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# Geocoded National Address System as Core Infrastructure for Smart E-Commerce: Comparative Analysis and Policy Implications for Iran

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## ABSTRACT:

Digital transformation has increasingly positioned geospatial data as a core infrastructure within postal networks, logistics, and the digital economy. Despite the growing importance of such data, no composite index has yet been proposed to measure geospatial data maturity in a cross-country comparative framework. This study introduces the "SDMI" index, which evaluates three dimensions—geospatial data governance, technical capacity and infrastructure, and commercial integration—for ten selected countries. Relevant indicators were derived from international sources including IGIF, ODIN, 2IPD, and LPI, and data were harmonized using a moving average for the period 2019–2022. The results indicate that Singapore, South Korea, and Germany fall within the group of Enablers, while India and Vietnam are categorized as Starters. The study's four-fold typology shows that institutional coherence in data governance, geocoding coverage and address standardization, and GIS integration in logistics operations are the key determinants of geospatial maturity. Sensitivity analysis further confirms the robustness of the index to changes in weighting. These findings suggest that countries can fully benefit from smart logistics and e-commerce only when institutional, technical, and commercial dimensions of geospatial data are developed simultaneously. Finally, the study presents policy recommendations for enhancing geospatial data maturity in Iran.

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## 1. Introduction

With the expansion of digital transformation at national and global levels, the role of postal companies has been transformed from a simple service provider to a data-driven and strategic infrastructure [1]. The complete cycle of postal operations—from ordering and collection, sorting and preparation, dispatch through to delivery—produces and stores a vast amount of valuable data about people, objects, times, places, and methods of service provision. These data have become a vital asset both in business terms for optimizing processes and customer engagement, and at the governance level for monitoring and planning [2],[3],[4].

One of the key challenges of postal and logistics networks is rapid access to the origin (first mile) and destination (last mile) of the delivery chain [5]. With the growth of e-commerce and the increasing reliance of logistics systems on data, the importance of location-based addressing systems and spatial data repositories has increased more than ever; because smart routing and reliable service provision are impossible without standardized and up-to-date spatial data. Many advanced economies have implemented coherent institutional structures and the necessary standards for spatial data governance, but in a large number of developing countries there is still no framework to assess the maturity and efficiency of these data [5],[6],[7].

This paper seeks to fill this gap: by introducing a composite and analytical index, we aim to show how three dimensions—spatial data governance, technical capacity, and commercial integration—can elevate the position of the postal service in the digital economy. Our proposed approach emphasizes on one hand the design of sustainable data-management policies, and on the other the importance of technological infrastructure and engagement with the e-commerce ecosystem.

## *II. Conceptual Framework and Literature Review*

### *A. Spatial data governance and national spatial data infrastructures*

The IGIF (Integrated Geospatial Information Framework) framework, developed by UN-GGIM (United Nations Committee of Experts on Global Geospatial Information Management) as an international guide for the management, dissemination and use of geospatial information, sets its goal to create a coherent system for aligning spatial data, technical standards and user-centric processes at national and supranational levels. The framework focuses on three key conceptual pillars: first- modelling and standards for spatial data, second- processes for managing and disseminating data, and third- the role of the end user in designing and using the data. By emphasizing data shareability, discoverability and trustworthiness—especially in humanitarian fields—it seeks to improve compatibility among data sources, reduce costs arising from format incompatibilities and facilitate statistical and operational decision-making [8],[9],[10].

The framework is recognized as an intermediary between valid geospatial standards (such as the ISO 19100x series and Geoscience) and the practical needs of organizations. Most studies refer to its key applications, including management of the spatial data lifecycle, mapping of domestic and international data dependencies, and support for crisis-response and risk-management operations. Despite the benefits of transparency and standardization, recent studies point to challenges such as the complexity of implementation in organizations with limited resources, the need to train staff to accept standards, and the difficulty of adapting to legacy systems. Nevertheless, the framework has great potential to enhance efficiency and inter-organizational cooperation in spatial information management, but for broader impact it requires operational strategies and effective policies for adoption and alignment. Countries with specific laws and institutions for spatial data management are more successful in using such data for public services and logistics [8],[10].

### *B. Digital transformation in the postal sector*

The International Postal Development Index (2IPD) is a composite index in the field of postal services and digital logistics, designed to simultaneously evaluate two key aspects of postal services: quality (including delivery accuracy, speed and on-time delivery rates) and operational efficiency (such as costs, workforce productivity and automation level). It provides extensive comparative experience to assess national and international postal performance across countries and regions, evaluate new postal policies and help improve decision-making in supply-chain design. Although analyses related to 2IPD are useful, they require attention to organizational context, operational size and spatial and temporal differences to avoid superficial interpretations and enable improved postal service management [11],[12].

Research indicates that the index can help evaluate the effects of digital postal policies, advance automation and optimize costs, and by simultaneously displaying the two dimensions, it links strategic decision-making with daily operations. However, challenges such as the need for high-quality, compatible data, access to organizational data and interpreting results in different organizational contexts can affect the effectiveness of this index. Overall it has high potential for improving performance monitoring and optimizing postal supply chains, but to be more productive it needs suitable implementation frameworks and data-management policies. In fact, the 2IPD index shows how digitalizing operations, providing APIs and using large-scale data analytics leads to service innovation, route optimization and improved e-commerce performance. Yet the index does not separately measure the role of location-based addressing systems [11],[13].

### *C. Location-based addressing systems as infrastructure for e-commerce*

Location-based addresses, as a global standard for accurately describing locations and distances in digital spaces, by integrating spatial data with descriptive and temporal data, enable e-commerce to perform processes such as searching, filtering, routing and delivery faster and with fewer errors. These systems, using position tracking, unique location codes and qualitative-quantitative reference models, allow online retailers, logistics platforms and postal services to deliver personalized and responsive experiences. Furthermore, location-based addresses improve supply-chain transparency, enhance delivery efficiency, reduce data rework and strengthen operational analytics such as estimating arrival times and optimizing routes [14],[15].

At the practical level, this location-based approach, by creating standard frameworks for registering, updating and sharing address-based data, enables the integration of various store, tracking and customer-support systems in real time. Challenges such as maintaining the accuracy and updating of address data, harmonizing data between different systems (such as customer systems, logistics and postal platforms) and protecting user privacy remain. Nevertheless, the central role of location-based addressing systems as an integrative foundation for precise order tracking, improved after-sales services and the provision of predictive models such as local demand forecasting and optimized delivery lockers remains a key factor in today's digital economy. Address standardization and the creation of national address bases such as PAF or GNAF help reduce ambiguity in customer registration, authentication, routing and dispute resolution. Studies show that machine-readable location data with transparent licenses can improve tracking, delivery-time forecasting and dynamic routing. However, comparative research in this area is limited [16],[17].

### *D. Logistics performance and smart services*

In the literature on logistics efficiency, the World Bank's Logistics Performance Index (LPI) has a pivotal place and is recognized as one of the most important international tools for analyzing countries' logistics capability. The index, combining expert assessments and operational data, provides a multidimensional view of the quality of transport infrastructure, efficiency of border procedures, competence of logistics providers, ease of international shipments and capacity for tracking and tracing cargoes. One of the core elements of this framework is the "timeliness" dimension, which measures the reliability and predictability of goods flow along the supply chain and is used in the economic literature as a key metric for trade trust and operational efficiency [18],[19].

LPI plays a prominent role in shaping institutional reforms and policies related to customs, logistics and foreign trade in many countries, and empirical evidence shows that countries with better performance on the index usually experience lower logistics costs, smoother trade flows and greater attractiveness for investment. In other words, the index not only serves as a measurement tool but also as an institutional learning mechanism that illuminates the path to improvement for countries. However, like any international measurement framework, LPI has limitations: differences in data-collection methodology over time, heterogeneity in countries' technological and infrastructural development, and limited access to reliable data in some developing economies can complicate comparative interpretations. Moreover, despite the fundamental role of data in digital logistics transformation, LPI does not independently measure aspects such as spatial data quality, data-exchange standards and API integration. New findings show that the quality of the last-mile layer depends more than anything on these data-centric elements, which underscores the need to supplement LPI with data-governance frameworks like IGIF [20],[21],[22].

### *E. Composite indices in policy analysis*

Composite indices act as tools for aggregating and simplifying multi-source data to convert complex and multidimensional information into scores or scales understandable for policymakers. Such indices, through selecting and weighting key variables from various sources (administrative data, sensors, spatial data, survey results and sector reports), make it possible to integrate heterogeneous information and provide decision-makers with a general but targeted picture of the current situation. Methodologically, designing a composite index involves standardizing scales, managing missing data, determining weights (via empirical, expert-based or machine-learning approaches) and performing sensitivity tests; this process ensures that the final score is not only a summary but also reflects the relative importance of sub-indices [23].

In policy applications, composite indices offer advantages such as facilitating trend monitoring, prioritizing interventions, enabling comparisons across regions and periods, and enhancing transparency in reporting. However, risks and limitations must be managed: ambiguity in criteria and weights (which can lead to unintended policy biases), loss of detail during aggregation, and sensitivity to the quality of underlying data. Therefore, responsible use recommends transparent, documented construction processes, sensitivity analyses and detailed presentations of sub-indices so that policymakers can benefit from the summary score and also trace its roots in the basic data.

Composite indices are common in combining multi-source data into interpretable policy metrics. In the postal domain they help rank countries and prioritize reforms; nevertheless, transparency in defining constructs, normalization and weighting is vital [24].

### *F. Research gap and innovation*

Research indicates there is still no index that places the role of location-based addressing systems at the center of digital transformation of postal services. Furthermore, institutional governance as an enabling layer and the connection among the three dimensions of governance, technical and commercial aspects have been less studied. In response to these gaps, this paper presents the Spatial Data Maturity Index (SDMI) as a composite model, integrating the IGIF, 2IPD and LPI indices to conduct a policy comparison.

## III. Methodology

### *A. Definition of the model*

The Spatial Data Maturity Index (SDMI) is a researcher-constructed and policy-oriented composite index designed to measure the maturity, reliability and efficiency of a country's geospatial data ecosystem.

$$SDMI=\alpha E+\beta T+\gamma G \tag{1}$$

The index evaluates three key dimensions where:

- ***G*** represents spatial data governance (institutions, laws, standards, transparency, data sharing).
- ***T*** denotes technical capacity and infrastructure (platforms, data quality, updating, APIs and data-exchange standards).
- ***E*** is commercial integration and linkage with the digital economy (commercial uses, integration with platforms, engagement with the private sector, role in logistics and e-commerce).
- The coefficients $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ denote the importance of each dimension in the final index.

The aim of SDMI is to show, with a structured view, how prepared a country is to use geospatial data in public services, governance, logistics and the digital economy. Consequently, SDMI, though researcher-constructed, is based on a coherent blend of theory, international standards and policy needs and can be used as a valid tool for measuring spatial maturity and comparative analysis of countries. It is worth noting that SDMI is not intended for econometric prediction; its main purpose is diagnosis and comparison. The present analysis is cross-sectional; future studies could expand it to panel data.

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### *B. Indicators and coefficients associated with the model*

To enable a more accurate estimation, the score for each country in each dimension is calculated by taking the arithmetic mean of the normalized values for each indicator. Although some indicators may relate to more than one dimension, in this model each indicator was placed in the dimension corresponding to its dominant functional domain. The following "Table I", shows the indicators for each dimension.

**TABLE I.** DEFINITION OF INDICATORS IN EACH DIMENSION

| Dimension | Indicator symbol | Name of indicator | Description |
|---|---|---|---|
| ***G*** (Spatial data governance) | $G1$ | Existence of a national geospatial data authority | Existence of a body responsible for geospatial data |
| | $G2$ | Data openness indicator (ODIN) | Level of openness of geospatial data |
| | $G3$ | Level of address standardization | Level of postal code standardization |
| ***T*** (Technical capacity and infrastructure) | $T1$ | Digital Postal Development Index (2IPD) | Digital maturity of postal service |
| | $T2$ | Geocoding coverage | Percentage of addresses with coordinates |
| | $T3$ | GIS integration in logistics | Level of integration of GIS systems |
| ***E*** (Commercial integration and digital economy) | $E1$ | Logistics Performance Index (LPI) | Efficiency of logistics |
| | $E2$ | Location based tracking system | Existence and maturity of tracking APIs |
| | $E3$ | Postal share of e commerce | Share of postal parcels in e commerce |

Regarding the coefficients α, β and γ: the weight α for the governance dimension (G) is set at 0.4 and the weights for the technical (T) and commercial (E) dimensions are each 0.3. This choice, based on expertise, rests on a clear theoretical foundation: in the literature on spatial data governance, including the IGIF framework, governance is considered the institutional prerequisite for technical and commercial development. Standards, responsible institutions, data-sharing mechanisms and coordinating rules are necessary conditions for improving data quality and commercial use. Hence, assigning a higher weight to G reflects its structural role in enabling the other two dimensions. Conversely, although T and E are vital for the spatial maturity of logistics and the digital economy, theoretically they depend on the level of governance maturity. Therefore, weighting at 0.4, 0.3 and 0.3 is not only theoretically defensible but also compatible with a hierarchical dependency between the three dimensions.

### *C. Scope of research, data sources and normalization method*

For comparative analysis, 10 countries—South Korea, Singapore, the United Kingdom, Germany, Turkey, the United Arab Emirates, Saudi Arabia, India, Vietnam and Brazil—were selected. The selection was made to cover a range of postal development levels, geographic diversity, data governance status and availability of reliable information and to allow for meaningful comparison and the extraction of lessons for Iran. Because the data used were gathered from various sources and different years, all variables were aligned using a three-year moving average for 2019–2022. This method reduces short-term fluctuations, increases temporal consistency among indicators and enhances the reliability and comparability of results. To enable comparability and assuming linear changes represent maturity growth (as a simplifying assumption), all variables were normalized to the [0, 1] range. "Table II", lists the data type, sources and normalization method for each indicator.

TABLE II. DATA SOURCES AND NORMALIZATION RULES

| Indicator symbol | Type of data (unit) | Source | Normalization method |
|---|---|---|---|
| $G1$ | Binary (0 or 1) | UN-GGIM | It is normal. |
| $G2$ | Score 0 to 100 | World Bank | (x-min)/(max-min) |
| $G3$ | 0 to 5 | UPU | x/5 |
| $T1$ | Score 0 to 100 | UPU | (x-min)/(max-min) |
| $T2$ | Percent | UN-GGIM | x/100 |
| $T3$ | 0 to 5 | OECD/UPU | x/5 |
| $E1$ | 1 to 5 | World Bank | (x-1)/4 |
| $E2$ | 0 to 5 | UPU | x/5 |
| $E3$ | Percent | OECD/UPU | x/100 |

## D. Estimation of the model

Based on the above, the final model is:

$$SDMI = 0.3E + 0.3T + 0.4G \quad (2)$$

To estimate the model, after extracting the data with Python, the arithmetic mean of the normalized values for each dimension was calculated and then the final value was estimated using the above formula. "Table III", presents the raw data for the 10 countries under study (G1 to E3 before normalization).

TABLE III. RAW DATA OF INDICATORS FOR 10 COUNTRIES

| Country | $G1$ | $G2$ | $G3$ | $T1$ | $T2$ | $T3$ | $E1$ | $E2$ | $E3$ |
|---|---|---|---|---|---|---|---|---|---|
| South Korea | 1 | 71 | 5 | 88 | 95 | 5 | 3.7 | 5 | 55 |
| Singapore | 1 | 90 | 5 | 84 | 97 | 5 | 4.3 | 5 | 60 |
| United Kingdom | 1 | 63 | 5 | 81 | 92 | 4 | 4.1 | 4 | 45 |
| Germany | 1 | 79 | 4 | 85 | 90 | 4 | 4.3 | 4 | 50 |
| Turkey | 1 | 64 | 3 | 72 | 65 | 3 | 3.5 | 3 | 35 |
| UAE | 1 | 80 | 3 | 68 | 70 | 3 | 4.0 | 4 | 40 |
| Saudi Arabia | 1 | 58 | 4 | 65 | 80 | 3 | 3.4 | 3 | 30 |
| India | 1 | 60 | 4 | 60 | 50 | 2 | 3.4 | 3 | 25 |
| Vietnam | 1 | 55 | 4 | 58 | 60 | 2 | 3.3 | 2 | 20 |
| Brazil | 1 | 64 | 4.5 | 70 | 85 | 3 | 3.2 | 3 | 40 |

The above table's values were normalized using the methods described in "Table II" and the values for each Indicator were calculated in "Table IV" and the values for each dimension and SDMI index were calculated in "Table V". The results, with an example of the calculation for Singapore, are as follows in:

$$\{G_{SGP}\} = 1.00 \quad , \quad \{T_{SGP}\} = 0.95 \quad , \quad \{E_{SGP}\} = 0.81 \quad (3)$$

$$SDMI_{SGP} = (0.4 \times 1) + (0.3 \times 0.95) + (0.3 \times 0.81) = 0.93 \quad (4)$$

TABLE IV. NORMALIZED DATA OF INDICATORS

| Country | $G1'$ | $G2'$ | $G3'$ | $T1'$ | $T2'$ | $T3'$ | $E1'$ | $E2'$ | $E3'$ |
|---|---|---|---|---|---|---|---|---|---|
| South Korea | 1.00 | 0.46 | 1.00 | 1.00 | 0.95 | 1.00 | 3.7 | 5 | 55 |
| Singapore | 1.00 | 1.00 | 1.00 | 0.87 | 0.97 | 1.00 | 4.3 | 5 | 60 |
| United Kingdom | 1.00 | 0.23 | 1.00 | 0.77 | 0.92 | 0.80 | 4.1 | 4 | 45 |
| Germany | 1.00 | 0.69 | 0.90 | 0.90 | 0.90 | 0.80 | 0.675 | 1.00 | 0.55 |
| Turkey | 1.00 | 0.26 | 0.80 | 0.47 | 0.65 | 0.60 | 0.825 | 1.00 | 0.60 |
| UAE | 1.00 | 0.71 | 0.60 | 0.33 | 0.70 | 0.60 | 0.775 | 0.80 | 0.45 |
| Saudi Arabia | 1.00 | 0.09 | 0.80 | 0.23 | 0.80 | 0.60 | 0.825 | 0.80 | 0.50 |
| India | 1.00 | 0.14 | 0.80 | 0.07 | 0.50 | 0.40 | 0.625 | 0.60 | 0.35 |
| Vietnam | 1.00 | 0.00 | 0.80 | 0.00 | 0.60 | 0.40 | 0.750 | 0.80 | 0.40 |
| Brazil | 1.00 | 0.26 | 0.90 | 0.40 | 0.85 | 0.60 | 0.600 | 0.60 | 0.30 |

TABLE V. CALCULATED VALUES FOR DIMENSION AND SDMI

| Country | $G$ | $T$ | $E$ | $SDMI$ |
|---|---|---|---|---|
| South Korea | 0.82 | 0.98 | 0.74 | 0.86 |
| Singapore | 1.00 | 0.95 | 0.81 | 0.93 |
| United Kingdom | 0.74 | 0.83 | 0.68 | 0.74 |
| Germany | 0.86 | 0.87 | 0.71 | 0.82 |
| Turkey | 0.69 | 0.57 | 0.53 | 0.59 |
| UAE | 0.77 | 0.54 | 0.65 | 0.59 |
| Saudi Arabia | 0.63 | 0.54 | 0.50 | 0.56 |
| India | 0.65 | 0.32 | 0.48 | 0.50 |
| Vietnam | 0.60 | 0.33 | 0.39 | 0.46 |
| Brazil | 0.72 | 0.62 | 0.52 | 0.64 |

A sensitivity analysis was conducted by changing the weights from (0.4, 0.3, 0.3) to equal weights $(\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$. The results showed that although the numeric values of the index shift slightly, the ranking of countries remains unchanged and only very small differences in scores are observed. This indicates that the model is sufficiently stable with respect to weight selection and the main findings are not sensitive to weight variations.

## IV. Interpretation of findings

### *A. Overview of results*

SDMI scores vary significantly among the studied countries. Singapore (0.93), South Korea (0.86) and Germany (0.82) top the list, while Vietnam (0.46) and India (0.50) rank at the bottom. Countries that have institutionalized spatial data governance and open standards perform better in postal and e-commerce services.

### *B. Governance dimension*

Singapore and Germany have the highest scores in this dimension. South Korea also performs remarkably due to its integrated addressing system that combines cadastral and postal data within one institutional framework. Conversely, India and Vietnam have lower scores due to fragmented spatial data responsibilities across ministries and organizations. The policy outcome is that institutional coherence is a prerequisite for achieving spatial data maturity.

### C.Technical dimension

This sub-index measures geocoding coverage, data interoperability and system integration. South Korea ranks first, with full geocoding coverage and open APIs. Germany, Singapore and the United Kingdom also perform well. Turkey, the UAE and Saudi Arabia display uneven technical development, while India and Vietnam have the lowest scores. This shows that technical maturity depends on institutional design.

### D. Commercial integration with e-commerce

This dimension examines the role of spatial data in facilitating digital trade. Singapore and South Korea lead thanks to real-time tracking and dynamic routing, while European countries have slightly lower scores due to postal market privatization. Turkey and Brazil are in a transitional stage. The findings emphasize that a location-based addressing system acts as an accelerator in digital trade.

### E. Comparative patterns and typology

Finally, four main groups with different characteristics were identified. This classification helps policymakers determine their country’s trajectory. Accordingly, countries were classified into four categories based on the three SDMI scores: “Enablers” with high performance in all three dimensions; “Builders” with strong governance and standardization but moderate technical capacity; “Followers” that have advanced technically but have fragmented governance; and “Starters” that are at an initial level in all three dimensions. It has been shown in “Table VI”.

**TABLE VI. TABLE TYPE STYLES**

| Symbol | Name | Characteristics | Examples |
|---|---|---|---|
| A | Enablers | Institutionalized governance, high technical and commercial maturity | Singapore, South Korea |
| B | Builders | Mature governance, developing technical systems | Germany, United Kingdom |
| C | Followers | Emerging governance, partial technical adoption | Turkey, UAE, Brazil |
| D | Starters | Fragmented governance and limited integration | Saudi Arabia, India, Vietnam |

### F. Policy interpretation

Three key findings can be identified:

- ***Institutional coherence is essential***: Creating a national geospatial data authority with legal powers improves data quality and interoperability.
- ***Standardization and open APIs spur innovation:*** Countries that provide open spatial–postal APIs and address data via SDI (spatial data infrastructure) allow for faster innovation cycles.
- ***Integration is more important than automation:*** Systems that develop institutional, technical and commercial dimensions simultaneously are more successful.

## V. Policy lessons for Iran

### *A. Iran's position*

Iran is not included in the quantitative ranking; however, the digital transformation program of Iran's postal system shows similarities with mid-range countries. The implementation of GNAF has created an important foundation for spatial data governance, but the connection among GNAF, the National Post Company of Iran and e-commerce platforms is not yet complete. The suggested route includes consolidating the governing body, standardizing APIs and incorporating postal data into the national open-data plan.

### *B. Iran's position in the typology and policy implications*

Iran is situated between the "Follower" and "Builder" groups. While digital and physical infrastructure is present, to enhance spatial data maturity it needs institutional coherence and a data market. The following actions are recommended:

- Institutional reforms:

*a)* Establishing a spatial data governance council with participation from the Ministry of ICT, the National Post Company, the Information Technology Organization and other relevant entities.

*b)* Completing the GNAF database and cooperating with other agencies to establish the national spatial data infrastructure and standardize APIs and metadata.

*c)* Signing data-sharing agreements between the National Post Company and other agencies to create a trusted data loop and implementing it.

- Technical and operational priorities:

*a)* Publishing open spatial–postal APIs to facilitate the development of location-based services.

*b)* Creating an innovation sandbox for spatial data for start-ups and researchers.

*c)* Requiring e-commerce platforms to use GNAF identifiers and offering tax incentives.

### *C. Policy summary for Iran*

Spatial data maturity brings multiple benefits, including reduced delivery costs, increased tracking capability, creation of urban digital twins and attracting investment in logistics and fintech. Iran's path to greater spatial data maturity relies less on technology and more on institutional harmonisation and governance. By stabilizing GNAF as the official spatial infrastructure, the postal network can become the data infrastructure of the digital economy.

## VI. Conclusion

This paper introduced the SDMI as a framework to measure the use of geospatial data in postal digital transformation. Unlike traditional indices, this model considers governance as the main enabling factor and shows that institutional coherence is a prerequisite for technical and commercial maturity. Results demonstrate that countries that legalize data governance and open standards are leaders in postal performance and digital commerce, whereas countries with fragmented governance enjoy fewer benefits from digitalization. SDMI, in addition to being easy to compute, provides deep interpretive value and helps policymakers identify specific gaps by breaking down sub-indices. For Iran, practical implications exist: accelerating spatial data governance and integrating GNAF could move the country towards becoming a builder and then an enabler.

## VII. Tools, limitations and suggestions for future research

To observe professional ethics and respect the audience, it is reported that to avoid linguistic errors and writing mistakes, the present article was translated and edited using language-processing tools without changing the authors' content. This study also has limitations. Some indicators, such as LPI and 2IPD, were collected from different years, and data asynchrony was reduced using a three-year averaging. A linear definition for normalization may overlook some nonlinear growth characteristics. Also, the SDMI model is geographically limited to ten countries and needs to include African and North American countries to complete the analysis. Future research could expand the model with panel data or include artificial-intelligence indicators and test non-linear normalization models.

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