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# From concept to method: A framework for measuring digital sovereignty

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**From concept to method: A framework for measuring digital sovereignty**


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**Abstract**

This study investigates digital sovereignty as a multidimensional concept shaped by technology, governments and society. It proposes a quantifiable Digital Sovereignty Framework to serve as a basis for digital policy development based on data as well as providing an objective and robust framework for measuring the effectiveness of public policies in the long term. Analysis reveals a high impact of technological development in the achievement of digital sovereignty, especially in the development of technological industry and emerging technologies. Findings also highlight the relevance of economic development in the early stages of digital sovereignty attainment, as well as the importance of having a diversifies economy to develop strategic autonomy.

**Keywords**

Digital Sovereignty, Europe, US, China, Geopolitics, Economic Complexity

# 1. Introduction

Digital sovereignty is a concept that has evolved significantly in recent years, and whose meaning varies depending on the stakeholder that identifies it (Falkner et al., 2024). For Europe, the term is centered around fundamental rights, data privacy and a reduction in reliance on non-European technologies. For this reason, regulatory initiatives such as the General Data Protection Regulation (GDPR), the digital services regulation and the artificial intelligence regulation have been developed. In addition, this has been complemented by multiple public policies such as the IA continent plan or the competitiveness compass, one of the pillars of which is the development of European strategic autonomy. On the other hand, the United States has a trend towards digital sovereignty developed from innovation and market freedom. For this reason, it has developed a model based on co-regulation, delegating a large part of the regulatory burden to the states that make it up. Finally, China has focused on state-centered sovereignty, where governance resides in control of content and technological self-sufficiency. Therefore, most of its public policy is focused on the development of its platforms supported by a large consumer market. However, despite the divergences between the different regions, a common ground appears, control over digital resources and infrastructure.

On this, the importance of economic development was highlighted, especially in the post-COVID era. Multiple studies highlight the strong relationship between the macroeconomic factors that describe a country and its digital development, especially to achieve strategic autonomy. Therefore, those countries with a resilient and diversified economy—such as the United States, Germany, Japan, or Korea—tend to have better levels of digitalization and digital ecosystem development. For example, the United States is home to both the main digital platforms globally and a strong chip manufacturing industry and high investments in the development of new technologies such as Artificial Intelligence. Germany has also developed a very strong automotive and pharmaceutical industry, leading Europe in the development of Industry 4.0. On the other hand, those countries with less economic development tend to show higher levels of technological dependence combined with a lower level of digital skills. This behavior suggests an intrinsic relationship between a country's levels of digital sovereignty and its social, economic, and geopolitical characteristics.

Although the relationship between digitalization and economic development has been widely studied, there is still a vast unexplored terrain when we analyze the relationship between digital sovereignty and the economy. One of the reasons for this is because a robust framework for measuring digital sovereignty quantitatively has not been developed. The development of an indicator that measures this phenomenon quantitatively is a fundamental step forward in the current debates,

as it will provide a basis for being able to compare countries objectively and academically. In addition, thanks to the development of a synthetic indicator, it will be possible to analyze the relationships between both phenomena from different perspectives, allowing the creation of public policies focused on specific areas and based on data.

With all this, we have developed this study around the following two research questions:

- How can digital sovereignty be effectively defined and quantified within a measurable framework?
- What is the relationship between a country's level of digital sovereignty and its macroeconomic indicators?

As a result of this analysis, it is expected to be able to develop a quantitative index that can help the creation of digital public policies based on data and adapted to the socio-economic characteristics of countries, thus contributing to the existing debate on digital sovereignty

## 2. Literature Review

The different interpretations of the concept of digital sovereignty depend fundamentally on the geographical context in which the stakeholders involved are located (Fratini et al., 2024). In the European Union, sovereignty is framed around the protection of fundamental rights (Von Brockdorff, 2022), data privacy (Madiega, 2020), and the reduction of dependence on non-European technologies (COM(2025) 30 final). For this reason, as a result of the Draghi report, the development of a European digital ecosystem based on innovation, the development of start-ups, and the creation of emerging technologies "made in Europe" has been sought (Draghi, 2024). This has led to the development of an extensive regulatory framework, starting with the General Data Protection Regulation (GDPR), the Digital Services Package—the Digital Services Regulation and the Digital Markets Regulation—or the development of the European Identity Framework with the revision of the eIDAS directive (Barrio Andrés, 2022). On the other hand, from the American model, digital sovereignty has been developed based on market opening and innovation, favoring the development of large digital platforms and a self-sufficient ecosystem from manufacturing to the consumption of technologies (Chander & Sun, 2023). All this focused-on co-regulation and sometimes self-regulation by companies along with open data flows. Consequently, one of the main characteristics of American digital sovereignty is its expansionist character, seeking control over different regions through technological dependence combined with the quest to become the leader of the alliance against its geopolitical competitors (Roberts, Hine, & Floridi, 2023). Thirdly,

China has adopted a state-centered model, developing its policies toward techno-nationalist approaches sovereignty (Information Office of the State Council of the PRC, 2010). As a result, it has focused on developing centralized internet governance, seeking greater control over the content posted on its social platforms—most of which have some form or other intervention by the state—and focusing its public policy on justified control over national security (Cong, 2021). However, due to the constant evolution of the Asian giant's market, its sovereign practices are still under development, with some such as "the great firewall" already consolidated and others such as its regulatory development around data flows outside the region still having complications in their practical implementation.

Despite this conceptual ambiguity, a recurring theme across literature is the notion of control, specifically, control over digital resources and infrastructures (Chander & Sun, 2023). Therefore, making digitalization a base for the creation and as the main result of digital sovereignty (Von Brockdorff, 2022).

The post-COVID-19 period has seen an increase in the recognition of the macroeconomic significance of digitalization and digital sovereignty. Many authors have established positive correlations between digital development and key economic outcomes, including GDP growth, trade diversification, and resilience to external shocks (Copestake et al., 2024). Also, cross-country analyses consistently show that more digitally advanced economies exhibit higher income levels and greater economic stability (Bilal, Aqib, & Raza, 2024).

Evidence also supports that even small improvements in digital infrastructure can have significant repercussions on the economy. For example, Tudose et al. (2023) conclude that a 10% increase in internet speed is associated with an approximate 0.5% increase in GDP per capita. Similarly, Zhang et al. (2022) demonstrate that, among the countries of the Belt and Road Initiative, the growth of the digital economy contributes significantly to overall economic development, mainly through industrial modernization and job creation. These results are also reflected in trade data: Ng et al. (2024) conclude that, in APEC economies, every one-point increase in digital intensity correlates with a 2.5% increase in digital services exports. Since the digital sector tends to expand faster than the broader economy, its effects are amplified across all productivity and trade channels (World Bank, 2024).

From a structural perspective, diversified and high-income economies tend to be more digitally developed. According to a recent World Bank report, technology, and in particular IT services, make up an increasing share of value added in high-income economies (World Bank, 2024). Similarly, the MBRSG Economic Diversification Index identifies the United States, China, and Germany among the most diversified

economies, helping them weather economic downturns such as the one experienced by COVID-19 more lightly than other economies, and suggesting a two-way dynamic between digital capability and macroeconomic resilience (MBRSG, 2025).

However, despite progress focused on bringing the economic benefits of new technologies to less advantaged regions, in line with the objectives of the United Nations 2030 agenda, significant differences persist in the adoption of digital technologies, especially between geographical regions. For example, while East Asian businesses accelerated digital adoption during the pandemic—quadrupling their level of digitalization in just two years—many small businesses in low-income countries in Africa and Latin America still lack basic internet access (Ávalos Almanza et al., 2023). The existence of these digital divides in the business fabric is reflected in gaps throughout the economy, preventing these countries from advancing in their contribution to the global digital value chain. Following this thread, the OECD and WTO (2019) point out that insufficient digital infrastructure, such as connectivity, and limited preparation for e-commerce are among the main challenges for economic diversification in developing economies.

Several country-level case studies further illustrate the economic implications of digital transformation and policy responses tied to digital sovereignty:

The U.S. digital economy accounted for approximately 10.2% of national GDP in 2020, equivalent to $2.1 trillion, and grew at an annual rate of 6.3% between 2012 and 2020, a higher rate than the broader of the economy (Highfill & Surfield, 2022). This growth is based on a very strong governmental support for innovation through the development of specific innovation and tech-development programs, supported by a well-established digital entrepreneurial ecosystem that has given birth to some of the most relevant multinational digital companies in the world. As a whole, this developments in the ICT sector correlate with stronger economic outcomes, as early adoption of digital infrastructure can enable “leapfrogging” in productivity (OECD/WTO, 2019). Conversely, US officials have pondered on the risks arrising from the lack of sovereignty, particularly when it threatens competitiveness and security, and showing an incentive towards maintaing both technological leadership and regulatory stability.

China’s digital economy expanded from ~20.9% to nearly ~39.8% of GDP between the mid-2010s and 2023 (Zhang, Liu, & Yang, 2024). This rise has been supported by government-led strategies such as the “Digital China” Initiative, that has promoted investment in areas such as big data, mobile platforms and Artificial Intelligence, highlighting the importance o digital technologies as drivers for economic modernization. This has been supported by the state’s support for digital self-sufficiency, specially regarding semiconductors, thus reflecting a broader ambition

towards achieving digital sovereignty through techno-nationalism as well as long-term macroeconomic stability (Fratini et al., 2024). However, as the restrictions on data flows and foreign platforms continue, questions also rise about the trade-offs between digital sovereignty and global integration.

The EU has positioned digital transformation as a growth and strategic imperative. Therefore it has developed a full digital agenda to obtain the full benefits derived from the digital transformation of its economy, starting with the digital decade, the competitiveness compass and most recently the International Digital Strategy. Specifically in relation to economic development, Bocean & Vărzaru (2023) showed that increased use of digital tools—such as cloud computing and e-commerce—correlates with higher GDP per capita across member states. Building on this, the EU's Digital Economy and Society Index (DESI), published annually by the European Commission, reports steady improvement in connectivity and skills, becoming a basis for the future of competitiveness in the Union (European Commission, 2024). Meanwhile, legislative frameworks like the GDPR, Digital Markets Act, and Data Governance Act embody the EU's distinctive model of "regulatory sovereignty" (Fleming, 2025; Schneider, 2025). This "third way" approach contrasts with the U.S. and Chinese models as the EU frames digital sovereignty on the one hand with a regulatory approach, ensuring equality in norms, especially those related to ICTs, across the single market; and on the other hand through the improvement of skills and capabilities of its citizens and companies, making sure that "no-one is left behind". Economically, the EU argues that coherent digital policy creates a stable business environment and fuels growth (the so-called "Brussels Effect" of standards).

India has rapidly expanded its digital infrastructure through public initiatives such as Aadhaar (digital ID) and UPI (digital payments), with broad macroeconomic impacts. Khera (2023) suggests that India's rapid digitization improves productivity and inclusion particularly studying the integration of digital payments and broadband showing their link to higher income growth and job creation. This is complemented by the SIDE Report that specifically concludes that provinces with stronger digital ecosystems exhibit higher economic growth rates (Mishra et al., 2024). Policymakers view digital transformation as key to transitioning the economy beyond agriculture and low-skill services, with digital adoption forming part of broader industrial diversification efforts.

Brazil's digital economy expanded significantly during the pandemic, particularly in e-commerce and fintech (Veiga et al., 2024). However, challenges such as unequal internet access and dependence on foreign platforms have sparked policy debates on digital sovereignty. Therefore, national strategies increasingly emphasize infrastructure investment and data protection as tools to foster both economic

autonomy and innovation (Ministério da Ciência, Tecnologia e Inovações, 2022). In addition, civil society actors have also advocated for stronger privacy rights and the development of local technological capacity as foundational to Brazil's digital and economic sovereignty (Pacheco da Silva et al., 2024). At the multilateral level, Brazil has called for global digital governance frameworks that support sovereignty alongside openness, especially in its role within BRICS.

Overall, literature suggests strong empirical links between digitalization and macroeconomic performance. Digitally advanced economies enjoy faster GDP growth and greater export diversification, partly by creating new digital services and improving efficiency. However, these gains often co-exist with policy challenges such as quality of digital infrastructure, regulatory coherence, and cybersecurity.

# 3. Conceptual Framework

## 3.1. Layers of sovereignty

A key area of divergence among scholars is how digital sovereignty is structured into different layers or dimensions. Various authors have proposed frameworks to explore these layers, typically encompassing aspects such as infrastructure, data governance, regulatory authority, and geopolitical influence.

For our indicator, we adopt a three-layer model that reflects the three different political discourses around digital sovereignty identified in Phole & Thiel (2020) combined with the frameworks proposed by León (2023) and Kaloudis (2022).

Firstly, the technology layer reflects the infrastructure necessary for a country to consider itself digitalized and have the necessary skills to act autonomously in the digital world in a sustainable way over time. This includes indicators related to the development of telecommunication infrastructures, control over data, and the development of new technologies. With this layer, we wanted to capture the capacity of countries to develop, exploit and sustain their technological environment to reduce dependencies on other countries, both by developing their local market and by creating strategic alliances.

Second, the governance layer must consider the legal and institutional mechanisms for exercising sovereignty over a region. This includes both regulatory practices and the development of policies and strategies, all of which focus on ICT development. With this layer, the institutional capacity to control the digital ecosystem has been represented.

Finally, in the social sovereignty layer, it has been sought to reflect how citizens use and access digital technologies, since a technological development or a regulatory framework cannot be sustained without a citizen base that uses these technologies

or that must be protected from the dangers found on the internet. This includes factors such as digital skills or accessibility that reflect the level of internet users in each region.

Together, these three layers are related to each other to create the entire framework of sovereignty of the countries, which will specialize in one or more of the dimensions to achieve strategic autonomy.

## 3.2. Components

Each of the layers identified before is basic to obtaining digital sovereignty: technological control ensures resilience and security; government control ensures a stable policy framework; societal control ensures legitimacy and inclusion.

But the question remains: how can we determine whether a state has achieved digital sovereignty? Two primary theories have been established to assess sovereignty: the chunk theory, which posits that a state either possesses sovereignty in its entirety or does not, and the basket theory, which envisions sovereignty as a collection of attributes that states accumulate to varying degrees (Fowler & Nunck, 1994). When considering performing quantitative analysis, the basket theory reflects more closely the evolving digital landscape, where states, organizations, and individuals share influence over digital governance (Parmar, 2017).

Therefore, for each of the layers, we have identified plausible proxy indicators:

### 3.2.1. Technological layer

The technological dimension of digital sovereignty is the one that has been most developed by companies and technologists. Large multinationals tend to describe sovereignty from control, whether of infrastructure, data, or other software elements. In particular, Google describes it as the protection and control of data by companies, focusing on legitimate access to information and the availability of software (Google, 2024), while Amazon describes it as control of digital assets and in particular data by users (Garman, 2022). These positions justify the inclusion of indicators such as cross-border and domestic data policies, secure internet servers, and cybersecurity capacity, which reflect infrastructural and procedural control over digital systems.

Floridi (2020) extends this vision to include broader control over digital standards, processes, and hardware. Therefore, our index includes measures of 5G and FTTH coverage, AI in scientific publications, and robot density, which assess a country's autonomy in both existing and emerging technologies. These metrics align with McKinsey's emphasis on reducing reliance on foreign technologies across critical sectors such as quantum computing, AI, and digital infrastructure (Iszkowska et al.,

2020), as well as Telefonica's assertion of sovereignty as control over the societal effects of new technologies (Shapiro, 2021). Finally, we have included ICT patents and software spending as proxies for national innovation capacity and autonomy in software ecosystems respectively.

Additionally, the sub-pillar "Tech Industry Development" reflects the strategic importance of developing local technological capabilities. Measures like unicorn valuation (% GDP) and generic TLDs per capita represent the development of a local digital ecosystem.

### 3.2.2 State Sovereignty

From the perspective of governments, digital sovereignty is usually interpreted from a point of view of control over existing digital resources within the region, along with the exercise of regulatory authority recognized by other states. An example of this is China, which exercises control over its digital resources from a state-centered policy and regulation (Information Office of the State Council of the PRC, 2010). This justifies the inclusion of metrics such as the ICT regulatory environment, regulation of emerging technologies, and e-commerce legislation within the "Policy & Regulation" sub-pillar of the index.

Mueller (2021) similarly highlights the importance of national capacity to regulate digital information flows and assert control over data and online activity. Therefore, we have included indicators such as data localization measures, investment promotion in emerging technologies, and open government data to evaluate the state's role as both regulator and promoter. This is supported by the development of a strong digital government and the online services that it implies, as Europe is aiming in one of the pillars of its digital compass.

Finally, Belli and Jiang (2025) and Roberts et al. (2021) frame digital sovereignty as the exercise of legitimate authority over digital infrastructure and protocols, highlighting the need for states to shape the digital ecosystem proactively. Therefore, in our index we have included variables like government support for emerging tech and public sector data initiatives reflecting this dynamic relationship between authority, legitimacy, and innovation governance.

### 3.2.3 Social Sovereignty

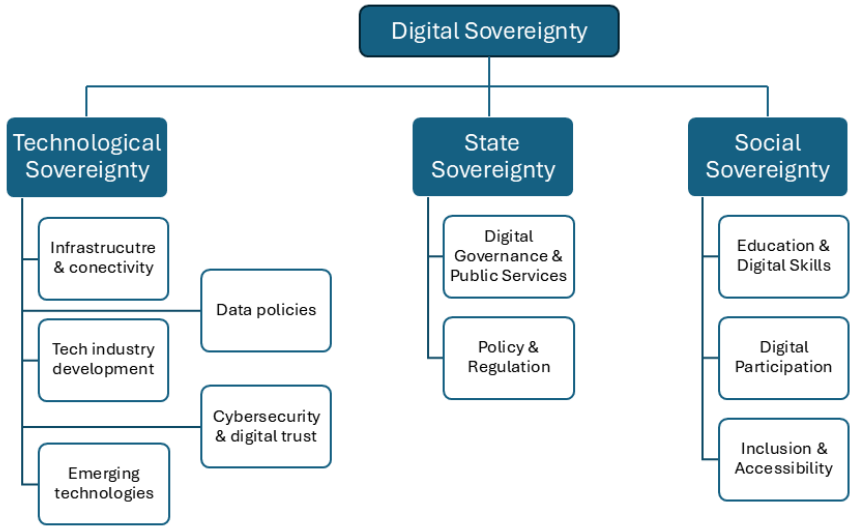
Finally, the social perspective of digital sovereignty reflects society's capacities and facilities for the use of technology. In line with this, Merkel's (2019) stated that "as I understand it, digital sovereignty does not mean protectionism, or that state authorities say what information can be disseminated—censorship, in other words; rather, it describes the ability of both individuals and of society to shape the digital transformation in a self-determined way", giving rise to the inclusion of indicators related to digital skills, tertiary enrollment, and ICT skills in education.

Phole and Thiel (2020) further argue that digital sovereignty encompasses the digital transformation of social institutions, requiring attention to inclusivity and participation. To this end, the index includes variables that measure e-participation, availability of local online content, and digital gaps—including gender, rural, and socioeconomic gaps in the use of ICTs; aligning with the view that sovereignty must extend to equitable digital citizenship.

Moreover, the inclusion of metrics such as mobile social media penetration, use of virtual networks, and GitHub commits per capita highlights the societal engagement with digital platforms and content creation, aligning with PWC's (2023) definition of sovereignty as self-determined development in the digital world. The indicator AI talent concentration is also included to reflect national capacity to retain and foster digital expertise, a key concern in both societal empowerment and techno-industrial competitiveness.

The summary of this framework can be seen in Figure XXX where we have highlighted the different category aggregations

*Figure 1: Digital Sovereignty Framework*




# 4. Research Methodology

This section outlines the methodology adopted to construct the Digital Sovereignty Index (DSI), following the guidelines provided by the OECD and the European Commission's Joint Research Centre for building composite indicators (OECD/European Union/EC-JRC, 2008). The methodology is structured around three key stages: data collection and processing, normalization, and aggregation.

To maintain comparability across countries while preserving data integrity, we applied a structured imputation protocol:

1. Countries with more than 5% of missing values across the total indicator set were excluded from the analysis.
2. When possible, missing values were supplemented using credible estimates identified in academic literature or related datasets.
3. Where no direct estimates could be sourced, missing values were imputed using the regional average within the same geopolitical grouping (EU, NAWA, SSA, etc.).

All imputation steps were recorded and sensitivity-tested to ensure the robustness of results.

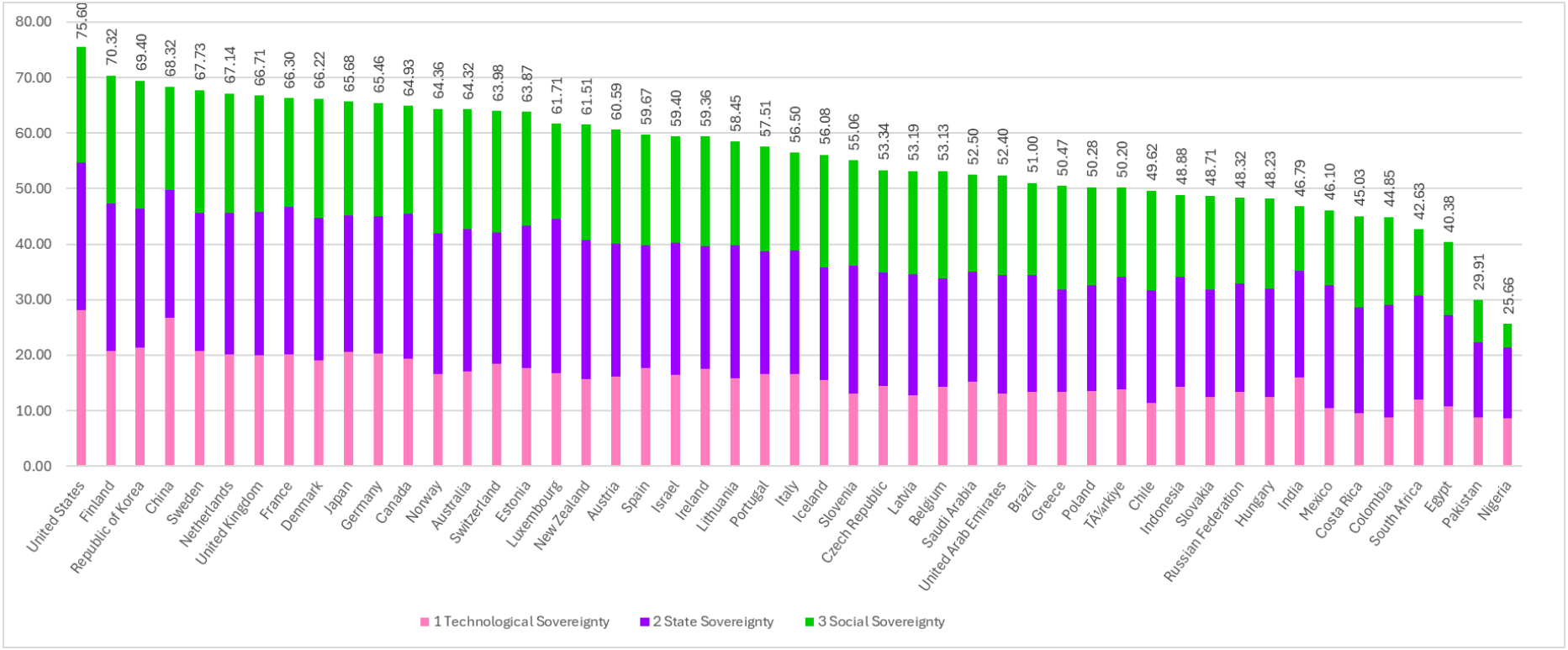
Given the diverse units and scales across indicators, a Min-Max normalization technique was applied to rescale all values to a common range [0,1]. This approach maintains the interpretability of the data and ensures that higher values uniformly reflect better performance or greater sovereign capacity. As outliers were limited and conceptually meaningful (e.g., global technological leaders), no correction for outliers was applied thus allowing exceptional performers to be appropriately rewarded.

We adopted an equal weighting scheme for the aggregation of indicators within each layer, consistent with OECD best practices when no strong theoretical or empirical justification exists for differential weighting. This choice reflects our views that each component of sovereignty—technical, institutional, or societal—contributes equally to the overall index. The normalized scores for each indicator were averaged to produce sub-dimension scores, which were then combined to generate the final composite index.

## 5. Results and Analysis

In order to answer the first research question presented, we have developed a digital sovereignty index for 123 selected countries. In Figure 2 we can see the results for the composite index divided into the three layers of sovereignty.

*Figure 2: Digital Sovereignty Index and sub indicators*




*We have represented 50 of the 123 countries, where the selection criteria was belonging to the OCDE group, or higher population according to the World Bank*

The first group of sovereignty leaders is characterized by a strong global technological sector and solid foundations in the creation of a digital society and government. At the forefront are the United States, Finland, South Korea, and China, followed by Sweden, Netherlands, UK, France, and Germany, and Japan. The US excels in manufacturing digital goods and offering online services, driven by a robust private sector focused on R&D and start-up innovation (Long, 2024). Its digital economy is concentrated in the West Coast's tech innovation hub (e.g., Google, Meta, Amazon) and the East Coast's business and international hub (NY Stock Exchange, UN headquarters), with central states increasingly attracting businesses through tax incentives and low energy costs. South Korea, on the other hand, stands out for its self-sustaining digital value chain, led by Naver and Kakao in digital services and Samsung and LG in hardware infrastructure (US Department of Commerce, 2024). This local ecosystem provides Korea with greater digital sovereignty compared to its Asian peers. China has established a local version of the Internet (Yang, 2012) and developed a robust local digital value chain. It boasts global leaders in hardware, such as Huawei and Xiaomi, and in software, including Tencent and ByteDance, which dominate social media, gaming, and fintech (Statista, 2025). Additionally, Alibaba stands as a major global e-commerce platform (Fortune, 2024). With a large domestic market representing 17% of the global population (World Bank, 2024), China is emerging as a strong contender to US digital dominance. European countries such as Sweden, Finland, Germany, and France also rank highly. The Nordic nations have achieved consistent digital transformation with strong infrastructure, skilled populations, and leading companies like Nokia and Ericsson (European Commission, 2024). Germany and France leverage their economic power by digitizing key industries — pharmaceuticals, automobiles, and retail—particularly Germany, a leader in Industry 4.0 (Ménière, Philpott, & Pose Rodríguez, 2020). These countries are focusing on the creation of strategic alliances with global partners to supply for raw materials and some basic ICT services. Lastly, Japan boasts strong digital skills and infrastructure but lacks a dynamic entrepreneurial ecosystem, remaining reliant on legacy firms like NTT, Sony, and Nintendo (McKinsey & Company, 2021).

The second group includes southern and eastern European countries like Spain and Italy together with OCDE countries such as Australia, New Zealand and Israel. Many European countries in this group continue to rely heavily on importing ICT goods and services, lacking a substantial local tech industry to support public investments (Hernández de Rojas, Rodriguez Pita, & Pérez Martínez, 2024). These nations focus on enhancing their local digital ecosystems to strengthen sovereignty by implementing regulatory frameworks, creating what is usually referred to as the 'Brussels effect' (Bradford, 2023).

The third group comprises large emerging economies such as Brazil, Türkiye, Indonesia, and India, which are building digital sovereignty by capitalizing on their large domestic markets and cost-effective ICT exports while importing advanced technologies to drive innovation. These nations function as technology intermediaries, crafting localized solutions to meet internal demands and producing affordable products for global markets (Baes et al., 2020). Initiatives like India's Aadhaar and Türkiye's National Technology Initiative highlight their investments in indigenous digital infrastructure and efforts to reduce foreign technology dependence, aiming to move up the global value chain. However, challenges remain, including dependence on foreign semiconductor production and skill gaps in the workforce, which call for long-term strategic planning. These countries navigate complex geopolitical landscapes by balancing collaborations with global tech leaders while influencing international digital standards through platforms like the G20 and BRICS (Carvalho, Azevedo, & Massuquetti, 2019). By promoting inclusive digital ecosystems and prioritizing low-cost ICT exports, they are bridging the digital divide and establishing themselves as emerging influencers in the global tech arena.

And lastly, we observe that most African countries are still far from achieving digital autonomy, most of them relying heavily on Chinese technological exports, with Huawei as a main infrastructure deployer (Bo, Lawal, & Sakariyahu, 2024).

## 6.1 Comparative USA vs China vs UE

The European Union is lagging when compared to the US and China's digital sovereignty. As we delve deeper into the Index in Table 1, we can see that the main reason is the lack of technological sovereignty, in particular in tech industry development, emerging technologies, and data policies. Firstly, on tech industry development, we can see that one of Europe's biggest weaknesses is the lack of unicorns, as its unicorn valuation as % of GDP is 9.6, more than three times less than the US (32.8). To address this issue, the EU has already highlighted as one of the objectives of the digital decade 2030, to double the number of unicorns in the Union (Decision (EU) 2022/2481). Secondly, in emerging technologies we can see that the Union is lagging in all indicators, it has six times less Ai presence in scientific publications compared to the US, and ten times less than China; its investment in emerging technologies is half of that in the US, and it has ten times less semiconductor fabrication plants than the two regions. Finally, on data policies, we can see that the EU has developed a strong foundational data enabling regulations framework, especially in the rise of the European single market for data that is being promoted as part of the European data strategy (COM(2020) 66 final). However, when we compare it to countries such as China, that have set forth a highly localized data policy framework, the number of measures is not as large.

On the other hand, China has a solid position in infrastructure, emerging technologies and data policies, while its tech industry development has stalled behind the US, getting a similar result to Europe. This has been mainly marked by two indicators: Generic top-level domains per population and software spending.

When we look at state sovereignty, the US has a lead over the other two regions, mainly owing to its digital governance and public services, especially regarding open data. While China and the EU maintain similar values, there is one indicator in which Europe has a marked lead: ICT regulatory environment.

Finally, when we look at the social sovereignty, we can find smaller differences between the regions, with China lagging slightly on digital skills and online participation.

*Table 1: Digital Sovereignty and sub-indices for EU, US and China*

| ECONOMY_NAME | United States | China | EU |
|---|---|---|---|
| **0 Digital Sovereignty Index** | **75.98** | **67.12** | **58.38** |
| **1 Technological Sovereignty** | **71.18** | **63.88** | **42.22** |
| 1.1 Infrastructure & Connectivity | 71.93 | 86.98 | 70.64 |
| 1.2 Tech Industry Development | 71.51 | 26.24 | 23.69 |
| 1.3. Emerging Technologies | 77.15 | 79.85 | 38.75 |
| 1.4. Data policies | 40.66 | 80.00 | 28.28 |
| 1.5 Cybersecurity & Digital Trust | 96.88 | 70.06 | 86.47 |
| **2 State Sovereignty** | **88.53** | **76.92** | **74.93** |
| 2.1 Digital Governance & Public Services | 84.41 | 73.80 | 63.66 |
| 2.2 Policy & Regulation | 92.66 | 80.03 | 86.20 |
| **3 Social Sovereignty** | **69.82** | **61.65** | **63.39** |
| 3.1 Education & Digital Skills | 63.62 | 52.47 | 54.24 |
| 3.2 Digital Participation | 58.93 | 49.76 | 56.68 |
| 3.3 Inclusion & Accessibility | 86.90 | 82.72 | 79.25 |

*The European Average was calculated using the average of the 27 member states*

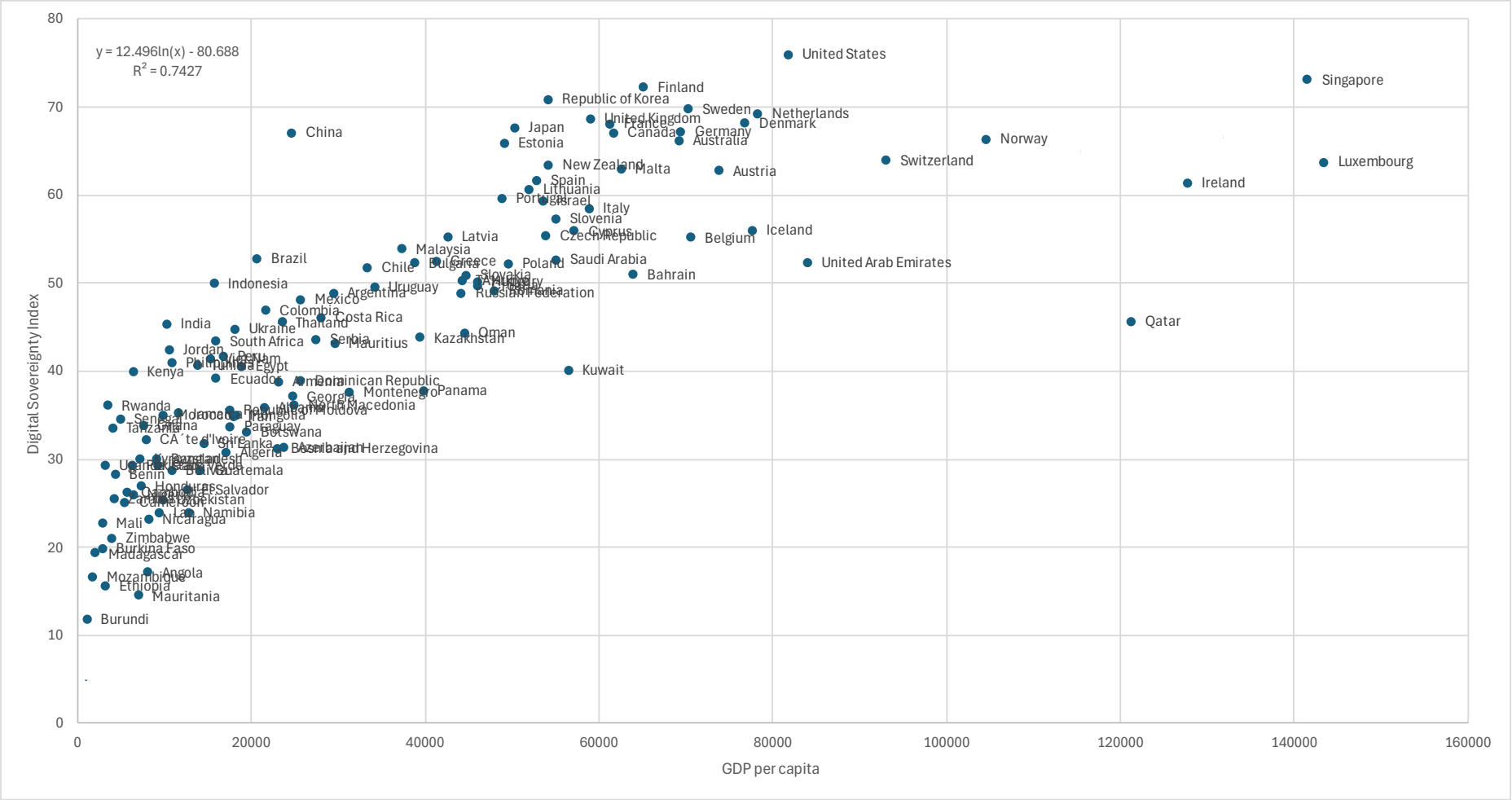
Technology dependencies create strategic vulnerabilities. The technological dominance carried out by the great world powers, the United States and China, has led to the creation of asymmetries in access to critical technologies such as the cloud, semiconductors, Artificial Intelligence systems or data infrastructures. This imbalance can limit the policy choices and national autonomy of countries, especially those with lower market strength. In this context, strengthening domestic research and development, supporting open-source ecosystems, and diversifying supply chains are seen as critical steps to safeguard sovereignty.

## 6.2 Relationship with economics

As we have seen in section 2. Literature Review, there is empirical evidence that supports the strong relationship between economic development and digitalization. Therefore, throughout this section we will explore the relationship between economic indicators and the digital sovereignty index we have developed in order to determine the possible relationships between the two.

Firstly, in Figure 3 we can see the relationship between the GDP per capita and the digital sovereignty index.

*Figure 3: GDP per capita vs Digital Sovereignty Index*



A clear positive relationship between the GDP per capita and the digital sovereignty index can be seen in the figure, with a correlation of $R^2 = 0.7427$. This leads us to formulate that those richer nations tend to have greater digital autonomy, with a very accelerated growth to approximately 4000 euros of per capita income, stabilizing from this value. However, outliers can be seen, as is the case with the United States, China, South Korea, and Japan, achieving significantly higher levels of sovereignty than their GDP per capita alone would predict.

Among Asian countries, Japan and Korea were pioneers in the development of industrial strategies from the 1970s onwards, based initially on trade protectionism and later on development and investment in research with the aim of reducing technological dependencies on foreign countries. More recently, China has embarked on "digital self-sufficiency" by boosting the development of domestic AI giants, developing its semiconductor industry, and leading quantum technologies, with state policies such as "Made in China 2025" directly supporting this goal (Martin, 2022). The United States has followed a trade policy that has changed over time, in which, after an expansionist period, it has been marked by periods of protectionist policies and a reduction in foreign trade in search of the development of local industries, through policies such as the Chips Act. This techno-nationalist framework positions advanced digital capabilities as pillars of national security and geopolitical competition, a clear reflection of state-led digital industrial strategies.

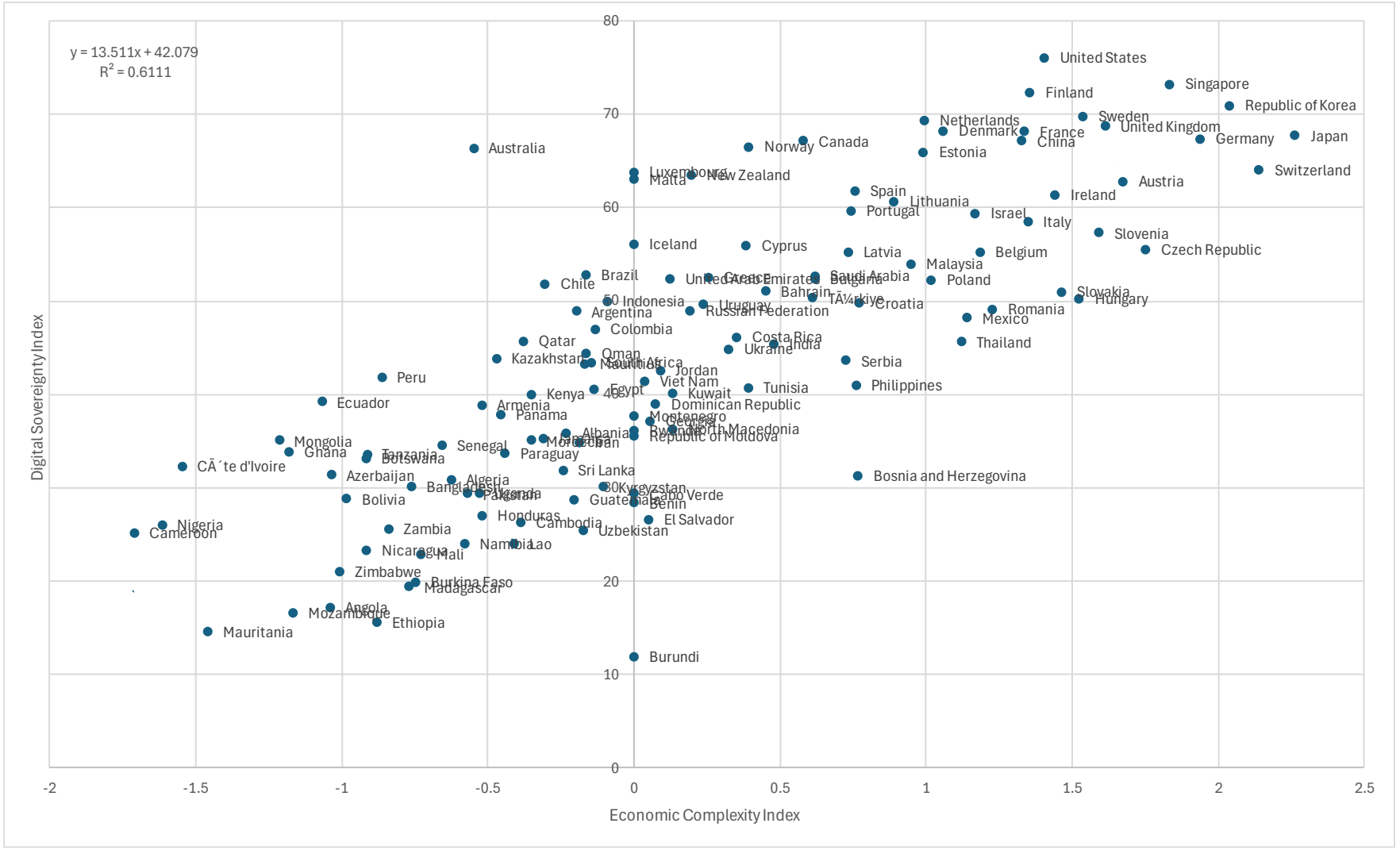
By contrast, countries with high GDP but lower GDP, such as Ireland, Luxembourg, Qatar and the United Arab Emirates, demonstrate that wealth alone is not enough to achieve autonomy. These nations often rely on foreign digital providers, as is the case with Ireland and Luxembourg, the entry countries of large American tech platforms into the European market and lack cohesive industrial or regulatory strategies to develop indigenous digital ecosystems.

These cases confirm that digital sovereignty arises from intentional strategic interventions, not just economic wealth. Digital industrial policy aligned with supply chain growth and resilience establishes why countries such as China, the United States, Korea, and Japan perform better in sovereignty relative to revenues.

*The relationship between digital sovereignty and economic complexity is strong and positive, as indicated by the $R^2$ value of 0.6111 in the*

Figure 4. Economic complexity, which reflects a country's capacity to produce and export sophisticated, knowledge-intensive goods, is closely tied to innovative ecosystems, industrial capabilities, and technological absorptive capacity. These are all basic for building digital sovereignty.

*Figure 4: Economic Complexity Index vs Digital Sovereignty Index*



Countries such as Japan, South Korea, Germany, and Switzerland stand out with high values on both indices. Their success reflects long-standing policies focused on advanced manufacturing, high-tech exports, and integrated research combined with education systems. These states develop economic complexity not only to generate economic value but also to ensure greater autonomy in digital infrastructure, standards, and capabilities.

However, resource-dependent economies like Qatar or the UAE—though economically wealthy—score lower on economic complexity and correspondingly on digital sovereignty. This indicates that a reliance on a narrower set of economic outputs does not provide the institutional or technical base needed for sovereign digital development.

These patterns reinforce the arguments of scholars such as Hidalgo and Hausmann (2009), who associate economic complexity with institutional capacity and innovation. When viewed through the lens of techno-nationalism and state-led digital strategies, the results are even more telling: countries with diversified, knowledge-intensive economies are better positioned to create national strategies for technological self-sufficiency and digital independence. In short, economic complexity functions as both a driver and an enabler of digital sovereignty, beyond what GDP alone can explain.

## 6. Conclusion and policy recommendations

This study has sought to fill two critical gaps in the literature on digital sovereignty: first, by proposing a clear, quantifiable framework for defining digital sovereignty; and second, by empirically exploring how a country's level of digital sovereignty relates to key macroeconomic indicators such as GDP and economic diversification.

Building on the existing definitions of digital sovereignty found in literature, we distilled three core dimensions of digital sovereignty—technology, government and society—that we have aggregated into a Digital Sovereignty Index following the recommendations for constructing composite indexes published by the OCDE. This index provides a ranking for countries to benchmark their advancements in digital sovereignty and each of its subindices, providing an objective and robust framework for measuring the effectiveness of public policies in the long term.

The US comes on top, followed by Korea, Japan, China, and some highly digitalized European countries such as Denmark, Finland, Netherlands and Sweden. One of the most notable aspects of this group is the advancement in technology, particularly from the US and China, giving them leverage over the rest of the

countries that depend on their technological exports to develop their own digital ecosystems.

When we examine the US, China, and the European countries average, we can find that despite the lack of technological sovereignty, it has a highly developed digital government and society. USA is predominant over its two competitors in tech industry development, but regarding emerging technologies both China and the US have similar values.

To improve this situation, the European Union has developed a digital framework based mainly on the digital decade 2030, the competitiveness compass and the recently published International Digital Strategy. This strategy aims at creating a comprehensive framework of partnerships, cooperation and technological development, through infrastructure, emerging technologies and cybersecurity, thus improving the European situation in terms of technological sovereignty and aligning the European response to its current digital gap with the results of our analysis. However, the effects of these strategies will start to become visible in the longer term. Therefore, in the current context, Europe must continue creating strategic and resilient alliances with the technological leaders, making sure to avoid bottlenecks in its digital supply chain and developing its local digital ecosystem with the existing recovery and resilience funds.

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## Annex 1: Variables and Sources

*Table 2: Pillars, Sub pillars, and variables of the Digital Sovereignty Index*

| Pillar | Sub pillar | Variable | Source |
|---|---|---|---|
| **Tech Sovereignty** | **Infrastructure & Connectivity** | 4G Population Coverage | GSMA |
| | | 5G Population Coverage | GSMA |
| | | FTTH/Building Internet Subscriptions | ITU DataHub |
| | **Tech Industry Development** | ICT Patents as % of total patents | Patent and Technology Information |
| | | Unicorn valuation, % GDP | WIPO |
| | | Generic top-level domains (TLDs)/th pop. 15-69 | Zooknic |
| | | Software spending, % GDP | WIPO |
| | **Emerging Technologies** | AI in scientific Publications | Portulans Institute |
| | | Adoption of emerging technologies | Portulans Institute |
| | | Investment in emerging technologies | Portulans Institute |
| | | Robot density | Portulans Institute |
| | | Frontier Technology Index | UNCTAD |
| | | Semiconductor Fabrication plants | WPR |
| | **Data Policies** | Cross-Border data policies restrictions | EUI |
| | | Domestic Data policies restictions | EUI |
| | | Cross-Border data policies enabling measures | EUI |
| | | Domestic Data policies enabling measures | EUI |
| | **Cybersecurity & Digital Trust** | Secure internet servers | Portulans Institute |
| | | Cybersecurity | Portulans Institute |
| **State Sovereignty** | **Digital Governance & Public Services** | Government's online service | United Nations |
| | | Publication and use of open data | Portulans Institute |
| | | Government promotion of investment in emerging technologies | Portulans Institute |
| | **Policy & Regulation** | ICT regulatory environment | Portulans Institute |

| | | | |
|---|---|---|---|
| | | Regulation of emerging technologies | Portulans Institute |
| | | E-commerce legislation | Portulans Institute |
| **Social Sovereignty** | **Education & Digital Skills** | Expenditure on education, % GDP | UNESCO |
| | | Tertiary enrolment, % gross | UNESCO |
| | | Graduates in science and engineering, % | UNESCO |
| | | ICT skills in the education system | Portulans Institute |
| | **Digital Participation** | Individuals using the Internet | ITU DataHub |
| | | Mobile Social Media Penetration | DataReportal |
| | | Use of virtual social networks | Portulans Institute |
| | | AI talent concentration | Portulans Institute |
| | | GitHub commits/mn pop. 15-69 | GitHub |
| | **Inclusion & Accessibility** | E-participation | United Nations |
| | | Socioeconomic gap in use of digital payments | Portulans Institute |
| | | Availability of local online content | Portulans Institute |
| | | Gender gap in Internet use | Portulans Institute |
| | | Rural gap in use of digital payments | Portulans Institute |