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Does the adoption of peer-to-government mobile payments improve tax revenue mobilization in developing countries?

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Abstract: Developing countries need to raise sufficient tax revenue to finance development. Revenue mobilization is often hampered by limited tax compliance, weak institutions, and technical problems with tax collection. One solution to these challenges is person-to-government (P2G) mobile phone payments, adopted in a number of developing countries since the early 2000s. This study assesses the causal effect of P2G adoption on tax revenue using propensity score matching. According to the matching estimates, countries that adopt P2G services experience a 1.2–1.3 percentage point boost in direct tax revenue as a share of GDP. P2G adoption increases revenue from both corporate and personal income taxes, with larger effects on the latter. The results remain robust to matching quality tests and alternative estimation methods, including function control, two-stage least squares, and system generalized method of moments. The average treatment effects are largest among lower-middle-income countries and countries characterized by limited tax compliance and corruption control, and by low levels of urbanization and domestic credit to the private sector. The findings suggest that developing countries, particularly those with poor institutions and low levels of financial inclusion, should promote the adoption and use of mobile money services for tax transactions.

Key words: mobile money, P2G, direct tax revenue, propensity score matching, developing countries

JEL classification: H2, O1, O3

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1 Introduction

Several studies have demonstrated a positive link between domestic tax revenue mobilization and economic development (Jenkins and Newell 2013; Owens and Carey 2009). Yet it is well established that developing countries, with tax revenues of 10–20 per cent of GDP, collect taxes much less effectively than their higher-income counterparts (Besley and Persson 2014). In addition to structural economic weaknesses, tax revenue mobilization in poorer countries is limited by their weak institutions, fragmented polities, and a poor norm of tax compliance (De Paepe and Dickinson 2014; Brun et al. 2020). The lack of sufficient resources makes it difficult for public administrations to function effectively and to provide public goods and services.

While alternatives exist for the financing of development goals, domestic taxation is generally considered a more reliable and sustainable revenue source than development aid, foreign direct investment (FDI), or debt (Rodríguez Bolívar et al. 2016; Moore and Prichard 2020). Development aid, for instance, is generally more unpredictable than tax revenue and its volatility tends to increase with the degree of aid dependence (Bulir and Hamann 2001), typically high in less-developed economies. Aid dependence can also reduce incentives for governments to maintain efficient institutions, such as an effective tax revenue administration (Djankov et al. 2008). The inflows of FDI are similarly unstable and also dependent on the economic conditions of countries of origin, while debt financing comes with well-known sustainability challenges. Tax revenues are critical for developing countries because they provide governments with reliable and independent revenue.

Several studies have assessed the determinants of tax revenue and factors that can improve tax revenue mobilization (Baunsgaard and Keen 2010; Besley and Persson 2009; Brückner 2012; Clist and Morrissey 2011; Gnangnon and Brun 2019a, 2019b; Lotz and Morss 1970; Mahdavi 2008). Among other factors, larger tax revenues are associated with trade openness, democracy, quality of institutions, foreign aid and assistance, and population size.

With the rise of information and communication technology (ICT), more attention has been directed in recent years to the effects of digitalization on tax revenue. Moore and Prichard (2020) argue that ICTs can help developing countries collect more taxes by improving transparency and centralizing the tax compliance process. Eilu (2018) emphasizes the critical need to better integrate ICTs into national tax systems in order to improve revenue collection and related enforcement.

Empirical research provides support for these arguments. Many studies have assessed the impact of the internet on tax revenue, generally relying on the two-step system generalized method of moments (GMM) estimator. They show that internet access has increased domestic (non-resource) tax revenue (Gnangnon and Brun 2018; 2019a), promoted related tax transition reforms (Gnangnon 2020a), and reduced tax revenue instability (Gnangnon 2020b). Using fixed time effects models, Koyuncu et al. (2016) show that the penetration of computers, mobile phones, and other ICTs improved tax revenues in a sample of 157 countries between 1990 and 2013. Similarly, using a panel of 96 developing countries from 2005 to 2016, Brun et al. (2020) find that ICT usage has had a positive effect on tax collection, channelled especially through government effectiveness, control of corruption, and better tax compliance.

This general evidence raises the question of which specific information technologies can further promote the mobilization of tax revenue in the developing world. More than a decade ago, Bird and Zolt (2008) argued that the widespread use of cell phones for conducting financial transactions in less-developed countries implies that electronic tax filing and payment using this method may

soon be possible. Since the beginning of the 2000s, Mobile Money (MM) services have in fact emerged as a plausible method of conducting such transactions.

First implemented in Russia in 2002, MM is a payment system that uses a mobile phone with an associated financial account to send and receive money. While several types of MM services exist,[1] this study focuses specifically on person-to-government (P2G) transfers, adopted in several developing countries over the past two decades. P2G payments are money transfers from individuals or businesses to governments, including agencies and other institutions at the municipal, state, and national level. P2G transfers can be statutory payments, such as fees or tax payments, or payments to government-owned utilities for obtaining documents such as marriage certificates or business licences (GSMA 2020). This study asks whether the adoption of P2G as a means of payment can increase direct tax revenues in developing countries, and, if so, how different country characteristics mediate this effect.

In most developing countries, tax collection has remained traditional until recent years. The collection process typically entails taxpayers visiting local tax authorities to discharge their tax obligations, usually by cash or cheque. Self-declaration, data entry, and manual collection often take several weeks and are fraught with a high risk of corruption, losing declarations, and also reducing taxpayer morale. Streamlining these processes can reduce both taxpayers' compliance costs and tax authorities' collection costs, ideally leading to greater revenue mobilization.

Existing literature has established several channels through which P2G payments can improve tax collection, especially in countries characterized by inefficient domestic revenue mobilization. First, P2G payments can reduce corruption in the tax administration by limiting physical interactions and payments by cash or cheque (Barasa 2021; Nwachi 2020).[2] Second, P2G transactions can address compliance challenges associated with the large informal sectors present in many developing countries (Besley and Persson 2014; Joshi et al. 2014). Small, informal enterprises are difficult for tax administrators to identify and target. Even when taxes can be levied, these companies often face long and complex procedures to discharge their tax obligations. Since informal and small firms already use MM payments in other contexts quite widely (GSMA 2019), dedicated P2G platforms can improve their compliance behaviour, help tax administrators identify more such firms, and thereby promote the broader formalization of the economy. Empirical evidence indicates that MM services can in fact induce formalization (Jacolin et al. 2019).

Despite the opportunities offered by P2G payment services, there are no studies, to the authors' knowledge, that assess the impact of their adoption on tax revenue. This paper addresses this gap by estimating the effect of P2G adoption on direct tax revenue, relying on a sample of 96 developing countries. The choice of direct (instead of indirect or overall) tax revenue as the main outcome is based on the notion that P2G payments are typically used by taxpayers to settle tax obligations imposed on them directly with the tax administration. In addition to providing the first empirical estimates on the impact on tax revenue of adopting P2G services, the work highlights how structural factors that differ across countries mediate the impact, demonstrating which types of countries are most likely to benefit from the technology.

In the analysis, propensity score matching (PSM) is used to estimate the average treatment effect on the treated, namely the effect of P2G adoption on direct tax revenues in developing countries

[1] Other MM services include person-to-person transfers, government-to-person transfers, merchant payment transfers, airtime top-ups, international remittances, and bill payments.

[2] See Brun et al. (2020) on the advantages of dematerializing tax payments.

that had adopted the technology by the end of 2018. The robustness of the results is tested using matching quality tests and alternative estimation methods, including function control, 2SLS, and system GMM. The main hypothesis is that P2G adoption improves direct tax revenues in adopting developing countries through providing a new, convenient mechanism for settling tax obligations, hence improving compliance, and through reducing corruption and improving administrative efficiency.

The matching estimates in the study show that PG2 adoption has a positive and significant effect on direct tax revenue, including both corporate income tax (CIT) and personal income tax (PIT). Using various matching estimates, the adoption of P2G services increases direct tax revenue by 1.21 to 1.32 percentage points. This effect is larger for revenues from PIT (0.68–0.85) than those from CIT (0.44–0.60). When assessing heterogeneity by income level using the control function method, the positive effect is only observed for low-income and lower-middle-income countries.

As for different transmission channels, P2G adoption is more effective for tax mobilization for countries characterized by an ineffective bureaucracy, extensive informality, and low levels of financial inclusion. Allowing and encouraging the use of P2G services for tax transactions in such countries would be a critical step towards improving tax compliance and overcoming existing institutional barriers to domestic tax revenue mobilization.

The treatment effects are also positive and significant for countries with low levels of development assistance and resource rents—potentially incentivizing tax collection reforms—and countries with high rates of labour force participation and school enrolment—indicating that reaping benefits from P2G services requires a large and capable user base.

The rest of the paper is structured as follows. Section 2 presents the data and the identification strategy. Section 3 presents the empirical results. Conclusions and policy implications are provided in Section 4.

2 Data and methodology

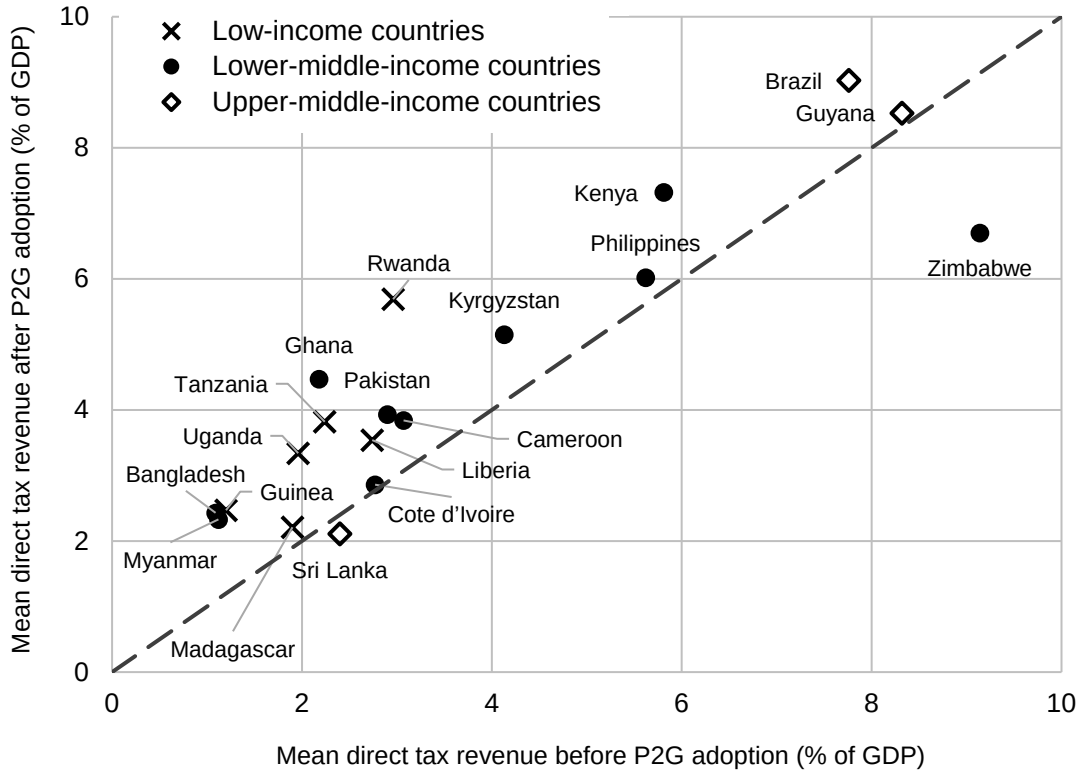
2.1 Data

The study uses data from 96 developing countries from 1994 to 2018. The data on tax revenue are compiled from the UNU-WIDER Government Revenue Dataset (GRD; UNU-WIDER 2021). The treatment variable for P2G adoption ('P2G') is constructed using the GSMA Mobile Money tracker, which records the year that mobile financial services were adopted for each adopter operator in each country. For a given country, 'P2G' is assigned a value of one for the years in which the service has been available, and zero otherwise. The rest of the control variables come from the World Development Indicators (WDI; World Bank 2021)).

Figure 1 illustrates mean direct tax revenues as a share of GDP in the adopter countries before and after P2G adoption; 17 out of 19 adopter countries experienced an increase in direct tax revenue after adopting the technology (i.e., they are located above the first bisector).[3]

[3] The list of adopter countries is provided in Table A1 in Appendix A, while the description of the variables and descriptive statistics are provided in Tables B1 and B2 in Appendix B.

Figure 1: Direct tax revenue to GDP ratio before and after P2G adoption



Note: ratio of mean direct tax revenue to GDP calculated from either all available years before P2G adoption (x-axis) or the first and following years after P2G adoption (Y axis); the ratio increased after P2G adoption for countries above the bisector.

Source: authors' elaboration of data from UNU-WIDER (2021) and World Bank (2021).

2.2 Methodology

We use PSM to evaluate the causal effect on direct tax revenue of adopting P2G services. The methodology, developed by Rosenbaum and Rubin (1983), has become increasingly popular in empirical economics (e.g. Combes et al. 2019; Imai and Azam 2012; Levchenko et al. 2009; Sawadogo 2020), including research on tax revenue topics (Balima et al. 2016; Ebeke et al. 2016; Lucotte 2012).

In non-randomized or observational studies, individual baseline characteristics generally influence exposure to a particular treatment. When baseline characteristics differ with treatment exposure, assessing the causal effect of the treatment on a given outcome requires such difference to be accounted for (i.e., addressing selection bias). PSM suits this study, as it can be used to evaluate the causal impact of a binary variable on any output from observational data (see e.g. Austin 2014).

This study implements a general three-step procedure to analyse the impact of P2G adoption on direct tax revenue. The first step entails the estimation of propensity scores (PS), or the probability of exposure to the treatment. The second step involves generating matched sets of P2G adopters and non-adopters with similar average PS. Finally, we estimate the average treatment effect on the treated (ATT) using various matching methods.

First, the PS is denoted by $l(Y_i)$, the probability of adopting P2G services given selected covariates:

$$l(Y_i) = P(P2G_i = 1|Y_i) \quad (1)$$

where $P2G_i$ signifies the treatment (P2G services adoption) and Y_i is a set of covariates that can simultaneously explain both P2G adoption and direct tax revenue.

The ATT can be formulated as follows:

$$ATT = E[(TX_i^1 - TX_i^0)|P2G_i = 1] \quad (2)$$

representing the average difference between tax revenue mobilized with and without P2G adoption (TX_i^1 and TX_i^0, respectively) in adopter countries ($P2G_i = 1$). Alternatively:

$$ATT = E(TX_i^1 \big| P2G_i = 1) - E(TX_i^0 \big| P2G_i = 1) \quad (3)$$

The last term, representing average tax revenue in adopter countries in a hypothetical case in which they had not adopted P2G services, is unobservable. Replacing it with mean tax revenue in non-adopter countries would lead to self-selection bias, because P2G adoption may be correlated with a set of observable characteristics across countries (Dehejia and Wahba 2002; Heckman et al. 1998; Lin and Ye 2007). Instead, the second term is replaced with tax revenue in non-adopter countries with basic characteristics comparable to those of their adopter pair:

$$ATT = E\left[TX_i^1 \big| P2G_i = 1, l(Y_i)\right] - E[TX_i^0 \big| P2G_i = 0, l(Y_i)] \quad (4)$$

where $l(Y_i)$ is the probability of P2G adoption given selected covariates from Equation 1.

The ATT is then estimated using various matching methods available in the literature, including: (1) nearest neighbour matching, which consists of matching each P2G adopter with the non-adopter with the closest PS (using $n = 1, 2, 3$); (2) radius matching (Dehejia and Wahba 2002), which retains non-adopters with a PS between a radius (using $r = 0.005, 0.01, 0.05$); (3) kernel estimator (Heckman et al. 1997, 1998), which matches each P2G adopter with a weighted average of all non-adopters; and (4) local linear regression (Heckman et al. 1997, 1998), which improves kernel estimator by adding a linear term in the weighting function (Fan 1993).[4]

3 Results

3.1 Propensity score estimation

PS are estimated using a probit model, in which the probability of adopting P2G services depends on various characteristics drawn from existing literature on MM service adoption and domestic tax revenue (Ebeke et al. 2016; Gupta et al. 2003; Imam and Jacobs 2007; Keen and Lockwood 2010; Khattry and Raos 2002; Le et al. 2008; Tanzi 1977). In total, nine covariates are included in the model: total population growth rate, mobile phone market penetration, growth rate of GDP per capita, agriculture value added, domestic credit to the private sector, trade openness, inflation, natural resource rents, and control of corruption. Table 1 presents the PS estimation results, with the basic specification shown in the first column.

[4] For more details, see Imbens (2004) and Smith and Todd (2005). Caliendo and Kopeinig (2008) cover the general background, advantages, and challenges concerning different matching strategies.

Table 1: Probit estimation of propensity scores

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Population growth	0.44***	0.47***	0.44***	0.61***	0.48***	0.51***	0.51***	0.50***	0.45***	0.47***	0.42***	0.44***
	(0.06)	(0.06)	(0.05)	(0.12)	(0.07)	(0.08)	(0.08)	(0.11)	(0.07)	(0.07)	(0.07)	(0.08)
Mobile phone penetration	0.02***	0.02***	0.01***	0.02***	0.02***	0.02***	0.02***	0.01***	0.02***	0.02***	0.01***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GDP per capita growth	0.07***	0.07***	0.07***	0.06**	0.08***	0.07***	0.08***	0.04	0.07***	0.07***	0.06**	0.032
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)
Domestic credit	−0.01***	−0.02***	−0.02***	−0.02***	−0.01***	−0.02***	−0.02***	−0.00	−0.02***	−0.01***	−0.02***	−0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Inflation	−0.03**	−0.02**	−0.02*	−0.02*	−0.03*	−0.03**	−0.00	−0.03*	−0.03**	−0.02	−0.04**	−0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
Control of corruption	−1.25***			−1.34***	−1.03***	−1.55***	−1.29***	−1.42***	−1.21***	−1.28***	−1.32***	−1.29***
	(0.16)			(0.20)	(0.18)	(0.21)	(0.19)	(0.30)	(0.17)	(0.15)	(0.20)	(0.17)
Agriculture value added	−0.01	−0.00	−0.01	−0.02**	−0.01	0.01	−0.01	−0.04***	−0.00	−0.02**	−0.01*	−0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Trade openness	−0.02***	−0.02***	−0.02***	−0.02***	−0.02***	−0.01***	−0.02***	−0.03***	−0.02***	−0.02***	−0.02***	−0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Resource rents	−0.08***	−0.08***	−0.08***	−0.09***	−0.08***	−0.09***	−0.07***	−0.05***	−0.08***	−0.09***	−0.08***	−0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Rule of law		−0.58***										
		(0.13)										
Government effectiveness			−0.40***									
			(0.15)									
School enrolment				0.02***								
				(0.01)								
Social conditions					−0.13**							
					(0.06)							
Bureaucracy quality						0.51***						
						(0.11)						
Tax compliance							0.18***					
							(0.05)					
Public admin. quality								0.15				
								(0.30)				
Net ODA									−0.03			
									(0.02)			

Labour force participation										0.03*** (0.01)		
Paying taxes: score											0.01*** (0.00)	
Urban population												-0.04*** (0.01)
Constant	−2.08*** (0.29)	−1.62*** (0.26)	−1.38*** (0.25)	−3.88*** (0.66)	−1.80*** (0.49)	−3.89*** (0.49)	−3.60*** (0.45)	−1.51 (1.23)	−2.07*** (0.30)	−4.13*** (0.56)	−1.52*** (0.44)	0.37 (0.38)
Observations	1,320	1,322	1,320	1,097	918	918	826	514	1,297	1,281	845	1,320
Pseudo R2	0.35	0.29	0.28	0.37	0.33	0.36	0.34	0.36	0.34	0.37	0.37	0.43

Note: robust standard errors in brackets; *p<0.10, **p<0.05, and ***p<0.01; ODA refers to official development assistance.

Source: authors' elaboration.

Columns 2–12 refer to alternative specifications that use institutional, economic, social, demographic, and administrative characteristics that can potentially explain both P2G adoption and tax revenue. The PSs resulting from these alternative specifications are used to assess the robustness of the results using different matching methodologies later, in Table 2. Given that McFadden's pseudo R2s range from 0.28 to up to 0.43, the tested specifications can be considered adequate in explaining the adoption of P2G services.

From the nine main variables, the first three demonstrate an expected positive association with P2G adoption. Rapid population growth and mobile phone penetration can facilitate adoption, as a growing number of potential users increases the utility of the technology via network effects. Countries with a strong economy, characterized by fast per capita GDP growth, are in turn expected to be well equipped and willing to adopt innovative payment solutions in general.

The next three variables are negatively correlated with P2G adoption, again in line with ex ante expectations. Significant domestic credit to the private sector is likely to reflect more-developed, traditional banking systems that are generally associated with lower financial exclusion and thereby lower incentives to adopt innovative payment solutions. High inflation is a sign of poor macroeconomic conditions, potentially discouraging the extensive adoption of new technologies. As for corruption control, an indicator of stable institutions, Evans and Pirchio (2014), Jacolin et al. (2019), and Pénicaud (2013) argue that countries with high institutional quality may not favour the adoption of novel innovations such as P2G due to their generally restrictive regulatory environments.

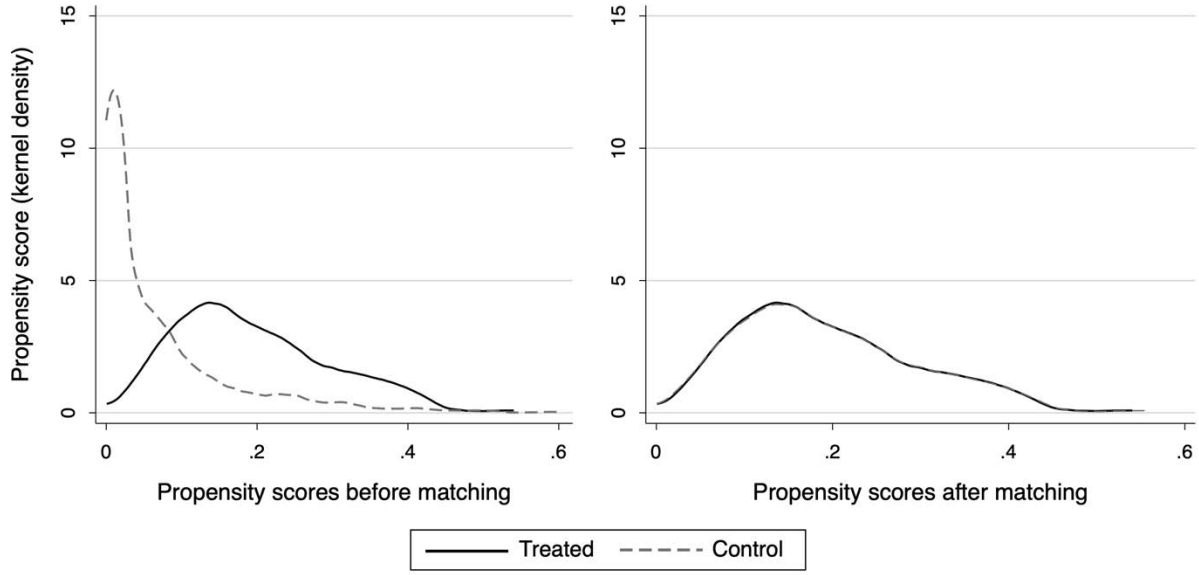
The remaining three variables are also negatively correlated with P2G adoption, with largely insignificant coefficients for agricultural value added and significant coefficients for trade openness and resource rents. On one hand, countries with a large informal sector, reflected by high levels of value added from agriculture, might favour P2G services to facilitate the formalization of their labour markets via new tax payment solutions. High agricultural value added may, however, also reflect poor socioeconomic conditions that reduce the likelihood of P2G adoption, explaining the negative coefficient.

The negative coefficient for trade openness could be explained by the notion that more-open economies are also more likely to have developed traditional financial systems and related services, with limited demand for alternative payment solutions. Such factors may be more important than the expected positive effect of trade openness on technology transfer, which could in turn facilitate P2G adoption.[5] Finally, the negative coefficient for natural resource trends may be explained by a version of the resource curse where less-diversified countries are less willing to adopt innovative technological solutions across the economy.

Figure 2 presents the distribution of PS across countries in the sample before and after matching for P2G adoption.

[5] Keen and Lockwood (2010) find a similar non-intuitive sign for trade openness when estimating its effect on VAT adoption.

Figure 2: Density plot for PS before and after matching for P2G



Source: authors' elaboration.

3.2 Matching results

Table 2 presents the evaluation results using a variety of matching techniques, along with selected statistics for standard diagnostic tests.

First, the pseudo R2 demonstrates the extent to which the control variables explain the probability of P2G services adoption and hence generate balanced scores (Sianesi 2004). Good model performance is associated with 'fairly low' values (Caliendo and Kopeinig 2008). Given that all pseudo R2s are lower than 0.03, the matchings yield balanced scores and the results broadly satisfy the common support assumption.

Second, the conditional independence assumption is tested for observables using the standardized bias test and for unobservables using the Rosenbaum upper bound sensitivity test (Rosenbaum 2002). The standardized bias test, which evaluates the marginal distance distributions of the control variables, generates p-values between 0.53 and 0.91. This suggests that there is no statistical difference between the characteristics of P2G adopters and non-adopters after matching.[6] The Rosembaum upper bound sensitivity test evaluates whether unobservables exist that could affect the estimated tax impact of P2G services adoption. The critical values vary between 2.4 and 2.7 and are comparable to those of other studies (Balima et al. 2016; Caliendo and Künn 2011), indicating that the results are robust to the conditional independence hypothesis.[7]

[6] Rosenbaum and Rubin (1985) propose a critical value of 0.2. In line with the larger p-values obtained, Figure 2 shows that the distribution of propensity scores after matching is comparable for P2G adopters and non-adopters.

[7] The test is conducted at a 5% level. The simulation-based sensitivity analysis presented by Ichino et al. (2008) is also implemented to test the robustness of the estimates under the failure of the conditional independence assumption. Based on the test, any unobserved factor correlated with each of the covariates used in this study would not be sufficient to drive the estimated average treatment effect to zero.

Table 2: Matching results for the effect of P2G on direct taxes

Treatment variable: P2G	**1-Nearest neighbour matching**	**2-Nearest neighbour matching**	**3-Nearest neighbour matching**	**Radius matching**			**Local linear**	**Kernel matching**
				r=0.005	**r=0.01**	**r=0.05**		
				Dependent variable: Direct taxes as percentage points of GDP				
ATT	1.28*** (0.30)	1.21*** (0.27)	1.32*** (0.28)	1.26*** (0.25)	1.29*** (0.23)	1.25*** (0.23)	1.25*** (0.23)	1.27*** (0.23)
				Quality of the matching				
Pseudo R2	0.025	0.021	0.022	0.013	0.013	0.012	0.025	0.012
Standardized bias (p-value)	0.53	0.65	0.61	0.88	0.9	0.91	0.53	0.91
Rosenbaum upper bound sensitivity test	2.4	2.4	2.7	2.7	2.6	2.5	2.4	2.5
ATT:				*Sensitivity analysis of the main results*				
[1] Controlling for rule of law	1.21***	1.18***	1.16***	1.12***	1.10***	0.98***	0.96***	0.99***
[2] Controlling for government effectiveness	1.14***	1.07***	1.10***	1.08***	1.01***	0.96***	0.94***	0.96***
[3] Controlling for school enrolment	1.03***	1.08***	1.05***	0.75***	0.82***	0.82***	0.80***	0.83***
[4] Controlling for social conditions	1.35***	1.34***	1.43***	1.40***	1.36***	1.24***	1.20***	1.25***
[5] Controlling for bureaucracy quality	1.10***	1.13***	1.15***	1.04***	1.23***	1.15***	1.07***	1.16***
[6] Controlling for tax compliance	1.39***	1.53***	1.48***	1.40***	1.48***	1.42***	1.42***	1.43***
[7] Controlling for public administration quality	1.33***	1.20***	1.15***	0.91***	0.98***	1.16***	1.21***	1.16***
[8] Controlling for ODA	1.05***	1.14***	1.21***	1.17***	1.28***	1.26***	1.24***	1.26***
[9] Controlling for labour force participation rate	1.41***	1.43***	1.38***	1.12***	1.11***	1.11***	1.12***	1.12***
[10] Controlling for taxpaying score	1.26***	0.97***	1.03***	0.93***	1.03***	1.06***	1.05***	1.05***
[11] Controlling for urban population	1.02***	1.22***	1.19***	1.27***	1.10***	1.32***	1.33***	1.31***
ATT:				*ATT by type of direct tax*				
CIT	0.46** (0.22)	0.60*** (0.19)	0.56*** (0.17)	0.50*** (0.15)	0.50*** (0.13)	0.44*** (0.13)	0.45*** (0.11)	0.44*** (0.12)
PIT	0.68*** (0.24)	0.79*** (0.22)	0.76*** (0.2)	0.76*** (0.18)	0.85*** (0.18)	0.82*** (0.17)	0.82*** (0.16)	0.82*** (0.16)

Note: for each model, there are 1,326 observations, 103 of which are treated; Standard errors in brackets; *p<0.10, **p<0.05, and ***p<0.01; 500 bootstrap replications.

Source: authors' elaboration.

The estimated treatment effect on direct tax revenue of adopting P2G services is between 1.21 and 1.32 percentage points, depending on the matching method, and consistently significant at the 1 per cent level. Developing countries that have adopted P2G services raise considerably more direct tax revenue than they would have raised without the adoption of the technology. The effect is sizeable, representing 45–49 per cent of the standard deviation of direct tax revenues.[8] The estimated ATTs also remain positive, significant, and comparable to the main estimates after including a range of alternative variables into the standard PS specification (see Table 1) and then re-evaluating the matching models (see Lines 1–11 in Table 3).

Finally, the ATTs are estimated separately for direct tax revenue from CIT and PIT. The estimates, again in percentage points of GDP, are significant, and consistently larger for PIT (0.68–0.85) than for CIT (0.44–0.60). This result may be explained by the fact that P2G services are more widely used by small and medium-sized companies, which contribute little to CIT revenues and more to PIT revenues.

3.3 Heterogeneity

Several studies have demonstrated notable heterogeneities in economic development and institutional characteristics across developing countries (Acemoglu et al. 2019; Balima et al. 2016; Lin and Ye 2009; Easterly 2002). To test whether and how such heterogeneities mediate the impact on direct tax revenue of adopting P2G services, this section follows Lin and Ye (2009) by using a control function regression methodology. The analysis is motivated by the following model:

$$tax\_revenue_{it} = \alpha + \beta * P2G_{it} + \gamma * PS_{it} + \tau * X_{it} + \delta * (P2G_{it} * X_{it}) + \varepsilon_{it} \quad (5)$$

where $tax\_revenue_{it}$ refers to direct tax revenues as a share of GDP, $P2G_{it}$ to the treatment variable, and PS_{it} to the estimated propensity score for country i in year t. Vector X_{it} includes a set of macroeconomic and institutional variables, while δ is the coefficient of interest for the interaction term between the treatment variable and vector X_{it}. In practice, however, the regression specification used in this analysis excludes the terms with the control vector ($\tau * X_{it} + \delta * P2G_{it} * X_{it}$). The coefficient for P2G adoption, β, in this reduced model is estimated separately for two groups for each institutional variable, separated based on its average value. As an exception, countries are divided into three standard groups based on income levels. Table 3 shows the related ATTs of P2G adoption on direct tax revenue.

Before the main heterogeneity analysis, direct tax revenue is regressed on the dummy for adoption of P2G services in Column 1. The coefficient for P2G is negative but not significant. Column 2 incorporates the estimated PS from Column 1 of Table 1 to control for self-selection in the model. The significant coefficient for the PS points to the presence of self-selection bias in the model, justifying the use of PSM. The estimated coefficient for P2G after controlling for self-selection bias becomes positive and significant at the 1 per cent level and is equal to 0.86 percentage points of GDP. This is in line with the previous finding and shows that countries that have adopted P2G services collect more direct tax revenue than their non-adopter peers.

The remaining columns in Table 3 demonstrate how different country characteristics mediate the impact of P2G adoption on direct tax revenue.

[8] The standard deviation of direct tax revenue is 2.71, as reported in Table B2 in Appendix B.

Table 3: Heterogeneity analysis of the effect of P2G adoption on direct taxes

	No control	Self-selectivity	Adoption preconditions	Experience	Income level			Control of corruption		Tax compliance		Paying taxes: score		Public admin. quality	
					LIC	*LMIC*	*UMIC*	*Low*	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**
P2G	−0.22	0.86***	−0.68**	−0.34	0.32	1.65***	−1.26	1.33***	−0.31	2.03***	0.31	1.43***	−0.12	0.81*	0.48
	(0.20)	(0.24)	(0.31)	(0.43)	(0.21)	(0.35)	(1.48)	(0.24)	(0.59)	(0.45)	(0.34)	(0.40)	(0.32)	(0.48)	(0.30)
PSCORE		−4.66***	−6.13***	−5.00***	−0.91*	−5.01***	−5.85***	−0.80*	−5.73***	−6.74***	−4.63***	−5.74***	−4.15***	0.13	−3.77***
		(0.46)	(0.50)	(0.49)	(0.47)	(0.85)	(0.77)	(0.46)	(1.03)	(1.02)	(0.87)	(0.71)	(0.80)	(0.99)	(0.57)
P2G* (PS−$\overline{PS}$)			8.80***												
			(1.20)												
P2G*time				0.24***											
				(0.06)											
Constant	4.64***	4.92***	5.00***	4.94***	3.16***	4.82***	5.70***	3.43***	5.91***	4.84***	5.21***	5.43***	5.65***	3.13***	4.97***
	(0.08)	(0.09)	(0.09)	(0.09)	(0.13)	(0.13)	(0.15)	(0.11)	(0.12)	(0.17)	(0.16)	(0.20)	(0.14)	(0.21)	(0.15)
Observations	1,320	1,320	1,320	1,320	276	487	557	653	667	295	531	363	482	138	376
R2	0.0005	0.04	0.062	0.048	0.008	0.059	0.040	0.041	0.027	0.078	0.038	0.082	0.062	0.026	0.057

	Agriculture VA		School enrolment		Domestic credit		Resource rents		Net ODA		Labour force		Urbanization rate	
	Low	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
	(16)	**(17)**	**(18)**	**(19)**	**(20)**	**(21)**	**(22)**	**(23)**	**(24)**	**(25)**	**(26)**	**(27)**	**(28)**	**(29)**
P2G	0.44	1.47***	0.23	0.60*	1.31***	−0.27	0.92***	0.43	0.83***	0.40	0.45	1.14***	1.35***	0.55
	(0.33)	(0.31)	(0.34)	(0.33)	(0.24)	(0.52)	(0.28)	(0.41)	(0.29)	(0.38)	(0.30)	(0.38)	(0.27)	(0.48)
PSCORE	−4.98***	−1.84***	−4.20***	−5.35***	−2.62***	−5.21***	−5.67***	−3.82***	−5.32***	−3.45***	−5.44***	−4.05***	−2.75***	−6.10***
	(0.68)	(0.47)	(0.58)	(0.86)	(0.48)	(0.95)	(0.50)	(1.40)	(0.59)	(0.63)	(0.57)	(0.72)	(0.65)	(0.58)
Constant	5.72***	3.22***	4.40***	5.29***	3.88***	6.10***	5.41***	3.74***	5.30***	3.92***	4.89***	4.97***	3.88***	5.80***
	(0.11)	(0.11)	(0.13)	(0.13)	(0.107)	(0.14)	(0.11)	(0.15)	(0.11)	(0.14)	(0.1342)	(0.13)	(0.11)	(0.13)
Observations	845	475	428	669	767	553	978	342	956	341	657	624	650	670
R2	0.039	0.054	0.064	0.035	0.032	0.038	0.071	0.015	0.051	0.032	0.058	0.031	0.035	0.063

Note: robust standard errors in brackets; *p<0.10, **p<0.05, and ***p<0.01; in Columns 8–29, the mean of each variable is used to divide the sample into two groups, countries with low values and high values respectively. LIC, LMIC, and UMIC refer to low-income, lower-middle-income, and upper-middle-income countries, respectively.

Source: authors' elaboration.

The first question analysed is whether countries that meet the preconditions for adoption of P2G services perform better in direct tax revenue mobilization. Column 3 adds an interaction between P2G and the difference between the estimated PS and its sample average to the previous specification in Column 2. The P2G coefficient turns negative, but the interaction term itself is positive and significant at the 1 per cent level. This suggests that countries that better meet the preconditions for P2G adoption collect more direct tax revenue. The result highlights the fact that meeting these preconditions is critical for a country to fully benefit from adopting P2G services.

The second estimate of interest is the experience effect, measured by time since the adoption of P2G services. This duration (in years) is interacted with the P2G dummy in Column 4. The coefficient for the interaction term is positive and significant at the 1 per cent level, suggesting that P2G-induced tax revenue mobilization improves over time. It is likely that taxpayers and tax administrations become progressively more familiar with the technology with time, increasing the utility derived from P2G services for facilitating tax transactions.

The third question is how the impact of P2G adoption on tax revenue differs depending on income levels. In Columns 5–7, the model is run separately for countries in three conventional income groups, using the standard model specification in Column 2.[9] The estimated coefficient for P2G adoption is positive and significant at the 1 per cent level only in lower-middle-income countries (LMIC). The ATT is 1.65 percentage points of GDP. This result may be explained by the fact that P2G services are more developed in this group of countries, which also better meet the preconditions for adoption compared with other income clusters.[10]

The remaining columns reflect the mediating effects of countries' socioeconomic conditions, corruption, bureaucracy quality, and urbanization. Countries in the sample are divided into two groups in the case of each variable, using the sample average as the cut-off point.

A significant revenue-increasing impact of P2G adoption is found for countries with low control of corruption, low tax compliance, low taxpaying score (i.e., low administrative burden of paying taxes), and low quality of public administration (Columns 8–15), the latter being significant only at the 10 per cent level. As discussed earlier, P2G can help to improve administrative quality, tax compliance, and corruption control by centralizing payments, reducing physical contact with tax administrators, and increasing the transparency of payment transactions.

The adoption of P2G services also has a positive and significant effect on direct tax revenue in countries with high levels of value added from the agricultural sector (Column 17), a proxy for the size of the informal sector, and correspondingly for countries with low levels of urbanization (Column 28). These findings are in line with Jacolin et al. (2019), who find that the adoption of mobile financial services has contributed to the decline of the informal sector in developing and emerging economies. Relatedly, countries with low levels of private sector credit (Column 20), which generally have low levels of financial inclusion, also appear to benefit from P2G. Mobile

[9] The countries are divided into low-income countries (LIC), lower-middle-income countries (LMIC), and upper-middle-income countries (UMIC), of which six, ten, and three, respectively, had adopted P2G services by the end of 2018.

[10] Mobile money services, including P2G services, facilitate financial inclusion by allowing informal workers and firms to access banking services at lower cost and without income criteria. Such enterprises, generally excluded from the mainstream banking system, are particularly prevalent in low-income and lower-middle-income economies, which explains why P2G is used more in such countries.

services that are used for tax payment transactions may facilitate financial inclusion for many individuals excluded from the traditional banking system.

A positive effect is also found for countries with high rates of school enrolment (Column 19). Adopting and setting up the service may alone be insufficient for a country to reap benefits from P2G; this also requires that the service is widely used in practice. The use of mobile-based payment services is likely more common among a more educated population, with sufficient knowledge of both the technology and related procedures for managing firms, such as budgeting and accounting.

P2G adoption has a positive and significant effect in countries with low levels of resource rents (Column 22) and ODA (Column 24), while their high-level counterparts do not appear to benefit from P2G (Columns 23 and 25). Notable resource rents and development assistance may both work to offset revenue needs from taxation, and especially taxation of the informal sector, disincentivizing capacity development projects and technology adoption that would facilitate tax collection.

Finally, the adoption of P2G services has a positive and significant impact only in countries with an above-average labour force participation rate (Column 27). This may reflect a larger potential user base for P2G. In general, of course, more direct tax revenue is likely to be mobilized in countries with a larger tax base, which is closely linked with labour force participation.

3.4 Addressing endogeneity

While the previous analysis suggests that the adoption of P2G services has led to an increase in direct tax revenue, the causality may also run in the opposite direction. Namely, the need to expand tax bases may give rise to the demand for innovative payment solutions and thus influence P2G adoption. Another potential source of endogeneity in the analysis could arise from the simultaneity of P2G adoption with other reforms in the tax administration.

To correct for endogeneity bias, a panel two-stage least squares (2SLS) estimator is adopted that uses the proportion of neighbouring P2G-adopter countries and the rate of mobile phone penetration as instruments. The first instrument follows Keen and Lockwood (2010), who use the proportion of VAT-adopter countries in the region as an instrument for VAT adoption. Likewise, P2G adoption in several neighbouring countries is likely to increase the probability of adopting the same service, for instance due to the imitation effect in policy adoption prevalent in developing countries (Klemm and Van Parys 2012), without direct impact on tax revenues in the country of interest. As for the second instrument, GSMA (2016) and Jacolin et al. (2019) argue that the adoption of mobile financial services such as P2G is closely associated with the development of the national mobile phone market.

The 2SLS estimates are presented in Columns 1–3 in Table 4. The coefficient for P2G adoption is positive and significant at the 10 per cent level in all specifications, in line with a positive causal effect of P2G adoption on tax revenues. Columns 5–7 show the estimated coefficients from the first-stage equations. The coefficients for the two instruments have the expected signs and are significant at the 1 per cent level. The p-values from the associated F-tests are below 1 per cent, endorsing the strength of the instruments, while p-values from the under-identification test by Kleibergen and Paap (2006) demonstrate that the instruments are correlated with the endogenous variable. Finally, the null hypothesis of the Hansen test is not rejected, supporting the validity of the instruments.

Table 4: Estimation results correcting for endogeneity bias and considering the persistence of tax revenues

	2SLS-1	2SLS-2	2SLS-3	System GMM	First stage 1	First stage 2	First stage 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
P2G	**1.834* (0.998)**	**1.661* (0.962)**	**1.889* (1.019)**	**0.448* (0.234)**			
Agriculture value added	0.017 (0.011)	0.020* (0.010)	0.026** (0.011)	0.067 (0.053)	−0.005** (0.002)	−0.005** (0.002)	−0.005** (0.002)
Domestic credit	0.022*** (0.004)	0.021*** (0.004)	0.021*** (0.004)	0.024** (0.010)	−0.002*** (0.001)	−0.002*** (0.001)	−0.002*** (0.001)
Trade openness	0.008*** (0.002)	0.010*** (0.003)	0.008*** (0.002)	0.001 (0.004)	−0.001* (0.000)	−0.001** (0.000)	−0.001* (0.000)
GDP per capita (log)	1.048*** (0.270)	1.088*** (0.265)	1.103*** (0.268)	0.492 (0.534)	0.038 (0.048)	0.037 (0.048)	0.038 (0.0491)
Inflation	0.002 (0.001)	0.002* (0.001)	0.002 (0.001)	0.007 (0.010)	0.0002 (0.000)	0.0002 (0.000)	0.0002 (0.000)
Total population (log)	1.843*** (0.622)	1.971*** (0.605)	1.778*** (0.643)	−0.046 (0.078)	0.409*** (0.084)	0.401*** (0.084)	0.404*** (0.085)
School enrolment	−0.005 (0.003)	−0.005* (0.003)	−0.006** (0.003)	0.007** (0.004)	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)
Resource rents		−0.010 (0.008)	−0.010 (0.008)	0.001 (0.009)		−0.0005 (0.001)	−0.0005 (0.001)
FDI			0.032*** (0.009)	−0.020 (0.040)			−0.001 (0.001)
Lag (direct tax revenue)				**0.779*** (0.075)**			
Mobile phone penetration					**0.0005*** (0.000)**	**0.0005*** (0.000)**	**0.0005*** (0.000)**
Neighbours with P2G					**0.304*** (0.099)**	**0.301*** (0.099)**	**0.297*** (0.099)**
Observations	1,305	1,296	1,291	1,040	1,305	1,296	1,291
Countries	96	96	96	92	96	96	96
R2 centred	0.23	0.26	0.24				
Kleibergen-Paap LM under-identification test (p-value)	0.00	0.00	0.00				
Hansen J test (p-value)	0.21	0.16	0.18	0.11			
Instruments	2	2	2	21			
AR(1) test (p-value)				0.00			
AR(2) test (p-value)				0.45			
F-test instruments (p-value)					0.0002	0.0001	0.0002
P2G (long-run coefficient)				**2.030* (1.071)**			

Note: *p<0.10, **p<0.05, and ***p<0.01; robust standard errors in brackets; in the system-GMM estimation (Column 4), the two-step estimator is used with Windmeijer's (2005) standard errors; P2G is instrumented with its first- and second-order lagged values and the two retained external instruments; the lagged dependent variable is instrumented with its first- and second-order lagged values; the instruments included in the system-GMM estimation are the first- and second-order lagged FDI, resource rents, total trade, GDP per capita, total population (log), and school enrolment; the set of instruments has been collapsed to overcome instrument proliferation (Roodman 2009); the standard error of the long-run P2G coefficient is determined using the delta method (Greene 2003).

Source: authors' elaboration.

It is also possible that tax revenues are persistent (Gupta 2007; Leuthold 1991), which is addressed by including lagged direct tax revenues in the model using system-GMM estimation (Blundell and Bond 1998). The related results are shown in Column 4 in Table 4. The p-values of the second-order autocorrelation test (AR2) and the Hansen test both support the validity of the estimation. The large and significant coefficient for the lagged dependent variable indicates that direct tax revenues are in fact persistent. The short-run (0.448) and long-run (2.030) coefficients for P2G adoption are positive and significant at the 10 per cent level, bolstering the previous finding that the positive effects of P2G services adoption increase over time.

4 Conclusion

Several studies have explored the determinants of tax revenues in developing countries. With the rise of ICT, more focus has been directed in recent years towards the contribution of different ICTs to tax revenue mobilization. This study contributes to the literature by assessing the causal effect on direct tax revenue in developing countries of person-to-government payment services using mobile phones (P2G). The adoption of P2G services can help developing countries to reduce corruption, strengthen tax compliance, and overcome a variety of institutional and technical barriers to domestic tax revenue mobilization.

Estimates using PSM point to positive and statistically significant average treatment effects for countries that have adopted P2G. Adopters experience a 1.2–1.3 percentage point boost in direct tax revenue compared with their non-adopter pair. The result remains robust to matching quality tests and alternative estimation methods, namely function control, 2SLS, and system GMM. The effect size also appears to increase with time since adoption.

Alternative model specifications are estimated to test how heterogeneities between countries mediate the impact of P2G adoption on tax revenue. Notably, the treatment effects are positive only for low-income and lower-middle-income countries, and significant only for the latter. Effects are also positive and significant for countries with high levels of value added from agriculture, low rates of urbanization, and low levels of domestic credit, control of corruption, and tax compliance—characteristics that reflect extensive informality, low levels of financial inclusion, and weak institutions.

Additionally, effects are positive for countries with high rates of labour force participation and high levels of schooling, indicating that the benefits of P2G are contingent on a large and capable user base. Countries with low levels of natural resource rents and development assistance, both potential substitutes for tax revenue, also benefit disproportionally from P2G services.

In light of these findings, developing countries, especially those with weak governance institutions and low levels of financial inclusion, should promote the adoption and use of MM services for tax transactions. In addition to improving tax revenue mobilization, P2G has the potential to reduce corruption, facilitate transparency between citizens and the public administration, and contribute to the broader socioeconomic inclusion of vulnerable and excluded populations.

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Appendix A: Adoption of P2G services

Table A1 shows the year of P2G adoption by country for low-income, lower-middle-income, and upper-middle-income countries, and mean direct tax revenues before and after adoption.

Table A1: P2G adopter countries, year of adoption, and direct tax revenues before and after adoption

Country	Year of P2G adoption	Direct tax before P2G % of GDP)	Direct tax after P2G (% of GDP)
Low-income countries			
Tanzania	2008	2.24	3.82
Rwanda	2009	2.96	5.69
Uganda	2009	1.96	3.34
Guinea	2012	1.20	2.47
Madagascar	2012	1.90	2.21
Liberia	2016	2.74	3.54
Lower-middle-income countries			
Philippines	2004	5.62	6.02
Kenya	2007	5.81	7.32
Cote d'Ivoire	2008	2.77	2.86
Ghana	2009	2.18	4.47
Bangladesh	2010	1.09	2.43
Cameroon	2010	3.07	3.84
Zimbabwe	2011	9.14	6.70
Pakistan	2012	2.90	3.93
Kyrgyzstan	2014	4.13	5.15
Myanmar	2017	1.12	2.33
Upper-middle-income countries			
Sri Lanka	2012	2.40	2.11
Guyana	2013	8.32	8.53
Brazil	2016	7.76	9.03

Source: authors' elaboration based on UNU-WIDER (2021), World Bank (2021) and GSMA mobile tracker.

Appendix B: Data description

Table B1 describes the variables used in the analysis, while Table B2 shows the descriptive statistics.

Table B1: Variable descriptions

Source	Variable	Definition
GRD	Direct tax revenue	Total direct tax revenues excluding social contributions and resource revenues
GRD	PIT	Taxes on income, profits, and capital gains
GRD	CIT	Corporate and other business tax revenues
Authors' construction using GSMA mobile tracker	P2G	Transfers of funds from individuals or businesses to governments for public services; recipient agencies and institutions may be at the municipal, state, or national level, and include, for example, public schools, police forces, and tax authorities
WDI	Agriculture value added	Silviculture, forestry, hunting and fishing, agriculture, and breeding; value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs; the measure captures primary sector value added
WDI	Domestic credit to the private sector	Financial resources provided to the private sector by financial corporations
WDI	GDP per capita	GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products; it is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources; GDP per capita is GDP divided by mid-year population
WDI	GDP per capita growth	Annual percentage growth rate of GDP at market prices, based on local currency in constant prices; aggregates are based on constant 2010 US dollars
WDI	Trade openness	The sum of a country's exports and imports as a share of its GDP; the measure captures the degree of openness of a country to the rest of the world
WDI	Resource rents	The sum of rents from oil, natural gas, hard and soft coal, minerals, and forests
WDI	Inflation	The annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that can be set or changed at annual intervals
WDI	Population growth rate	The growth rate of the population, expressed as the speed at which the population increases from one year to the next
WDI	School enrolment	Ratio of total enrolment in school, regardless of age, to the population in the age group that officially corresponds to the level of education
WDI	Net ODA	Net ODA consists of disbursements of loans made on concessional terms (net of repayments of principal) and grants by official agencies of the members of the Development Assistance Committee (DAC), by multilateral institutions, and by non-DAC countries, to promote economic development and welfare in countries and territories on the DAC list of ODA recipients; it includes loans with a grant element of at least 25% (calculated at a discount rate of 10%)

WDI	Urban population share	Urban population refers to people living in urban areas as defined by national statistical offices; the indicator is calculated using population estimates from the World Bank and urban ratios from the United Nations World Urbanization Prospects; the share is calculated in relation to total population
International Telecommunication Union (ITU)	Total market penetration	Mobile-cellular subscriptions per 100 inhabitants
Worldwide Governance Indicators (WGI)	CCE: control of corruption	An assessment of corruption within the political system; such corruption is a threat to foreign investment for several reasons: it distorts the economic and financial environment; it reduces the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability; and it introduces an inherent instability to the political process
WGI	GEE: government effectiveness	Perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government 's commitment to such policies
WGI	RLE: rule of law	Perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development
International Country Risk Guide (ICRG)	Social conditions	Assessment of socioeconomic pressures at work in the society that could limit government action or fuel social discontent; the measure takes into account unemployment, poverty, and consumer confidence; the score ranges from 0 (a weak socioeconomic environment) to 12 (a very strong socioeconomic environment)
ICRG	Bureaucracy quality	Countries with strong bureaucracies that have the strength and expertise to govern without radical policy change or disruption of government services are assigned high points; those countries that lack the cushioning effect of a strong bureaucracy receive low points because a change in government tends to be traumatic in terms of policy formulation and day-to-day administrative functions
Economic Freedom database	Tax compliance	Measures the level of tax compliance in a country
World Bank Group, CPIA database	Public administration quality	Assesses the extent to which civilian central government staff is structured to design and implement government policy and deliver services effectively
International Labour Organization's ILOSTAT database	Labour force participation rate	The ratio between the labour force and the overall size of their cohort, i.e., national population of the same age rang; the labour force includes people aged 15 and older who are currently employed, unemployed but looking for work, or first-time job-seekers
World Bank's Doing Business project	Paying taxes: score	An indicator that captures the mandatory taxes and assessments that a medium-sized company must pay each year, as well as the administrative burden of paying taxes, assessments, and complying with post-filing procedures
Authors' construction	Neighbour	Neighbouring country that adopted P2G

Source: authors' elaboration based on UNU-WIDER (2021), World Bank (2021), and other databases as listed in Column 1.

Table B2: Descriptive statistics

Variable	Observations	Mean	St. dev.	Min.	Max.
Direct tax revenues	1,326	4.62	2.712	0.15	17.44
PIT	1,000	2.08	1.82	0	10.25
CIT	982	2.41	1.54	0	13.79
P2G	1,326	0.08	0.27	0	1
Agriculture value added	1,326	16.28	12.10	0.89	79.04
Domestic credit to the private sector	1,326	34.99	30.51	0	160.1
GDP per capita	1,313	3,500	3.17	221.1	20.53
GDP per capita growth	1,326	2.48	4.15	−31.33	50.24
Trade openness	1,326	77.23	38.25	0.27	311.4
Resource rents	1,326	7.27	10.53	0	81.95
Inflation	1,326	7.08	16.43	−18.11	513.9
Population growth rate	1,326	1.64	1.17	−2.17	6.57
School enrolment	1,101	103.0	17.20	29.01	151.8
Net ODA	1,303	5.27	7.79	−0.48	92.14
Urban population share	1,326	47.55	19.91	7.41	90.98
Total market penetration	1,320	61.02	48.18	0	207.8
CCE: control of corruption	1,326	−0.49	0.59	−1.77	1.65
GEE: government effectiveness	1,326	−0.44	0.58	−2.27	1.27
RLE: Rule of law	1,326	−0.50	0.58	−1.91	0.93
Social conditions	921	4.36	1.74	0	10.29
Bureaucracy quality	921	1.67	0.77	0	3
Tax compliance	826	6.07	2.10	0	9.05
Public administration quality	519	3.05	0.50	2	4
Labour force participation rate	1,287	65.52	11.40	41.53	90.34
Paying taxes: score	851	61.09	23.66	0	95.83
Neighbour	1,326	0.05	0.13	0	1
Number of countries	96	96	96	96	96

Source: authors' elaboration based on UNU-WIDER (2021), World Bank (2021), and other databases as listed in Table B1, Column 1.