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Determinants of Digital Public Infrastructure Implementation

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Abstract

As digital transformation accelerates globally, Digital Public Infrastructure (DPI) is emerging as a key framework for public service delivery. This study investigates which country-level conditions, specifically population size, enabling infrastructure, and state capacity, are associated with the successful adoption of DPI. To examine this, a dataset of countries was constructed using publicly available global indicators, including both DPI adopters and non-adopters to assess the individual and joint effects of the selected indicators on DPI adoption. Independently, indicators for population size, enabling infrastructure, and state capacity were found to be higher in countries with digital ID systems. However, when analyzed collectively, digital infrastructure was found to have the strongest association with overall DPI implementation, followed by population size. State capacity was not associated with higher rates of overall DPI implementation. By identifying the conditions most strongly associated with DPI adoption, this study provides a framework for governments to assess whether they are well-suited to implement DPI and likely to benefit from such investments.

I. Introduction

Over the course of nearly two decades, India constructed one of the most ambitious digital governance projects in the world. Through a set of interoperable platforms for digital identity, payments, and data sharing, collectively known as the “India Stack,” the government has enabled more than a billion people to prove their identity, move money instantly, and access public and private services online. Today, over 97% of Indians possess a digital identity, and digital payments account for nearly 90% of all transactions by volume, signaling a fundamental shift in how citizens interact with markets and the state (Srivastava et al.). The India Stack is one of the most comprehensive and successful examples of digital public infrastructure, or DPI, implementation.

DPI systems are "society-wide, digital capabilities that are essential to participation in society and markets as a citizen, entrepreneur, and consumer in a digital era" (Eaves and Sandman). It is public in that it is created through a collaborative process involving cross-sectoral stakeholders and is proactively governed by the state to provide for the common good (Mazzucato et al.). Rather than delivering services directly, DPI operates as an enabling layer between physical infrastructure and sector-specific applications including social protection, healthcare, and e-commerce (World Bank, 2024). The three pillars of DPI are digital identity, payments, and data exchange (Eaves and Sandman). Digital identity refers to "the representation of our identities in a machine-readable, datafile format" and serves to authenticate individuals (Giannopoulou). Payment systems enable payments between individuals, businesses, and governments for welfare transfers, retail transactions, interbank payments (DPI Map). Data exchange systems "enable the secure transfer of information across institutions" (Fetter et al.).

Research done with a global dataset has shown that higher income countries are more likely to have implemented all three pillars and Europe, with its greater levels of regional integration, leads in DPI implementation (Fetter et al.). Existing literature on Digital Public Infrastructure has largely focused on identifying the qualitative enablers and prerequisites necessary for successful implementation. However, this body of work offers limited empirical evidence on which of these commonly cited enablers are most strongly associated with DPI adoption across countries. This study addresses that gap by testing the hypothesis that DPI adoption is driven by three factors: population size, enabling infrastructure, and state capacity.

Scale pressures are expected to shape the cost-benefit analysis for DPI adoption. Countries with larger populations face higher administrative complexity and higher costs of delivering public services through traditional systems. At the same time, DPI systems exhibit strong economies of scale due to high fixed costs and low marginal costs. As a result, DPI becomes more economically attractive in larger countries because it improves service delivery efficiency and reduces per-user administrative costs.

Second, enabling digital infrastructure determines whether DPI systems are technically feasible and widely usable. Even if DPI systems are implemented, low connectivity limits uptake and reduces effectiveness. Therefore, stronger existing digital infrastructure is expected to be a necessary precondition for effective DPI adoption.

Finally, state capacity constraints, measured through government effectiveness and administrative capacity, are expected to be the determinants of whether DPI systems can be successfully designed, implemented, and maintained. DPI requires coordination across agencies, reliable execution capacity, and institutional stability. Countries with stronger bureaucratic systems are therefore more likely to move from feasibility to actual implementation.

While the study design cannot establish causality, the findings offer governments and multilateral organizations an evidence-based way to prioritize investment and technical assistance, for example by identifying which structural gaps are most closely linked to weak DPI adoption and worth addressing first, or by benchmarking a country's readiness against the global distribution of similar countries.

II. Methodology

The foundational dataset for this study is the DPI Map, produced by the Institute for Innovation and Public Purpose at University College London (UCL). The DPI Map records, for each of 211 countries, whether three core DPI systems, digital identity (ID), payment, and data exchange, are present, using a binary indicator (1 = present, 0 = absent), along with the underlying evidence used to justify each coding decision. Where a country was recorded as operating more than one system of a given type, such as multiple digital ID schemes, the system with the highest DPI count was considered for analysis.

Each binary DPI indicator was assigned according to a set of standardized conditions defined by the DPI Map. A country was coded 1 on Digital ID if it met four conditions:

i. The government claimed to have a digital ID system
ii. The system was either officially announced as fully implemented or showed strong evidence of being fully operational
iii. The system supported a "digital authentication function," meaning it could provide a straightforward confirmation of an individual's identity through mechanisms such as biometric verification, facial recognition, or one-time passwords
iv. The system was documented as having "two or more sectoral use cases" beyond citizen identification alone (DPI Map).

The Payment indicator followed similar logic. A country was coded 1 if it:

i. Had an active real-time payment system, defined by the system being operational (as inferred from transaction volume, transaction value
ii. Was present on the central bank's website, being formally "listed on the central bank website as an offering" or reporting transaction volumes

iii. Had an operator identified as the central bank based on a review of its governance structure (DPI Map).

The Data Exchange indicator was coded 1 when two conditions were both satisfied:

i. Implementation status indicated the system was "fully operational and being used," with data exchange activity occurring as intended

ii. The system's scope was classified as cross-sectoral, meaning it was documented as operating across multiple sectors rather than a single sector. Where scope could not be determined, the system was coded as "Unknown" (DPI Map).

To contextualize DPI adoption, five additional indicators were merged onto the DPI Map dataset at the country level, drawn from three publicly available sources, as seen in Figure 1.

Because digital ID systems represent the most foundational layer of a DPI stack and digital citizenship, the first stage of analysis evaluated each supplementary indicator in relation to a country's Digital ID DPI count (0 or 1). For each indicator, the mean and median were calculated separately for countries coded 0 and countries coded 1 on Digital ID, with countries missing data on a given indicator excluded from the corresponding comparison. A Mann-Whitney U test was then conducted for each indicator to assess whether the distributions differed significantly between countries with and without an operational digital ID system. This non-parametric test was selected given the likely non-normal distribution of several indicators, such as population size, and the absence of an assumption of equal variances across groups.

The indicator within each construct that showed the strongest statistical association with digital ID status in the first stage, namely total population for population size, the EGDI for existing digital infrastructure, and the Government Effectiveness score for state capacity, was carried forward into the second stage of analysis. Using the medians established previously, each

Variable	Source	Indicator	Indicator Description
Population Size	World Bank World Development Indicators	Total population (in thousands), 2025	An estimate of the total population, regardless of citizenship or legal status.
Digital Infrastructure	World Bank World Development Indicators	Individuals Using the Internet (% of population), most recent year available between 2014 - 2024	A percentage of how many individuals have used the Internet via any device in the last 3 months.
	World Bank World Development Indicators	Mobile Cellular Subscriptions (per 100 people), most recent year available between 2021 - 2025	A count of how many active prepaid or postpaid subscriptions that provide voice access to the public mobile telephone network using cellular technology per 100 people.
	UN E-Government Knowledgebase	E-Gov Development Index (UN EGDI) - Overall Score, 2024	A measure (ranging from 0 to 1) of how effectively a country uses IT infrastructure and human capital to deliver government services, based on online service provision, telecommunication connectivity, and human capacity.
State Capacity	World Bank World Governance Indicators	Government Effectiveness Score, 2024	A measure (ranging from -2.5 to +2.5) of perceived public-sector quality, including civil service competence and independence, policy formulation and implementation, and the credibility of government commitments.
	World Bank World Governance Indicators	Control of Corruption Score, 2024	A measure (ranging from -2.5 to +2.5) of the extent to which public power is exercised for private gain, encompassing both petty and grand corruption as well as elite capture of the state.

Figure 1: Additional Variables and Associated Indicators

country was classified as High or Low on each of these three indicators relative to the sample median. Because data availability varied across indicators, the analytic sample for this stage was restricted to 190 countries with complete data on all three measures.

For these 190 countries, a composite DPI Count Sum was constructed by summing each country's binary DPI codes across the three system types (ID, Payment, and Data Exchange), yielding a score ranging from 0 to 3. A multivariate regression was then estimated with the DPI Count Sum as the dependent variable and population size, existing digital infrastructure, and state capacity (each entered as High/Low classifications) as independent variables, to identify which is most strongly associated with overall DPI adoption.

III. Results & Discussion

Mann-Whitney U tests reveal statistically significant differences in the distributions of total population, internet usage, mobile cellular subscriptions, E-Government Development Index score, Government Effectiveness score, and Control of Corruption score between countries with a Digital ID DPI Count of 0 and those with a DPI Count of 1 (all p-values < 0.05). Therefore, as Figure 2 indicates, independently, each of the six indicators examined is associated with digital ID adoption status. It is important to note that the indicator data used in this analysis was not necessarily collected prior to DPI implementation or adoption. As a result, a causal or temporal association between these indicators and digital ID adoption cannot be inferred from this analysis alone.

For each indicator, the median value among countries with a Digital ID DPI Count of 1 is higher than the median among countries with a Digital ID DPI Count of 0. This pattern indicates a positive association between digital ID adoption and higher population size, greater digital infrastructure development, and stronger state capacity. Additional supporting data appears in the Appendix.

	Median for ID DPI Count = 0	Median for ID DPI Count = 1	Mann-Whitney U	*p*-value	Decision
Total population (in thousands), 2025	5688.83	12051.26	3330	0.0014	Reject H_0
Individuals Using the Internet (% of population), most recent year available between 2014 - 2024	70	90	2376	1.88008E-08	Reject H_0
Mobile Cellular Subscriptions (per 100 people), most recent year available between 2021 - 2025	108	122.5	3384.5	0.0028	Reject H_0
E-Gov Development Index (UN EGDI) - Overall Score, 2025	0.574	0.830	1283.5	1.2751E-10	Reject H_0
Government Effectiveness Score, 2024	50.665	62.63	2428.5	4.23352E-08	Reject H_0
Control of Corruption Score, 2024	41.09	58.08	2937	2.78642E-05	Reject H_0
H_0 = There is no difference in the distribution of the indicator between countries with a DPI Count of 0 and countries with a DPI Count of 1 H_1 = There is a difference in the distribution of the indicator between countries with a DPI Count of 0 and countries with a DPI Count of 1 $\alpha = 0.05$					

Figure 2: Univariate Comparison of Country-Level Indicators by Digital ID DPI Count (0 vs. 1)

In the second stage, the E-Government Development Index was selected to represent the Digital Infrastructure variable. This index is a weighted average of the scope and quality of online services, the development status of telecommunication infrastructure, and human capital (United Nations Division for Public Institutions and Digital Government). This composite measure was chosen because it encompasses the most important facets of digital governance. The government effectiveness score was selected to represent the State Capacity variable because it most directly relates to state capacity, with inputs including the state of infrastructure, quality of bureaucracy, and state failure (World Bank, 2025).

	Coefficients	Standard Error	*p*-value	Lower 95%	Upper 95%	t-Stat	Decision
Digital Infrastructure	1.383	0.157	9.7567E-16	1.072	1.693	8.792	Reject H_0
State Capacity	0.130	0.159	0.41369252	-0.184	0.445	0.819	Fail to Reject H_0
Population Size	0.343	0.129	0.00823206	0.090	0.597	2.671	Reject H_0
H_0 = There is no difference in the DPI Count Sum between countries with an indicator value above the median and countries with an indicator value blow the median H_1 = There is a difference in the DPI Count Sum between countries with an indicator value above the median and countries with an indicator value blow the median $\alpha = 0.05$							

Figure 3: Multivariable Regression of DPI Count Sum on Digital Infrastructure, State Capacity, and Population Size

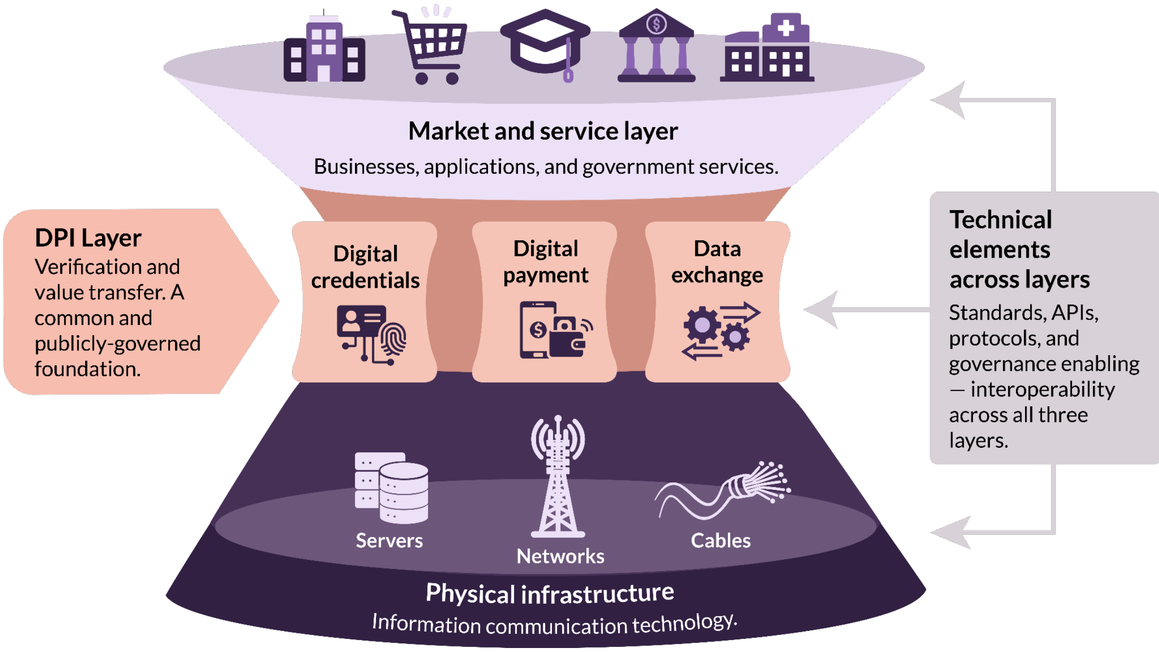

Figure 4: Digital Infrastructure and Services Layers. Image from Canda School of Public Service

Figure 3 shows that digital infrastructure is the variable most strongly associated with DPI adoption across digital identification, payment, and data exchange systems, as indicated by its t-Stat magnitude (8.792) and coefficient (1.383). This suggests that digital infrastructure serves as the foundation upon which DPI is built, ensuring that individuals have the connectivity and digital literacy needed to access these systems (Figure 4). Without this foundation, DPI systems would see limited uptake, reducing the incentive to develop them in the first place. Stronger digital infrastructure also appears to enable countries to implement a fuller DPI stack, supporting the development of multiple interconnected systems rather than a single isolated one.

Population size shows a moderate, statistically significant association with DPI adoption. This raises the possibility that larger countries pursue more comprehensive DPI ecosystems potentially due to economies of scale or greater returns to investment in multi-pillar digital systems. Building the backend for DPI systems requires the same amount of investment, regardless of population size, however, when these fixed costs are spread across a larger population, there is a lower cost-per-citizen. Additionally, the aggregate benefits increase when more individuals use the systems, suggesting that governments may consider this economy of scale effect when deciding whether to adopt DPI.

State capacity does not show a statistically significant association with DPI adoption in this model, as the 95% confidence interval for its coefficient includes 0, meaning that a null effect cannot be ruled out. This result is notable because the univariate Mann-Whitney test showed that the state capacity indicators (the Government Effectiveness score and Control of Corruption score) were each independently associated with Digital ID DPI Count. Once digital infrastructure and population size are accounted for in the multivariable regression, however, this association no longer remains significant. This pattern indicates that the relationship between state capacity and DPI adoption observed in the first stage may be explained by state capacity's overlap with digital infrastructure, rather than reflecting an independent contribution of state capacity to DPI adoption once infrastructure and population size are held constant or that state capacity is associated with digital ID adoption, but not digital payment and data exchange system adoption. This may be because the adoption of digital IDs in countries without legacy identity systems requires a large-scale government effort to identify every individual and enroll each one in the national ID system. Comparatively, the adoption of digital payment and data exchange systems do not require the same upfront population-wide enrollment and are intended to be used optionally.

IV. Conclusion

The purpose of this study was to examine the strength of association between population size, digital infrastructure, and state capacity and DPI implementation, with the goal of understanding which of these factors is most closely associated with the implementation of DPI.

The findings indicate that all six indicators selected were significantly higher in countries with digital ID systems than in countries without them. This suggests that population size, digital infrastructure, and state capacity are independently associated with DPI implementation. When considered collectively across all types of DPI systems, however, digital infrastructure, measured through the E-Government Development Index overall score, showed the strongest association with DPI implementation. Higher levels of digital infrastructure were associated with the successful implementation of more DPI systems. In contrast, state capacity, measured through the Government Effectiveness Score, was not significantly different in countries with more DPI systems.

These findings should be considered within the limitations of the study. Because the analysis does not establish temporality, it cannot determine causality or conclude that any of these indicators are necessary preconditions for DPI implementation. It is possible that digital infrastructure is endogenous to the implementation of DPI systems. Further research should therefore examine the causal relationship between these variables and DPI implementation. Individual case studies could provide a stronger understanding of the factors that influence stakeholder decisions to plan, pilot, and ultimately implement DPI systems. Future research should also examine the role of regional partnerships and international investment in creating the conditions for successful DPI implementation and supporting countries that may not yet have the necessary infrastructure.

Understanding these conditions is particularly important because, while the positive effects of DPI are well-documented, implementation also carries potential risks. DPI can expand financial inclusion for vulnerable communities, improve health outcomes, and encourage further technological innovation in the private sector (Desai and Manoharan). At the same time, poorly designed or inadequately governed systems can increase vulnerability to financial scams or exclude individuals from essential welfare. Although state capacity was not found to be significantly associated with overall DPI implementation in this model, effective governance remains an important component of ensuring the long-term success of DPI (Clark et al.). Countries seeking to implement DPI must therefore look beyond technological and economic readiness. Successful implementation also requires investment in public institutions and governance protocols capable of mitigating potential harms and ensuring that DPI delivers its intended benefits.

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Appendix

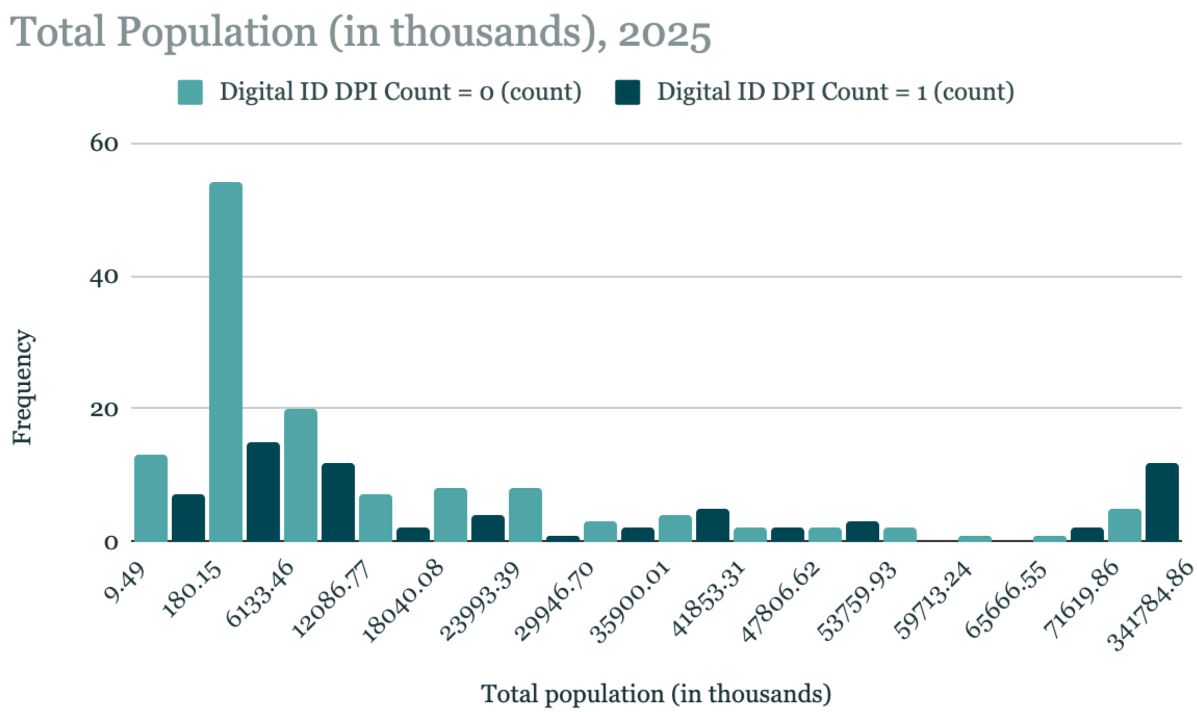

Figure 1A: Histogram of Total Population in Digital ID DPI Count 0 and Digital ID DPI Count 1 Countries. Data from World Bank World Development Indicators and DPI Map.

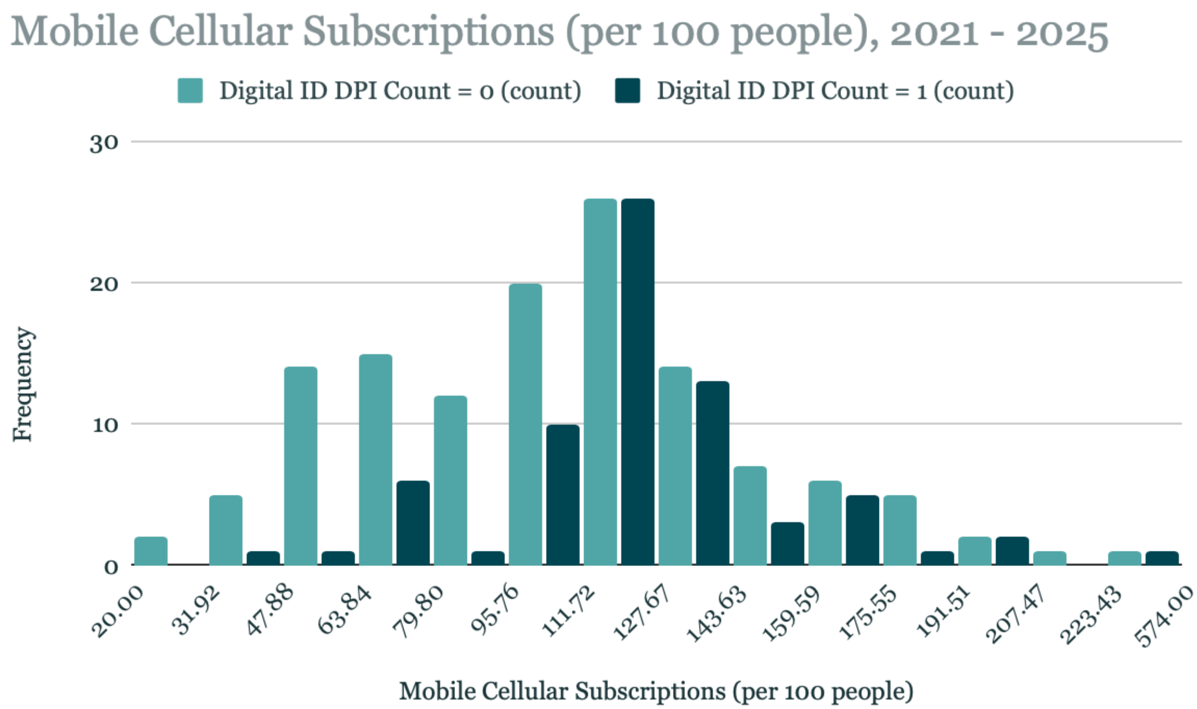

Figure 2A: Histogram of Mobile Cellular Subscriptions in Digital ID DPI Count 0 and Digital ID DPI Count 1 Countries. Data from World Bank World Development Indicators and DPI Map.

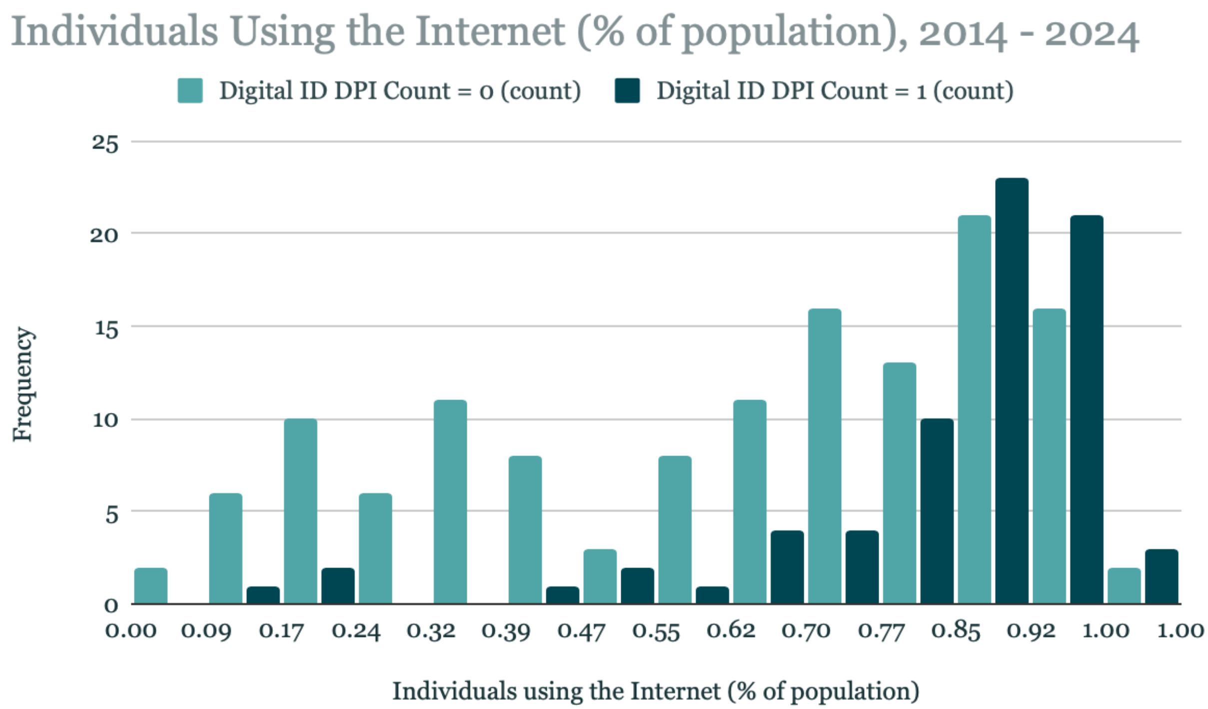

Figure 3A: Histogram of Individuals Using the Internet in Digital ID DPI Count 0 and Digital ID DPI Count 1 Countries. Data from World Bank World Development Indicators and DPI Map.

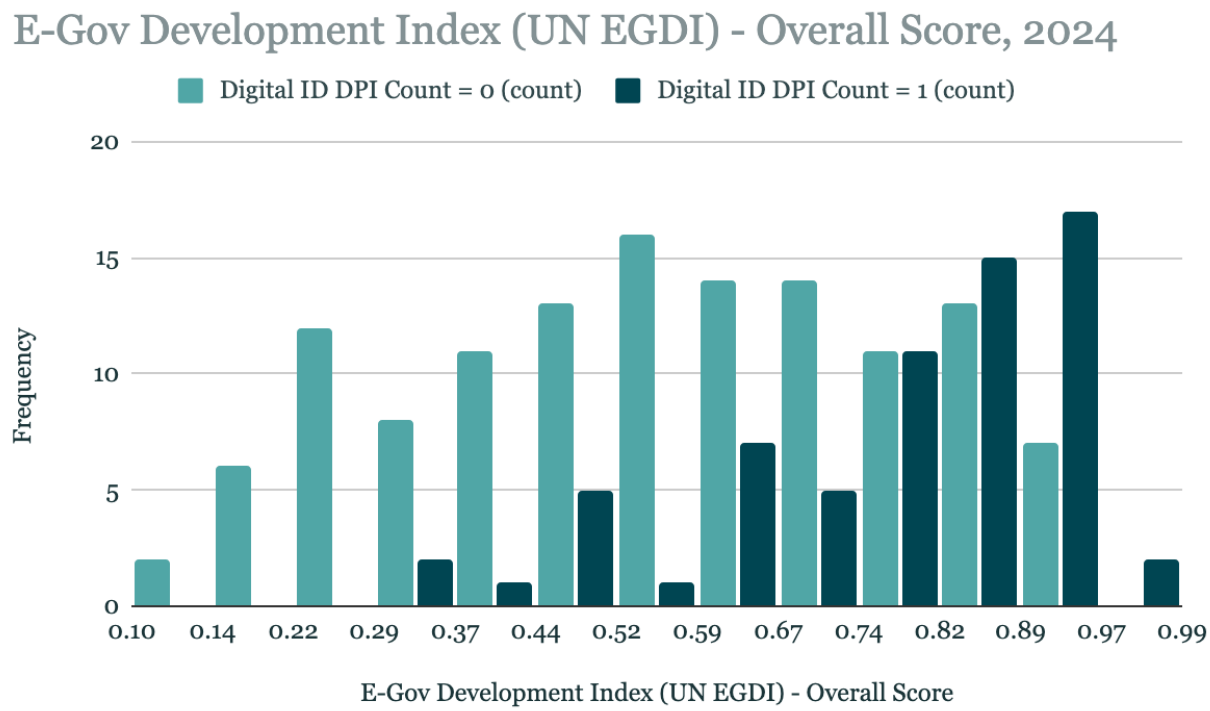

Figure 4A: Histogram of UN EGDI in Digital ID DPI Count 0 and Digital ID DPI Count 1 Countries. Data from UN E-Government Knowledgebase and DPI Map.

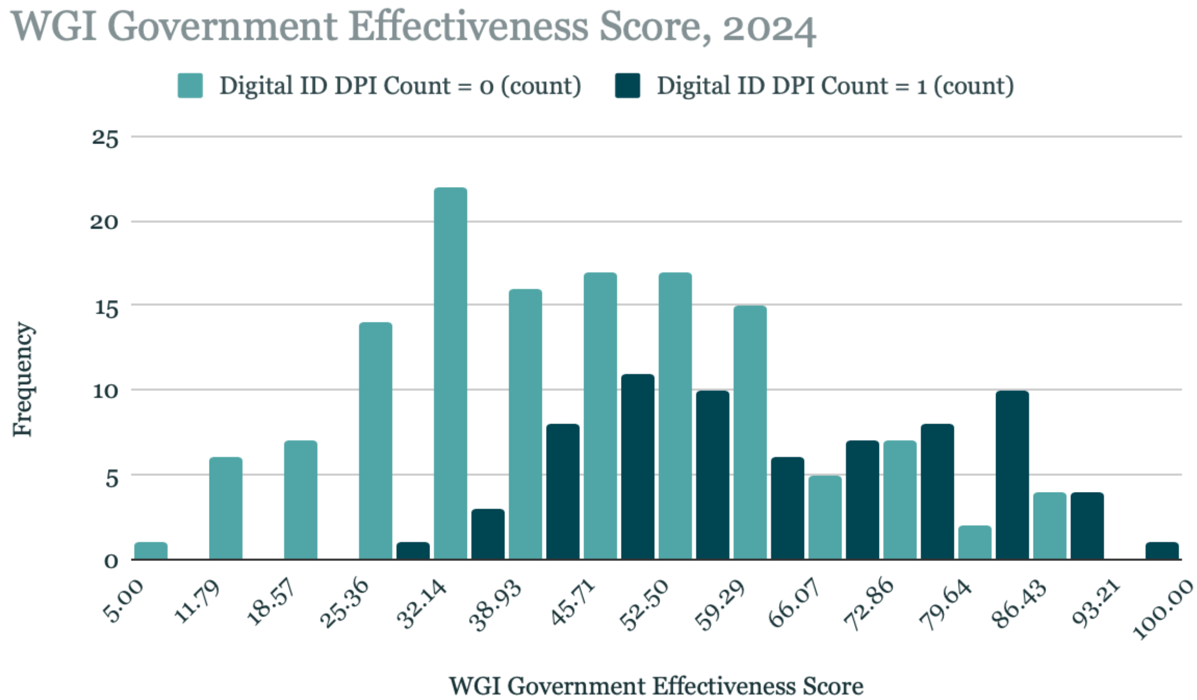

Figure 5A: Histogram of WGI Government Effectiveness Score in Digital ID DPI Count 0 and Digital ID DPI Count 1 Countries. Data from World Bank World Governance Indicators and DPI Map.

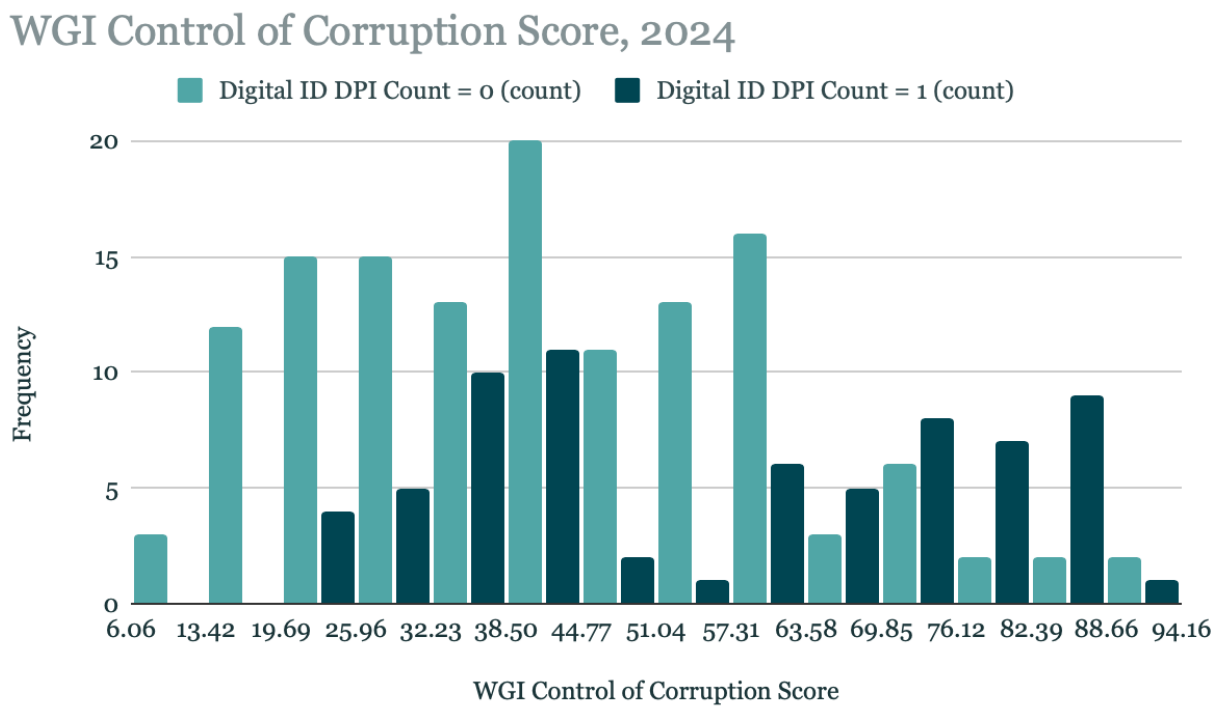

Figure 6A: Histogram of WGI Control of Corruption Score in Digital ID DPI Count 0 and Digital ID DPI Count 1 Countries. Data from World Bank World Governance Indicators and DPI Map.

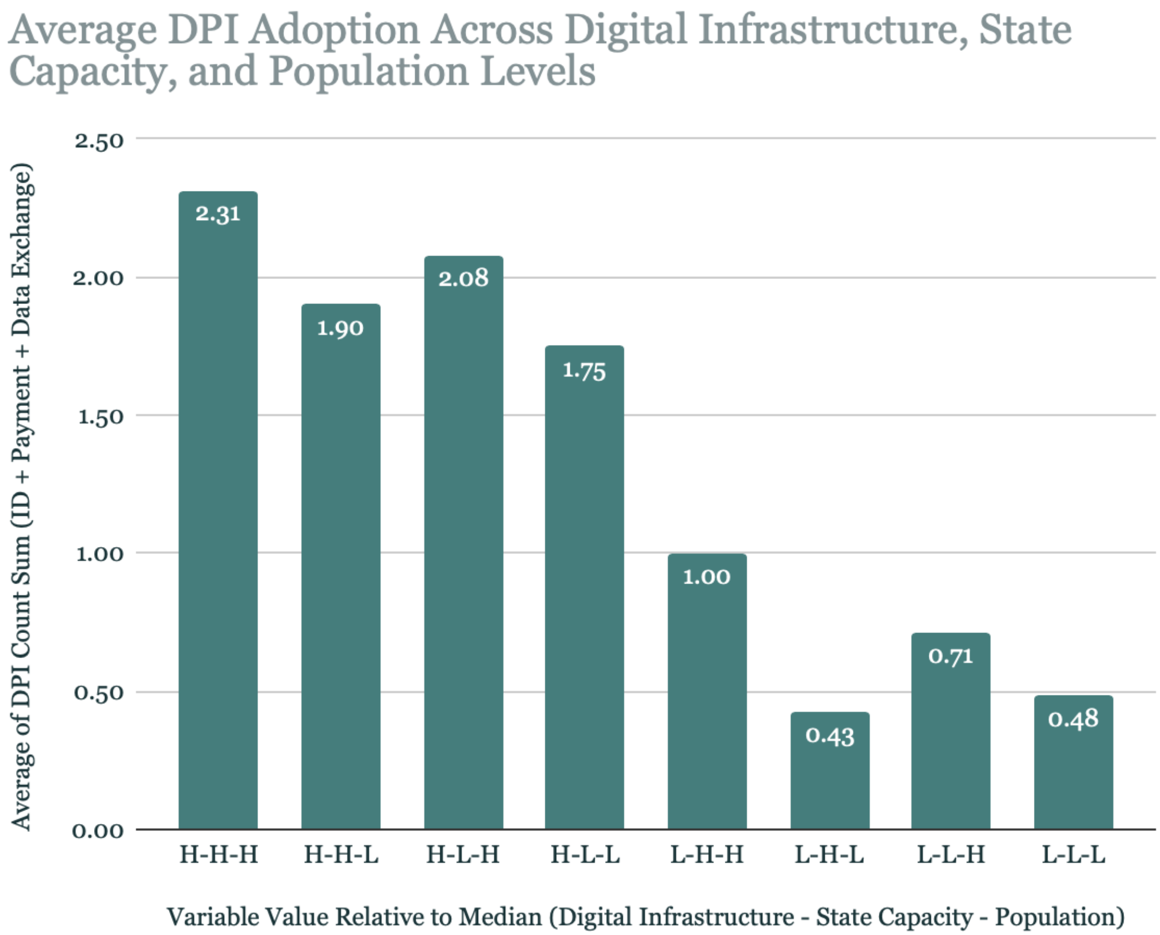

Figure 7A: Average DPI Adoption Across Digital Infrastructure, State Capacity, and Population Levels. Data from World Bank World Development Indicators, UN E-Government Knowledge Base, World Bank World Governance Indicators, and DPI Map.