Digital Dependence vs. National Performance – Preliminary Data Analysis

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Abstract. Countries differ in their capacity to develop and use digital technology – some build such capacity locally, others rely on foreign countries and corporations, and yet others do both. While sourcing arrangements may vary, the outcome is critical to countries' performance – their ability to pursue national goals and priorities. The paper explores the relationship between the countries' digital dependence and performance, relying on the calculation of the Spearman correlation coefficient between the Digital Dependence Index and the Online Service and E-Participation Indices, for 23 countries in 2020. The calculation established a small to moderate negative correlation between the variables, i.e. the better performance, the lower dependence, in line with theoretical assumptions, and identified cases that violate these assumptions.

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1. Introduction

Governments around the world struggle to predict and manage the effect of digital transformation scaling up from the individual (citizens and businesses) to the system (economies and societies) level. System-level risks are particularly dangerous at the times of geopolitical tensions when the countries' capabilities to implement digital transformation is essential. For countries lacking indigeneous capabilities, it is a major risk.

In the international arena, countries' digital capabilities are represented by digital sovereignty, digital autonomy, and digital dependence. Digital sovereignty "encompasses the authority of a state to control data, infrastructure, and digital policies, ensuring that these elements reflect national laws and interests" (Bennett & Raine, 2020). Digital autonomy is "the ability of a state to shape its digital landscape, allowing for self-determination in technological adoption and policy formulation" (Mann & Wadhwa, 2019). Digital dependence is "the extent to which actors in a particular country have to rely on foreign-controlled digital technologies to perform digital activities" (Mayer & Lu, 2022a). Thus, digital sovereignty asserts the country's control over digital activities within its borders, while digital autonomy vs. dependence represents its independence vs. dependence on external entities in deciding over such activities. Stronger digital dependence weakens both sovereignty and autonomy.

Digital dependence also undermines national performance. According to Steward (1981), "technology imported from industrialized countries is often inappropriate" for developing countries, and lack of local capacity makes it more challenging to "adapt imported technology to local conditions". Fabayo (1996) contents that reliance on technology imports undermines African countries' indigenous technological development and contributes to their "distorted development or underdevelopment". Relying on import arrangements like the digital Silk Road might, in turn, entrap them "problematic digital dependence" (Seoane, 2022). Even countries like South Korea may experience "profound technological dependence" limiting their "autonomous economic growth" (Smith, 1993).

The country's performance also depends on the policy-implementation capacity of its public administration system and its digital counterpart – digital government. According to Srivastava (2007), there is a significant association between digital government and "administrative process efficiency" which in turn reduce "social divide". A

significant positive correlation is also present between e-government readiness and GDP (Saghafi et al., 2011) and between digital government maturity and government quality (Durkiewicz et al, 2018). How investing in digital government can produce value for countries is part of the digital government value chain (Durkiewicz et al., 2021). However, the relationship between digital dependence and digital government is largely unexplored.

To fill this gap, we explore if the relationship between the Digital Dependence Index (DDI) (Mayer & Lu, 2022a) and Online Service and E-Participation Index (United Nations, 2020) fulfils theoretical assumptions, i.e. lower dependence, higher performance. To this end, we calculate the Spearman correlation coefficients and identify countries that violate these assumptions, combining high dependency with high performance or low dependency with low performance. High or low designations represent indicator values below the first quartile or above the third quartile. The data reveals negative correlations but with several exceptions.

The paper is structured as follows. Section 2 introduces digital dependence and its measurement followed by research method in Section 3. Section 4 describes the results, followed by the discussion in Section 5 and conclusions – findings, limitations, and directions for future research – in Section 6.

2. Concept

Digital Dependence (DD) and related terms have a modest coverage in literature. On Scopus, "digital dependence" OR "digital autonomy" OR "digital sovereignty" yielded 487 results on 11 February 2025. DD is addressed from varied positions: resilience to the power of foreign corporations (Gaie & Langlois-Berthelot, 2024), troubling patterns of social behavior (Gonzales, 2024), threats to privacy and data integrity (Ilves & Osula, 2020), and geopolitical tensions (Budnitsky, 2022). Hu (2024) suggests that DD grow as a "side-effect" of foreign countries' development programs while technological sovereignty forces "difficult trade-off between taking advantage of the benefits of digital technologies and surrendering control" (Ilves & Osula, 2020).

DD is introduced in Mayer & Lu (2022a) which features "Digital Dependence Index" (DDI) that measures "the share of foreign suppliers in the total demand for certain digital technologies for each country" (Mayer & Lu, 2022b). DDI consists of hardware, software, and intellectual property subindices, ranging between 0 for countries that do not "use or consume any foreign-controlled or imported digital technologies" and 1 for countries that do not "have any domestic sources of supply for the needed digital technologies". The calculation of the index for 23 countries – G20 plus Estonia, Israel, Singapore, and Kenya in 2019 uncovered no country where "domestic digital technology is in a dominant position", one country – the USA where "domestic supply delivers majority of digital tech", two countries – China and South Korea where "global markets supply majority of digital tech", and the rest where "Foreign digital technology is in a dominant position". The latter concerns not only developing countries but also countries associated with technological advancement, like Japan, Singapore, or Australia.

3. Methods

The analysis targeted the countries' combined Digital Dependency (DD) and Digital Government (DG) performance. Two questions were formulated: 1) How does the DDI dataset appear when completed with the DG performance data? 2) Which country cases are characteristic given their performance in both areas? In particular, we look at four categories of countries with: high dependence and high performance, high dependence and low performance, low dependence and high performance, and low dependence and low performance.

To answer the first question, we built the dataset for 23 countries from the 2019 DDI study (Mayer & Lu, 2022b) including DDI's trade, infrastructure, and intellectual property subindices. The dataset was complemented with the 2020 E-Government Survey (United Nations, 2020) and its two indicators, i.e. Online Service Index (OSI) and E-Participation Index (EPI). Due to the varied distributions of data among countries, their ranks rather than index values were used. While the country selection in DDI is not a statistically-relevant sample, the Spearman rank correlation matrix was elaborated to support the supposed negative correlation between the levels of DD and DG.

To answer the second question, the 1st and 3rd quartiles for each indicator were calculated, and the countries with performance above the 3rd quartile were marked with "+" while those below the 1st quartile were marked with "-". A country was considered interesting if it belonged to either categories for any DD and DG indicators. The results were then analyzed with respect to the cases that represent (1) high dependence and high performance, or (2) low dependence and low performance. These cases were identified as possibly worth further exploration.

4. Findings

The Spearman correlation matrix between the DD and DG indicators in the created dataset is presented in Table 1. According to this, there is a small to moderate negative correlation between DD and DG, confirming the assumption that the better DG performance, the lower DD, and the other way round. We did not provide p-values since this is

not meant to be a statistically representative dataset: the data refers to a specific point and range of measurement.

Tab 1. Spearman rank correlation coefficient values between the 2019 Digital Dependency Index and its Trade, Infrastructure and Patents subindices vs. the 2020 Online Service Index and e-Participation Indices

	DDI	TRADE	INFRASTRUCTURE	PATENTS
OSI	-0.32	-0.39	-0.14	-0.34
EPI	-0.34	-0.35	-0.21	-0.38

Table 2 contains the dataset for 23 countries in the DD study (Mayer & Lu, 2022b). Each country's performance is described in thirteen columns. The first six contain the DDI ranks (DDI-2019) and its three subindices – trade (TRADE-2019), infrastructure (INFRASTRUCTURE-2019) and patents (PATENTS-2019), and two columns representing Online Service Index (OSI-2020) and e-Participation Index (EPI-2020). The following six columns indicate whether the previous indices' values are above the 3rd ("+") or below the 1st quartile ("-") of all values in that index. The final column indicates whether, following the logic of this research, a case is "interesting".

According to Table 2, there are three cases (Germany, Israel, Kenya) where either of the dependence indicators is very low at the same time as one of the digital government indicators. Also, there are cases – USA and Korea, with low dependence and high performance, and the other way round – Indonesia and Saudi Arabia.

Tab 2. Rank data for G20, Estonia, Israel, Singapore, and Kenya for the 2019 DDI and its Trade, Infrastructure and Patents subindices vs. the 2020 OSI and EPI, with particularly low (-) or high (+) values.

Country	Index rankings						Best-worst analysis						Interesting?
	DDI-2019	TRADE-2019	INFRASTRUCTURE-2019	PATENTS-2019	OSI-2020	EPI-2020	DDI-2019	TRADE-2019	INFRASTRUCTURE-2019	PATENTS-2019	OSI-2020	EPI-2020	
Argentina	6	5	5	7	13	15		+					
Australia	3	4	2	3	6	8	+	+	+	+			
Brazil	1	1	2	1	10	11	+	+	+	+			
Canada	10	12	5	10	14	9							
China	22	23	22	22	8	8	-	-	-	-			
Estonia	17	19	15	14	2	2		-			+	+	
France	10	11	9	14	9	11							
Germany	13	15	12	19	20	19				-	-		yes
India	17	17	18	14	12	15							
Indonesia	4	3	9	3	22	19	+	+		+	-		
Israel	20	21	18	18	19	22	-	-				-	yes
Italy	8	10	5	7	15	17							
Japan	17	9	16	21	8	4				-		+	
Kenya	17	13	20	14	23	23			-		-	-	yes
Korea, Rep.	21	21	21	20	1	2	-	-	-	-	+	+	
Mexico	17	17	15	14	16	17							
Russian Federation	11	8	20	10	17	13			-				
Saudi Arabia	3	2	3	3	21	22	+	+	+	+	-	-	
Singapore	14	17	12	14	3	6					+		
South Africa	6	6	9	7	19	19							
Turkey	8	8	12	7	11	12							
United Kingdom	13	15	9	14	4	6					+		
United States	23	21	23	23	6	2	-	-	-	-		+	

Fig. 1 visualizes how the data is scattered. Digital Dependence Index values are plotted against Digital Government performance (average of OSI and EPI). For readability, particular country points are labeled with respective ISO alpha-3 codes. Notice the distinct separateness of three countries, the United States, China, and Korea.

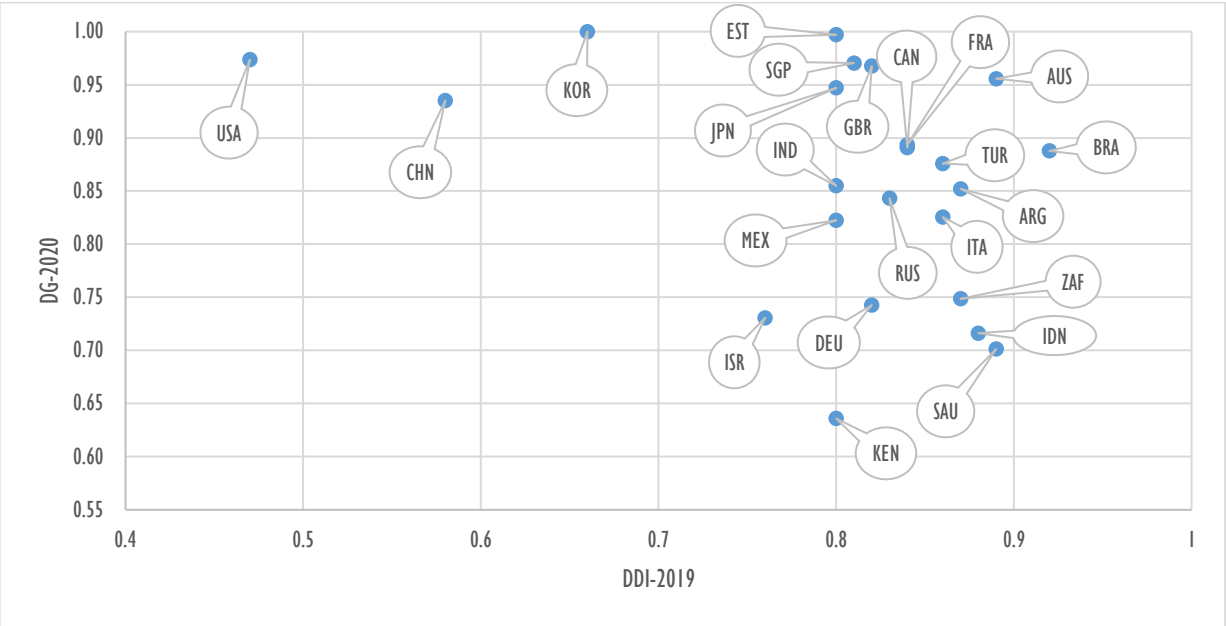

Fig. 1. DDI and DG performance data scatterplot with country labels.

5. Discussion

Today's global digital landscape is dominated by one or two countries, the second trying to catch up with the first (Mayer & Lu, 2022a). Most countries seem to surrender to this dichotomy despite the enormous impact of digital technologies on them. As noted, the most capable and committed countries "are keen to exploit their 'cyberpower'" employing "companies under their jurisdiction and control as their agents" (Ilves & Osula, 2020, p. 26).

This study pursued the ambition to start defining a new direction in DG studies: exploring the relationship between countries' DG and DD. To our knowledge, it is a pioneering effort of this kind. We brought conceptual recognition and theoretical soundness to this problem, revealed some discrepancies between DD and DG performance, and identified countries that need policy analysis. We learned that DD is a highly relevant and timely concept, beyond unequal distribution of economic power. However, conceptual clarification is first needed, starting with definitions of "sovereignty", "autonomy" and "dependence", and their digital counterparts, and how they affect governments and countries. Then, the concepts should be mapped to the elements of the national or international public policy.

6. Conclusions

This study was built upon the premise that "digital dependence" affects the countries' digital policies and their capacity to pursue national development. While terms like "digital sovereignty" or "digital autonomy" have already settled in the academic and policy discourse, "digital dependence" remains elusive. With this paper, we intend to address this gap and reveal some insights emerging from the official international data.

Since this study is based on (Mayer & Lu, 2022a), which itself is limited, our observations may not exactly reflect the global state of affairs, although we would be surprised if they are refuted by a more comprehensive study. We identified countries with problematic relationships between DD and DG but all need in-depth studies. Also, the theoretical constructs provided should lead to more sophisticated models, providing a nuanced analysis of DD.

We plan to further develop our insights into DD. A formal model is a work in progress. We also intend to enhance the DD concept aimed at spotting its causes, including the unprecedented power of global technology corporations.

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