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Does e-government improve government capacity? Evidence from tax compliance costs, tax revenue and public procurement competitiveness[*]

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Abstract

Using cross-country data on e-government systems, we analyze whether e-filing of taxes and e-procurement adoption improves the capacity of governments to raise and spend fiscal resources through lowering tax compliance costs, improving tax collection and public procurement competitiveness, and reducing corruption. We find that adopting e-filing systems reduces tax compliance costs as measured by the time to prepare and pay taxes, the likelihood and frequency of firms being visited by a tax official, and the perception of tax administration as an obstacle to firms' operation and growth. E-filing is also associated with a moderate increase in the income tax revenue to GDP ratio. The results for e-procurement are weaker, with the number of firms securing or attempting to secure a government contract increasing only in countries with higher levels of development and better institutions. We find no strong relationship between e-government and corruption.

JEL Codes: H11, H26, H57, O38
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1. Introduction

Economic development requires a government that can successfully implement policies, protect property rights, and deliver public goods and services. A necessary prerequisite is the ability to raise and spend fiscal resources effectively. But many governments, particularly in low- and middle-income countries, lack these capacities (Besley and Persson, 2010). High tax compliance costs due to cumbersome regulations and harassment by tax officials deter investment, encourage tax evasion, and undermine economic growth (Hindriks et al., 1999; Djankov et al., 2006; Coolidge, 2012; Alm et al. 2015; Jerbashian and Kochanova, 2016a). The public procurement of goods and services is often rife with collusive practices and corruption, resulting in the misallocation or waste of resources and poor quality infrastructure (Auriol, 2016; Center for Global Development, 2014).

This paper investigates whether the use of information and communication technology (ICT) by government—electronic government (e-government)—can strengthen its capacity to raise and spend fiscal resources effectively, and to improve the business environment. Most countries have invested heavily in e-government over the past two decades to improve revenue mobilization, budget preparation and execution, and to deliver a variety of services to citizens.[1] However, very little is known about the returns on such investments. We aim to fill this gap by examining the effects of two aspects of e-government: the electronic filing and payment of taxes (e-filing) on tax compliance costs, tax revenue and corruption; and electronic procurement (e-procurement) on the competitiveness of public procurement and corruption. For these purposes we employ novel cross-country data on e-government systems adoption dates.

E-filing should, in theory, reduce the costs to businesses and individuals for complying with tax regulations and increase tax revenue. The reduction of tax compliance costs can occur through decreasing the time and resources taxpayers spend on gathering information to file taxes; decreasing

[1] Almost all countries have some form of automated financial management system in place, according to World Bank's *Global e-Government Systems Database*, which is used in this paper and described in Section 2.
Governments also tend to use more ICT than the private sector. Van Reenen et al. (2010) report that public sector establishments in 2005–2008 used on average 1.32 computers per employee as compared to 0.64 in the manufacturing and 1.18 in the services sector.

data duplication across different tax forms which also lowers errors in filing; reducing the time for submitting tax forms and receiving tax refunds; and minimizing face-to-face interactions with tax officials and inspectors. Lowering these costs can improve the business climate, the allocation of resources, and eventually increase tax revenues for governments. Similarly, adopting e-procurement can increase competition in government procurement by making information about government tenders, bidding processes and contract awards more widely available and transparent. It can reduce the costs of submitting bids, attract bidders of higher quality and from outside of existing collusive cartels, all of which should decrease corruption.

However, the investments in e-government might not bring the expected returns if countries lack the human capital, technology, and good institutions to exploit fully the advantages of ICT (Yilmaz and Coolidge, 2013; Lewis-Faupel et al., 2016; World Bank, 2016). E-government may fail if businesses do not have access to reliable internet services, if they have to invest considerable time and resources to adapt to new electronic platforms, or are still able to evade taxes through, for example, collusion with tax officials. It may also fail if government policies require parallel paper filing of taxes or bids, or if public officials retain discretion in determining technical qualifications of bidders and thus limit competition. We test these conjectures using the interaction between e-government adoption and a country's level of development, which we proxy with various indicators.

We find that the adoption of e-filing reduces tax compliance costs measured by the time to prepare and pay taxes, the probability and frequency of firms being visited by tax officials, and the perception of tax administration as an obstacle to firms' operation and growth. The effects are generally stronger in countries with higher levels of development. E-filing also decreases the solicitation of bribes by tax officials in the more developed Europe and Central Asia (ECA) region, but not across the larger range of developing counties. Further, we find that e-filing increases the income tax revenue to GDP ratio in less developed countries, which signals a reduction of tax evasion. In more developed countries, by contrast, we observe a decrease of the goods and services

tax revenue (and also total tax revenue) to GDP ratio. We argue that these differing effects are because more developed countries are able to better internalize the benefits of e-government and are subject to less tax evasion.

The impact of e-government on public procurement is weaker. The adoption of e-procurement systems improves public procurement competitiveness, measured by the propensity of firms to apply for public tenders and the likelihood that firms are expected or requested to pay bribes to secure a government contract, only in more developed countries.

Our findings shed light on the potential and limitations of ICT to improve government capacity. First, the varying impacts of e-filing and e-procurement suggest that technology can increase government capacity for some functions more than for others. Second, the interaction effects of development measures on our variables of interest suggest that the quality of infrastructure, institutions, and human capital condition the impact of e-government. This finding is consistent with the literature on ICT and firm productivity, which emphasizes the importance of complementary organizational changes within firms to reap the benefits of ICT (Bresnahan et al., 2002; Brynjolfsson and Hitt, 2000), and with the few studies on the impact of ICT on public sector performance (Garicano and Heaton, 2010; Seri and Zanfei, 2013). The absence of institutional changes in developing countries therefore may explain their poor returns on ICT investments, particularly for large and complex ICT systems (Heeks, 2005; World Bank, 2016).

While there have been an increasing number of studies on the impact of ICT on various aspects of development (Aker and Mbiti, 2010; Jack and Suri, 2014), industry competition (Jerbashian and Kochanova, 2016b), and aggregate economic performance (Ketteni et al., 2011), empirical research of e-government is very scarce. Ali et al. (2015) and Eissa and Zeitlin (2014) find that the introduction of electronic machines to record sales transactions of firms improved tax compliance and revenue mobilization in Ethiopia and Rwanda, respectively. Yilmaz and Coolidge (2013) show that e-filing significantly reduced tax compliance costs for firms in South Africa, but not in Ukraine or Nepal, which indicates possible limits of e-government. These studies, however,

are country specific or compare a few cases at best. Our paper examines the effects of e-filing cross-nationally, and it shows that government investments in e-filing systems can substantially reduce tax compliance costs, and in some instances increase tax revenue collection.

Existing empirical studies on the impact of e-procurement are also country-specific or limited to small samples of relatively homogenous cases. For example, Heeks (2005) reports that e-procurement expanded the number of small businesses participating in public tenders in Brazil and reduced opportunities for corruption in Romania. Nepelski (2006) finds that e-procurement increases the amount of market transactions and improves supply chain management on the sample of several European countries. Singer et al. (2009) argue that e-procurement in Chile reduces government administrative costs and, with more bidders, the prices of contracts. Lewis-Faupel et al. (2016) find that e-procurement in India and Indonesia improves the quality of public infrastructure projects through reduced costs of submitting bids and increased competition among bidders. In this paper, we analyze the effects of adopting e-procurement on public procurement competitiveness for a large sample of low- and middle-income countries. We show that e-procurement improves competitiveness only in countries with relatively high levels of development.

This paper is also related to the literature on the impact of ICT on corruption. In a cross-country study Andersen (2009) finds that e-government reduces corruption, especially in non-OECD countries. Muralidharan et al. (2016) and Barnwal (2014) show that biometric registration, authentication, and payment systems significantly reduce corruption and inefficiencies in government workfare and fuel subsidy programs in India by automating tasks and improving monitoring. Banerjee et al. (2014), using the evidence from a large field experiment in one Indian state, conclude that e-government reduces fiscal leakages, but does not necessarily improve outcomes of public programs. This paper finds only weak evidence of a reduction in corruption due to e-government adoption.

The remainder of the paper is structured as follows. The next section describes the data sources and variables. Section 3 outlines the empirical strategy. Section 4 discusses the results and presents the robustness checks, and Section 5 concludes.

2. Data

This paper uses a number of datasets collected by the World Bank. Our primary variables of interest, e-filing and e-procurement adoption dates and the types of electronic system functionality, are from the *Global e-Government Systems Database (GeGSD).*[2] The data were compiled by World Bank experts by visiting government websites and consulting World Bank project documents, national legislation and implementation reports, and validated by country economists and government officials. The data cover 198 countries over the 1990-2014 period.

The e-filing implementation date refers to the year in which the country first introduced an e-filing system at a particular level of functionality. Typically, this occurs after core tax administration systems are in place. Since e-filing is a relatively new e-government technology, countries have only one iteration of an e-filing system. System upgrades that do not constitute an improvement in system functionality are not recorded in the dataset. E-filing functionality is assessed at three levels: 1) informational systems, which provide policy guidance and forms for download; 2) transactional systems, which allow taxes to be filed electronically; and 3) transactional systems with e-payment, which allow for electronic filing and payment of taxes. One drawback of the dataset is that it does not record adoption dates for countries with basic informational systems, and countries without any e-filing system cannot be distinguished from those with unknown systems. Therefore, countries with informational, unknown or no e-filing systems are pooled together in one group "none". In the empirical analysis thus we distinguish between transactional systems and transactional systems with e-payment functionality. GeGSD also does not report the coverage of the e-filing system in terms of the types of taxes that can be filed

[2] The Global e-Government Systems Database consists of variables related to management information systems for public finance, tax administration, customs, procurement, and human resources, as well as digital identification schemes. Data can be accessed at http://data.worldbank.org/data-catalog/pfm-systems-eservices-dataset. In the online Appendix, we also report the years in which countries in our analysis implemented e-filing and e-procurement.

electronically in each country. It is common, however, for e-filing to begin with taxes levied on businesses – the corporate income taxes and the value-added taxes – and then to expand in coverage to the personal income tax, property tax and other smaller taxes (Yilmaz and Coolidge, 2013). Our tax compliance cost measures, as described below, are specifically for firms and therefore should be more strongly affected by e-filing adoption.

The e-procurement adoption date refers to the year in which the most recent iteration of a country's e-procurement system was introduced. E-procurement functionality is also assessed at three levels: 1) informational systems, which provide information about tenders and the results of bid evaluations; 2) transactional systems, which also allow tenders and supporting documents to be submitted and evaluated electronically; and 3) connected systems, in which the transactional system is integrated with other financial management information systems so that budgets, contractual commitments, and payments to vendors are automated. Only four developed countries had adopted connected systems by 2014, but the data on public procurement competitiveness is not available for them. Therefore, in the empirical analysis, we distinguish between informational and transactional systems, and we pool together countries with unknown or no e-procurement systems in one group "none". GeGSD does not provide details on the type of tenders or government departments participating in e-procurement. Usually the e-procurement systems are supported by requisite legislation, comprehensive in the types of contracts, and require that all government departments use the systems.[3] Finally, in many countries, firms and individuals are advised, but not obliged to use electronic platforms either for filing and paying taxes or public procurement.

Figure 1 shows the total number of e-filing and e-procurement systems adopted each year, by functionality. During the period 1990-2014, 125 countries adopted e-filing systems and 73 countries did not, while 142 countries adopted e-procurement systems and 56 countries did not.

[3] E-procurement systems in general have e-tendering and e-purchasing components, with the former a solution for high-value, but low-volume works, goods and services, which are specialized and complex; and the latter for low-value, but high-volume standard goods and services, such as office supplies, lap top computers, and other items for regular use. GeGSD only captures the e-tendering dimension of e-procurement systems.

To evaluate the impact of e-government, we focus on tax compliance costs, tax revenue, public procurement competitiveness, and corruption measures at the country and firm level. Tax compliance costs at the country level are the time to prepare and pay taxes,[4] which is available from the *Doing Business (DB)* database.[5] These costs include the time in hours per year to collect information that is necessary to compute the tax payable and amount payable, file all tax forms, and to pay. They are estimated for a typical, medium-sized, manufacturing, and domestically-owned firm by in-country experts based on existing regulations and their own professional experience. The data cover 2004-2014. Country-level data on income tax revenue and goods and services tax revenue to GDP ratios come from the IMF's *World Revenue Longitudinal Dataset (WoRLD)*. These data are available for fewer countries than the data on the time to prepare and pay taxes. For consistency we restrict tax revenue data to 2004-2014. The information on public procurement competitiveness are not available at the country level.

Firm-level outcome and control variables are from the anonymous *World Bank Enterprise Surveys (WBES)*.[6] This survey was conducted only for developing counties, in different years during 2006-2015. Tax compliance costs are measured by four variables: whether the firm was visited or inspected by tax officials; the frequency of such visits; whether a gift or informal payment was expected or requested in any of the inspections or meetings with tax officials; and the extent to which tax administration is an obstacle to business operation and growth. We measure public procurement practices using two variables: whether the firm has secured or attempted to secure a government contract over the last year; and whether the firm had to pay a bribe to get the contract. Firm-level controls comprise firm productivity (real sales per employee) and a vector of indicator

[4] In the online Appendix C we report additional results for a similar, but more endogenous measure of tax compliance costs – the number of tax payments, obtained from the same DB database. The results for these two outcome variables measuring tax compliance costs are in line with each other.

[5] This tax compliance costs measure comes from the "Paying Taxes" methodology developed jointly by the World Bank Group and PricewaterhouseCoopers (PwC). The advantage of this methodology is that it covers virtually all countries in the world over a relatively long time period. Another country-level data source for tax administration costs (by means of government budgets) is the Collecting Taxes Database produced by USAID. However, it covers only the period between 2008 and 2013. There are also other alternative approaches of measuring tax compliance costs, which are country or region specific (e.g., see European Commission, 2013).

[6] The data is available at http://enterprisesurveys.org. The *Enterprise Surveys* are also known as the *Business Environment and Enterprise Performance Surveys* (BEEPS) in the Europe and Central Asia (ECA) region.

variables for whether a firm exports; has foreign or state ownership; is of medium or large size; communicates with customers using e-mail or a website; and is publicly traded. We consider only those countries for which we have data from at least two survey waves.

Our main country-level controls are GDP per capita, expressed in terms of purchasing power parity (PPP) from the *World Development Indicators (WDI)* database; and the overall polity score (Polity), from the *Polity IV* database, which measures political competitiveness, executive recruitment, and constraints on executive action. In addition, we control for a measure of overall reforms and ease of doing business in a country (Reform). This is a first principal component of the time to enforce a contract, the time and number of procedures to start a business, and the time and number of procedures to register a property, all of which taken from the DB database. Higher values of this variable reflect a larger burden on business. To proxy for the level of development, we use the number of internet users, GDP per capita (PPP) and gross secondary school enrollment from the WDI database; measures of the rule of law and government effectiveness from the *Worldwide Governance Indicators (WGI)* database; and an index of business freedom from the *Heritage Foundation*. Finally, we exclude from the sample countries with populations below 500,000, as they have unique features and are more sensitive to yearly fluctuations in the available indicators.

A complete list of the variables with definitions is provided in Appendix A. Tables B.1-B.5 in the online Appendix present summary statistics and correlations between the variables.

3. Empirical strategy

To assess the impact of adopting e-government, we employ a difference-in-difference (DID) approach in a fixed effects regression framework. The treatment is the year of e-government implementation, which varies across countries. Countries that adopted e-government systems during the sample period are the treated group. Countries that had not adopted e-government systems when the sample period ended, or that adopted before the sample period begun are the control group.

Including countries that have and have not implemented e-government systems in the control group helps ensure that the characteristics of treated and control groups are similar to each

other on average.[7] However, the presence of countries that have already adopted e-government systems, especially shortly before the start of the sample period, can underestimate the desired treatment effect if this effect does not remain constant, but increases over time. The figure in Appendix B, for example, plots the average time to prepare and pay taxes (in logarithms) over the sample period for five groups of countries: never adopted e-filing systems; adopted transactional systems before or during 2004; adopted transactional systems with e-payment functionality before or during 2004; adopted transactional systems during the sample period; and adopted transactional systems with e-payment functionality during the sample period. The graph shows that countries that adopted e-filing before or during 2004 still exhibit decreasing trends in tax compliance costs, while countries that never had an e-filing system show more or less a flat trend. To account for these disparities and for different timing of e-government adoption, we include individual linear trends for the countries that adopted e-government before the sample period in the empirical specification.[8] Another solution would be to drop these countries from the sample, which we do in the robustness check in Section 4.4, and show that in the main analysis we report rather lower bound results.

After controlling for country and time fixed effects, the important identification assumption for the DID estimation is that the control and treated groups have similar trends in the outcome variable prior to treatment. If it holds, one assumes that the control and treated groups would remain on the parallel trends in the absence of treatment, and that the control group is appropriate for comparison. In the country-level analysis, we validate this assumption following Autor's (2003) approach. We estimate the effects in the years prior to the e-filing adoption date (leads) and confirm that they are not significantly different from zero. This ensures that, on average, there were no special events in treated countries that would lead to e-filing implementation. However, the timing of adoption may still coincide with other changes associated with taxes, such as a simplification of tax filing procedures or a change of tax rates, happening either at the same time or shortly after the

[7] Countries that have already adopted e-government are on average richer, while countries that have not adopted are poorer than those that implemented e-government during the sample period. Combing these two sets of countries therefore makes the treated and control groups more similar.

[8] In the most restrictive scenario, we could include individual trends for all countries. We do not do it, since our outcome and independent variables vary very little over time.

adoption. To alleviate these concerns, we first control for a few time-varying country characteristics, including the Reform variable, which captures the overall business climate and the pace of reforms in a country. Second, we control for a full set of geographical region-year fixed effects, removing yearly changes that are common for whole regions.[9]

We also estimate the effects in the years subsequent to the e-filing adoption date (lags) to observe their evolution over time. The country-level empirical specification is the following:

$$y_{ct} = \sum_{n=-4}^{5} \alpha_{1,-n} Egov2_{ct-n} + \sum_{n=-4}^{5} \alpha_{2,-n} Egov3_{ct-n} + \beta X_{ct} + \eta_c + \lambda_t + \nu_r \times \lambda_t + e_c \times t + \varepsilon_{ct} \quad (1)$$

The outcome variable y_{ct} is the logarithm of the time to prepare and pay taxes, or tax revenue to GDP ratio in country *c* at time *t*. For $n < 0$, $Egov2_{ct-n}$ is an indicator for an observation taking place $|n|$ years before the adoption of a transactional e-filing system and $Egov3_{ct-n}$ is an indicator for an observation taking place $|n|$ years before the adoption of a transactional e-filing system with e-payment functionality. For $n \geq 0$, $Egov2_{ct-n}$ ($Egov3_{ct-n}$) is an indicator for an observation taking place n years after the adoption of a transactional e-filing system (with e-payment functionality). Since all countries have only one iteration of e-filing on record, we can include $Egov2$ and $Egov3$ jointly in one regression line. We use five-year cut-offs, with observations occurring five years after the introduction of the e-filing system merged into categories $Egov2_{ct-5}$ and $Egov3_{ct-5}$, respectively. The reference groups in this regression are observations occurring five years or more before the adoption of the e-filing system. X_{ct} is a vector of control variables that includes the logarithm of GDP per capita (PPP), Polity and Reform indices; η_c represents the country fixed effects that remove time-invariant country characteristics; λ_t captures the year fixed effects and allows for DID estimation;[10] ν_r is the set of dummy variables indicating the country's geographical region, so that $\nu_r \times \lambda_t$ is the full set of region-year fixed effects; e_c is the set of

[9] We have seven regions: East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, South Asia and Sub-Saharan Africa.

[10] Without year fixed effects, the identification would come only from within-country variation for counties that switched e-government status during the sample period. Countries that never changed e-government status would not be taken into account when estimating $\alpha_{1,-n}$ and $\alpha_{2,-n}$.

dummy variables indicating countries that have adopted an e-filing system before the sample period; t is the time trend; $e_c \times t$ is the set of linear trends capturing different trajectories in outcome variables for countries early adopters; and ε_{ct} is the error component.

The coefficients of interest are $\alpha_{1,-n}$ and $\alpha_{2,-n}$, where $n \in [-4; 5]$. Each coefficient is the expected difference in the outcome variable between treated and control groups in years before or after treatment relative to the reference group (five years or more before e-government implementation). Four leads, $\alpha_{i,-4}$, $\alpha_{i,-3}$, $\alpha_{i,-2}$ and $\alpha_{i,-1}$ (*i=1, 2*), are anticipatory effects. We expect them to be insignificantly different from zero, which would support the DID identification assumption that pre-trends in outcome variables are similar for treated and control groups. The effect in the year of adoption $\alpha_{i,0}$ and five lags, $\alpha_{i,1}$, $\alpha_{i,2}$, $\alpha_{i,3}$, $\alpha_{i,4}$ and $\alpha_{i,5}$ (*i=1, 2*), are post-treatment effects. The negative signs of these coefficients would suggest a reduction of tax compliance costs after the adoption of e-filing systems. They also show whether e-filing effects strengthen or diminish with time.

We estimate specification (1) using ordinary least squares (OLS) method with fixed effects,[11] and cluster standard errors at the country level to correct for serial correlation and a general arbitrary correlation structure in the error term ε_{ct} (Bertrand et al. 2004).[12]

We use firm-level data from the WBES to evaluate the impact of e-filing on tax compliance costs and e-procurement on public procurement competitiveness. Since all but two countries were surveyed only twice and we cannot test parallel pre-trends assumption, we estimate the following regression:

$$y_{ict} = \alpha_1 Egov2_{ct} + \alpha_2 Egov3_{ct} + \beta X_{ct} + \gamma Z_{ict} + \mu_s + \eta_c + \lambda_t + e_c \times t + \varepsilon_{ict} \quad (2)$$

[11] Although the dependent variable is restricted to zero from the bottom and tobit models would be appropriate, we use OLS method, since non-linear regressions with many fixed effects are subject to incidental parameters problem (e.g., see Lancaster, 2000). For a robustness check we estimate (1) using a tobit model, and report it in the online Appendix.

[12] We are also concerned that the measurement error in variables can bias our results. Under the plausible assumption of the classical measurement error – it does not correlate with the error from the regression – only errors in the outcome variable would lead to unbiased/consistent, but less efficient results. Errors in the variables of interest (e-government adoption dates) would bias the estimates towards zero, and we would get more conservative estimates. Errors in other control variables, however, may bias the estimates of interest in any direction, since all country-level variables are correlated. Applying country fixed effects accelerates possible measurement biases. This needs to be kept in mind when interpreting the estimation results.

To test the effects of e-filing adoption, the outcome variables y_{ict} are the indicator of whether a firm *i* in country *c* was visited by a tax official at time *t*, the number of such visits, whether a bribe was requested or expected during the visits, and the firms' perception of tax administration as an obstacle to conducting business. $Egov2_{ct}$ ($Egov3_{ct}$) is an indicator for whether a transactional system (transactional system with e-payment functionality) is in place. To test the effects of e-procurement adoption, the outcome variables y_{ict} are two indicators of whether a firm secured or attempted to secure a government contract and whether a firm offered a bribe to secure the contract. $Egov2_{ct}$ ($Egov3_{ct}$) is an indicator for whether an informational system (transactional system) is in place.

We add a vector of firm-specific characteristics, Z_{ict}, to the set of country-level control variables X_{ct}. These variables are described in Section 2 and defined in details in Appendix A. In contrast to specification (1), we control for sector fixed effects μ_s, and do not control for the region-specific shocks $\nu_r \times \lambda_t$, since our sample includes only a few countries outside of Europe and Central Asia (ECA) and Sub-Saharan Africa (SSA) regions. In addition, WBES for the ECA region follows a part of firms over time, which allows us to control for firm fixed effects and to remove time-invariant firm-specific characteristics. We use OLS to estimate all specifications,[13] and cluster standard errors at the country level.

Finally, we are interested in whether the effects of e-government vary with a country's level of development. We expect that countries with higher income, better institutions and technology, and more skilled workers experience greater returns from e-government. To explore this question, we remove leads, and combine lags and indicators of e-government functionality, as we are interested in more general effects. The country-level specification is therefore:

$$y_{ct} = \alpha Egov_{ct} + \theta Egov_{ct} \times Dev_{ct} + \beta X_{ct} + \eta_c + \lambda_t + \nu_r \times \lambda_t + e_c \times t + \varepsilon_{ct} \quad (3)$$

[13] For robustness check, we estimate (2) using probit models for binary dependent variables and a tobit model for the number of tax visits, since it is restricted to zero from the bottom. We report these results in the online Appendix. We remove the 95th percentile of the distribution of the number of tax visits as outliers in all specifications.

$Egov_{ct}$ is an indicator of whether e-government is in place in country *c* at time *t*. Dev_{ct} is the proxy for the level of development, which includes the number of internet users per capita, GDP per capita (PPP), gross secondary school enrollment, rule of law, government effectiveness, and business freedom. Since these development measures are highly correlated, we estimate separate regressions for each of them. The vector X_{ct} includes Dev_{ct}; and the coefficient of interest is θ. We build firm-level empirical specifications in a similar manner.

4. Results and discussion

4.1. Tax compliance costs and e-filing

4.1.1. Country-level evidence

The coefficients $\hat{\alpha}_{1,-n}$ and $\hat{\alpha}_{2,-n}$, estimated from specification (1), are depicted in Figure 2 on the left and right graphs, respectively. Each dot on the solid line shows the estimated coefficient, and dashed lines show the 95 percent confidence intervals. The complete estimates are presented in Appendix C, Columns I and II.

According to both graphs on Figure 2, the identification assumptions for DID estimation about parallel pre-trends in the control and treated groups are satisfied, as the coefficients $\hat{\alpha}_{1,-n}$ and $\hat{\alpha}_{2,-n}$ for $n < 0$ are not significantly different from zero. The left graph shows that implementing transactional e-filing systems that do not feature e-payment functionality does not significantly reduce the time to prepare and pay taxes in the short or medium run, as the coefficients $\hat{\alpha}_{1,-n}$ for $n \geq 0$ are non-significantly different from zero. However, the fact that these coefficients are negative, exhibit the downward slopping trend and the fact that $\hat{\alpha}_{1,-5}$ is significant at 10 percent might suggest that transactional e-filing systems without e-payment functionality have more prominent impact in the long run.

In contrast, the adoption of transactional e-filing systems with e-payment functionality significantly reduces the time to prepare and pay taxes (Figure 2, right graph). The effects are almost immediate and become stronger in subsequent years. The results thus imply that only the adoption of the more advanced e-filing system significantly reduces tax compliance costs borne by

businesses. Another observation from the right graph of Figure 2 is that all coefficients $\hat{\alpha}_{2,-n}$ are gradually decreasing. This suggests that the time to prepare and pay taxes was slightly decreasing even before e-filing adoption, either in anticipation of innovation or due to other business climate reforms. It is important for our inference however, that they become statistically significant only after the adoption of e-filing systems.

Using the coefficients from regression (1), we can estimate the economic impact of introducing e-filing systems.[14] Compared to one year prior to adoption, the average time to prepare and pay taxes is reduced by 3 percent in the year of adoption (the effect is not yet significant), by 8 percent in the first year after adoption (significant at 10 percent), by 12 percent in the second year (significant at 5 percent), and by 16, 24, and 27 percent in the third, fourth, and fifth or more years following the adoption (all significant at 1 percent). These are economically sizable numbers.[15]

Table 1, Column I, also presents the estimates without pre-treatment effects and when all after-treatment effects are pooled together. As expected, the coefficient on transactional e-filing systems adoption is non-significant, and the coefficient on transactional e-filing systems with e-payment functionality adoption is significant at 1 percent.

Next we examine whether the impact of e-government depends on countries' level of development. Our main proxy for development is the number of internet users per capita, as it is directly related to the diffusion of ICT and availability of technology needed for e-government adoption. Table 2, Column I, presents the results of estimating specification (3). The coefficient on the interaction term between the e-filing indicator and the number of internet users per capita is negative and significant at 1 percent level. The results for other measures of development are very similar (Table C.2 in the online Appendix). The effects on interaction terms are especially strong when GDP per capita (PPP) and the secondary school enrollment are used to proxy development. These results support expectations that more developed countries have higher returns of e-

[14] To derive these effects, we compute $|\hat{\alpha}_{2,-n} - \hat{\alpha}_{2,1}|$ for $n \geq 0$, while the coefficients $\hat{\alpha}_{2,-n}$ themselves show the effects of e-filing adoption relative to five years or more before the adoption.

[15] Since no cross-national data are available on the costs of e-government systems implementation, we are unable to provide any cost-benefit analysis of these investments. Clearly these returns also depend on maintenance of the ICT infrastructure, data integrity and cyber-security.

government. More developed countries also tend to have greater resources to design and implement advanced e-filing systems with e-payment functionality, which contributes to greater reductions in tax compliance costs.

The estimates allow us to calculate the level of development variables at which e-filing decreases tax compliance costs. When the number of internet users exceeds 0.12 per capita, the adoption of e-filing leads to the reduction of the time to prepare and pay taxes. Similarly, when gross secondary school enrollment exceeds 56 percent or GDP per capita (PPP) exceeds approximately $2,700, e-filing adoption starts reducing tax compliance costs.

4.1.2. Firm-level evidence

Table 1, Columns II-V, shows the results of the estimation of specification (2) for the firm-level outcome variables related to tax compliance costs for a sample of developing counties. According to Column II, the coefficients α_1 is negative and significant at 10 percent.[16] The probability of being inspected by a tax official thus drops by 7.5 percent when transactional e-filing systems are adopted. The number of tax visits also drops by 11 percent (6 percent) with transactional e-filing systems (with e-payment functionality) adoption – the coefficients α_1 and α_2 are negative and statistically significant at 10 and 15 percent respectively (Column III). The decrease in tax compliance costs is also supported by the fact that firm managers are less likely to perceive tax administration as an obstacle to firms' operation and growth when transactional e-filing systems with e-payment functionality are adopted (Column IV). These results are consistent with our inference from the previous subsection, and with country case studies that find an impact of e-filing on tax compliance costs, such as Yilmaz and Coolidge (2013) for South Africa, Ali et al. (2014) for Ethiopia, and Eissa and Zeitlin (2014) for Rwanda.

We however, find that e-filing does not reduce the probability of paying bribes to tax officials. Instead, the adoption of transactional e-filing systems with e-payment functionality increases this probability by 7.5 percent (Column V).

[16] We cluster standard errors of the coefficients at the country level, because our variables of interest vary at that level. This significantly inflates standard errors, since firms even within a country tend to be heterogeneous. Consequently, we also recognize coefficients that are significant at 15 percent.

When we focus on the ECA region and control for firm fixed effects, the results are stronger and more consistent with our country-level evidence, despite using different measures of the same concept. As Table 3, Columns I-IV, reports, implementing transactional e-filing systems with e-payment functionality decreases the likelihood of being visited by tax officials by 14 percent and decreases the number of visits by 22 percent.[17] Both coefficients are significant at 5 percent (Columns I and II). Another important result is that the likelihood that firms are requested or expected to pay bribes is significantly reduced when either e-filing systems is adopted (Column IV). As ECA is a relatively well-developed region in comparison to others, our finding suggests that e-government has greater impact on tax compliance costs when countries are more capable of fully exploiting ICT. We also test this conjecture by estimating specification (3).

We find negative, albeit non-significant, coefficients on the interaction terms of e-filing and the number of internet users per capita for the probability of being visited by tax officials and the likelihood to pay bribes to tax inspectors; and significant at 10 percent coefficient for the number of tax visits (Table 2, Columns II-V). These findings are again in line with our expectations. The results for other measures of development and institutional quality are mixed and often non-significant (Table C.5 in the online Appendix). For example, we find negative and significant at 15 percent coefficients on the interaction terms with the rule of law indicator for the likelihood of being visited by tax inspectors and the number of such visits.

4.2. Tax revenue and e-filing

The results from the previous section suggest that e-filing adoption improves the business environment by reducing the tax compliance costs borne by firms. Lower costs can lead to more efficient allocation of resources within a firm and to higher outputs and profits, which can increase the tax base and, consequently, government tax revenues. In this section we test whether e-filing adoption alters the tax revenue to GDP ratio.

[17] Table C.7 in the online Appendix reports the complete estimates and compares the results for the ECA region when we do not control and control for firms fixed effects.

The effect of e-filing on the tax revenue to GDP ratio can be positive if the increase in taxes exceeds the increase in GDP. This could happen if companies and individuals pay more taxes without a proportional increase of output, consumption or investments/savings and therefore could signal the reduction of tax evasion. Otherwise, the tax to GDP ratio can remain unchanged, or decrease if the components of GDP internalize the effects from e-filing faster than tax revenue. To test these effects we focus on two parts of tax revenue. Income tax revenue, which includes taxes payable by individuals and corporations; and goods and services tax revenue, which includes value added taxes and excises. These two types of taxes comprise the bulk of total tax revenue and are among the first to be affected by e-filing.[18] We use the same specification (1) to estimate the effects.

Figures 3 and 4 depict the coefficients $\hat{\alpha}_{1,-n}$ and $\hat{\alpha}_{2,-n}$, estimated from specification (1) for income, and goods and services tax revenues as shares of GDP (in percent), while corresponding estimates are in Appendix C, Columns III-VI. Table 1, Columns VI and VII, also reports the effects of e-filing without leads and when all lags are pooled together. According to the estimates, the parallel pre-trend assumption is satisfied for both tax revenue measures. The e-filing effects, however, are mixed and moderate. We observe an increase of the income tax revenue to GDP ratio after the adoption of transactional e-filing systems. The average increase is 0.75 percent (Table 1, Column VI). Given that sample average of the income tax revenue to GDP ratio is 7.1 percent, this increase accounts for 11 present of that average. The adoption of transactional e-filing systems with e-payment functionality does not have significant effect on income tax revenue. By contrast, the adoption of only transactional e-filing systems with e-payment functionality leads to a decrease of the goods and services tax revenue to GDP ratio. The average decrease is 0.65 percent (Table 1, Column VII), which accounts for 8 percent of the sample average (8.5 percent).

On the one hand, our results suggest that e-filing adoption helps reduce income tax evasion by companies and individuals (in line with Ali et al., 2015; Eissa and Zeitlin, 2014). This effect is

[18] In the online Appendix C we present the results for total tax revenue as a share of GDP. They are qualitatively similar to the results for goods and services tax revenue as a share of GDP, meaning that the adoption of e-filing systems with e-payment functionality reduces tax to GDP ratio.

driven largely by less developed countries, because they more often implement simpler transactional e-filing systems. Less developed countries also have lower tax collection rates and, presumably, higher incentives to evade taxes. In addition, income tax evasion is technically easier and therefore a more common practice than goods and services tax evasion. Bird and Gendron (2007), for example, advocate for VAT in developing countries to increase tax collection efficiency. This result is also consistent with our finding from the previous section. Adopting transactional e-filing systems can decrease the likelihood and frequency of being visited by tax officials, which reduce opportunities to collude with tax officials for tax evasion.

On the other hand, we find a negative effect of e-filing on the goods and services tax revenue to GDP ratio. This effect is driven by more developed countries, because they are more likely to adopt advanced transactional e-filing systems with e-payment functionality. These countries also face fewer incentives to evade taxes and a higher ability to internalize the benefits of technology. The decrease of tax compliance costs therefore can raise firm profits and outputs without disproportional increase in taxes.

When we estimate specification (3) and test the significance of interaction terms between e-filing adoption and the number of internet subscribers, we obtain negative and highly significant coefficients (Table 2, Columns VI and VII). Both the income and goods and services tax revenue to GDP ratios decrease with higher levels of development, meaning that more developed countries are able to internalize the advantages of e-government in GDP. When the number of internet users exceeds 0.45 (0.13) per capita, the adoption of e-filing leads to the reduction of the income (goods and services) tax revenue to GDP ratio. The results for other development measures are very similar (Table C.3 and C.4 in the online Appendix).

4.3. Public procurement competitiveness and e-procurement

We next assess the relationship between the adoption of e-procurement systems and the level of competition and corruption in public procurement (Table 1, Columns VIII and IX). We find very small and non-significant coefficients on both $Egov2$ and $Egov3$ for the participation in public

tenders. The results for the probability to pay bribes to secure a government contract are also statistically insignificant, although the coefficients are larger in size and similar to those obtained for the probability to bribe tax officials.

We find stronger results when we control for firm fixed effects in the regressions for the ECA region. Both coefficients on informational and transactional e-procurement systems are positive and statistically significant at 10 percent for the likelihood of participation in public procurement (Table 3, Column V)[19]. It might suggest that the effectiveness of e-procurement is conditional on the countries' level of development and the quality of institutions. We test and confirm this by estimating specification (3) for e-procurement. As Table 2, Columns VIII-IX, shows e-procurement significantly increases the probability that firms bid on government contracts and reduces corruption in public procurement in countries with greater diffusion of ICT. For the other development and institutional quality measures (Table C.6 in the online Appendix), the results are qualitatively similar.

The result that e-government does not systematically improve public procurement competitiveness, in comparison to the case of e-filing and tax compliance costs, contrasts with the findings from country-specific studies (Heeks, 2005; Singer et al., 2009; Lewis-Faupel et al., 2016). There could be various reasons for this weak result. First, our data on participation in public tenders are very limited, as we do not know whether a firm won a contract, the costs of submitting a bid, the number of bids per contract, or other relevant details. Second, the number of countries in our sample is small and countries are very heterogeneous, which might make it difficult to estimate statistically significant results. This is consistent with Heeks (2005), who estimates that only 15 percent of e-government initiatives are successful, 50 percent are partial failures and 35 percent are total failures in developing countries. In addition, high heterogeneity of firms within countries might lead to imprecise estimates. Once we control for firm fixed effects, which reduce firm heterogeneity, we estimate positive effects of e-procurement. Finally, public procurement requires

[19] Table C.8 in the online Appendix reports the complete estimates and compares the results for the ECA region when we do not control and control for firms fixed effects.

more discretion from government officials than tax administration, particularly for complex or expensive projects, which might limit the benefits of e-government. More data and research are therefore needed to assess the impact of e-government on public procurement competitiveness and corruption across countries.

4.4. Robustness checks

We conduct several tests to check the robustness and sensitivity of our findings.[20] First, we check how the results change if we drop from specification (1): region-specific shocks; individual trends for countries that adopted e-filing before or during 2004; and all countries that adopted e-filing before or during 2004. For these exercises, we remove leads and combine lags, so that $Egov2$ and $Egov3$ indicators equal one if e-government has been adopted, and zero otherwise. We expect to obtain greater effects in absolute value by dropping region-specific shocks, since they absorb some country-level variation. If all countries that adopted e-filing earlier had downward trends in outcome variables, we would expect to obtain smaller in absolute value e-filing effects when not controlling for individual trends and bigger – when dropping them altogether. Table D.1, Columns II-IV, of the online Appendix compares the results of such exercises to the estimates obtained using the original specification (Column I) for the time to prepare and pay taxes. In all cases, the coefficients on transactional e-filing adoption ($Egov2$) remain non-significant. Meanwhile, the coefficients on transactional e-filing with e-payment functionality adoption ($Egov3$) are greater in absolute value than the original estimate in all three cases, which is in accordance with our expectations. However, not all countries that adopted e-filing before or during 2004 had downward trends in time to prepare and pay taxes, as Appendix B depicts. All in all, these suggest that our reported estimates for time to prepare and pay taxes are conservative. We repeat the same exercises for the income and goods and services tax revenues to GDP ratios and find qualitatively similar results (Tables D.2 and D.3 in the on-line Appendix).

[20] Due to the space limitation, the results from robustness checks are available in the online Appendix.

Second, we check whether our results hold on the "balanced" samples. We restrict the sample of countries to those that implemented e-filing systems during the 2006-2012 period, and exclude those that implemented e-filing in 2004-2005 and in 2013-2014. Using this "balanced" sample, we can observe tax compliance costs and tax revenues at least two years before and two years after the adoption of e-filing systems, which allows for a better comparison before and after. Tables D.1-D.3, Column V, shows that the coefficients that have been significant in the original estimates, increased in absolute value. If we also exclude countries that adopted e-filing in 2006 and 2012, then these coefficients increase farther in absolute value (Column VI). This suggests that the actual impact of e-filing might be larger than the impact presented in our main analysis.

We perform the same exercises using firm-level data for both e-filing and e-procurement, and find very similar results to those presented in the main text (Tables D.4 and D.5 in the online Appendix).

Third, we conduct a falsification test to ensure that the estimated effects of e-filing are not random. Keeping the distribution of treated countries and treatment years as in the original data, we randomly select treated countries and the years of e-filing implementation, and estimate specification (1) 500 times. We find that the coefficients of interest have the appropriate sign and are significant at 5 percent in 10-12 cases (about 2.2 percent of the time). We thus support the claim that the estimated relationships between e-filing adoption and the time to prepare and pay taxes, and tax revenues in our main analysis are not a coincidence.

Finally, we confirm that in all cases we get similar results if we use tobit and probit instead of OLS. For firm-level analysis, we also confirm that the results remain qualitatively the same if we do not control for the labor productivity measure, which increases the sample size by 15 percent.

5. Conclusion

To the best of our knowledge, this paper is the first attempt to assess cross-nationally the impact of e-government adoption on public sector capacity to raise and spend fiscal resources. We exploit e-government implementation dates and types of e-government system functionality from the *Global*

e-Government Systems Database, developed by the World Bank, and measures of tax compliance costs, tax revenues and public procurement competitiveness from the *Doing Business, World Revenue Longitudinal Dataset* and *Enterprise Survey* databases. Our results show that e-government can substantially improve government capacity, but the estimated effects often vary by counties' economic and institutional context and the functionality of e-government systems they adopt.

We find that e-filing systems significantly reduce the time to prepare and pay taxes, and the likelihood and frequency of visits by tax officials. Since these tax compliance costs are often cited as an impediment to doing business, investing in e-filing can have high returns for firms and the countries. However, these benefits accrue most reliably with e-filing systems that feature an e-payment option, which are more advanced and therefore costlier. We also find that investments in e-filing can reduce tax evasion in less developed countries, as evidenced by the increase in the income tax revenue to GDP ratio with transactional e-filing systems adoption.

In contrast, we do not find a significant, direct association between e-procurement and the competitiveness of public procurement, which also indicates the limitations of technology in addressing government capacity problems. Only when we remove time-invariant firm characteristics for the sample of countries from the ECA region are we able to observe a positive and significant impact of adopting e-procurement on the probability that firms participate in government tenders.

Finally, it is notable that the gains from both e-filing and e-procurement are often conditional on a country's level of development, access to technology and human capital, and institutional environments. Structural and institutional reforms must therefore accompany investments in e-government, especially in lower-income countries, if benefits are to be realized.

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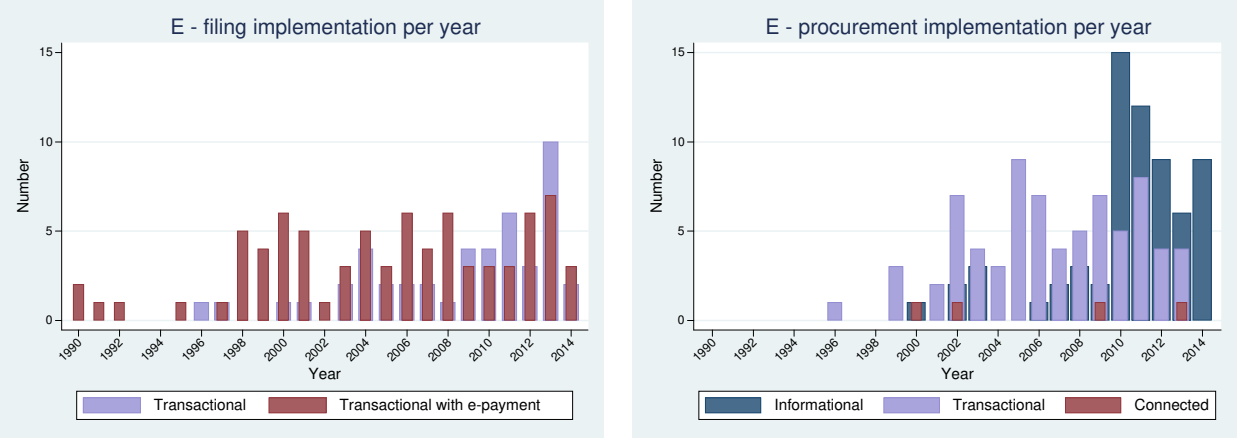
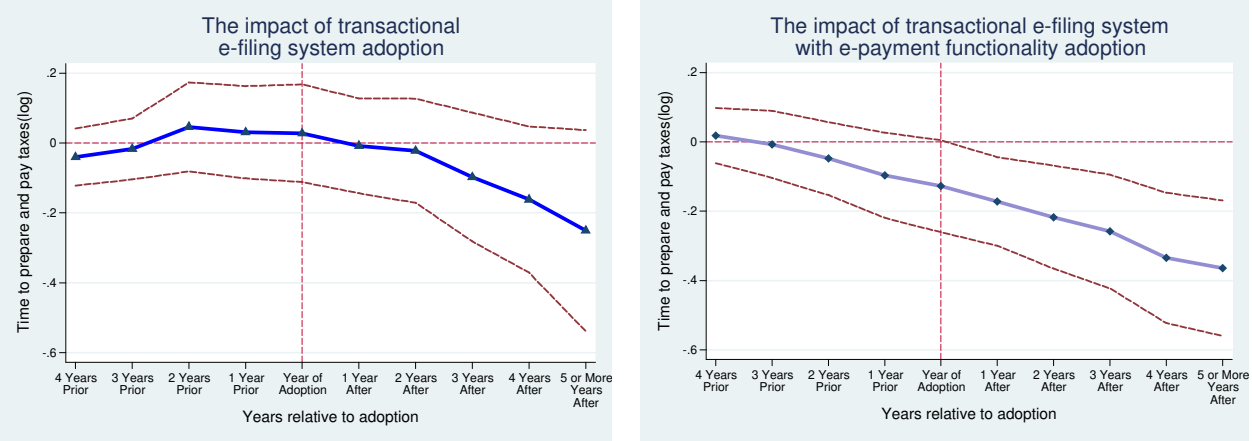
Figures and Tables

Figure 1: Timing of e-filing and e-procurement adoption, by system functionality



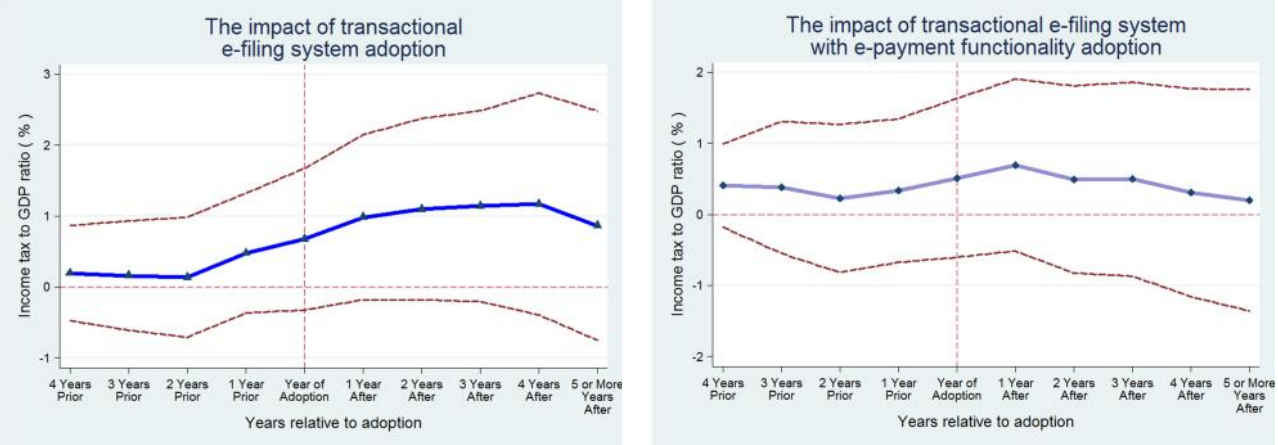
Note: These figures show the number of countries that adopted e-filing and e-procurement systems each year by the level of system functionality. For example, in 2000, one country adopted transactional e-filing systems and six countries adopted transactional e-filing systems with e-payment functionality (left graph).

Figure 2: The impact of e-filing on time to prepare and pay taxes



Note: These figures plot the coefficients on indicator variables for the years before and after the adoption of the e-filing systems, estimated using specification (1). The reference groups are observations taking place five or more years before adoption. The left graph shows the effects of adopting transactional e-filing systems, while the right graph shows the effects of adopting transactional e-filing systems with e-payment functionality. The dashed lines are 95% confidence intervals.

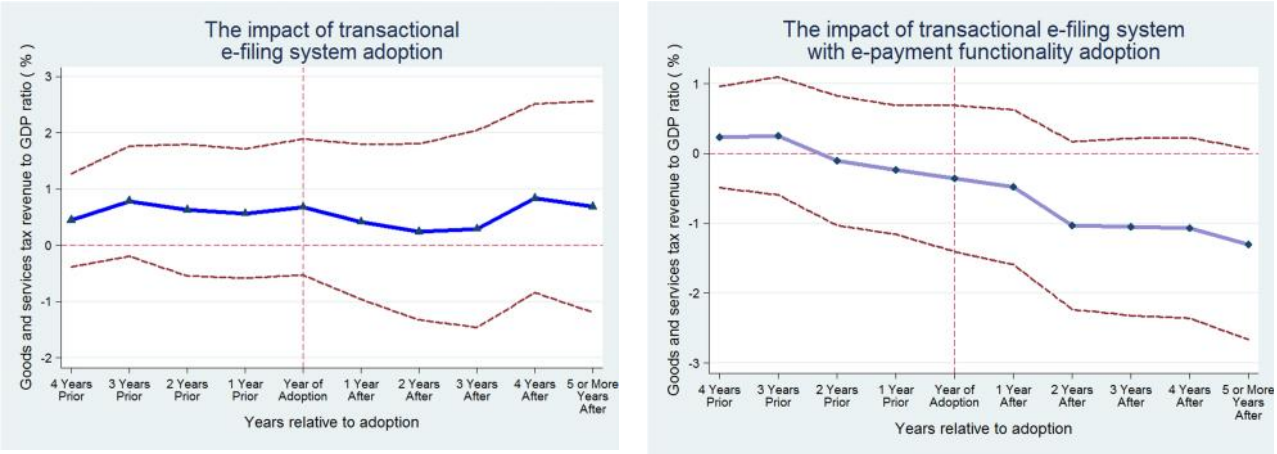
Figure 3: The impact of e-filing on income tax revenue



Note: These figures plot the coefficients on indicator variables for the years before and after the adoption of the e-filing systems, estimated using specification (1). The reference groups are observations taking place five or more years before adoption. The left

graph shows the effects of adopting transactional e-filing systems, while the right graph shows the effects of adopting transactional e-filing systems with e-payment functionality. The dashed lines are 95% confidence intervals.

Figure 4: The impact of e-filing on goods and services tax revenue



Note: These figures plot the coefficients on indicator variables for the years before and after the adoption of the e-filing systems, estimated using specification (1). The reference groups are observations taking place five or more years before adoption. The left graph shows the effects of adopting transactional e-filing systems, while the right graph shows the effects of adopting transactional e-filing systems with e-payment functionality. The dashed lines are 95% confidence intervals.

Table 1: The impact of e-government adoption on tax compliance costs, tax revenue and public procurement competitiveness

	Tax time (I)	Tax Visit (II)	Tax visit number (III)	Tax obstacle (IV)	Tax bribe (V)	Income tax (VI)	Goods and services tax (VII)	Procurement (VIII)	Procurement bribe (IX)
E-filing2	0.025	-0.075*	-0.111*	-0.043	-0.047	0.746**	0.226		
	(0.047)	(0.044)	(0.058)	(0.087)	(0.053)	(0.300)	(0.339)		
E-filing3	-0.124***	-0.033	-0.062#	-0.140***	0.075***	0.200	-0.647**		
	(0.047)	(0.050)	(0.041)	(0.052)	(0.025)	(0.227)	(0.275)		
E-procurement2								0.001	-0.060
								(0.037)	(0.073)
E-procurement3								-0.020	0.058
								(0.027)	(0.046)
GDP per capita	-0.150	-0.007	0.293#	0.097	0.025	2.840**	-0.361	0.072	-0.656***
	(0.155)	(0.142)	(0.192)	(0.291)	(0.206)	(1.360)	(1.060)	(0.094)	(0.250)
Polity	0.030	-0.102	-0.345#	0.193	0.138	0.541#	0.906**	0.119**	-0.054
	(0.046)	(0.121)	(0.220)	(0.197)	(0.135)	(0.329)	(0.376)	(0.059)	(0.202)
Reform	0.021	0.024	-0.034	-0.019	0.016	-0.149	0.182	-0.001	-0.046#
	(0.025)	(0.025)	(0.026)	(0.037)	(0.020)	(0.170)	(0.217)	(0.018)	(0.029)
Productivity		0.013***	0.011*	-0.003	-0.001			0.006**	-0.004
		(0.003)	(0.006)	(0.003)	(0.002)			(0.003)	(0.005)
Exporter		0.028***	0.029***	0.031***	0.006			-0.022***	0.037**
		(0.009)	(0.011)	(0.006)	(0.006)			(0.008)	(0.015)
Foreign		0.003	-0.004	-0.013*	-0.003			-0.032***	0.013
		(0.010)	(0.011)	(0.008)	(0.010)			(0.011)	(0.019)
State		-0.014	0.017	-0.010	-0.011			0.084***	-0.031
		(0.023)	(0.020)	(0.022)	(0.018)			(0.024)	(0.027)
Medium		0.086***	0.034***	0.023***	0.011*			0.050***	-0.024*
		(0.008)	(0.007)	(0.006)	(0.006)			(0.006)	(0.014)
Large		0.189***	0.070***	0.030***	0.004			0.064***	-0.052***
		(0.015)	(0.015)	(0.008)	(0.008)			(0.011)	(0.020)
Internet use		0.013	-0.009	0.033***	0.007			0.080***	0.037*
		(0.011)	(0.011)	(0.011)	(0.010)			(0.011)	(0.022)
Listed		0.011	-0.006	0.013	-0.034***			0.043***	-0.077***
		(0.014)	(0.012)	(0.012)	(0.011)			(0.013)	(0.020)
N obs.	1,626	67,655	37,227	68,144	39,860	1,226	1,217	40,588	5,983
N countries	150	68	68	68	68	127	126	44	44
R2 adjusted	0.413	0.153	0.231	0.099	0.156	0.304	0.251	0.099	0.158

Note: This table reports the results from estimating specifications (2) and (3) for the dependent variables identified in the headline. E-filing2 equals 1 if a transactional e-filing system is in place. E-filing3 equals 1 if a transactional e-filing system with e-payment functionality is in place. E-procurement2 equals 1 if an informational e-procurement system is in place. E-procurement3 equals 1 if a transactional e-procurement system is in place. Definitions of the variables are in Appendix A and in Section 2 of the text. Standard errors are clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1, # p<0.15.

Table 2: The impact of e-government conditional on the level of development

	Tax time	Tax visit	Tax visit number	Tax obstacle	Tax bribe	Income tax	Goods and services tax	Procurement	Procurement bribe
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
E-filing	0.050	-0.027	-0.016	-0.108	0.050	0.912***	0.353		
	(0.051)	(0.072)	(0.068)	(0.119)	(0.057)	(0.279)	(0.326)		
E-filing*Internet	-0.412***	-0.089	-0.279*	0.150	-0.180	-2.023**	-2.768***		
	(0.159)	(0.212)	(0.169)	(0.380)	(0.151)	(0.780)	(0.983)		
E-procurement								-0.054#	0.191*
								(0.033)	(0.113)
E-procurement* Internet								0.113**	-0.389**
								(0.055)	(0.197)
Internet	-0.116	0.010	0.046	-0.324	0.163	0.108	1.013	-0.177	-0.143
	(0.221)	(0.206)	(0.255)	(0.261)	(0.125)	(1.192)	(1.236)	(0.166)	(0.168)
N obs.	1,600	67,655	37,227	68,144	39,860	1,220	1,211	40,588	5,983
N countries	149	68	68	68	68	127	126	44	44
R2 within/adjusted	0.410	0.153	0.231	0.099	0.155	0.312	0.262	0.099	0.159

Note: This table reports the results from estimating specification (3) for the dependent variables identified in the headline. E-filing equals 1 if an e-filing system is in place. E-procurement equals 1 if an e-payment system is in place. The number of internet users per capita is a proxy for the level of development in a country. Definitions of the variables are in Appendix A and Section 2 of the text. Standard errors are clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1, # p<0.15.

Table 3: The impact of e-government adoption on firms-level tax compliance costs and public procurement, ECA region

	Tax visit	Tax visit number	Tax obstacle	Tax bribe	Procurement	Procurement bribe
	(I)	(II)	(III)	(IV)	(V)	(VI)
E-filing2	0.020	-0.073	-0.010	-0.137**		
	(0.036)	(0.090)	(0.171)	(0.044)		
E-filing3	-0.140**	-0.218**	-0.159	-0.123**		
	(0.041)	(0.090)	(0.121)	(0.041)		
E-procurement2					0.075*	-0.200
					(0.044)	(0.234)
E-procurement3					0.055*	0.005
					(0.029)	(0.054)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
N obs.	20,477	10,592	20,614	11,495	20,417	3,661
N countries	29	29	29	29	29	29
R2 adjusted	0.055	0.084	0.153	0.094	0.025	0.209

Note: This table reports the results from estimating specification (2) with firm fixed effects for the dependent variables identified in the headline. E-filing2 equals 1 if a transactional e-filing system is in place. E-filing3 equals 1 if a transactional e-filing system with e-payment functionality is in place. E-procurement2 equals 1 if an informational e-procurement system is in place. E-procurement3 equals 1 if a transactional e-procurement system is in place. Definitions of the variables are in Appendix A and in Section 2 of the text. Standard errors are clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1, # p<0.15.

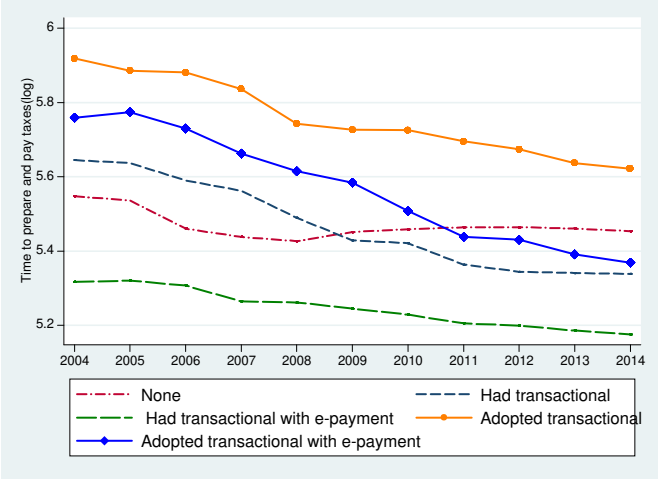
Appendix

Appendix A: Description of variables

Variable	Description
Main Country-level variables	
E-filing2	Indicator variable that equals 1 if a transactional e-filing system is in place. Source: GeGSD.
E-filing3	Indicator variable that equals 1 if a transactional e-filing system with e-payment functionality is in place. Source: GeGSD.
E-procurement2	Indicator variable that equals 1 if an informational e-procurement system is in place. Source: GeGSD.
E-procurement3	Indicator variable that equals 1 if a transactional e-procurement system is in place. Source: GeGSD.
Tax time	Logarithm of time to prepare and pay taxes (in hours). Source: DB.
Income tax	Income tax revenue as a share of GDP in percent. Source: WoRLD.
Goods and services tax	Goods and services tax revenue as a share of GDP in percent. Source: WoRLD.
GDP	Logarithm of GDP per capita (in PPP terms) in international 2011 constant dollars. Source: WDI.
Polity	Polity2 index divided by 10. Source: Polity IV dataset.
Reform	The first principle component of the time to enforce a contract, the time and number of procedures to start a business, and the time and number of procedures to register a property. Source: DB.
Other Country-level variables	
Enrollment	Gross secondary school enrollment (proportion of school-age population). Source: WDI.
Internet	Number of internet users per capita. Source: WDI.
Rule of law	Index measuring the perception of the extent to which agents have confidence in and abide by the rules of society, in particular the quality of contract enforcement and property rights, confidence in the police and courts, and the likelihood of crime and violence. Source: WGI.
Government effectiveness	Index measuring the perception of the quality of public and civil services and the degree of their independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Source: WGI.
Business freedom	Index of the efficiency of government regulation of business. Source: The Heritage Foundation
Firm-level variables	
Tax visit	Indicator variable that equals 1 if respondent replies "yes" to the following question: "Over the last 12 months, was this establishment visited and/or inspected by tax officials?" Source: WBES.
Tax visit number	Logarithm of the number of tax visits, derived from the question: "Over the last 12 months, how many times was this establishment either inspected by tax officials or required to meet with them?" Source: WBES.
Tax obstacle	Indicator variable that equals 1 if respondent replies "Major Obstacle" or "Very Severe Obstacle" to the following question: "As I list some of many factors that can affect the current operations of a business, please look at this card and tell me if you think that each factor [tax administration] is No Obstacle, a Minor Obstacle, a Major Obstacle, or a Very Severe Obstacle to the current operations of this establishment." Source: WBES.
Tax bribe	Indicator variable that equals 1 if respondent replies "yes" or refuses to reply to the following question: "In any of these inspections or meetings was a gift or informal payment expected or requested?" Source: WBES.
Procurement	Indicator variable that equals 1 if respondent replies "yes" to the following question: "Over the last 12 months, has this establishment secured a government contract or attempted to secure a contract with the government?" Source: WBES.
Procurement bribe	Indicator variable that equals 1 if respondent reports a positive amount or refuses to reply to the following question: "When establishments like this one do business with the government, what percent of the contract value would be typically paid in informal payments or gifts to secure the contract?" Source: WBES.
Productivity	The real sales in US dollars over number of employees. Source: WBES.
Exporter	Indicator variable equal to 1 if a firm exports. Source: WBES.
Foreign	Indicator variable equal to 1 if a firm has any amount of foreign ownership. Source: WBES.
State	Indicator variable equal to 1 if a firm has any amount of state ownership. Source: WBES.
Medium	Indicator variable equal to 1 if a firm has more than 20 employees but fewer than 99. Source: WBES.
Large	Indicator variable equal to 1 if a firm has more than 100 employees. Source: WBES.
Internet use	Indicator variable equal to 1 if a firm uses e-mail or a website to communicate with customers and suppliers. Source: WBES.
Listed	Indicator variable equal to 1 if a firm is listed on the stock exchange. Source: WBES.

Note: The following abbreviations are used. GeGSD: Global e-Government Systems Database; DB: Doing Business database; WoRLD: World Revenue Longitudinal Dataset; WDI: World Development Indicators database; WGI: World Governance Indicators database; WBES: World Business Enterprise Survey database.

Appendix B: Average time to prepare and pay taxes



Note: These figure plots the average time to prepare and pay taxes (in logarithms) for five groups of countries: never adopted e-filing systems; adopted transactional e-filing before or during 2004; adopted transactional e-filing with e-payment functionality before or during 2004; adopted transactional e-filing; and adopted transactional e-filing with e-payment functionality during the sample period.

Appendix C: The impact of e-filing adoption on the time to prepare and pay taxes

	Time to prepare and pay taxes		Income tax		Goods and services tax	
	(I)	(II)	(III)	(IV)	(V)	(VI)
	Coefficient	SE	Coefficient	SE	Coefficient	SE
E-filing2$_{t+4}$	-0.040	(0.041)	0.195	(0.339)	0.444	(0.419)
E-filing2$_{t+3}$	-0.017	(0.044)	0.159	(0.388)	0.785#	(0.495)
E-filing2$_{t+2}$	0.047	(0.065)	0.136	(0.428)	0.627	(0.590)
E-filing2$_{t+1}$	0.031	(0.067)	0.476	(0.426)	0.566	(0.580)
E-filing2$_{t}$	0.028	(0.071)	0.672	(0.504)	0.682	(0.611)
E-filing2$_{t-1}$	-0.008	(0.069)	0 .982*	(0.587)	0.419	(0.697)
E-filing2$_{t-2}$	-0.022	(0.075)	1.095*	(0.646)	0.241	(0.790)
E-filing2$_{t-3}$	-0.097	(0.093)	1.139*	(0.680)	0.293	(0.885)
E-filing2$_{t-4}$	-0.162#	(0.106)	1.167#	(0.790)	0.837	(0.848)
E-filing2$_{t-5}$	-0.251*	(0.146)	0.863	(0.817)	0.688	(0.948)
E-filing3$_{t+4}$	0.018	(0.040)	0.404	(0.296)	0.234	(0.366)
E-filing3$_{t+3}$	-0.007	(0.049)	0.379	(0.468)	0.252	(0.426)
E-filing3$_{t+2}$	-0.048	(0.053)	0.226	(0.527)	-0.101	(0.469)
E-filing3$_{t+1}$	-0.096#	(0.062)	0.335	(0.510)	-0.233	(0.466)
E-filing3$_{t}$	-0.128*	(0.067)	0.512	(0.564)	-0.357	(0.528)
E-filing3$_{t-1}$	-0.172***	(0.065)	0.694	(0.611)	-0.480	(0.560)
E-filing3$_{t-2}$	-0.217***	(0.075)	0.491	(0.666)	-1.031*	(0.606)
E-filing3$_{t-3}$	-0.258***	(0.083)	0.495	(0.689)	-1.051#	(0.641)
E-filing3$_{t-4}$	-0.335***	(0.095)	0.306	(0.739)	-1.065#	(0.653)
E-filing3$_{t-5}$	-0.364***	(0.099)	0.199	(0.789)	-1.300*	(0.689)
GDP	-0.156	(0.154)	2.570*	(1.467)	-0.445	(0.986)
Polity	0.060	(0.044)	0.543#	(0.335)	1.025**	(0.369)
Reform	0.023	(0.024)	-0.147	(0.159)	0.187	(0.206)
N observations	1626		1,226		1,217	
N countries	150		127		126	
R2 within	0.458		0.315		0.288	

Note: This table reports the results from estimating specification (1) for the time to prepare and pay taxes, income tax revenue and goods and services tax revenue. Detailed definitions of the variables are in Appendix A and Section 2 and 3 of the text. Standard errors are clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1, # p<0.15.