

Using mobile technologies to increase VAT compliance in Rwanda

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Draft submitted to CSAE Conference

October 2014

Abstract

The expansion of the tax base in developing countries is increasingly recognized as an important policy goal. An increase in (relatively) non-distortionary domestic revenue sources promises to reduce dependence on aid and consequent exposure, and perhaps to increase scope for democratic political participation (Tilly 1990). This paper analyzes the adoption rate and tax compliance impacts of an innovative program in Rwanda, which introduced Electronic Billing Machines to strengthen VAT compliance. To do so, we combine quarterly data on all VAT payments from 2012 through 2014q1 with data on EBM activation over the same period. During the period studied, EBM adoption rates were incomplete but growing exponentially. This growth was unevenly distributed across sectors and, to some extent, concentrated among historically high-VAT firms. The adoption of an EBM is estimated to increase VAT payments by an average of 8 percent. These effects, however, are highly variable by sector and firm size, with smaller firms as well as firms in computing/printing, construction, and restaurant sectors experiencing larger impacts. Although available data do not allow us to test alternative mechanisms, the data appear consistent with a view that the sectors that experienced smaller changes in VAT payments following EBM adoption were those in which VAT compliance was already relatively high. Taken together, the findings of this paper suggest scope for targeting future encouragement activities toward smaller firms in sectors such as retail and construction, which as of 2014q1 had experienced comparatively smaller adoption rates, combined with robust impacts on those firms that did adopt.

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In this paper, we assess the incidence and revenue impacts of Electronic Billing Machines on VAT-paying enterprises in Rwanda. Electronic Billing Machines (EBMs) represent a potentially important tax administration initiative, aimed at improving VAT compliance by transmitting transaction records directly to the Rwanda Revenue Authority in real time. The paper makes use of data on both VAT payments (from 2012q1–2014q1 inclusive) and EBM adoption during the same time to address three primary questions: what are the characteristics of firms who have adopted EBMs; what has the overall effect of EBM adoption been on revenue generated from VAT; and how do these impacts vary by enterprise sector, size, and location.

Our main findings are as follows. We find that adoption through 2014q1 was growing rapidly but remained incomplete, and that it varied substantially by sector. The average impact of EBM adoption on enterprises' VAT payments is estimated to be approximately 8 percent. Again, these effects vary substantially by sector and size. In general, EBM impacts are greater for smaller firms and for firms in sectors such as printing & computing services, construction, and restaurants, where pre-intervention VAT compliance may have been comparatively low. Taken together, these findings suggest that future strategies could appropriately be focused on targeting specific sectors and firm sizes where both adoption rates are low and potential impacts are highest.

1 Context

In August 2013, new legislation was introduced in Rwanda, to assist firms book-keeping, level the playing field amongst all retailers, and, most importantly, reduce tax evasion for value added tax (VAT). This legislation, announced in Ministerial Order 002/13/10, and the accompanying Commissioner General (CG) rules,¹ states that businesses registered for VAT must provide customers, at each sale, a certified VAT receipt generated by an Electronic Billing Machine purchased from an Rwanda Revenue Authority (RRA)-approved vendor and activated by RRA. This EBM must consist in a Certified Invoicing System (CIS) and a Sales Data Controller (SDC) working together.

In time all firms must have and use active, verified, EBM machines. However, the programme is being rolled out in stages, with firms that must comply announced by intermittent public notices. By the end of all stages of notices, every registered business in Rwanda will be legally required to provide a certified EBM receipt for all sales; if a business does not have EBM installed by their assigned date, they will be due a large fine.

EBM machines can malfunction, or suffer power outages. If a machine malfunctions, the firm “is obligated to notify Authority [RRA] as soon as possible and to have the machine repaired within 48 hours, during which period the user must continue issuing hand-written VAT receipts.” Once the machine is fixed, the sales recorded in these hand-written receipts must be entered into the EBM, and stored together with the new certified receipts. Likewise, if there is a power failure, hand-written receipts must be issued until power is restored, at which point they must be entered into the electronic system.

Certain exemptions from EBM usage and VAT payment are achievable. Firstly, certain items are tax exempt by law: these must still be processed using EBM, but if entered under the correct code, are automatically processed at the zero percent tax rate. Exemptions from EBM-usage (but not from VAT) can also be awarded at the firm level through a firms application to RRA. Such firms can be awarded exemption from EBM reporting if they can demonstrate that either:

¹For all EBM-related laws and rules, see http://www.rra.gov.rw/rra_article1037.html

1. their annual sales total less than 1.2m Rwf;
2. the vast majority of their sales are VAT exempt, and VAT-qualifying sales are minimal;
3. their VAT-qualifying sales only take place at very limited periods during the year; or
4. their current VAT system is sufficient and using EBMs causes “unfair technical difficulty”.

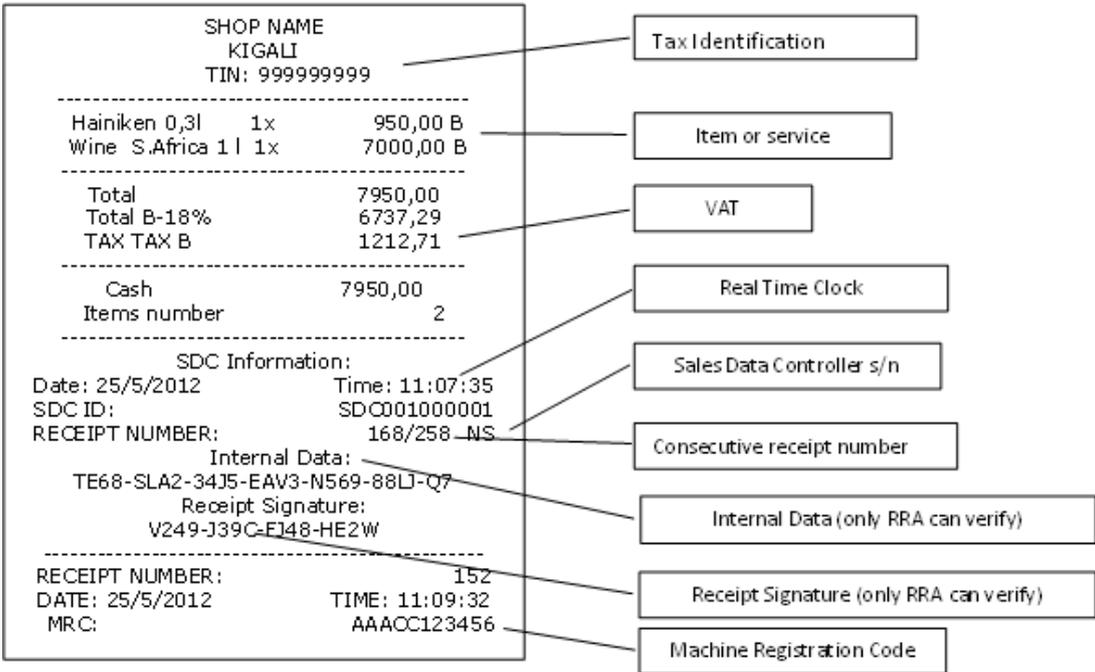
2 Data

Our analysis draws on two Rwanda Revenue Authority (RRA) data sets.

First, to estimate patterns in VAT payments among EBM- and non-EBM firms, both before and after adoption of this technology, we make use of data that include the universe of VAT payments from January 1, 2012 to April 1, 2014. In addition to payment types, dates, and amounts, these data also include the primary firm activity, which we use to classify firms by sector as described below. We aggregate VAT payments to the quarterly level, and conduct our analysis at that level. The data used therefore comprise 7,879 unique firms (defined by the taxpayer ID number) who pay VAT between 2012q1 and 2014q1, inclusive. These firms comprise an unbalanced panel, paying VAT in a total of 40,374 quarters in the period and data we study.

Second, to assign EBM ‘treatment’ status to each firm in each quarter, we use RRA’s EBM registration data. These show for each EBM machine (identified by an SDC code), the firm name, tax identification number (TIN), EBM activation date, EBM personalization date, location, and product/activity type for the firm to which it belongs. Any single firm may have more than one EBM machine, in which case a firm has multiple entries and its single TIN is associated with multiple SDC IDs. This dataset is continuously updated at RRA as EBM registrants come online, and we use a

Figure 1: Identification of a valid EBM receipt



Source: Rwanda Revenue Authority, “Electronic Billing Machines; Presentation for Foreign Visitors”

version up-to-date as of May 27, 2014.

Using these data, we define a firm as ‘treated’ with an EBM in a given quarter if it had at least one SDC code shown as activated before the last date of that quarter. This approach ensures that we do not understate EBM impacts by treating a given firm as though it had an active EBM, when in fact it had only begun the registration process but did not yet have an active machine. However, since a large number of firms were in the process of complying with EBM requirements as of the end of the first quarter, 2014, this choice of definition has important implications for the total take-up numbers that we report. *Our take-up numbers should be taken as a lower bound, since they do not count firms that had begun the registration process by April 1, 2014, but had not yet had their EBMs fully activated prior to that date.*

In the analysis that follows, we make use of three observable, predetermined characteristics of firms in the RRA data.²

Table 1: Enterprise sectors

sector	RRA activity codes	firms	VAT, 2012q1	
			mean	st. dev.
retail	11	1806	698,643	(2,929,305)
wholesale	11	1225	2,496,454	(9,529,109)
construction ¹	9	1167	66,375,564	(337,272,224)
other services ²	1	837	9,557,549	(42,023,504)
transportation ³	17	523	4,792,883	(24,964,344)
business services ⁴	10	414	1,665,780	(5,283,065)
restaurants	4	335	10,404,240	(35,502,912)
computing ⁵	7	219	2,955,765	(7,728,985)
manufacturing	28	144	5,498,219	(27,923,706)
hotels	1	101	211,952,224	(694,998,208)
telecoms	1	55	4,318,767	(18,610,056)
total	100	6,826	6,176,411	(76,034,922)

¹ Includes architecture, engineering, and construction services. ² Enterprises in this sector correspond to the RRA activity code ‘other service activities’. ³ Includes domestic and international freight, as well as clearing agents. ⁴ Includes advertising, legal, financial, and management consultancy. ⁵ Includes computing services, software, and printing.

We define a set of eleven **sectors** based on the enterprise’s primary activity in RRA’s tax payments database. There are a total of 166 such activity codes used in RRA’s data. Since such a large number would both stretch statistical power and pose challenges for interpretation, we aggregate these codes into a set of broad categories covering the largest sectors in the data. These are outlined in Table 1. The 11 sectors that resulted cover all RRA activity codes with at least 200 firms. As Table 1 shows, the sectors so defined vary in the number of corresponding RRA activity codes, and in the corresponding number of firms. Table 1 presents means and standard deviations of VAT payments for all of these firms paying VAT in 2012q1, prior to the introduction of EBMs.

In our data, geography is proxied by the tax center to which a given enterprise submits its taxes. Table 2 describes the 30 tax centers to which enterprises in our data submit VAT from 2012q1 onward.³

²In order to estimate causal effects of EBMs by observable subgroups, it is necessary that the characteristics used to define these subgroups be ‘predetermined’ with respect to the EBM treatment, in the sense that they cannot be affected by EBM adoption.

³While we will generally interpret this variable as a measure of geography, several of the tax centers apply to enterprises in Kigali; we do not aggregate these since they serve distinct subpopulations by location or by enterprise

This table shows that there is substantial heterogeneity across tax centers. The number of enterprises submitting VAT to a given tax center ranges from less than 10 to 3,746 in the case of Kigali Small TC. While retail is the most common sector for the majority of tax centers, wholesale, ‘other service activities’, construction, and business services also feature prominently.

Table 2: Descriptive statistics by Tax Center

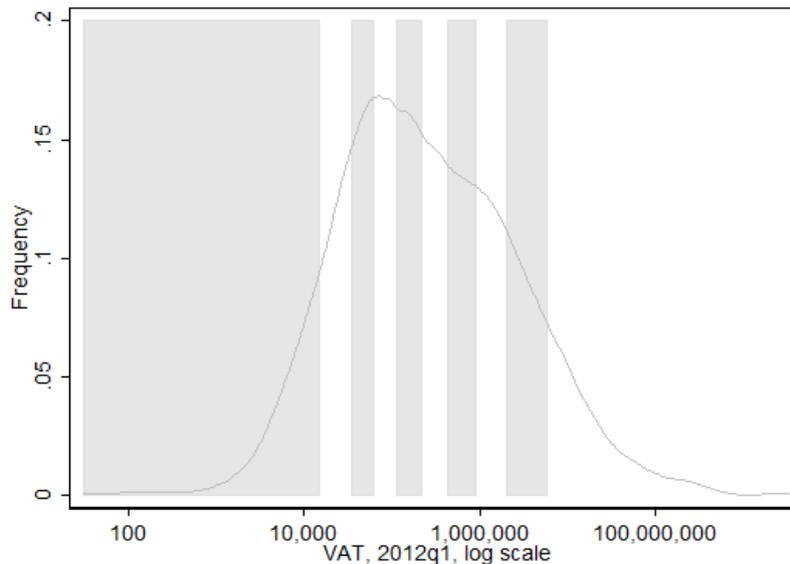
	enterprises	sector	VAT, 2012q1	
			mean	st dev
Bugesera	33	retail	744,804	1,561,984
Gasabo	62	other services	1,366,886	3,043,971
Gatsibo	9	retail	7,390	.
Gicumbi	72	construction	668,334	1,049,748
Huye	219	retail	567,017	1,173,042
Kabuga	18	retail	3,540,316	9,329,798
Kamonyi	2	retail		
Karongi	76	wholesale	601,548	1,445,434
Kayonza	2	wholesale		
Kicukiro	24	retail	484,426	1,223,653
Kigali LTO	268	construction	84,724,171	324,127,347
Kigali Medium	1,086	retail	1,650,619	4,395,328
Kigali Small	3,746	wholesale	1,199,658	12,158,487
Kirehe	12	wholesale	290,909	403,425
Muhanga	258	retail	485,131	1,843,727
Musanze	288	retail	848,353	3,839,546
Ngoma	121	retail	203,423	478,399
Ngororero	6	business services	261,073	297,273
Nyagatare	57	wholesale	305,727	557,501
Nyamagabe	73	retail	487,424	830,732
Nyamasheke	15	retail	315,468	573,601
Nyanza	73	retail	244,584	748,586
Nyarugenge	308	retail	1,726,249	7,382,449
Rubavu	266	retail	1,551,513	3,857,436
Ruhango	29	retail	84,559	124,875
Rulindo	4	wholesale		
Rusizi	326	retail	235,816	529,007
Rutsiro	1	retail		
Rwamagana	81	retail	2,182,244	10,148,008
Top Medium	344	other services	9,551,659	16,562,646

NOTES: Variable *enterprises* gives the total number of enterprises filing taxes at a given tax center over the period 2012q1 - 2014q1 inclusive. *Sector* is defined as the most common sector among enterprises filing taxes at that tax center. The final two columns present the mean and standard deviation, respectively, of VAT payments for 2012q1. Note that not all firms in our data paid VAT in this quarter (some may be more recent enterprises); consequently, there are no data to compute summary statistics for that quarter for some tax centers.

We also use deciles of pre-program VAT submissions to examine whether firms who appeared smaller in pre-EBM data respond differently to the advent of EBMs. To do so, we will focus on enterprises that submit VAT in 2012q1—again, it is important for identification purposes to use levels of VAT payment that predate EBM introduction for all firms.

type, and because the tax center may be an analytical unit of interest to RRA *per se*.

Figure 2: Pre-treatment VAT payments



Notes: Figure shows the distribution of pre-treatment (2012q1) VAT payments. Horizontal axis is on a log scale, with amounts in Rwf indicated. Shaded areas indicate decile groups used in subsequent analysis.

Figure 2 shows the distribution of quarterly VAT payments for 2012q1. The data are highly skewed, with many firms concentrated at the low end of the payments distribution, so we plot these on a log scale. The shaded regions of Figure 2 show the deciles that will be used for analytical purposes. These imply, for example, that firms at the 10th, 50th, and 90th percentiles of the distribution paid Rwf 14,975, Rwf 211,631, and Rwf 5,861,815, respectively, for that quarter.

3 Takeup

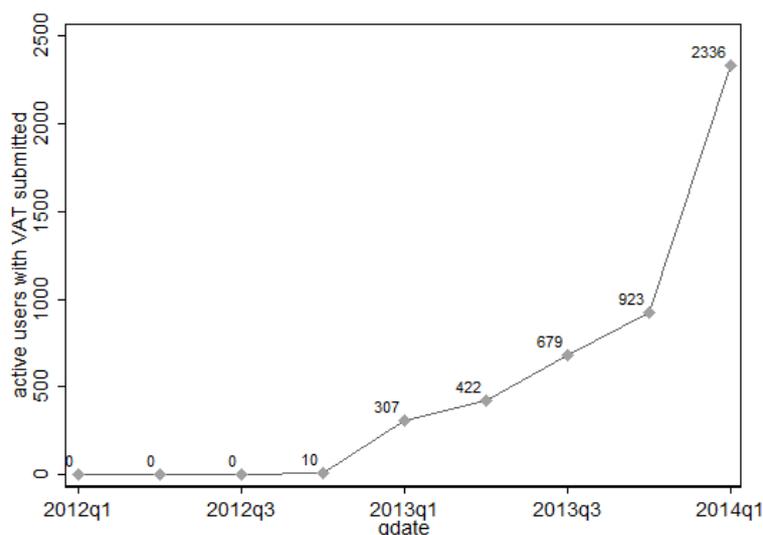
Total utilization has increased exponentially since the pilot phase of EBMs.

Figure 3 illustrates this overall trend. This figure presents the total number of firms who paid VAT in each quarter, and who had completed the activation process for at least one EBM by the end of that quarter (this coincides with the definition of EBM ‘treatment’ that we will use to study impacts in the following section). Thus the numbers reflected for each quarter represent a lower bound on the number of entrepreneurs who have initiated the process of adopting EBMs; in each quarter, there will be a number of firms who have begun the process but have not yet achieved the final (activation) stage by the close of the quarter. Even by this conservative estimate, a total of 2,336 entrepreneurs had achieved active EBMs by April 1, 2014. This corresponds to 52 percent of those who paid VAT in 2014q1.

In Table 3, we show how the activation rates achieved by 1 April 2014 vary by the sectors previously defined in Table 1. The first column of this table presents the fraction of VAT-paying enterprises in each sector who had a fully activated EBM by the close of 2014q1, while the second column shows firms with either an activated or personalized EBM by the closing date of April 1.

Completed EBM adoption as of 2014q1 was highest in the manufacturing sector, at 76 percent, with hotels and wholesalers following suit. Retail firms, which occupy the largest share of VAT-paying enterprises, exhibit fairly high compliance rates. Perhaps surprisingly, adoption was lowest in

Figure 3: Taxpayers with activated EBMs



Notes: Figure counts taxpayers as having activated EBMs in a given quarter if activation date occurs before the close of that quarter. Consequently, estimated activations by 2014q1 do not include firms that had begun—but not completed—activation process by April 1, 2014.

the group of activities that we have defined here as ‘business services’, which includes legal, financial, management, and advertising consultancy services.

Taken together, the patterns of growth in EBM adoption suggest that utilization is growing quickly. The backlog of firms that have undergone personalization but not activation is small, suggesting effective turnaround on the part of RRA. It is likely that adoption figures for 2014q2 will continue to show substantially increased utilization, though RRA might consider further mechanisms to address the ‘last mile’ challenge of attaining complete coverage.

A better understanding of the constraints to non-adopting firms might assist to that end. To provide a partial answer to this, we show how the incidence of EBM adoption varies by observable

Table 3: EBM adoption rates by sector, as of 2014q1

	activated	personalized
retail	55.2	59.7
wholesale	64.4	67.7
manufacturing	76.0	77.0
business services	27.1	28.8
transportation	51.4	59.2
restaurants	50.0	58.9
hotels	67.1	70.0
computing	54.7	56.4
construction	48.6	52.7
telecoms	47.1	47.1
other services	49.0	53.3

Notes: Figures reported are the fraction of enterprises that paid VAT in 2014q1 who had an activated or personalized EBM by the close of that quarter.

(and predetermined) firm characteristics. In Table 4, we regress an indicator for EBM takeup on the log of firms' 2012q1 VAT payment.⁴ Results show a statistically significant, modest positive relationship between 2012q1 VAT payments and the likelihood of having an activated EBM by the close of 2014q1. The unconditional estimates of column (1) imply that a firm that was at the 75th percentile of 2012q1 VAT payments is approximately 6 percentage points more likely than a firm at the 50th percentile of 2012q1 VAT payments to have an EBM as of 2014q1.

Table 4: Firm size and EBM adoption as of 2014q1

	(1)	(2)	(3)	(4)	(5)
ln VAT, 2012q1	0.0348*** (0.00)	0.0428*** (0.00)	0.0189*** (0.01)	0.00733 (0.01)	0.00833 (0.02)
Observations	2390	2390	2390	676	220
Sector indicators	No	Yes	Yes	N/A	N/A
Tax center indicators	No	No	Yes	Yes	Yes
Sectors in sample	All	All	All	Retail	Business services

Notes: Dependent variable is an indicator taking a value of one if the firm had an activated EBM in 2014q1. Table shows regression coefficient and associated standard errors for a regression of EBM adoption on log VAT, 2012q1, and other controls as indicated. Sample in columns (4) and (5) is restricted to Retail and Business Services sectors, respectively.

Accounting for differences in average firm size by sector and geography reduces the predictive effect of past VAT payments on current EBM adoption. Moreover, as reported in columns (4) and (5) of Table 4, respectively, we estimate a smaller, and statistically insignificant relationship, for two sectors of ongoing strategic importance: retail, which given its size has by far the greatest absolute number of non-adopting enterprises, and business services, which has the lowest adoption rate, expressed as a share of that sector's size. These findings suggest that, while bigger firms are somewhat more likely to have adopted EBMs on average, ongoing strategy should not focus disproportionately on small firms within a given sector.

4 Average impacts of EBM on VAT payments

To estimate the impacts of EBM on VAT payments, we merge the full set of VAT payments from 2012 onwards with data on the activation date of firms. We estimate impacts at the firm-quarter level, adjusting for quarterly aggregate shocks and controlling for firm characteristics as outlined in the discussion of the identification strategy in Subsection 4.1 below. Our preferred estimate, presented in the empirical results of Subsection 4.2, is that the adoption of EBMs has caused firms to increase their VAT payments by an average of 8 percent.

4.1 Identification strategy

To estimate the effects of EBM on VAT payments, we employ a variant on a difference-in-differences estimator. The rich series of data provided by RRA allow us to undertake this estimation with plausible and relatively mild assumptions about the process by which firms adopted EBMs. In this

⁴Because contemporaneous VAT payments may themselves be affected by EBM adoption, it is necessary to use VAT payments dated prior to the introduction of EBMs altogether. This analysis is therefore restricted to firms who paid VAT in 2012q1 and 2014q1, and which fall into one of the primary sectors defined in Table 1.

section, we provide the technical details of this estimation strategy. Readers interested in the main results can skip to Section 4.2.

A general framework for understanding our estimation strategy is based on the following characterization of the process generating VAT data:

$$\ln VAT_{isq} = \tau EBM_{isq} + \mu_s + \eta_{is} + \gamma_q + q\kappa_{is} + \varepsilon_{isq} \quad (1)$$

where $\ln VAT_{isq}$ is the log VAT payment of enterprise i in sector s and quarter q . In this general framework, EBM_{isq} is an indicator variable taking a value of one if the firm has an active EBM within that quarter, or zero otherwise; τ , the causal effect of EBMs, is the primary parameter of interest in this paper. Equation (1) allows for several forms of unobserved determinants of VAT payments, which threaten to bias estimates of τ insofar as they may be correlated with EBM_{isq} . Addressing such biases is the chief objective of our estimation strategy. In particular, μ_s and η_{is} are time-invariant shocks to DGP that are sector (s) and enterprise (i) specific, respectively.⁵ γ_q represents a quarter-specific, aggregate shock to VAT payments, while κ_{is} is a time-trend that is specific to enterprise i in sector s . Finally, ε_{isq} is an idiosyncratic, time-varying shock that will be assumed to be uncorrelated with EBM adoption throughout.

We present three sets of estimates for τ , increasing in their robustness to potential sources of bias and, consequently, in the plausibility of their assumptions. First, a sector-fixed-effects estimate exploits only variation (across enterprises and time) within each sector to identify the effects of EBM. Second, an enterprise-fixed-effects estimate allows arbitrary correlation between unobserved enterprise (and therefore sector) characteristics and EBM adoption. This is a classic difference-in-differences estimator (we also include quarter indicators in each of the first two approaches to allow for aggregate shocks to VAT payments in these periods that may be correlated with EBM adoption). Third, our most plausibly identified estimator is a ‘triple difference’ estimator that allows for firm-specific time trends (indicated by κ_{is}) to be arbitrarily correlated with EBM adoption. We implement this by first-differencing the data to estimate

$$\Delta \ln VAT_{isq} = \tau \Delta EBM_{isq} + \kappa_{is} + \Delta \gamma_q + \Delta \varepsilon_{isq} \quad (2)$$

where the operator ‘ Δ ’ indicates a first difference, e.g., $\Delta \ln VAT_{isq} = \ln VAT_{isq} - \ln VAT_{is,q-1}$. Equation (2) will be estimated with fixed effects to capture the firm-specific trends, κ_{is} , and with quarter dummies to capture the (change in) aggregate shocks, $\Delta \gamma_q$. In this specification, bias arises for the estimation of τ only if there are firm-specific, time-varying shocks to VAT payments that are correlated with the timing of switching into EBM use. While this is certainly not impossible, given that much of EBM adoption was driven by external pressure, we are reasonably comfortable with the resulting estimates.

4.2 Average effects of EBM adoption on VAT payments

Our preferred estimate of the average effect of EBM adoption on (the natural logarithm of) VAT payments is presented in Column (3) of Table 5. This column presents the estimated parameters of the triple-difference specification in equation (2): it is estimated using the *change* in VAT payments as dependent variable to difference out both sector- and firm fixed effects, and it demeans these changes

⁵In this sense, the data-generating process of equation (1) is overparameterized, since enterprises do not switch sectors in these data. We include sector fixed effects for expositional purposes only.

within firms to identify the estimated effect off of the association between the change in VAT and the change in EBM use, in the quarter of adoption. We estimate an average effect of EBM adoption on log VAT payments of 0.08.

Table 5: Estimated impacts of EBM adoption on log VAT receipts

	(1)	(2)	(3)
EBM treatment active	0.673*** (0.04)	0.194*** (0.03)	0.0800** (0.03)
Observations	68710	68710	55815
Quarter indicators	Yes	Yes	Yes
Sector fixed effects	Yes	-	-
Firm fixed effects	No	Yes	Yes
Firm-specific trends	No	No	Yes

This corresponds to an impact of approximately 8 percent on the level of VAT payment, on average across firms. To put this in economic perspective, consider that the median firm in the first quarter of 2012 had a quarterly VAT payment of 211,631, so for such a firm the estimated impact of EBM adoption is Rwf 16,930 per quarter, or 67,722 per year. Since enterprises have been asked to cover the costs of EBM equipment, one way to think about the merits of the EBM approach is to consider how long it would take for the increased revenue to exceed the up-front costs of the machinery. In the pilot, the costs of an EBM to the firm were approximately Rwf 211,050, which implies that the increase in VAT payments by the median firm will exceed the costs of the machine in just over three years. For a firm at the 75th percentile of 2012 VAT, or 1,319,258 per quarter, the impact on VAT payments would exceed the cost of the EBM equipment in under two years.⁶ For larger enterprises—and recalling the highly skewed distribution of value added—increased VAT payments will exceed machine costs much sooner. Any ongoing reductions in EBM costs will further this argument, even though the outlay for small firms may pose a liquidity challenge.

The contrast between these main results and those in columns (1) and (2) is instructive about the nature of early adoption of EBMs. In particular, controlling for unobserved time-invariant sector characteristics (column 1), time-invariant firm characteristics (column 2), and firm-specific trends (column 3) that may be correlated with adoption progressively reduces the estimated effect of EBMs from an implausibly large value of 0.673 to a reasonable value of 0.08. This contrast suggests that sectors and firms that have high *levels* of VAT payment, and that were on comparatively fast-rising *trends* in VAT payment, were more likely to be early adopters of EBMs.

5 Heterogeneity in EBM impacts

The average treatment effect reported in Section 4.2 is the key statistic for determining the cost-benefit of the EBM initiative to date. Of course, further refinements to the design and implementation of this initiative may still be possible, including the targeting of ongoing inspection and enforcement activities. In this section, we extend our analysis to offer guidance to such future targeting and design refinements. To do so, we disaggregate both the take-up and the treatment effects of EBMs along three observable, pre-determined dimensions: sector, firm size, and geography.

⁶Note that we assume a zero discount rate for simplicity in this calculation.

In addition to presenting take-up rates for each of these dimensions, we will modify the preferred (triple-differences) empirical specification of equation (2) to allow the treatment effect of EBMs, τ , to be distinct for each value of a given characteristic, x , where x will define sectors, tax centers, and firm sizes in the corresponding sections below. Thus for each dimension of heterogeneity we estimate the following equation:

$$\Delta \ln VAT_{isq} = \tau_x \Delta EBM_{isq} + \kappa_{is} + \Delta \gamma_q + \Delta \varepsilon_{isq} \quad (3)$$

where τ_x is a series of EBM effects, one for each level of characteristic x , and κ_{is} is a firm-specific trend, and $\Delta \gamma_q$ and ε_{isq} are aggregate quarterly and firm-specific shocks, respectively.⁷ This specification allows us to separately estimate the impacts of EBM adoption on each level of a given dimension of heterogeneity—sector, size, or location.

5.1 EBM impacts by sector

Figure 4 shows estimated impacts of EBM adoption on VAT payments estimated for each of the sections described in Table 1. Given that sample sizes vary dramatically by sector, and that other, unobserved characteristics may be associated with sectors, caution is required in interpreting cross-sector comparisons. While only the more extreme contrasts are statistically significant in their differences, the comparisons are suggestive.

The largest effects are observed in the *computing* sector, which, it should be noted, also includes activities of software and printing services. This is followed—in descending order of EBM impacts—by construction, restaurants, business services, and retail. The estimated impact on retail enterprises is nearly identical to the average effect overall. By contrast, sectors such as telecoms, hotels, manufacturing, transportation and other services have relatively small effects, which are statistically indistinguishable not just from the average effect (illustrated by the dotted line) but also from zero.

Small effects of EBMs can arise for at least two reasons. It may be the case that some firms manage to evade VAT in spite of the presence of EBMs. However, it is equally possible that some sectors do not display large responses to the introduction of EBMs not because the technology is ineffective, but instead because their prior rates of VAT compliance are relatively good. The latter explanation seems particularly plausible in the hotel sector, for example. Distinguishing between these two reasons for heterogeneity in EBM effects—low impacts of EBMs or good prior compliance—has important implications for the subsequent policy response, and we suggest that further work on this question may be informative.⁸

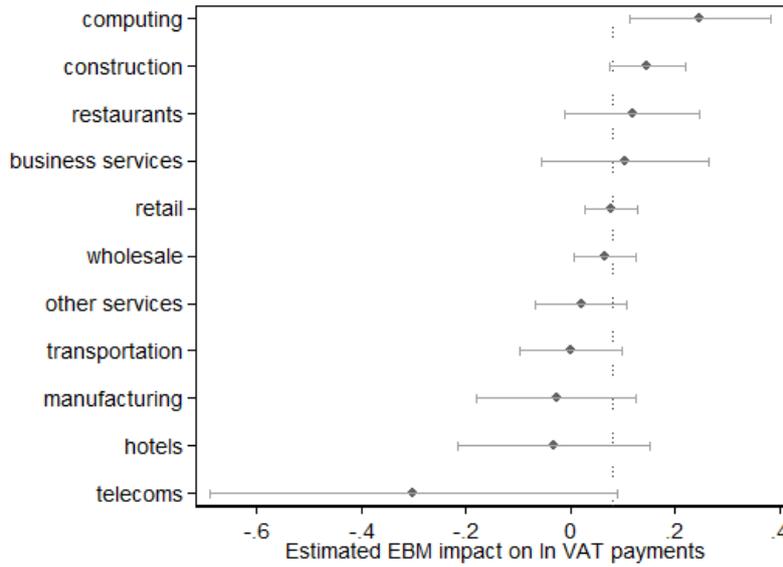
5.2 Treatment effects by firm size

A second dimension of heterogeneity in the effects of EBMs is firm size, which also has implications for the targeting of enforcement measures and other refinements to VAT administration. Given that it is important to use pre-exposure VAT payment levels to define these categories, we base our definition of firm size deciles on 2012q1 VAT payments, and restrict analysis to firms that made nonzero payments

⁷Equivalently, we could denote this by having a vector indicator variables for each value of characteristic x , which is interacted with EBM_{isq} .

⁸The IGC’s own, ongoing, ‘mystery shopper’ exercise may help to shed light on this, but it is inherently restricted to retail and service sectors. Another approach would be to look at patterns in transaction-level VAT data to try to discern between these mechanisms.

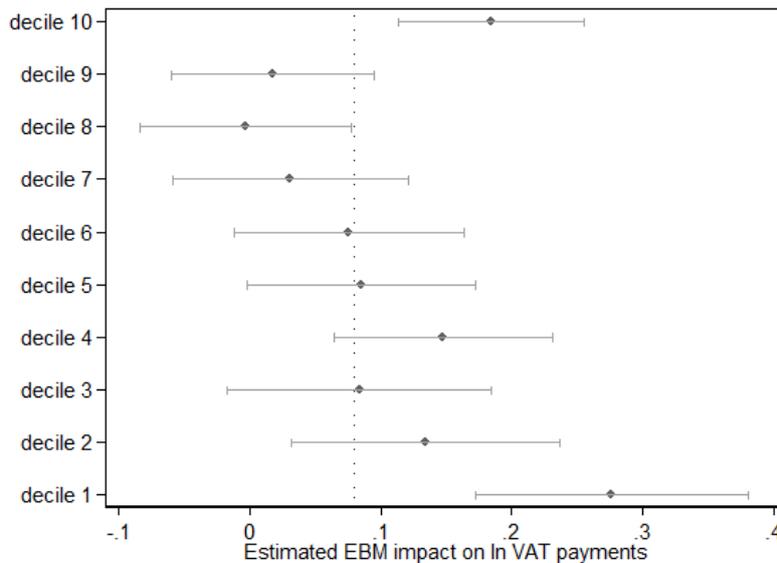
Figure 4: EBM impacts by sector



Notes: Figure illustrates estimated impacts, τ_x , and corresponding standard errors for estimates of equation (3), allowing separate treatment effects for each sector. Dotted line indicates estimate of average EBM impact from Table 5.

in that quarter in order to do so. The resulting deciles were described in Section 2 and illustrated there in Figure 2. We estimate a variant of equation (3), allowing for separate effects by deciles of the VAT payments distribution, and present the estimated treatment effects by decile of firm size in Figure 5.

Figure 5: EBM impacts by decile of firm size



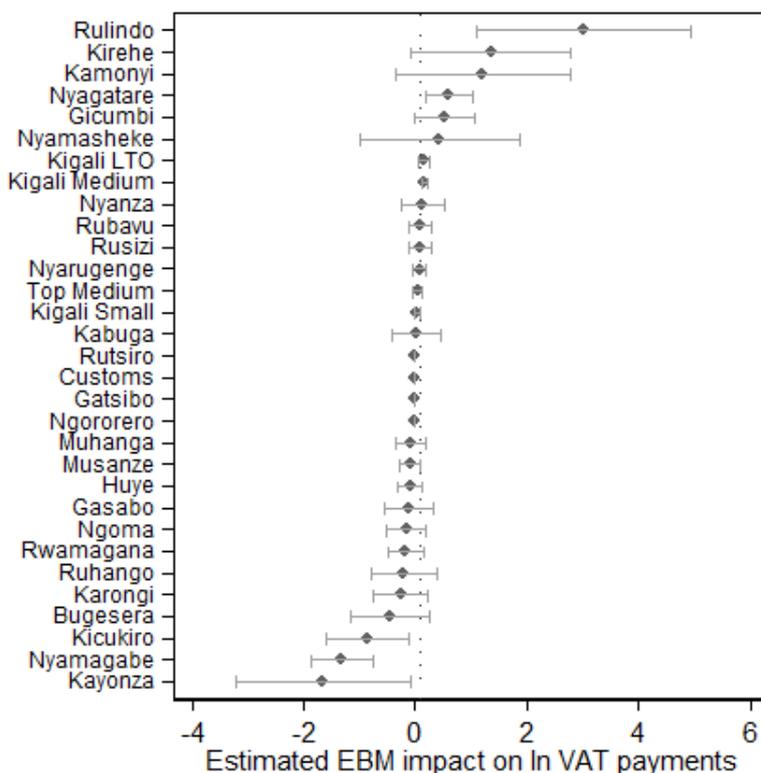
Notes: Figure illustrates estimated impacts, τ_x , and corresponding standard errors for estimates of equation (3), allowing separate EBM effects by deciles of 2012q1 VAT payments. Note 2012q1 VAT submissions are prior to any EBM adoption. Estimating sample includes only firms who submitted VAT in 2012q1. Dotted line indicates estimate of average EBM impact from Table 5.

From the bottom decile (decile 1) nearly the top decile (decile 9), the general pattern is that firms that paid higher levels of VAT in 2012q1 exhibited smaller proportional responses to the adoption of EBMs. The top decile of firms represent an apparent exception to this pattern, for reasons that require further investigation in transaction-level or other data. Nonetheless, this broader pattern is consistent with one of the two mechanisms put forward in the preceding subsection: namely, that some firms experienced low EBM impacts because their pre-treatment VAT compliance rates were already high.

5.3 Takeup and treatment effects by Tax Center

Finally, we consider the impacts of EBM adoption on enterprise subgroups defined by the tax center to which they submit VAT payments. As described in Table 2, there are 30 such tax centers that receive at least one VAT payment in our data. Given the substantial variation in the number of enterprises paying VAT across tax centers, one caveat to any conclusions that might be drawn from this is that the precision of tax-center-specific estimates varies widely from center to center.

Figure 6: EBM impacts by tax center



Notes: Figure illustrates estimated impacts, τ_x , and corresponding standard errors for estimates of equation (3), allowing separate EBM effects by Tax Center. Dotted line indicates estimate of average EBM impact from Table 5.

Figure 6 presents the results of these estimates. We see that, tax centers with either very large or very small (even negative) estimated average impacts are typically estimated very imprecisely, as indicated by the large error bars. (This causes the scale of the horizontal axis to be considerably larger than in Figures 4 and 5.) For tax centers with sufficient firms to be estimated precisely, estimated EBM effects are clustered quite closely around the estimated average effect, as indicated by the dotted

line.

Consequently, we would not suggest disproportionate application of either carrots (e.g., rewards for high performance) or sticks (e.g., targeted inspections) across the dimension defined by tax centers. The fact that some centers have too few firms adopting EBMs in these data to precisely identify EBM impacts means that we cannot reject the hypothesis that even the more extreme positive and negative effects are statistically equivalent to the average estimated effect of an 8 percent increase in VAT payment.

6 Conclusions and directions

This report has analyzed the adoption rate and VAT impacts of Electronic Billing Machines among enterprises in Rwanda. Overall, we find adoption rates to be incomplete but rapidly growing during the period (through 2014q1) under study. We estimate the average impact of EBM adoption on VAT payments is approximately 8 percent. To put this in perspective, back-of-the-envelope calculations presented in Section 4.2 suggest that, for the median firm, the increase in revenues would equal the cost outlay required for the EBM machine itself in just over three years.

These average results mask substantial heterogeneity in uptake and impacts by size and sector (though to a much lesser extent by geography), which may form the basis of future targeted encouragement activities by RRA. In general, adoption is slightly lower, and impacts on VAT payments are higher, for small firms. This suggests a strategy that skews encouragement activities somewhat toward this end of the firm size distribution. Similarly, sectors such as construction, which as of 2014q1 had experienced comparatively low adoption rates coupled with large effects on the enterprises that did adopt, would be natural areas for RRA to focus.

Future analysis can extend this work to include subsequent quarters. In addition, IGC is currently undertaking and analyzing results from a pilot ‘mystery shopper’ survey, which seeks to understand compliance with EBMs among adopting firms—an important margin that is beyond the scope of the administrative data analyzed here.