% public expenditure)
Mobile money	−0.848***	−0.878***	−0.926***	−0.954***	−1.022***	−0.920***	−0.862***	−1.071***	−1.044***	−0.953***	−0.949***
	(0.2387)	(0.2472)	(0.2138)	(0.2266)	(0.2244)	(0.3077)	(0.2214)	(0.2093)	(0.2387)	(0.2079)	(0.2501)
Covariates in the second step	No	No	No	No	No	No	No	No	No	No	No
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1231	1702	1318	1318	1318	1687	1490	1467	1562	1467	1472

(*continued on next page*)

Table 12 (*continued*)

	[1] GDP volatility per capita	[2] Public investment volatility	[3] Financial openness	[4] Financial openness squared	[5] ODA	[6] Human capital	[7] Initial GDP per capita	[8] Social globailisation	[9] Exchange rate	[10] Vulnerability	[11] Resilience
				Panel B: Additional controls in both the second stage and the first stage							
Mobile money	−1.519***	−1.319***	−1.591***	−1.586***	−1.618***	−1.592***	−1.654***	−1.456***	−1.586***	−1.439***	−1.476***
	(0.1439)	(0.1486)	(0.1445)	(0.1444)	(0.1439)	(0.1479)	(0.1472)	(0.1545)	(0.1443)	(0.1467)	(0.1651)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1655	1426	1604	1604	1547	1574	1616	1702	1702	1537	1537
	[12] Rule of law	[13] Investment freedom	[14] Exchange rate regime	[15] Trade openness	[16] Financial development	[17] Remittances	[18] Electricity access	[19] Electricity consumption	[20] Agricultural productivity	[21] Public debt	[22] Mobile cellular
Mobile money	−1.105***	−1.434***	−1.633***	−1.600***	−1.466***	−1.643***	−1.544***	−1.002***	−1.297***	−1.075***	−0.930***
	(0.1621)	(0.1465)	(0.1502)	(0.1380)	(0.1457)	(0.1490)	(0.1407)	(0.1637)	(0.1665)	(0.1593)	(0.1872)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1231	1564	1702	1691	1571	1608	1702	1205	1571	1469	1702
	[23] Corruption	[24] Internet adoption	[25] Internal conflict	[26] External conflict	[27] Conflict	[28] Weather shocks	[29] Commodity price shock	[30] Current expenditure (% GDP)	[31] Public investment (% GDP)	[32] Current expenditure (% public expenditure)	[33] Public investment (% public expenditure)
Mobile money	−1.099***	−1.570***	−1.166***	−1.171***	−1.188***	−1.620***	−1.182***	−1.639***	−1.532***	−1.616***	−1.492***
	(0.1624)	(0.2178)	(0.1521)	(0.1544)	(0.1545)	(0.1599)	(0.1372)	(0.1614)	(0.1476)	(0.1591)	(0.1523)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1231	1702	1318	1318	1318	1687	1490	1467	1562	1467	1472

Unreported constant included. Standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Note: The differences that can be observed between observations in Table 5 and those in this table (except columns [8], [9], [14], [18], [22], and [24]) are attributable to the number of observations of additional variables.

Table 13
Mobile money and consumption volatility: adding control variables by groups

	[1] Economic variables group	[2] Political and institutional conditions group	[3] Climate considerations group	[4] Infrastructure and structural issues group	[5] All groups
Panel A: Adding groups in the second stage only					
Mobile money	−0.437**	−1.098***	−0.587***	−0.441**	−0.470*
	(0.2048)	(0.2303)	(0.2174)	(0.2154)	(0.2458)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes
Observations	980	1459	1028	1204	768
	[1] Economic variables group	[2] Political and institutional conditions group	[3] Climate considerations group	[4] Infrastructure and structural issues group	[5] All groups
Panel B: Adding groups in the first stage only					
Mobile money	−0.464***	−1.301***	−0.667***	−0.721***	−0.721***
	(0.1658)	(0.1576)	(0.1750)	(0.2006)	(0.2006)
Covariates in the second step	No	No	No	No	No
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes
Observations	980	1459	1028	1204	1204
	[1] Economic variables group	[2] Political and institutional conditions group	[3] Climate considerations group	[4] Infrastructure and structural issues group	[5] All groups
Panel C: Adding groups in both the second stage and the first stage					
Mobile money	−0.384*	−1.066***	−0.658***	−0.467**	−0.468*
	(0.2069)	(0.2224)	(0.2435)	(0.2328)	(0.2447)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes
Observations	980	1459	1028	1204	768

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: Differences between observations in columns [1–5] and those of Table 5 are due to differences in observations of additional covariates.

Table 14
Mobile money and consumption volatility: changing the moving window

Consumption volatility (using 4-year moving window)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	−1.253***	−1.564***	−1.254***	−1.566***	−1.314***	−1.109***	−1.316***	−1.110***
	(0.2282)	(0.1453)	(0.2281)	(0.1457)	(0.2231)	(0.2310)	(0.2227)	(0.2312)
Covariates in the second step	No	No	No	No	Yes	Yes	Yes	Yes
Year fixed effects in the second step	No	No	Yes	Yes	No	No	Yes	Yes
Country fixed effects in the second step	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1763	1763	1763	1763	1763	1763	1763	1763
Consumption volatility (using 3-year moving window)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	−1.084***	−1.471***	−1.084***	−1.469***	−1.127***	−1.106***	−1.128***	−1.104***
	(0.2269)	(0.1553)	(0.2267)	(0.1555)	(0.2198)	(0.2231)	(0.2195)	(0.2233)
Covariates in the second step	No	No	No	No	Yes	Yes	Yes	Yes
Year fixed effects in the second step	No	No	Yes	Yes	No	No	Yes	Yes
Country fixed effects in the second step	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1822	1822	1822	1822	1822	1822	1822	1822
Consumption volatility (using 2-year moving window)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	−1.055***	−1.473***	−1.055***	−1.467***	−1.073***	−1.060***	−1.073***	−1.056***
	(0.2438)	(0.1762)	(0.2438)	(0.1762)	(0.2371)	(0.2509)	(0.2370)	(0.2508)
Covariates in the second step	No	No	No	No	Yes	Yes	Yes	Yes
Year fixed effects in the second step	No	No	Yes	Yes	No	No	Yes	Yes
Country fixed effects in the second step	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1880	1880	1880	1880	1880	1880	1880	1880

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: The differences between observations in this table and those in Table 5 are mainly due to the manner the outcome variable is computed. Table 5 uses a 5-year moving window while, here, we use 4-, 3-, and 2-year moving windows, respectively.

Table 15
Mobile money and consumption volatility: using residual approach

Consumption volatility (residual approach)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	−1.408***	−1.546***	−1.415***	−1.554***	−1.455***	−0.921***	−1.463***	−0.925***
	(0.2703)	(0.1695)	(0.2699)	(0.1698)	(0.2851)	(0.2362)	(0.2843)	(0.2362)
Covariates in the second step	No	No	No	No	Yes	Yes	Yes	Yes
Year fixed effects in the second step	No	No	Yes	Yes	No	No	Yes	Yes
Country fixed effects in the second step	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1592	1592	1592	1592	1592	1592	1592	1592

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: Differences in the outcome variable construction using a residual approach explain some loss of observation compared to Table 5.

Table 16
Mobile money and consumption volatility: using IMF Financial Access Survey

Consumption volatility	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money (FAS)	−1.371***	−1.733***	−1.372***	−1.735***	−1.426***	−0.920***	−1.430***	−0.922***
	(0.2282)	(0.1726)	(0.2282)	(0.1731)	(0.2266)	(0.2332)	(0.2265)	(0.2333)
Covariates in the second step	No	No	No	No	Yes	Yes	Yes	Yes
Year fixed effects in the second step	No	No	Yes	Yes	No	No	Yes	Yes
Country fixed effects in the second step	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1702	1702	1702	1702	1702	1702	1702	1702

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: No difference with observations in Table 5.

Table 17
Mobile money and consumption volatility: altering mobile money definition

Consumption volatility	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Mobile money (w/o banks)	−1.111***						
	(0.2328)						
Mobile money (w/o first year adoption)		−1.217***					
		(0.2458)					
Anticipated mobile money			−0.914***				
			(0.1824)				
Lagged mobile money				−1.099***			
				(0.2292)			
Mobile money (initial adoption year only)					−1.888***		
					(0.1712)		
Placebo mobile money (random dates)						0.041	
						(0.1517)	
Placebo mobile money (start date before the actual start date)							0.442
							(1.1749)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1608	1652	1701	1702	520	1262	1301

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: With the exception of columns [4] and, to some extent [3], differences in the observations of columns [1–2] and [5–7] compared to Table 5 arise from changes in the definition of the treatment variable and sample alteration. Observations in column [1] in which the dependent variable is different are similar to those in Table 4.

Table A.1
Mobile money and consumption volatility: alternative measure of volatility

Consumption volatility	[1] Skewness	[2] Kurtosis	[3] Negative skewness	[4] Positive skewness
Mobile money	−9.683**	−8.531**	9.055***	−8.929***
	(3.7759)	(3.3362)	(3.2391)	(3.4033)
Covariates in the second step	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes
Observations	1702	1702	924	778

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. No difference with observations in Table 5 regarding columns [1–2] and [3–4] when aggregating observations from each sub-sample.

Table A.2
Mobile money and consumption volatility: using OLS

	[1] OLS	[2] OLS	[3] OLS	[4] OLS	[5] OLS	[6] OLS
Mobile money	−1.568***	−1.514***	−0.780***	−0.766***	−0.768***	−0.753***
	(0.1425)	(0.1463)	(0.1945)	(0.1957)	(0.1958)	(0.1957)
Inflation		0.002	0.001	0.001	0.001	0.001
		(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Real GDP per capita (log)			−2.385***	−2.543***	−2.534***	−2.457***
			(0.4425)	(0.4824)	(0.4824)	(0.4834)
Fixed telephone				0.028	0.028	0.030
				(0.0196)	(0.0195)	(0.0196)
Labor force					−0.027	−0.027
					(0.0717)	(0.0717)
Urban population growth						0.165*
						(0.0928)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1873	1702	1702	1702	1702	1702
R^2	0.538	0.617	0.628	0.628	0.628	0.629

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: The differences between the observations in columns [1] and those in Table 5 are due to the non-inclusion of covariates.

Table A.3
Mobile money and consumption volatility: using OLS

	[1] Consumption volatility	[2] Consumption volatility	[3] Consumption volatility	[4] Consumption volatility	[5] Consumption volatility
Mobile money	−0.537***	−0.669***	−0.425**	−0.607***	−0.371*
	(0.1828)	(0.1983)	(0.1994)	(0.1906)	(0.2114)
Inflation	0.039*	0.010***	0.040**	0.001	0.022
	(0.0223)	(0.0033)	(0.0186)	(0.0013)	(0.0179)
Real GDP per capita (log)	−0.669	−1.405	−0.199	−3.446	0.099
	(2.0552)	(0.9825)	(0.9090)	(3.6587)	(1.6234)
Fixed telephone	0.008	0.023	0.049	0.043	0.053
	(0.0316)	(0.0305)	(0.0336)	(0.0411)	(0.0360)
Labor force	0.093	0.036	0.002	−0.051	0.094
	(0.0970)	(0.0941)	(0.0880)	(0.1036)	(0.0985)
Urban population growth	0.106	0.009	0.326	0.178	0.077
	(0.1135)	(0.2096)	(0.1965)	(0.1482)	(0.2182)
GDP volatility per capita	0.429*				0.304
	(0.2485)				(0.2260)
Commodity price shock	−0.240				−0.096
	(0.1594)				(0.1091)
Current expenditure (% GDP)	0.141				0.219
	(0.1036)				(0.1120)
Public investment (% GDP)	−0.122				−0.232
	(0.1117)				(0.1378)
Current expenditure (% public expenditure)	−5.518				−7.987
	(2.7777)				(3.8930)
Public investment (% public expenditure)	3.199				5.660
	(3.2260)				(3.6699)
Public investment volatility	0.483				1.342**
	(0.4639)				(0.5061)
Public debt	0.017*				0.014
	(0.0090)				(0.0086)
Financial development	−3.840				−4.242
	(5.1260)				(3.6841)
Financial openness	−0.216				−0.375
	(0.2319)				(0.3553)
Financial openness squared	0.160				0.349
	(0.1645)				(0.2113)
ODA	−0.034				−0.100
	(0.0557)				(0.0697)
Remittances	−0.145**				−0.118**
	(0.0644)				(0.0587)
Trade openness	0.025*				0.035**
	(0.0138)				(0.0167)

(*continued on next page*)

Table A.3 (*continued*)

	[1] Consumption volatility	[2] Consumption volatility	[3] Consumption volatility	[4] Consumption volatility	[5] Consumption volatility
Exchange rate regime	−1.356***				−1.529***
	(0.4928)				(0.4109)
Exchange rate	0.934				0.204
	(0.6151)				(0.6242)
Vulnerability		−18.526			−17.555
		(16.3195)			(11.8288)
Resilience		7.379			−0.846
		(7.0694)			(7.6855)
Weather shocks		−0.316			0.115
		(0.2345)			(0.1444)
Internal conflict			−0.019		0.018
			(0.1005)		(0.1174)
External conflict			0.224		−0.071
			(0.1982)		(0.1861)
Rule of law			−1.016		−2.138**
			(0.7519)		(0.9896)
Investment freedom			0.019		0.023
			(0.0119)		(0.0138)
Corruption			0.126		1.081
			(0.5971)		(0.8237)
Social globalisation				0.633	0.500
				(0.3805)	(0.3479)
Mobile cellular				−0.271	−0.042
				(0.2728)	(0.2569)
Internet adoption				−0.965**	−0.557*
				(0.4544)	(0.3113)
Electricity access				−0.352	−0.296
				(0.2193)	(0.2166)
Electricity consumption				−0.015	0.220
				(0.5187)	(0.5816)
Human capital				−0.480*	−0.356
				(0.2621)	(0.2897)
Agricultural productivity				−0.462	0.065
				(0.2516)	(0.2993)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	980	1459	1028	1205	763
R^2	0.710	0.685	0.674	0.632	0.781

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: Differences between observations in columns [1–5] and those of Table 5 are due to differences in observations of additional covariates.

Table A.4
Mobile money and consumption volatility: using PSM

Dependent Variable	Nearest-Neighbor Matching			Radius Matching			Kernel Matching	Local Linear Regression Matching
Consumption volatility	N = 1	N = 2	N = 3	r = 0.005	r = 0.01	r = 0.05		
	Mobile money on consumption volatility							
ATT	−1.716***	−1.516***	−1.463***	−1.495***	−1.550***	−1.529***	−1.528***	−1.533***
	(0.4482)	(0.3964)	(0.3688)	(0.2779)	(0.2626)	(0.2538)	(0.2554)	(0.2384)
Number of Treated Obs.	440	440	440	440	440	440	440	440
Number of Controls Obs.	1262	1262	1262	1262	1262	1262	1262	1262
Observations	1702	1702	1702	1702	1702	1702	1702	1702
Pseudo R^2	0.003	0.007	0.005	0.006	0.007	0.005	0.005	0.003
Standardized biases (p-value)	0.680	0.159	0.357	0.213	0.154	0.327	0.301	0.680
Rosenbaum bounds sensitivity tests	1.6	2.1	2.7	4.1	4.5	4.6	4.7	4.7

Bootstrapped standard errors based on 500 replications reported in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: No difference with observations in Table 5.

Table A.5
Mobile money and consumption volatility: using System-GMM

	[1] System-GMM	[2] System-GMM
Mobile money (dummy)	−0.287*	
	(0.1606)	
Log mobile money account (% population)		−0.058**
		(0.0276)
Inflation	0.004	0.004
	(0.0026)	(0.0024)
Real GDP per capita (log)	−0.144	−0.169
	(0.3278)	(0.2324)
Fixed telephone	0.027	0.021
	(0.0358)	(0.0236)
Labor force	0.084	0.045
	(0.0817)	(0.0504)
Urban population growth	0.197	0.122
	(0.1202)	(0.1154)
Lag consumption volatility	0.793***	0.788***
	(0.0416)	(0.0401)
AR(1)/AR(2) p-value	0.002/ 0.822	0.003/ 0.805
Hansen test p-value	0.195	0.195
Observations	1639	1639

Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: In the GMM estimation, the use of lagged variables explains the loss of some observations compared to Table 5. The number of instruments is 52 and that of countries is 73. The regressions include time fixed effects.

Appendix B

Table B.1
Mobile money and consumption volatility: testing additional channels

	[1] Aggregate shock	[2] Agricultural shock	[3] Inflation shock	[4] Economic vulnerability	[5] Unemployment rate	[6] Working poverty rate
Mobile money	−0.629***	−1.285***	−0.708*	−2.013***	−0.151***	-3.330***
	(0.1267)	(0.4458)	(0.3704)	(0.2827)	(0.0419)	(0.4286)
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1762	1711	1859	1193	1252	1259
	[7] Poverty rate	[8] Inequality	[9] Human capital	[10] Corruption	[11] Informal sector (% of GDP)	
Mobile money	−5.890***	−1.102***	0.193***	−0.144***	−2.462***	
	(0.4919)	(0.1415)	(0.0120)	(0.0504)	(0.2763)	
Covariates in the second step	Yes	Yes	Yes	Yes	Yes	
Year fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	
Country fixed effects in the second step	Yes	Yes	Yes	Yes	Yes	
Observations	1882	1637	1779	1438	1585	

Unreported constant included. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Note: In this table, differences in observations arise from outcome variables that are quite different from the dependent variable used in Table 5.

B.1. *Justification of the groups of Sections 5.1 and 5.3.*

Recall that the groups, which are of four, are the following: *i- economic variables*: GDP volatility per capita, commodity price shock, public investment volatility, public investment (% GDP), current expenditure (% GDP), public investment (% public expenditure), current expenditure (% public expenditure), public debt, financial openness, financial openness squared, ODA, remittances, trade openness, exchange rate, exchange rate regime; *ii- political and institutional conditions: internal conflict, external conflict, conflict, the rule of law, investment freedom, corruption; iii- climate considerations: climate resilience, climate vulnerability, weather shocks; iv- infrastructure and structural issues: social globalization, mobile cellular, internet adoption, electricity access, electricity consumption, human capital, agricultural productivity, initial GDP per capita*.

First, we suspect that economic variables may influence the relationship between mobile money and consumption volatility for several reasons. Indeed, macroeconomic instability captured by GDP volatility per capita represents a key factor that may affect consumption volatility. For example, as illustrated by Herrera, 2008 and Combes and Ebeke, 2011 GDP volatility per capita positively influences consumption volatility illustrating the effect of aggregate shock on consumption volatility. An additional macroeconomic shock variable that can shape household consumption volatility is commodity price shock. As illustrated by Kebede, 2022, variations in commodity prices can have significant pass-through to household food and non-food consumption. Based on Ethiopia, a coffee-producing country, the authors show that a reduction in international coffee prices reduces household consumption. In addition, commodity price shock can reduce growth and increase inflation, thus reducing the ability of households to access consumption goods (Cavalcanti et al., 2015; Sekine & Tsuruga, 2018) and consequently their ability to smooth their consumption.

Fiscal policy can also influence consumption volatility through public expenditure composition or policy space availability to mitigate the effect of shocks. For example, current expenditure might matter critically in times of crisis or rising commodity prices through subsidies or wage increases. Similarly, public investment can also play an important role in supporting the ability of households to smooth their consumption. Indeed, Mondal and Khanam, 2018 stress that an important omission in consumption volatility literature is the lack of consideration of public investment or government investment in fixed capital formation. Specifically, according to the authors, these expenditures allow governments to finance assets that households cannot produce, although these assets are important to smooth their consumption. In addition to public investment in level, we add public investment volatility to account for the effect of instability in public asset financing on household consumption and, as Mondal and Khanam, 2018 we expect public investment volatility to increase consumption volatility. Finally, public debt represents a policy space tool, especially fiscal space, that allows governments to provide support programs to households in times of crisis, for example. Indeed, as shown by Apeti, Combes, Debrun, and Minea, 2021, the size of fiscal response to crises–that generate consumption volatility (Combes & Ebeke, 2011)–depends on fiscal space. Indeed, the authors find that countries with relatively low debt levels are more likely to support households in times of crisis through discretionary fiscal policies, i.e., increased spending. This conclusion found by the authors in the context of the Covid-19 crisis is consistent with the literature on countries' responses to crises or shocks (Aizenman & Jinjarak, 2010; Jordà, Schularick, & Taylor, 2016; Romer & Romer, 2018; Romer & Romer, 2019). Conversely, public debt can reduce households' ability to smooth their consumption due to the crowding-out effect of higher taxes (Barro, 1974) or higher interest rates and, consequently, lack of access to credit.

Financial conditions and integration into global finance and trade can influence consumption volatility. For example, financial development is identified in the literature as a driver of consumption smoothing given that efficiency of the financial market can shape the degree of consumption volatility (Bekaert, Harvey, & Lundblad, 2006; Ahmed & Suardi, 2009; Combes & Ebeke, 2011; Mondal & Khanam, 2018). Financial and trade openness influence consumption volatility. On the one hand, financial openness increases the degree of exposure to global financial crises but also offers new opportunities for portfolio diversification. On the other hand, trade openness may offer greater real integration, allow greater specialization of sectors and further diversification of sources of demand, but also create macroeconomic instability which could undermine consumption stabilization (Giovanni & Levchenko, 2009; Kose, Prasad, & Terrones, 2003; Combes & Ebeke, 2011; Mondal & Khanam, 2018; Riley, 2018). Consistent with these discussions, we think the sign of financial openness, as well as trade openness, to be ambiguous; i. e., each of these variables can negatively or positively influence consumption volatility. Following Kose et al., 2003 and Combes and Ebeke, 2011, we add to these two variables financial openness squared to capture potential nonlinearities that may characterize the relationship between consumption volatility and financial openness. Official Development Assistance (ODA) and remittances are introduced to harness their risk-sharing and consumption-smoothing power as shown by several authors in the literature (Amuedo-Dorantes & Pozo, 2011; Combes & Ebeke, 2011; Ebeke & Combes, 2013; Combes, Ebeke, Etoundi, & Yogo, 2014; Jack & Suri, 2014; Balli & Rana, 2015; Gröger & Zylberberg, 2016; Munyegera & Matsumoto, 2016; Mondal & Khanam, 2018; Riley, 2018; Giannelli & Canessa, 2022; Islamaj & Kose, 2022). In addition to financial and trade variables, we suspect that monetary conditions may also affect the ability of households to smooth their consumption. For example, exchange rate volatility induces risk premiums for long-term agreements, increases production costs, and reduces consumption growth. Also, exchange rate uncertainty leads to high risk in investment decisions, threatening the performance of macroeconomic variables that correlate positively with household consumption. Finally, given that developing countries rely heavily on imported raw materials in their domestic production process, changes in exchange rates may affect domestic goods prices, thus shaping household consumption patterns (Oseni, 2016). Therefore, we can expect that stable exchange rates, or exchange rate regimes that provide exchange rate stability, can potentially protect household consumption from exchange rate fluctuations, thus providing an opportunity for consumption smoothing. In line with this literature, we control for the effect of monetary policy by including two variables, namely exchange rate regime and exchange rate.

Second, we suppose that our relationship can be influenced by political and institutional frameworks. For example, political shocks such as conflict may influence the relationship between mobile money and consumption volatility. In analyzing the effect of conflict on consumption smoothing, Ibáñez and Moya, 2006 find a negative effect, i.e., conflict limits households' ability to smooth their consumption. The mechanism behind this result is that conflict causes a significant loss of assets, limits the ability of households to generate income, disrupts risk-sharing mechanisms, and forces households to resort to costly strategies in order to smooth their consumption. This negative effect of conflict on consumption is also supported by Adong, Kornher, Kirui, and von Braun, 2021. Also, institutional conditions may determine mobile money and/or consumption volatility. On the one hand, as discussed by Jacolin et al., 2021, less restrictive investment environments and

sound institutional frameworks measured by investment freedom and the rule of law, respectively, favor successful mobile money. On the other hand, countries with low corruption and sound rule of law may promote better allocation of resources and better production of public goods required for household consumption smoothing. Third, we assume that our results may be influenced by climate conditions. As shown by Gregory, Ingram, and Brklacich, 2005; Jack and Suri, 2014; Riley, 2018, climate shocks have a negative impact on household consumption. To control this effect, we include three climate variables, namely weather shocks, supplemented by climate shock vulnerability and resilience to address the role of adaptation to climate shocks that determines households' predisposition to contain the negative effect of climate shocks and thus their ability to smooth their consumption (Di Falco, Veronesi, & Yesuf, 2011).

Finally, we control the influence of infrastructure and structural factors. The existing studies document the effect of information and communication technology (ICT) on household welfare. The conclusion indicates that ICT improves households' welfare. For example, cell phones (or mobile cellular) could enhance market integration, income, and economic performance (Aker, 2010; Andrianaivo & Kpodar, 2012; Khanal, Mishra, & Koirala, 2015; Wamboye, Adekola, & Sergi, 2016; Appiah-Otoo & Song, 2021; Gurning & Khaliqi, 2021; Mora-Rivera & García-Mora, 2021; Yang, Lu, Wang, & Li, 2021) thus reducing income unpredictability and promoting consumption smoothing (Herrera, 2008). In addition, cell phones allow network expansion and efficient communication, thus helping reduce household consumption volatility. To control the effect of ICT, we include cell phones in our baseline model that we complement with internet adoption and social globalization index, which captures international interpersonal contacts, cultural proximity, and information flow through television, internet use, and the presence of foreign population. It is important to note that internet, which promotes GDP per capita, offers consumption smoothing mechanisms to households (Koutroumpis, 2009; Qiang, Rossotto, & and Kimura, 2009; Czernich, Falck, Kretschmer, & Woessmann, 2011; García & López-Rivas, 2012; Minges, 2015). Also, social globalization can help to smooth household consumption by promoting institutional quality such as the rule of law and corruption reduction through the diffusion of ideas and information via internet or television (Keohane, Nye, & Donahue, 2002; Berdiev & Saunoris, 2018). Next, we control the effect of access to energy, especially access to electricity and electricity consumption. On the one hand, access to energy emerges as an important infrastructure for mobile phone use–which represents important support or infrastructure for mobile money service use– by making its battery easier to regenerate. On the other hand, access to electricity and electricity consumption are identified as drivers of economic performance, notably an increase in GDP per capita and an increase in household consumption, thus presenting an important framework for household consumption management (Best & Burke, 2018; Falentina & Resosudarmo, 2019; Stern, Burke, & Bruns, 2019; Lee, Miguel, & Wolfram, 2020; Moore et al., 2020; Candelise, Saccone, & Vallino, 2021). In addition, we control the role of human capital, captured by years of schooling and returns to education, on consumption volatility and mobile money adoption. Indeed, compared to less educated households, better-educated households may have better financial literacy and, consequently, be more willing to embrace financial innovations such as mobile money. On the other hand, education provides stable or better-paid jobs, thus empowering households to better manage their consumption. Finally, we consider the influence of agricultural productivity and initial GDP per capita. Agricultural productivity can promote consumption smoothing in two main ways. First, higher agricultural productivity can lower the prices of agricultural products, stabilize agricultural supply, reduce poverty, and increase household access to consumer products. The second way is that raising agricultural productivity can diversify household income sources through structural transformation, i.e., migration of additional labor arising from productivity gains in agriculture to the manufacturing sector (Block, 1995). Finally, as consumption volatility is lower in higher per capita income countries (Combes & Ebeke, 2011; Mondal & Khanam, 2018), we expect a negative relationship between initial GDP per capita–also used in the literature to capture the level of development–and consumption volatility.

Appendix C

Table C.1
Countries with mobile money.

Country	Country	Country
Albania	Kazakhstan	Rwanda
Argentina	Kenya	Senegal
Armenia	Kyrgyz Republic	Sierra Leone
Benin	Cambodia	El Salvador
Burkina Faso	Sri Lanka	Eswatini
Bangladesh	Lesotho	Togo
Bolivia	Morocco	Thailand
Brazil	Madagascar	Tajikistan
Botswana	Mexico	Tunisia
Cameroon	Mali	Turkey
Colombia	Mozambique	Tanzania
Dominican Republic	Mauritania	Uganda
Egypt, Arab Rep.	Mauritius	South Africa
Gabon	Namibia	
Guatemala	Niger	
Haiti	Nigeria	
Indonesia	Nicaragua	
India	Peru	
Iran, Islamic Rep.	Philippines	
Jordan	Paraguay	

Table C.2
List of countries.

Country	Country	Country	Country
Albania	Costa Rica	Lesotho	Rwanda
Argentina	Dominican Republic	Morocco	Senegal
Armenia	Algeria	Moldova	Sierra Leone
Azerbaijan	Ecuador	Madagascar	El Salvador
Benin	Egypt, Arab Rep.	Mexico	Eswatini
Burkina Faso	Gabon	Macedonia, FYR	Togo
Bangladesh	Guatemala	Mali	Thailand
Bulgaria	Croatia	Mozambique	Tajikistan
Bahamas, The	Haiti	Mauritania	Tunisia
Belarus	Hungary	Mauritius	Turkey
Belize	Indonesia	Namibia	Tanzania
Bolivia	India	Niger	Uganda
Brazil	Iran, Islamic Rep.	Nigeria	Ukraine
Bhutan	Jordan	Nicaragua	Uruguay
Botswana	Kazakhstan	Panama	Venezuela, RB
Chile	Kenya	Peru	South Africa
China	Kyrgyz Republic	Philippines	
Cameroon	Cambodia	Poland	
Colombia	Lebanon	Paraguay	
Comoros	Sri Lanka	Romania	

Table C.3
Descriptive statistics of baseline variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Household consumption volatility	1,873	4.297	4.528	0.046	39.79
Mobile money	2,280	0.203	0.402	0	1
Inflation (lag)	1,949	30.947	255.544	−30.243	7481.664
Urban population growth (lag)	2,204	2.506	1.901	−3.448	17.499
Fixed telephone subscriptions (lag)	2,204	10.214	10.321	0.035	48.103
Log real GDP per capita (lag)	2,186	7.865	1.054	5.302	10.381
Labor force participation rate (lag)	2,204	61.914	11.316	39.247	91.102

Table C.4
Mobile money and consumption volatility: moving window change and residual approach

	[1]	[2]	[3]	[4]
Mobile money	−1.265***	−1.356***	−1.099***	−1.404***
	(0.3368)	(0.3404)	(0.3319)	(0.3844)
Main controls	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Observations	1822	1763	1834	1592
R_2	0.444	0.539	0.340	0.650

Unreported constant included. Standard errors in brackets. Main controls are those of Tables 1 and 2. *** p<0.01, ** p<0.05, * p<0.1. Note: Columns [1–4] include consumption volatility based on 4-year moving window, 3-year moving window, 2-year moving window, and residual approach, respectively. The differences between this table's observations and those of Table 5 reflect changes in the dependent variable.

Table C.5
Mobile money and consumption volatility: altering the sample and mobile money definition

	[1]	[2]	[3]	[4]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
Mobile money	0.277***	−0.926***	−1.501***	−1.427***								
	(0.0307)	(0.1671)	(0.1756)	(0.1807)								
Mobile money (FAS)					−1.291***							
					(0.3320)							
Mobile money (w/o banks)						−1.261***						
						(0.3329)						
Mobile money (w/o first year adoption)							−1.375***					
							(0.3327)					
Anticipated mobile money								−1.198***				
								(0.2734)				
Lagged mobile money									−1.302***			
									(0.3241)			
Mobile money (initial adoption year only)										−1.843***		
										(0.0198)		
Placebo mobile money (random dates)											0.051	
											(0.1517)	
Placebo mobile money (start date before the actual start date)												−0.559
												(0.3432)
Main controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1844	1376	1345	1560	1702	1608	1652	1701	1702	520	1262	1301
R^2	0.973	0.693	0.656	0.623	0.632	0.641	0.636	0.634	0.634	0.693	0.650	0.635

Unreported constant included. Standard errors in brackets. Main controls are those of Tables 1 and 2. *** p<0.01, ** p<0.05, * p<0.1. *Note*: In column [1], the dependent variable is household consumption (log) while in columns [2–11], the dependent variable is consumption volatility. Compared to the other columns, the columns [2–4] modify the baseline sample by excluding 90s, former and current communist countries, and new mobile money countries.

Table C.6
Mobile money and consumption volatility: alternative measure of volatility

	Skewness	Kurtosis	Negative skewness	Positive skewness
Mobile money	−5.411	−8.780***	8.493***	−6.862**
	(3.7383)	(3.2099)	(3.1605)	(3.4782)
Main controls	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Observations	1702	1702	924	778
R^2	0.171	0.122	0.195	0.189

Unreported constant included. Standard errors in brackets. Main controls are those of Tables 1 and 2. *** p<0.01, ** p<0.05, * p<0.1. No difference with observations in Table 5 regarding columns [1–2] and [3–4] when aggregating observations from each sub-sample.

Appendix D

Table D.1
Mobile money, financial inclusion, and remittances

	[1] Remittances (%GDP)	[2] Financial inclusion
Mobile money	0.855***	0.061***
	(0.2924)	(0.0044)
Main controls	Yes	Yes
Year fixed effects	Yes	Yes
Country fixed effects	Yes	Yes
Observations	1804	1727
R^2	0.690	0.921

Unreported constant included. Standard errors in brackets. Main controls are those of Tables 1 and 2. *** p<0.01, ** p<0.05, * p<0.1. Note: Compared to Table 5, the observations in this table are different. This is mainly due to differences in the dependent variable in each of these tables.

Sources, and definitions of the data

Household consumption volatility: Standard deviation of the real household consumption per capita growth rate estimated over a 5-year moving window. *Source*: Authors' calculation based on World Development Indicators (WDI).

Mobile money: Dummy variable taking 1 if a country at date t adopts mobile money and 0 otherwise. *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker.

P2P transfer: 1 if a country adopts P2P service. Person-to-Person (P2P) transfers are domestic transfers that are made between two customer accounts including OTC transactions, off-net/cross- net transfers, bank account-to- mobile money account transfers, and mobile money-to- bank account transfers. *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker.

Bill payment: 1 if a country adopts bill payment service. Bill payment is a payment made by a person from either their mobile money account or over-the-counter to a biller or billing organisation via a mobile money platform in exchange for services provided. *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker.

Table D.2
Mobile money, remittances, and consumption volatility

	[1] Remit<2.14	[2] Remit > 2.14	[3] Remit<2	[4] Remit > 2	[5] Remit<5.5	[6] Remit > 5.5
Mobile money	−0.884***	−1.343***	−0.876***	−1.335***	−1.236***	−0.908***
	(0.2446)	(0.1697)	(0.2503)	(0.1700)	(0.1969)	(0.2225)
Main controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	769	933	749	953	1168	534
R^2	0.773	0.626	0.774	0.616	0.698	0.629

Unreported constant included. Standard errors in brackets. Main controls are those of Tables 1 and 2. *** p<0.01, ** p<0.05, * p<0.1. Columns [1] and [2] are based on the median value of remittances. Columns [3–4] and [5–6] consider respectively Chami et al., 2009 and Combes and Ebeke, 2011 thresholds. Note: No difference with observations in Table 5 when aggregating observations from each sub-sample.

Table D.3
Mobile money and consumption volatility: disaggregating mobile money

Consumption volatility	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
International remittances	−1.129***							
	(0.3567)							
P2P transfer		−1.223***						
		(0.3024)						
Bill payment			−1.272***					
			(0.3013)					
P2G transaction				0.022				
				(0.5320)				
G2P transaction					−1.388**			
					(0.5437)			
Bulk payment						−1.307***		
						(0.3432)		
Airtime top up							−1.262***	
							(0.3142)	
Merchant payment								−1.280***
								(0.3255)
Main controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1702	1702	1702	1702	1702	1702	1702	1702
R^2	0.631	0.633	0.634	0.628	0.630	0.634	0.634	0.634

Unreported constant included. Standard errors in brackets. Main controls are those of Tables 1 and 2. *** p<0.01, ** p<0.05, * p<0.1. Note: No difference with observations in Table 5.

Table D.4
Mobile money and consumption volatility: mobile money effect over time

Consumption volatility	[1]	[2]	[3]	[4]	[5]	[6]
Mobile money adoption (t0)	−0.688**					
	(0.3159)					
First year after adoption (t + 1)		−0.725***				
		(0.2299)				
Second year after adoption (t + 2)			−0.880***			
			(0.1912)			
Third year after adoption (t + 3)				−0.998***		
				(0.1738)		
Fourth year after adoption (t + 4)					−1.054***	
					(0.1649)	
Five year after adoption (t + 5)						−1.135***
						(0.1579)
Main controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1312	1361	1409	1457	1502	1546
R^2	0.648	0.644	0.642	0.640	0.638	0.637

Unreported constant included. Standard errors in brackets. Main controls are those of Tables 1 and 2. *** p<0.01, ** p<0.05, * p<0.1. Note: Compared to Table 5, observations related to the treatment variable differ. The first column constructs a new treatment variable by dropping all observations following the mobile money initiation year. Columns [2–6] consider only observations for 1, 2, 3, 4 and 5 years after the mobile money adoption year, respectively.

P2G transaction: 1 if a country adopts G2P transaction. Person-to-government (P2G) transaction is the transfer of funds from an individual to a government agency to pay for a public good (e.g. school fees), settle an outstanding amount (e.g. a traffic fine) or file taxes (e.g. individual or business tax returns). *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker.

G2P transaction: 1 if a country adopts G2P transaction. Government-to-person (G2P) transaction is a payment by a government to a person's mobile money account. *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker.

Bulk payment: 1 if a country adopts bulk payment service. Bulk payment is a payment made by an organisation via a mobile money platform to a person's mobile money account. For example, salary payments made by an organisation to an employee's mobile money account, payments made by a government to a recipient's mobile money account or payments made by development organisations to a recipient's mobile money account. *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker.

Airtime top-up: 1 if a country adopts airtime top up service. Airtime top-up is a purchase of airtime via mobile money, funded from a mobile money account. *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker.

Merchant payment: 1 if a country adopts merchant payment service. Merchant payment is a payment made from a mobile money account via a mobile money platform to a retail or online merchant in exchange for goods or services. *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker.

International remittances: 1 if a country adopts international remittances service. International remittances service is a cross-border fund transfers that are made from one person to another

Table D.5
Mobile money and consumption volatility: structural factors

	[1]	[2]	[3]	[4]	[5]
Mobile money	−0.988**	−2.278***	−0.662***	−1.558***	−0.944***
	(0.3955)	(0.2610)	(0.2238)	(0.2854)	(0.2258)
Mobile money*trade openness	−0.010*				
	(0.0052)				
Trade openness	0.037*				
	(0.0205)				
Mobile money*inflation		−0.168***			
		(0.0408)			
Inflation		0.005***			
		(0.0016)			
Mobile money*rural population			−0.850***		
			(0.2928)		
Rural population			0.231		
			(0.3123)		
Mobile money*rule of law				−0.823***	
				(0.2441)	
Rule of law				−0.332***	
				(0.1017)	
Mobile money*middle income countries					0.180*
					(0.0958)
Main controls	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	1860	1873	1616	1333	1616
R^2	0.677	0.676	0.631	0.689	0.631

Unreported constant included. Standard errors in brackets. Main controls are those of Tables 1 and 2. *** p<0.01, ** p<0.05, * p<0.1. Note: The difference between columns [1–4] and Table 5 is due to differences in observations on the interaction variables.

person. This transaction can be a direct mobile money remittance, or can be completed using an intermediary organisation, such as Western Union. *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker.

Inflation: Inflation, average consumer prices (Percent change). *Source*: WDI

Urban population growth: Urban population refers to people living in urban areas as defined by national statistical offices. *Source*: WDI.

Fixed telephone subscriptions: Fixed telephone subscriptions refers to the sum of active number of analogue fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones. *Source*: WDI.

Real GDP per capita: GDP per capita is gross domestic product (constant 2010 U.S. dollars) divided by midyear population. *Source*: WDI.

Initial GDP per capita: Real initial (1990) GDP per capita. *Source*: Authors' calculation based on WDI.

Labor force participation rate: Labor force participation rate is the proportion of the population ages 15 and older that is economically active: all people who supply labor for the production of goods and services during a specified period. *Source*: WDI.

Communist countries: 1 if a country is or was communist. *Source*: Authors' calculation based on https://www.infoplease.com/world/diplomacy/communist-countries-past-and-present

Real GDP per capita volatility: Standard deviation of the real GDP per capita estimated over a 5-year moving window. *Source*: Authors' calculation based on WDI

Public investment volatility: Standard deviation of the public gross fixed capital formation growth rate estimated over a 5-year moving window. *Source*: Authors' calculation based on IMF World Economic Outlook (WEO-IMF)

Financial openness: Capital Account Openness index. *Source*: Chinn and Ito, 2006.

ODA: Net ODA received (% of GNI). *Source*: WDI.

Human capital: Human capital, based on years of schooling and returns to education. *Source*: Penn World Table 10.0.

Social Globalisation: KOF Social Globalisation Index. *Source*: Dreher, 2006 and Gygli et al., Gygli, Haelg, Potrafke, and and Sturm, 2018.

Exchange rate: Exchange rate, national currency/USD (market + estimated). *Source*: Penn World Table 10.0.

Vulnerability: Propensity or predisposition of human societies to be negatively impacted by climate hazards. *Source*: University of Notre Dame Global Adaptation Index.

Resilience: Readiness to make effective use of investments for adaptation actions thanks to a safe and efficient business environment. *Source*: University of Notre Dame Global Adaptation Index.

Rule of Law: Rule of Law includes several indicators which measure the extent to which agents have confidence in and abide by the rules of society. These include perceptions of the incidence of crime, the effectiveness and predictability of the judiciary, and the enforceability of contracts. Together, these indicators measure the success of a society in developing an environment in which fair and predictable rules form the basis for economic and social interactions and the extent to which property rights are protected. *Source*: Teorell et al., 2020.

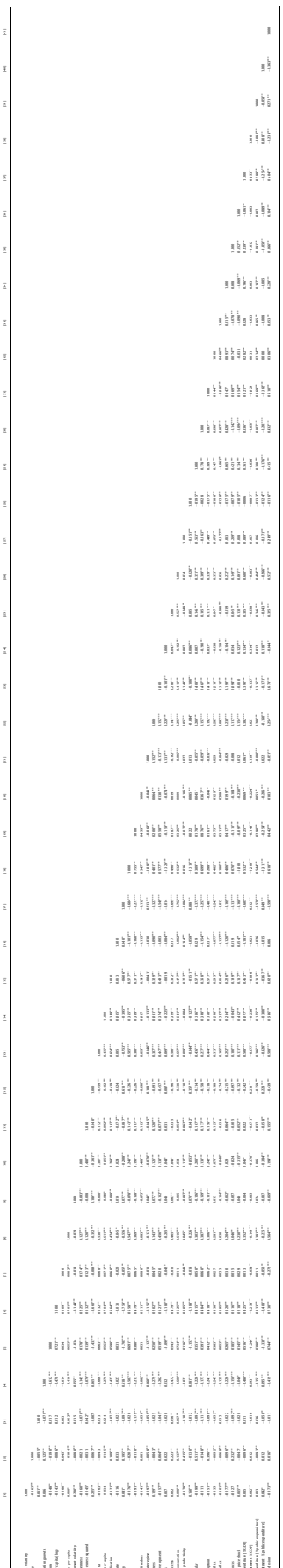
Investment Freedom: This factor scrutinizes each country's policies toward foreign investment, as well as its policies toward capital flows internally, in order to determine its overall investment climate. The country's investment freedom ranges between 0 and 100, where 100 represent the maximum degree of investment freedom. *Source*: Teorell et al., 2020.

Exchange rate regime: Dummy variable equal to 1 if a country is classified as having a de facto fixed exchange rate regime (hard or soft peg) and 0 otherwise. *Source*: Ilzetzki, Reinhart, and Rogoff, 2019.

Trade openness: Trade (% of GDP). *Source*: WDI.

Financial development: Financial development index. *Source*: IMF Financial Development database.

Table D.6
Correlation matrix.



*** p<0.01, ** p<0.05, * p<0.1.

Remittances (%GDP): Personal remittances comprise personal transfers and compensation of employees. Personal transfers consist of all current transfers in cash or in kind made or received by resident households to or from nonresident households. Personal transfers thus include all current transfers between resident and nonresident individuals. Compensation of employees refers to the income of border, seasonal, and other short-term workers who are employed in an economy where they are not resident and of residents employed by nonresident entities. *Source*: WDI.

Access to electricity (% of population): Access to electricity is the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources. *Source*: WDI.

Electric power consumption (kWh per capita): Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants. *Source*: WDI.

Agricultural productivity: Agricultural Total Factor Productivity Index (output growth minus input growth). *Source*: USDA, Economic Research Service (https://www.ers.usda.gov/data-products/international-agricultural-productivity/), Fuglie, 2012; Fuglie, 2015.

Mobile money (FAS): Dummy variable taking 1 if a country at date t adopts mobile money and 0 otherwise. *Source*: Authors' calculation based on IMF Financial Access Survey (FAS).

Household Consumption: Households Final consumption expenditure per capita (constant 2010 US$). *Source*: WDI.

Aggregate shock: Standard deviation of the real GDP per capita growth estimated over a 5-year moving window. *Source*: Authors' calculation based on WDI.

Agricultural shock: Standard deviation of the agricultural value added growth rate estimated over 5-year moving window. *Source*: Authors' calculation based on WDI.

Inflation shock: Standard deviation of the consumer price index growth rate estimated over5-year moving window. *Source*: Authors' calculation based on WDI.

Economic vulnerability: Probability that a country's economic development may be hampered by unforeseen exogenous shocks. *Source*: FERDI database, Guillaumont, 2009; Feindouno et al., 2016.

Unemployment rate: Unemployment rate (Percent of total labor force). *Source*: WDI.

Working poverty rate: The working poverty rate conveys the percentage of employed persons living in poverty in spite of being employed. Poverty is defined using the international poverty line of US$1.90 per day in purchasing power parity (PPP). *Source*: ILOSTAT

Poverty rate: The share of individuals living below the 'International Poverty Line' of 1.90 international-$ per day. *Source*: Roser and Ortiz-Ospina, 2013.

Inequality: GINI index (World Bank estimate). *Source*: WDI.

Financial inclusion: Financial inclusion. *Source*: IMF Financial Development database.

Household consumption skewness: Skewness of the real household consumption per capita growth rate estimated over a 5-year moving window. *Source*: Authors' calculation based on WDI.

Household consumption kurtosis: Kurtosis of the real household consumption per capita growth rate estimated over a 5-year moving window. *Source*: Authors' calculation based WDI.

Rural population: Rural population refers to people living in rural areas as defined by national statistical offices. *Source*: WDI.

Public debt: Public debt (%GDP). *Source*: Abbas, Belhocine, El-Ganainy, and Horton, 2011.

Corruption: Corruption measures perceptions of corruption, conventionally defined as the exercise of public power for private gain. The particular aspect of corruption measured by the various sources differs somewhat, ranging from the frequency of "addi-

tional payments to get things done", to the effects of corruption on the business environment, to measuring "grand corruption" in the political arena or in the tendency of elite forms to engage in "state capture". *Source*: Teorell et al., 2020.

Internet adoption: Individuals using the Internet (% of population). *Source*: WDI.

Internal conflict: This is an assessment of political violence in the country and its actual or potential impact on governance. The highest rating is given to those countries where there is no armed or civil opposition to the government and the government does not indulge in arbitrary violence, direct or indirect, against its own people. The lowest rating is given to a country embroiled in an on-going civil war. The risk rating assigned is the sum of three subcomponents, each with a maximum score of four points and a minimum score of 0 points. A score of 4 points equates to Very Low Risk and a score of 0 points to Very High Risk. *Source*: The International Country Risk Guide (ICRG).

External conflict: The external conflict measure is an assessment both of the risk to the incumbent government from foreign action, ranging from non-violent external pressure (diplomatic pressures, withholding of aid, trade restrictions, territorial disputes, sanctions, etc) to violent external pressure (cross-border conflicts to all-out war). External conflicts can adversely affect foreign business in many ways, ranging from restrictions on operations to trade and investment sanctions, to distortions in the allocation of economic resources, to violent change in the structure of society. The risk rating assigned is the sum of three subcomponents, each with a maximum score of four points and a minimum score of 0 points. A score of 4 points equates to Very Low Risk and a score of 0 points to Very High Risk. *Source*: ICRG.

Conflict: Simple average of internal and external conflicts. *Source*: Authors' calculation based ICRG.

Weather shocks: This indicator presents the mean surface temperature change during the period 1961–2019, using temperatures between 1951 and 1980 as a baseline. Use the drop-down menus to search for temperature changes by country. *Source*: IMF Climate Change Indicators Dashboard.

Commodity price shock: Standard deviation of Commodity price estimated over 5-year moving window. *Source*: Authors' calculation based on Gruss and Kebhaj, 2019

Current expenditure (% GDP): Cash payments for operating activities of the government in providing goods and services. It includes compensation of employees (such as wages and salaries) and subsidies, grants, social benefits, and other expenses such as rent and dividends but excludes interest payment. It is expressed as a percentage of GDP. *Source*: WEO-IMF.

Public investment (% GDP): Public gross fixed capital formation over GDP. *Source*: WEO-IMF.

Current expenditure (% public expenditure): Current expenditure as a percentage of total public expenditure. *Source*: Authors' calculation based on WEO-IMF.

Public investment (% public expenditure): Public investment as a percentage of total public expenditure. *Source*: Authors' calculation based on WEO-IMF.

Mobile money account (% population): Mobile money accounts in percentage of population. *Source*: IMF Financial Access Survey (FAS).

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