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Inclusive GovTech: Enhancing Equity and Efficiency Through Public Service Digitalization

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**Inclusive GovTech: Enhancing Efficiency and Equity Through Public Service Digitalization
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ABSTRACT: How could the GovTech improve budget processes and execution efficiency? Could the GovTech strengthen redistributive function of public expenditure? Based on an event-study method, this paper finds that the introduction of digital budget payments and e-procurement could significantly enhance budget transparency and help expand the coverage of social assistance to reach the most vulnerable population. Exploiting staggered adoption of digital budget payments, a synthetic control regression identifies meaningful increase in pre-tax income shares among the bottom 50th percentile and female workers, especially for emerging market and developing countries, with effects materializing gradually over 10-year period. The paper delves into the potential mechanism driving these equity benefits, highlighting the reduction in business informality as a primary channel. However, the paper emphasizes that the mere adoption of GovTech strategies or digital technologies is insufficient to unlock its full potential. The outcomes are intricately linked to supporting policies, regulations, organizational and system integration, and robust digital connectivity. The paper underscores that inter-agency coordination facilitated by a dedicated GovTech institution emerges as a critical factor for reaping both efficiency and equity gains from GovTech initiatives.

JEL Classification Numbers:	D31, E60, H11, H50, H61, H83, O23, O38
Keywords:	GovTech; Inclusion; Staggered technology adoption; Synthetic control; Expenditure efficiency; Coordination in organizations
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Contents

I.   Introduction[1]

The rapid expansion in the use of Information and Communication Technologies (ICT) has changed market structure and transactions and reshaped public service provision. Since the 1980s, digital technologies have been deployed in upgrading tax collection, social benefit payment, and public procurement. This process creates significant opportunities for governments to raise the quality of their public service – rich and poor alike. In developed countries, the government digital ("GovTech") agenda encompasses the use of advanced solutions – the use of "disruptive technologies" (e.g., artificial intelligence (AI), machine learning, cloud computing) and public data platforms that facilitate innovations for more efficient public service provision. At the same time, adopting digital technologies opens possibilities for developing countries to leapfrog the technology frontier and overcome pre-existing barriers in delivering goods and services to the population, particularly the vulnerable groups typically living in rural areas (Gupta et al., 2017).

Microeconomic literature has found the efficiency gains by promoting GovTech in specific country cases. Recent papers examined the effective modality of social welfare programs, showing that digitalized cash transfer helps better access and target social assistance to the poor in developing countries (Aiken et al., 2023; Aker et al., 2016; Aker and Blumenstock, 2015; Muralidharan, Niehaus, and Sukhtankar, 2016). E-procurement is expected to improve the efficiency of public expenditure by reducing corruption and leakage of anti-poverty welfare programs (Banerjee et al., 2020) and by raising the quality of infrastructure investments (Lewis-Faupel et al., 2016). The e-government platform facilitates citizens' interaction with government officials, cuts out administrative tiers, and strengthens the monitoring of public service quality (Grossman et al., 2018).

Besides efficiency gains, GovTech has the potential to create large economic and social dividends (Kumar et al., 2023; Nose and Honda, 2023). GovTech helps strengthen Public Financial Management (PFM) by automating budget cycle, data reconciliation, and payment process. Beyond efficiency improvement, the automation of budget processes reduces bureaucratic discretion and makes the expenditure policy more inclusive (Zouhar et al., 2021). Literature also argues that enhanced fiscal transparency (for example, through e-procurement) could reduce bias toward small firms (especially women-led SMEs), which could create a positive macroeconomic impact (di Giovanni et al, 2022).[2] On the other hand, technological progress is inherently a skill-biased process which raises concern of "digital divide" based on skill levels, gender, and residential locations (Agrawal and Bütikofer, 2022).[3] Given challenging trade-off between *efficiency* and *equity*, the distributional impact of GovTech is *a priori* ambiguous, which calls for a robust empirical study.

This paper first describes significant cross-country disparity in the speed of GovTech diffusion in public finance. The analysis uses World Bank's GovTech Maturity Index (GTMI) (World Bank, 2022), which provides cross-country variations in both *intensity* and *timing* of digital technology adoption in many layers of fiscal policy operations (e.g., treasury operation, tax administration, procurement, and public investment).

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[1] Annex I of Amaglobeli, de Mooij et al (2023) provides glossary of key concepts and a list of abbreviations and acronyms.

[2] See https://blogs.worldbank.org/governance/gender-and-equality-public-procurement.

[3] Technology generally contributes to better tax compliance but may introduce new avenues of tax evasion for high-income taxpayers (Alm, 2021). Product innovation and cheaper access to online information led to a very competitive and long-tail market (Bar-Isaac et al., 2012) while accelerating the concentration of rents to "superstar firms" (Autor et al., 2020). Women are generally at higher risk for displacement through automation in works than men (Brussevich et al., 2018).

The paper estimates the efficiency gains of GovTech while exploring its potential to strengthen the redistributive function of public expenditure. Despite being evident anecdotally, empirical evidence regarding which aspects of GovTech enhance budget implementation efficiency is scarce. Using the GTMI data, encompassing GovTech application practices over 198 countries, a cross-country panel regression estimates the average treatment effect of each GovTech type on budget transparency and execution efficiency. Moreover, employing two event-study methods, it evaluates whether digital budget payments, as opposed to traditional cash or in-kind payments, can yield greater equity benefits by increasing the income share of both poor individuals and female workers in the economy.[4] The application of Sun and Abraham (2021)'s interaction-weighted estimator unpacks the impact heterogeneity by cohorts (i.e., country groups based on the year of GovTech adoption). A synthetic control (SC) estimation (Abadie, 2021; Arkhangelsky et al., 2021; Xu, 2017) enables us to establish a robust identification of GovTech's equity gains and provides insights into the time horizon of its effect, clarifying how long it takes for the reforms to materialize.

The paper clarifies key pre-conditions for materializing the equity impact of GovTech while delving into the possible mechanism of how digital payments could support inclusive growth. World Bank (2016) reported that the poor tend to benefit *only modestly* from digital technologies compared with the true potential in developing countries. The reasons behind the imperfect outcome relate to the weakness in GovTech enabling institutions – lack of inter-agency coordination, limited organization and (new and existing) IT system integration, inadequate digital connectivity, and low digital literacy.[5,6] The event-study analysis will estimate the difference in treatment effects by the strength of GovTech enabling institutions to identify key pre-conditions.

Results consistently demonstrate a positive association between GovTech initiatives and budget transparency, execution, and control of corruption. Based on aggregate GTMI, the Open Budget Index, and the PEFA index, a cross-sectional regression analysis describes that GovTech maturity (in core budget operations, government online services, and citizen engagement) is positively associated with budget transparency and better expenditure management. Using GTMI sub-indices for specific technological domains, panel data regressions find that digital budget payments and e-procurement have the potential to strengthen budget transparency and citizen engagement in the budgetary process. Moreover, digital payments can expand social assistance program coverage to the extremely poor (living below $1.9 a day poverty line) by 7 percent, leading to a more significant impact on poverty reduction per unit of spending. Nevertheless, it is imperative to acknowledge that the positive impact of GovTech on budget implementation hinges on a country's progress in legislative reforms (e.g., cybersecurity) and robust system and organizational integrations. Specifically, the expansion of social assistance coverage to poor individuals is typically accomplished when a country's GovTech strategy is coordinated across ministries and facilitated through a centralized GovTech institution.

A synthetic control regression identifies a meaningful increase in pre-tax income shares among the bottom 50th percentile and female workers, primarily through a reduction in business informality. The positive impact of digital budget payments (with fintech payment application) on the income share of the poor (bottom half of the population) is larger among Emerging Market and Developing Economics (EMDEs) and

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[4] Recent papers propose a robust estimator of treatment effects in the presence of heterogeneity (Borusyak, Jaravel and Spiess, 2023; Sun and Abraham, 2021; Callaway and Sant'Anna, 2021; de Chaisemartin and d'Haultfoeuille, 2020).

[5] In Uganda, the benefit of a new ICT platform was short-lived unless the adoption of new technology accompanies complementary improvements in the quality of civil service and citizen empowerment (Grossman et al., 2018). The effectiveness of digital transfers also depends on sufficient integration of the digital payment system into the overall PFM platform (Cangiano et al., 2019).

[6] Digitalization is generally associated with lower corruption and higher trust from citizens (Ouedraogo and Sy, 2020). However, in the digitalization of revenue administration, resistance to the deployment of new digital technologies could possibly worsen transparency and digital governance (Okunogbe and Santoro, 2022).

materializes gradually over ten years. However, a country can reap the full equity benefit of GovTech only when adequate digital infrastructure connectivity and complementary GovTech enabling institutions are in place. A centralized GovTech institution is found to be necessary (though not sufficient) to unlock both the efficiency and equity gains of GovTech. Finally, the impact of digital budget payments on female workers is found to be more prominent when the informal sector is large, which appears consistent with the U-shape pattern of female labor force participation (Goldin, 1994; Fruttero et al., 2020).

This paper is organized as follows. Section II describes data and provides stylized facts. Section III examines the effect of GovTech on budget transparency and public expenditure efficiency. Section IV undertakes the event-study to estimate the dynamic effect of GovTech on income inequality. Section V explores possible channels in which GovTech could promote inclusion. Section VI concludes.

II.   Diffusion of GovTech: Stylized Facts

A. Data

The World Bank GTMI database measures the state and practices of public financial operations and public service delivery. Unlike traditional indicators like the United Nations e-Government Index, World Bank Digital Adoption Index, and OECD's Digital Government Index, which broadly gauges a country's digital adoption maturity, GTMI delves into how specific GovTech solutions are used across individual areas of public services. The latest vintage of the GTMI data covers 198 countries and offers a comprehensive measure of a country's GovTech maturity, including the operational status of systems, interoperability of online services, and the adoption year for each digital solution. The aggregate GTMI index evaluates GovTech maturity in four key areas: (a) supporting core government systems (GT1), (b) improving public service delivery (GT2), (c) enhancing citizen engagement (GT3), and (d) fostering GovTech enabling factors (GT4) (Annex 1).

The GTMI records both the *timing* and *intensity* of GovTech adoption.[7] Based on official data and in-depth online surveys involving government officials, the GTMI records the establishment year of a dedicated GovTech institution (an agency responsible for the National Digital Strategy)[8] and the adoption years for key digital initiatives. The initiatives encompass digital budget payments via the Financial Management Information System (FMIS), the Treasury Single Account (TSA) IT system, the e-procurement portal, and the Public Investment Management System (PIMS). Moreover, the GTMI database captures the degree of GovTech adoption to some extent. It details the GovTech institution's responsibility (whether it plays a Whole-of-Government coordination role or not), digital payment type (internet-based fintech payment (e-payment) or mobile payment integrated with the FMIS), e-procurement portal interoperability (interface with Government Service Bus platform), and the PIMS functional capability (digital project management and data disclosure at each stage of public investment management cycle).[9]

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[7] The GTMI data is compiled through official records and detailed online surveys conducted with relevant government officials at both central and subnational levels. The compiler verified source data with input from World Bank experts and shared the verified data with country officials for final adjustments before publication (see World Bank (2022) for the methodological details). Despite multiple verification processes, possible measurement errors due to lack of official information should still be noted for cross-country comparisons using the index. As GTMI relies on self-reported surveys, the recorded intensity of GovTech adoption may not perfectly measure the actual quality of PFM operations.

[8] As of 2022, about half of the GovTech institutions are under the Ministry of ICT, and others are either under the President/Prime Minister's Office, line ministries, or an autonomous agency (World Bank, 2022).

[9] See del Paso et al. (2023) for technical concepts and discussion on operational aspects of digitalization in PFM.

Figure 1 describes the speed of GovTech adoption in public administration and budget operations over the last two decades. In 2000, only 11 countries had a dedicated GovTech institution (top left), which increased to 51 within 10 years and reached 155 countries by 2022. Moreover, in the past 12 years, there has been a substantial increase in the number of countries launching various GovTech technologies.

The figure highlights significant disparities in the diffusion of GovTech across income groups. The speed of digital diffusion varies across five GTMI sub-indices related to the FMIS, TSA, PIMS, e-procurement portal, and social insurance and pension management information systems. Generally, European countries, for example Nordic countries, have embraced digitalization at a faster pace, whereas progress has been slower in sub-Saharan Africa. Digitalization in budgetary systems was uncommon in 2000. However, by 2010, key systems such as FMIS, TSA, and social insurance were digital in over 100 countries, albeit with disparities among income groups. A decade ago, digitalization in public procurement and PIMS was limited to Advanced Economies (AEs). However, in the past decade, Emerging Market Economies (EMEs) and Low-Income Developing Countries (LIDCs) have caught up with AEs, which was accelerated during the COVID-19. Consequently, digital adoptions in all aspects (except PIMS) have nearly reached 100 percent in 2022.

Figure 1. Diffusion in GovTech Adoption (by Income Groups)
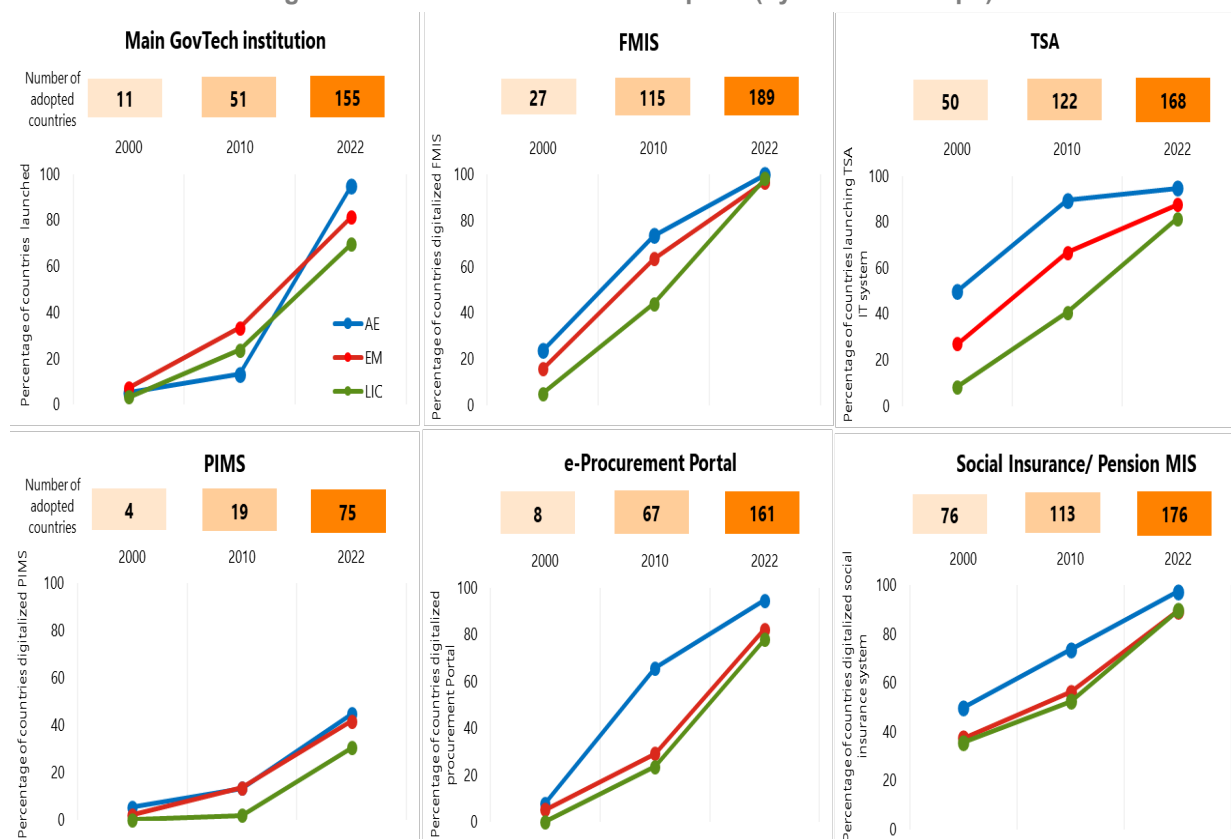
Source: World Bank GTMI and author's estimates.

The GovTech enabling environment generally improves with the rise in national income, although the development of enabling institutions follows a non-linear trajectory (Figure 2). This paper uses two cross-country datasets (GTMI GovTech Enabler Index (Figure 2, upper chart) and Alper and Miktus (2019)'s Enhanced Digital Access Index (EDAI) (the bottom chart)) to gauge a country's readiness for GovTech implementation.[11] While a clear positive correlation exists between digital accessibility and per-capita income (the bottom chart), the correlation with the level of institutional development necessary to support GovTech initiatives (GTMI Enabler Index) is ambiguous. The GTMI Enabler Index exhibits significant variation, particularly for EMEs and upper LICs (the upper chart). Countries on the margin (between the 25th and 40th percentile of the GTMI Enabler Index) are transitioning toward advancing digitalization agenda, whereas those at the lower end (below the 25th percentile) are lagging behind.

Figure 2. Level of GovTech Enablers by Per Capita Income
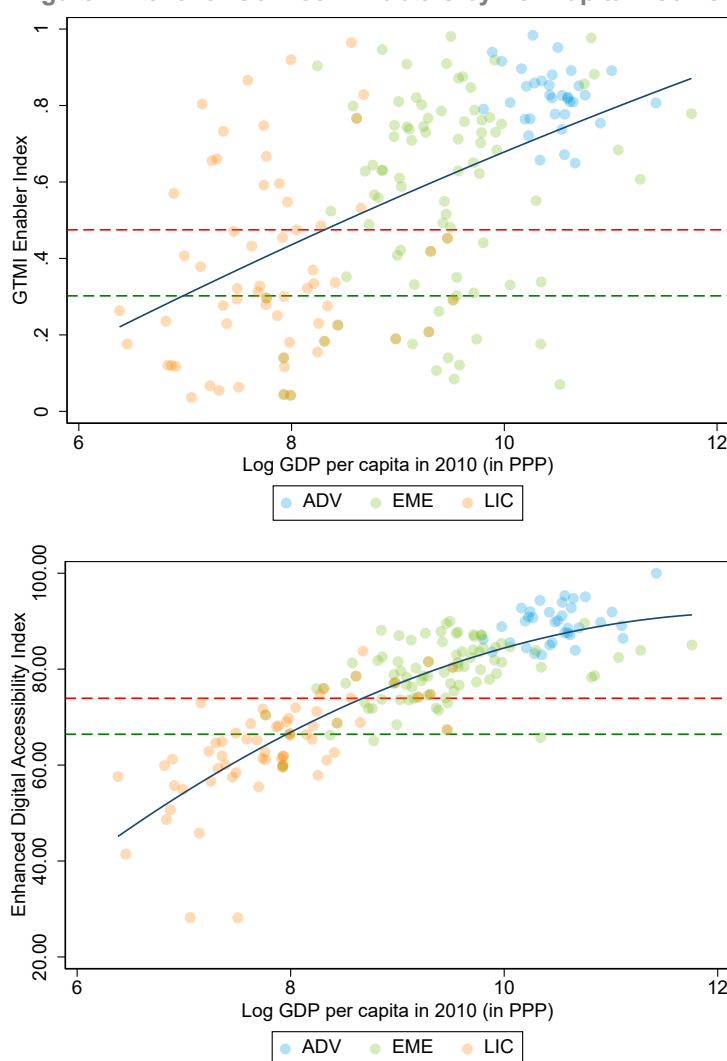
Source: World Bank GTMI, Alper and Miktus (2019).

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[11] The EDAI is the composite digital connectivity index, which comprehensively measures each country's level of digital connectivity from both demand-side (affordability of access, education level of population, actual internet usage) and supply-side (availability of digital infrastructure, the quality of ICT services).

Note. The *x*-axis is the sample average of GDP per capita while the *y*-axis is the latest available data on the GTMI Enabler Index and the EDAI. Quadratic prediction line is shown in bold lines. The horizontal red line and green line indicate the 40th and 25th percentiles of GTMI Enabler Index and EDAI respectively.

B. The Nexus Between GovTech and Inequality

Progress in GovTech maturity is positively associated with an increase in the share of pre-tax income for individuals at the bottom 50th income percentile and female workers (Figure 3). While a simple correlation is suggestive, it hints at the potential contribution of GovTech to a country's inclusion agenda. The World Inequality Database (WID) monitors global income inequality since 1980s and measures the income gap across each income percentile and female income share in the population. In Figure 3, the *y*-axis presents the income share of the bottom 50th percentile (on the left) and female income share (on the right). An improvement in the GTMI index from the 25th to 75th percentile corresponds to a significantly higher portion of income earned by the lower half of the population as well as female workers (in level). Marginal equity gains from enhancing GovTech maturity seem to plateau beyond the 75th percentile. Regarding changes in pre-tax income shares, there is a moderate upward shift in the inclusion curve over a decade. The figure illustrates a global trend showing a relatively larger increase in the income share of the bottom half of the population, potentially reflecting a "backwardness advantage" for LIDCs in digitalization. However, the contribution of GovTech to the inclusion agenda remains empirically unknown, which will be explored in section IV.

Figure 3. GovTech Maturity and Inclusion Curve
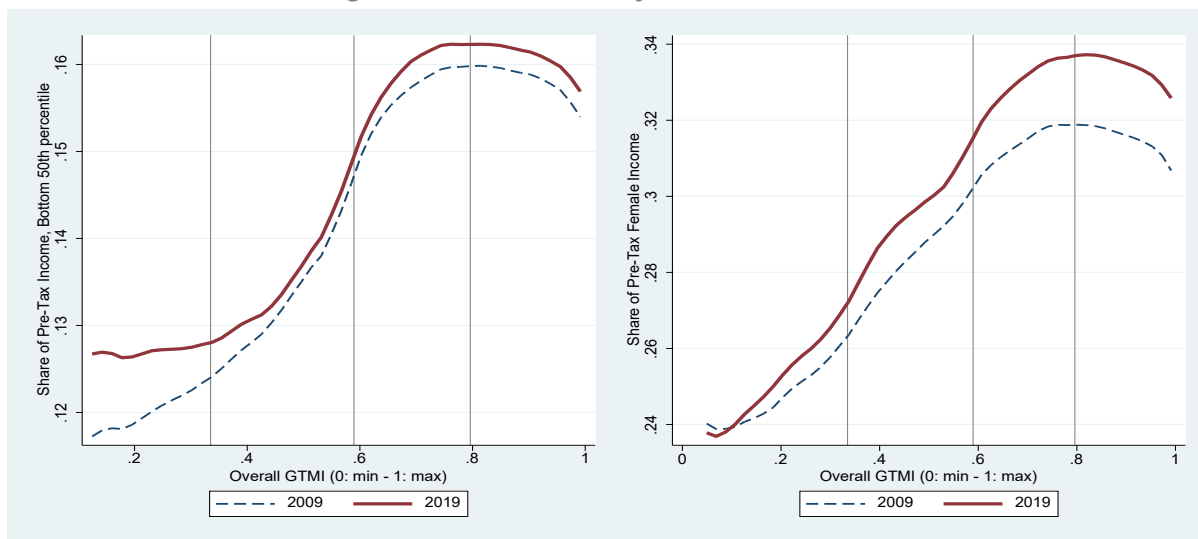
Source: World Inequality Database, World Bank GTMI, and author's estimates.
Note: The *x*-axis shows overall GTMI (the average of GT1-GT4). Vertical lines indicate 25th, 50th, and 75th percentiles of the overall GTMI index. Kernel-weighted local-mean smoothing with bandwidth 0.1 is applied after trimming outliers.

III. Impact of GovTech on Budget Transparency and Expenditure Efficiency

A. Theoretical Background

The automation of budget cycles induces budget process innovation, enhances budget transparency, and helps governments strengthen fiscal policy (Montes et al., 2019; Alt and Lassen, 2006). The automation of budget payments reduces leakage and enhances transparency in cash or in-kind payments. Digital platforms for managing procurement and public investment systematize expenditure management and enhance disclosure of fiscal outcomes (relative to budget plans) to citizens. The promotion of fiscal transparency and the effectiveness of fiscal policies through digital solutions would be particularly important during the crisis (IMF, 2022). The past crisis episodes revealed that serious weaknesses in fiscal reporting and fraud in financial statements could deepen macroeconomic vulnerabilities. Literature shows that higher budget transparency could help reduce sovereign risk premia and create fiscal savings (Albatli and Escolano, 2015). The improvement in budget execution and management utilizing digital solutions could also strengthen the redistributive function of fiscal policy.[12]

Digital technologies through GovTech create an "information revolution" in public administration. This could strengthen the monitoring of fiscal policymaking and mitigate coordination problems among government agencies (e.g., Ministry of Finance, line ministries) through real-time online data exchange.

However, the GovTech could produce intended benefits only when solid physical and institutional infrastructure are in place. The size and sustainability of the GovTech's treatment effect depends on a country's physical capital investment (digital infrastructure), organizational and institutional design in public administration (i.e., GovTech enabling maturity), and citizen's digital literacy**.** As the EDAI captures, government could reduce digital divide through supply-side policies (to provide affordable and accessible digital infrastructure) or demand-side policies (to improve citizen's digital literacy). Digital registration system and safeguard institutions (related to information security, privacy, data protection) are also needed.

A comprehensive legal and institutional reforms should underpin the implementation of the GovTech agenda to reap efficiency gains. Public administration involves a complex *multi-layer hierarchy within* a ministry/government agency as well as *coordination problems across* multiple agencies. In organizational economics theory, this is expressed as a "coordination game" where multiple equilibria with pareto inefficiency could arise. In contract theory literature, the optimal hierarchical structure (a trade-off between centralized and decentralized team decision), the role of leadership, and information and communication structure are considered to mediate the coordination problem (Hart and Moore, 2005; Alonso, Dessein and Matouschek. 2008; Mookherjee, 2006). In the GovTech context, a centralized process through the National Digital Strategy (NDS) and a GovTech institution have been pursued, which plays a key role in taking leadership in inter-ministerial coordination and facilitates public sector innovation. By nature, the accumulation of digitally administered information on capital projects, taxpayers, beneficiaries of social programs, etc., would help facilitate information sharing and communication among government entities. However, the lack of (new and existing) systems integration is one of the factors that can hinder developing countries from taking the full

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[12] See https://blogs.lse.ac.uk/africaatlse/2020/05/12/kenya-budget-transparency-poverty-and-inequalities-covid/.

potential of GovTech. The integration of new online IT platforms with the government's existing internal system (including manual-based) could foster efficiency and equity impact of GovTech through timely provision of social services.

B. Would GovTech Enhance Budget Transparency and Execution?

This subsection quantifies the impact of different facets of GovTech, such as digital budget payments, e-procurement, and PIMS, on budget transparency and execution efficiency. Despite being evident anecdotally, empirical analysis in this area has been scarce due to the challenges in measuring GovTech application practices. The analysis provides empirical evidence drawing on data from the International Budget Partnership (IBP)'s Open Budget Index (OBI) 2006-2017 and the Public Expenditure and Financial Accountability (PEFA) assessment.[13]

Significant gaps exist across countries in terms of the level of budget disclosure, budget execution reporting, and systematic monitoring of performance budgeting (OECD, 2019). Governments should ideally disclose the overall impact of the budget, including its gender and poverty impact. The budget allocation to poverty alleviation programs could be clearly stated in the budget document and explained to the public. While OECD countries have adopted performance-based budgeting (such as gender budgeting), it has not systematically aligned expenditure with relevant development goals. Many countries do not adequately publish information on the impact of their budget policies on the poor and women. Even if published, the information is often presented in unhelpful or partial formats (de Renzio, 2019).

Figure 4 consistently demonstrates a positive correlation between the GTMI and budget transparency. In Panel A, the coefficient plots illustrate the OLS estimates of each GTMI index on the Open Budget Index and PEFA, while controlling for basic confounding factors. For the ease of interpretation, outcome variables are standardized as z-scores. In Panel B, the PEFA sub-indices evaluate various aspects of budget management efficiency, including budget outturns (vis-a-vis original budget targets), the quality of public service delivery, fiscal reporting and disclosure, public investment and procurement management, and control over expenditure arrears.

- In panel A, the adoption of digital technologies in core fiscal functions (GT1) and the improvement of government online services (GT2) are associated with higher budget transparency and better expenditure management. A higher level of citizen engagement (GT3) also enhances budget transparency.

- The analysis using the PEFA sub-index (Panel B) shows that a 50 percent increase in the digital adoption of core fiscal functions (GT1) is associated with significant improvement in fiscal risk reporting (exceeding 1 standard deviation (SD) from the mean), public investment and procurement management (with an impact of about 0.8 SD), and expenditure/cash control. The enhancement of government service quality through GovTech (GT2) yields similar results, showing a relatively larger positive association with the efficiency of service delivery and budget outturns than GT1/GT3. Finally, the increase in citizen engagement through GovTech (GT3) exhibits strong correlation with fiscal risk reporting and procurement management.

- Annex II explores the heterogeneity in the impact of GovTech services (GT2) on budget transparency, contingent upon the country's GovTech enabling maturity and digital accessibility. Figure AII.1 illustrates the mean difference in the treatment effect between high and low group, highlighting the importance of the

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[13] The PEFA index evaluates a county's PFM capacity, analyzing its strengths and weaknesses. It examines 94 dimensions across 31 key components of PFM. The key indicators include assessing budget reliability, ensuring transparency of public finances, managing assets and debt for long-term financial stability, aligning budget plans and fiscal strategy (such as public investment, procurement) with national priorities, and maintaining predictability and control in budget execution.

GovTech institutional maturity. Countries that have advanced in establishing supportive GovTech institutions tend to experience greater benefits in fiscal transparency and public investment management compared to nations with lower levels of institutional maturity. At the cross-country level, the heterogeneous effect on budget transparency due to digital connectivity appears relatively minor.

Figure 4. Digitalization and OBI/PEFA Index
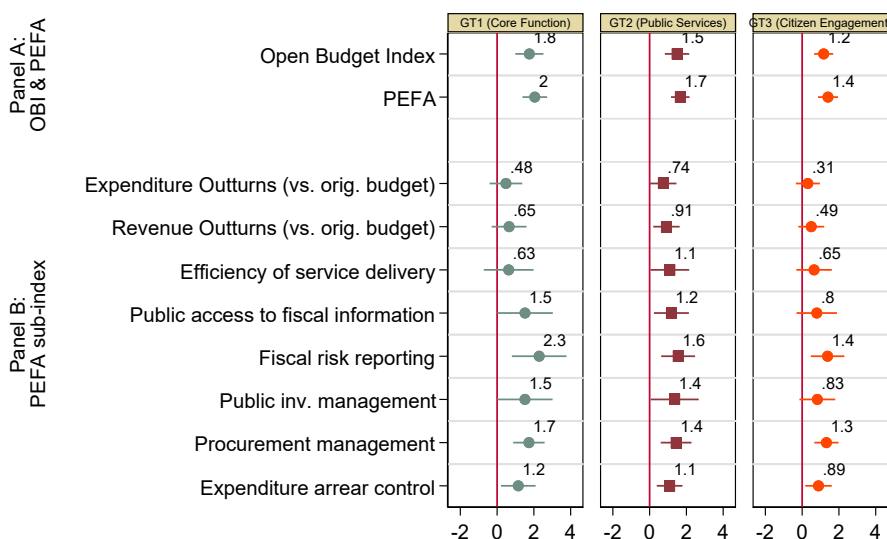
Source: International Budget Partnership (IBP), PEFA, and author's estimates.

Note: The coefficient plot of each digitalization index from the OLS regression: $z\ score\ (OBI\ or\ PEFA)_i = \beta GTMI_i + \gamma X_i + \varepsilon_i$ where control variables include GDP per capita (linear and squared terms), rule of law, and control of corruption of country i, and regional dummy. Error bars indicate 95 percent confidence intervals calculated using Huber-White heteroskedasticity-robust standard errors.

Figure 5. Digitalization and Governance Indicators
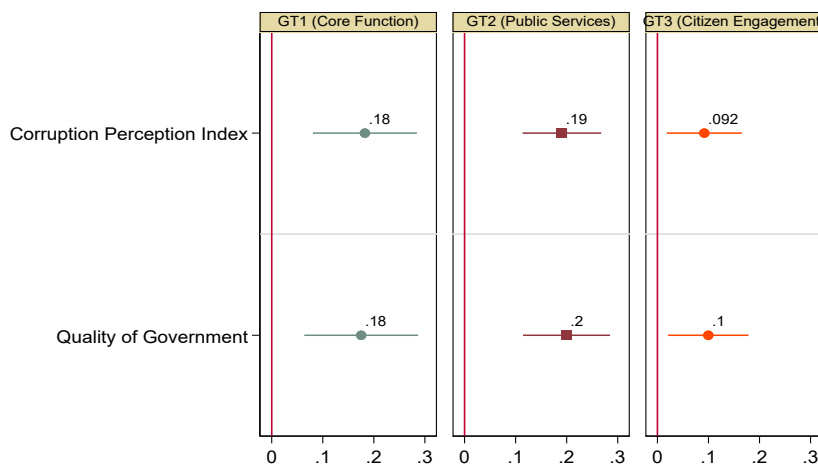
Source: Transparency international, ICRG, and author's estimates.

Note: The coefficient plot of each GTMI from the OLS regression which controls for GDP per capita (linear and squared terms) and regional dummy. Error bars indicate 95 percent confidence intervals calculated using Huber-White heteroskedasticity-robust standard errors.

Beyond the impact on budget transparency, digitalization is expected to enhance government accountability (Figure 5). Literature found that e-procurement could reduce the risk of corruption by addressing market failure (Abdou et al., 2022; Lewis-Faupel et al., 2016). In sub-Saharan Africa, Ouedraogo and Sy (2020) provides cross-country evidence that the government's digital adoption is associated with a reduction in the perception of corruption, contingent on each country's digital accessibility. In line with the literature, GovTech adoption in core fiscal functions, public service delivery, and citizen engagement are associated with a higher Corruption Perception Index and the Quality of Government (QoG) index.[14]

A cross-country panel regression estimates the impact of GovTech adoption on budget transparency. Two-way fixed effect model controls for key macroeconomic and institutional factors of budget transparency.

$$y_{igt} = \beta_1 GT_{it} + \beta_2 X_{it} + \tau_t + \mu_g + \varepsilon_{igt} \quad (3)$$

where y_{igt} is budget transparency index for country i in region-income group g at year t.[15] X_{it} is a set of variables to control for macroeconomic conditions (e.g., GDP, CPI inflation, debt, and agricultural output share in GDP) and the strength of governance (rule of law). GT_{it} is the time-varying GovTech index, which takes value one for years after the introduction of GovTech and zero otherwise. As the benchmark, it also presents the result using the United Nation's e-Government index. τ_t and μ_g are year and country group fixed effects. Huber-White heteroskedasticity-robust standard errors are consistently used.

GovTech variables (the first six rows in Table 1) are positively associated with increases in budget transparency (column 1-6) and enhanced citizen participation in budget discussion (column 7-12). Table 1 shows the estimates for all countries, while the result for EMDEs is reported in the Annex III. An increase in E-Government Index significantly improves the OBI scores. It is noteworthy that merely establishing GovTech institutions is insufficient to enhance budget transparency; however, the digitalization of individual PFM functions holds the potential to improve budget transparency significantly. Specifically, column 4 shows that the digitalization of treasury operations through mobile payment is associated with higher OBI score by about 7 points. In line with prior literature (Grossman et al, 2018), the launch of e-procurement is associated with higher budget transparency, particularly large effect for EMDEs by 11 points (see column 5 in Annex Table AIII.1). This result confirms the anecdotal evidence suggesting that an integration of digital technologies to replace or redesign paper-based procedure in public procurement has material implications for fiscal transparency.[16]

Interpreting the point estimates of individual GovTech measures on budget transparency requires caution. Although the analysis utilizes the unique feature of GTMI data (the varying timing and intensity of GovTech adoption), digital technologies often serve overlapping function in budget management and are interlinked through the FMIS. At the cross-country level, it should be recognized that the identification of individual digital effects is inevitably weak in the absence of transparency measures specific to each digital technology. Nevertheless, the cross-country estimate provides a reasonable upper-bound estimate in line with micro-level case studies.

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[14] The control of corruption index measures the perceived level of public sector corruption, as determined by expert assessments and opinion surveys with 0 (highly corruption) to 100 (very clean). The QoG index is the simple average of three ICRG sub-indices (Corruption, Law and Order, and Bureaucracy Quality) on a 0-1 scale, with a larger value indicating higher quality of government.

[15] Due to limited time series and variations in the OBI score, the estimation with both country and year-fixed effects does not produce meaningful results. In this regard, country-level unobservables could potentially create bias to the point estimate.

[16] See https://www.oecd.org/governance/procurement/toolbox/principlestools/e-procurement

Table 1. Two-way Fixed Effect Model, Effect on Budget Transparency

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OBI (IBP)						Public Participation (IBP)					
E-Government Index	45.717***						95.411***					
	(16.162)						(18.411)					
Establishment of GovTech institution		0.356						1.356				
		(1.680)						(1.398)				
TSA/FMIS adopted with e-payment			5.484***						5.483***			
			(1.561)						(1.404)			
TSA/FMIS adopted with mobile payment				7.378***						5.403***		
				(1.552)						(1.329)		
e-Procurement adopted with network interface					8.740***						4.080***	
					(1.440)						(1.487)	
PIMS fully adopted						7.803***						3.109
						(2.276)						(2.298)
Log (Per Capita GDP_PPP), lagged	46.505**	66.009***	70.164***	66.897***	74.625***	67.340***	22.302	37.099***	42.008***	38.956***	47.956***	40.485***
	(19.899)	(12.810)	(13.012)	(13.092)	(13.250)	(13.022)	(21.069)	(10.331)	(10.377)	(10.343)	(10.276)	(10.667)
Square log (Per Capita GDP_PPP), lagged	-3.305***	-4.092***	-4.368***	-4.211***	-4.609***	-4.212***	-1.716	-2.210***	-2.512***	-2.350***	-2.817***	-2.424***
	(1.089)	(0.723)	(0.735)	(0.737)	(0.738)	(0.738)	(1.168)	(0.598)	(0.603)	(0.599)	(0.596)	(0.620)
CPI inflation, lagged	82.504***	12.977	11.784	16.521	15.445	15.317	-13.871	16.787**	18.198**	20.724***	13.434*	18.993**
	(22.721)	(13.884)	(13.191)	(13.611)	(14.177)	(13.621)	(24.728)	(7.519)	(7.285)	(7.772)	(7.068)	(7.819)
External debt (%GDP), lagged	-1.795	-1.443	-1.827	-2.274	-0.840	-1.109	-15.945***	-4.889***	-5.315***	-5.592***	-4.607***	-4.931***
	(2.433)	(1.741)	(1.720)	(1.725)	(1.716)	(1.731)	(4.281)	(1.630)	(1.705)	(1.724)	(1.636)	(1.595)
Log (Agriculture, %GDP), lagged	-3.090	-1.388	-3.538*	-3.253*	-3.140*	-2.543	-1.882	-2.486*	-4.127***	-3.612**	-3.725**	-3.185**
	(2.307)	(1.637)	(1.922)	(1.889)	(1.796)	(1.738)	(3.228)	(1.412)	(1.551)	(1.521)	(1.516)	(1.496)
Rule of Law	14.809***	16.077***	15.740***	15.697***	14.949***	16.253***	2.678	6.551***	6.400***	6.238***	5.670***	6.969***
	(1.893)	(1.387)	(1.375)	(1.342)	(1.362)	(1.420)	(2.890)	(1.322)	(1.277)	(1.286)	(1.381)	(1.411)
Constant	-120.205	-207.745***	-220.547***	-205.072***	-243.214***	-208.680***	-72.900	-126.811***	-145.155***	-131.491***	-173.922***	-138.233***
	(90.240)	(56.490)	(57.607)	(58.102)	(59.655)	(57.124)	(96.624)	(44.296)	(44.207)	(44.222)	(44.089)	(45.458)
Observations	251	593	582	582	582	586	91	381	373	373	373	377
Number of countries	92	102	100	100	100	101	91	102	100	100	100	101
Adj. R-squared	0.4883	0.4264	0.4303	0.4414	0.4621	0.4423	0.4537	0.2957	0.3142	0.3167	0.3156	0.3027
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Income FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Huber-White heteroskedasticity-robust standard errors are presented in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

C. Would GovTech Strengthen Expenditure Efficiency?

Digital adoption is expected to benefit the poor by improving basic public services as well as the adequacy and coverage of social transfer programs. Digital technology adoption in treasury operations and procurement helps reduce leakage and transaction costs, allows faster payments online, and strengthens the monitoring and evaluation of social assistance programs. It also strengthens Social Safety Nets (SSNs) through better identification, eligibility verification, and payment mechanisms. Better adequacy and coverage can be achieved using socio-economic data to reduce leakages, while digital payments using internet or mobile accounts expand SSN benefits horizontally and vertically (Bird and Hanedar, 2023).

In response to the COVID-19, several Emerging Market and Developing Economics (EMDEs) leveraged digital tools and big data (IMF, 2022). The fiscal response to the pandemic in EMDEs were constrained by limited fiscal space. Automatic stabilizers through social insurance are also typically less prevalent due to high informality. In such context, the adoption of digital tools, such as Government-to-Person (G2P) payments, digital transfers through mobile money and e-wallets (alongside traditional bank transfers), and digital social care support have rapidly progressed (Lowe, 2022; Prady, 2020; Una et al., 2020). Selected examples include digital cash transfers to informal workers (Colombia), digital registration for social benefits (Indonesia, Thailand), and digital eligibility identifications of cash transfers using big data/machine learning (Togo, Nigeria).

Digitalization is positively associated with improved efficiency and coverage of social programs (Figure 6). The analysis uses the efficiency score of different types of public expenditure, including health, education, and public investment from recent IMF publications (Garcia-Escribano et al, 2022; IMF, 2021; Baum et al., 2020) (Panel A).[17] Panel B uses the efficiency and coverage of social assistance at the extremely poor (people living below $1.9 a day poverty line) and at the poorest income quintile.[18] Besides government digitalization, the impact of increased digital penetration in the economy (measured by the percentage of the work-age population with access to the internet) is also shown. The main findings are as follows:

- In panel A, the positive association between GovTech maturity and three public expenditure efficiency indices may seem marginal at first glance. However, this should be interpreted carefully, given that all efficiency scores considered here pertain solely to the pre-COVID period. Given the transformative impact of digital technologies during the pandemic, it is reasonable to anticipate larger efficiency gains from GovTech in the midst of global health and economic challenges. Moreover, the positive association between improved household internet access and enhanced education outcomes should be noted. This reflects the essential role of internet accessibility in improving student learning and school enrollment, as highlighted by Michaud-Leclerc and Moszoro (2023). Increased digitalization and connectivity also help enhance the quality medical care while optimizing resource utilization (Wang and Bloch, 2023).

- In panel B, it is noteworthy that GT1 and GT2 exhibit a clear and significant association with increased efficiency and broader coverage of social assistance programs, in line with country experiences (Bird and Hanedar, 2023). The BCR concerning the extremely poor shows weak correlation, which likely stems from high costs associated with delivering social assistance to the most vulnerable population.

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[17] All efficiency scores are estimated based on Data Envelopment Analysis at different time points. For health, output is life expectancy, and input is total per capita health expenditure. For education, outputs are test scores, and net enrollment rates and input is public education spending per student. For infrastructure, outputs are the volume and quality of infrastructure and inputs are public capital stock and GDP per capita. As the index is only cross-sectional, the correlation analysis uses the latest available year of each efficiency scores.

[18] The efficiency of social assistance in reducing poverty is measured by the **benefit-cost ratio (BCR)** – the reduction in the poverty gap obtained for each $1 spent in all social assistance programs. The performance in terms of SSN coverage is measured by the **coverage ratio** – the percentage of the poor/extremely poor (those living below PPP $1.90 a day) covered by cash transfers, noncontributory social pensions, in-kind transfers, public work programs and so on.

- Annex IV explores the heterogeneity in the impact of GovTech services (GT2) on expenditure efficiency, contingent upon a country's GovTech enabling maturity and digital accessibility. Countries in the high group, in contrast to countries in the bottom quartile of institutional maturity, experience expanded social assistance coverage. The result also indicates the significance of digital connectivity in effectively delivering social assistance to the extremely poor.

Figure 6. Digitalization and Expenditure Efficiency
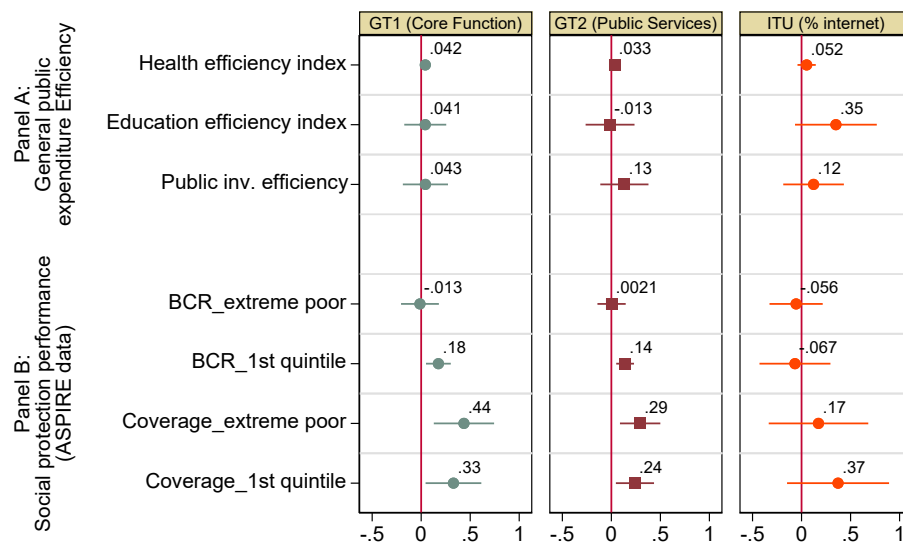
Source: ASPIRE, Garcia Escribano et al (2022), IMF (2021), Baum et al (2020), the International Telecommunication Union (ITU), and author's estimates.

Note: The coefficient plot of each digitalization index from the OLS regression which controls for GDP per capita (linear and squared terms), control of corruption, and regional dummy. The third column uses ITU's internet penetration in the economy (i.e., the percentage of work-age population using internet). Error bars indicate 95 percent confidence intervals using Huber-White heteroskedasticity-robust standard errors.

A panel regression confirms sizable gains of digitalization in enhancing the effectiveness of social assistance programs, which supports the poorest segments of the population, as similarly found in the literature. The cross-country correlations in Figure 6 could still be biased due to the omission of other confounding factors. In Table 2, panel regression estimates she light on the impact of GovTech on the coverage of social assistance for the poor. The adoption of treasury payments via mobile phones, representing government-to-persons (G2P) cash transfers, and internet-based e-payments including government-to-business (G2B) payments to vendors are key indicators considered. Controlling for key macroeconomic determinants of SSN coverage, the introduction of an e-payment system is positively associated with higher SSN coverage for both the extremely poor and the poorest population (the second row). The digitalization of budget payment using the internet (integrated into FMIS) exhibits the potential to expand SSN coverage for the extremely poor by 7 percent (the third row).[19] The e-procurement enhances transparency in public procurement and also potentially contributes to higher SSN coverage for the poor (the fourth row).

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[19] The fintech application in the PFM requires sound FMIS IT system to exchange data automatically with the fintech sector and to ensure strong authentication of citizens (Una et al., 2023).

Table 2. Two-way Fixed Effect Model – The Coverage of Social Assistance Program in EMDEs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Coverage in extreme poor (%)						Coverage in 1st quintile (poorest) (%)					
Establishment of GovTech institution	0.047* (0.028)						0.051* (0.026)					
e-payment adopted		0.098*** (0.030)						0.100*** (0.029)				
TSA/FMIS adopted with e-payment			0.074*** (0.028)						0.037 (0.028)			
TSA/FMIS adopted with mobile payment				0.046 (0.030)						0.067** (0.028)		
e-Procurement adopted with network interface					0.079*** (0.030)						0.101*** (0.029)	
PIMS fully adopted						-0.033 (0.030)						-0.003 (0.034)
Log (Per Capita GDP_PPP), lagged	1.277*** (0.415)	1.203*** (0.433)	1.337*** (0.403)	1.326*** (0.408)	1.601*** (0.435)	1.244*** (0.427)	0.606 (0.419)	0.594 (0.419)	0.667 (0.424)	0.705* (0.417)	1.337*** (0.360)	0.603 (0.430)
Square log (Per Capita GDP_PPP), lagged	-0.070*** (0.024)	-0.066*** (0.025)	-0.074*** (0.023)	-0.073*** (0.023)	-0.090*** (0.025)	-0.068*** (0.025)	-0.031 (0.024)	-0.030 (0.024)	-0.035 (0.024)	-0.036 (0.024)	-0.074*** (0.021)	-0.030 (0.025)
CPI inflation, lagged	-0.010 (0.033)	0.000 (0.032)	-0.018 (0.034)	-0.014 (0.034)	0.002 (0.033)	-0.010 (0.035)	-0.028 (0.026)	-0.018 (0.023)	-0.024 (0.026)	-0.025 (0.026)	-0.025 (0.024)	-0.029 (0.026)
External debt (%GDP), lagged	0.164*** (0.036)	0.192*** (0.034)	0.198*** (0.037)	0.186*** (0.038)	0.176*** (0.036)	0.162*** (0.038)	0.195*** (0.036)	0.211*** (0.035)	0.214*** (0.038)	0.216*** (0.036)	0.203*** (0.036)	0.201*** (0.039)
Log (Agriculture, %GDP), lagged	-0.080* (0.045)	-0.072 (0.044)	-0.080* (0.046)	-0.067 (0.048)	-0.086* (0.044)	-0.074 (0.048)	-0.092** (0.040)	-0.091** (0.039)	-0.085* (0.041)	-0.065 (0.043)	-0.126*** (0.039)	-0.094** (0.042)
Rule of Law	0.099*** (0.024)	0.091*** (0.024)	0.107*** (0.024)	0.109*** (0.025)	0.098*** (0.024)	0.099*** (0.024)	0.046** (0.023)	0.041* (0.025)	0.059** (0.024)	0.071*** (0.024)	0.048** (0.024)	0.043* (0.024)
Constant	-5.045*** (1.814)	-4.771** (1.909)	-5.346*** (1.763)	-5.324*** (1.792)	-6.413*** (1.911)	-4.924*** (1.861)	-2.298 (1.811)	-2.253 (1.824)	-2.574 (1.833)	-2.812 (1.804)	-5.325*** (1.587)	-2.280 (1.857)
Observations	239	238	239	239	236	237	326	320	324	324	322	324
Number of countries	73	73	73	73	72	72	89	88	88	88	88	88
Adj. R-squared	0.6127	0.6229	0.6190	0.6119	0.6288	0.6109	0.4245	0.4416	0.4287	0.4367	0.4807	0.4172
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Huber-White heteroskedasticity-robust standard errors are presented in parentheses. As the sample is limited to developing economies, only regional fixed effects are included.
* p < 0.10, ** p < 0.05, *** p < 0.010

The impact of digital treasury payments on SSN coverage is deeply intertwined with the prevailing GovTech enabling environment. Table 3 summarizes the interactive effects of digital budget payment with three GovTech enabling variables: (a) the presence of a dedicated GovTech institution, (b) high GTMI enabler index dummy, and (c) high EDAI dummy. The positive impact of digital payments (both e-payment and mobile payment) on SSN coverage becomes evidence in countries where a dedicated GovTech institution was already in place at the time of adopting digital treasury operations (columns 1, 4, 7, and 10). The positive impact is also closely tied to the overall maturity level of GovTech enabling institutions. The positive interaction term with the GTMI enabler index underscores the crucial role of fundamental enabling factors such as a robust social assistance database, a secure digital identity system, and effective practices in information security, privacy, and data protection. The absence of these fundamental elements could adversely affect SSN coverage, as evidenced by the negative single term of digital payment variables (columns 2, 5, 8, and 11). Moreover, in the context of reaching the poorest households, the presence of economy-wide digital connectivity emerges as a pivotal factor (column 9).

Table 3. Heterogeneous Impact of Digital Payments on the Coverage of Social Assistance Program

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Coverage in extreme poor (%)						Coverage in 1st quntile (poorest) (%)					
TSA/FMIS with e-payment	0.0421	-0.221**	0.062				-0.0146	-0.225**	-0.186**			
	(1.18)	(0.101)	(0.081)				(-0.43)	(0.096)	(0.077)			
-- x GovTech institution	0.0981*						0.164***					
	(1.97)						(3.46)					
-- x High GTMI Enabler Index		0.298***						0.260***				
		(0.103)						(0.099)				
-- x High Digital Connectivity Index			0.011						0.239***			
			(0.082)						(0.077)			
TSA/FMIS with mobile payment				0.00519	-0.303***	-0.057				0.0208	-0.186**	-0.064
				(0.14)	(0.075)	(0.134)				(0.63)	(0.077)	(0.117)
-- x GovTech institution				0.146***						0.149***		
				(2.90)						(2.92)		
-- x High GTMI Enabler Index					0.344***						0.239***	
					(0.071)						(0.077)	
-- x High Digital Connectivity Index						0.105						0.133
						(0.131)						(0.116)
Observations	239	239	239	239	239	239	324	324	324	324	324	324
Adj. R-squared	0.6273	0.6352	0.6169	0.6275	0.6256	0.6120	0.4503	0.4696	0.4695	0.4562	0.4695	0.3027
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0.4376
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Huber-White heteroskedasticity-robust standard errors are presented in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

IV.   Impact of GovTech on Income Inequality

A. Theoretical Background

Digitalization helps address market and government failures, through which the poor's earning capacity could be enhanced. Digital technologies reduce transaction costs related to search, replication, transportation, tracking, and verification (Goldfarb and Tucker, 2019). By lowering the cost of searching for information in the labor market or public procurement, digital technologies have a potential to create job opportunities for the poor or promote the participation of small or female-owned businesses in market opportunities. This contributes to formalizing the economy with equalized market opportunities for marginal groups from different segments of society that tend to lack market access before.

Significant efficiency gains in public expenditure through GovTech adoption (as implied by empirical findings in section III) could possibly contribute to inclusive growth (Zouhar et al., 2021). Digitalization can yield large social dividends if it is done right (Amaglobeli et al., 2023; Kumar et al., 2023). As part of the National Digital Strategy (NDS), the government makes efforts to maximize social welfare by addressing the "digital divide" with a focus on "hard-to-reach" households in rural areas. For successful digital transformation, a country needs to develop an adequate GovTech enabling environment and digital infrastructure access.[20] The efficiency gain typically materializes with lags as it takes time to train or recruit government officials with competency in applying new technology.

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[20] Gender gaps in internet and mobile phone access (measured using Facebook data) are found to be large especially in low-income countries (Fatehkia et al., 2018). Based on this evidence, achieving inclusive digital access would be the pre-condition for reaping the full benefits of digitalizing budget planning and execution (Una et al., 2023).

The inclusion effect of GovTech likely depends on a country's level of informality, although the exact impact direction is ambiguous. GovTech adoption could create a larger positive externality when the private economy constitutes more formal business with widespread ICT technology adoption. On the contrary, economies with substantial informal sectors might experience larger marginal gains, especially if new technologies significantly enhance better targeting of "hard-to-reach" households. This hypothesis could be examined using cross-country data on informality (informal outputs-to-GDP ratio) covering 156 countries from 1990-2018 (Elgin et al., 2021).

B. Staggered GovTech Adoption: Treatment Effect by Cohorts

This subsection explores distributional consequences of GovTech using the event-study method. Digital technology has been rolled out and fully integrated into fiscal operations at a different time. Using the GTMI database, Figure 7 illustrates the year of GovTech adoption for countries in Asia and Pacific region in four key areas: the establishment of a dedicated GovTech institution (Figure 7a); the launch of TSA IT system with full integration to FMIS (Figure 7b); launch of e-Procurement platform (Figure 7c) and the digitalization of PIMS (Figure 7d).[21] As Figure 7d shows, the launch of PIMS is a recent event and many Asian countries are yet to establish IT system to systematically manage their capital budgets. Historically, countries that implemented GovTech early ("**longtime adopter**") are generally high-income or upper middle-income countries. In contrast, countries that adopted GovTech in later years ("**recent adopter**") are typically developing countries. The longtime adopters possess extensive experience in GovTech strategy implementation and the use of digital solutions in budget operations, making them more likely to reap larger benefits from GovTech initiatives.

The effect of digitalization is expected to differ across cohorts, grouped by the year when GovTech technology was adopted. Sun and Abraham's (2021) interaction-weighted estimator is used to estimate cohort-specific treatment effect on the treated, which allows the estimated effect to vary across cohorts.[22] The estimation proceeds in three steps.

- In **step 1**, the cohort-specific treatment effect on the treated (CATT) $\delta_{e,l}$ is estimated using a two-way fixed effects specification (equation 1) that interacts "relative time" indicator $D_{it}^l = 1[t - E_i \geq 0]$ (the number of years since the treatment year E_i) with cohort indicator $1[E_i = e]$ for cohort e.

$$y_{it} = \alpha_i + \lambda_t + \sum_{e \neq \max\{E_i\}} \sum_{l \neq -4} \delta_{e,l}\{1[E_i = e] \times D_{it}^l\} + \beta \mathbf{X}_{it} + \varepsilon_{it}$$

  where $\mathbf{X}_{it}$ is a vector of observed macroeconomic control variables (e.g., log per capita GDP (in PPP terms) and the square term, CPI, external debt, the share of agriculture, control of corruption). α_i and λ_t are unit and year fixed Effects. $CATT_{e,l}$ represents the average treatment effect for l period away from the year of treatment for each cohort.

- **Step 2** calculates the weight as the sample share of each cohort.

- **Step 3** uses $\widehat{\delta_{e,l}}$ and the weight to calculate the weighted average of CATT.

[21] See Annex V for the same event-study treatment plot for other regions.

[22] The estimator uses "last-treated units" as a control group to estimate potential outcomes. In this regard, the estimator relies on different identification assumptions from the estimators proposed by Callaway and Sant'Anna (2021) and Borusyak et al. (2023), which uses only not-treated observations ("never-treated" or "not-yet-treated" units).

Figure 7. Year of GovTech Adoption in the Asia and Pacific Region
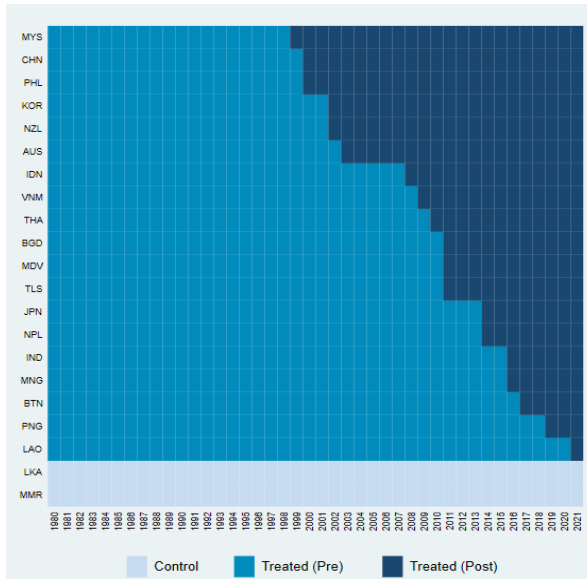
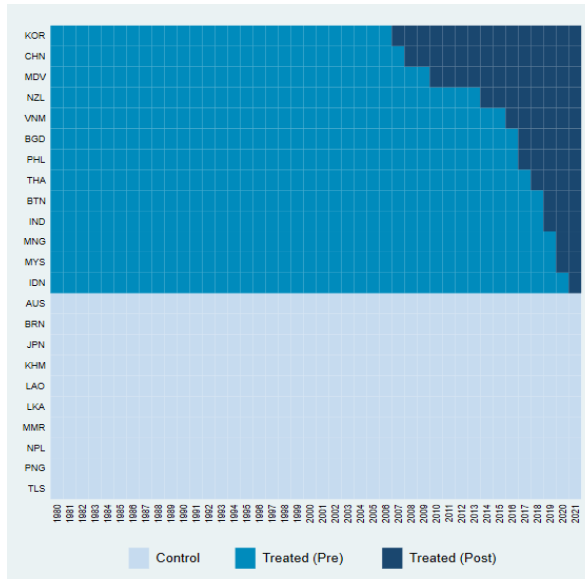*a. Establishment of a Dedicated GovTech institution*
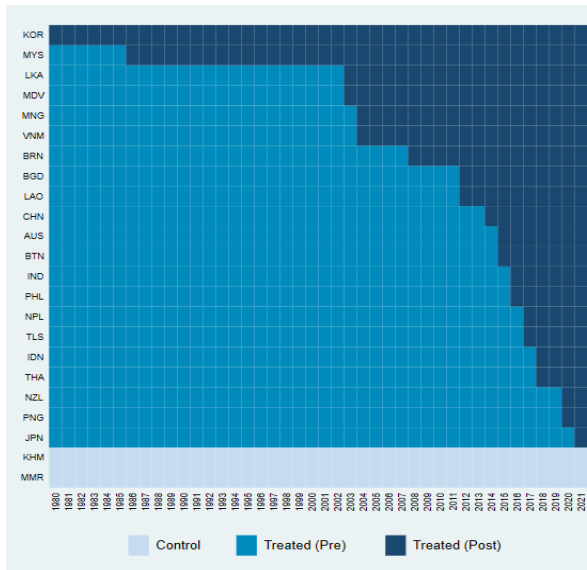
b. Launch of TSA IT System (linked with the FMIS)
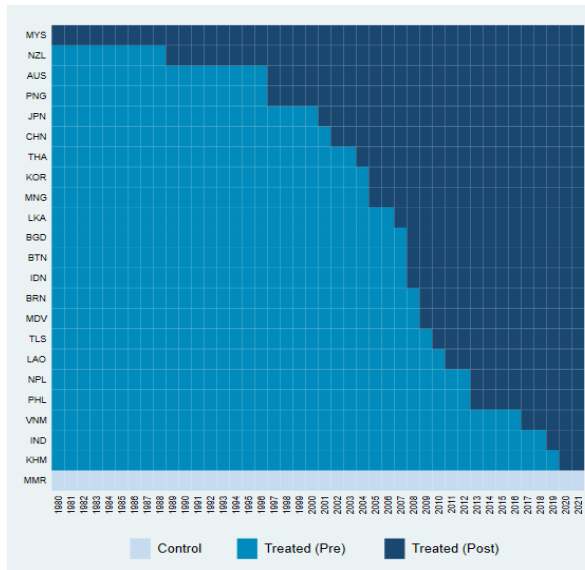
c. Digitalized e-Procurement Portal

d. Digitalized PIMS

Source: GovTech Maturity Index, 2020 and 2022.

Note: The dark blues indicate the period after the digitalization. The countries that are yet to digitalize respective government function are categorized as a control group.

C. Results

After the introduction of centralized GovTech institutions or digital budget payments, a country's income share of the poor (the bottom 50th percentile) and female workers tends to rise, on average.
Figure 8 compares the average treatment effect of each GovTech measure on treated (ATT) between two cohorts: "**recent adopter**" (a group that introduced the GovTech measure just recently and has only two years of experience) vs. "**longtime adopter**" (a group that has ten years of experience).

Main results are as follows:

- After the initiation of a national GovTech strategy (with a dedicated GovTech institution facilitating cross-agency coordination), countries tend to observe an increase in pre-tax income share, particularly among women. The finding suggests that GovTech initiatives may drive progress in gender equality agenda, albeit with delays. The positive impact on female income share increases by 1.6 percentage points over 10 years for longtime adopters. Given the sluggish pace of progress in gender inequality (as evidenced by a mere 4 percentage points increase in average female income share over 30 years since 1990, based on World Inequality Report (2022)),[23] the effect size emerges as impactful. The result also highlights the necessity for countries to allow longer adjustment periods to achieve success in new digitalization initiatives.

- The launch of digital budget payment via the TSA contributes to raising market income of the poor. By reducing leakages and inclusion/exclusion errors often associated with traditional cash or in-kind transfers, digital payments elevate the income share of the bottom 50th percentile by approximately 0.5 percent. Considering the persistently low income share of the bottom 50th percentile without a clear trend of improvement (World Inequality Report, 2022), the estimated gain due to digital payment emerges meaningful. The positive impact on female income share, although marginally significant, further underscores the potential to make positive strides through digital payment initiatives.

- The launch of digitalized PIMS does not exhibit a statistically significant inclusion effect. Unlike digital budget payments, public investment projects (primarily infrastructure investments serving as public goods) do not directly target the poor. It is also partly because many countries have yet to adopted PIMS.

Figure 8. CATT of GovTech on Income Inequality (by Cohorts)

Pre-tax Income Share of Bottom 50th Percentile

Female's Pre-tax Income Share
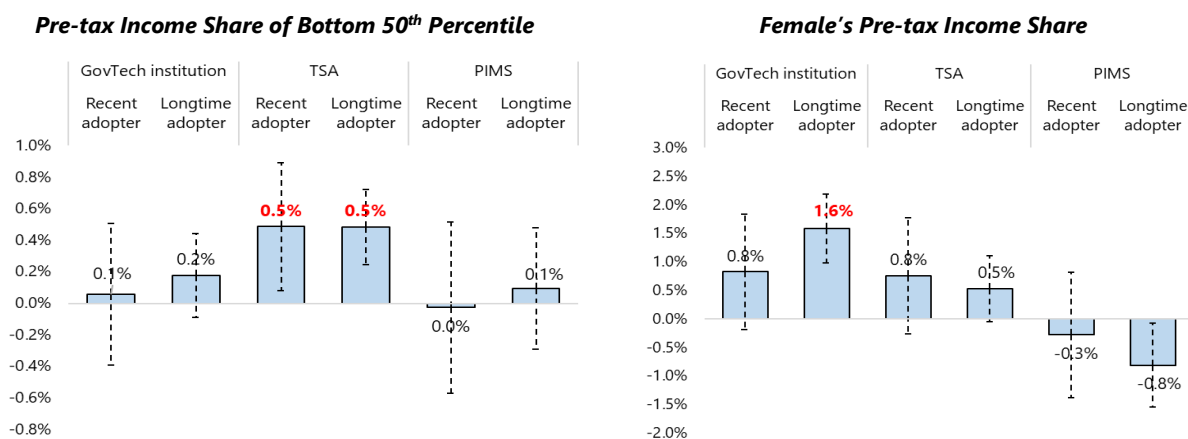
Source: Author's estimates.
Note: Outliers in the outcome variables are trimmed. Error bars indicate 95 percent confidence intervals.

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[23] Chancel L., Piketty, T., Saez, E, and G. Zucman (2022) "World Inequality Report 2022", Harvard University Press.

D.   Heterogeneity in Inclusion Effect by Enablers

The average effect masks significant heterogeneity across countries depending on a country's digital connectivity, GovTech enabling institutions, and informality (as similarly found in Table 3). Figure 9 highlights these disparities where the bar chart shows the mean difference in the distributional impact of GovTech institutions and digital budget payments between high and low categories (with individual effects for high or low groups marked in red circles or green squares, respectively).[24] High digital connectivity and mature GovTech institutions generally yield larger treatment effects.

Specifically, the result indicates that the initiation of a national GovTech strategy leads to increased pre-tax income shares of the bottom 50th percentile, particularly in EMDEs, provided there exist robust GovTech enabling maturity and institutional safeguards. Digital budget payments via TSA significantly raises income shares for the bottom 50th percentile in countries with high digital connectivity (Panel A). In EMDEs, the treatment effect of digital payments gets significantly larger for countries with high digital connectivity than those with low connectivity by 0.6 percent.

Regarding females' pre-tax income share, the treatment effect of GovTech institutions and TSA are consistently positive (around 2 percent) when digital connectivity and GovTech maturity are high. Nevertheless, in EMDEs, the impact of digital budget payments could be negative in case of weak digital connectivity or low GovTech enabling maturity.

As discussed in section IV.A, the impact of digital budget payment hinges on informality with mixed findings. Digital budget payments tend to positively impact the pre-tax income share of the bottom half of the population when informality is low, especially in AEs (Panel A). In contrast, the impact on female's pre-tax income is more pronounced in high informality contexts (Panel B). The latter is consistent with the well-known U-shape pattern seen in female labor force participation (FLFP) with regard to economic development (Goldin, 1994; Fruttero et al, 2020). This result implies that digital budget payment would have a more pronounced impact on the FLFP when the informal sector is large (mainly for low-income countries).

[24] Countries are categorized into high or low groups based on the median value of the digital connectivity index, GovTech enabler index, and informality index. Main results in Figure 9 remain broadly robust (though with different magnitudes) even when alternative threshold values are used.

Figure 9. Heterogeneous Effect of GovTech on Income Inequality

Panel A. Impact on the Pre-tax Income Share of Bottom 50th Percentile
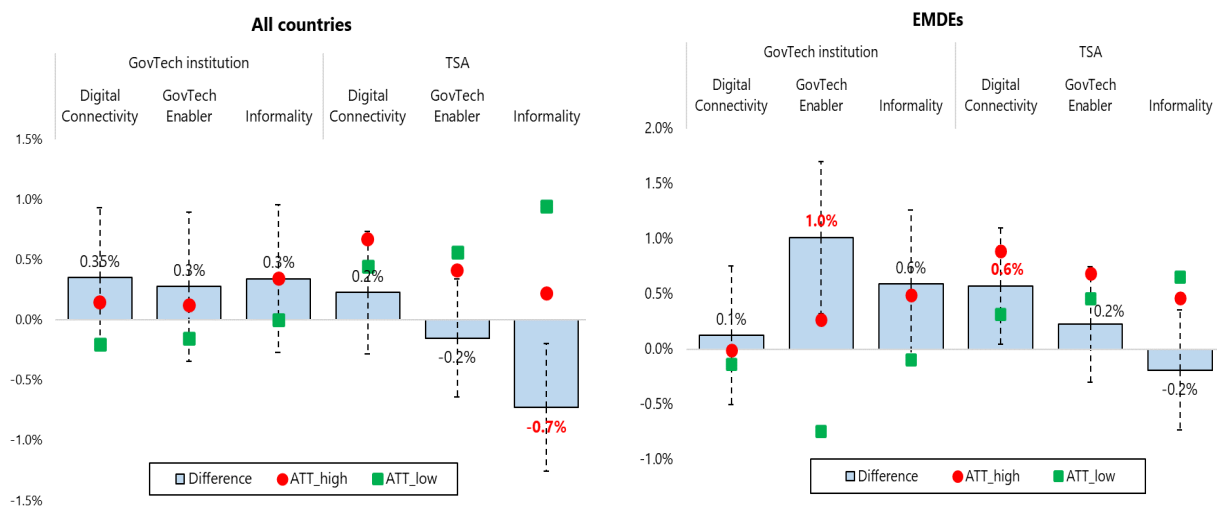
Panel B. Impact on the Female's Pre-tax Income Share
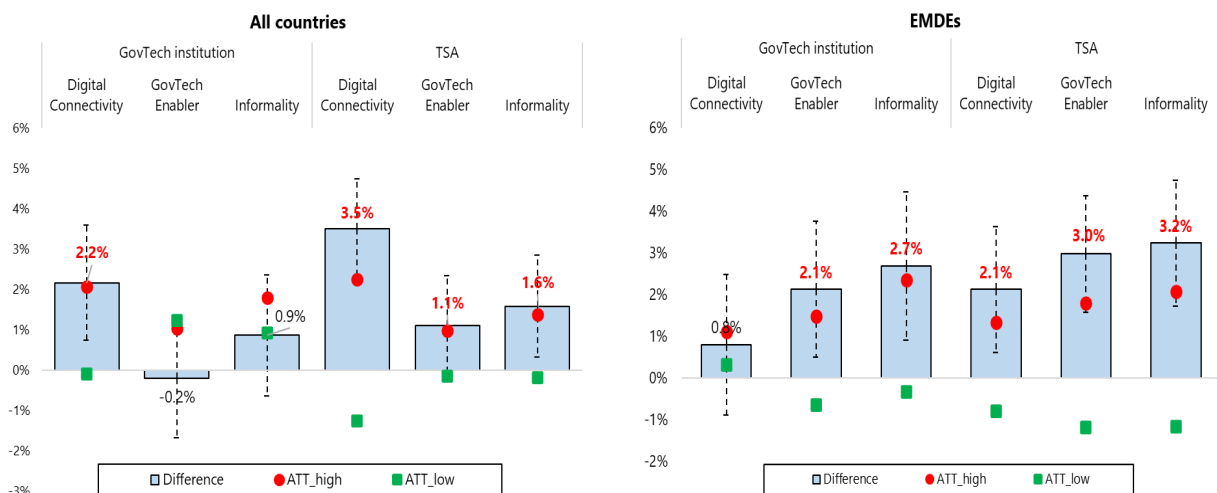
Source: Author's estimates.

Note: Error bars indicate 95 percent confidence intervals. High vs. low groups in digital connectivity, GovTech enablers, and informality are defined by the Alper and Miktus (2019)'s EDAI, the GTMI enabler index, and Elgin et al (2021)'s informal output-to-GDP ratio using their median value as the threshold.

E. Synthetic Control Estimation: Dynamic Impact with Lags

This subsection applies a synthetic control (SC) with staggered treatment (Abadie, 2021; Arkhangelsky et al., 2021; Xu, 2017) to robustly estimate the dynamic effect of digitalization on income inequality. The SC method relaxes the often-violated assumption of parallel trend in the difference-in-difference design by reweighting units to match their pre-treatment trends.[25] This paper uses generalized synthetic control (Xu, 2017) that unifies the SC method with a linear fixed effect model. The imputation of counterfactuals based on a linear interactive fixed effect model addresses the endogeneity of GovTech adoption related to unobservables, which allows the correlation between the treatment and unobserved unit and time heterogeneities. Furthermore, the method supports unbalanced panel data unlike synthetic difference-in-difference (Arkhangelsky et al., 2021). This paper estimates the following linear factor model with two-way fixed effects:

$$y_{it} = \beta GT_{it} + \gamma_{it}\mathbf{X}_{it} + \delta_i\mathbf{f_t} + \lambda_i + \mu_t + \varepsilon_{it} \quad (2)$$

where the treatment indicator GT_{it} equals one if country i has adopted digital technologies at time t and zero otherwise. $\mathbf{X}_{it}$ is a vector of observables and $\mathbf{f_t}$ is a vector of unknown factor loadings (in a linear additive form). The number of factors is automatically chosen through a cross-validation procedure. The dynamic treatment effect for country i at time t is the difference between the actual and counterfactual outcomes:

$$\widehat{\tau_{i,t}} = y_{it} - \sum_{j \neq i}^{J} w_j^* y_t$$

Annex VI reports the specification test that compares the dynamic average treatment effect (ATE) estimates between a traditional two-way fixed effect (TWFE) OLS model and generalized synthetic control. With my data, the estimated coefficient using a traditional TWFE (or an alternative DID estimator like Borusyak et al (2023)) tends to be unstable with large standard errors, partly due to the violation of parallel trend. In contrast, the performance of generalized SC is relatively stable with tighter confidence intervals and provides better identification of the treatment effect.[26]

The actual and counterfactual estimate are closely aligned in the pre-treatment period, illustrating the validity of pretreatment fit of the generalized SC model (Figure 10)**.** In the analytical sample, the number of pre-treatment period is sufficiently large such that the bias of $\widehat{\tau_{i,t}}$ is minimized (Abadie, Diamond, and Hainmueller, 2010). The gap in actual treated average (bold line) and the estimated counterfactual average (dash line) after the treatment year (time 0; dashed vertical line) represents the dynamic ATE of GovTech adoption. In Figure 10, the pre-tax income share of the bottom 50th percentile starts to grow faster after 7 years of digital payment adoption for treatment group relative to control group. Similarly, the pre-tax female income share shows clear bifurcation between treatment and control group immediately after the technology adoption. The gap in the average pre-tax female income share continues to expand over time.

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[25] The SCM constructs the counterfactual trajectory of income share in the absence of a GovTech adoption by taking the weighted average of countries without a GovTech such that it closely resembles the economic structure and outcomes of the country with a GovTech. Specifically, The SC algorithm chooses the optimal country weight w_j^* such that the synthetic country matches the pre-treatment trajectory of the outcome variable of the treated country as closely as possible.

[26] My preferred SC specification includes only country fixed effect given that it minimizes the mean squared prediction error (MSPE). Given limited number of control group, the performance of an SC model with both country and year fixed effects is unstable with larger MSPE. The specification test is summarized in Annex VI.

Figure 10. Synthetic Control Estimation in Digital Budget Payment
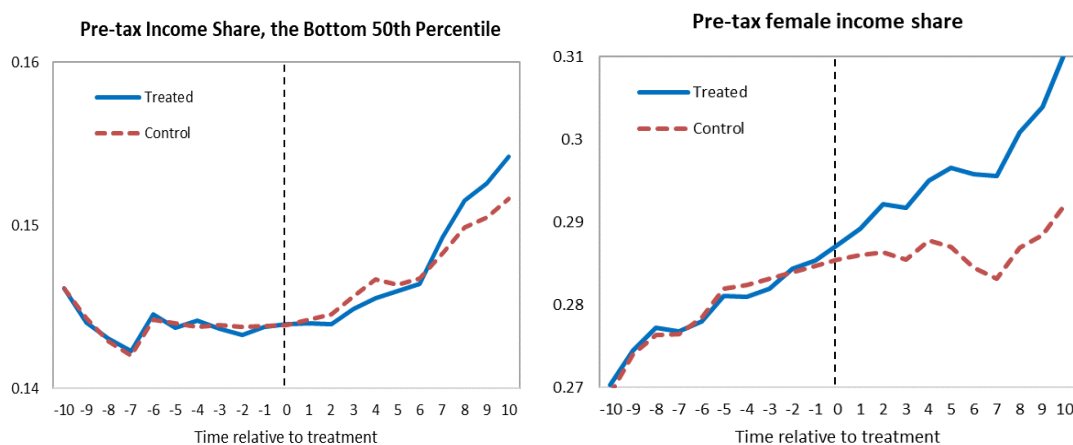
Note: The figure shows the synthetic control estimates in case of the adoption of digital treasury payments. The left chart is the effect on income share of the bottom 50th percentile and the right chart is on female income share.
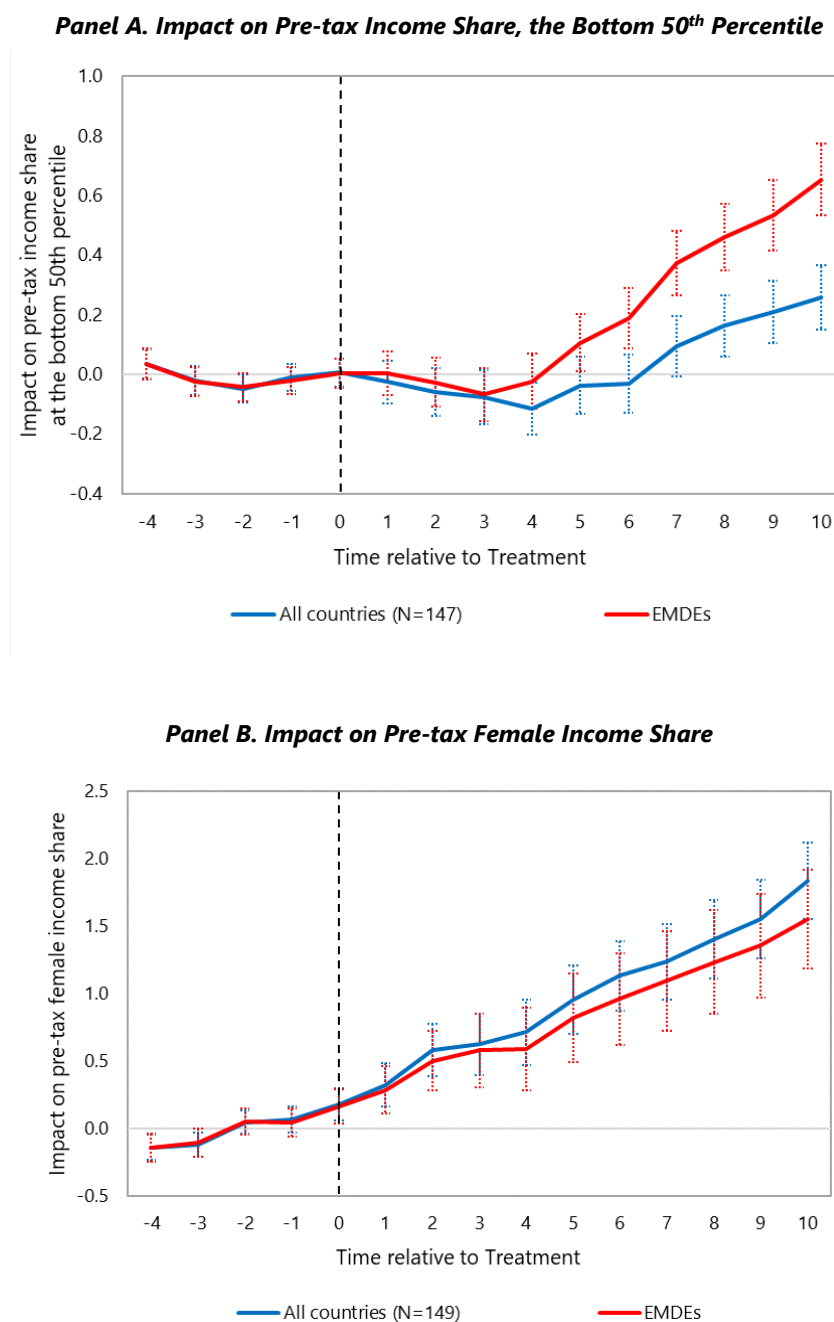
Figure 11 presents the dynamic average treatment effect of digital budget payments (through TSA/FMIS) on income share of the bottom 50th percentile (Panel A) and on female (Panel B). The result is shown separately for all economies and EMDEs.

▪ In Panel A, adopting digital budget payments leads to a notable increase in the pre-tax income share of the bottom half of population. This impact is more pronounced and immediate in EMDEs compared to AEs, consistent with the diminishing marginal returns of GovTech as national income rises (Figure 2). In EMDEs, a significant positive effect materializes after 5 years from adoption, signifying the time required for implementing accompanying institutional reforms. This effect accumulates to reach 0.65 percentage points over 10 years. Across all countries, the positive distributional effect emerges with a delay, typically 7-8 years after adoption.

▪ In Panel B, the findings similarly demonstrate that the introduction of digital budget payments leads to an increase in pre-tax female income share. This impact gradually increases, reaching about 1.8 percentage points over 10 years. There is no statistically significant difference in the treatment effect between the overall sample and EMDEs.

The impact of digital budget payments on the poor and female workers gets larger with robust digital connectivity and GovTech enabling institutions in place (Figure 12). Within the sub-sample of countries with a dedicated GovTech institution (green line), high GovTech enabling institutions (red line), and high digital connectivity (purple line), the ATT increases at a faster rate than the baseline over time.[27] The estimated heterogeneous effect using the SC method aligns with the finding in Figure 9. Notably, Panel A underscores strong complementarity between a centralized GovTech agency and digital budget payments. This is consistent with a strong positive interactive effect between the two, as found in Table 3.

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[27] The threshold values defining high groups are selected to ensure an adequate number of treatment and control groups in running the SC estimation (in Figure 12). Specifically, countries with digital connectivity index above the 25 percentile value (excluding the last miles, below green line in Figure 2) are classified as high digital connectivity group. Countries with GTMI Enabler index above the 40 percentile value (above red line in Figure 2) are categorized as high GovTech Enabler. Even when including countries on the margin (between the 25th to 40th percentile values of GovTech enabler index, between green and red lines in Figure 2), main results remain robust.
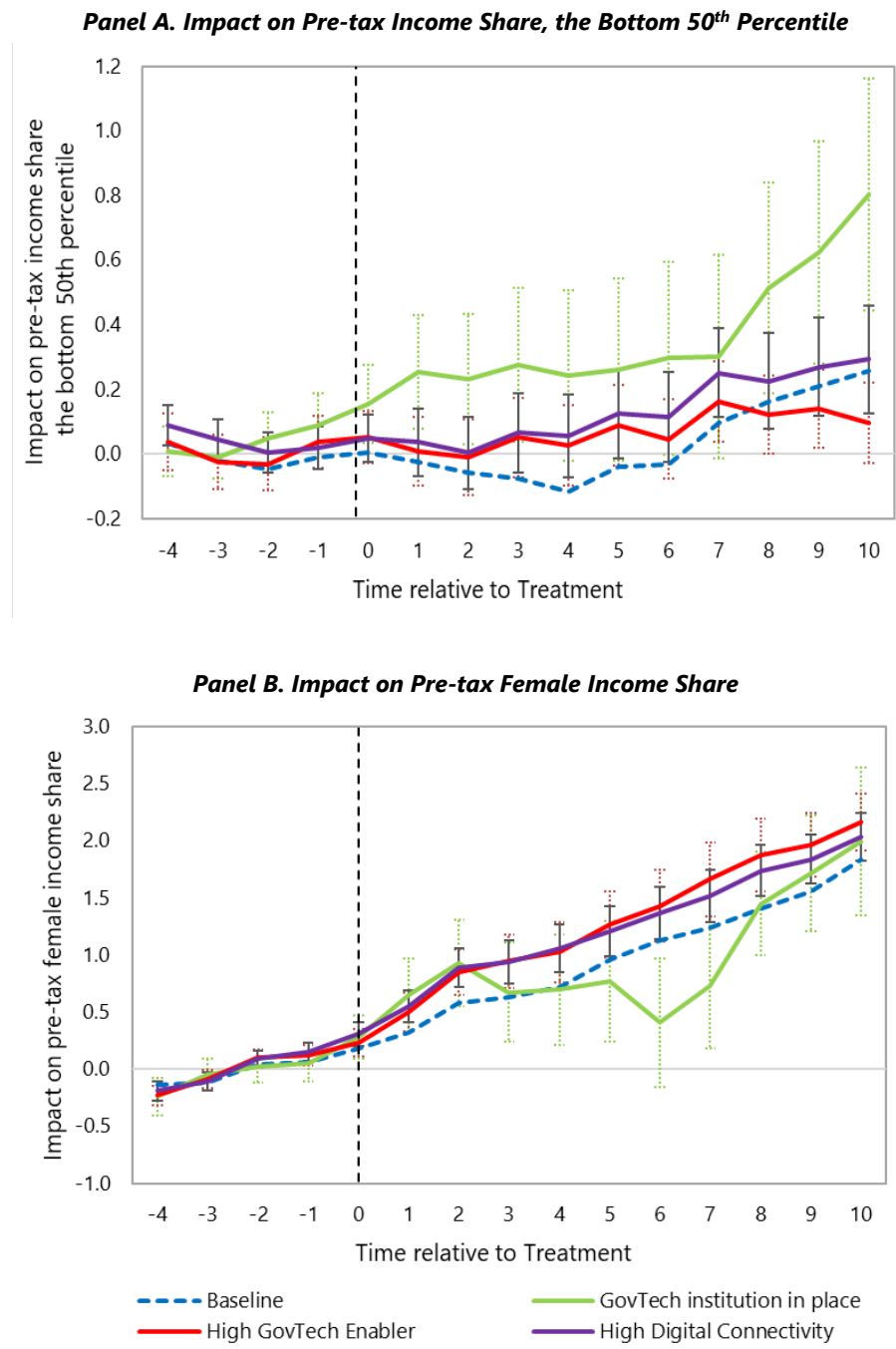
Figure 11. Dynamic Treatment Effect of Digital Budget Payments with FMIS/TSA

Panel A. Impact on Pre-tax Income Share, the Bottom 50th Percentile

Panel B. Impact on Pre-tax Female Income Share

Source: Author's estimates.
Note: The figure shows the synthetic control estimates in case of the adoption of digital treasury payments. Error bars indicate 95 percent confidence intervals computed using a parametric bootstrap procedure. The charts include the additive component of country fixed effects which minimizes the mean square prediction errors. The number of unobserved factors is automatically selected based on a cross-validation procedure.

Figure 12. Heterogeneous Treatment Effect of Digital Payments with FMIS/TSA

Panel A. Impact on Pre-tax Income Share, the Bottom 50th Percentile

Panel B. Impact on Pre-tax Female Income Share
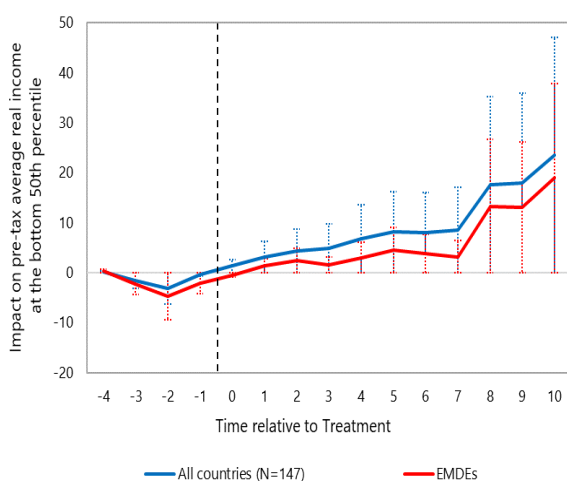

Source: Author's estimates.

V.   How Does GovTech Foster Inclusion?

The literature acknowledges the benefit of digital payments (such as Fintech) in reducing business informality. Recent studies highlight how Fintech initiatives alleviate financial constraints for the poor and women, thereby enhancing their labor force participation (IMF 2023; Bakker et al., 2023). Digital payments, accessible regardless of recipients' physical location, tend to be more inclusive than traditional cash or in-kind transfers. This helps reduce exclusion errors, expanding the coverage of transfers to unbanked populations living in remote areas. For example, Paraguay successfully implemented *Pytyvõ* cash transfer program for informal sector workers by adopting mobile money as the main mean of payment (Una et al., 2023). Fintech payments similarly help reduce inclusion errors by improving payment transparency through timely and systematic collection, processing, and publication of payments integrated into the FMIS.[29] Moreover, the benefit of digitalization extends beyond financial benefits through better coverage and efficiency of SSN as it also has the potential to improve basic public services in education and health (Wang and Bloch, 2023; Michaud-Leclerc and Moszoro, 2023; Bird and Hanedar, 2023).

The event-study analysis reveals a steady increase in real income of the poor and a reduction in business informality following the adoption of digital payments (Figure 13). The average real income of the poor gradually increases and reaches about 20 percent higher in real terms over 10 years (left chart). This translates to annual real income gains of about 2 percent. Using the Informal Economy database, the analysis also corroborates a gradual reduction in the size of informal businesses after GovTech adoption, with informal outputs reaching 3 percentage points lower as a percent of GDP within 10 years (right).

Figure 13. The Channels behind the Inclusion Effect of Digital Payments

Impact on Real Income of the Bottom 50th Percentile   *Impact on Informality*
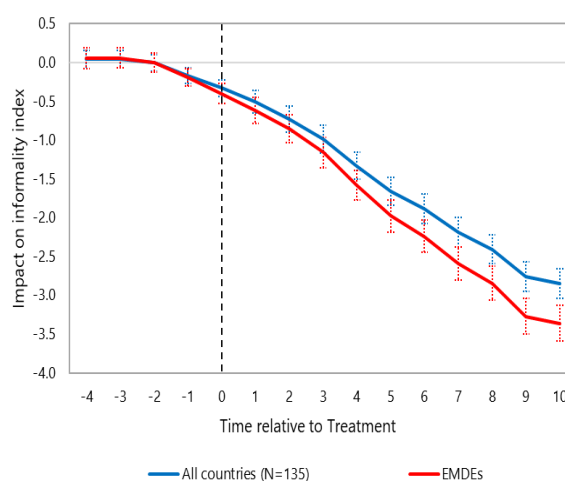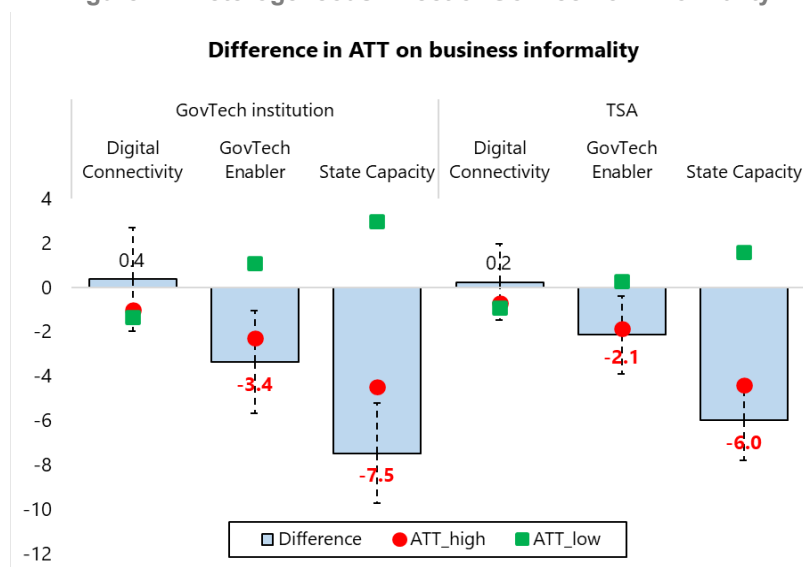
Source: Author's estimates.

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[29] See Wendling et al. (2020) for the example of improved transparency of COVID-19 emergency support to vulnerable households thanks to fintech payments of cash transfers in Iceland, Indonesia, Peru, and the United Kingdom.

Overall, the digitalization of public services improves pre-tax income distribution through various channels, including enhanced fiscal transparency and expenditure efficiency, lower corruption, and lower transaction costs for informal businesses to register as formal businesses. South Asia's experience highlights the transformative potential of establishing foundational Digital Public Infrastructure (DPI) in promoting inclusive growth and narrowing gender gaps (IMF 2023; Alonso et al., 2023). For example, India's pioneering DPI, known as "India Stack", which encompasses unique digital identification, payments systems, and data exchange,[30] has spurred innovation, market expansion, financial inclusion, and boosted government revenue and expenditure efficiency. Alonso et al. (2023) report that India's digital infrastructure development and governance reforms resulted in significant fiscal savings and timely fiscal supports for vulnerable population during the COVID-19 pandemic. While identifying the importance of each mechanism is left for future empirical research, this paper contributes new evidence, showing the reduction in business informality as the primary channel behind the equity benefits of GovTech initiatives.

The reduction in business informality due to GovTech institutions and digital budget payments is contingent upon GovTech enabling maturity and a country's state capacity (Figure 14). In consistent with India's case study, the most significant reduction in informality occurs through public service digitalization when mature GovTech enabling institutions and strong state capacities are present.

Figure 14. Heterogeneous Effect of GovTech on Informality

Source: Author's estimates.
Note: Error bars indicate 95 percent confidence intervals. High vs. low groups in digital connectivity, GovTech enablers, and state capacity are defined by the Alper and Miktus (2019)'s EDAI, the GTMI enabler index, and ICRG's quality of government indicator using their median as the threshold value.

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[30] India's Stack is the collective name of a set of commonly used DPIs in India - "unique identity (Aadhaar), "complementary payments systems" (Unified Payments Interface, Aadhaar Payments Bridge, Aadhaar Enabled Payment Service), and "data exchange" (DigiLocker and Account Aggregator). Together, they enable online, paperless, cashless, and privacy-respecting digital access to a variety of public and private services.

VI. Conclusion

The empirical studies that examine the size of efficiency gains from GovTech and its equity impact are scarce. The benefits of digitalization are felt to be prominent during the pandemic, though the size of digital dividend remains unclear. The efficiency gains are not uniform and heterogeneous across countries depending on the private sector's access to digital infrastructure and the soundness of GovTech enabling institutions. Given the pre-existing digital divide within and across countries, the equity implication of digitalization is *a priori* ambiguous, which needs robust empirical evidence.

Using granular GovTech index, an event-study analyses consistently show that digital payments and e-procurement could enhance budget transparency and strengthen expenditure efficiency. The GovTech index is positively associated with budget transparency and the efficiency of public expenditure. The panel regression provides robust evidence to confirm such cross-country correlations, controlling for comprehensive sets of covariates.

Digital budget payments, besides the efficiency gains, have the potential to gradually raise the market income of poor individuals and female workers, contingent upon adequate digital connectivity and GovTech enabling institutions. A centralized GovTech coordination agency is found to play a critical role (though not sufficient) in reaping both efficiency and equity gains of GovTech. A reduction in business informality is found to be one of the primary channels behind the equity benefit of GovTech. In LIDCs with a high informal sector, digital budget payments could create a prominent impact on gender equity, which appears consistent with the U-shape pattern of female labor force participation.

The findings lend general support to advancing the GovTech agenda, but significant heterogeneity in treatment effect underscores the importance of policy designs in promoting digitalization. Digitalization in fiscal operations should continue, supported by technical assistance from development partners, to further strengthen fiscal transparency and expenditure efficiency. However, when formulating policies to encourage digital adoption, the government must address gaps in the FMIS function, data exchange capabilities, interoperability between old and new IT systems, and legal and regulatory framework. In low-income countries with limited digital network coverage and state capacity, unintended negative outcome may arise, leaving vulnerable population unattended. To reap full benefits of digitalization, the government must invest in ICT infrastructure, promote digital skill development, and coordinate inter-agency GovTech initiatives to establish adequate GovTech enabling institutions.

While the analysis provides new cross-country perspectives, results should be treated with caution. The analysis relies on the timing of GovTech adoption (at the extensive margin) and cross-sectional information on the intensity of digital adoption in PFM currently available in the 2022 GTMI dataset. As World Bank (2022) notes, the compiler of the GTMI data validates the source data through multiple processes (with inputs from World Bank experts and country officials), though possible measurement errors due to lack of official records should still be noted. In future research, the analysis should be strengthened with better measurement of each country's status of GovTech adoption at the intensive margin over time. Like other cross-country analyses, country-specificity also needs to be carefully considered in combination with detailed case studies.

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Annex I. List of Variables

A. Measure of Government Digital Adoption

1. World Bank GTMI Aggregate Index

- *GT1: **Supporting core government systems*** ("**Core Government systems**"). the composite score (normalized) captures the modernization and integration of government systems through cloud services, interoperability framework, and other digital platforms. It covers digital technologies in tax administration, treasury and budget operations, public procurement (e.g., e-procurement), public investment management, and human resource management.

- *GT2: **Enhancing public service delivery*** ("**Public service delivery**"). the composite score (normalized) measures the presence of government's online service portals and the maturity of government public services in tax administration, e-payment, custom administration and so forth. It accounts for the simplicity, transparency, and universal accessibility of government online services. The index also accounts for services accessibility from demand-side, e.g., affordability of digital solutions such as mobile phones and free open-source applications to reach all intended beneficiaries and users.

- *GT3: **Mainstreaming citizen engagement*** ("**Citizen engagement**"). the composite score (normalized) captures the progress in citizen's on-line participation and feedback process in policy decision through the CivicTechtools (e.g., citizen feedback and complaint-handling mechanisms) on the Open Government/data portal. It also accounts for the degree of government's efforts to achieve greater transparency using accountability tools as well as the government's responsiveness to public options (e.g., response time, information disclosure policy).

- *GT4: **Fostering GovTech enabling factors*** ("**GovTech enablers**"). the index measures a country's progress in the establishment of legal and regulatory regimes, safeguarding institutions, and national strategy to promote the GovTech agenda. The index is constructed based on 16 key indicators related to the foundations of digitalization. The indicators are related to data governance, citizen's right-to-information (RTI) law, data protection and privacy law, data-driven service orientation (e.g., digital identification system, digital signature), ITU's cybersecurity index, citizen's digital skill level and skill development strategy, public sector innovation strategy, and private sector involvement in GovTech.

Annex Table AI.1. Summary Statistics: GovTech Measures

	N	Mean	Std dev.	p25	p50	p75
Panel A. Aggregate GTMI index						
GT1 (Core Government System)	186	0.494	0.224	0.315	0.467	0.668
GT2 (Public Service delivery)	186	0.614	0.244	0.434	0.646	0.815
GT3 (Citizen Engagement)	186	0.469	0.301	0.196	0.403	0.789
GT4 (GovTech enablers)	186	0.536	0.281	0.273	0.544	0.793

Source: World Bank.

2. World Bank GTMI Sub-Index (used for the analysis)

➢ The **dedicated GovTech institution**
  - o   Digital government strategy should be typically supported by a dedicated agency to implement newly emerging initiatives and whole-of-government approach, while addressing country-specific challenges in the implementation in alignment with each country's national priorities, capacity and budget constraint. In most countries, the *centralized* approach – establishing the dedicated organization – is a stepping-stone to promote an inter-agency coordination for digital transformation.
  - o   The availability of GovTech institutions is not a sufficient condition for the success in digitalization agenda (World Bank, 2021). The implementation status is mixed and varies widely across countries depending on the country's capacity and resource constraints, digital inclusion, data privacy, cybersecurity, and other factors.

➢ The **Treasury Single Account (TSA) IT system**
  - o   In many countries, core PFM system (e.g., Financial Management Information System (FMIS), budget planning, cash management, commitment control, tax, customs, debt management, and HR management information system) is not fully interconnected. The data exchange could be automated by adopting web services or application programming interfaces (APIs).
  - o   A launch of TSA IT system will improve the interconnectivity and interoperability of existing PFM systems. The centralized TSA at the central bank will also improve the efficiency of budget financial and treasury operations.
  - o   Budget payments to beneficiaries will be more efficient when a TSA IT system is integrated with an FMIS in automating cash payments and back reconciliation.

➢ The **e-Procurement** portal
  - o   E-procurement platform as directed by a potential buyer (a government agency or firm) would facilitate transactions between buyers and potential sellers of goods and services related to recurrent budgetary and/or capital budget transactions.
  - o   The integrity, transparency, and efficiency of public spending attract large public attention and concern. E-procurement has potential to make a radical change in improving the efficiency of public procurement, which will likely benefit buyers as well as suppliers and citizens.

➢ The **Public Investment Management System** (**PIMS**)
  - o   Once projects are registered at the Public Investment Management Information System (PIMIS), it streamlines, automates, and supports the management of the public investment throughout the entire project lifecycle - the submission, review, and approval of project proposals, as well as the execution and monitoring of the projects. The centralization of PIMS is expected to improve efficiency and transparency in implementing infrastructure investments.

B.   Definition and Sources: Digitalization and Budget Transparency Variables

Measure	Definition	Source
GTMI Sub-index A dedicated GovTech institutions	The presence of a government body focused on GovTech – digital transformation, whole-of-government strategy, services, and so on. (0/1)	World Bank GTMI
TSA IT system fully operational	The centralized TSA (treasury account at Central Bank) is interconnected with FMIS, data exchange is automated, and the IT system fully operational, capturing both revenue and expenditure transactions for more than 75 percent of total transactions. (0/1)	World Bank GTMI
E-procurement platform	E-procumbent portal supports public procurement including the announcement of tenders and publication of contract information (0/1)	World Bank GTMI
Public investment management system operational	The presence of public investment management system (PIMS), which streamlines, automates and supports the management of public investment lifecycle, involving the submission, review, and approval of project proposals as well as the execution and monitoring of the projects (0/1)	World Bank GTMI
Digital accessibility data Enhanced Digital Access Index (EDAI)	The composite digital connectivity index (normalized), summarizing the level of country's digital connectivity from both demand-side (affordability of access, education level of population, actual internet usage) and supply-side (availability of digital infrastructure, the quality of ICT services).	Alper and Miktus (2019)
Percent of work-age population using internet	The percentage of work-age population with internet access	International Telecommunication Union (ITU)
Budget transparency Open Budget Index (OBI)	The average score of questions on public's access to timely and comprehensive budget information related to key budget documents (including pre-budget statement; executive's budget proposal; enacted budget; citizen's budget; in-year, mid-year, and end-year reports; and audit report). The score above 61 indicates that a country is publishing sufficient information for public debate (the value ranges from 0 to 100)	International Budget Partnership (IBP)'s Open Budget Survey
Public Participation Index	The measure of public participation in budget decision-making and monitoring	International Budget Partnership (IBP)'s Open Budget Survey

Annex II. Coefficient Plot: Heterogeneous Impact of GovTech Services on Budget Transparency

Annex Figure AII.1. Heterogeneous Impact of GovTech Services (GT2) on Budget Transparency (between High vs. Low group)
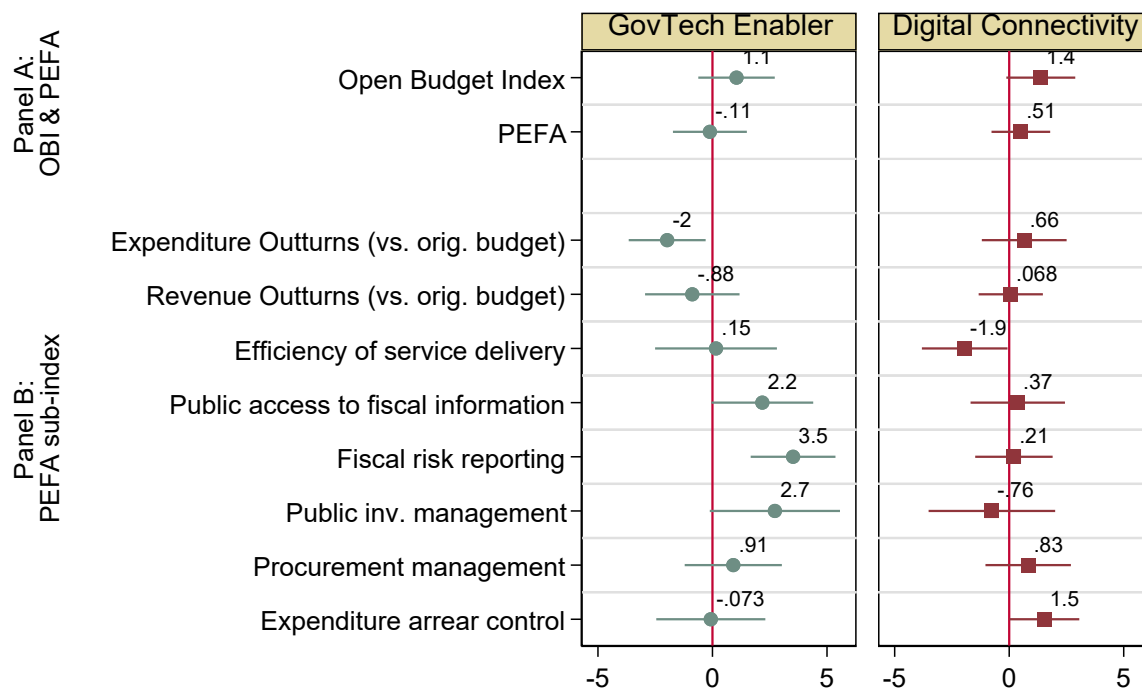
Note: High vs. Low defined by 40th percentile threshold value of GovTech Enabler Index and Enhanced Digital Connectivity Index. Result using 25th percentile threshold value is similar with smaller impact heterogeneity between two groups.

Annex III. Regression Results for EMDEs

Annex Table AIII.1. Two-way Fixed Effect Model – Effect on Budget Transparency in EMDEs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OBI (IBP)						Public Participation (IBP)					
E-Government Index	38.051*						68.158***					
	(20.269)						(17.179)					
Establishment of GovTech institution		0.021						-0.004				
		(1.773)						(1.244)				
TSA/FMIS adopted with e-payment			4.597***						3.510**			
			(1.764)						(1.422)			
TSA/FMIS adopted with mobile payment				6.882***						4.257***		
				(1.709)						(1.365)		
e-Procurement adopted with network interface					10.918***						4.769***	
					(1.618)						(1.372)	
PIMS fully adopted						8.032***						-0.176
						(2.729)						(1.733)
Log (Per Capita GDP_PPP), lagged	56.349***	75.002***	77.717***	74.642***	87.437***	76.904***	32.454	43.406***	45.757***	43.722***	55.818***	46.237***
	(20.180)	(12.977)	(13.153)	(13.370)	(13.602)	(13.172)	(20.479)	(9.564)	(9.573)	(9.721)	(9.241)	(9.933)
Square log (Per Capita GDP_PPP), lagged	-3.901***	-4.676***	-4.854***	-4.697***	-5.439***	-4.832***	-2.214*	-2.629***	-2.773***	-2.663***	-3.337***	-2.804***
	(1.106)	(0.737)	(0.749)	(0.760)	(0.760)	(0.752)	(1.129)	(0.548)	(0.554)	(0.560)	(0.533)	(0.574)
CPI inflation, lagged	82.689***	11.547	9.621	13.902	15.057	13.845	-5.403	13.662*	13.618*	15.776**	10.018	14.555*
	(23.062)	(14.162)	(13.534)	(13.844)	(14.550)	(13.823)	(22.524)	(7.970)	(7.671)	(7.979)	(7.292)	(8.028)
External debt (%GDP), lagged	-0.408	-0.316	-0.514	-0.766	-0.056	-0.402	-9.442**	-2.142	-2.293*	-2.413*	-1.960	-2.386*
	(3.131)	(2.034)	(2.006)	(1.996)	(1.998)	(2.012)	(3.694)	(1.362)	(1.377)	(1.371)	(1.395)	(1.392)
Log (Agriculture, %GDP), lagged	-4.192*	-2.216	-4.021**	-3.681*	-4.890**	-3.573*	-2.382	-2.912**	-4.050**	-3.694**	-4.625***	-3.353**
	(2.422)	(1.727)	(2.017)	(1.996)	(1.959)	(1.866)	(3.149)	(1.392)	(1.550)	(1.535)	(1.512)	(1.495)
Rule of Law	14.803***	15.834***	15.377***	15.342***	14.261***	15.728***	2.832	5.679***	5.348***	5.198***	4.491***	6.040***
	(2.081)	(1.462)	(1.465)	(1.426)	(1.400)	(1.497)	(2.710)	(1.268)	(1.241)	(1.227)	(1.283)	(1.328)
Constant	-156.778*	-241.772***	-249.885***	-236.535***	-290.477***	-244.395***	-114.559	-150.651***	-159.384***	-150.985***	-203.417***	-160.468***
	(90.281)	(56.557)	(57.462)	(58.405)	(60.902)	(57.029)	(94.511)	(41.572)	(41.172)	(41.939)	(40.317)	(42.518)
Observations	225	533	522	522	522	526	81	341	333	333	333	337
Number of countries	82	92	90	90	90	91	81	92	90	90	90	91
Adj. R-squared	0.4883	0.4264	0.4303	0.4414	0.4621	0.4423	0.4537	0.2957	0.3142	0.3167	0.3156	0.3027
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Income FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Annex IV. Heterogeneous Impact of GovTech Services on Social Assistance

**Annex Figure AIV.1. Heterogeneous Impact of GovTech Services (GT2) on Social Assistance
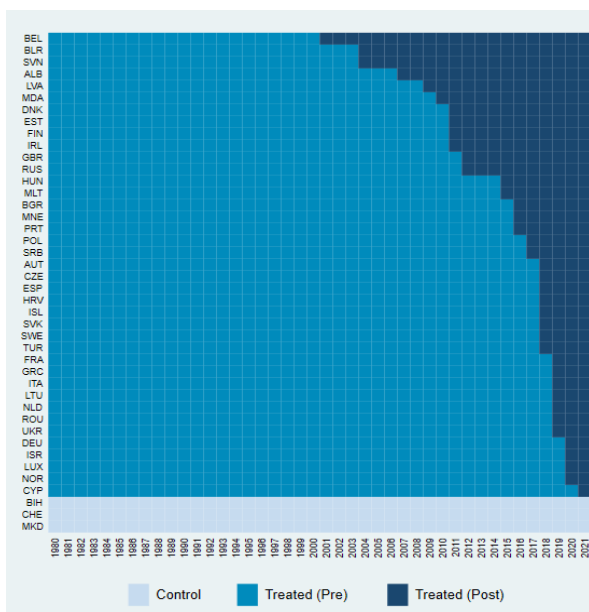(between High vs. Low group)**
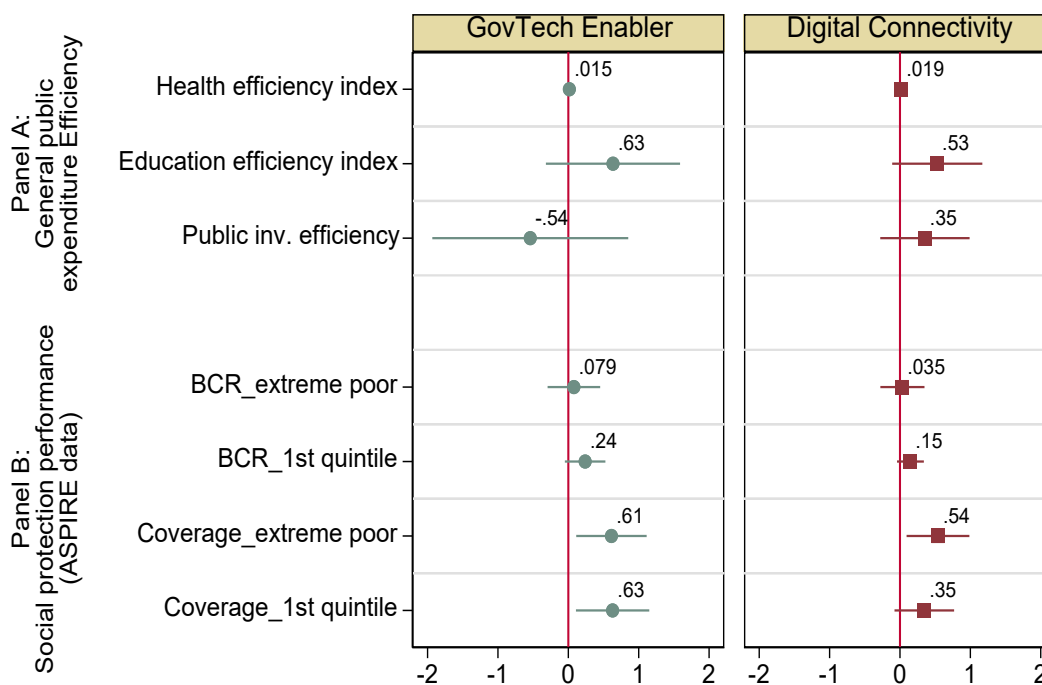
Note: High vs. Low defined by 25th percentile threshold value of GovTech Enabler Index and Enhanced Digital Connectivity Index.
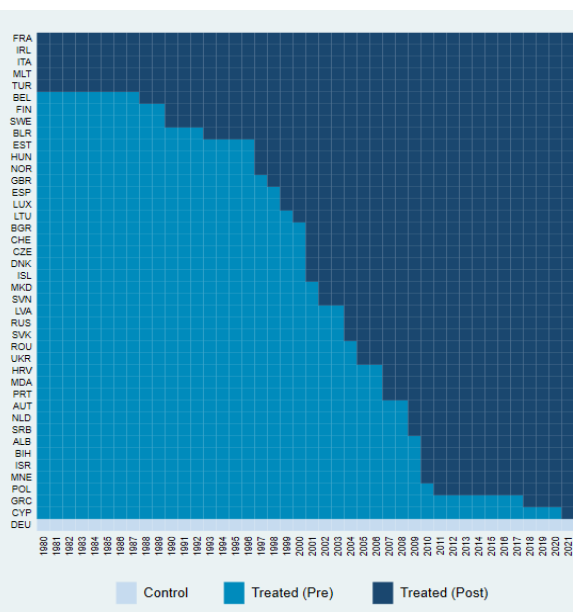
Annex V. GovTech Adoption Status in Other Regions

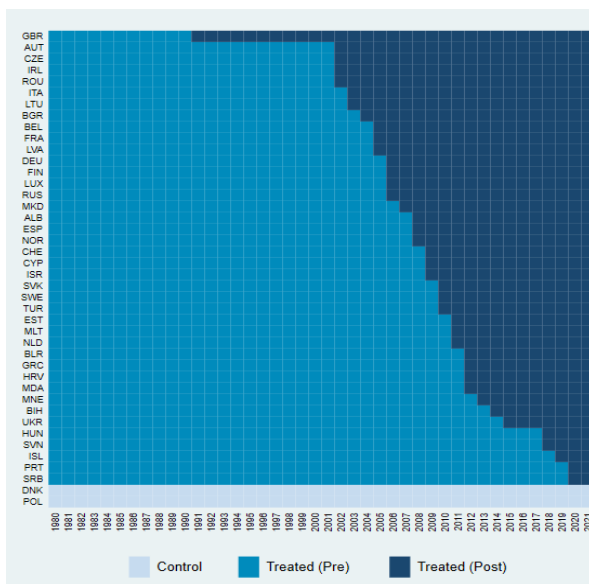**Annex Figure AV.1. Year of GovTech Adoption in the European Region**
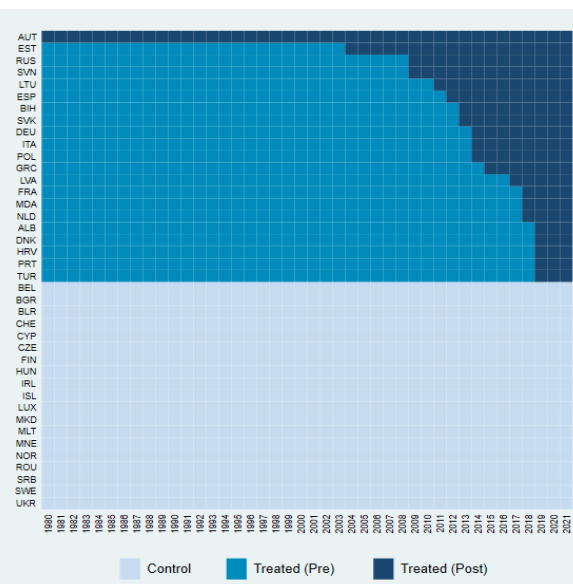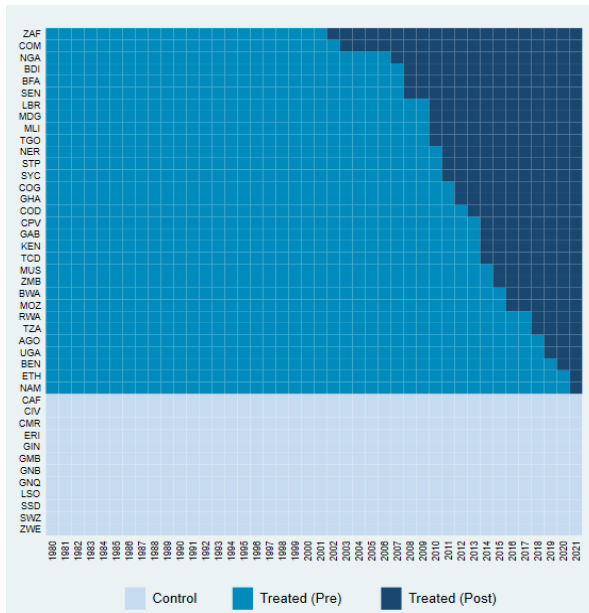
a. Establishment of a Dedicated GovTech institution

b. Launch of TSA IT System (linked with the FMIS)

c. Digitalized e-Procurement Portal

d. Digitalized PIMS

Source: GovTech Maturity Index, 2020 and 2022.

Note: The dark blues indicate the period after the digitalization. The countries that are yet to digitalize respective government function are categorized as a control group.

Annex Figure AV.2. Year of GovTech Adoption in the African Region

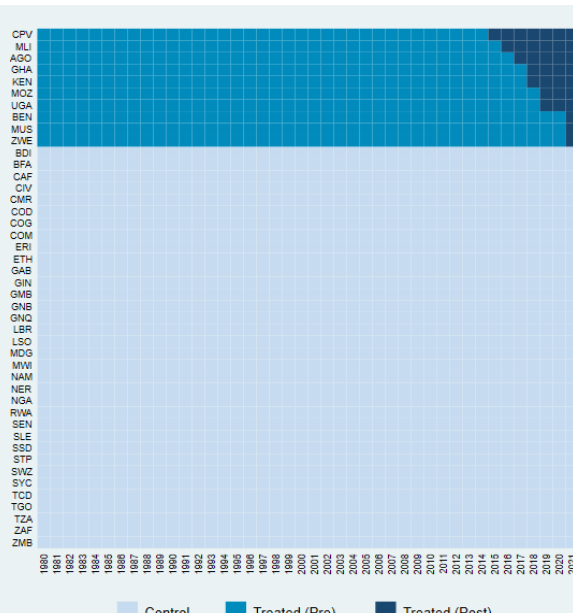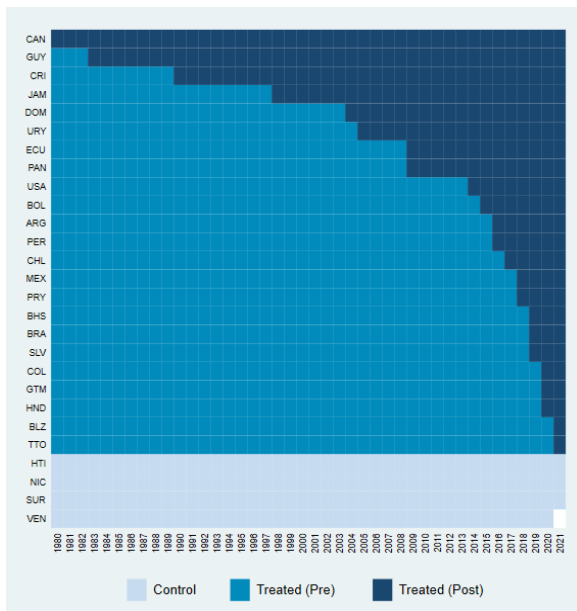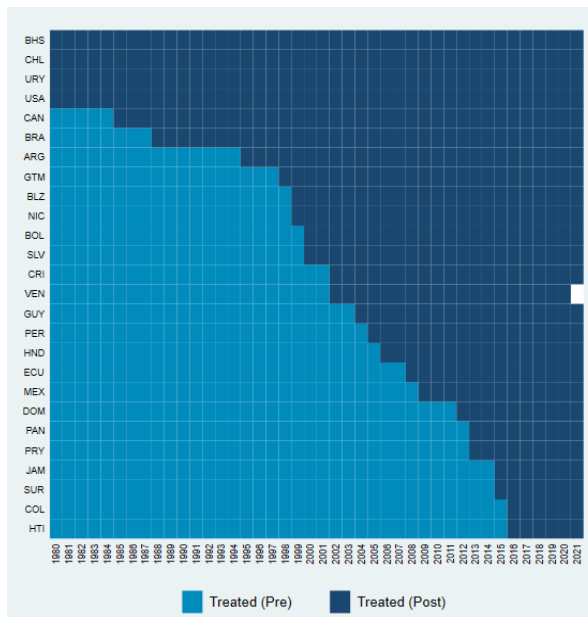**a. Establishment of a Dedicated GovTech institution**
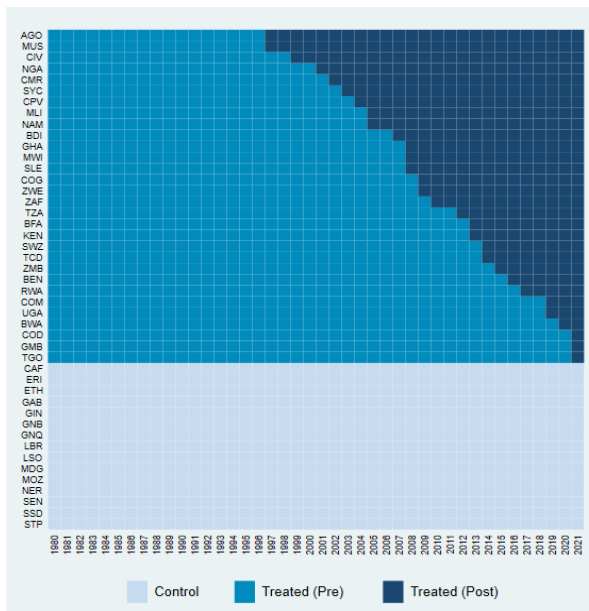
b. Launch of TSA IT System (linked with the FMIS)
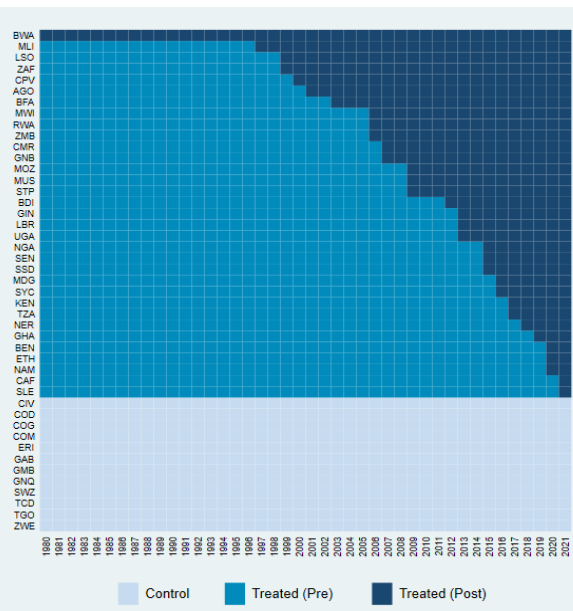
c. Digitalized e-Procurement Portal

d. Digitalized PIMS

Source: GovTech Maturity Index, 2020 and 2022.

Note: The dark blues indicate the period after the digitalization. The countries that are yet to digitalize respective government function are categorized as a control group.

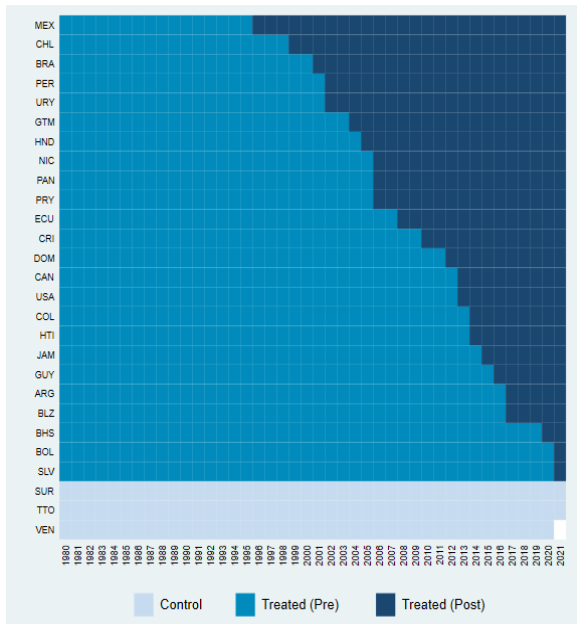**Annex Figure AV.3. Year of GovTech Adoption in the Western Hemisphere Region**

a. Establishment of a Dedicated GovTech institution
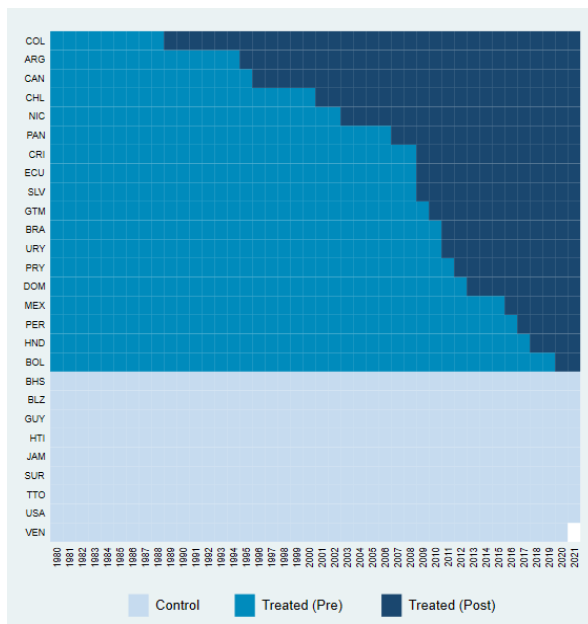

b. Launch of TSA IT System (linked with the FMIS)

c. Digitalized e-Procurement Portal
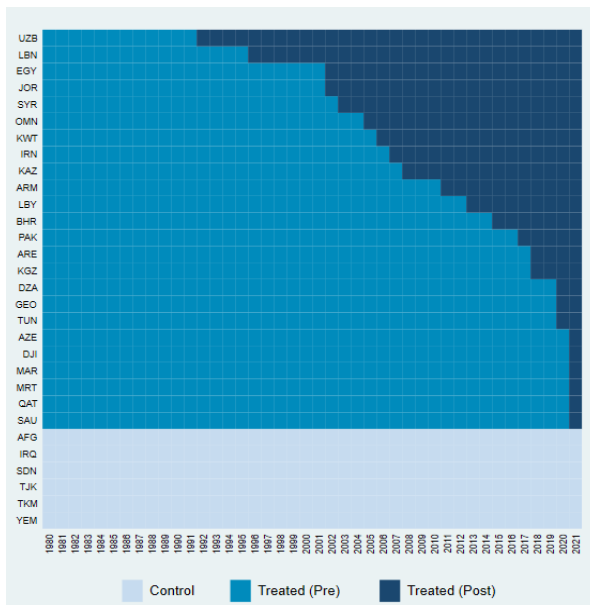

d. Digitalized PIMS

Source: GovTech Maturity Index, 2020 and 2022.

Note: The dark blues indicate the period after the digitalization. The countries that are yet to digitalize respective government function are categorized as a control group.

Annex Figure AV.4. Year of GovTech Adoption in the Middle East & Central Asia Region

a. Establishment of a Dedicated GovTech institution

b. Launch of TSA IT System (linked with the FMIS)

c. Digitalized e-Procurement Portal

d. Digitalized PIMS
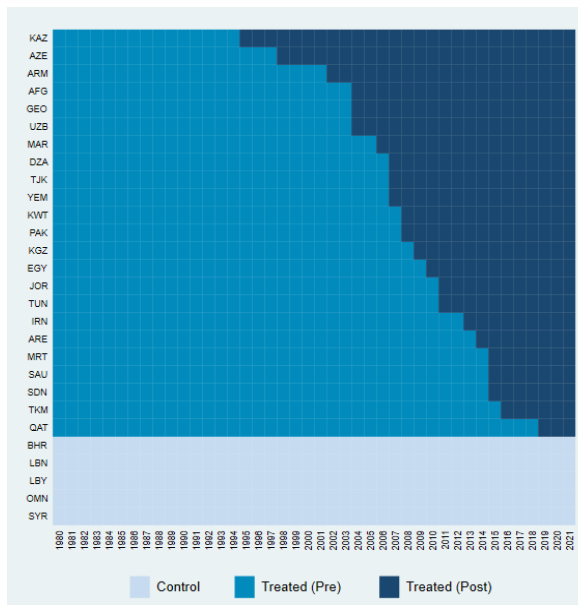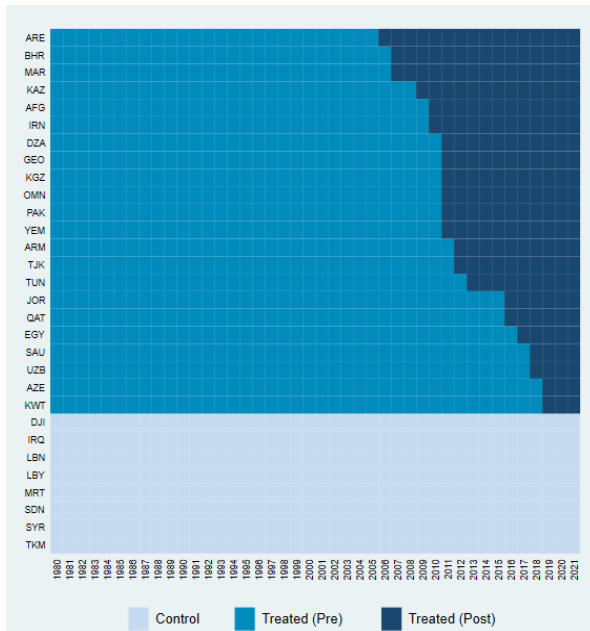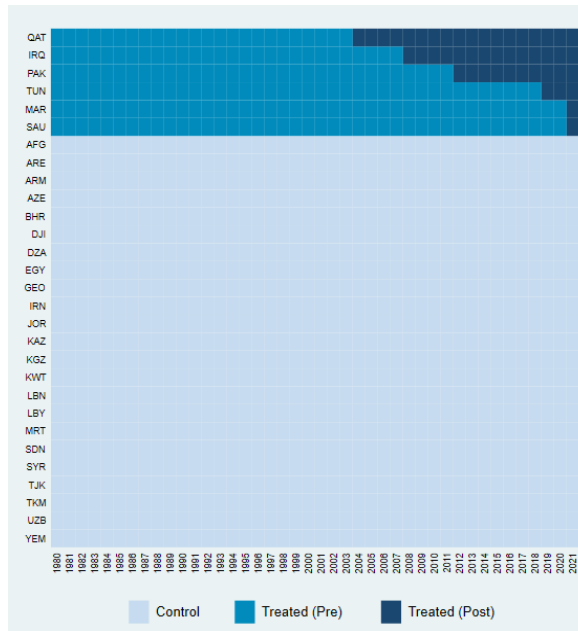

Source: GovTech Maturity Index, 2020 and 2022.

Note: The dark blues indicate the period after the digitalization. The countries that are yet to digitalize respective government function are categorized as a control group.

Annex VI. Specification Test

Annex Table AVI.1. Average Treatment Effect of GovTech Adoption on the Pre-tax Income Share of the Bottom 50th Percentile: Comparison across Alternative Specifications

Specification	(1) OLS (TWFE)		(2) Synthetic control (country FE)		(3) Synthetic control		(4) Synthetic control (year FE)	
-4	0.082		0.035		0.034		0.034	
-3	0.057		-0.020		-0.026		-0.003	
-2	0.078		-0.048	**	-0.043	*	-0.041	
-1	0.000		-0.009		-0.020		-0.008	
0	0.057		0.006		0.003		0.007	
1	0.112		-0.025		0.002		0.014	
2	0.122		-0.060		-0.027		-0.028	
3	0.092		-0.077	*	-0.067		-0.014	
4	0.226		-0.116	**	-0.024		0.030	
5	0.219		-0.038		0.106	**	0.112	
6	0.300		-0.031		0.188	***	0.145	
7	0.264		0.095	*	0.373	***	0.277	*
8	0.282		0.163	***	0.460	***	0.281	*
9	0.314		0.209	***	0.535	***	0.371	**
10	0.610	*	0.258	***	0.654	***	0.318	*
Sample	ALL		ALL		EMDEs		ALL	
MSPE	…		0.000085		0.000082		0.000290	

* p < 0.10, ** p < 0.05, *** p < 0.010

Note: The blue shaded cells indicate the estimate under the baseline synthetic control model with country fixed effect (reported in Figure 11, Panel A).

Annex Table AVI.2. Average Treatment Effect of GovTech Adoption on the Pre-tax Female Income Share: Comparison across Alternative Specifications

Specification	(1) OLS (TWFE)	(2) Synthetic control (country FE)		(3) Synthetic control 		(4) Synthetic control (year FE)	
-4	-0.531	-0.143	*	-0.147	*	-0.141	
-3	-0.372	-0.120	***	-0.107	***	-0.103	
-2	-0.340	0.043	***	0.048	**	0.073	
-1	0.000	0.065		0.040		0.091	
0	-0.138	0.177		0.163		0.225	
1	0.072	0.321	***	0.284	**	0.386	*
2	0.128	0.582	***	0.500	***	0.607	**
3	-0.090	0.624	***	0.578	***	0.509	*
4	-0.146	0.715	***	0.590	***	0.503	*
5	0.090	0.956	***	0.819	***	0.726	**
6	0.161	1.131	***	0.960	***	0.645	*
7	0.422	1.238	***	1.094	***	0.598	
8	0.405	1.405	***	1.232	***	0.646	
9	0.569	1.555	***	1.358	***	0.687	
10	0.765	1.836	***	1.554	***	0.790	
Sample	ALL	ALL		EMDEs		ALL	
MSPE	…	0.000077		0.000080		0.000726	

* p < 0.10, ** p < 0.05, *** p < 0.010

Note: The blue shaded cells indicate the estimate under the baseline synthetic control model with country fixed effect (reported in Figure 11, Panel B).

PUBLICATIONS