# A Composite Indicator to Describe Digital Technology in Europe

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**Abstract.** The "Digital Europe" program is a central element of the Commission's comprehensive response to the challenge of digital transformation and is included in the proposal on the Multiannual Financial Framework (MFF) for the period 2021–2027. Its aim is to provide a spending instrument adapted to the operational requirements of capacity building in the areas identified by the European Council, as well as to exploit the synergies between them. The program aims, among other things, to develop and strengthen basic skills in artificial intelligence, such as data resources and archives of artificial intelligence algorithms and make them accessible to all enterprises and public administrations; ensure that the essential capabilities needed to secure the EU's digital economy, society and democracy are available and accessible to the EU public sector and businesses, as well as improve the competitiveness of the EU cybersecurity industry; expand the optimal use of digital capabilities, in particular high-performance computing, artificial intelligence and cyber-security, in all sectors of the economy, in sectors of public interest and in society, including the implementation of interoperable solutions in areas of public interest, as well as facilitating access to technology and know-how for all enterprises.

To better understand the phenomenon, this study aims to analyse the use of digital technology among European enterprises through a composite index of artificial intelligence (AI) and information technologies (ICT) (using the Wellness Methodology Fair and Sustainable) to measure the territorial gaps and to know the European countries more or less inclined to use it.

For this purpose, this contribution develops with the following structure:

– description of the theoretical reference framework and the indicators used to regard "artificial intelligence" and "information technologies";
– description of the methodology for the construction of the composite indicator;
– description of the results, also through a geo-referenced map of European countries willing to use digital technology;
– conclusions

**Keywords:** Digital · Index · Europe


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## 1 Introduction

The “Digital Europe” program is a central element of the Commission’s comprehensive response to the challenge of digital transformation and is included in the proposal on the Multiannual Financial Framework (MFF) for the period 2021–2027. Its aim is to provide a spending instrument adapted to the operational requirements of capacity building in the areas identified by the European Council, as well as to exploit the synergies between them. The program aims, among other things, to develop and strengthen basic skills in artificial intelligence, such as data resources and archives of artificial intelligence algorithms and make them accessible to all enterprises and public administrations; ensure that the essential capabilities needed to secure the EU’s digital economy, society and democracy are available and accessible to the EU public sector and businesses, as well as improve the competitiveness of the EU cybersecurity industry; expand the optimal use of digital capabilities, in particular high-performance computing, artificial intelligence and cyber-security, in all sectors of the economy, in sectors of public interest and in society, including the implementation of interoperable solutions in areas of public interest, as well as facilitating access to technology and know-how for all enterprises [1].

To better understand the phenomenon, this study aims to analyse the use of digital technology among European enterprises through a composite index of artificial intelligence (AI) and information technologies (ICT) (using the Wellness Methodology Fair and Sustainable) to measure the territorial gaps and to know the European countries more or less inclined to use it.

The choice of a composite index is dictated by the fact that it has the advantage of avoiding the presentation and interpretation of many elementary indicators to perform simpler and faster analyses, especially in comparative terms, obviously preserving coherence between the individual elements and their synthesis. On the other hand, in the last decades, to respond to the ever increasing needs to have systematic information on complex realities, attempts have increased to create synthetic and complex indicators, in many sectors and in many areas of knowledge and knowledge, to integrate a large amount of information in formats that can be easily understood by a large number of people.

For this purpose, this contribution develops with the following structure:

- description of the theoretical reference framework and the indicators used to regard “artificial intelligence” and “information technologies”;
- description of the methodology for the construction of the composite indicator; in particular, the robustness of the method identified will be assessed through the “influence analysis”, which makes it possible to verify if and with how much intensity the rankings of the composite indices change following the elimination of an elementary indicator from the starting set and therefore the indicators that “weigh” more (COMIC software - Composite Indices Creator);
- description of the results, also through a geo-referenced map of European countries willing to use digital technology;
- conclusions

## 2 Background

Digital transformation is verticalizing industrial processes and public administration. European systems, especially those of countries characterised by high public debt, have identified PNRR as a fundamental tool to change their models without affecting the sustainability of their finances. But innovation both in the economy and in the management of public administration and, more generally, structural reforms in Italy have always been a process characterised by strong slowdown factors that have adversely affected development.

It therefore appears necessary, after becoming aware and conscious of the failures of some reforms in recent years, to identify a pragmatic approach and governance models capable of basing innovations and reforms on reality and data, leaving aside ideological and dogmatic positions. There is therefore a need to redefine the set of innovative public policies and reformulate a digital decision-making process that obviously cannot simply follow and borrow from traditional processes. One of the main objectives of the PNRR must be to incentivise innovative sectors and to invest to stimulate the innovative potential of territories and put it at the service of the regional and national economy. To do this, we need to change our approach from what has been done so far and embrace the paradigm of harmonious innovation, which aims to accompany companies and territories in the challenges of digital and technological, green and circular, social and economic transitions, in a logic of convergence between tech and social innovation and in the perspective of Super Smart Society 5.0 and Industry 4.0.

However, the point we want to start from is to consider harmonic innovation, i.e. innovation that is born and develops if all the agents involved interact positively with each other and with the external environment. Businesses, territories and institutions, thus become pieces of a larger puzzle that can only grow if all the actors cooperate and contribute to collective growth. "Innovation, in the broadest sense, can be identified as the most powerful agent of change in the history of mankind, intimately linked to the concept of progress, which is oriented and shaped by innovation itself [...] It is not a question of reasoning about the many innovations, the many actions, the many possible interventions: it would risk being a weak exercise if it lacked solid foundations. Rather, it is a matter of stopping to reflect on the very concept of innovation, rethinking its foundations. This effort takes on a precise formula: the Harmonic Innovation paradigm, i.e. the circular innovation that pursues the 'right relationship' and knows how to combine contrasting elements and tones in a logic of consonance" [7, 8].

Innovation must be harmonious, i.e. it must be an innovation that is born and develops in such a way that all the agents involved interact positively with each other and with the external environment. Businesses, territories, institutions thus become pieces of a larger puzzle that can only grow if all actors cooperate and contribute to collective growth. It is not a question of reasoning about the many innovations, the many actions, the many possible interventions: this would risk being a weak exercise if lacking a solid foundation. Rather, it is a matter of pausing to reflect on the very concept of innovation, rethinking its foundations. Through harmonious innovation, we can foster the formation of new skills, the enhancement of young talents and the construction of new generational leadership, the birth and support of start-ups, spin-offs and innovative SMEs of value, the construction of qualified and stable networks and networks for innovation, actions that become drivers of development for the territories. Measuring the innovation and innovation capacity differentials between different European countries is therefore an essential starting point in this process of building a new set of policies.

## 3 Methodology

The measurement of a complex phenomenon such as the digitality of a company requires a preliminary conceptual definition, conducted through the decomposition of the general concept into its main components of meaning.

By digital enterprise, also known as Industry 4.0, we mean a permanently connected enterprise that works actively thanks to the integrated use of a set of technological resources that manage and solve most of the procedures, helping to build and enhance business relationships. Business.

The values of the index consequently measure different degrees of predisposition of the company to conditions of digitality and the main dimensions that have been taken into consideration, based on the factors that can most determine a computerization condition, are artificial intelligence (AI) and information technologies (ICT).

The approach used involves the construction of 2 macro areas, artificial intelligence (AI) and information technologies (ICT) that is two pillars by aggregating elementary indicators. Both pillars and elementary indicators have been considered non-replaceable. To construct synthetic index, we adopted the following indicators all with positive polarity [2] where the ‘polarity’ (or ‘towards’) of an elementary indicator is the sign of the relationship between the indicator and the phenomenon to be measured (for example, in the construction of a synthetic index of development, the “life expectancy” has polarity positive, while “infant mortality” has a negative polarity). Therefore, it was necessary to bring the indicators to the same standard, reversing the polarity, where necessary, and transforming them into pure, dimensionless numbers:

The matrix relating to data on European enterprises was divided into four progressive steps:

a) Selection of a set of basic indicators on the basis of an ad hoc evaluation model hinging upon the existence of quality requirements;
b) Further selection aimed at balancing the set of indicators within the theoretical framework of the structure. Outcome indicators are impact indicators as the ultimate result of an action as a result of a stakeholder activity or process;
c) Calculation of synthetic indices (pillars), by making use of the methodology proved more appropriate to obtain usable analytical information;
d) Processing of a final synthetic index as a rapid empirical reference concerning the degree of digital technology of European enterprises.

Missing values were attributed via the *hot-deck* imputation (missing data is provided by a “donor”, that is a case with no missing data, chosen, usually within the same database, within a set of cases similar to the case with data missing) and, where not possible, with Europe’s average value.

The choice of the synthesis method is based on the assumption of a formative measurement model, in which the indicators are seen as the ‘cause’ of the phenomenon to be measured, so a change in the latent variable does not necessarily imply a change in all the observed indicators (the indicators are not interchangeable and the correlations between them are not explained by the model).

The exploratory analysis of input data was performed by calculating the mean, average standard deviation and frequency, as well as correlation matrix and principal component analysis. Since this is a non-compensatory approach, the simple aggregation of elementary indicators was carried out using the correct arithmetic average with a penalty proportional to the “horizontal” variability.

Normalization of primary indicators took place by conversion into relative indexes compared to the variation range (*min-max*): the value assumed by each unit is re-proportioned so that it oscillates between the lowest assumed value by the indicator set equal to 0 and the highest set equal to 1.

Attribution of weights to each elementary indicator has followed a subjective approach, opting for the same weight for each of them. Since, in some cases, the elementary indicators showed different polarity, it was necessary to reverse the sign of negative polarities by linear transformation.

For the synthetic indicator calculation, we used the *Adjusted Mazziotta-Pareto Index* (AMPI), which is used for the min-max standardization of elementary indicators and aggregate with the mathematical average penalized by the “horizontal” variability of the indicators themselves. In practice, the compensatory effect of the arithmetic mean (average effect) is corrected by adding a factor to the average (penalty coefficient) which depends on the variability of the normalized values of each unit (called horizontal variability) or by the variability of the indicators compared to the values of reference used for the normalization.

The synthetic index of the i-th unit, which usually varies between 70 and 130, is obtained by applying, with negative penalty, the correct version of the penalty method for variation coefficient (AMPI $\pm$), where:

$$AMPIi- = Mri - Sricvi \tag{1}$$

where *Mri* e *Sri* are, respectively, the arithmetic mean and the standard deviation of the normalized values of the indicators of the i unit, and $cvi = Sri / Mri$ is the coefficient of variation of the normalized values of the indicators of the i unit [5].

The correction factor is a direct function of the variation coefficient of the normalized values of the indicators for each unit and, having the same arithmetic mean, it is possible to penalize units that have an increased imbalance between the indicators, pushing down the index value (the lower the index value, the lower the level of digital technology).

This method satisfies all requirements for the wellbeing synthesis and related phenomena [4]:

- Spatial and temporal comparison
- Irreplaceability of elementary indicators
- Simplicity and transparency of computation
- Immediate use and interpretation of the obtained results
- Strength of the obtained results

An influence analysis was also performed to assess the robustness of the method and to verify if and with which intensity the composite index rankings change following elimination from the starting set of a primary indicator. This process has also permitted us to analyse the most significant indicators.

The analysis was conducted using the *COMIC* (Composite Indices Creator) software, developed by ISTAT. The software allows calculating synthetic indices and building rankings, as well as easily comparing different synthesis methods to select the most suitable among them, and write an effective report based upon results [6].

## 4 Results

Tables 2, 3 and 4 reveal a good variability, in particularly we can see a greater variability of the ICT macro area compared to the AI macro area ($\sigma = 11.49$) and among the indicators of the ICT macro area VAR 8 (Percentage of enterprises with e-commerce sales of at least 1% turnover), VAR 9 (Percentage of enterprises' total turnover from e-commerce sales) and VAR 10 (Percentage of enterprises provided training to their personnel to develop their ICT skills) show a greater standard deviation (respectively 7.73, 8.43 and 7.80).

Tables 5, 6 and 7 show significant correlations between AI e ICT macro areas ($r = 0.683$) and, in particularly, there are significant direct correlations between percentage of enterprises analysing big data internally using machine learning (VAR1) and percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR5) ($r = 0.907$), between percentage of enterprises analysing big data internally using machine learning (VAR1) and Percentage of enterprises that use two AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR6) ($r = 0.708$), between Percentage of enterprises with a chat service where a chatbot or a virtual agent replies to customers (VAR4) and Percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR5) ($r = 0.714$) and Percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR5) and Percentage of enterprises that use two AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR6) ($r = 0.779$), between Percentage of enterprises with e-commerce sales of at least 1% turnover (VAR8) and Percentage of enterprises' total turnover from e-commerce sales (VAR9) ($r = 0.651$), between Percentage of enterprises provided training to their personnel to develop their ICT skills (VAR10) and Percentage of enterprises that recruited/tried to recruit personnel for jobs requiring ICT specialist skills (VAR11) ($r = 0.616$).

The influence analysis describes the indicators that most influence the composition of rosters of European countries. In analysing Tables 9 and 10, we can see that the most significant macro area is ICT (mean = 2.862, $\sigma = 3.280$) and the most important indicators concerns percentage of enterprises with e-commerce sales of at least 1% turnover (VAR8) (mean = 1.793, $\sigma = 1.864$), percentage of enterprises with a chat service where a chat-bot or a virtual agent replies to customers (VAR4) (mean = 1.621, $\sigma = 1.622$) and percentage of enterprises that employ ICT specialists (VAR12) (mean = 1.517, $\sigma = 1.567$).

**Table 1.** Macro areas and Indicators

| Macro areas | Indicators |
|---|---|
| Artificial Intelligence [3] | Percentage of enterprises analysing big data internally using machine learning (VAR1)<br>Percentage of enterprises analysing big data internally using natural language processing, natural language generation or speech recognition (VAR2)<br>Percentage of enterprises using service robots (VAR3)<br>Percentage of enterprises with a chat service where a chatbot or a virtual agent replies to customers (VAR4)<br>Percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR5)<br>Percentage of enterprises that use two AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR6)<br>Percentage of enterprises that use three AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (VAR7) |
| ICT [4] | Percentage of enterprises with e-commerce sales of at least 1% turnover (VAR8)<br>Percentage of enterprises' total turnover from e-commerce sales (VAR9)<br>Percentage of enterprises provided training to their personnel to develop their ICT skills (VAR10)<br>Percentage of enterprises that recruited/tried to recruit personnel for jobs requiring ICT specialist skills (VAR11)<br>Percentage of enterprises that employ ICT specialists (VAR12) |

**Table 2.** Mean, $\sigma$ and frequency macro areas

| | AI | ICT |
|---|---|---|
| Mean | 100.969 | 101.903 |
| $\sigma$ | 9.172 | **11.49** |
| Frequency | 29 | 29 |

**Table 3.** Mean, $\sigma$ and frequency AI macro area

| | VAR1 | VAR2 | VAR3 | VAR4 | VAR5 | VAR6 | VAR7 |
|---|---|---|---|---|---|---|---|
| Mean | 3.31 | 1.207 | 2.034 | 2.207 | 5.931 | 0.897 | 0.103 |
| $\sigma$ | 3.892 | 0.94 | 1.052 | 1.424 | 3.909 | 0.724 | 0.31 |
| Frequency | 29 | 29 | 29 | 29 | 29 | 29 | 29 |

**Table 4.** Mean, $\sigma$ and frequency ICT macro area

| | VAR8 | VAR9 | VAR10 | VAR11 | VAR12 |
|---|---|---|---|---|---|
| Mean | 20.103 | 17.966 | 21.31 | 8.966 | 20.897 |
| $\sigma$ | **7.734** | **8.437** | **7.802** | 3.438 | 5.115 |
| Frequency | 29 | 29 | 29 | 29 | 29 |

**Table 5.** Correlation matrix of the macro areas

| **Macro areas** | AI | ICT |
|---|---|---|
| AI | 1.000 | |
| ICT | **0.683** | 1000 |

**Table 6.** Correlation matrix of the AI's indicators

| **Indicators** | VAR1 | VAR2 | VAR3 | VAR4 | VAR5 | VAR6 | VAR7 |
|---|---|---|---|---|---|---|---|
| VAR1 | 1.000 | | | | | | |
| VAR2 | 0.216 | 1.000 | | | | | |
| VAR3 | 0.215 | 0.173 | 1.000 | | | | |
| VAR4 | 0.497 | 0.180 | 0.495 | 1.000 | | | |
| VAR5 | **0.907** | 0.305 | **0.504** | **0.714** | 1.000 | | |
| VAR6 | **0.708** | 0.452 | **0.614** | **0.610** | **0.779** | 1.000 | |
| VAR7 | 0.475 | 0.169 | 0.098 | 0.273 | 0.418 | 0.208 | 1.000 |

**Table 7.** Correlation matrix of the ICT's indicators

| **Indicators** | VAR8 | VAR9 | VAR10 | VAR11 | VAR12 |
|---|---|---|---|---|---|
| VAR8 | 1.000 | | | | |
| VAR9 | **0.651** | 1.000 | | | |
| VAR10 | **0.552** | **0.531** | 1.000 | | |
| VAR11 | 0.415 | 0.353 | **0.616** | 1.000 | |
| VAR12 | 0.313 | **0.503** | **0.570** | **0.611** | 1.000 |

**Table 8.** Influence Analysis: mean and s of the shifts of the rankings by basic indicator removed of macro areas

| **Macro areas** | Mean | $\sigma$ |
|---|---|---|
| IA | 2.621 | 2.833 |
| ICT | **2.862** | **3.280** |
| **Mean** | **2.741** | **3.057** |
| $\sigma$ | **0.121** | **0.223** |

**Table 9.** Influence Analysis: mean and s of the shifts of the rankings by basic indicator removed of AI's indicators

| **Indicators** | Mean | $\sigma$ |
|---|---|---|
| VAR1 | 0.621 | 0.762 |
| VAR2 | **1.276** | **1.236** |
| VAR3 | **1.034** | **1.066** |
| VAR4 | **1.621** | **1.622** |
| VAR5 | 0.414 | 0.683 |
| VAR6 | 0.345 | 0.603 |
| VAR7 | 0.690 | 1.289 |
| **Mean** | **0.857** | **1.037** |
| $\sigma$ | **0.436** | **0.346** |

**Table 10.** Influence Analysis: mean and s of the shifts of the rankings by basic indicator removed of ICT's indicators

| **Indicators** | Mean | $\sigma$ |
|---|---|---|
| VAR8 | **1.793** | **1.864** |
| VAR9 | 1.448 | 1.567 |
| VAR10 | 1.379 | 1.518 |
| VAR11 | 1.379 | 1.324 |
| VAR12 | **1.517** | **1.567** |
| **Mean** | **1.503** | **1.567** |
| $\sigma$ | **0.154** | **0.173** |

## 5 Discussion

The values of the composite index of Artificial Intelligence (AI), information technologies (ICT) and digital technology are described in Table 11, Table 12 and Fig. 1.

As regards digital technology, the “best” performances are grouped in north-eastern Europe, in particular in Denmark (total index 125.7, AI index 110.8, ICT index 125.5), Finland (total index 122,2, AI index 114.3, ICT index 115.7), Belgium (total index 121.8, AI index 106.1, ICT index 126.2), Sweden (total index 111,4, AI index 103.8, ICT index 112.3) and Lithuania (total index 106.8, AI index 113.5, ICT index 97.1), but the most

**Table 11.** Synthetic European Index ranking of AI

| Nations | Value | Rank |
|---|---|---|
| Ireland | 124,24 | 1 |
| Malta | 120,90 | 2 |
| Finland | 114,36 | 3 |
| Lithuania | 113,50 | 4 |
| Denmark | 110,86 | 5 |
| Belgium | 106,11 | 6 |
| Portugal | 104,24 | 7 |
| Sweden | 103,85 | 8 |
| Slovakia | 103,52 | 9 |
| Italy | 103,35 | 10 |
| Spain | 102,87 | 11 |
| Germany | 101,87 | 12 |
| Czechia | 101,55 | 13 |
| Norway | 100,00 | 14 |
| Austria | 99,78 | 15 |
| Luxembourg | 99,56 | 16 |
| Croatia | 99,50 | 17 |
| France | 99,50 | 18 |
| Netherlands | 98,04 | 19 |
| Estonia | 97,65 | 20 |
| Romania | 95,16 | 21 |
| Bulgaria | 93,51 | 22 |
| Poland | 93,09 | 23 |
| Slovenia | 93,09 | 24 |
| Bosnia and Herzegovina | 92,03 | 25 |
| Cyprus | 91,77 | 26 |
| Latvia | 89,69 | 27 |
| Hungary | 89,68 | 28 |
| Greece | 84,86 | 29 |
| **EUROPE** | **100,00** | |

digital European nation is Ireland (total index 135.6, AI index 124.2, ICT index 123.9) followed by Malta (index 126.0) and Denmark (index 125.7). Italy ranks 24th (out of 29) in the ranking of digital technology (index 111.18), in particular 10th in the ranking of artificial intelligence (index 103.3) and 26th (index 85.9) for the use of ICT, a clear sign that AI is widespread in the few companies that use ICT.

**Table 12.** Synthetic European Index ranking of ICT

| **Nations** | **Value** | **Rank** |
|---|---|---|
| Belgium | 126,28 | 1 |
| Denmark | 125,53 | 2 |
| Ireland | 123,96 | 3 |
| Finland | 115,77 | 4 |
| Malta | 114,45 | 5 |
| Sweden | 112,36 | 6 |
| Czechia | 108,05 | 7 |
| Netherlands | 107,08 | 8 |
| Spain | 104,10 | 9 |
| Norway | 103,62 | 10 |
| Croatia | 103,21 | 11 |
| Hungary | 102,44 | 12 |
| Germany | 102,31 | 13 |
| Portugal | 101,71 | 14 |
| Austria | 101,23 | 15 |
| Cyprus | 100,96 | 16 |
| Luxembourg | 99,65 | 17 |
| Slovenia | 99,04 | 18 |
| France | 97,17 | 19 |
| Lithuania | 97,16 | 20 |
| Poland | 96,19 | 21 |
| Estonia | 94,40 | 22 |
| Slovakia | 94,36 | 23 |
| Bosnia and Herzegovina | 91,44 | 24 |
| Latvia | 91,30 | 25 |
| Italy | 85,97 | 26 |
| Greece | 85,75 | 27 |
| Romania | 85,31 | 28 |
| Bulgaria | 84,38 | 29 |
| **EUROPE** | **100,00** | |

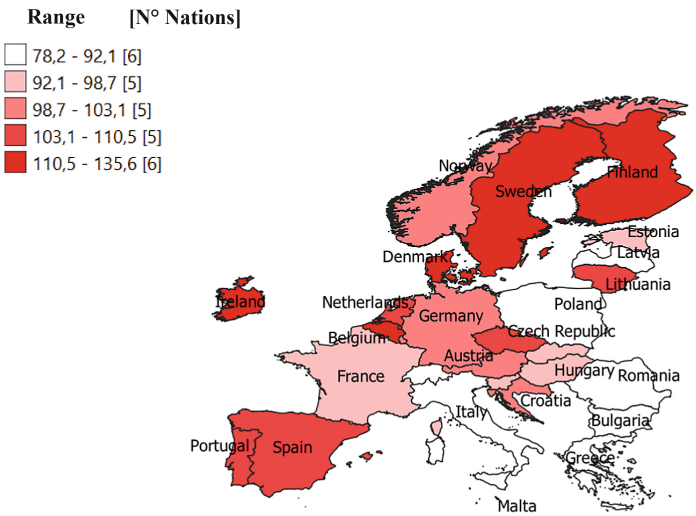


**Fig. 1.** Territorial distribution of the European synthetic index of digital technology

## 6 A Focus for Italy

According to the European Innovation Scoreboard 2019, Italy has a lower innovation rate than the EU average and is therefore considered a 'moderate innovator'. The regions as a whole have shown signs, albeit weak, of innovative capacity, but to date only Friuli Venezia Giulia is a 'strong innovator' in Europe. The 2021–2017 programming being implemented must therefore aim to incentivise innovative sectors and to invest to stimulate the territories' innovative potential and put it at the service of the regional and national economy.

European programming 2021–2027 must focus on research and development much more than 2014–2020. Italy currently spends 6.7 billion resources related to cohesion policies (4 billion from EU coffers, 2.7 from national ones) on research and innovation. The new programming will total EUR 272 billion. Of this, 226 billion for the ERDF and 46 billion for the Cohesion Fund. These investments are to be concentrated on five thematic objectives:

1) innovative, smart and inclusive development, connectivity, development of information and communication technologies, efficient public administration;
2) a greener, low-carbon and resilient Europe, energy transition, green and blue investments, the circular economy, climate change adaptation and risk prevention; and the circular economy;
3) a more interconnected Europe by improving mobility;
4) a more social and inclusive Europe implementing the European pillar of social rights;
5) a Europe closer to the citizens, promoting the sustainable and integrated development of cities and other non-urban areas through local initiatives.

The Regulation stipulates that region (according to their level of development) will have to concentrate a predefined percentage of resources on two of the five objectives: innovative development (OT1) and environment (OT2).

This means that the:

a) more developed regions will have to concentrate 50% in OT1 and 30% in OT2;
b) transition regions will have to concentrate 40% OT1 and 30% OT2;
c) less developed regions shall concentrate 30% OT1 and 30% OT2.

In the 2021–2027 programming, therefore, a fundamental principle is affirmed that investments in innovative, intelligent and inclusive development must constitute the prevailing part of the programmed investments, especially with reference to advanced regions, and in any case may not be less than 30% with reference to less developed regions. Translated into numbers, we are talking about EUR 100 billion.

To this must be added the PNRR resources. Next Generation EU has a budget of 208.6 billion euros, of which 191.4 billion for the Recovery and Resilience Facility. Regarding the Recovery and Resilience Facility (RRF), the resources available to Italy are estimated at 63.8 billion in grants and 127.6 billion in loans. Seventy per cent of the resources are to be committed in 2021–2022, the remainder in 2023. The Italian share of the grants is calculated for the entire period based on the data available to date. However, the actual amount of the remaining 30% of the programme will depend on the fall in GDP in 2020–2021 The amount of loans is calculated as the maximum that can be drawn given the expected level of Gross National Income (GNI) and the ceiling of 6.8% in relation to GNI.

There will be no shortage of resources, and the next five-year period could be an opportunity to increase research and development spending in Italy, which has always been the Cinderella of all investment spending. The fact that Italy is not a strong innovator denotes a fundamental failure of structural and regional development policies. Because a country that does not innovate or innovates little is a country that loses competitiveness, and loss of competitiveness is the antechamber to decline.

For Italy, therefore, spending the PNRR and Structural Funds resources well will be crucial. Today, the lack of innovation has caused us to lose our competitive capacity and pushed us into a situation of decline from which, if we do not take immediate action, it will be difficult to lift ourselves, also due to the government's ordinary policies that have privileged welfare spending over investment spending and the weight of public debt that constitutes a constraint on the very possibility of investing. It is necessary, then, to have the courage to invest in innovation through ambitious, coordinated and wide-ranging projects. It is necessary to think of major revolutionary projects to which sufficient resources can be allocated, avoiding the use of resources for patronage purposes by distributing them in a haphazard manner and scattering them in a thousand rivulets. The basic flaw of past Structural Fund programming has also been this, and the obvious result has been the poor quality and quantity of innovation produced by the Italian system.

Acknowledging past mistakes is certainly the first step to avoid making them again in the future, and it is therefore to be hoped that these analyses and programmes will be shrewder and more efficient.

Losing competitiveness and innovative capacity today is very dangerous. Thirty years ago, a loss of competitiveness produced delayed effects on GDP of up to decades. Today, the loss of competitiveness is reflected almost in real time on GDP. In fact, Italy is a country that grows little, one of the last in terms of speed of development in Europe and among advanced countries.

The 2021–2027 planning and the PNRR must be the opportunity to reverse the course and start a path of growth in innovation and growth in competitiveness. If this opportunity is not seized, Italy's future will be characterised by the word 'decline' [7, 8].

## 7 Conclusions

Composite indicators (CIs) which compare country performance are increasingly recognised as a useful tool in policy analysis and public communication. The number of CIs in existence around the world is growing year after year.

For a recent review see Bandura, 2006, which cites more than 160 composite indicators, even if the inventory presented in this paper is not exhaustive [10]. In fact, the research leading to the inventory was based on reports, websites, books, and academic papers. The inventory presents indices in alphabetical order, providing for each entry the author or organization responsible for it, a description of the index and its methodology together with the year of creation, frequency of issuance and the relevant sources, including websites. This information corresponds to indices found in publications or websites, which are either updated frequently or are "one-time events". Private firms offer online paid subscription services (for example, credit rating agencies or private consultancy firms) and sometimes do not disclose their methodologies to the public, thus only the limited information available in their websites is included in the inventory.

Such composite indicators provide simple comparisons of countries that can be used to illustrate complex and sometimes elusive issues in wide-ranging fields, e.g., environment, economy, society or technological development.

It often seems easier for the general public to interpret composite indicators than to identify common trends across many separate indicators, and they have also proven useful in benchmarking country performance (Saltelli, 2007). However, composite indicators can send misleading policy messages if they are poorly constructed or misinterpreted. Their "big picture" results may invite users (especially policy-makers) to draw simplistic analytical or policy conclusions. In fact, composite indicators must be seen as a means of initiating discussion and stimulating public interest. Their relevance should be gauged with respect to constituencies affected by the composite index [9].

The synthetic index which has been calculated in this paper can be useful to get an idea of the use of digital technologies at a territorial level, but above all it can constitute a support for the decisions of European policy makers who must encourage companies to develop them, as part of one of the 6 priorities of the European Commission 2019–2024, namely «A Europe ready for the digital age».

In this *scenario*, a type of "compensatory" or "add-on" regional development policy ends up accentuating the differences between regions, which are due to the different regional response to policies stimuli. Instead of fostering convergence, traditional policies create underdevelopment traps.

Peripheral regions are the ones most exposed to loss of competitiveness since the rules governing the economic system promote the aggregation of factors and "classic" regional policy is unable to counter this trend, despite generous financial compensation. An effective regional policy should work on two levels: modify the response function of regional economy and also provide an investment able to generate diffuse positive externalities [11, 12]. Moreover, interventions should be minimal and aimed at creating stronger connections between economic agents and, in particular, combining production activities with services, to foster the servitisation that probably influences "soft" factors inside the regional economy.

## Appendix

**Table 13.** AI macro area indicators (percentage)

| Nation | VAR1 | VAR2 | VAR3 | VAR4 | VAR5 | VAR6 | VAR7 |
|---|---|---|---|---|---|---|---|
| Austria | 3 | 2 | 2 | 1 | 4 | 1 | 0 |
| Belgium | 3 | 1 | 2 | 3 | 5 | 1 | 1 |
| Bosnia and Herzegovina | 1 | 0 | 1 | 3 | 3 | 0 | 0 |
| Bulgaria | 1 | 0 | 2 | 2 | 5 | 0 | 0 |
| Croatia | 2 | 1 | 3 | 1 | 5 | 1 | 0 |
| Cyprus | 1 | 1 | 1 | 1 | 3 | 0 | 0 |
| Czechia | 2 | 3 | 2 | 1 | 6 | 1 | 0 |
| Denmark | 5 | 1 | 5 | 3 | 9 | 2 | 0 |
| Estonia | 3 | 1 | 1 | 2 | 4 | 1 | 0 |
| Finland | 5 | 2 | 3 | 6 | 10 | 2 | 0 |
| France | 2 | 1 | 3 | 1 | 5 | 1 | 0 |
| Germany | 2 | 2 | 2 | 2 | 6 | 1 | 0 |
| Greece | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hungary | 1 | 0 | 1 | 1 | 3 | 0 | 0 |
| Ireland | 20 | 1 | 2 | 4 | 20 | 2 | 1 |
| Italy | 2 | 1 | 3 | 3 | 7 | 1 | 0 |
| Latvia | 1 | 1 | 1 | 0 | 2 | 0 | 0 |
| Lithuania | 3 | 3 | 3 | 3 | 7 | 1 | 1 |
| Luxembourg | 2 | 1 | 2 | 2 | 5 | 1 | 0 |
| Malta | 12 | 2 | 3 | 5 | 15 | 3 | 0 |
| Netherlands | 4 | 1 | 1 | 2 | 4 | 1 | 0 |
| Norway | 3 | 1 | 2 | 2 | 5 | 1 | 0 |
| Poland | 1 | 0 | 2 | 2 | 4 | 0 | 0 |
| Portugal | 3 | 1 | 3 | 3 | 8 | 1 | 0 |
| Romania | 1 | 1 | 1 | 3 | 5 | 0 | 0 |
| Slovakia | 1 | 1 | 3 | 4 | 6 | 1 | 0 |
| Slovenia | 2 | 1 | 1 | 0 | 2 | 1 | 0 |
| Spain | 4 | 1 | 3 | 2 | 7 | 1 | 0 |
| Sweden | 5 | 4 | 1 | 2 | 7 | 1 | 0 |

(*continued*)

**Table 13.** (*continued*)

| Nation | VAR1 | VAR2 | VAR3 | VAR4 | VAR5 | VAR6 | VAR7 |
|---|---|---|---|---|---|---|---|
| **EUROPE** | **2** | **1** | **2** | **2** | **6** | **1** | **0** |

Legend:
VAR1: Percentage of enterprises analysing big data internally using machine learning
VAR2: Percentage of enterprises analysing big data internally using natural language processing, natural language generation or speech recognition
VAR3: Percentage of enterprises using service robots
VAR4: Percentage of enterprises with a chat service where a chat-bot or a virtual agent replies to customers
VAR5: Percentage of enterprises that use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS)
VAR6: Percentage of enterprises that use two AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS)
VAR7: Percentage of enterprises that use three AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS)

**Table 14.** ICT macro area indicators (percentage)

| Nation | VAR8 | VAR9 | VAR10 | VAR11 | VAR12 |
|---|---|---|---|---|---|
| Austria | 22 | 17 | 18 | 9 | 20 |
| Belgium | 26 | 31 | 33 | 18 | 30 |
| Bosnia and Herzegovina | 19 | 8 | 15 | 8 | 15 |
| Bulgaria | 8 | 6 | 7 | 9 | 16 |
| Croatia | 31 | 14 | 23 | 8 | 19 |
| Cyprus | 15 | 6 | 25 | 11 | 25 |
| Czechia | 30 | 30 | 25 | 8 | 18 |
| Denmark | 38 | 29 | 30 | 14 | 29 |
| Estonia | 17 | 14 | 17 | 7 | 17 |
| Finland | 19 | 20 | 38 | 13 | 28 |
| France | 14 | 23 | 15 | 9 | 18 |
| Germany | 18 | 18 | 24 | 10 | 19 |
| Greece | 8 | 4 | 12 | 6 | 19 |
| Hungary | 14 | 23 | 16 | 8 | 29 |
| Ireland | 33 | 44 | 27 | 10 | 30 |
| Italy | 12 | 13 | 15 | 4 | 13 |
| Latvia | 12 | 10 | 17 | 5 | 20 |
| Lithuania | 28 | 14 | 14 | 9 | 16 |
| Luxembourg | 10 | 15 | 21 | 12 | 22 |

(*continued*)

**Table 14.** (*continued*)

| Nation | VAR8 | VAR9 | VAR10 | VAR11 | VAR12 |
|---|---|---|---|---|---|
| Malta | 25 | 15 | 28 | 14 | 29 |
| Netherlands | 19 | 17 | 24 | 12 | 24 |
| Norway | 22 | 19 | 33 | 8 | 17 |
| Poland | 14 | 17 | 18 | 4 | 25 |
| Portugal | 20 | 20 | 23 | 7 | 20 |
| Romania | 18 | 12 | 6 | 3 | 16 |
| Slovakia | 17 | 21 | 16 | 5 | 17 |
| Slovenia | 18 | 18 | 26 | 7 | 17 |
| Spain | 25 | 19 | 20 | 13 | 17 |
| Sweden | 31 | 24 | 32 | 9 | 21 |
| **EUROPE** | **18** | **20** | **20** | **8** | **19** |

Legend:
VAR8: Percentage of enterprises with e-commerce sales of at least 1% turnover
VAR9: Percentage of enterprises' total turnover from e-commerce sales
VAR10: Percentage of enterprises provided training to their personnel to develop their ICT skills
VAR11: Percentage of enterprises that recruited/tried to recruit personnel for jobs requiring ICT specialist skills
VAR12: Percentage of enterprises that employ ICT specialists

**Table 15.** AI and ICT composite indices (range 70–130)

| Nation | AI | ICT |
|---|---|---|
| Austria | 99,8 | 101,2 |
| Belgium | 106,1 | 126,3 |
| Bosnia and Herzegovina | 92,0 | 91,4 |
| Bulgaria | 93,5 | 84,4 |
| Croatia | 99,5 | 103,2 |
| Cyprus | 91,8 | 101,0 |
| Czechia | 101,5 | 108,1 |
| Denmark | 110,9 | 125,5 |
| Estonia | 97,6 | 94,4 |
| Finland | 114,4 | 115,8 |
| France | 99,5 | 97,2 |
| Germany | 101,9 | 102,3 |
| Greece | 84,9 | 85,8 |

(*continued*)

**Table 15.** (*continued*)

| Nation | AI | ICT |
|---|---|---|
| Hungary | 89,7 | 102,4 |
| Ireland | 124,2 | 124,0 |
| Italy | 103,3 | 86,0 |
| Latvia | 89,7 | 91,3 |
| Lithuania | 113,5 | 97,2 |
| Luxembourg | 99,6 | 99,6 |
| Malta | 120,9 | 114,4 |
| Netherlands | 98,0 | 107,1 |
| Norway | 100,0 | 103,6 |
| Poland | 93,1 | 96,2 |
| Portugal | 104,2 | 101,7 |
| Romania | 95,2 | 85,3 |
| Slovakia | 103,5 | 94,4 |
| Slovenia | 93,1 | 99,0 |
| Spain | 102,9 | 104,1 |
| Sweden | 103,9 | 112,4 |
| **EUROPE** | **100,0** | **100,0** |

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