

Tax compliance and electronic invoicing in Ecuador: an impact assessment

José Ramírez-Álvarez,^a Nicolás Oliva^b and Mauro Andino^c

^a Escuela Politécnica Nacional, Department of Quantitative Economics, Ecuador.

^b Centro estratégico Latinoamericano de Geopolítica, Ecuador.

^c Inter-American Development Bank (IDB), Ecuador.

Email addresses: jose.ramirez@epn.edu.ec; niolasolivap@gmail.com and Mauroalejandroandino@gmail.com, respectively.

Project financed by the IDB with institutional support from the Internal Revenue Service of Ecuador. The authors would like to thank Alberto Bareix for his comments.

Date received: January 19, 2021. Date accepted: August 9, 2021.

Abstract

In 2013, the Ecuadorian Tax Administration officially launched the electronic invoicing system as a strategy to reduce tax evasion in tax returns. These information systems allow for designing better monitoring and auditing tools; consequently, such systems increase the subjective risk perceived by taxpayers, thus increasing their compliance. The aim of this article is to determine the effect that this system had on value-added tax (VAT) returns in the period 2014-2016, using the difference-in-differences (DID) technique. The results show that the increased coverage of the electronic system over time had positive effects on the declaration of sales, purchases, and taxes.

Keywords: value-added tax (VAT); tax compliance; tax evasion; invoicing.

1. INTRODUCTION

It has been proven at the international level how third-party information systems improve taxpayers' tax compliance and reduce tax evasion. To be precise, there is evidence that if taxpayers' transactions are not registered in parallel by third parties in the economy, there is a lower level of compliance compared to those whose are (Alm *et al.*, 2010; Carrillo *et al.*, 2014 and 2017; Kleven *et al.*, 2011).

The Ecuadorian Tax Administration,¹ like other tax administrations in the region, intensively rely on third-party information to better control tax administration and collection. Starting in 2013, this agency undertook an extensive process of digitizing their tax system, featuring the implementation of electronic invoices² (EI), making them mandatory for a specific group of taxpayers.

This system proposed making the issuance of electronic invoices mandatory for a group of 25,853 Value Added Tax (VAT) taxpayers in the period of 2014-2016. In order to issue these invoices, taxpayers had to be certified by means of a three-stage process: *i*) developmental stage, where the taxpayers in the group developed their own invoicing system and adapted their accounting systems; *ii*) testing stage, where it was verified whether the invoicing systems developed worked in issuing electronic invoices with and without legal validity, and *iii*) production stage, in which electronic invoices are formally issued in intermediate consumption transactions or, optionally, in end consumer transactions.

The objective of this study is to determine the effect had by this system on the VAT declarations for the period of 2014-2016 by means of the differences in differences (DID) technique, taking advantage of the measured pace in which taxpayers were introduced into the process described above. It is of interest to observe whether, given these circumstances, taxpayers who formally issued electronic invoices in Ecuador (those in the production stage), improved in reporting their sales, purchases and tax generated when compared to taxpayers in the earlier stages of the system (development and testing stages) but were yet to formally issue invoices.

The results showed that the effect of the electronic invoicing system was gradual and positive as the system's coverage increased over the course of time. In 2014, the effect of this system was practically nil. In 2015 there was a positive effect that increased the tax declared by 19.4%. Finally, in 2016, the strongest effect was achieved with an increase of 28.1% in declared tax.

This article is organized as follows: section two reviews the theoretical effects of information from third-parties and the influence of electronic invoicing. Section three describes the electronic invoicing system in Ecuador and its implementation in recent years. Section four shows the data used and the makeup of the control and treatment groups. Section five briefly explains the evaluation methodology used. Section six shows the results. Finally, section seven outlines some conclusions.

2. THEORETICAL FRAMEWORK. DETERRENT EFFECT OF THIRD-PARTY REPORTS IN TAXPAYER COMPLIANCE

An EI system is a process which automatically captures, tabulates and integrates transactional information. This allows for quick access to information regarding transactions carried out by taxpayers within an economic system. This type of process is designed with the aim of closing the reporting gaps

in returns and exercising better tax control.³

There are several experiences in Latin America that show that this type of system works well (Barreix and Zambrano, 2018). For example, the Electronic Invoicing System in Argentina produced a significant statistical growth in taxed sales declarations in the period of 2007-2015, with the exception of the years 2008 and 2009. In Brazil, the São Paulo *Nota Fiscal* raised reported business earnings by 22% in four years.

On the other hand, the adoption of the digital invoices in Mexico had an impact greater than 10% in 2011, 2012 and 2013 in VAT returns while simultaneously increasing Income Tax (*ISR*) collected. Likewise, in Uruguay, electronic tax documentation generated an impact of 3.7% on the amount corporations paid. It should be noted that the purpose of these systems is not only to improve tax control, but also to increase subjective risk.

What is this subjective risk? This risk corresponds to the taxpayer's perceived probability of being found out or sanctioned if they are not fulfilling their tax obligations.⁴ The EI system has two channels through which to spread subjective risk: *i)* the direct effect, where taxpayers know that their information now resides in digital files and, as such, the tax administration knows exactly what they sold, at what price, in what amount and to whom. That is, the information that was previously private (the physical invoice) and which the administration was unlikely to see, is now public and immediately accessible. *ii)* The indirect effect, where taxpayers know that they are part of a network of business transactions. By being part of this productive network, taxpayers now assume that other taxpayers who issue EI are reporting the same information they are; as such, there is a greater perceived risk and tax control.

Specialized literature tells of various field experiments that demonstrate the effects had by third-party information systems on tax compliance.⁵ For example, Alm *et al.* (2006) designed an experiment in the United States to examine the income tax compliance of individuals in situations where an audit would be unlikely to detect a portion of their income due to a lack of information from third-parties. Their results indicated that tax compliance decreased as individuals earned a higher proportion of unverifiable income (e.g., income that cannot be cross-checked with other information sources).

This phenomenon shows that taxpayers actively seek out these income sources precisely because they have an inherently lower risk and a greater chance for evasion.

Kleven *et al.* (2011) found that audits in Denmark had significant effects on self-declared income (i.e., income reported by taxpayers themselves), but had no effect on income reported by third parties. In this regard, one can conclude that tax evasion levels due to under-declaring income by those whose taxes are registered by other taxpayers was extremely low even without an audit. This result is due to how third-party information increases the taxpayer's sense of being monitored and therefore the risk of being captured.

On the other hand, Carrillo *et al.* (2017) found that notices of assessment due to a difference in income as reported by third parties in Ecuador significantly increased taxpayers' declared income. This is because this type of notification makes taxpayers acutely aware of the information to which the tax administration has access for tax control. However, the authors also found that expenses declared increased in a like manner, meaning that the net impact on income tax was imperceptible. In other words, there was a sort of substitution where tax evasion by means of under-declaring revenue was replaced with tax evasion by means of over-declaring expenses.

Likewise, Pomeranz (2013) demonstrated, by means of a field experiment, that letters warning of a possible audit caused a sharp increase in the VAT declared among companies in Chile. However, this impact was lower for those transactions for which the tax administration had a record submitted by third parties (i.e., if there was a paper trail). This fact suggests that the prior existence of transaction records created a deterrent effect promoting VAT compliance as it led to lower levels of *ex-ante* evasion.

3. DATA AND INTERVENTION

The information used to evaluate the EI system comes from forms 104 and 104A for declaring VAT in the period of 2014-2016 and was provided by the Tax Administration of Ecuador.⁶ These forms collect the values corresponding to a business's sales and acquisitions of, both domestically and abroad, goods, services and fixed assets which are taxed or not with VAT, as well as allowing for payment of taxes along with any applicable tax credit. This information is captured online through declarations made on a monthly basis for individuals who are not obligated to keep accounts, and on a semi-annual basis for companies and individuals obligated to keep accounts. Furthermore, information from the Taxpayer Unique Registry (TUR) was used. This registry contains taxpayers' socioeconomic variables such as registered tax domicile, economic activity, whether they are individuals or corporations, if they are private or public corporations, etc.

The EI system in Ecuador imposed the task of issuing formal electronic invoices for 25,853 VAT taxpayers in the period of 2014-2016. These taxpayers were mostly financial institutions, credit card issuers and administrators, telecommunications and pay-TV companies, exporters, internet sales companies, the public sector and *special taxpayers*.⁷

These taxpayers were incorporated into the system gradually between 2014-2016 in three stages: development, testing and production. The first two stages consisted of designing and verifying a functioning system for the selected taxpayers, while the last stage empowered taxpayers to formally issue electronic invoices. The issuance of these invoices was established as mandatory for transactions that qualified for VAT tax credits, but optional for end consumer transactions.

The use of three stages introduced taxpayers to the EI system in a gradual and controlled manner, making it possible to identify control and treatment groups for each year through the use of the *Pipeline* technique.⁸

For the control group we used those taxpayers chosen for the EI system who, at the end of each year, remained in the development or testing phase (i.e., those taxpayers who, for reasons of the system's schedule, have not been certified to issue electronic invoices). On the other hand, the treatment group was composed of those taxpayers who at the end of each year had already joined the production phase and were certified to issue electronic invoices, but had not been so in years prior.

The makeup of these groups for the years 2014, 2015 and 2016 is shown below in the transition matrices in Table 1. The control groups for each year are identified by the light gray cells, while the treatment groups are identified by the dark gray cells.

**Table 1. Transition matrices between development, testing and production stages.
Number of taxpayers. Years 2014, 2015, 2016**

		<i>Year 2014</i>			
		<i>In development</i>	<i>Testing</i>	<i>Production</i>	<i>Total</i>
Year 2013	In development	15 798	4 551	3 669	24 018
	Testing	0	1 442	256	1 698
	Production	0	0	137	137
	Total	15 798	5 993	4 062	25 853
		<i>Year 2015</i>			
		<i>In development</i>	<i>Testing</i>	<i>Production</i>	<i>Total</i>
Year 2014	In development	7 239	1 806	6 753	15 798
	Testing	0	2 964	3 029	5 993
	Production	0	0	4 062	4 062
	Total	7 239	4 770	13 844	25 853
		<i>Year 2016</i>			
		<i>In development</i>	<i>Testing</i>	<i>Production</i>	<i>Total</i>
Year 2015	In development	0	2 403	4 836	7 239
	Testing	0	4 145	625	4 770
	Production	0	0	13 844	13 844
	Total	0	6 548	19 305	25 853

Notes: Light gray cells indicate control groups, while dark gray cells indicate treatment groups.

Source: Taxpayer Registry. Ecuador Tax Administration.

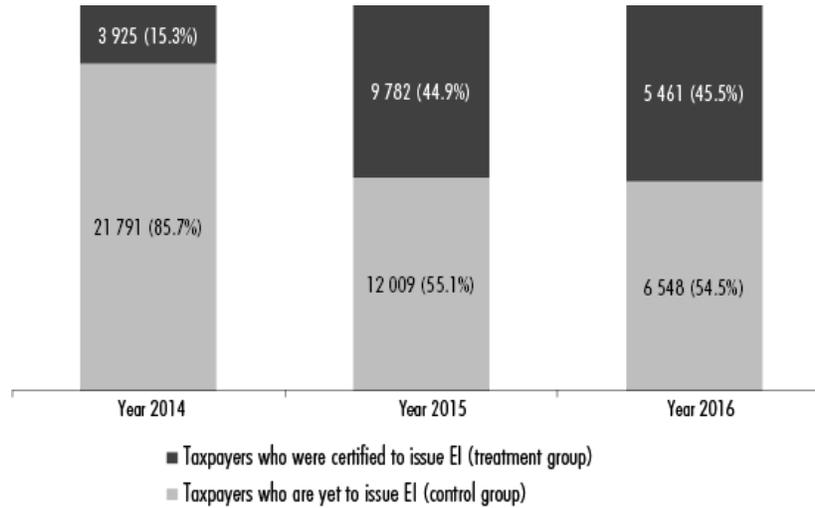
For example, in 2014, the control group was made up of 21,791 taxpayers (15,798 in the development phase and 5,993 in the testing phase) who were not certified to issue electronic invoices in 2013 and 2014. The treatment group on the other hand was composed of 3,925 taxpayers (3,669 who transitioned from development to production, and 256 who went from testing to production) who at the end of 2013 remained in the testing and/or development phase, but were certified in 2014 to issue electronic invoices.

Groups were created in the same manner for the other years. In 2015, the control group had 12,009 taxpayers (7,239 in development and 4,770 in the testing phase), while the treatment group had 9,782 taxpayers (6,753 who went from development to production, and 3,029 who went from testing to

production). Finally, in 2016, the control group was made up of 6,548 taxpayers, all in the testing phase, while the treatment group was composed of 5,461 contributors (4,836 who went from development to production, and 625 who went from testing to production).

Next, we use a bar graph to summarize the number of taxpayers who were certified to issue electronic invoices (treatment group – dark gray cells in Table 1) and the number of taxpayers who were yet to do so for each year (control group – light gray cells of Table 1), along with the corresponding percentages. It should be noted that both groups do not total the 25,853 taxpayers in Table 1. As is with the *Pipeline* technique, there were taxpayers who were persistently in the production stage year to year (for example, in the transition of 2013-2014, there was a total of 137 in production), therefore they do not belong to either the control group or the treatment group.

Figure 1. Control and treatment groups identified using the *Pipeline* technique.
Years 2014, 2015 and 2016



Note: the control and treatment groups were identified using the Pipeline technique. This means that the control group was made up of those taxpayers chosen for the electronic invoicing system but who at the end of each year continued to be in the testing or developmental phase. On the other hand, the treatment group consisted of those contributors who transitioned into the production phase that year and were therefore certified to issue EI but which had not been in that phase the previous year.

Source: Taxpayer Registry. Ecuador Tax Administration.

Table 2 shows the averages of taxed and untaxed local sales, taxed and untaxed purchases and tax generated for each period's control and treatment groups.

Table 2. VAT declarations. Average dollars per taxpayer. Years 2014, 2015 and 2016

	<i>Local sales 12%</i>	<i>Local sales 0%</i>	<i>Local purchase 12%</i>	<i>Local purchase 0%</i>	<i>Tax generated</i>
2013-2014 Transition					
Control group					
2013	999 695	474 420	1 107 057	495 575	38 547
2014	1 001 196	516 010	1 118 745	456 581	40 656
Treatment group					
2013	14 838 099	5 030 004	9 434 972	3 927 871	497 196
2014	17 604 864	5 393 234	10 027 791	4 409 731	534 357
2014-2015 Transition					
Control group					
2014	317 900	204 181	247 650	146 377	14 193
2015	362 574	174 505	255 888	126 549	13 870
Treatment group					
2014	1 738 974	852 703	2 059 296	791 518	69 228
2015	1 897 773	860 356	1 945 306	746 221	66 045
2015-2016 Transition					
Control group					
2015	250 451	104 169	200 009	76 489	9 585
2016	256 445	94 668	201 113	71 373	14 984
Treatment group					
2015	509 168	266 464	328 945	191 998	19 473
2016	480 633	290 979	333 852	173 690	20 777

Note: the control and treatment groups were identified using the Pipeline technique. This means that the control group was made up of those taxpayers chosen for the electronic invoicing system but who at the end of each year continued to be in the testing or developmental phase. On the other hand, the treatment group consisted of those contributors who transitioned into the production phase that year and were therefore certified to issue EI but which had not been in that phase the previous year.

Source: VAT return forms. Ecuador Tax Administration.

As one can see, the control and treatment groups have different characteristics in each transition period. In general, one can see how in each period the average sales, purchases and taxes paid are lower for the control groups than for the treatment groups. However, this difference decreases over time. For example, in the 2013-2014 transition, the average local sales taxed for the control and treatment group were approximately \$1 million USD and \$17 million USD in 2014, respectively, a difference of about 17-fold. On the other hand, in the 2015-2016 transition, these sales reached on average around \$250,000 USD for the control group and \$500,000 USD for the treatment group in 2016; that is, only double.

Likewise, one can see that the impact had by the EI system in the early years, having greater amounts, is more significant. For example, for the treatment group in the 2013-2014 transition, taxed local sales averaged about \$17 million USD in 2014. Then, for the treatment group in the 2014-2015 transition period, these sales averaged \$1.8 million USD in 2015. Finally, for the treatment group in the transition period of 2015-2016, these sales averaged \$480,000 USD in 2016.

The large quantities registered in the first transition periods of the EI system, as well as the relevance of the treatment groups, are due to the early incorporation into the production phase of taxpayers whose transactions are high in value/number (such as *special taxpayers* and State suppliers).

4. METHODOLOGICAL STRATEGY

This study uses the DID technique to determine if the EI system affected the sales, purchases and VAT reported in the years 2014, 2015 and 2016, taking into account the makeup of the control and treatment groups created using the *Pipeline* technique.

The hypothesis to be tested is the following: taxpayers who issued formal electronic invoices had a greater tax compliance with an increase in sales, purchases and taxes reported than the other taxpayers enrolled in the system, but who, for scheduling reasons, were yet to issue electronic invoices.

The DID technique is a quasi-experimental strategy which assumes the conditional exogeneity of the model's observable variables. Within the context of the study, this assumption can represent a serious disadvantage as it can cause selection bias due to the presence of time-invariant non-observable factors in the tax returns. As mentioned in the theoretical framework, there is an underlying trait affecting taxpayers' behavior, subjective risk, which is difficult to measure and can vary depending on the control actions carried out by the tax administration and the type of taxpayer. For example, public corporations and *special taxpayers*, the sectors with which the EI system was first implemented, may have a higher perceived risk due to their greater organization and close ties to the State, making it easy to overestimate the effect of the EI system.

On the other hand, the control and treatment groups may not be comparable if there are economic shocks that affect both groups differently during the implementation of the EI system. This is the case with the 7.8 magnitude earthquake Ecuador felt in 2015, and with the drop in crude oil prices in 2016, events which would asymmetrically influence taxpayers' behaviors. Macroeconomic theory states that tax evasion behaves countercyclically, so that collection gaps grow in times of recession and, vice versa, decrease in times of growth. In this regard, taxpayers who are not subject to control mechanisms such as electronic invoicing, and who for the purposes of the study are treated as being counterfactual in estimating the impact, will presumably have a lower level of tax compliance, not only due to the lack of perceived risk, but to the economic contraction that forces them to safeguard their resources and evade taxes. As such, these events, the earthquake and the drop in crude oil prices, could also cause an overestimation of the EI system's effects.

To apply the DID technique and determine if the EI system changed the VAT return, a proposal was made to carry out three separate evaluations (one for each transition period) using the following two-period panel model:⁹

$$y_{it} = \alpha_0 + \alpha_1 T_t + \alpha_2 D_i + \beta(T_t \times D_i) + \gamma X_{it} + u_{it}$$
$$i = 1, \dots, n; t = 0, 1 \quad (1)$$

where y_{it} is the variable in the VAT return form upon which we wish to measure the effect had by the EI system. To do this, four dependent variables were taken into account: taxed and untaxed sales, taxed and untaxed purchases,¹⁰ and tax generated in dollars, all measured in terms of the logarithm, for taxpayer i in year t . T_t is a binary variable which takes on the value of 1 if the time period corresponds to the intervention or post-treatment period; D_i is a binary variable that takes on the value of 1 if the taxpayer belongs to the treatment group (i.e., if the taxpayer was certified to formally issue electronic invoices in the production phase); $T_t \times D_i$ is a variable for interaction between the intervention period and the group to which the taxpayer belongs (that is, this variable allows us to identify those taxpayers who passed into the production phase in the post-treatment period); X_{it} is a vector of the taxpayer's socioeconomic variables (economic activity, province, class and type of taxpayer, total lagged sales and purchases, and lagged VAT and tax credits); and u_{it} is a random error with a zero mean and constant variance.

The values of α_1 , α_2 , α_3 , β and γ are the coefficients of the model related to each of the explanatory variables. In particular, the coefficient β is the parameter of interest in the study, as it allows us to quantify the causal effect of the EI system on the variables of interest; that is, it measures the effect of formally issuing electronic invoices for those taxpayers who transitioned to the production phase in the post-treatment period.

Model (1) was estimated using the heteroscedasticity-corrected ordinary least squares (OLS) method. All continuous variables were introduced in logarithmic terms to reduce the estimators' variance, while categorical variables were introduced through their corresponding dummy variables. It should be noted that this model is a log-linear model when exclusively analyzed focusing on the explanatory variables of interest T_t , D_i , $T_t \times D_i$, which are binary variables.

To ensure that the estimation of the causal effect (coefficient β) is not biased by any other factor outside the intervention, we did a graphical analysis to see if the assumption of parallel trends for the period 2009-2013 was not violated (see Appendix 1). This assumption suggests that the trend of the treatment and control groups' variables of interest is the same in the pretreatment period; that is, in the absence of treatment, the treatment group has the same behavior as the control group so any *ex-post* change can be an effect of the treatment itself. According to the results, we were able to establish that the average of most of the interest variables, taxed and untaxed sales, taxed and untaxed purchases, and tax generated, had a similar evolution for both the control and treatment groups, so that any difference in the intervention period can correctly be attributed to the employment of the EI system.

Finally, it is necessary to state that the estimation for the model (1) had some data lost, stemming from VAT not being declared, tax obligations with the collecting entity being suspended, or the taxpayers' ceasing activities. As such, it is an unbalanced panel model, in which the total number of available observations is less than double the number of taxpayers shown in Figure 1 for each year.

5. RESULTS

Next, we present the estimates of the causal effects of issuing electronic invoicing in Tables 3, 4 and 5 for the years 2014, 2015 and 2016, respectively, given the creation of the control and treatment groups using the *Pipeline* technique. For more details, the estimates of the complete model are shown in

Appendix 2. It should be noted that the estimates in Tables 3, 4 and 5 take into account the log-lin nature of model (1), so they were previously adjusted by the antilogarithm of the coefficient of interest minus one (*i.e.*, $e^{\beta} - 1$). This adjustment is noticeable for coefficients that are far from zero.

Table 3 shows the effects of the EI system in 2014 for different variables of interest: taxed and untaxed local sales, taxed and untaxed local purchases and, finally, the tax generated.

Table 3. Effect of the Electronic Invoicing System. 2014

	<i>Local sales 12%</i>	<i>Local sales 0%</i>	<i>Local purchases 12%</i>	<i>Local purchases 0%</i>	<i>Tax generated</i>
Issues electronic invoice	0.009 (0.080)	-0.019 (0.118)	-0.019 (0.063)	0.005 (0.079)	-0.009 (0.064)
Number of observations	40 057	40 058	40 065	40 059	40 058

Note: the table shows the estimated effect of the EI system on VAT returns using the DID model, adjusted by $(e^{\beta} - 1)$. Standard errors are in parentheses and corrected for heteroscedasticity. *, **, represent significance levels at 90, 95 and 99% certainty, respectively.

Source: VAT return forms. Ecuador Tax Administration.

As one can see, all the effects are statistically non-significant, which is consistent with the initial EI system's original scheduling. According to the 2013-2014 transition matrix in Table 1, the system's level of inclusion was limited in 2014, with less than 4,000 taxpayers issuing EI. In this regard, the risk propagation channels were still weak at that time. Although the first taxpayers who entered the system were aware that from that moment on their information would be public (that is, that their sales would be registered continuously with the Tax Administration), they still had dealings with suppliers who did not have the obligation to issue electronic invoices, so their sense of risk was lower.

In 2015, the EI system was in full effect and it was this year in which the largest number of contributors moved into the production phase, as seen in the 2014-2015 transition matrix in Table 1.¹¹ The effect of the system this year is shown in Table 4.

Table 4. Effect of the Electronic Invoicing System. 2015

	<i>Local sales 12%</i>	<i>Local sales 0%</i>	<i>Local purchases 12%</i>	<i>Local purchases 0%</i>	<i>Tax generated</i>
Issues electronic invoice	0.191** (0.077)	0.030 (0.099)	-0.080 (0.062)	-0.014 (0.074)	0.194*** (0.061)
Number of observations	32 475	32 469	32 476	32 471	32 468

Note: the table shows the estimated effect of the EI system on VAT returns using the DID model, adjusted by $(e^{\beta} - 1)$. Standard errors are in parentheses and corrected for heteroscedasticity. *, **, represent significance levels at 90, 95 and 99% certainty, respectively.

Source: VAT return forms. Ecuador Tax Administration.

It is interesting to see that this year the electronic invoice system had a significant and positive on tax compliance, likely the result of a greater perceived risk after the system had been in effect for a year. When looking at the effect on taxed local sales, the estimate showed with a 95% degree of certainty that taxpayers who issued electronic invoices increased their declarations by 19.1% compared to those taxpayers who did not. There is a 99% degree of certainty that this fact caused the generated tax to see an increase of 19.4%. In other words, it can be said that evasion by underreporting income decreased. On the other hand, as expected, untaxed local sales did not improve. As these sales do not generate taxes nor tax credits, they are not an instrument in taxpayers' tax planning.

Another important finding in the second year is that declarations of purchases did not improve. This makes sense as sales are the first accounting records to be reported digitally since they are issued by the taxpayers themselves. On the other hand, the digital record of purchases depends on whether the taxpayers' suppliers are enrolled in the EI system, which is by no means guaranteed given this year's coverage.

In 2016, the effects of the EI system achieved grew compared to the previous year. As can be seen in Table 5, there was, with 95% certainty, an increase of statistical significance in the declaration of all variables of interest for those taxpayers who issued electronic invoices, with the exception of untaxed local sales where there was no significant effect.¹²

Table 5. Effect of the Electronic Invoicing System. 2016

	<i>Local sales 12%</i>	<i>Local sales 0%</i>	<i>Local purchases 12%</i>	<i>Local purchases 0%</i>	<i>Tax generated</i>
Issues electronic invoice	0.463*** (0.116)	0.085 (0.135)	0.590*** (0.101)	0.488** (0.115)	0.281*** (0.092)
Number of observations	16 079	16 079	16 079	16 079	16 079

Note: the table shows the estimated effect of the EI system on VAT returns using the DID model, adjusted by $(e^{\beta} - 1)$. Standard errors are in parentheses and corrected for heteroscedasticity. *, **, represent significance levels at 90, 95 and 99% certainty, respectively.

Source: VAT return forms. Ecuador Tax Administration.

This fact demonstrates the ability of the EI system to increase the level of tax compliance. Specifically, this new system's impact is clearly positive when it comes to tax returns with 99% certainty of a substantial increase of 28.1%. That is, the tax generated by those taxpayers who issued electronic invoices was 28.1% higher than the taxpayers who did not, thereby reducing what evasion there was prior to the implementation of this system.

It is important to note that once a significant period had passed and almost all taxpayers were certified in the production phase, there was a positive and significant effect on purchases. This confirms that the risk generated by adhering to the EI system within the productive network also puts significant pressure on taxpayers. This means that as a company believes it should declare its sales more faithfully, then the logical conclusion is that it should also do a better job of declaring its purchases in order to benefit from a greater tax credit. This credit is supported by the issuance of electronic invoices, which its suppliers are now obliged to give them, and their suppliers in turn, and so on. This domino effect raises the economy's level of formalization, thereby creating a systemic effect on tax compliance and reducing evasion.

In summary, the effect of the EI system on VAT returns in Ecuador grew as its implementation and reach spread, causing taxpayer's subjective risk to gradually increase, creating less leeway for tax evasion and subsequently resulting in better declarations. The system had no effect on taxpayers' declarations in 2014. However, in 2015 and 2016, after the system had established itself within the IRS and in taxpayers' practices, the effect was positive and significant on tax generated, and registered increases of 19.4% for 2015 and 28.1% for 2016.

In hindsight, one can say that the results suggest that the impact of the EI system on compliance can take between two and three years to properly take effect. In terms of revenue, this impact meant around \$89.3 million USD for 2015 and \$43.3 million USD for 2016, a total of \$132.6 million USD. This total increase is equivalent to 0.132% of the GDP in 2016.

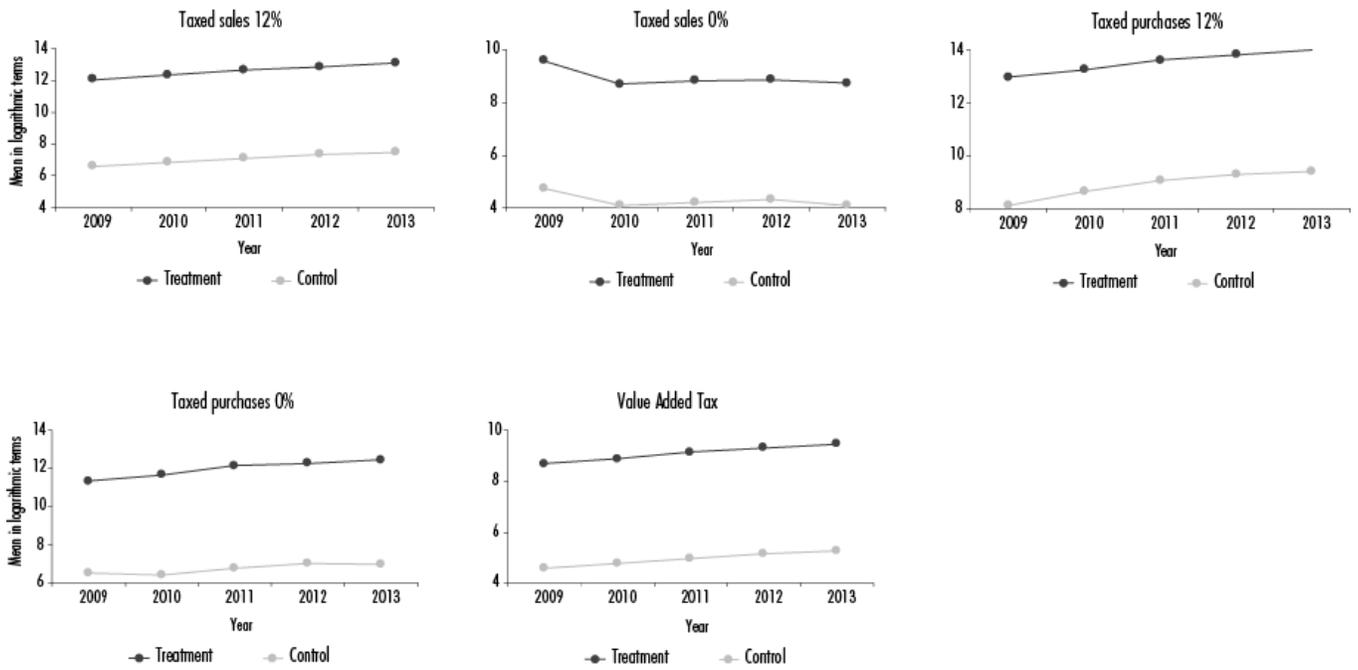
6. CONCLUSIONS

Several international studies show that third-party information systems, when implemented by tax administrations, have an important effect on taxpayers' tax compliance and tax evasion. Within this context, some tax administrations in the region have made progress this last decade in digitalizing their tax systems. The end goal is electronic invoices.

This study shows that the EI system implemented in 2013 in Ecuador improved tax compliance for taxpayers obliged to issue electronic invoices, with a positive and gradual impact on VAT returns. In 2014, the effect of this system was practically nil. Nevertheless, over the next two years, the effect was strengthened little by little as the system's reach grew. In 2015 there was a positive effect on a reduced set of variables, causing an increase of 19.4% in the tax generated. Meanwhile, in 2016 there was a positive effect on almost all the variables for declarations, causing a substantial increase of 28.1% in tax.

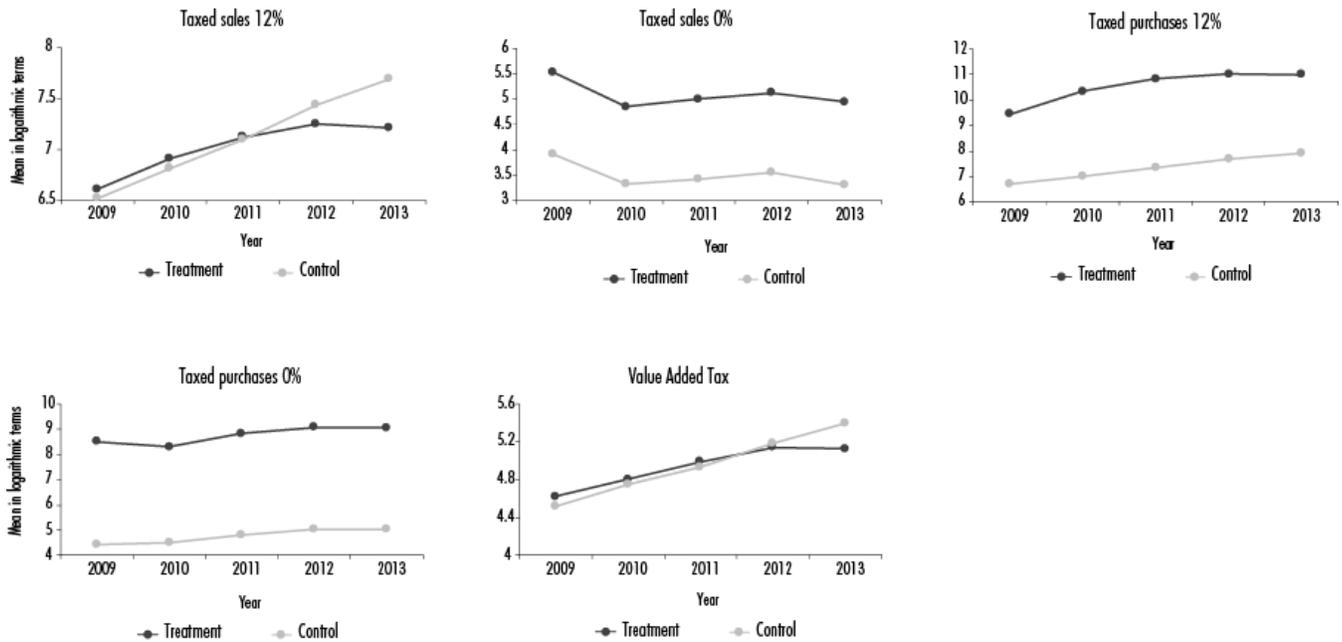
It is important to highlight that the subjective risk created by the electronic invoicing system may disappear over time if the tax administration does not execute strong control actions along with this new system. In this regard, the future success of the EI system depends not only on the system itself, but also on the control measures implemented by the tax administration.

APPENDIX 1. EX-ANTE PARALLEL TRENDS



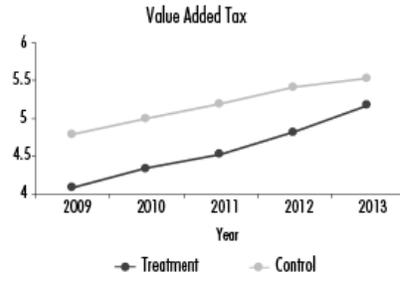
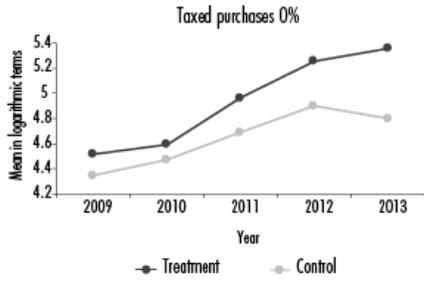
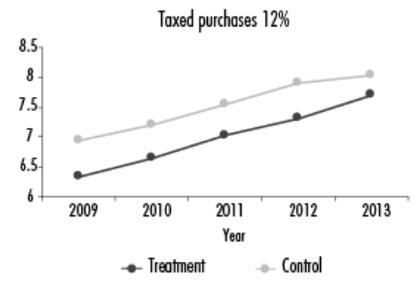
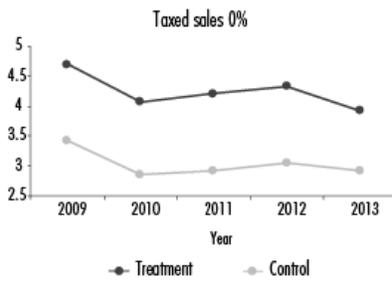
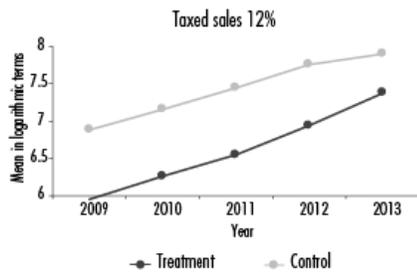
Note: the control and treatment groups were created using the Pipeline technique. See section 3.
 Source: VAT return forms. Ecuadorian Tax Administration.

Figure 3. Trends in 2009-2013 for evaluating the electronic invoicing system in 2015.



Note: the control and treatment groups were created using the Pipeline technique. See section 3.
 Source: VAT return forms. Ecuadorian Tax Administration.

Figure 4. Trends in 2009-2013 for evaluating the electronic invoicing system in 2016.



Note: the control and treatment groups were created using the Pipeline technique. See section 3.
 Source: VAT return forms. Ecuadorian Tax Administration.

Table 6. DID model. Electronic Invoicing year 2014

<i>Dependent variables</i>	1	2	3	4	5
<i>VAT return form F104 fields</i>	<i>Local sales 12%</i>	<i>Local sales 0%</i>	<i>Local purchase 12%</i>	<i>Local purchase 0%</i>	<i>VAT</i>
Interaction variable: TxD	0.009 (0.080)	-0.019 (0.118)	-0.019 (0.063)	0.005 (0.079)	-0.009 (0.064)
Dummy year 2014: T	0.656*** (0.063)	0.914*** (0.093)	0.417*** (0.050)	0.752*** (0.062)	0.355*** (0.050)
Dummy treatment: D	-0.059* (0.035)	-0.263*** (0.051)	-0.060** (0.027)	-0.106*** (0.034)	-0.057** (0.028)
Taxpayer Class (ref. Special)					
Rise ^a	-0.959*** (0.046)	-2.302*** (0.068)	-1.192*** (0.036)	-1.654*** (0.046)	-0.704*** (0.037)
Other	-3.896*** (0.644)	-3.202*** (0.948)	-3.107*** (0.506)	-3.067*** (0.636)	-2.881*** (0.510)
Type (ref. Individuals)					
Corporations	0.419*** (0.043)	1.486*** (0.064)	1.454*** (0.034)	2.828*** (0.043)	0.545*** (0.034)
Sector (ref. Private Sector)					
Public Sector	-3.139*** (0.073)	-0.545*** (0.107)	0.474*** (0.057)	-0.549*** (0.072)	-2.082*** (0.058)
Continuous variables					
Total lagged sales, 2 years	0.003 (0.006)	0.726*** (0.009)	-0.062*** (0.005)	0.130*** (0.006)	-0.068*** (0.005)
Total lagged purchases, 2 years	0.003 (0.006)	0.059*** (0.009)	0.548*** (0.005)	0.504*** (0.006)	0.006 (0.005)
Lagged VAT, 2 years	0.753*** (0.005)	-0.518*** (0.008)	0.088*** (0.004)	-0.154*** (0.005)	0.757*** (0.004)
Lagged Tax credit, 2 years	0.150*** (0.004)	-0.162*** (0.006)	0.027*** (0.003)	-0.022*** (0.004)	0.027*** (0.003)
Constant	3.678*** (0.121)	2.492*** (0.178)	5.062*** (0.095)	3.278*** (0.119)	1.657*** (0.096)
Fixed effects by activity	x	x	x	x	x
Fixed effects by province	x	x	x	x	x
Number of observations	40 057	40 058	40 065	40 059	40 058

^a TL note: Rise (Régimen Impositivo Simplificado). This is a voluntary modality offered by the Ecuadorian Tax Administration which allows individuals who meet the requirements to pay a fixed monthly rate in lieu of traditional VAT and income tax payments. Its purpose is to simplify the system and thereby improve tax compliance.

Note: the table shows the estimated effect of the FE system on the VAT return using the DID model. Standard errors are in parentheses and corrected for heteroscedasticity. *, **, represent significance levels at 90, 95 and 99% certainty, respectively.

Source: VAT return forms. Ecuadorian Tax Administration of Ecuador.

Table 7. DID model. Electronic Invoicing year 2015

<i>Dependent variables</i>	1	2	3	4	5
<i>VAT return form F104 fields</i>	<i>Local sales 12%</i>	<i>Local sales 0%</i>	<i>Local purchase 12%</i>	<i>Local purchase 0%</i>	<i>VAT</i>
Interaction variable: TxD	0.174** (0.077)	0.029 (0.099)	-0.083 (0.062)	-0.014 (0.074)	0.177*** (0.061)
Dummy year 2015: T	0.544*** (0.061)	0.410*** (0.079)	0.938*** (0.049)	1.577*** (0.059)	0.371*** (0.049)
Dummy treatment: D	-0.268*** (0.054)	-0.105 (0.070)	-0.178*** (0.044)	-0.184*** (0.053)	-0.239*** (0.043)
Taxpayer Class (ref. Special)					
Rise	-1.171*** (0.063)	-2.497*** (0.082)	-1.409*** (0.051)	-1.720*** (0.061)	-0.885*** (0.050)
Other	-3.910*** (0.818)	-3.581*** (1.061)	-3.725*** (0.661)	-2.886*** (0.791)	-3.046*** (0.649)
Type (ref. Individuals)					
Corporations	0.403*** (0.052)	1.639*** (0.068)	1.447*** (0.042)	2.845*** (0.051)	0.513*** (0.042)
Sector (ref. Private Sector)					
Public Sector	-3.965*** (0.087)	-0.822*** (0.112)	-0.050 (0.070)	-1.373*** (0.084)	-2.755*** (0.069)
Continuous variables					
Total lagged sales, 2 years	-0.022*** (0.007)	0.675*** (0.009)	-0.055*** (0.006)	0.128*** (0.007)	-0.062*** (0.006)
Total lagged purchases, 2 years	-0.024*** (0.007)	0.029*** (0.009)	0.465*** (0.005)	0.411*** (0.007)	-0.017*** (0.005)
Lagged VAT, 2 years	0.731*** (0.007)	-0.538*** (0.009)	0.084*** (0.005)	-0.152*** (0.006)	0.688*** (0.005)
Lagged Tax credit, 2 years	0.119*** (0.006)	-0.121*** (0.007)	0.008* (0.005)	-0.027*** (0.005)	0.031*** (0.005)
Constant	4.131*** (0.156)	3.461*** (0.202)	5.699*** (0.126)	3.882*** (0.151)	2.152*** (0.124)
Fixed effects by activity	x	x	x	x	x
Fixed effects by province	x	x	x	x	x
Number of observations	32 475	32 469	32 476	32 471	32 468

Note: the table shows the estimated effect of the FE system on the VAT return using the DID model. Standard errors are in parentheses and corrected for heteroscedasticity. *, **, represent significance levels at 90, 95 and 99% certainty, respectively.

Source: VAT return forms. Ecuadorian Tax Administration of Ecuador.

Table 8. Model. Electronic Invoicing year 2016

<i>Dependent variables</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>VAT return form F104 fields</i>	<i>Local sales 12%</i>	<i>Local sales 0%</i>	<i>Local purchase 12%</i>	<i>Local purchase 0%</i>	<i>VAT</i>
Interaction variable: TxD	0.381*** (0.116)	0.081 (0.135)	0.464*** (0.101)	0.397*** (0.115)	0.247*** (0.092)
Dummy year 2016: T	0.617*** (0.086)	0.790*** (0.100)	0.526*** (0.075)	1.042*** (0.085)	0.427*** (0.068)
Dummy treatment: D	-0.583*** (0.073)	-0.213** (0.085)	-0.533*** (0.064)	-0.435*** (0.073)	-0.439*** (0.058)
Taxpayer Class (ref. Special)					
Rise	-0.625*** (0.171)	-3.041*** (0.199)	-1.394*** (0.150)	-2.321*** (0.170)	-0.634*** (0.135)
Other	-4.632*** (1.215)	-3.213** (1.411)	-3.825*** (1.064)	-3.257*** (1.210)	-4.156*** (0.962)
Type (ref. Individuals)					
Corporations	0.508*** (0.074)	1.799*** (0.086)	1.872*** (0.065)	3.510*** (0.074)	0.721*** (0.059)
Sector (ref. Private Sector)					
Public Sector	-4.775*** (0.245)	-1.857*** (0.285)	-1.102*** (0.215)	-1.992*** (0.244)	-3.351*** (0.194)
Continuous variables					
Total lagged sales, 2 years	1.888*** (0.611)	1.017 (0.710)	0.991* (0.535)	0.672 (0.609)	1.750*** (0.484)
Total lagged purchases, 2 years	-0.173*** (0.012)	0.546*** (0.014)	-0.080*** (0.011)	0.132*** (0.012)	-0.130*** (0.010)
Lagged VAT, 2 years	0.104*** (0.011)	0.096*** (0.013)	0.442*** (0.010)	0.372*** (0.011)	0.060*** (0.009)
Lagged Tax credit, 2 years	0.713*** (0.011)	-0.583*** (0.013)	0.119*** (0.010)	-0.131*** (0.011)	0.610*** (0.009)
Constant	0.076*** (0.010)	-0.096*** (0.012)	-0.004 (0.009)	-0.016 (0.010)	0.033*** (0.008)
Constant	3.262*** (0.280)	5.000*** (0.325)	5.704*** (0.245)	4.193*** (0.279)	2.020*** (0.221)
Fixed effects by activity	x	x	x	x	x
Fixed effects by province	x	x	x	x	x
Number of observations	16 079	16 079	16 079	16 079	16 079

Note: the table shows the estimated effect of the FE system on the VAT return using the DID model. Standard errors are in parentheses and corrected for heteroscedasticity. *, **, represent significance levels at 90, 95 and 99% certainty, respectively.

Source: VAT return forms. Ecuadorian Tax Administration of Ecuador.

BIBLIOGRAPHY

Allingham, M. G. and Sandmo, A. (1972). Income tax evasion: a theoretical analysis. *Journal of Public Economics*, 1(3-4). [https://doi.org/10.1016/0047-2727\(72\)90010-2](https://doi.org/10.1016/0047-2727(72)90010-2)

Alm, J., Cherry, T., Jones, M. and McKee, M. (2010). Taxpayer information assistance services and tax compliance behavior. *Journal of Economic Psychology*, 31(4). <https://doi.org/10.1016/j.joep.2010.03.018>

_____, Deskins, J. A. and McKee, M. (2006). Third-party income reporting and income tax compliance. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.895344>

Barreix, A. and Zambrano, R. (2018). *Factura electrónica en América Latina*. Inter-American Development Bank. <https://doi.org/10.18235/0001038>

Carrillo, P., Pomeranz, D. and Singhal, M. (2014). Tax me if you can: Evidence on firm misreporting behavior and evasion substitution. *Working Paper*. <http://docplayer.net/1563520-Tax-me-if-you-can-evidence-on-firm-mis-reporting-behavior-and-evasion-substitution-february-2014-abstract.html>

_____, Pomeranz, D. and Singhal, M. (2017). Dodging the taxman: Firm misreporting and limits to tax enforcement. *American Economic Journal: Applied Economics*, 9(2). <https://doi.org/10.1257/app.20140495>

Hallsworth, M. (2014). The use of field experiments to increase tax compliance. *Oxford Review of Economic Policy*, 30(4). <https://doi.org/10.1093/oxrep/gru034>

Khandker, S., Koolwal, G. B. and Samad, H. (2009). *Handbook on impact evaluation*. The World Bank. <https://doi.org/10.1596/978-0-8213-8028-4>

Kleven, H. J., Knudsen, M. B., Kreiner, C. T., Pedersen, S. S. and Saez, E. (2011). Unwilling or unable to cheat? Evidence from a tax audit experiment in Denmark. *Econometrica*, 79(3). <https://doi.org/10.2307/41237767>

Pomeranz, D. (2013). No taxation without information: Deterrence and self-enforcement in the value added tax. *The American Economic Review*, 105(8). <https://doi.org/10.1257/aer.2013039>

¹ The Internal Revenue Service (*Servicio de Rentas Internas*) is the institution responsible for collecting and administrating national taxes in Ecuador.

² TL note: *Invoice* is the normal English translation for the Spanish *factura* though there are some differences pertinent to this article. In various Spanish speaking countries, a "receipt" (*nota*) is not legally valid for tax purposes (as it lacks the taxpayer's information), while an invoice is. For that explicit purpose it is normally required that the "invoice" have both the buyer's and seller's information, including tax identification numbers, and the tax "paid," even if payment is still pending. If an invoice indicates that payment has not been made or has a due date for payment it is not considered a proper *factura* but rather just a bill. This is why the article refers to official invoices both with legal validity and without (*notas* or those just requesting payment).

³ An EI establishes the minimum conditions in order to make efficient use of the mass controls provided by cross-checking. Cross-checking with third-parties is a tax control technique employed by administrations where the taxable event is verified by comparing two types of information: the amounts declared by the taxpayer and the same amount as registered by a secondary source of information. This source can be external to the administration by means of information exchange agreements or it can be internal by means of processing third-party information.

⁴ Risk is one of the key elements in assessing tax evasion. In Allingham's and Sandmo's (1972) seminal work, they establish that evasion increases if: *i*) the probability of being found out decreases, *ii*) the penalty decreases, *iii*) the tax rate increases, or *iv*) income increases.

⁵ Within the framework of tax administration there are various experiences which evaluate the effect of tax control on taxpayers' behavior using experiments. Hallsworth (2014) has created a large compilation about it.

⁶ We were authorized by the Internal Revenue Service to access and process this data using their computers in their installations due to privacy and confidentiality laws and policies regarding the information which this entity handles.

⁷ *Special taxpayers* are the ones who contribute the most to the tax collected in Ecuador. Typically, these taxpayers are required to withhold tax for other taxpayers with whom they conduct business.

⁸ This technique allows one to use as a control group those individuals who were chosen to participate in a program but were not introduced until a later period due to scheduling. That is, for the year prior to the program these individuals are considered as a control group, but for the year in which they entered the program they are considered a treatment group.

⁹ Khandker *et al.* (2009) provide a complete set of material for evaluating impact using the DID method.

¹⁰ In Ecuador, goods and services are taxed with either 12% VAT or 0% VAT. That is why there are two options in declaring sales and purchases. For just one year –June 2016 to June 2017–, VAT was increased by 2 percentage points, exclusively for goods with a 12% tax to compensate for the effects of the earthquake.

¹¹ According to the Ecuadorian Tax Administration, in 2015, 72% of sales made by taxpayers were carried out with the use electronic invoices.

¹² The result that the effect on untaxed sales remains non-significant strengthens the validity of the evaluation method. Untaxed sales do not generate a risk of evasion since their declaration does not generate VAT. This is in line with fiscal logic and with the experience of the Ecuadorian Tax Administration.