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Tax revenue and mobile money in developing countries

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ABSTRACT

This paper analyzes the effect of mobile money adoption on tax revenue performance in a large sample of 104 developing countries over the period 1990–2019. Estimations, based on the entropy balancing method, show that mobile money significantly increases tax revenue in mobile money countries relative to non-mobile money countries. This result remains robust to various robustness tests and may depend on time perspective, the type of mobile money service, and some structural factors, including a country's level of development, corruption level, rural population size, inflation rate, education level, tax revenue sample 25th percentile and average, revenue administration efficiency, and mature markets. A first level of disaggregation of tax revenue into direct and indirect tax revenue shows that mobile money increases both types of tax revenue, with a larger impact on direct tax revenue. A second level of disaggregation of these two components into different sub-categories shows that the effect on direct tax revenue is driven by personal income tax revenue and corporate income tax revenue and that on indirect tax revenue is determined by taxes on goods and services. Finally, a broadening tax base (proxied by GDP per capita), better institutional quality, and tax payment process simplification are the main channels through which mobile money adoption increases tax performance in developing countries.

1. Introduction

The Covid-19 pandemic and the ensuing social and economic crisis have set the progress of fighting poverty back more than ten years. It has increased inequalities and devastated economies. Financing the recovery will need increased domestic resource mobilization that protects the most vulnerable while at the same time stimulates economic growth and service delivery. Domestic resource mobilization of public revenue is going to be even more important in the recovery, both because of the need for increased financing but also because other sources of financing to developing countries have decreased.[1]

Tax revenue mobilization—a crucial tool for strong and inclusive state-building— remains historically low in developing countries.[2] Several authors have discussed the poor tax revenue performance of developing countries. For example, Okunogbe and San-toro (2021) note that developing countries' tax revenue is only 11% GDP compared to 20% for relatively developed countries. This low tax revenue in developing countries raises important development issues as the Sustainable Development Goals identify tax performance of 15% GDP as the minimum required to build a strong state.[3] Several other authors, such as Besley and Persson (2014); Mascagni et al. (2014); Akitoby (2018); Basri et al. (2021); Okunogbe and Santoro (2022), produce evidence around poor tax revenue mobilization in developing countries. In the literature,[4] several factors have been identified as determinants of this weak tax revenue capacity in developing countries, including high levels of informality, limited state capacity, a taxable base consisting largely of micro and small entities, the lack of automation and digitalization, weak financial system development, and institutional and cultural factors.[5]

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[1] https://www.wider.unu.edu/parallel-session/improving-tax-collection.

[2] Among the numerous benefits of tax revenue we can mention the promotion of public investments such as infrastructure, health, and education, support for redistribution policies, market economy, and public goods such as good governance. In addition, tax revenue reduces dependence on (volatile) external financial flows such as official development assistance and natural resource revenues (see for instance Mascagni et al., 2014; Okunogbe and Santoro, 2021).

[3] https://www.oecd.org/ctp/countries-must-strengthen-tax-systems-to-meet-sustainable-development-goals.htm.

[4] See for instance Gordon and Li (2009); Besley and Persson (2014); Kleven et al. (2016); Basri et al. (2021); Okunogbe and Santoro (2021); Santoro (2021); Jensen (2022); Mascagni and Nell (2022); Mascagni et al. (2022a).

[5] These factors act as a bottleneck as they limit tax authorities' ability to identify the true tax base and collect taxes efficiently and fairly.

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The development of digital transactions and mobile payments has transformed the financial landscape in developing countries, making it easier for many people to access basic financial services. Since its introduction in 2001 in the Philippines and its success stories by M-PESA in Kenya in 2007, mobile money has emerged in developing countries as the most effective way to provide (poor) households with access to financial services on the one hand, and to modernize financial transactions on the other, in a context of strong preference for cash. Currently, we identify 1.21 billion accounts with nearly 740,000 active accounts for a daily transactions of 2.10 billion USD. The Global System for Mobile Communications (GSMA) projection expects transactions to increase by nearly 50% in 2022, representing 3 billion USD per day. Around the world, there are currently 390 mobile money services in 96 countries. In 2020, the number of accounts increased by 13%, while the volume and value of transactions increased by 15% and 22%, respectively. Meanwhile, tax revenue in developing countries remains structurally low for achieving Sustainable Development Goals. In this context, the Covid-19 crisis offers an opportunity to rethink tax revenue mobilization in these countries by testing new revenue mobilization instruments.

Mobile money has received considerable attention in the existing literature in recent years. Early studies, essentially microeconomics, present mobile money as a welfare tool welfare tool that promotes financial inclusion, increases consumption and household income (Jack and Suri, 2014; Munyegera and Matsumoto, 2016; Suri and Jack, 2016; Riley, 2018). In addition, other studies explore the effect of mobile money on self-entrepreneurship, as well as on the ability of households to obtain well-paying jobs, receive remittances, invest, and on firm performance (Suri and Jack, 2016; Gosavi, 2018; Islam et al., 2018; Aggarwal et al., 2020; Patnam et al., 2020; Lee et al., 2021). Although macroeconomic studies remain scarce, some studies identify mobile money as a mechanism for economic formalization (Jacolin et al., 2021), inequality reduction (Asongu, 2015), monetary policy efficiency via low inflation, better macroeconomic performance,[6] improved level and volatility of household consumption (Apeti, 2023). Despite the evolution of the literature on mobile money and its effects on development, to the best of our knowledge, little has been said about revenue performance. This paper aims to fill this gap by analyzing whether adopting digital financial services such as mobile money can help developing countries improve their tax performance.

Based on the literature, we assume that mobile money can impact tax revenue through three main channels namely a broader tax base (or better economic activity), better institutional quality, and tax payment process simplification. The economic activity channel is justified by the ability of digital financial services to stimulate supply through investment promotion, and demand through consumption, as well as their ability to reshape the labor market, expand market size through low transaction costs, and modernize transactions.[7] For example, existing studies show that mobile money promotes financial services access to households and firms previously excluded from traditional financial services, helping them obtain credit for investment and move from less productive sectors such as agriculture to the business sector or from the informal to the formal sector.[8] Similarly, Aron (2018) and Ahmad et al. (2020) show that mobile money transactions can be used to establish credit scores that can help users get loans to finance their investments. In addition, mobile money allows access to external financing such as remittances (see for instance, Munyegera and Matsumoto, 2016; Apeti, 2023), which relax the financial constraints of households, allowing them to make investments or spend on consumption.[9] In addition, the reduction in transaction costs created by mobile money widens market size and fosters economic activity. Finally, modernizing transactions could provide tax authorities with information on taxpayer incomes and provide an opportunity to digitize tax services, thus reducing revenue administration costs and facilitating broader geographic coverage. The second channel is the promotion of better institutional quality. Indeed, by making payment data more transparent and limiting the availability of economic rents in the billing and payment process, mobile money can reduce potential fraud and improve the delivery of public services (Krolikowski, 2014). This creates an appropriate institutional framework for tax revenue collection and improved tax compliance or tax morale through efficient delivery of public goods and services (Gadenne, 2017; Hendren and Sprung-Keyser, 2020; Krause, 2020; Cohen, 2021).[10] Finally, as mobile money offers the possibility of paying taxes digitally, it simplifies tax payment procedures, thus helping to increase tax revenue, as the literature identifies heavy tax payment procedures as one of the determinants of tax evasion (Beck et al., 2014).

To identify the causal effect of mobile money, we rely on entropy balancing, an impact analysis method, developed by Hainmueller (2012). Using a sample of 104 developing countries over the period 1990–2019, we show that mobile money adoption increases tax revenue performance in mobile money countries, relative to non-mobile money countries. This result is robust to several robustness tests, including a placebo test, changing the definitions of mobile money, tax revenue, adding additional control variables, altering the sample design, and using alternative estimation methods such as Propensity Score Matching, the Inverse Probability Weighting, the Inverse Probability Weighted Regression Adjustment, panel fixed effects, and the system-GMM. In addition, we show that mobile money's impact on tax revenue performance is driven by significant improvement in direct tax revenue relative to indirect tax revenue. This result is fueled by the increase in personal income tax revenue and corporate income tax revenue on the direct tax revenue side and by the increase in taxes on goods and services on the indirect tax revenue side. Furthermore, the heterogeneity tests performed show that: *i*-the effect of mobile money may depend on economic development, institutional quality, rural population, inflation rate, tax revenue sample 25th percentile and average, revenue administration efficiency, and mature markets, defined as mobile money services access above 12%; *ii*-the effect of mobile money may depend on the type of mobile money service; and *iii*-the effect of mobile money on tax revenue is time-sensitive i.e., the effect of mobile money increases with time. Finally, we analyze three transmission channels through which mobile money could affect tax revenue. We provide evidence that broadening the tax base through higher GDP per capita, better institutional quality, and simplification of the tax payment process are channels through which mobile money positively affects tax revenue performance in developing countries.

The rest of the paper is organized as follows. Section 2 presents the methodology. Section 3 presents the data and descriptive statistics. The results are presented in Section 4, followed by a robustness analysis in Section 5. Sections 6-8 present the composition effect, the heterogeneity tests, and the transmission channels, respectively. Section 9 concludes.

2. Methodology

This paper aims to analyze the effect of mobile money adoption on

[6] See for instance Adam and Walker (2015); Aron et al. (2015); Dunne and Kasekende (2018); Kipkemboi and Bahia (2019); Mawejje and Lakuma (2019).

[7] See for instance Andrianaivo and Kpodar (2012); Mawejje and Lakuma (2019); Ahmad et al. (2021); Jacolin et al. (2021); Ogawa et al. (2021); Shen et al. (2021).

[8] See for instance Bruhn and Love (2014); Nampewo et al. (2016); Suri and Jack (2016); Islam et al. (2018); Jacolin et al. (2021).

[9] See for instance, Woodruff and Zenteno (2001); Giuliano and Ruiz-Arranz (2009); Adams Jr and Cue-cuecha, 2010; Amuedo-Dorantes and Pozo (2011); Chiodi et al. (2012); Adams Jr and Cuecuecha (2013); Combes et al. (2014); Ebeke (2014); Asatryan et al. (2017); Jacolin et al. (2021).

[10] Also https://blogs.worldbank.org/impactevaluations/increasing-tax-revenue-developing-countries.

tax revenue performance in developing countries. The biggest challenge is to establish a causal link between mobile money adoption and tax revenue performance. Indeed, mobile money adoption is not a random event. For example, it may depend on a country's economic performance, level of development, access to traditional financial services, access to cell phones, and its institutional quality. These factors, which can also influence tax revenue mobilization, make mobile money adoption endogenous through the selection bias problem. To circumvent this problem, we use an impact assessment method, called entropy balancing, developed by Hainmueller (2012). This method is widely used in the literature, including in Neuenkirch and Neumeier (2016) to assess the impact of U.S. sanctions on poverty, in Balima (2017) to estimate the effect of domestic sovereign bond market participation on financial dollarization, in Balima (2020) to assess the effect of coups on the cost of debt, in Balima and Sy (2021) to assess the fiscal effect of IMF programs, and in Apeti (2023) to explore the effect of mobile money on household consumption volatility. A similar approach is used by Jacolin et al. (2021) to identify the impact of mobile financial services on the informal sector, by Riley (2018) to assess the effect of mobile money on risk-sharing, and by Munyegera and Matsumoto (2016) to evaluate the impact of mobile money on the welfare of a panel of 846 rural Ugandan households.

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 in observable characteristics, while controlling for time and country-fixed effects. This method offers some advantages compared to concurrent impact analysis methods[11] such as propensity score matching (PSM) or difference-in-differences. First, it allows for a high degree of balance between the treatment and control groups by creating a synthetic group as close as possible to the treatment group. Second, unlike other impact analysis methods such as PSM, it does not require an empirical model for mobile money adoption, thus limiting specification and multicollinearity problems. Third, unlike classical matching methods, entropy balancing uses a more flexible reweighting approach by keeping the weights closer to the base weights to avoid information loss. Unlike conventional matching, which is based on the assumption of conditional independence, the fourth advantage is that entropy balancing allows us to exploit the panel aspect of our data and control for time and country-fixed effects in the second stage of our regression.

The approach used in this study is based on the principle that mobile money adoption is the treatment variable, and tax revenue is the outcome variable. The units of observation are country-year observations. The observations with mobile money represent the treatment group, and those without mobile money represent the control group. Having set the scene, we enter into the heart of the issue by trying to estimate the treatment effect on the treated (ATT), computed as follows:

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

where $Y(.)$ is the outcome variable measuring tax revenue. T indicates whether the observation unit is subject to mobile money adoption ($T = 1$) or not ($T = 0$). $E[Y_{(1)}|T = 1]$ is the expected outcome for mobile money countries (treatment group), and $E[Y_{(0)}|T = 1]$ is the counterfactual outcome for countries that have adopted mobile money, i.e., tax revenue in mobile money countries if they had not adopted mobile money.

The issue is that $E[Y_{(0)}|T = 1]$ is not observable due to the non-random nature of mobile money adoption. If it were observable, the ATT could easily be identified by comparing tax revenue in mobile money countries with that of non-mobile money countries. Hence, the identification of ATT 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 in terms of observable characteristics that meet two criteria, namely correlation with mobile money adoption and tax revenue. Under the condition that the non-mobile money units are relatively close to the mobile money units, any difference in tax revenue mobilization is attributable to mobile money adoption. Based on these different elements, we can rewrite equation (1) as follows:

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

where $X = x$ is the vector of observable covariates that can affect both countries' decision to adopt mobile money and their level of tax revenue mobilization; $E[Y_{(1)}|T = 1, X = x]$ represents tax revenue for mobile money countries, and $E[Y_{(0)}|T = 0, X = x]$ is the expected tax revenue for non-mobile money countries (synthetic control units).

Estimating ATT by entropy balancing requires two steps. The first step is to compute the weights of the control groups (untreated groups). These weights may satisfy pre-specified balanced constraints involving the sample moments of observable characteristics (X). Following Neuenkirch and Neumeier (2016), we choose equilibrium constraints that impose equal covariate means between the treatment and control groups. By 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. The second stage uses the weights from the first stage in a regression analysis where tax revenue is the dependent variable, and the mobile money dummy is the main explanatory variable, in order to estimate in a second stage the average treatment effect of mobile money (ATT) on tax revenue. In the second stage, we also control for entropy balancing covariates as well as for time and country-specific effects, as in a randomization experiment, to increase the efficiency of the estimations.

Although entropy balancing is our baseline method, we also use other impact analysis methods such as Propensity Score Matching (PSM), Inverse Probability Weighting (IPW), and Inverse Probability Weighted Regression Adjustment (IPWRA) to test the robustness of our results. Moreover, like any impact analysis method, entropy balancing would fail to control endogeneity bias resulting from unobserved time-varying factors that affect both tax revenue and mobile money adoption or omitted variables. Accordingly, we complete our robustness tests by adding additional control variables in our entropy balancing specification (see Gutmann et al., 2021) and use additional methods such as panel fixed-effects regression and the system-GMM.

3. Data, and descriptive statistics

3.1. Data

To assess the effect of mobile money, we draw on a large panel data covering 104 developing countries over the period 1990–2019. We focus on developing countries as mobile money adoption is specific to them. The time horizon is mainly determined by the paucity of fiscal data, including tax revenue data, in developing countries prior to the 1990s. Our main variables are mobile money (treatment) and tax revenue (outcome). Following previous studies (Kikulwe et al., 2014; Munyegera and Matsumoto, 2016; Riley, 2018; Jacolin et al., 2021; Apeti, 2023), we measure mobile money as a dummy variable taking 1 when a country i at date t adopts mobile money and 0 otherwise, using the GSMA's mobile money deployment tracker.[12]

Our main dependent variable, tax revenue excluding resource taxes and social contributions, is drawn from the UNU-WIDER Government

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

[12] https://www.gsma.com/mobilemoneymetrics/#deployment-tracker.

Revenue Dataset (GRD).[13] The key advantage of the GRD over other sources of government revenue data, such as the World Revenue Longitudinal Database (WoRLD) or the Organization for Economic Cooperation and Development (OECD), is that it distinguishes between resource and non-resource sector revenues based on disaggregated data from the IMF Article IV reports (Prichard, 2016).

Regarding 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 pre-treatment characteristics. Following the literature on the determinants of mobile money adoption and tax revenue, we select the following control variables: real GDP per capita, rural population growth, inflation rate, financial deepening measured by domestic credit to private sector, investment freedom, labor force participation rate, and fixed telephone. To contain the reverse causality, we lag these variables by one period. We expect a negative correlation between GDP per capita and mobile money adoption, as mobile money is considered a low-cost solution for low-income countries compared to relatively high-income countries, which would have access to a variety of payment methods. We expect a positive correlation for rural population growth and labor force, as mobile money adoption may be higher in areas with poor infrastructure, allowing rural populations to access financial services that would otherwise be inaccessible to them and to meet a need for remote payments (Hamdan, 2019). The correlation between inflation and mobile money adoption could be ambiguous, i.e., positive or negative. Two arguments support this relationship. The first stems from the role of a healthy economic environment in reform efficiency. The second stems from the fact that high inflation periods could incite economic agents to adopt mobile money to mitigate the *shoe leather cost* effect. We expect a negative sign for the fixed-line telephone as the deployment of mobile money is fundamentally related to the dynamism of mobile phone market size (Jacolin et al., 2021; Apeti, 2023). Finally, we expect a positive sign for financial deepening and investment freedom, as non-restrictive regulatory en-vironments and lack of investment barriers are important incentives for mobile money adoption (Penicaud and Katakam, 2013; Evans and Pirchio, 2014; Jacolin et al., 2021).

The full definitions of each variable used in this paper and their sources are compiled in the Appendix.

3.2. Descriptive statistics

We begin this section by analyzing the performance of entropy balancing. To do so, we present some descriptive statistics obtained before and after the weighting used to estimate the treatment effect of mobile money adoption. In Table 1, we present 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] reports the differences in mean between two groups and their statistical significance. The results reveal that mobile money countries are characterized by low GDP per capita, high rural population growth, low levels of inflation, high financial deepening, high investment freedom, high labor force, and low fixed-telephone line subscriptions. These findings, which are consistent with the expected relationship between the probability of mobile money adoption and the various control variables discussed in the previous section demonstrate the importance of selecting an appropriate control group when estimating the treatment effect of mobile money adoption to avoid incorrectly estimated treatment effects.

Table 1
Descriptive statistics before weighting.

	[1]	[2]	[3] = [2]-[1]
	Mobile money	No mobile money	Difference
Lag real GDP per capita	3773	5576	1803***
Lag rural population growth	0.830	0.524	−0.306***
Lag inflation	5.443	8.878	3.435***
Lag financial deepening	36.86	32.49	−4.37***
Lag investment freedom	50.71	49.66	−1.05*
Lag labor force	65.67	62.56	−3.11***
Lag fixed telephone	5.641	11.58	5.939***
Observations	594	1146	

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

Table 2 shows in columns [1] and [2] the sample mean after weighting between the treated and the synthetic control groups obtained by entropy balancing, and column [3] presents the differences in mean between columns [2] and [5]. The analysis of the two groups in this table reveals the effectiveness of entropy balancing for estimating the effect of mobile money, as the difference shown in the previous table seems to disappear. Consequently, entropy balancing allows us to construct a perfect control group that is closely similar to mobile money countries in terms of the mean values of the pre-treatment covariates.

A first look at the relationship between tax revenue and mobile money can be revealed by comparing average tax revenue in the treated and control countries. In Table 3, we show this statistic by comparing the average tax revenue in the two groups of countries. The average tax revenue of mobile money countries is 15.75 percent of GDP, while the non-mobile money countries' average tax revenue is 14.00 percent of GDP, with a difference of 1.75 percentage points significant at 1%.[14] This relationship, while not causal, provides a picture of the treatment effect of mobile money adoption.

4. Baseline results

With the synthetic controls in Table 2, we estimate the effect of mobile money on tax revenue (ATT) in developing countries using the weighted least squares method. The results are presented in Table 4. Columns [1]-[4] show the regression result without the matching covariates used in the first step to construct the synthetic group. Column

Table 2
Descriptive statistics after weighting.

	[1]	[2]	[3] = [2]-[1]
	Mobile money	Control	Difference
Lag real GDP per capita	3773	3806	33
Lag rural population growth	0.830	0.821	−0.009
Lag inflation	5.443	5.552	0.109
Lag financial deepening	36.86	36.85	−0.01
Lag investment freedom	50.71	50.72	0.01
Lag labor force	65.67	65.64	−0.03
Lag fixed telephone	5.641	5.746	0.105
Observations	594	1146	
Total of weights	594	594	

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

Table 3
Tax revenue by mobile money adoption.

	Mobile money	No mobile money	Difference	Ttest	P-value
Tax revenue	15.75	14.00	1.75	−5.15	0.0000

[13] For simplicity, tax revenue excluding resource taxes and social contributions is called tax revenue in this paper.

[14] We corroborate this finding with Fig. 1 in the Appendix.

Table 4
Mobile money and tax revenue (% GDP).

Tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	1.888***	1.892***	2.004***	1.985***	1.908***	0.965***	2.039***	1.027***
	(0.3216)	(0.1319)	(0.3258)	(0.1331)	(0.2707)	(0.1342)	(0.2742)	(0.1364)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%
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	1420	1420	1420	1420	1420	1420	1420	1420
$_R2$	0.024	0.890	0.027	0.891	0.320	0.910	0.324	0.910

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

[1] excludes country and time-fixed effects. Columns [2]-[3] include country and time fixed effects, respectively, 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 real GDP per capita, rural population growth, inflation, financial deepening, investment freedom, labor force, and fixed telephone. Including the matching covariates in the second stage of entropy balancing increases the quality of the matching while controlling for country and year fixed-effects eliminates any country or year-specific effects.

Irrespective of the specifications, mobile money adoption significantly increases (at 1%) tax revenue in mobile money countries compared to non-mobile money countries. The magnitude of the coefficients varies between 0.97 percentage points (column [6]) and 2.40 percentage points (column [7]). This result is robust given the relative stability of the coefficients across the eight specifications in the table, with an average effect of 1.71 percentage points. In other words, mobile money adoption increases tax revenue by 1.71 percentage points in mobile money countries compared to non-mobile money countries. Relative to the control group, these coefficients represent between 7% and 17%—12% on average—of its non-conditional average tax revenue of 14%.

5. Robustness checks[15]

Our previous findings indicate that mobile money adoption increases tax revenue. In this section, we test the robustness of these results.

5.1. Alternative specifications

Our first alternative specification involves some adjustments concerning the treatment variable, which is mobile money. The effect captured in this study may be subject to some problems. Indeed, mobile money adoption can lead to a change in the economic environment of countries. In this sense, the effect captured might not be driven by mobile money adoption but by the changes in institutional, political, social, or economic conditions after its adoption. In addition, given that no country has abandoned mobile money after its adoption, any characteristic that could determine mobile money deployment can potentially be a source of endogeneity. To circumvent these two issues, we employ an approach similar to that of Neuenkirch and Neumeier (2015) by constructing five new treatment variables defined over a window of five years before mobile money adoption to five years after its adoption, i.e., from five years before to five years after, from four years before to four years after, from three years before to three years after, from two years before to two years after, from one year before to one year after. We expect that the narrow time windows that characterize our new mobile money variables should provide more robust estimates of its effect on tax revenue since the (generally slow-changing) institutional, political, social, and economic environment is more likely to be stable over narrow time periods. Using entropy balancing, we test the robustness of our baseline results with each of these variables as a treatment variable. The re-sults are compiled in Table A1 in the Appendix. Columns [1]-[5] present, respectively the five-year windows around the adoption year [−5; 5], the four-year windows [−4; 4], the three-year windows [−3; 3], the two-year windows [−2; 2], and the one-year window [−1; 1]. The results of these different specifications, which are consistent with our baseline findings, reveal that the effect of mobile money on tax revenue is not driven by any change in the political, economic, or institutional environment of countries following the regime's adoption or by characteristics that might predict its introduction.

Second, we modify the definition of our treatment variable by removing mobile money services provided by banks, the first year of mobile money adoption, and by leading (lagging) mobile money adoption by one year.[16] The results of these alternative definitions are compiled in columns [1]-[4] of Table A2 in the Appendix. The results indicate that, changing the definition of the treatment variable does not alter our results since the coefficients remain positive and statistically significant.

Third, we perform a placebo test (falsification) in two ways. First, we define a placebo or arbitrary adoption date calculated by randomly assigning adoption dates to the countries in our sample. Second, we use resource revenue as an alternative dependent variable. The idea is to test whether the treatment effect is due to mobile money adoption, and to check if the treatment effect reported in our baseline results is specific to tax revenue. The results, based on entropy balancing and using placebo mobile money and resource revenue, are presented in columns [5]-[6] of Table A2 in the Appendix. The non-significant effect obtained underscores the robustness of our findings. In other words, mobile money adoption is the cause of our results, and the effects highlighted in this paper are specific to tax revenue rather than to any other public revenue, such as that generated from natural resources.

Our fourth robustness exercise consists of making some changes to our dependent variable. To do so, we use three alternative measures for tax revenue: *i*-non-resource tax revenue, including social contributions; *ii*-government revenue, defined as non-resource tax revenue including social contributions and resources revenue; and *iii*-tax effort/

[15] Additional robustness can be found in the penultimate section of the Appendix (Tables C1-C3).

[16] Like in Yeyati and Panizza (2011), this exercise allows us to test the robustness of our results to measurement errors.

efficiency.[17] With these new measures, we estimate the effect of mobile money using entropy balancing. The results in columns [1]-[3] of Table A3 in the Appendix show that mobile money adoption increases tax revenue regardless of the measure used.

Five, we test the robustness of our results using a continuous version of our treatment variable. Indeed, the use of a binary variable does not consider two major problems: the deployment of mobile money and the intensity of its use. To overcome these problems, we use the number of active mobile money accounts per population from the IMF's Financial Access Survey (FAS), which offers a broader time coverage than the FINDEX data. The results estimated by the two-step system-GMM (Blundell and Bond, 1998) to control for the potential endogeneity problem,[18] presented in column [1] of Table A4 in the Appendix, show a positive and significant effect of mobile money adoption on tax revenue. Therefore, we can conclude that our results are not sensitive to the measure of the treatment variable.

Finally, we test the sensitivity of our results to additional control variables that may affect both mobile money adoption and tax revenue collection. For this purpose, we first include a set of additional control variables in the second stage of entropy balancing. These variables include: mobile money agent/km,[2] mobile phone subscriptions, the rule of law, government consumption, population density, a conflict dummy, financial openness, trade openness, official development assistance (ODA), natural resources, exchange rate, foreign direct investment, remittances in logarithms, agriculture, climate vulnerability, age dependency ratio, education, control of corruption, social globalisation, internet adoption (proxy of Information and Communication Technology (ICT) adoption), democracy, and time to pay taxes. Results reported in columns [1]-[22] of Table A5 in Panel A show that including these variables yields similar results to our initial findings. Finally, since any characteristics that may predict mobile money adoption can be a source of endogeneity, we augment the variables used in our baseline first stage model by adding these additional control variables to construct the synthetic control. The results in Panels B and C of Table A5 (columns [1]-[20]) in the Appendix show that adding these variables to the determinants of mobile money does not alter our baseline results.[19]

5.2. Alternative estimation methods

We begin this exercise using the Ordinary Least Squares (OLS) method. Starting with the most concise model that includes only the treatment variable as explanatory variable, we gradually add the same control variables as those used in the entropy balancing approach, taking care to control for country and year-fixed effects (see Neuenkirch and Neumeier, 2016).[20] The results in columns [1] (the most concise specification) to [8] (the baseline specification) of Table B1 in the Appendix show that, similar to the entropy balancing approach, mobile money fosters tax revenue independently of the specification. Second, we augment our baseline specification with additional control variables borrowed from the literature.[21] The results compiled in columns [1]-[20][22] of Table B2 in the Appendix show that, despite the reduction in the number of observations,[23] mobile money increases tax revenue, with coefficients very close to our baseline coefficients.[24]

We conclude this section by estimating the effect of mobile money using the Blundell and Bond (1998) two-step system-GMM dynamic panel estimator.[25] This method provides us with two major opportunities. First, it allows us to include the lagged tax revenue in the control variables, which allows us to control the relatively high inertia that can characterize fiscal variables such as tax revenue. Second, this method addresses the lack of valid external instruments for estimating the causal effect of mobile money on tax revenue while controlling for the Nickell bias that arises when estimating a dynamic panel with fixed effects. Finally, in order to avoid the eventual problem of non-stationarity of some variables eventually tax revenue indicator—as the time period of the analysis runs from 1990 to 2019, i.e, 30 years—and mitigate

[17] Tax effort is defined as the ratio between real and potential tax performance. To calculate tax effort we use the stochastic frontier analysis (SFA) method (Aigner et al., 1977; Pessino and Fenochietto, 2010). Following the existing literature, we choose the parametric version of SFA of Kumbhakar et al. (2015) to estimate tax effort. In contrast to existing methods (Kumbhakar, 1991; Battese and Coelli, 1992; Stotsky and WoldeMariam, 1997), this method divides the error term into four components allowing to clearly define long-term and short-term efficiency.

[18] Our data are organized into 6 non-overlapping 5-year averages.

[19] Following a similar approach to Riley (2018), we test whether, before mobile money adoption, tax revenue is similar for treated and control units. Specifically, this approach defines a period of adoption for future mobile money units over a time period prior to the actual date. In this paper, we define a pre-treatment period of seven years prior to the actual adoption dates of each country. The actual mobile money adoption dates are dropped to ensure that the sample consists of only pre-treatment years. The pre-treatment date is calculated by taking half of the year difference between the first year of mobile money adoption (2004) and the starting year of our study (1990) (see Balima et al., 2021). As reported in the literature (Ogrokhina and Rodriguez, 2018; Riley, 2018), the non-statistical significance of the coeffi-cients means that the treatment and control groups follow a similar trend before treatment. Results, not reported in this paper but available on request show that the control and treated units are similar before treatment, as the effect of mobile money on tax revenue over the pre-treatment period is statistically non-significant. Finally, this result further supports that our results are due to mobile money adoption.

[20] Note that the statistically significant control variables show a sign consistent with the existing literature.

[21] These variables are also used in the robustness section of the entropy balancing approach where they are included additively as in Ogrokhina and Rodriguez (2018); Balima (2020) to avoid potential problems of multicollinearity and significant observations losses that can come from differences in observations of different variables.

[22] Our specifications exclude internet adoption due to its high collinearity with social globalization, as discussed by Gygli et al. (2019) and Jacolin et al. (2021). Note that social globalisation index captures international interpersonal contacts, cultural proximity, and information flows (through television, internet use, and the presence of foreign populations). Finally, we exclude time to pay taxes for its low number of observations.

[23] Observation loss ranges from 37% to 66% compared, to Table 4.

[24] Results of additive rather than successive addition of additional control variables also support the conclusion that mobile money adoption has a positive effect on tax revenue. These results are available on request. One of the challenges of our study is to distinguish between mobile money and cell phone impacts, since cell phones can also influence tax revenues. To circumvent this problem, we first exclude observations from country-years with low cell phone usage on a median basis. Second, we use successive regression approach. To do so, we first replace mobile money with cell phone in the OLS specifications. Second, we remove cell phones from our specifications, keeping only mobile money. Finally, we jointly include mobile money and cell phone in each OLS specification. The results show that the effect of mobile money remains statistically significant regardless of the specification. In contrast, the effect of cell phone dis-appears when adding additional control variables, thus allowing us to conclude that cell phone is not a robust determinant of tax revenue in developing countries. These results are not reported in the paper but are available on request.

[25] This method combines equations in levels and first differences in a system and estimates 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, the system-GMM estimator allows the introduction of 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 the number of lags is limited to a maximum of one as in Jacolin et al. (2021). 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.

spurious regressions concern, we follow existing literature[26] by reorganizing our panel data into 6 sub-periods of 5 non-overlapping years. Thus, using five-year averages allows us to obtain more efficient estimates. Results presented in column [2] of Table A4 in the Appendix show that mobile money adoption significantly increases tax revenue, although the estimated effect is somewhat lower. Concretely, mobile money increases tax revenue by 0.92 percentage points. In addition, results show some persistence of tax revenue over time. This is signaled by a positive and significant coefficient of 0.83 for lagged tax revenue.

6. Composition effects

The previous section shows that mobile money adoption significantly increases tax revenue mobilization in developing countries. In this section, we analyze the composition effect of mobile money on tax revenue to identify the types of tax revenue that might be most affected by mobile money adoption. Indeed, the economic structure of developing countries characterized for example, by low financial development, limits third-party development, which remains important for tax administration efficiency due to its role in providing information on taxpayers (Kleven et al., 2016). Using mobile money facilitates the visibility of financial flows of companies by allowing automatic transfer of invoicing information between companies and tax administration agencies. In addition, electronic invoicing allows tax authorities to have an overview of a company's turnover, which limits tax leakage on corporate income tax revenue. Moreover, our data indicate that indirect tax revenue is twice as high as direct tax revenue. Therefore, since developing countries have difficulty collecting direct tax revenue, the marginal effect on it would be higher. Thus, we assume that the impact of mobile money may depend on the type of tax revenue component, with a stronger effect on direct tax revenue and its components than on indirect tax revenue. To test this hypothesis, we first disaggregate tax revenue into direct and indirect tax revenue, and then we break these two down into various sub-components.

6.1. Direct versus indirect tax revenue

Using entropy balancing and the covariates used in the baseline model, we estimate the effect of mobile money on direct and indirect tax revenue (as a percentage of GDP). The results presented in Tables 5 and 6 reveal that mobile money increases both types of tax revenue. However, a closer look at the coefficients indicates a greater effect of direct tax revenue than of indirect tax revenue, thus corroborating our assumptions. Concretely, mobile money increases direct tax revenue by an average of 1.03 percentage points (i.e., 23% compared to the control group sample average of 4.45%) and indirect tax revenue by 0.61 percentage points (i.e., 6.2% the control group sample average of 9.79%). Therefore, we can easily claim that mobile money adoption is associated with a composition effect on tax revenue, favoring direct tax revenue collection.

6.2. Different types of tax revenue

In this section, we estimate the effect of mobile money on the major components of direct and indirect tax revenue. Following Abdelwahed, 2020 and Gupta et al. (2021) we focus on five tax categories, namely personal income tax revenue (PIT), corporate income tax revenue (CIT), property tax revenue (PT), taxes on goods and services (G&S) which include VAT, and tax on international trade (trade taxes). The results are presented in columns [1]-[5] of Table 7. We find that, mobile money has a positive and significant effect on personal and corporate income tax revenue, and on taxes on goods and services. At the same time, there is no statistically significant effect on property tax revenue and international trade tax revenue. In sum, this result allows us to conclude that adopting mobile money promotes *hard tax* mobilization by stimulating direct tax revenue, such as personal and corporate income tax revenue, and broad-based consumption tax revenue such as taxes on goods and services (including VAT, for example) instead of volatile and distortive taxes such as those on trade.[27] A closer look at the coefficients of the significant tax revenue components supports the finding of the previous section: the effect of mobile money is relatively larger on direct tax revenue components. Specifically, relative to their respective control group mean, mobile money increases PIT by 16.35%, CIT by 11%—direct tax revenue components—, and G&S by 9.6%—indirect tax revenue component.

In summary, Sections 6.1 and 6.2 show that: *i*-mobile money increases both direct and indirect tax revenue, however, the effect on direct tax revenue is greater; *ii*-mobile money increases corporate income tax revenue, personal income tax revenue, and taxes on goods and services. As previously stated, developing countries' tax structure is characterized by a larger share of indirect tax revenue–relatively easy to collect–than direct tax revenue. Unlike indirect tax revenue, direct tax revenue is difficult to collect as this involves both sound tax policy and sound tax administration (see Baskaran and Bigsten, 2013; Besley and Persson, 2014; Mascagni et al., 2022b).

Mobile money's effect on direct tax revenue—hard-to-collect—is in line with the ongoing debate about the role of Information and Communication Technologies (ICTs) on tax administration and tax policy efficiency.[28] Taking advantage of the above mentioned literature, we can identify some key arguments that support the fact that mobile money countries could collect more direct tax revenue. First, mobile money would improve tax base identification by mitigating information problems. Unlike indirect tax revenue, third-party play a major role in collecting direct tax revenue, thus limiting potential tax evasion—which hardly works in developing countries where financial (banking) systems are poorly developed. Mobile money would therefore limit this challenge by giving tax authorities the ability to obtain information on taxpayer liabilities that may otherwise be hidden or manipulated by taxpayers by revealing information on personal income through digital salary payments and on corporate income through digital invoices and sales. In other words, digital financial services such as mobile money can help tax authorities monitor taxpayer compliance by facilitating the use of electronic tax technology that provides information on sales as they occur, as well as of electronic payments that provide a paper trail of an individual's or company's incomes. Second, by offering the ability to pay taxes digitally, mobile money can help limit underreporting, reach people previously excluded from financial services, expand the tax base—a critical component of tax revenue collection (Besley and Persson, 2014)—, and reduce compliance costs for individuals and businesses since time-consuming tax payment procedures are associated with tax evasion (Beck et al., 2014). Next, by making it possible to detect potential tax-payers, mobile money offers the possibility for tax authorities to send messages directly to taxpayers' phones in order to boost their tax compliance (Mascagni and Nell, 2022; Santoro, 2022). Finally, in addition to better identifying the tax base, mobile money, which enables business growth and formalizes formerly informal businesses, could help broaden the tax base and therefore apply tax policy laws more effectively to a larger number of taxpayers (Mascagni et al., 2022b).

[26] See for example, Combes and Ebeke (2011); Docquier et al. (2016); Fosu and Abass (2019); Pleninger and Sturm (2020).

[27] In alternative specifications, we explore the effect of mobile money on these different components as a share of total tax revenue. The results not reported in this paper but available on request are broadly consistent with those highlighted in this section.

[28] See for instance Santoro (2021); Okunogbe and Santoro (2022); Okunogbe and Santoro (2021); Okunogbe and Pouliquen (2022); Mascagni et al. (2021); Mascagni et al. (2022b); Santoro (2022).

Table 5
Mobile money and direct tax revenue (% GDP).

Direct tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	1.151***	1.106***	1.227***	1.146***	1.122***	0.638***	1.184***	0.663***
	(0.1908)	(0.0602)	(0.1923)	(0.0603)	(0.1451)	(0.0589)	(0.1463)	(0.0597)
Control group mean	4.42%	4.42%	4.42%	4.42%	4.42%	4.42%	4.42%	4.42%
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	1270	1270	1270	1270	1270	1270	1270	1270
$_R2$	0.028	0.938	0.034	0.939	0.446	0.953	0.450	0.953

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 6
Mobile money and indirect tax revenue (% GDP).

Indirect tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	0.640***	0.876***	0.712***	0.942***	0.527**	0.258*	0.595***	0.309**
	(0.2448)	(0.1209)	(0.2479)	(0.1221)	(0.2269)	(0.1335)	(0.2299)	(0.1359)
Control group mean	9.80%	9.80%	9.80%	9.80%	9.80%	9.80%	9.80%	9.80%
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	1331	1331	1331	1331	1331	1331	1331	1331
$_R2$	0.005	0.837	0.008	0.838	0.159	0.851	0.161	0.851

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 7
Main components of tax revenue.

	[1]	[2]	[3]	[4]	[5]
	PIT	CIT	PT	G&S	Trade taxes
Mobile money	0.327***	0.214***	0.009	0.481***	−0.344
	(0.0448)	(0.0532)	(0.0118)	(0.0528)	(0.2283)
Control group mean	2%	2.06%	0.29%	4.96%	2.78%
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	1067	916	1071	1195	1375
$_R2$	0.952	0.894	0.882	0.936	0.816

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

7. Heterogeneity

Our results reveal that mobile money adoption increases developing countries' tax revenue performance. In this section, we check the sensitivity of the above finding according to the type of mobile money services, time perspective, and some structural factors.

7.1. The role of structural factors

First, we distinguish countries in our sample according to their development level using IMF classifications. Despite sharing some common characteristics, developing countries show significant heterogeneity. To take this heterogeneity into account, we place our sample countries into two groups: developing countries (low-income countries) and emerging countries. Results presented in columns [1]-[2] of Table 8 show that mobile money adoption increases tax revenue in both groups. However, the effect of mobile money is higher in developing than in emerging countries.

Second, we analyze the sensitivity of our results to the role of institutions, namely corruption, since good institutions may foster policy reform efficiency (Llanto and Gon-zalez, 2007). We distinguish between low and high corruption countries based on the sample median. The results in Table 8, columns [3]-[4] show that mobile money increases tax revenue regardless of the level of institutional quality. However, we notice that mobile money's effect on tax revenue is greater in the context of better institutional quality, i.e., a lower level of corruption.

Third, we analyze the effectiveness of mobile money according to the size of the rural population. To do this, we split our sample into two groups, based on the sample median: countries with high rural populations and those with low rural populations. Results in columns [5]-[6] of Table 8 show that mobile money's effect on tax revenue seems to be higher in countries with large rural populations.

Fourth, we take a closer look at the level of inflation, as mobile money adoption may contain inflationary pressures by reducing cash demand or improving monetary policy efficiency (Adam and Walker, 2015; Kipkemboi and Bahia, 2019). Accordingly, we assume that mobile money can help improve tax performance by mitigating the Keynes-Oliveira-Tanzi effect (Tanzi, 1992). Using the sample median, we show in columns [7]-[8] of Table 8 a bigger effect of mobile money in times of high inflationary pressure, supporting our intuition.

Fifth, we assess the sensitivity of our results to the level of education. The idea is to test the assumption that education may improve mobile money efficiency. Indeed, people with a high school education are likely to adapt to financial innovations, like mobile money services, more easily than those with less education, making them more efficient in adopting these services to manage their daily transactions (Seng, 2021; Morgan, 2022). Education thus acts as a driver of people's financial literacy (see, for example, Santoso, 2013). We use the sample median to distinguish people with a higher level of education from those with a lower level. The results in columns [9]-[10] of Table 8 show that mobile

Table 8
The role of structural factors.

Tax revenue (%GDP)	[1] Low income countries	[2] Emerging countries	[3] Low corruption	[4] High corruption	[5] Low rural population	[6] High rural population
Mobile money	1.125*** (0.2108)	0.377* (0.2109)	1.451*** (0.1508)	0.972*** (0.2396)	0.763*** (0.1990)	1.003*** (0.2258)
Control group mean	14%	14%	14%	14%	14%	14%
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	777	643	591	829	734	686
$_R2$	0.892	0.935	0.934	0.905	0.934	0.888
	[7]	[8]	[9]	[10]	[11]	[12]
Tax revenue (%GDP)	Low inflation	High inflation	Low education	High education	Top 25th percentile	Bottom 25th percentile
Mobile money	0.862*** (0.2003)	1.141*** (0.2085)	1.019*** (0.2126)	1.030*** (0.2003)	0.751 (0.4660)	0.895*** (0.2139)
Control group mean	14%	14%	14%	14%	14%	14%
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	738	682	537	883	359	293
$_R2$	0.905	0.921	0.935	0.912	0.789	0.841
	[13]	[14]	[15]	[16]	[17]	
Tax revenue (%GDP)	Above average	Below average	Low rev. adm. eff.	High rev. adm.eff.	Mature markets	
Mobile money	0.706*** (0.2370)	0.927*** (0.1198)	1.215*** (0.2765)	0.769*** (0.1799)	0.442*** (0.1556)	
Control group mean	14%	14%	14%	14%	14%	
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	697	723	117	1096	1188	
$_R2$	0.841	0.861	0.962	0.912	0.929	

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

money adoption increases tax revenue regardless of education level. However, the effect appears slightly greater in high education conditions.

Sixth, we analyze the differential impacts of mobile money adoption once initial conditions are taken into account. The underlying assumption is that countries with relatively low tax revenue collection (below the sample average and bottom 25th percentile of tax revenue distribution, i.e., 14% and 10% GDP, respectively) and countries with low revenue administration efficiency can rely more on digital technology such as mobile money to close the potential fiscal gap, in contrast to countries with an already high tax effort (see Crivelli and Gupta (2016) for a similar approach). The results in Table 8 (columns [11]-[16]) show that: *i*-mobile money improves tax revenue in countries with tax-to-GDP ratios lower than the 25th percentile. However, the effect is positive but not statistically significant for countries ranked in the top 25% tax revenue distribution (column [11] of Table 8), *ii*-mobile money increases tax revenue irrespective of the position relative to the sample average, but the impact appears to be larger for countries with tax revenue below the sample average (column [14] of Table 8), and *iii*--mobile money increases tax revenue regardless of revenue administration efficiency, but with a stronger effect in countries with low revenue administration efficiency.

As discussed earlier, there are potential shortcomings due to data limitations, particularly the use of a dummy variable defined by the year of mobile money services, which fails to account for the level of access to these services. We finally use data from the IMF's Financial Access Survey to identify mature markets (i.e., markets with intensive mobile money use) to capture such effects. We define mature markets as markets with a percentage of active mobile money accounts (% population) of at least 12% (which isabout 16% our sample).[29] Regressions excluding mature markets show that adopting mobile money increases tax performance (Table 8, column [17]). However, the magnitude of the effect remains small relative to our baseline coefficients, suggesting that the increase in tax collection induced by mobile money adoption rises with access to mobile money services. Put differently, the effects of financial digitization on tax performance are likely to increase as services become available to a wider customer base.

7.2. The effect of mobile money over time

Following Fang and Miller (2011), we highlight a time-varying treatment effect. This dynamic effect would allow us to isolate the lagged effect of mobile money adoption. The intuition behind this approach is the potential time lag separating mobile money adoption and its effect on tax performance. For this purpose, we estimate the ATTs of the year of adoption (t = 0) and the five years following the adoption year (t = 1,

[29] The observed dynamic effect may suggest a linear trend in the outcome variable, i.e., tax revenue. In other words, we suspect that the popularity of mobile money coincides with an increase in tax revenue in the countries in our sample. If this is the case, we will capture a simple trend effect that would not necessarily be associated with mobile money adoption. Although using time-fixed effects may allow us to control for such trend effects and identify a causal effect, we test this intuition by adding time trends in our baseline specification. The results remain consistent with those previously highlighted. In other words, the positive effect of mobile money remains robust, suggesting that linear trends in the outcome variable do not drive our results. These results are available on request.

2,3,4,5). Results compiled in Table 9, columns [1]-[6] reveal the existence of a dynamic effect of mobile money adoption on tax revenue. This effect appears as soon as mobile money is adopted and increases over time. As a result, we can conclude that the effect of mobile money on tax revenue is time-sensitive. This result may reflect an increase in mobile money deployment over time, thus supporting the mature market effect previously discussed.[30]

7.3. The type of mobile money services

The GSMA's database allows for a disaggregation of the different services, including P2P transfer, P2G transfer, G2P transfer, airtime transaction, merchant payment, international remittances, bill payment, and bulk payment. Given the specificity of each service with respect to transactions, we assume that the effect of mobile money may depend on the type of service. For example, P2G transfers promote compulsory and unrequited payments to the government, including business registration, customs duties, income tax, import tax, employment tax, hotel tax, and value-added tax (VAT). International remittance services, by lowering transaction costs, increase the volume and frequency of remittances (Jack and Suri, 2014). As remittances are more typically consumed than invested (Asatryan et al., 2017), the effect of this type of transfer on tax revenue may be different from that of other services such as G2P transfers, which appear to affect both consumption-related aspects of revenue such as VAT and income-related aspects such as income and employment taxes. Therefore, we estimate the effect of each mobile money service on tax revenue performance using entropy balancing. The results presented in Table 10, columns [1]-[8] show that mobile money adoption increases tax revenue regardless of the type of service considered. However, we observe some relative variations in the coefficients according to the type of mobile money, corroborating our intuition.

8. Channels

Our results indicate that mobile money increases tax revenue in developing countries. This section aims to shed light on the mechanisms underlying this result. Drawing on the discussion in the introduction, we test the relevance of our three potential transmission channels, using GDP per capita, democracy, and time to pay taxes as indicators of economic activity, institutional quality, and tax payment process simplification.

Before testing our channels, we evaluate their relevance to tax revenue using a panel fixed-effects regression (OLS).[31] The aim of this approach is to see if the three identified channels are each correlated with tax revenue. The results presented in Table 11 suggest that GDP per capita, democracy, and time to (prepare and) pay taxes are highly correlated with tax revenue, representing potentially important transmission channels through which mobile money can have a positive effect on tax revenue in developing countries.[32]

Based on entropy balancing, we use the same covariates as in our baseline specification while taking care to control for country and time-fixed effects to test whether our three channels are related to mobile money. The results compiled in Table 12 show that mobile money is associated with a significant increases in GDP per capita and institutional quality and a decrease in time to pay taxes. [33] In summary, mobile money increases tax collection through better institutional quality, a broader tax base through higher GDP per capita, and simplified tax payment processes through lower time to pay taxes, i.e, reduced compliance cost.

9. Conclusion

This paper analyzes whether adopting mobile money improves developing countries' tax performance. Using entropy balancing to control endogeneity on a sample of 104 developing countries over 1990–2019, our study concludes that mobile money increases tax revenue in mobile money countries relative to non-mobile money countries. This finding is robust to several alternative specifications, including extending the vector of control variables, altering the sample, using various alternative definitions of the treatment and dependent variables, and using concurrent estimation methods. Additional estimations on tax revenue components reveal that the increase in tax revenue in developing countries can be attributed to relatively higher increases in direct tax revenue compared to indirect tax revenue. Further disaggregation of these two components into sub-components suggests that the positive effect of mobile money on tax revenue can be attributed to the increase in both personal and corporate income tax revenue, and in taxes on goods and services. In addition, the heterogeneity tests conducted show that the effect of mobile money may depend on the type of mobile money services, time perspective, and some structural factors. Finally, we provide evidence that a broadening tax base (proxied by GDP per capita), better institutional quality, and tax payment process simplification (proxied by time to prepare and pay taxes) are potential transmission channels through which mobile money affects tax revenue.

This paper contributes to the literature on tax revenue mobilization strategies in developing countries by analyzing the role of digital financial services like mobile money. In a post-Covid-19 environment marked by higher public debt, international tensions, and rising borrowing costs due to interest rate hikes to combat inflation, this paper may have economic policy implications for both governments and tax administrations. This paper calls for governments support of telecommunication companies to ensure better deployment of mobile money in order to maximize its economic and fiscal effects. Indeed, the paper shows that in addition to the positive effect on tax revenue, mobile money's effect is reinforced in mature markets, i.e. economies where mobile money coverage is large. Therefore, in order to increase tax revenue and fill the financing gap resulting from tighter access to international financial markets, governments can support telecom companies in more broadly deploying mobile money to maximize its effect on public finances, especially tax revenue in order to develop fiscal capacity and build a strong state. Moreover, the composition effect observed shows that promoting mobile money can help governments in developing countries that struggle to levy direct tax revenue to develop tax structures where the share of direct tax revenue—which remains a major tool of redistribution—gains more weight. Finally, a key issue

[30] In Table B3 of the Appendix, we provide the bivariate correlations between tax revenue and proxy variables for economic activity, institutional quality, and time to pay taxes in order to assess their rele-vance to tax revenue (see, for instance, Gutmann et al., 2021 for a similar approach). However, we prefer the panel fixed-effects model as, by controlling for time and country fixed effects and the series of time-varying control variables used in entropy balancing, it provides a more robust correlation than a simple bivariate correlation matrix.

[31] Time to (prepare and) pay taxes is the time in hours per year, it takes to prepare, file, and pay (or withhold) three major types of taxes: the corporate income tax, the value-added or sales tax, and labor taxes, including payroll taxes and social security contributions.

[32] In alternative specifications, we define economic performance as GDP per worker like Dincecco and Prado (2012), consumption per capita and poverty, and institutional quality by corruption. The results reveal that mobile money increases GDP per worker, and consumption per capita and, decreases poverty and corruption. These findings, not reported in this paper, are available on request.

Table 9
Effect of mobile money over time.

Tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]	[6]
Mobile money adoption (t0)	0.574*** (0.1175)					
First year after adoption (t+1)		0.820*** (0.1254)				
Second year after adoption (t+2)			0.983*** (0.1260)			
Third year after adoption (t+3)				1.054*** (0.1321)		
Fourth year after adoption (t+4)					1.066*** (0.1381)	
Fifth year after adoption (t+5)						1.041*** (0.1408)
Control group mean	14%	14%	14%	14%	14%	14%
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	1090	1147	1201	1256	1304	1344
$_R2$	0.944	0.936	0.934	0.923	0.913	0.907

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 10
Disaggregating mobile money.

Tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
P2P transfer	0.964*** (0.1389)							
P2G transaction		0.683*** (0.1832)						
G2P transaction			0.998*** (0.1842)					
Airtime top up				1.112*** (0.1394)				
Merchant payment					1.041*** (0.1433)			
International remittances						1.129*** (0.1621)		
Bill payment							1.062*** (0.1414)	
Bulk payment								1.219*** (0.1502)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%
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	1420	1420	1400	1420	1420	1420	1420	1420
$_R2$	0.910	0.897	0.897	0.911	0.909	0.912	0.910	0.907

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 11
Correlation between mobile money and main channels.

	[1]	[2]	[3]
	Tax revenue (% GDP)	Tax revenue (% GDP)	Tax revenue (% GDP)
Log GDP/cap.	5.045*** (0.4931)		
Inst. qual.		0.198*** (0.0681)	
Time to pay taxes			−0.003** (0.0011)
Main controls	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Observations	1330	1303	829
$_R2$	0.915	0.907	0.920

Unreported constant included. Robust standard errors in brackets. Main controls are those of Tables 1 and 2 ***p < 0.01, **p < 0.05, *p < 0.1. Estimations are based on OLS.

Table 12
Transmission channels.

	[1]	[2]	[3]
	Log GDP/cap.	Inst. qual.	Time to pay taxes
Mobile money	0.111*** (0.0070)	0.199*** (0.0616)	−26.196*** (4.9219)
Control group mean	7.77	5.55	323
Covariates in the second step	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes
Observations	1739	1452	1182
$_R2$	0.991	0.892	0.942

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

facing citizens in paying taxes is the management of the collected tax revenue. By improving institutional quality—important for the management of the public purse—mobile money can serve as a tool for governments to enhance citizens' ability and willingness to pay taxes in the spirit of "tax me, but spend wisely" principle (Gadenne, 2017). For tax administrations, this paper offers two messages. First, digital financial instruments provide an opportunity for developing countries to develop the missing third-party role, crucial for the efficiency of their

tax administrations. Secondly, by offering the ability to pay taxes digitally, mobile money can simplify the tax payment process and increase tax compliance or reduce compliance cost.

However, data sharing between telecom companies and tax administrations has not yet established. Indeed, a collaboration between governments/tax administrations and mobile network operators regarding information sharing remains a challenge or is currently only at the early stage and highly debated. Concretely, in many countries, mobile money data is not accessible to the tax administration. Accordingly, reforms are needed to facilitate the collaboration between mobile network operators and tax authorities to support tax policy and tax administration in developing countries where governments lack adequate resources to finance development. Finally, in response to the urgency of revenue collection, many countries are beginning to tax mobile money services—what the public calls the "lazy tax". In other words, mobile money is now on the radar of many governments—for example, in Africa—as a potential source of additional revenue, often with serious equity implications. While discussions on the effects of mobile money taxation are still ongoing, we identify two potential effects on tax revenue. In the short term, the policy may boost revenue in countries where the Covid crisis placed pressure on public finances. However, in the medium to long term, given that the market of digital financial services is quite concentrated, taxing mobile money could also increase transaction costs and deter the use of this service in an environment where almost half are excluded from the financial system. As a result, the possibility of third-party development and broadening of the tax base which is necessary for a sound tax structure would be undermined, jeopardizing the goals of raising tax revenue to finance Sustainable Development Goals. While these two possible effects seem to suggest a clear trajectory for the effect of mobile money taxation on tax revenue, for example, the literature tends to suggest that the actual effects remain relatively uncertain (see for instance Munoz et al., 2022). Given this uncertainty about the real effects of mobile money taxation, we can hardly conclude whether the introduction of such taxation by various governments is a "good" or "bad" idea. However, as Munoz et al. (2022) argue, more evidence is needed in order to better understand the implications of new taxes, to assess the broader rationale for specific taxes on digital financial services in general and on mobile money in particular, to facilitate dialogue between different stakeholders, and to support broader evidence-based policy-making.

Author statement

Ablam Estel Apeti: Conceptualization; Data curation; Formal analysis; Methodology; Software; Writing – original draft; Writing – review & editing. Eyah Denise Edoh: Conceptualization; Data curation; Formal analysis; Methodology; Software; Writing – original draft; Writing – review & editing.

Data sources, and definitions

Tax revenue (% GDP): non-resource tax excluding social contributions (% GDP). *Source*: UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU- WIDER/GRD-2021

Government revenue (% GDP): revenue including social contributions. *Source*: UNU- WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU- WIDER/GRD-2021

Resource taxes (% GDP): component of reported tax revenue that is from natural re-source sources, most often corporate taxation of resource firms. *Source*: UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD- 2021

Non-Resource tax w/social contributions (% GDP): total non-resource tax revenue, including social contributions. *Source*: UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021

Tax effort: Tax effort. *Source*: authors' calculation based on UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021 *Direct taxes (% GDP)*: direct taxes excluding social contributions and resource revenue. *Source*: UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/WIDER/GRD-2021

Indirect taxes (% GDP): non-resource component of indirect tax. *Source*:UNU- WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU- WIDER/GRD-2021

Personal income tax (% GDP): total income, capital gains, and profit taxes on individuals. This figure is always exclusive of resource revenue in available sources. *Source*: UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU- WIDER/GRD-2021

Corporate income tax (% GDP): total income and profit taxes on corporations, including taxes on resource firms. *Source*: UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021

Property tax (% GDP): total taxes on property. *Source*: UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021

Taxes on goods and services (% GDP): total taxes on goods and services, which includes sales taxes and excise taxes. *Source*: UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021

VAT (% GDP): value-added tax. *Source*: UNU-WIDER Government Revenue Dataset.

Version 2021. https://doi.org/10.35188/UNU-WIDER/GRD-2021

Trade taxes (% GDP): total taxes on international trade, including both import and

export taxes. *Source*: UNU-WIDER Government Revenue Dataset. Version 2021. https://doi.org/WIDER/GRD-2021

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

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)

Mobile money account (% of population): number of active mobile money accounts per 1000 adults *Source*: FAS

P2P transfer: 1 if a country use 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

P2G transaction: 1 if a country use 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 use 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

Airtime top up: 1 if a country use 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 use 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 use international remittances service. In-ternational remittances service is a cross-border fund transfer made from one person to another person. This transaction can be a direct

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

Bill payment: 1 if a country use 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 organization via a mobile money platform in exchange for services provided. *Source*: Authors' calculation based on GSMA Mobile Money Deployment Tracker

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

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

Rural population growth: rural population refers to people living in rural areas as defined by national statistical offices. It is calculated as the difference between the total and urban populations. *Source*: WDI

Inflation: inflation, average consumer prices (Percent change). *Source*: WDI *Financial deepening*: domestic credit to private sector (% GDP). *Source*: WDI *Investment freedom*: this factor scrutinizes each country's policies toward foreign

investment, as well as its policies toward capital flows internally, to determine its overall investment climate. The country's investment freedom ranges between 0 and 100, where 100 represents the maximum degree of investment freedom. *Source*: Teorell et al. (2020) *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

Fixed telephone subscriptions: fixed telephone subscriptions (per 100 people) refers to the sum of an active number of analog fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equiv-alents, and fixed public payphones. *Source*: WDI

Mobile money agent: mobile money agent outlets: active per 1000 km2. *Source*: IMF Financial Access Survey (FAS)

Mobile cellular subscriptions: mobile cellular subscriptions (per 100 people). *Source*: WDI

Rule of law: the 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 enforce ability of contracts. Together, these indicators measure the success of 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)

Government consumption (% GDP): general government final consumption expenditure (formerly general government consumption) includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security but excludes government military expenditures that are part of government capital formation. *Source*: WDI

Population density: population density (people per sq. km of land area). *Source*: WDI

Conflict dummy: if the country has experienced war. *Source*: Authors' calculation based on UCDP/PRIO Armed Conflict Dataset

Financial openness: Capital Account Openness index. *Source*: Chinn and Ito (2008)

ODA: net ODA received (% GNI). *Source*: WDI

Natural resources (% GDP): total natural resources rents (% GDP). *Source*: WDI

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

FDI (% GDP): foreign direct investment is the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital, as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors and is divided by GDP. *Source*: WDI

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 employed in an economy where they are not residents and of residents employed by nonresident entities. Data are the sum of two items defined in the sixth edition of the IMF's Balance of Payments Manual: personal transfers and compensation of employees. *Source*: WDI

Agriculture (% GDP): agriculture, forestry, and fishing, value added (% GDP). *Source*: WDI

Climate vulnerability dummy: 1 if high vulnerability to climate change. *Source*: Authors' calculation based on Notre Dame Global Adaptation Index

Age dependency ratio (% of working-age population): age dependency ratio is the ratio of dependents–people younger than 15 or older than 64–to the working-age population–those ages 15–64. Data are shown as the proportion of dependents per 100 working-age population. *Source*: WDI

Education level: average total years of schooling for adult population. *Source*: Roser and Ortiz-Ospina (2016)

Control of corruption: control of corruption index. *Source*: International Country Risk Guide (ICRG)

Democracy: democracy index. *Source*: Teorell et al. (2020)

Social globalisation: KOF Social Globalisation Index. *Source*: Dreher (2006)

Internet: individuals using the internet (% of population). *Source*: WDI

Revenue administration efficiency: CPIA revenue mobilization efficiency rating. *Source*: WDI

Time to pay taxes: time to prepare and pay taxes is the time, in hours per year, it takes to prepare, file, and pay (or withhold) three major types of taxes: the corporate income

tax, the value-added or sales tax, and labor taxes, including payroll taxes and social security contributions. *Source*: WDI

Data availability

Data will be made available on request.

Acknowledgments

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Appendix A

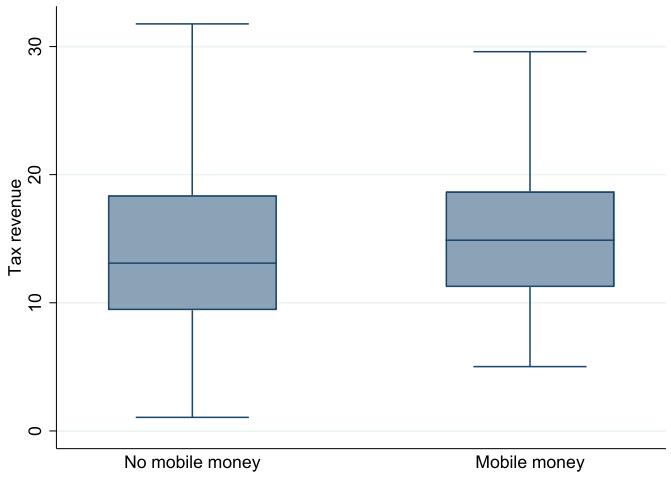

Fig. 1. Tax revenue by mobile money adoption. Note: In the box plots, the lower and upper hinges of each box show the 25th and 75th percentiles of the samples, the line in the box indicates the respective medians, and the end-points of whiskers mark next adjacent values.

Table A1
Adjusting the treatment variable

Tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]
	[-1;1]	[-2;2]	[-3;3]	[-4;4]	[-5;5]
Mobile money	0.809*** (0.1702)	0.858*** (0.1595)	0.772*** (0.1705)	0.754*** (0.1730)	0.738*** (0.1694)
Control group mean	15%	15%	15%	15%	15%
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	510	622	734	836	927
$_R2$	0.957	0.952	0.936	0.927	0.921

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table A2
Alternative definition of mobile money

Tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]	[6]
W/o banks	1.060*** (0.1435)					
W/o adoption year		1.132*** (0.2994)				
Forward (lead) of mobile money			0.938*** (0.2755)			
Lagged mobile money				1.050*** (0.2975)		
Placebo mobile money					0.034 (0.1009)	
Placebo using resources taxes						0.080 (0.0623)
Control group mean	14%	14%	14%	14%	14.30%	0.87%
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	1365	1362	1420	1420	1420	1324
$_R2$	0.901	0.912	0.906	0.911	0.900	0.722

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table A3
Alternative definition of tax revenue

	[1] Non-Resource tax w/social contribution (%GDP)	[2] Government revenue (%GDP)	[3] Tax effort/efficiency
Mobile money	1.310*** (0.1467)	1.386*** (0.1667)	0.364*** (0.1237)
Control group mean	15.93%	16.75%	62.38%
Covariates in the second step	Yes	Yes	Yes
Year fixed effects in the second step	Yes	Yes	Yes
Country fixed effects in the second step	Yes	Yes	Yes
Observations	1344	1387	1306
$_R2$	0.929	0.919	0.982

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table A4
System-GMM method

Tax revenue (%GDP)	[1] System-GMM	[2] System-GMM
Mobile money		0.924** (0.3637)
Log mobile money account (% population)	0.452*** (0.1476)	
Lag tax revenue (%GDP)	0.773*** (0.0862)	0.827*** (0.1267)
Control group mean	14%	14%
Main controls	Yes	Yes
Fixed effects	Yes	Yes
AR(1)/AR(2) p-value	0.054/0.723	0.011/0.498
Hansen test p-value	0.937	0.143
Number of instruments/number of countries	31/86	32/95
Observations	257	353

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table A5
Potential omitted covariates or additional control

	[1] Mobile money agent/ km2	[2] Mobile cellular subscriptions	[3] Rule of law	[4] Government consumption	[5] Population density	[6] Conflict dummy	[7] Financial openness	[8] Trade openness	[9] ODA	[10] Natural resources	[11] Exchange rate
Panel A: Additional control variables in the second stage only											
Mobile money	1.534*** (0.1652)	1.036*** (0.1779)	0.947*** (0.1485)	0.918*** (0.1377)	1.067*** (0.1478)	1.027*** (0.1364)	1.051*** (0.1393)	0.956*** (0.1375)	0.978*** (0.1446)	1.020*** (0.1373)	1.043*** (0.1398)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
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	895	1420	1228	1267	1420	1420	1390	1394	1282	1416	1391
$_R2$	0.930	0.910	0.913	0.916	0.910	0.910	0.910	0.913	0.909	0.910	0.910
	[12] FDI	[13] Log remittances	[14] Agriculture	[15] Climate vulnerability	[16] Age dependency ratio	[17] Education	[18] Control of corruption	[19] Social globalisation	[20] Internet	[21] Democracy	[22] Time to pay taxes
Mobile money	0.989*** (0.1372)	0.851*** (0.1470)	0.953*** (0.1404)	0.807*** (0.1423)	0.908*** (0.1590)	0.729*** (0.1752)	0.953*** (0.1474)	0.781*** (0.1841)	1.196*** (0.1524)	0.990*** (0.1394)	0.908*** (0.2140)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
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	1416	1315	1401	1420	1420	1389	1228	1398	1412	1390	852
$_R2$	0.910	0.909	0.910	0.912	0.910	0.908	0.914	0.910	0.910	0.911	0.915

(*continued on next page*)

Table A5 (*continued*)

	[1] Mobile money agent/ km2	[2] Mobile cellular subscriptions	[3] Rule of law	[4] Government consumption	[5] Population density	[6] Conflict dummy	[7] Financial openness	[8] Trade openness	[9] ODA	[10] Natural resources	[11] Exchange rate
	[1] Mobile money agent/ km^2	[2] Mobile cellular subscriptions	[3] Rule of law	[4] Government consumption	[5] Population density	[6] Conflict dummy	[7] Financial openness	[8] Trade openness	[9] ODA	[10] Natural resources	[11] Exchange rate
Panel B: Additional control variables in the first stage only											
Mobile money	0.854*** (0.3103)	0.899*** (0.2008)	0.982*** (0.1416)	1.019*** (0.1481)	0.992*** (0.1339)	1.025*** (0.1363)	1.028*** (0.1384)	0.946*** (0.1427)	0.940*** (0.1436)	1.034*** (0.1353)	1.024*** (0.1362)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
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	405	852	1228	1267	1420	1420	1390	1394	1282	1416	1391
$_R2$	0.948	0.914	0.921	0.908	0.913	0.910	0.910	0.907	0.907	0.912	0.916
	[12] FDI	[13] Log remittances	[14] Agriculture	[15] Climate vulnerability	[16] Age dependency ratio	[17] Education	[18] Control of corruption	[19] Social globalisation	[20] Internet	[21] Democracy	[22] Time to pay taxes
Mobile money	1.021*** (0.1379)	0.905*** (0.1621)	0.995*** (0.1406)	1.037*** (0.1346)	0.914*** (0.1367)	0.949*** (0.1425)	0.962*** (0.1382)	0.947*** (0.1505)	1.027*** (0.1396)	0.991*** (0.1413)	0.875*** (0.2074)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
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	1416	1315	1401	1420	1420	1389	1228	1331	1323	1303	773
$_R2$	0.910	0.908	0.907	0.912	0.912	0.905	0.922	0.910	0.919	0.919	0.920
	[1] Mobile money agent/ km^2	[2] Mobile cellular subscriptions	[3] Rule of law	[4] Government consumption	[5] Population density	[6] Conflict dummy	[7] Financial openness	[8] Trade openness	[9] ODA	[10] Natural resources	[11] Exchange rate
Panel C: Additional control variables in both the second and first stage											
Mobile money	1.643*** (0.1708)	1.047*** (0.1397)	0.982*** (0.1416)	1.019*** (0.1481)	0.992*** (0.1339)	1.025*** (0.1363)	1.028*** (0.1384)	0.946*** (0.1427)	0.940*** (0.1436)	1.034*** (0.1353)	1.024*** (0.1362)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
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	887	1412	1228	1267	1420	1420	1390	1394	1282	1416	1391
$_R2$	0.926	0.915	0.921	0.908	0.913	0.910	0.910	0.907	0.907	0.912	0.916
	[12] FDI	[13] Log remittances	[14] Agriculture	[15] Climate vulnerability	[16] Age dependency ratio	[17] Education	[18] Control of corruption	[19] Social globalisation	[20] Internet	[21] Democracy	[22] Time to pay taxes
Mobile money	1.021*** (0.1379)	0.905*** (0.1621)	0.995*** (0.1406)	1.037*** (0.1346)	0.914*** (0.1367)	0.949*** (0.1425)	0.962*** (0.1382)	0.947*** (0.1505)	1.027*** (0.1396)	0.990*** (0.1394)	0.908*** (0.2140)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
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	1416	1315	1401	1420	1420	1389	1228	1331	1323	1390	852
$_R2$	0.910	0.908	0.907	0.912	0.912	0.905	0.922	0.910	0.919	0.911	0.915

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table B1
Mobile money and tax revenue over GDP (OLS).

Tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money	2.652***	2.401***	2.384***	2.337***	2.177***	1.798***	1.485***	1.471***
	(0.3455)	(0.3587)	(0.3630)	(0.3701)	(0.3454)	(0.3305)	(0.2884)	(0.2869)
Real GDP per capita		0.000*	0.000*	0.000*	0.000 (0.0002)	−0.000	−0.000	−0.000
		(0.0002)	(0.0002)	(0.0002)		(0.0002)	(0.0002)	(0.0002)
Rural population			−0.066	−0.069	−0.125	−0.098	−0.307	−0.307
growth			(0.1619)	(0.1653)	(0.2020)	(0.2292)	(0.2929)	(0.2850)
Labor force				−0.038	−0.048	−0.045	−0.037	−0.032
				(0.0567)	(0.0538)	(0.0751)	(0.0739)	(0.0729)
Inflation					−0.000	−0.001	0.002 (0.0013)	0.002 (0.0013)
					(0.0004)	(0.0004)		
Financial deepening						0.038**	0.044**	0.045**
						(0.0150)	(0.0181)	(0.0180)
Investment freedom							−0.011	−0.009
							(0.0128)	(0.0126)
Fixed telephone								0.036 (0.0509)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2623	2503	2503	2477	2157	1733	1420	1420
R^2	0.843	0.852	0.852	0.846	0.869	0.896	0.907	0.907

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table B2
Potential omitted covariates or additional control (OLS)

Tax revenue(%GDP)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
Mobile money	1.961***	1.808***	1.621***	1.636***	1.520***	1.520***	1.571***	1.514***	1.387***	1.373***	1.028**	1.039**	1.057**	1.028**	1.041**	1.058**	1.001**	1.011**	1.123**	1.268**
	(0.3947)	(0.5243)	(0.4837)	(0.4437)	(0.4403)	(0.4403)	(0.4575)	(0.4928)	(0.5042)	(0.4886)	(0.4486)	(0.4614)	(0.5036)	(0.4930)	(0.4980)	(0.5118)	(0.4507)	(0.4496)	(0.4880)	(0.5191)
Real GDP per capita	0.000	−0.000	−0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Rural population growth	−0.016	−0.002	0.043	0.186	0.262	0.262	0.264	0.252	0.152	0.152	0.086	0.089	0.088	0.089	0.076	0.067	0.023	0.017	−0.038	−0.044
	(0.2700)	(0.2699)	(0.2626)	(0.2278)	(0.2615)	(0.2615)	(0.2630)	(0.2652)	(0.2660)	(0.2667)	(0.3018)	(0.2992)	(0.3092)	(0.3082)	(0.3014)	(0.3121)	(0.3205)	(0.3241)	(0.3441)	(0.3373)
Labor force	0.042	0.039	0.031	−0.017	−0.011	−0.011	−0.021	−0.019	−0.020	−0.012	0.034	0.033	0.032	0.040	0.049	0.054	0.076	0.073	0.059	0.050
	(0.0830)	(0.0827)	(0.0791)	(0.0774)	(0.0766)	(0.0766)	(0.0738)	(0.0742)	(0.0640)	(0.0646)	(0.0729)	(0.0726)	(0.0751)	(0.0758)	(0.0751)	(0.0779)	(0.0808)	(0.0793)	(0.0819)	(0.0797)
Inflation	0.001	0.001	−0.012	−0.012	−0.013	−0.013	−0.012	−0.010	−0.015	−0.016	−0.008	−0.008	−0.014	−0.013	−0.014	−0.014	−0.011	−0.011	−0.012	−0.012
	(0.0010)	(0.0010)	(0.0109)	(0.0169)	(0.0169)	(0.0169)	(0.0167)	(0.0174)	(0.0156)	(0.0154)	(0.0136)	(0.0136)	(0.0136)	(0.0159)	(0.0154)	(0.0155)	(0.0147)	(0.0147)	(0.0149)	(0.0147)
Financial deepening	0.059***	0.057***	0.054**	0.054**	0.054**	0.054**	0.053**	0.055**	0.049**	0.050**	0.047**	0.047**	0.049**	0.049**	0.047**	0.047**	0.048**	0.050**	0.044**	0.046**
	(0.0193)	(0.0212)	(0.0222)	(0.0214)	(0.0215)	(0.0215)	(0.0220)	(0.0232)	(0.0223)	(0.0223)	(0.0220)	(0.0221)	(0.0214)	(0.0210)	(0.0199)	(0.0200)	(0.0197)	(0.0194)	(0.0204)	(0.0196)
Investment freedom	0.001	0.002	−0.002	−0.007	−0.009	−0.009	−0.005	−0.004	−0.003	−0.003	−0.003	−0.003	−0.001	−0.000	0.001	0.000	0.003	0.002	0.007	0.006
	(0.0147)	(0.0152)	(0.0144)	(0.0144)	(0.0143)	(0.0143)	(0.0154)	(0.0155)	(0.0166)	(0.0166)	(0.0165)	(0.0169)	(0.0172)	(0.0171)	(0.0169)	(0.0167)	(0.0165)	(0.0169)	(0.0163)	(0.0163)
Fixed telephone	0.016	0.013	0.039	0.115	0.116	0.116	0.114	0.105	0.197**	0.193**	0.196**	0.197**	0.200**	0.197**	0.186*	0.194**	0.206**	0.202**	0.193**	0.208**
	(0.0751)	(0.0761)	(0.0762)	(0.0763)	(0.0765)	(0.0765)	(0.0791)	(0.0884)	(0.0870)	(0.0870)	(0.0933)	(0.0936)	(0.0975)	(0.0954)	(0.0956)	(0.0929)	(0.0917)	(0.0932)	(0.0890)	(0.0894)
Mobile money agent/ km^2	−0.000	−0.000	−0.000	−0.000	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0006)	(0.0006)	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0006)	(0.0006)
Mobile cellular subscriptions		0.003	0.004	0.000	−0.000	−0.000	−0.001	−0.000	0.001	0.001	0.005	0.005	0.005	0.005	0.003	0.004	0.006	0.005	0.006	0.008
		(0.0070)	(0.0066)	(0.0059)	(0.0060)	(0.0060)	(0.0061)	(0.0061)	(0.0063)	(0.0064)	(0.0060)	(0.0061)	(0.0060)	(0.0061)	(0.0060)	(0.0066)	(0.0070)	(0.0072)	(0.0083)	(0.0084)
Rule of law			0.673	0.726	0.670	0.670	0.653	0.649	0.440	0.462	0.601	0.602	0.490	0.521	0.584	0.602	0.604	0.421	0.825	0.771
			(0.7543)	(0.6825)	(0.6907)	(0.6907)	(0.7018)	(0.7008)	(0.7551)	(0.7586)	(0.7238)	(0.7239)	(0.7288)	(0.7238)	(0.6928)	(0.6906)	(0.6825)	(0.8801)	(0.8196)	(0.8212)
Governement consumption				0.087	0.086	0.086	0.089	0.085	0.089	0.098	0.219***	0.217***	0.224***	0.222***	0.221***	0.220***	0.230***	0.230***	0.243***	0.248***
				(0.0854)	(0.0838)	(0.0838)	(0.0844)	(0.0854)	(0.0696)	(0.0695)	(0.0681)	(0.0675)	(0.0682)	(0.0676)	(0.0672)	(0.0672)	(0.0671)	(0.0664)	(0.0682)	(0.0691)
Population density					0.009	0.009	0.008	0.008	0.005	0.005	0.003	0.003	0.001	−0.000	−0.002	−0.001	−0.002	−0.002	−0.004	−0.002
					(0.0100)	(0.0100)	(0.0096)	(0.0100)	(0.0090)	(0.0089)	(0.0077)	(0.0078)	(0.0076)	(0.0075)	(0.0073)	(0.0072)	(0.0071)	(0.0071)	(0.0071)	(0.0071)
Conflict dummy						3.097*	3.170*	3.127	2.118	2.750	3.751*	3.768*	3.609*	4.495*	3.246	3.879	4.473	4.318	3.579	3.111
						(1.6800)	(1.8811)	(1.9042)	(1.8795)	(2.0826)	(2.0244)	(2.0272)	(2.0148)	(2.3216)	(2.9054)	(4.0406)	(4.1504)	(4.2187)	(4.2294)	(4.2178)
Financial openness							0.120	0.078	0.246	0.255	0.301	0.302	0.287	0.272	0.263	0.270	0.247	0.249	0.253	0.250
							(0.2425)	(0.2492)	(0.2348)	(0.2394)	(0.2362)	(0.2365)	(0.2412)	(0.2377)	(0.2337)	(0.2434)	(0.2541)	(0.2537)	(0.2416)	(0.2382)
Trade openness								0.003	0.011	0.010	0.008	0.008	0.006	0.005	0.004	0.004	0.002	0.002	−0.002	−0.001
								(0.0156)	(0.0181)	(0.0189)	(0.0184)	(0.0188)	(0.0200)	(0.0199)	(0.0207)	(0.0208)	(0.0202)	(0.0203)	(0.0205)	(0.0206)
ODA									0.033	0.036	0.029	0.030	0.030	0.035	0.039	0.039	0.053	0.052	0.036	0.034
									(0.0370)	(0.0366)	(0.0359)	(0.0401)	(0.0397)	(0.0418)	(0.0436)	(0.0437)	(0.0507)	(0.0499)	(0.0464)	(0.0461)
Total natural resources rents										0.023	0.015	0.015	0.026	0.029	0.030	0.030	0.033	0.035	0.025	0.026
										(0.0298)	(0.0291)	(0.0293)	(0.0327)	(0.0334)	(0.0340)	(0.0336)	(0.0352)	(0.0347)	(0.0319)	(0.0321)
Exchange rate											0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
											(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
FDI												−0.004	−0.006	−0.006	−0.008	−0.008	−0.008	−0.009	−0.004	−0.004
												(0.0149)	(0.0168)	(0.0169)	(0.0176)	(0.0176)	(0.0180)	(0.0180)	(0.0170)	(0.0163)
Log remittances													0.127	0.115	0.113	0.111	0.137	0.137	0.129	0.153
													(0.1587)	(0.1564)	(0.1478)	(0.1494)	(0.1610)	(0.1610)	(0.1557)	(0.1677)
Agriculture														−0.038	−0.039	−0.041	−0.055	−0.051	−0.039	−0.043
														(0.0372)	(0.0379)	(0.0386)	(0.0397)	(0.0402)	(0.0445)	(0.0449)
Climat vulnerability															−17.277	−17.747	−16.233	−15.717	−8.583	−10.155
															(22.2982)	(21.8724)	(22.8348)	(22.4233)	(20.4899)	(20.3866)
Age dependency ratio																				

(*continued on next page*)

Table B2 (*continued*)

Tax revenue(%GDP)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
																0.014	0.010	0.007	0.006	0.001
																(0.0417)	(0.0455)	(0.0468)	(0.0477)	(0.0469)
Education																	−0.183	−0.188	−0.178	−0.136
																	(0.4758)	(0.4777)	(0.4780)	(0.4794)
Corruption																		0.321	0.291	0.296
																		(0.7176)	(0.6411)	(0.6427)
Democracy																			0.001	0.031
																			(0.1172)	(0.1196)
Social globalisation																				−0.041
																				(0.0326)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
Main controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	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	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	895	895	703	628	628	628	607	597	567	567	560	560	537	535	535	535	526	526	486	486
$_{R}2$	0.925	0.925	0.929	0.935	0.935	0.935	0.935	0.935	0.934	0.934	0.936	0.936	0.932	0.932	0.933	0.933	0.932	0.932	0.937	0.937

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table B3
Bivariate correlations

	Tax rev. (%GDP)	Log GDP/cap.	Inst. qual.	Time to pay taxes
Tax revenue (%GDP)	1.0000			
Log GDP/capita	0.3763*	1.0000		
Institutional quality	0.3447*	0.2873*	1.0000	
Time to pay taxes	−0.0199	−0.0036	0.0377	1.0000

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

Table B4
Descriptive statistics of baseline variables

Variables	Obs	Mean	Std. Dev.	Min	Max
Tax revenue (%GDP)	2623	14.278	6.392	1.065	56.916
Mobile money	3120	0.207	0.405	0	1
Real GDP per capita (lag)	2941	4297.333	6641.531	190.015	69679.09
Rural population growth (lag)	3016	0.754	1.568	−7.866	10.905
Inflation (lag)	2596	24.136	215.867	−30.243	7481.664
Financial deepening (lag)	2397	30.726	27.054	0	160.125
Investment freedom (lag)	2332	49.554	18.424	0	90
Labor force (lag)	2987	63.789	11.467	39.247	91.102
Fixed telephone (lag)	3016	8.695	9.462	0	43.882

Table B5
Mobile money countries

Albania	Gabon	Kenya	Namibia	Chad
Argentina	Georgia	Kyrgyz Republic	Niger	Togo
Armenia	Ghana	Cambodia	Nigeria	Thailand
Burundi	Guinea	Liberia	Nicaragua	Tajikistan
Benin	Gambia, The	Sri Lanka	Nepal	Tunisia
Burkina Faso	Guinea-Bissau	Lesotho	Peru	Turkey
Bangladesh	Guatemala	Morocco	Philippines	Tanzania
Bolivia	Guyana	Madagascar	Papua New Guinea	Uganda
Brazil	Honduras	Mexico	Paraguay	Vanuatu
Botswana	Haiti	Mali	Qatar	South Africa
Central African Republic	Indonesia	Myanmar	Rwanda	Zambia
Cameroon	India	Mongolia	Senegal	Zimbabwe
Colombia	Iran, Islamic Rep.	Mozambique	Sierra Leone	
Dominican Republic	Jamaica	Mauritania	El Salvador	
Egypt, Arab Rep.	Jordan	Mauritius	Eswatini	
Fiji	Kazakhstan	Malawi	Seychelles	

Table B6
Country list

Angola	Cameroon	Croatia	Moldova	Papua New Guinea	Uganda
Albania	Colombia	Haiti	Madagascar	Poland	Ukraine
Argentina	Comoros	Hungary	Mexico	Paraguay	Uruguay
Armenia	Costa Rica	Indonesia	Macedonia, FYR	Qatar	Uzbekistan
Azerbaijan	Djibouti	India	Mali	Romania	Venezuela, RB
Burundi	Dominican Republic	Iran, Islamic Rep.	Myanmar	Rwanda	Vanuatu
Benin	Algeria	Jamaica	Mongolia	Saudi Arabia	South Africa
Burkina Faso	Ecuador	Jordan	Mozambique	Senegal	Zambia
Bangladesh	Egypt, Arab Rep.	Kazakhstan	Mauritania	Sierra Leone	Zimbabwe
Bulgaria	Fiji	Kenya	Mauritius	El Salvador	
Bahamas, The	Gabon	Kyrgyz Republic	Malawi	Eswatini	
Belize	Georgia	Cambodia	Namibia	Seychelles	
Bolivia	Ghana	Lao PDR	Niger	Chad	
Brazil	Guinea	Lebanon	Nigeria	Togo	
Bhutan	Gambia, The	Liberia	Nicaragua	Thailand	
Botswana	Guinea-Bissau	Libya	Nepal	Tajikistan	
Central African Republic	Guatemala	Sri Lanka	Panama	Tunisia	
Chile	Guyana	Lesotho	Peru	Turkey	
China	Honduras	Morocco	Philippines	Tanzania	

Additional robustness

In the spirit of the first paragraph of Section 5.1 we compute five additional new treatment defined over five years before mobile money adoption to the initial year of adoption, i.e., from five, four, three, two, one year(s) before adoption to the year of adoption, respectively. Columns [1]-[5] of Table C1 present, respectively, the windows of the 5 years preceding the adoption year to the initial adoption year [−5; 0], four years preceding [−4; 0], three years preceding [−3; 0], two years preceding [−2; 0] and one year preceding [−1; 0]. The findings remain consistent with our baseline results: mobile money increases tax revenues in developing countries.

Second, we test the robustness of our results by altering our baseline sample by excluding some countries or periods. We start by excluding non-mobile money countries from our sample. Indeed, mobile money countries may differ from non-mobile money countries in ways that go beyond the country and time fixed effects that we control for in our empirical analysis (see, for instance, Neuenkirch and Neumeier, 2015). Second, we exclude new mobile money countries, i.e., those that recently adopted mobile money, as the level of mobile money deployment may not yet be extensive enough to have a significant effect on tax revenue, suggesting that our results could be downward biased by keeping these countries in the sample. Third, we exclude Sub-Saharan African countries and resource-rich countries to account for potential outliers. Indeed, since mobile money penetration is very high in Sub-Saharan African countries, excluding these countries in our sample allows us to isolate their impact. In addition, excluding resource-rich countries allows us to control for the natural resource curse that leads to low tax performance in these countries. Fourth, we look for the potential role of tax revenue outliers. For this purpose, we exclude countries with tax ratios above 30% GDP (see Balima et al., 2016 for a similar approach), which is roughly the average level in developed countries (Fricke and Süssmuth, 2014). Next, for counterfactual purposes, we exclude countries that qualify as tax havens. These countries, which can be described as non-cooperative, compete internationally through favorable tax legislation. In addition, we exclude high-income countries in order to isolate the impact of these countries in our sample. Finally, we analyze whether our results remain valid after excluding the Global Financial Crisis (GFC) years and hyperinflation episodes characterized by annual inflation of over 40%. Results compiled in Table C2 (columns [1]-[9]), present the results of these various specifications. The estimated coefficients remain statistically significant, with magnitudes close to the average effect of our baseline results. Therefore, we can safely say that altering our sample does not change our baseline conclusions.

Third, we use the IMF's Financial Access Survey (FAS) dataset to ensure that the results are robust to alternative mobile money databases. Results using this alternative database are presented in Table C3, and show a positive and significant effect at 1% level of mobile money adoption on tax revenue. The estimated coefficients are similar to the average effect of our baseline results, so we can safely claim the robustness of our baseline findings.

Four, we use the Propensity Score Matching method (PSM) developed by Rosenbaum and Rubin (1983). This method is part of the impact analysis family methods and allows us to correct endogeneity problems, especially selection bias. Using four matching methods: Nearest Neighbor Matching, Radius Matching, Kernel Matching, and Local Linear Regression Matching, results in Table C4 show a positive and significant effect of mobile money adoption on tax revenue.

Five, we use the Inverse Probability Weighting (IPW) to estimate the causal effect of mobile money adoption because of its robustness to sample size and missing data bias. The results of this method, presented in Table C4, are consistent with the findings of entropy balancing.

Six, we use the Inverse Probability Weighted Regression Adjustment or IPWRA (see Imbens and Wooldridge, 2009) for its robustness to mis-specification bias and non-sensitivity to sample size. Results in Table C4 show that the estimated coefficient using this method remains positive and statistically significant, highlighting the robustness of our results.

Table C1
Adjusting the treatment variable

Tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]
	[-1;0]	[-2;0]	[-3;0]	[-4;0]	[-5;0]
Mobile money	0.488*** (0.1500)	0.443*** (0.1522)	0.313* (0.1602)	0.309** (0.1533)	0.347** (0.1470)
Control group mean	15%	15%	15%	15%	15%
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	453	511	568	622	673
$_R2$	0.970	0.963	0.955	0.955	0.954

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table C2
Altering the sample

	[1]	[2]	[3]	[4]	[5]
	Excl. non mobile money countries	Excl. new mobile money adopters	Excl. Sub-Saharan Africa	Excl. natural resources countries	Excl. tax revenue>30
Mobile money	1.157*** (0.1625)	1.029*** (0.1357)	1.071*** (0.1358)	1.087*** (0.1443)	1.155*** (0.1159)
Control group mean	13.51%	14%	14%	14.78%	13.80%
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	1083	1318	1420	1287	1411

(continued on next page)

Table C2 (*continued*)

	[1]	[2]	[3]	[4]	[5]
	Excl. non mobile money countries	Excl. new mobile money adopters	Excl. Sub-Saharan Africa	Excl. natural resources countries	Excl. tax revenue>30
$_R2$	0.916	0.919	0.914	0.910	0.926
Tax revenue	[6]	[7]	[8]	[9]	
	Excl. high income countries	Excl. tax haven countries	Excl. the 2008–2009 crisis episodes	Excl. hyperinflation episodes	
Mobile money	0.988*** (0.1478)	1.157*** (0.1606)	1.084*** (0.1411)	1.055*** (0.1365)	
Control group mean	13.62%	13.26%	14%	14%	
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	1233	1162	1290	1401	
$_R2$	0.912	0.898	0.912	0.914	

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table C3
Alternative mobile money database

Tax revenue (%GDP)	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mobile money (FAS)	0.913** (0.4480)	1.655*** (0.1830)	1.043** (0.4521)	1.766*** (0.1842)	1.694*** (0.3708)	0.812*** (0.1800)	1.856*** (0.3740)	0.872*** (0.1817)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%
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	1337	1337	1337	1337	1337	1337	1337	1337
$_R2$	0.003	0.894	0.006	0.896	0.354	0.917	0.358	0.917

Unreported constant included. Robust standard errors in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

Table C4
Mobile money and tax revenue over GDP (PSM, IPW, IPWRA)

Dependent variable	Nearest-Neighbor Matching			Radius Matching			Kernel Matching	Local Linear Regression Matching	IPW	IPWRA
Tax revenue (% GDP)	N = 1	N = 2	N = 3	r = 0.005	r = 0.01	r = 0.05				
Treatment effect of mobile money on tax revenue (%GDP)										
Mobile money	1.557** (0.6055)	1.496*** (0.5667)	1.437*** (0.5242)	1.454*** (0.4289)	1.326*** (0.4145)	1.630*** (0.3479)	1.617*** (0.3606)	1.516*** (0.3654)	1.603*** (0.3337)	1.306*** (0.3225)
Control group mean	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
Number of Treated Obs	403	403	403	403	403	403	403	403	403	403
Number of Controls Obs.	1116	1116	1116	1116	1116	1116	1116	1116	1017	903
Observations	1519	1519	1519	1519	1519	1519	1519	1519	1420	1306
Pseudo R^2	0.004	0.007	0.007	0.005	0.006	0.003	0.003	0.004	–	–
Standardized biases (p-value)	0.694	0.388	0.380	0.683	0.561	0.882	0.864	0.694	–	–
Rosenbaum bounds sensitivity tests	1.2	1.3	1.3	1.3	1.2	1.4	1.4	1.3	–	–

Bootstrapped standard errors based on 500 replications reported in brackets. ***p < 0.01, **p < 0.05, *p < 0.1.

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