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eGovernment Implementation in Italy. Regional Index for NRRP Goals Evaluation

Susanna Traversa[1] · **Enrico Ivaldi**[2,3]

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Abstract
The rapid acceleration of digitalization in response to the Sars-Cov-2 pandemic in 2020 has necessitated the development of policy strategies to manage the new phase of digital transition. The public sector has been particularly impacted during critical pandemic phases, requiring the assurance of uninterrupted essential service delivery to citizens. Despite eGovernment being recognized as a crucial element for digital recovery and innovation by European institutions, there is a need to consider the potential distortive impact of poorly informed digital policies, which could worsen existing territorial inequalities and hamper national economic resilience, as exemplified in the case of Italy. To address this, the present study proposes the creation of a regional eGovernment indicator based on the recovery and resilience goals outlined in M1C1 of the National Recovery and Resilience Plan. This indicator identifies primary functional objectives for the digital transition in Public Administration. The methodology for synthesizing the indicator utilizes the Peña distance method, providing a more robust measurement compared to techniques found in the literature. Additionally, it enables the production of a spatial and temporal comparison of regional performance, offering policymakers a tailored tool to monitor recovery performance at the regional level. The indicator underscores a significant digital divide between northern and southern Italy, highlighting regions like Lazio that exhibit opposing trends compared to their respective macro-areas.

Keywords eGovernment · Digital transition · Recovery and resilience plan · Synthetic index · Peña distance index · DP2 · Regional analysis

✉ Susanna Traversa
susanna.traversa@edu.unige.it

Enrico Ivaldi
enrico.ivaldi@iulm.it

[1] Italian Center of Excellence in Logistics, Transport and Infrastructures (CIELI), Department of Economics, University of Genoa, Via Francesco Vivaldi, 5, 16126 Genoa, Italy

[2] Faculty of Communication, IULM University, Via Carlo Bo, 1, 20143 Milan, Italy

[3] C.I.E. Centro de Investigaciones en Econometría—Universitad de Buenos Aires, C1113 CABA Buenos Aires, Argentina

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1 Introduction

The outbreak of the Sars-Cov-2 pandemic has functioned as a trigger, leading in a brief period to a strong acceleration in digitization processes that affected the different spheres of society across the board (Almeida et al., 2020; Grasso et al., 2021; OECD, 2020).

The unpreparedness of States to deal with an event of this magnitude has led to the adoption of contingency measures to minimize the risk of transmission of the virus within the population, with the introduction of more or less restrictive forms of lockdown and social distancing (Alfano & Ercolano, 2020).

The strategic use of policies and protocols that included increased digitization made it possible, in the early stages of the health emergency, to preserve alternative forms of socialization, limit damage to national economies and ensure access to essential public services (OECD, 2020; European Commission, 2020; European Commission, 2021; Casquilho-Martins et al., 2022). As well as in the case of the extensive use of e-disclosure methods (Padeiro et al., 2021), aimed at the dissemination of protocols and verified information about the progress of outbreaks among the population (Mori et al., 2023), throughout the use of institutional social media, both from national and local governments.

On the latter strategy, in a 2021 article, Landi et al. confirm the actual positivity from the perspective of digital communication strategy, although of varying magnitude among the cases investigated as a result of a different spread of digital skills and resources, in part necessary to counter the spread of fake news through unofficial channels (Landi et al., 2021; Mori et al., 2020).

However, the increase in demand for connectivity has not only produced palliative effects but has also led to the emergence of new forms of inequality. Several states have had to face digital re-conversion processes encountering inadequate digital infrastructures vulnerable to cyber-attacks, a still too widespread digital illiteracy among the population and the presence of financial barriers (Bratta et al., 2020; Rückert et al., 2020; Wilson & Mergel, 2022).

For this reason, policymakers often approach the digitisation process as an exogenous factor, setting aside the social context when developing new strategies (Musik & Bogner, 2019). To limit the potential distortions produced by the acceleration of digitisation processes, the European Union has promoted, through a series of special investment funds and political agendas, the implementation of an equitable, sustainable, and digital strategy inspired by European values (European Commission 2020a, b; European Commission, 2023).

Although not always concerning the EU context, digitization does not produce a significant impact on sustainable development (Lucendo-Monedero et al., 2023), several studies confirm how technological development and per-capita GDP are interrelated (Parra et al., 2021; Stavytskyy et al., 2019), thus making correct digital transition strategies extremely important for the recovery, even in public sector, with the aim to raise national competitivity, the quality of public services and the efficiency of e-Government processes (Kotarba, 2017; Lindgren & Jansson, 2013).

Referring to this latter, the process of digital integration within the public dimension is defined by the term eGovernment (eGov), which consists of a complex multidimensional construct, of which scientific literature still provides an ambiguous and not empirically accepted definition (Malodia et al., 2021), mainly due to the rapid technological and digital evolution, which leads eGov processes to continuous rethinking and innovation (Relyea, 2002). The common interpretation proposed by the OECD defines eGov as the use

of information and communication technologies (ICTs), particularly the Internet, for the provision of digital public services by establishing relationships between their stakeholders (such as citizens, businesses, employees, and the public sphere itself) (Gartner Study Group, 2003).

Thus, it is possible to develop new models of public services to improve a greater quality, accountability, transparency, and efficiency of the public sphere (Alshehri et al., 2012; Dawes, 2009; Malodia et al., 2021), as well as respond to the new demand of services from citizens while containing costs (OECD, 2005).

1.1 Italy and eGovernment

According to the objectives set by the European Institutions, the Member States actions needs to be directed towards the promotion of new reform and investment policies capable of limiting the spread and strengthening of asymmetries within the national territory (European Commission 2020a, b). Among the possible growth opportunities promoted by European institutions, the Italian Government has identified the opportunity of using European funds to start a transversal digital implementation program (Italian Government, 2021). In this way, the Italian country aims to improve its performance within the European scenario, where it is currently extremely disadvantaged compared to the European average (European Commission, 2023).

For the digital transition, 27% of European funds obtained have been allocated to the Italian "National Recovery and Resilience Plan" (NRRP), in order to be invested in the objectives contained in Mission 1 "Digitisation, innovation, competitiveness, culture and tourism" (Italian Government, 2021). Among the investments included in the recovery plan, great importance is given to the modernisation of the current digital infrastructure, the strengthening of cybersecurity—extremely fragile in the Italian public sector, the pursuit of greater interoperability between internal databases (thanks also to the development of common cloud clients between the different administrative levels), and an improvement in the quality of public digital services currently offered to citizens and businesses.

The European Commission's Digital Decade Report of 2023 describes the national status of digital development initiatives against the Italian targets included in the NRRP (European Commission, 2023).

In terms of infrastructure, Italy reconfirms itself as one of the most advanced member states. Among the most promising achievements, the report highlights the broad 5G coverage-which by 2023 for 3.4–3.8 GHz band coverage will reach 80% of households-and the status of TeRABIT implementation ahead of the European average, an infrastructure based on the last-generation dedicated fibre-optic. Also mentioned from the perspective of cloud computing is Leonardo S.p.A.'s development of Europe's first quantum computer e and its possible involvement in the European Cybersecurity Skill Academy Establishment Project promoted by the European Digital Infrastructure Consortium (EDIC).

On the other hand, the situation found by the report about achievements from the perspective of digital skills and indicators closely related to the digitization of public services is different.

From the point of view of basic digital skills, the value on the population in 2023 is still very low (46%), affecting both from the point of view of digital skills in the head of the workforce and the actual user use of digital public services. Although compared to 2020 there is an improvement from the point of view of offering them to citizens, the low skills of the population undermine their effective use, making upskilling and reskilling necessary.

It is important to note, however, that the effects and performance of eGov may vary greatly from a geographical perspective (Furuholt & Wahid, 2008; Heeks, 2003; Horobet et al., 2023), mainly due to the presence of regulatory, legislative, and financial barriers, competing in the widening digital divide even at a regional level (Bratta et al., 2020; Rückert et al., 2020). From a broader point of view, the presence of a digital divide portrays a complex pattern of inequalities among citizens, which can compromise access to digitized public services and generate several repercussions on the state fiscality, credibility and trust in digitization policies, and a forecast increase in future operating costs (Hwang et al., 2004; Larsson, 2021). Digital illiteracy or disadvantaged socio-economic status also creates a further type of non-monetary cost to which the state should pay attention, including the social stigma related to the lack of own resources to learn—or put into practice—a new form of dialogue with the PA (Larsson, 2021; Mesa, 2023).

1.2 How to Measure Digitization in Italy: Regional Approaches

It becomes evident the importance of having tools to assess special-temporal performances and monitoring the progress of the interventions put in place by the government, to determine which areas are more critical compared to the national scenario.

In the literature, specific proposals for the Italian case are currently limited to the construction of synthetic indices that, tracing the Digital Economy and Society Index (DESI) experience, propose the development of tools that assess digitization in its broadest sense (Table 1).

Among recent experiences in this field, the proposal of the "Osservatorio dell'Agenda Digitale" of the Milan Polytechnic university represents the first example of a regional index for digital development in Italy, inspired by the European DESI. The composite index constructed for the year 2020 was realised using 35 of the 37 variables provided by the European DESI, although some of the variables used do not have the data available for the regional territorial level. Then, the regional ICT Observatory of Piedmont has carried out a survey in 2019 and 2020 on the technological and digital development of Piedmont, comparing its performance with that of other Italian regions. Although the proposal is structurally inspired by the dimensions used for the European DESI, an aggregation phase is not carried out in order to obtain a synthetic index that provides an overall digitization score for the regions (Osservatorio Digitale Regione Piemonte, 2019). Then, more recent, and comprehensive is the proposal put forward in November 2021 by the Bank of Italy (Benecchi et al., 2021). In an occasional economics and finance paper, the Bank of Italy presents its version of rDESI, which maintains the dimensions and weighting system used for the European DESI, using Principal Component Analysis as the aggregation technique. In 2023, the same authors presented a review of their previous work, presenting a revisited methodology for the rDESI, adapting the approach to the data available for the Italian NUTD-2 regions (Benecchi et al., 2023). Similar approach was adopted by Traversa et al. (2022), which regional index has highlighted the criticalities related to the presence of the strong digital gap between the northern and the southern regions of the country, especially within human capital and integration of digital technologies sub-dimensions.

All proposals presented note the actual existence of a digital gap between the regions of Northern and Southern Italy. The development of an accurate mapping and monitoring quantitative tool for the NUTS-2 Italian level will represent a useful and strategic analysis of public policy performances to promote investment in the digital transition.

Table 1 Proposals of digitalization indices for Italy. All the proposals do not solely consider the development of eGovernment but include dimensions related to the development of digital public services. Authors' own elaboration

	Author	Dimension/Indicators	Methods
European DESI	European Commission	**5 indicators**: eGovernment; pre-filled forms; Digital public services for citizens; Digital public services for business; Open data	Composite indicator **Aggregation method**: min–max scaling method **Weight**: unequal weighting approach **Spatial dimension**: NUTS-1
Italian DESI	Digital Agenda Observatory of the Polytechnic of Milan	Inspired by the dimensions and indicators used by European DESI **4 indicators**: Development of digital public services; Data and interoperability; Use of eGovernment; Impact on digitization	Composite indicator **Aggregation method**: min–max scaling method **Weight**: unequal weighting approach **Spatial dimension**: NUTS-2
Italian DESI (Alternative proposal)	ICT Observatory of Piedmont	Survey in 2019 and 2020 on the technological and digital development of Piedmont, comparing its performance with other Italian regions Inspired by the dimensions and indicators used by European DESI **4 indicators**: Development of digital public services; Data and interoperability; Use of eGovernment; Impact on digitization	Composite indicator **Aggregation method**: min–max scaling method **Weight**: unequal weighting approach **Spatial dimension**: NUTS-2
rDESI	Benecchi et al., 2021 and Benecchi et al., 2023	Compared to existing attempts to replicate the DESI index at the local level, the proposed indicator uses new data sources **2 indicators**: eGovernment users; eGovernment services	Composite indicator **Aggregation method**: PCA **Weight**: unequal weighting approach **Spatial dimension**: NUTS-2
Regional DESI	Traversa et al., 2022	**5 indicators**: Online PA interactions (get information); Online PA interaction pre-filled modules); Online PA interaction (deliver module); Use of eGovernment services by enterprises; Research of medical information online	Composite indicator **Aggregation method**: min–max scaling method **Weight**: unequal weighting approach **Spatial dimension**: NUTS-2

2 Research Question

The main proposals discussed in the literature for the Italian case tend to approach the study of eGovernment only transversally, analyzing it as a component of the more composite process of economic and social digitization. Given the complexity and number of factors involved in public digitization, an approach inspired by the European DESI would risk oversimplification. As can be seen from the literature and the goals set by the Italian government in the NRRP for the mission dedicated to eGovernment, it depends not only on the delivery of digital public services by the state, but also, by way of example, on the ability of citizens and businesses to access them thanks to the widespread distribution of the infrastructure, to use it securely (e.g., by implementing cybersecurity protocols) and on the citizens' skills to make proper and widespread use of it. For this reason, the possibility of constructing an ad-hoc tool for the Italian context, calibrated to the Public Administration digitization targets envisaged by the NRRP and assessing regional performance to emphasise the problem of the digital divide and support an efficient allocation of public funds, deserves further investigation.

The choice of implementing the study of the spread of the eGovernance model concerning the NUTS-2 territorial dimension is to be found in the strong heterogeneity that characterises the Italian nation. Moreover, the monitoring carried out at the national and European levels confirmed the existence of a marked gap between the northern and southern Italian regions in terms of digitisation of the peninsula. In this way, the synthetic indices can be exploited to highlight any criticalities in the Italian context to the more specific objectives described by the NRRP, thus directing policy interventions.

3 Proposal of a Regional Index of eGovernment for Italy

3.1 Data Selection

The strong heterogeneity exhibited by Italian territory complicates the proper assessment of local performances over national policies. Among the determinants behind this digital divide, capable of creating a strong north–south gap between regions (Benecchi et al., 2023; Traversa et al., 2022), could derive from the allocation of State-Region competencies that characterize the Italian constitutional system, which only assigns to the State the definition of minimum ICT standards and whose implementation and enrichment depends on the proactive action of regional governments.[1]

For this reason, the implementation of the index approached considering the European territorial classification NUTS-2, corresponding in Italy with regional administrative units. This will allow a greater focus on the different distribution of digitalization processes among the territory and provide policymakers with key instruments for the evaluation of territorial investment interventions.

The identification of the dimensions to be used for the synthesis of indicators was carried out by combining a careful review of the theoretical framework related to the eGovernment phenomenon, the analysis of previous experiences—Italian and European

[1] Art.14 D.Lgs. n82/2005 "Codice dell'Amministrazione Digitale", Italian Government.

Table 2 Basic indicators derived from Italian National Recovery and Resilience Plan Mission 1, Component 1 "Digitalisation, innovation and security within the PA". Authors' own elaboration

Basic indicator	Codification
% of the Population who have access to a broadband connection	BBC
% of Public Administration that use cloud services	CCS
% of Institution which adopts all of the cybersecurity protocols	CS
% of the Population with basic digital skills	BDS
% of People who have submitted online forms to Public Administrations	DS_SF
% of People who have downloaded pre-filled forms online from Public Administrations	DS_PFF
% of People who have obtained information online from Public Administrations	DS_I

Table 3 Order of variables entrance in the DP2 and correction factor values

Sort	Variable Cod	Linear Correlation Coefficient	Correction Factor ($1–R^2$)
1	DS_I	0.85	1
2	DS_SF	0.75	0.15
3	BBC	0.74	0.36
4	DS_PFF	0.68	0.16
5	CCS	0.66	0.70
6	CS	0.57	0.84
7	BDS	0.41	0.92

ones—concerning the development of digitisation indexes and the study of the digital transition goals contained in the NRRP (Italian Government, 2021).

The seven basic indicators are identified according to the I.Stat databases were summarized in the following table (Table 2).

It seems clear that, compared to the sub-dimensions of digitization indices addressed earlier (Table 1), there is greater complexity and heterogeneity in the attribution of variables that contribute to the definition of the eGovernment phenomenon.

The selection of indicators was carried out in compliance with the criteria of data availability both from a territorial point of view for 2019 and 2020. In this way, the aim is to set the reference year before the outbreak of the pandemic, and then compare them with the moment when the definition of digitisation targets and policy agendas accelerated significantly. Due to the methodological techniques adopted for the index synthesis, explained below, and concerning the updating of the I.Stat datasets, it is planned to keep monitoring the index trend over time (Table 3).

3.2 Aggregation Method

Drawing on the evidence gathered from the literature review, composite indicators are identified as a powerful tool for understanding the evolution of a complex phenomenon like eGovernment, providing a synthetic metric easy to interpret and able to guide the actions of public decision-makers (Maggino, 2017, Alaimo et al. 2022, Bruzzi et al., 2022).

Because of the complexity involved in the process of synthesizing multidimensional phenomena, it is appropriate to refer to established techniques, such as in the case of Lazarsfeld's hierarchical model, theorized in 1958, which helps to limit interpretative errors of the results (Lazarsfeld, 1958). In this case, following a comprehensive definition of eGov through the identification of peculiarities and potential criticalities, a formative approach was adopted as a measurement model (Blalock, 1964; Diamantopoulos et al., 2008; Mazziotta & Pareto, 2017). Assuming the existence of a bottom-up relationship between the indicators and the latent variable, indicators with high levels of internal correlation are excluded to limit the risk of redundancies within the final index (Nardo et al., 2005).

As reconstructed in the previous paragraphs, the phenomenon of digitization—in a broad sense or limited to the public dimension—observes a preponderance of tools that exploit aggregation-type synthesis techniques.

Aggregative indices, or composite indices, represent the most widespread approach in the literature (Ciacci et al., 2023; Maggino, 2017; Mazziotta & Pareto, 2018). Since synthesis by aggregation consists of a complex and articulated process, several authors tend to follow the theoretical framework described in 2008 by the OECD in the "Handbook on Constructing Composite Indicators" (OECD, 2008). Key steps are widely discussed in the literature include the necessity to validate the final index, aiming to confirm the robustness of the measure resulting from the normalization and aggregation process (Diamantopoulos et al., 2008; Mazziotta & Pareto, 2020; Nardo et al., 2005).

Since differently from the proposals identified in the literature the index proposed here is intended to investigate only the public dimension of digitization, an alternative methodology was adopted through the use of the Peña Distance method (DP2) (Peña, 1977).

In contrast to the methods observed earlier, DP2 employs a parametric-distance index formulated through the implementation of a linear regression model (Mazziotta & Pareto, 2018, 2020; Nayak & Mishra, 2012).

The choice to test the validity of an alternative methodology stems from the versatility and robustness of DP2 compared to min–max scaling and PCA, widely discussed in the literature (Montero et al., 2010; Penco et al., 2020; Nayak & Mishra, 2012, Ivaldi et. al. 2020). The main properties of the DP2 index have been extensively discussed in the literature, as highlighted in works by Sommariba and Peña (2009), Nayak and Mishra (2012), and Ivaldi and Ciacci (2023).

One of them is that DP2 allows inter-spatial and inter-temporal analysis due to its nature as a quantitative distance indicator (Sommariba & Peña, 2009). This is stemmed from the construction process of the index. First, the basic units—spatial or temporal—are computed, which represents the minimum benchmark of any indicator, i.e. the worst-case scenario obtainable from each variable and on which the distance expressing the improvement or worsening of the phenomenon over time is calculated (Ivanovic, 1974):

$$d_{kj} = \left| v_{kj} - v_{kj}^{*} \right|$$

where v_{kj}^{*} is the *kth* component of the reference base vector for each indicator *j*.

Then, the indicators are normalised by computing a global index using the Frechet Distance (DF) defined as

$$DF(j) = \sum_{k=1}^{K} \frac{d_{kj}}{\sigma_k} = \sum_{k=1}^{K} \frac{\left|v_{kj} - v_{kj}^{*}\right|}{\sigma_k}; j = 1, \ldots, m$$

where σ_k express the standard deviation of partial indicator k.

DF contribute also to another notable aspect of the index, pertains to the variable weighting process. Similar to the one used for heteroskedastic models, it hinges on the sequence of incorporation within the partial indicator, recognizing less importance to those distances that presents more variability (Montero et al., 2010). The determination of this order is grounded in the absolute values of the linear correlation coefficients between the indicator values and the synthetic indicator, as outlined by Ivaldi and Ciacci in 2023. However, as the Frechet Distance is only theoretically functional for sets of uncorrelated indicators, DP2 foresees the introduction of a second corrective component, with the aim of eliminating possible dependency effects between variables related to a redundancy of information included in the overall indicator (Domínguez & Martos, 2012; Ciacci et al. 2021; Penco et al. 2020).

From a mathematical viewpoint, the synthesis of the NUTS-2 index for Italy is presented as follows. Considering a region j, variables are computed as:

$$DP_2 = \sum_{i=1}^{n} \left(\frac{d_{ij}}{\sigma_i} \left(1 - R^2_{i,i-1,\ldots,1} \right) \right) \text{ with } R^2_1 = 0$$

$d_i = d_i(r^*) = \left| x_{ji} - x_{*i} \right|$ with the reference base $X_* \left(x_{*1}, x_{*2}, \ldots, x_{*n} \right)$, where:

- n = number of variables.
- x_{ji} = value of the i variable in the region j.
- σ_i = standard deviation of the variable I.
- $R_{i,\, i-1},\ldots,1$ = coefficient of determination in the regression of $X_{ix*1}, x_{*2},\ldots,x_{*n}$;
- $1 - R_{i,\, i-1},\ldots,1$ = correction factor (abstract concept unrelated to the measurement units of indicators).

In this way, it is also possible to exploit the 'exhaustive' nature of DP2, which benefits from the inclusion of a high number of variables each with a varying correlation degree between them, as the correction factor intervenes in the elimination of multicollinearity, considering only the useful part of the variance of each indicator, thus purging the final result of duplicates and redundancies (Landi et al., 2018; Montero et al., 2010). Therefore, the choice of the order in which the indicators are placed within the overall indicator becomes decisive elementary, as it is decisive for the definition of the residual contribution made by the subsequent elementary indicators. For this motive, a hierarchical objective approach is adopted, which consists in the identification of the indicator most correlated with DF (i.e. summarising all partial indicators) since it contributes most to the overall variance of the index.

As stated before, the DP2 index thus quantifies each NUTS-2 region's distance from a reference value that expresses the worst-case scenario for all basic indicators considered. Each benchmark assigned a value of zero in the eGovernment indicator. Therefore, a higher DP2 value indicates a higher degree of regional eGov implementation, signifying a higher distance from the theoretical worst condition.

4 Results

The index computation was carried out using the R package "p2distance" (Pérez-Luque et al., 2012). The following table, besides the value of the ($1\text{-}R^2$) correction factor, derives the order of entry of the elementary indicators due to the correlation coefficient between the values expressed by each variable and the DP2 index.

DS_I resulted as the first variable in order of entrance with a correction factor of 1, which expresses a plain capacity of the variable to measure the development of regional eGov in Italy. The other variables related to digital services, DS_SF and DS_PFF, contribute to the overall indicator with 15% and 16% of their variance respectively. Greater is the contribution of BBC, which enters as the third variable with a correlation of 0.74 (very high) compared to the indicators preceding it and with a residual contribution of 36%.

Next come CCS, CS and BDS which, compared to the indicators before them, contribute 70%, 84% and 92% of their variance, respectively, to the information contained within the overall eGov indicator.

Based on the index computation, the regional ranking was derived by the assignation of the first position to the region with the highest DP2 score. To ensure a greater interpretation of the index results, interquartile ranges were calculated and implemented in Table 4.

The results drawn from the construction of the eGov index, according to the digitization goals included by the Italian government in the PNRR, confirm not only a generalized increase in eGov processes in response to Covid-19 but also the critical presence of a digital divide among Italian regions.

From an initial analysis of the seven basic indicators selected for the 2019–2020 biennium, it is evident for the country a penalty from the point of view of all indicators, with the only exception of BBC expressing the spread of broadband connection (Italian average 2020 77.8% of households reached). The national average (44.87%) shows that the percentage of CCSs implementation in 2020 is still modest. Although the gap between the single regions does not describe a marked digital divide, two northern regions occupy the first two positions, EMI_20 (57.19%) and VEN_20 (55.49%), pointing out the potential of the "Cloud for PA" strategy and the central role play by SaaS within the public digital transition.

Extremely critical instead is the result of the full adoption of cybersecurity protocols. The national average of PAs that have adopted all the measures required by cybersecurity protocols is 2%, describing a severely penalized context that does not, however, present the logic of a digital divide between the North and South of the Country.

Regarding BDS and the set of digital public services (DS_I, DS_PFF, DS_PF), national performance in the two years is similar between 20 and 30% in 2020, confirming the need for action to strengthen digital skills among the population in order to ensure full use of digitized services.

Once the overall context with respect to the individual dimensions of public digitization is understood, we proceed with a discussion of the results obtained as a result of the construction of the DP2 index, addressing the analysis of regional performance by starting with the top performing regions ranked highest (Table 4).

Starting from the interquartile range expressing better regional performance for 2019–2020, with DP2(9.55:13.56), we obtain Trentino-Alto Adige as the most developed region, occupying the first and second places in the ranking, registering a confirmatory improvement in 2020 (TRE_20 = 13.56, + 1.42 DP2 score). Over individual dimensions of digitization, the region reports excellent results compared to the national average,

Table 4 DP2 index of eGovernment for Italian regions (NUTS-2)

Region	Cod	DP2 score		Global rank	
		2019	2020	2019	2020
Abruzzo	*ABR*	5.11	7.31	37	22
Basilica	*BAS*	3.75	7.25	39	23
Calabria	*CAL*	2.32	3.27	42	40
Campania	*CAM*	5.33	8.62	32	16
Emilia-Romagna	*EMI*	9.46	9.58	12	11
Friuli-Venezia Giulia	*FVG*	10.05	10.37	6	5
Lazio	*LAZ*	9.06	11.71	15	4
Liguria	*LIG*	6.6	6.28	27	28
Lombardy	*LOM*	8.4	9.34	17	14
Marche	*MAR*	5.26	4.84	34	38
Molise	*MOL*	5.14	5.92	36	30
Piedmont	*PIE*	9.66	9.79	9	8
Apulia	*APU*	5.20	7.42	35	21
Sardinia	*SAR*	5.78	6.74	31	26
Sicily	*SIC*	2.61	5.31	41	33
Tuscany	*TUS*	8.2	7.91	19	20
Trentino Alto-Adige	*TRE*	12.14	13.56	2	1
Umbria	*UMB*	6.9	6.03	25	29
Aosta Valley	*VDA*	9.59	12	10	3
Veneto	*VEN*	9.4	9.81	13	7
Italy	*ITA*	7.15	8.32	24	18
Embedded Scale					
Max	*13.56*				
Third Quartile	*9.55*				
Median	*7.37*				
First Quartile	*5.45*				
Min	*2.32*				

occupying high positions in individual rankings within the basic indicators in the two years.

Third place is taken by VDA_20 (DP2 = 12) with an advance of 6 places in the rankings compared to 2019 (VDA_19 = 9.59) due to a small improvement in the BDS and DS_I dimension and more considerable for DS_PFF (+ 8%) and DS_SF (+ 6.2%).

Significant is the result obtained by the Lazio region (LAZ_20 = 11.71, 4th rank), which moves up the ranking by 11 positions and + 2.64 DP2 allowing it to exceed the benchmark calculated on the third quartile of the distribution. Thus, this is the result of a generalized improvement in all dimensions of eGov, leading in 2020 the region to occupy the first place for BBC (83.8%) and observe an increase of 9.2% over the variable DS_PFF.

Veneto also improves, although to a lesser extent, moving from VEN_19 = 9.40 to VEN_20 = 9.81. Lastly, FVG and PIE follow, confirming a trend over the two years, consolidating their position among the most advanced regions with respect to the NRRP goals.

Moving on now to the second interval by implementation degree, ranging from the median value (7.37) to the third quartile (9.55), the first region by DP2 score is

Emilia-Romagna, which straddles the two intervals, improving compared to 2019 (EMI_20 = 9.58, + 0.12) in the three dimensions of digital services. It worsens instead on the BDS side, sharing the last position with Sardinia (22.5%).

Ranking 14th, with an advance of 3 positions compared to 2019, is Lombardy (LOM = 9.34), which improves within the range (confirming a baseline situation above the median) although positive fluctuations in individual dimensions are small. Importantly, however, LOM_19 still reports a higher DP2 score than ITA_20, denoting a positive place for the region to start compared to the previous year.

Ranking 16th instead is Campania, the region that most observes a strong improvement over the two years by gaining 16 positions and moving from CAM_19 = 5.33 to CAM_20 = 8.62. This is a strong improvement, which can be mainly attributed to an increase in BDS that takes the region from being inferior to the national average in 2019 (23.4%) to be the second highest in 2020 in terms of diffusion among the population of basic digital skills (28.8%). Peculiar, however, is the case of Tuscany. In fact, the region is the first for which a worsening compared to 2019 is observed, with TUS_20 (7.91) dropping one position and obtaining the 20th rank. Although remaining above the national average for the period, the region worsens in BBC, BDS, DS_PFF and DS_I if compared with other Italian regions' trends. Critical, however, is the data for CS, where only 0.9% of PAs appear to have implemented all cybersecurity protocols.

The last region in the range is Apulia, which, as in the case of Campania, observes a strongly positive trend over the two years, rising from 35th rank (APU_19 = 5.20) to 21st (APU_20 = 7.42). Compared to Campania, however, with the only exception of BDS, Apulia never reports values above the two-year national average despite an improvement.

The results obtained by the regions with lower performance than the two-year median is now presented. In this range, with a more heterogeneous composition when considering the division into macro areas, three cases are particularly interesting. First, Umbria, which not only ranks below ITA_19 (7.15) but also presents as in the case of Tuscany a worsening. If UMB_19 with a DP2 score of 6.90 ranked 25th, the following year it drops to 29th (UMB_20 = 6.03) as a result of a slowdown in BBC and BDS.

The same pattern can be observed for Liguria, the only region in the North to fall below the median benchmark, as well as registering a slight worsening between 2019 and 2020. Compared to the national average of individual dimensions, the region is weak in infrastructure, cybersecurity, and cloud services deployment. On the other hand, the result of the digitization of public services is positive.

Sardinia improves within the range (SAR_20 = 6.74, + 0.96) and stands out as an island compared to Sicily for better performance in the three SDs, CS, and infrastructural setup (although lower than ITA_19 and ITA_20).

Finally, regarding the interval that expresses a major gap in eGov implementation, with DP2 values below 5.45, a predominance of southern regions is observed, with the only exception of Sicily (classified as an Island despite its geographical location) and Marche, a region included among those in central Italy. Compared to the latter, as in some cases addressed previously, the region failed in the two years to respond to the acceleration initially produced by the health crisis, suffering a worsening for MAR_20 (4.84, -0.42).

Improving, however, is the trend for Sicily although small and not particularly significant in terms of single indicators, with a DP2 SIC_20 score of 5.3 (+ 2.70).

Attention is drawn to the region of Calabria, which presents a critical performance in all dimensions considered within the development plan foreseen by the NRRP, ranking according to the DP2 index at the bottom of the two-year ranking and thus making it

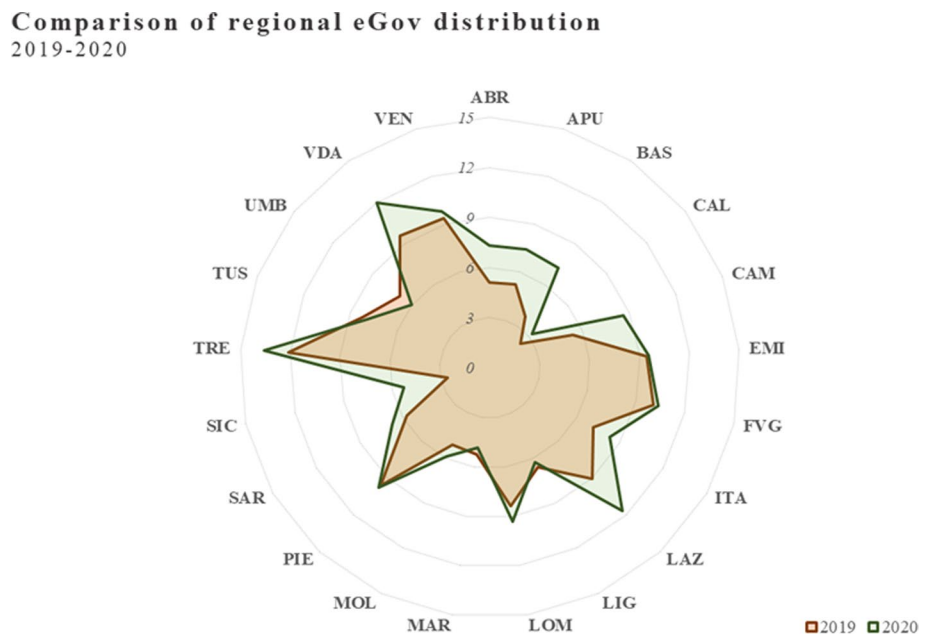

Fig. 1 Spatial and temporal Peña score comparison of the evolution of Italian regional eGov in 2019 and 2020

necessary to increase the attention from the public intervention standpoint, in order to limit possible distortive and penalizing effects on the population, due to the strong digital gap.

To conclude, the distribution of DP2 scores in Italian regions divided by the two years considered is depicted below (Fig. 1). This makes it easier to identify the regions that, in contrast to the average for the period, observed a worsening in 2020, namely Umbria (UMB), Marche (MAR) and Liguria (LIG).

Finally, to assess the robustness of the index, an influence analysis was performed, repeating the construction of DP2 by excluding one of the elementary indicators in turn (Maggino, 2017). Once the new rankings were derived from the alternative versions of eGov's DP2, the average absolute deviation of the ranks' rankings from the one initially obtained was calculated (Mazziotta & Pareto, 2018, 2020; Bruzzi et al. 2019). The DP2 index of eGov results is robust, with an influence value of 1.85.

5 Discussion

From a methodological point of view, 7 basic eGov indicators were selected from the I.Stat website (ISTAT) that traced the development goals defined by the Italian government (Table 1). However, the indicator selection phase indirectly allowed us to understand an additional limitation related to digital processes, concerning data dissemination and accessibility. In order to ensure the spatial and temporal completeness of the dataset, the survey was conducted over only one two-year period (2019–2020) still allowing for an understanding of how the pandemic containment strategies impacted the public sector in the

initial phase. The geographical unit of analysis was also identified in the regional dimension (NUTS-2), based on the strong presence of an internal digital divide with respect to digital development (Traversa et al., 2022), which therefore makes it necessary to compare trends with respect to individual regional units.

Regarding the aggregation technique, the choice fell on the Peña Distance Index (DP2) a nonparametric index whose characteristics allow for greater index robustness than more popular techniques in the literature for constructing eGov and digitization indices (e.g., min–max scaling and PCA) (Ivaldi & Ciacci, 2023). Indeed, the robustness test conducted using influence analysis on the obtained index reports an average value of deviation from ranks of 1.85, indicating good robustness of the index with respect to the computed variables.

The scenario obtained from the index computation confirms the evidence reported in the literature.

An improvement between 2019 and 2020 can be observed in some dimensions, due to the strong accelerating boost of the health crisis, but, on the other hand, the inability to adapt in the short term in specific dimensions has worsened the previously observed digital divide phenomenon.

Interpreting the results obtained in light of the regional macro areas defined by the I.Stat nomenclature (Table 5), better performance is obtained for regions belonging to the Northeast macro area, with DP2 values for 2020 of its component regions placed within the range defined between the third quartile and the maximum value assumed by DP2 [9.55:13.56].

Next are the Northwest regions, positioned above the median value for the two years in both years. The only exception given by the region of Liguria, which in contrast to the belonging macro-area ranks below the benckmark defined by the median, suffering a downgrading in 2020 (28th rank) from the rankings due to a lower adaptive capacity to the increase in demand for digitization in 2020. Among the main weaknesses characterising the region and identified within the regional development plan for 2023–2026, is the strong internal social digital divide mainly linked to the high presence of the elderly population within the Liguria region.[2]

Moving down to Central Italy, the effects of the digital divide start to be observed. Three of the four regions that belong to the macro area in fact experienced a worsening of varying magnitude between 2019 and 2020, with the only exception of Lazio, which not only improves compared to its placement within the ranks, but in 2020 places itself as the 4th region for eGov implementation according to the recovery targets.

In the end, there are Southern Italy and the Islands. For the most part, the two macro areas occupy the lower part of the ranking, showing strong starting difficulties in 2019 and adjustment difficulties in 2020, with insignificant and insignificant increases in individual eGov dimensions between the two years. Standing out in this case are Puglia and Campania, which in 2019 were placed as DP2 values in the last range between the lowest value and the first quartile, expressing a very low level of eGov. In 2020, however, they scored above the median for the period, with CAM_20 exceeding the national average for the first time in the base year. However, despite the fact that, as observed by the reconstruction of the trend of the single eGov dimensions, Campania has a high percentage compared to the national average in terms of BDS (28.8%), it observes serious shortcomings in terms of the

[2] Programma Strategico Digitale Della Liguria 2023–2025, Regione Liguria: https://www.regione.liguria.it/components/com_publiccompetitions/includes/download.php?id=61816:programma-strategico-digitale-regione-liguria-2023-2025.pdf.

Table 5 Italian macro areas (source: Italian National Institute of Statistics (ISTAT)), NUTS-2 regions and area unite codification. Authors' own elaboration

Macroarea	NUTS-2	Codification
North-West	Piedmont, Aosta Valley, Liguria, Lombardy	PIE, VDA, LIG, LOM
North-Est	Friuli-Venezia Giulia, Trentino-Alto Adige, Veneto, Emilia-Romagna	FVG, TRE, VEN, EMI
Centre	Tuscany, Umbria, Marche, Lazio	TUS, UMB, MAR, LAZ
South	Abruzzo, Apulia, Basilicata, Calabria, Campania, Molise	ABR, APU, BAS, CAL, CAM, MOL
Island	Sardinia, Sicily	SAR, SIC

supply and use of digital public services, which play a central role among the development objectives included in the regional digital agenda 2022–2024.[3]

Lastly, it is necessary to mention Calabria, a region that suffers greatly from a condition of strong backwardness with respect to the development objectives defined by the government in the NRRP, raising the need to focus attention on the region's development policies to limit possible negative repercussions in the long run due to an exacerbation of the digital gap compared to other regions.

An analysis of the regional digital agendas shows that there is in general towards eGovernment among the regions with the best DP2 performance a perspective of intervention mainly focused on improving the services offered from a qualitative point of view, as opposed to expanding the offer. An example of this is the region of Lazio, which, among the objectives identified for the period 2022–2026, strategies to strengthen basic digital skills (BDS) in order to expand the number of users of digitised public services while intervening on aspects related to accessibility and usability.[4]

A further critical point that emerged during the course of the study is related to the low diffusion of general protocols related to cybersecurity adopted within the Public Administration, with a national average of 2.4% adoption of all preventive procedures. For this reason, we would like to point out the initiative promoted during the meeting of the "Commission for Technological Innovation and Digitisation" of the Conferenza delle Regioni e delle Province Autonome, held on 04 August 2021, in which the establishment of a task force on cybersecurity among the Regions to work with the Government was proposed.

6 Conclusion

The digitization of the public sector represents today a current and strategic issue for Italy. During the Covid-19 emergency, the weaknesses in the preview digital transition strategies within the Italian system emerged, exposing a strong territorial division to the disadvantage of southern regions (Benecchi et al., 2023; Traversa et al., 2022).

[3] *Strategia Digitale della Regione Campania, Region Campania:* https://www.regione.campania.it/assets/documents/piano-triennale-per-il-digitale.pdf.

[4] *Agenda Digitale 2022–2026, Region Lazio:* https://agendadigitalelazio.lazioinnova.it/app/uploads/2022/05/Agenda-Digitale-maggio-2022_WEB.pdf.

Despite the progress highlighted over the last few years by the reports produced by the European Commission with respect to the objectives described in the EU's 10-year digital plan, mainly related to the infrastructural dimension, Italy still observes to date difficulties mainly related to the diffusion and consolidation among the population of (basic) digital skills, and backwardness compared to the European context in the process of digitization of the PA and of the services offered to citizens (European Commission, 2023).

In light of the ambitious goals described within the Italian PNRR for the implementation of eGovernment processes, the proposal for the construction of an ad hoc digitization index for monitoring the goals included within M1.C1 of the NRRP dedicated to "Digitalisation, innovation and security within the PA" was presented in this study.

As reconstructed extensively from the analysis of the literature, eGovernment represents a complex topic, for which in recent years a strong simplification from the point of view of its measurement has been observed in contrast within the main digitalization indices developed for the Italian context. Examining the main proposals made over the last few years, inspired mainly by the European DESI, it is observed that eGovernment is studied as a single dimension in itself, often limiting its analysis to the single implementation of digital services. However, as is evident from the goals of the NRRP, there are several dimensions to be considered in order to properly assess digital transition performance within the public sector.

If compared with the results obtained using indices inspired by the European DESI, which are more widely used in the literature for the regional study of digitisation in Italy, a discrepancy emerges with respect to the DP2 index. An example of this is the different positioning obtained for TRE, FVG, VDA, which on average are ranked lower in the previous contributions examined in the literature (Benecchi et al., 2023), compared to the one drawn up according to the eGov targets set by the NRRP. This represents a strength of the present contribution, whose main aim is to highlight the necessity of developing a specific tool for the digital recovery plan of the public sector, since as also highlighted in the contribution of Benecchi et al. (2023), the current structure of the DESI and rDESI sees a poor composition of the eGov subdimension with a consequently limited impact on the final result obtained by the overall index.

However, this contribution is not free of limitations. Firstly, there is the availability and harmonisation of the data, which for some variables is limited by the fact that they were collected in one-off surveys (eg. CS). Secondly, there is the close relationship between the choice of variables and the country surveyed, which would in this case limit the application to the Italian case. Future research could concern the comparison between the national recovery plans of other European countries, by developing specific indices for national cases and analysing their capacity to achieve the defined objectives. Possible future developments would include also the continuous annual monitoring of national and local performance, through the updating of the index, and its comparison with other indices capable of measuring the variation of the phenomenon over time.

Appendix 1

See Table 6.

Table 6 Basic indicators derived from Italian National Recovery and Resilience Plan Mission 1, Component 1. The codification of basic indicators is defined in Table 2 (par. 2.1). Source: I. Stat (2019, 2020)

		CCS		BBC		CS		BDS		DS_I		DS_PFF		DS_SF	
Region	Cod	2019	2020	2019	2020	2019*	2020	2019	2020	2019	2020	2019	2020	2019	2020
Abruzzo	*ABR*	3.20	33.9	75.2	75.5	2.7	2.7	18.3	33.9	22.9	23.5	22.8	25.7	18.3	17.5
Basilica	*BAS*	14.10	41.4	67.5	68.6	2.5	2.5	14.2	41.4	19.5	22.5	15.0	24.4	14.2	19.1
Calabria	*CAL*	69.50	41.6	66.9	66.3	1.5	1.5	13.3	41.6	18.2	16.6	18.2	18.7	13.3	13.9
Campania	*CAM*	33.70	46.6	72.2	76.8	2.8	2.8	14.3	46.6	20.0	21.5	17.7	22.8	14.3	15.9
Emilia-Romagna	*EMI*	8.90	57.2	77.3	82.5	2.9	2.9	17.9	57.2	24.4	27.1	22.5	31.1	17.9	20.8
Friuli-Venezia Giulia	*FRI*	2.60	47.7	77.2	80.6	3.8	3.8	18.1	47.7	23.7	30.0	22.1	33.7	18.1	22.1
Lazio	*LAZ*	2.60	50.9	79.2	83.8	2.9	2.9	20.3	50.9	27.2	31.4	23.4	32.6	20.3	23
Liguria	*LIG*	5.30	36.3	74.0	77.0	1.5	1.5	18.5	36.3	23.6	28.9	20.8	30.4	18.5	22
Lombardy	*LOM*	4.60	42.2	77.4	81.5	1.8	1.8	19.6	42.2	26.2	27.5	21.9	29.3	19.6	21
Marche	*MAR*	15.70	39.4	75.6	77.3	1.3	1.3	14.8	39.4	22.8	22.1	18.1	27.1	14.8	18.6
Molise	*MOL*	4.00	39.9	66.7	68.6	1.9	1.9	15.3	39.9	19.9	21.9	19.1	26.6	15.3	19.5
Piedmont	*PIE*	11.00	47.7	71.4	75.2	4.4	4.4	16.2	47.7	22.4	28.2	19.4	30.2	16.2	21.8
Apulia	*APU*	29.80	49.4	68.4	70.5	1.6	1.6	15.3	49.4	21.9	22.8	19.0	24.6	15.3	16
Sardinia	*SAR*	34.80	36.6	75.6	77.3	2.7	2.7	21.9	36.6	24.9	26.9	25.3	32.4	21.9	24.1
Sicily	*SIC*	0.90	40.0	67.9	70.1	2.6	2.6	11.7	40.0	16.0	19.4	14.3	21.3	11.7	15.2
Tuscany	*TUS*	12.60	49.8	76.4	78.5	0.9	0.9	18.1	49.8	26.1	26.2	21.9	27.0	18.1	18.3
Trentino Alto-Adige	*TRE*	3.10	47.7	79.4	82.8	4.4	4.4	21.6	47.7	27.9	31.7	26.5	35.6	21.6	26
Umbria	*UMB*	33.60	46.6	76.5	75.2	1.7	1.7	16.4	46.6	22.1	23.4	21.9	27.1	16.4	19
Aosta Valley	*VDA*	40.00	47.0	75.9	74.2	2.6	2.6	20.5	47.0	28.5	32.7	26.4	34.4	20.5	26.7
Veneto	*VEN*	5.70	55.5	79.2	79.5	2.2	2.2	20.1	55.5	26.2	28.6	23.6	32.1	20.1	22.5
Italy	*ITA*	9.30	44.9	74.7	77.8	2.4	2.4	17.5	44.9	23.6	26.0	20.8	28.3	17.5	19.9

*CS values estimated for the year 2019 based on the ones recorded in 2020 by the Permanent Census of Public Institutions (I.Stat, 2020)

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