Digital Entrepreneurship: A Theory-Based Systematization of Core Performance Indicators

Liliya Satalkina 1,* and Gerald Steiner 1,2,*

1 Department for Knowledge and Communication Management, Danube University Krems, 3500 Krems, Austria
2 Complexity Science Hub Vienna, 1080 Vienna, Austria
* Correspondence: liliya.satalkina@donau-uni.ac.at (L.S.); gerald.steiner@donau-uni.ac.at (G.S.)

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Abstract: Digital transformation affects socioeconomic systems, bringing inevitable changes to business processes, particularly those related to resource demands, networking processes, and communication mechanisms within entrepreneurial activities. Furthermore, digital transformation leads to unintended side effects on the societal system and affects the competitiveness, resilience, and viability of the overall innovation system. It also fosters the formation of new business models or the reshaping of existing ones and determines digital entrepreneurship as a process or as an outcome of business activity. The tendencies of digital entrepreneurship differ concerning the underlying innovation system conditions. The analysis and the systematization of categories and performance indicators of digitalization and digital entrepreneurship provide a framework for micro- and macro analytic perspectives. This research aims to provide a theory-based systematization of the existing performance indicators that characterize digital entrepreneurship, with a particular focus on compound indicators that characterize the tendencies of digital entrepreneurship on a country basis in the period from 2016 to 2019. As a theoretical basis for categorization and further analysis of the indicators, we applied a set of 10 determinants of digital entrepreneurship. These determinants cover a broad range of elements (from individual patterns to organizational management processes and the influence of external infrastructure and institutional settings) that define the phenomenon of digital entrepreneurship within three core dimensions: the entrepreneur, the entrepreneurial process, and the relevant ecosystem. We defined how the subindices of the chosen compound indicators are interrelated with the determinants of digital entrepreneurship. Further correlation analysis was applied in order to define the systematic interrelations between the different dimensions of digital entrepreneurship as part of a socioeconomic system.

Keywords: digital entrepreneurship; digital transformation; integrated performance indicators; sustainable transformation and transition capacity; innovation system resilience; complex societal transitions

1. Introduction

Current societal systems are characterized by the rapid development of technologies and digitalization. Closely related to communication methods and processes, networking processes, and information flows [1,2], digital transformation has become a factor of the societal transitions affecting different innovation systems. This fosters the innovative integration of entrepreneurial and business models in different industries [3–7], determining the development of digital entrepreneurship. We suggest that digital entrepreneurship relates not only to specific outcomes of business activities. It is rather a multidimensional phenomenon that interrelates various elements in industrial supply chains within various innovation systems. The development and impact of digital entrepreneurship...
differ in regard to the different socioeconomic conditions, determining different patterns of digital transformation. This may also include challenges (e.g., [8]) and supporting conditions for doing digital business (e.g., [9]). The variety of existing indicators and indices provides measurements for specific digital categories (e.g., ICT, value in a digital economy, digital risk), as well as for the impact of digitalization on socioeconomic processes (e.g., employment, innovation development, financial flows). However, the interrelation of existing indicators, including those that measure digital business and its different dimensions, with the overall digital transformation process is highly dynamic and non-deterministic.

According to Tilson et al., digitalization is “a sociotechnical process of applying digitizing techniques to broader social and institutional contexts that render digital technologies infrastructural” [10]. As a source of digital transformation, digitalization is interpreted as “the changes that the digital technology causes or influences in all aspects of human life” [11]. In its turn, digital entrepreneurship as a part of such transformation processes may be considered, on the one hand, a driving force for innovation development [5,12,13]. On the other hand, it becomes a challenge (i.e., vulnerabilities and opportunities) for the resilience and, ultimately, the sustainability of the innovation system in general [14,15]. Therefore, it is particularly important to understand how digital entrepreneurship as a driver of digital transformation may affect the sustainable transition capacity of the innovation system and, consequently, the socioeconomic system. In our research, we consider the innovation system as a subsystem and important driver within the dynamics of the total socioeconomic system, particularly with respect to its development, transition, and sustainability processes.

The research aims to provide a theory-based systematization of core performance indicators of digital entrepreneurship in order to understand its role within multidimensional digital transformation processes. We aim to understand the interrelation between different aspects of digital entrepreneurship as part of the innovation and, consequently, socioeconomic system. To achieve this aim, we provide a critical reflection on core indicators of digitalization and digital entrepreneurship and analyze their interrelations. As a basis for our reflections, we apply the results of theory systematization acquired in previous research [16]. The research provides the determinants of digital entrepreneurship within the three dimensions of the innovation system (i.e., entrepreneur, entrepreneurial process, and ecosystem), which cover a broad scope of elements from mentality patterns, personal characteristics, and outcomes to the organizational management process and the influence of external infrastructure and institutions. The analysis of the correlations between the determinants of digital entrepreneurship in the framework of the innovation system provides a useful basis for further determination of the correlates between such entrepreneurship and its sustainable implications for the socioeconomic system in general.

In addition to the main objective, the research aims to provide a supporting consolidation of the relevant digital entrepreneurship indicators for its target group (e.g., policy makers, business agents, and entrepreneurs as well as researchers).

The article is organized as follows. In Section 2, we describe a working process and research design that was applied for systematization of core performance indicators. Section 3 provides an overview of the existing data sources and relevant indicators that characterize digitalization and digital entrepreneurship. In Section 4, we provide an overview of the core indices and indicators based on a country comparison. In Section 5, we analyze how the indicators and subindices are correlated within the determinants of digital entrepreneurship and, therefore, different dimensions of the innovation system.

2. Materials and Methods

The research includes two stages: (1) theory systematization and (2) core performance indicators systematization (Figure 1).
Results acquired in previous research

We further extend the theoretical achievements with the systematization of core performance indicators.

As a first step, we screened the existing pool of indicators and indices and identified the most relevant.

According to the PRISMA method, the selection process was performed in four steps: (1) the identification of relevant research by briefly searching through the databases (Harvard Hollis and Web of Knowledge); (2) a screening of abstracts; (3) a full-text assessment; and (4) decision-making concerning eligibility. After all screening stages 52 peer-reviewed articles published in journals from 2014 to 2018 in the English language were included in the review. For the detailed description of the method as well as the review process (including the exclusion and inclusion criteria, coding, and consolidation) see [16].

In this article, we apply the findings of the abovementioned research as a conceptual basis. We further extend the theoretical achievements with the systematization of core performance indicators. As a first step, we screened the existing pool of indicators and indices and identified the most relevant concerning the focus of our research (see Section 3). Based on the chosen indices, we provide an overview of the main tendencies of digitalization and digital entrepreneurship on a country basis (see Section 4). Further, we build a matrix that shows how the existing metrics (i.e., indicators and indices) and their subindices are interconnected with the determinants of the digital entrepreneurship (see the Matrix of indicators and indices in relation to determinants of digital entrepreneurship in Section 5). In order to analyze digital entrepreneurship within the framework of digital transformation, we apply correlation analysis, which allows for defining the interrelatedness of the core indicators and indices within the different dimensions of the innovation system. A detailed description of the correlation dataset and coefficients is provided in Section 5.2.1.

3. Indicator Analysis

3.1. Underlying Basis: Relevant Learning from the Systematic Literature Review

Theoretical systematization was based on the qualitative analysis of 52 articles published in peer-reviewed journals. Within the systematic literature review, we extracted the categories mentioned by authors in relation to digital entrepreneurship and clustered them into the initial nodes. Further, the initial nodes were grouped according to three core scopes: (1) the behavioral, competence,
and mentality patterns, as well as the personal outcomes and consequences, of entrepreneurial activity; (2) the activities related to digitalization in the organizational management process, transformation within strategic and operational activities, digital start-up establishment, etc.; and (3) the influences that external infrastructure and institutions have on digital entrepreneurship development. The three core scopes were classified into three dimensions: Entrepreneur, Entrepreneurial Process, and Ecosystem. The analysis of the initial nodes allowed us to define the main determinants of digital entrepreneurship within each of the three dimensions (Table 1).

Table 1. Determinants of digital entrepreneurship [16].

| Dimensions     | Determinants                                                                 |
|----------------|-----------------------------------------------------------------------------|
| **Entrepreneur** | Determinant 1: Personal characteristics and competences                     |
|                | ➢ Basic characteristics for starting a digital business                      |
|                | ➢ Professional flexibility                                                  |
|                | Determinant 2: Decision-making and bounded rationality                      |
|                | ➢ Opportunity–risk attitude                                                 |
|                | ➢ Personal motivation                                                       |
|                | Determinant 3: Personal outcomes                                            |
|                | ➢ Social positioning                                                        |
|                | ➢ Access to new entrepreneurial possibilities                                |
| **Entrepreneurial Process** | Determinant 4: Prerequisites for digitalization                          |
|                | ➢ Digital capabilities                                                      |
|                | ➢ Adoption of digital drivers                                               |
|                | ➢ Digital facilities                                                        |
|                | Determinant 5: Dynamic shifts in the transformation of business              |
|                | ➢ Digital features in operation activities                                  |
|                | ➢ Merging of value creation                                                 |
|                | ➢ Revenue mechanism                                                         |
|                | ➢ Competition and leadership                                                |
|                | ➢ Knowledge acquisition and strategic learning                              |
|                | ➢ Digital business tendencies                                               |
| **Ecosystem**  | Determinant 6: Digital business model innovation                            |
|                | ➢ Shifts in digital business model configurations                           |
|                | ➢ Digital tools                                                             |
|                | ➢ Risks associated with innovative business models                          |
|                | ➢ Digital innovation models’ validation and assessment                      |
|                | ➢ Shortcomings in digital business models                                   |
|                | Determinant 7: Digital business affordances                                 |
|                | ➢ Intermediary role                                                         |
|                | ➢ Enhancing role                                                           |
|                | ➢ Social influence                                                          |
| **Ecosystem**  | Determinant 8: Regional digital business environment                        |
|                | ➢ Resource availability/constraints                                         |
|                | ➢ Digital entrepreneurship attitudes                                        |
|                | ➢ Context effect on digital start-up formation                              |
| **Ecosystem**  | Determinant 9: Digital business infrastructure                              |
|                | ➢ Digital cluster framework                                                 |
|                | ➢ Facilitating conditions within the infrastructure                         |
|                | ➢ Digital infrastructure architecture                                       |
| **Ecosystem**  | Determinant 10: Collaboration and social values                             |
|                | ➢ System of relationships                                                   |
|                | ➢ Community and network patterns                                            |
3.2. Systematization of Core Performance Indicators

The consolidation of the results of existing research within the defined determinants provided a theoretical basis for the comprehensive analysis of integrated indicators. As shown in Figure 1, the systematization of indicators, which characterize the embeddedness of digital entrepreneurship within socioeconomic transformation, was conducted in several steps. Initially, we defined the pool of existing indicators, indices, and metrics that characterize digitalization as well as digital businesses and entrepreneurial processes. We used the reports of international organizations and research institutions, as well as statistical databases for the main data sources. The following sources were screened: reports of the European Commission, the Organisation for Economic Cooperation and Development (OECD), the United Nations, and the World Economic Forum; research reports produced by The Fletcher School at Tufts University; and Eurostat and OECD statistical databases. An Excel spreadsheet was created with a list of 207 indicators with relevant data sources. Table 2 presents an overview of the identified indicators.

Table 2. Digital economy indicators relevant for digital entrepreneurship.

| Source                          | Indicators                                                                 |
|---------------------------------|---------------------------------------------------------------------------|
| European Commission Reports     | International Digital Economy and Society Index                           |
| Autoio, E.; Szerb, L.; Komlósi, É.; Tiszberger, M. (2018). The European Index of Digital Entrepreneurship Systems (EUR 29309 EN). Publications Office of the European Union. [https://ec.europa.eu/jrc/en/publication/european-index-digital-entrepreneurship-systems](https://ec.europa.eu/jrc/en/publication/european-index-digital-entrepreneurship-systems) | European Index of Digital Entrepreneurship Systems                        |
| OECD                            | Access and connectivity (Chapter 3)                                       |
| Organisation for Economic Co-operation and Development. (2017). OECD Digital Economy Outlook 2017. OECD Publishing. [https://doi.org/10.1787/9789264276284-en](https://doi.org/10.1787/9789264276284-en) | ■ Access and connectivity (Chapter 3) |
| Organisation for Economic Co-operation and Development. (2017). Entrepreneurship at a Glance 2017. OECD Publishing. [https://doi.org/10.1787/entrepreneur_aag-2017-en](https://doi.org/10.1787/entrepreneur_aag-2017-en) | ■ International trade and SMEs with digital presence |
| Organisation for Economic Co-operation and Development. (2017). Entrepreneurship at a Glance 2017. OECD Publishing. [https://doi.org/10.1787/entrepreneur_aag-2017-en](https://doi.org/10.1787/entrepreneur_aag-2017-en) | ■ Digital presence, international trade and business confidence |
| Organisation for Economic Co-operation and Development. (2017). Entrepreneurship at a Glance 2017. OECD Publishing. [https://doi.org/10.1787/entrepreneur_aag-2017-en](https://doi.org/10.1787/entrepreneur_aag-2017-en) | ■ Digital presence, international trade and prospects of job creations (Chapter 1: Recent developments in entrepreneurship) |
| Official webpage: OECD. Stat Services Trade Restrictions: [https://stats.oecd.org/?datasetcode=STRI_DIGITAL](https://stats.oecd.org/?datasetcode=STRI_DIGITAL) | ■ Digital services trade restrictiveness index (Digital STRI) |
| Official webpage: OECD. Stat Services Trade Restrictions: [https://stats.oecd.org/?datasetcode=STRI_DIGITAL](https://stats.oecd.org/?datasetcode=STRI_DIGITAL) | ■ Digital STRI Heterogeneity indices |
| The Fletcher School, Tufts University | Digital Evolution Index                                                   |
| Chakravorti, B.; Bhalla, A.; Chaturvedi, R.S. (2017). Digital Planet 2017. How Competitiveness and Trust in Digital Economies Vary Across the World. The Fletcher School, Tufts University. | Digital Evolution Index                                                   |
| Chakravorti, B.; Chaturvedi, R.S.; Fillpovic, C. (2019). Ease of Doing Digital Business 2019. Which Countries Help Expedite Entry, Growth, and Exit of Technology-Based Businesses? The Fletcher School, Tufts University. | Ease of Doing Digital Business                                             |
Table 2. Cont.

| Source                                             | Indicators                                                                 |
|----------------------------------------------------|---------------------------------------------------------------------------|
| United Nations Reports                             | Various indicators that show trends in:                                   |
|                                                   | ■ Recent trends in the digital economy (Chapter 1)                       |
|                                                   | ■ Measuring value in the digital economy (Chapter 3)                     |
|                                                   | ■ Value creation and capture in the digital economy: A global perspective (Chapter 4) |
|                                                   | ■ Opportunities and limitations in developing countries (Chapter 5)      |
| Nations Conference on Trade and Development. (2019). Digital Economy Report 2019: Value Creation and Capture: Implications for Developing Countries. S.l.: UNITED NATIONS |                                                           |
| World Economic Forum                               | The Networked Readiness Index and subindices                             |
| Baller, S.; Dutta, S.; Lanvin, B. (2016). The Global Information Technology Report 2016: Innovating in the Digital Economy. http://www.deslibris.ca/ID/10090686 |                                                           |
| Eurostat                                           | Topic—“Science, technology, digital society”                             |
| Database (Official webpage: https://ec.europa.eu/eurostat/data/database) | Subtopic—“Digital economy and society”:                                  |
|                                                   | ■ ICT usage in households and by individuals                             |
| Eurostat Statistics Explained                      | ■ ICT usage in enterprises                                               |
| Category Digital economy and society               | ■ Digital skills                                                         |
| Statistical article “Digital economy and society statistics—enterprises” (see https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Digital_economy_and_society) | ■ ICT sector                                                            |
|                                                   | ■ Digital economy and society—historical data                            |
|                                                   | ■ E-business                                                             |
|                                                   | ■ Digital economy and society—enterprises                                |

For further analysis, we focused on integrated indices, which, as compound indicators, measure the complex patterns of digitalization and digital entrepreneurship more holistically. In the research, we apply the following indicator sets:

1. International Digital Economy and Society Index;
2. European Index of Digital Entrepreneurship Systems;
3. Digital Evolution Index;
4. Digital Trust;
5. Ease of Doing Digital Business;
6. Network Readiness Index.

As mentioned in relation to Figure 1, the theory-based analysis of the defined indicators allowed us to determine how digital entrepreneurship is embedded within the pattern of digital transformation.

4. Results

In general, the indicator sets discussed are related to digital business and digital entrepreneurship as part of digital transformation at a country level. Particularly, applying the Digital Evolution Index, Digital Trust (The Fletcher School of Tufts University), the International Digital Economy and Society Index (European Commission), and the Network Readiness Index (World Economic Forum), we analyze the overall tendency of digitalization and the factors that show its interconnectedness with the core elements of the socioeconomic system. The European Index of Digital Entrepreneurship Systems (European Commission) and the Ease of Doing Digital Business (The Fletcher School of Tufts University) are the indicators that we apply for the analysis of digital business, its core elements, and their interrelatedness with the other factors of digitalization.
4.1. Digital Evolution Index

The Digital Evolution Index (DEI) was developed by researchers at The Fletcher School of Tufts University (US) and provides an analysis of the current state of countries’ digitalization levels as well as digital potential and prospects (“momentum”) [17]. According to the original report (Digital Planet 2017. How Competitiveness and Trust in Digital Economies Vary Across the World) the structure of the index comprises the following elements [17]:

(1) Supply Conditions: Access Infrastructure (communication, sophistication, and coverage security); Transaction Infrastructure (access to financial institutions and electronic payment options); Fulfillment Infrastructure (the quality of transportation infrastructure, logistics performance);

(2) Demand Conditions: Consumer Capacity to Engage (consumer ability and willingness to spend and the gender digital divide); Digital Payment Uptake (the degree of financial inclusion and use of digital money); Digital Uptake (device prevalence and density, technology, Internet and mobile connection uptake, and digital consumption);

(3) Institutional Environment: Institutions and the Business Environment (the legal environment and efficiency in settling disputes, IP and investment protections and bureaucracy); Institutions and the Digital Ecosystem (government uptake and the use of ICT and digital technology, and telecom competition); Institutional Effectiveness and Trust (transparency, rule of law, and regulatory quality);

(4) Innovation and Change: Inputs (financing options and opportunities, start-up capacity, ability to attract and retain talent); Process (sophistication of business practice, and R&D); Output (the depth of mobile engagement, reach of innovation, and use of social networks and digital entertainment).

The country rates for the Digital Evolution Index in 2017, with the rates of digital momentum are shown in Figure 2.

![Figure 2. Digital Evolution Index (developed based on the data from [17] (pp. 21–22)).](image)

4.2. Digital Trust

In addition to the Digital Evolution Index, the mentioned research includes the Digital Trust (DT) framework, which includes four main drivers [17]:

(1) Behavior that shows the correlation between the engagement behavior of users and their attitude toward digitalization;

(2) Attitudes that relate to users’ feelings about the digital environment and their trust in transactions and data security;
(3) Experience – based on the quality of users’ digital experiences as a proxy measurement that demonstrates “the extent of frictions” in a country’s digital environment, i.e., the speed and ease of digital interactions and transactions with respect to different sources of frictions (e.g., regulatory, infrastructural);

(4) Environment – an evaluation of the “maturity” of trust indicators, such as privacy, security, and accountability measures.

The scores for the four drivers of Digital Trust in 2017 are shown in Figure 3.

As shown in Figure 3, the country rankings also differ within each of the four drivers. Country leaders according to the scores for the Attitudes driver are Australia, China, and Sweden. The highest rankings for the Behavior driver were for China, Ireland, and Spain. Estonia, the Netherlands, and Switzerland are the leaders in the Environment driver. Finally, Experience is the strongest driver of digital trust in Norway, South Korea, and Switzerland.

4.3. The International Digital Economy and Society Index

The International Digital Economy and Society Index (I-DESI) was prepared for the European Commission and provides analyses and comparisons of the digital performance of 45 countries (the EU’s 28 member states and 17 non-EU countries). According to the European Commission, the I-DESI is an extended version of the Digital Economy and Society Index (DESI) since it measures similar variables for EU and non-EU countries. The I-DESI combines 24 indicators in five different dimensions [18]:

(1) Connectivity (fixed broadband, mobile broadband, speed, and affordability);
(2) Human capital (basic skills and usage, advanced skills and development);
(3) Citizen Internet use (content, communications, transactions, and ubiquitous use);
(4) Business technology integration (business digitization, e-Commerce);
(5) Digital public services (e-Government development index).

For further analysis, we chose the I-DESI because, on the one hand, there is no difference in structure compared to the DESI, and, on the other hand, it allows the comparison of the trends of
digital transformation within different country groups (i.e., EU and non-EU countries). Figure 4 illustrates a comparison of the overall I-DESI rates for EU and non-EU countries as well as the rates of its different dimensions.

![Figure 4. International Digital Economy and Society Index comparison for EU and non-EU countries (developed based on the data from [18] (pp. 47–61)).](image)

The analysis of the I-DESI demonstrates that the digital performance of EU and non-EU countries in 2016 increased to 0.59, compared to 0.51 and 0.50, respectively, in 2013. During the analyzed period, the largest change for both country groups was within the Connectivity dimension. Although there were no significant differences in the overall rates of the I-DESI for both country groups, the largest variations of the index within the dimensions were Digital public services and Citizen Internet use. Figure 5 shows the EU and non-EU countries with I-DESI rates in 2016 higher than the average.

![Figure 5. EU and non-EU countries with I-DESI rates higher than average (developed based on the data from [18] (p. 47)).](image)
4.4. The Network Readiness Index

The Network Readiness Index (NRI) was initially developed in 2001 and extended in 2012 by the World Economic Forum. The core implication of the index relates to the assessment of a country’s ability to benefit from digital transformation. In other words, NRI measures at what rate digital technologies may be implemented within a certain socioeconomic system and how they impact it [19]. The index consists of 53 indicators structured within four subindices [19]:

1. Environment subindex: Political and regulatory environment, business and innovation environment;
2. Readiness subindex: Infrastructure, affordability, skills;
3. Usage subindex: Individual usage, business usage, government usage;
4. Impact subindex: Economic impacts, social impacts.

The overall scores of the NRI and rates of its subindices in 2016 are shown in Figure 6.

Among the analyzed countries, the highest NRI score relates to Finland, which is also among the leaders in terms of all subindices, except for the Usage subindex. The lowest NRI score relates to China.

4.5. Ease of Doing Digital Business

As previously noted, in addition to the DEI and DT, researchers at The Fletcher School developed the Ease of Doing Digital Business scale (EDDB) in 2019, which combines the basic measures that are important for doing digital business on different stages. Particularly, the index combines [20]:

1. Platform levers: e-commerce, for online trading and delivery platforms (e.g., Amazon, eBay); digital media, referring to platforms for distributing media and entertainment (e.g., YouTube); sharing economy, meaning platforms for sharing items between individuals and groups (e.g., Uber, Airbnb); online freelance, for platforms connecting individual freelancers with potential employees (e.g., Upwork);
2. Foundational factors: data accessibility, meaning the intensity of data flows, the extent of free flow of data, policies for public data sharing; digital and analog foundations referring to conditions of demand, supply, institutions, and innovation; World Bank Doing Business, including the Doing Business Distance to Frontier score by the World Bank, which shows how far an economy’s performance is from the best performance observed for each Doing Business topic across all economies and years (“frontier”).

The scores of the EDDDB scale for 2019 are shown in Figure 7.
4.6. The European Index of Digital Entrepreneurship Systems

The European Index of Digital Entrepreneurship Systems (EIDES), provided by the European Commission, measures physical and digital ecosystem conditions for stand-up, start-up, and scale-up ventures in 28 EU countries [21]. The EIDES structure includes two condition frameworks [21]:

(1) General Framework Conditions that are applied broadly to entrepreneurship and include the following “pillars”: Culture and Informal Institutions; Formal Institutions, Regulation, and Taxation; Market Conditions; and Physical Infrastructure;

(2) Systemic Framework Conditions that affect the entrepreneurial dynamic and are related to resources in terms of such “pillars” as Human Capital; Knowledge Creation and Dissemination; Finance; and Networking and Support.

Table 3 illustrates the country distribution according to the scores of the EIDES rates for the year 2018.

**Table 3.** European Index of Digital Entrepreneurship Systems by country groups (developed based on the data from [21]).

| Countries       | Index Score |
|-----------------|-------------|
| **I. Leaders**  |             |
| Denmark         | 80.7        |
| Sweden          | 75.6        |
| Luxembourg      | 74.0        |
| Finland         | 72.4        |
| **II. Followers** | **52.3**   |
| Germany         | 63.8        |
| United Kingdom  | 63.7        |
| Netherlands     | 62.2        |
| Ireland         | 61.3        |
| Belgium         | 57.6        |
| Austria         | 54.3        |
| Malta           | 54.3        |
| Estonia         | 51.0        |
| France          | 49.6        |
According to the rates for the EIDES, the 28 EU countries are clustered in four groups based on their general and systemic framework conditions for digital entrepreneurship. Denmark, Sweden, Luxembourg, and Finland were country leaders, with an average rate of 75.7 on the EIDES. Comparatively, the average EIDES rate for the countries lagging behind (e.g., Poland, Latvia, Italy) was 24.9.

As noted above, according to the methodology of the index, the Systemic Framework Conditions depend on the entrepreneurial dynamic, which includes three phases, namely the stand-up, start-up, and scale-up stages (see Figure 8).

![Figure 8. EIDES scores according to the stages of entrepreneurial dynamic (developed based on the data from [21] (p. 38)).](image-url)
The structure of the EIDES according to the scores of the main pillars for each country group is shown in Figure 9.

According to the main dimensions in the framework conditions, the highest rate of EIDES scores among the country leaders had the Culture and Informal Institutions pillar, 91.3. For laggard countries, the highest rate of EIDES had a Networking and Support pillar, 35.1.

5. Discussion

5.1. Systematization of Core Performance Indicators—Systems Understanding of Digital Entrepreneurship

The systematic literature review on digital entrepreneurship and the analysis of the indices and indicators of digitalization and digital entrepreneurship in different countries support the role of digital entrepreneurship as a driver of digital transformation at all levels of the socioeconomic system (i.e., from the level of the individual entrepreneur to the company, organizational, and regional ecosystem levels).

Based on the determinants of digital entrepreneurship (see Section 3.1) and the structure of integrated indicators (see Section 4), we propose a matrix that illustrates how certain indicators and their subindices are interrelated with the determinants of digital entrepreneurship (Table 4).
Table 4. Matrix of indicators and indices in relation to determinants of digital entrepreneurship.

| Indicator Sets                          | Digital Entrepreneurship | Entrepreneurial Process | Ecosystem |
|----------------------------------------|--------------------------|-------------------------|-----------|
|                                        | Personal Characteristics | Decision-Making and Bounded Rationality | Personal Outcomes | Prerequisites for Digitalization | Dynamic Shifts in the Transformation of Business | Digital Business Model Innovation | Digital Business Affordances | Regional Digital Business Environment | Digital Business Infrastructure | Collaboration and Social Values |
| Digital Evolution Index (DEI)          |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Access infrastructure                  |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Transaction infrastructure             |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Fulfillment infrastructure             |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Consumer capacity to engage            |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Digital payment uptake                 |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Digital uptake                         |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Institutions and the business environment |                        |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Institutions and the digital ecosystem |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Institutional effectiveness and trust  |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Inputs                                 |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Process                                |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Outputs                                |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Digital Trust (DT)                     |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Behavior                               |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Attitudes                              |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Experience                             |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Environment                            |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| International Digital Economy and Society Index (I-DESI) |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Connectivity                           |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Human capital                          |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Citizen use of Internet                |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Business technology integration         |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
| Digital public services                 |                          |                         |            |                              |                                              |                                      |                                    |                                   |                                 |                                   |
### Table 4. Cont.

| Indicator Sets | Digital Entrepreneurship | Entrepreneur | Entrepreneurial Process | Ecosystem |
|----------------|--------------------------|--------------|-------------------------|-----------|
|                | Personal Characteristics and Competences | Decision-Making and Bounded Rationality | Personal Outcomes | Prerequisites for Digitalization | Dynamic Shifts in the Transformation of Business | Digital Business Innovation | Digital Business Affordances | Regional Digital Business Environment | Digital Business Infrastructure | Collaboration and Social Values |
| Network Readiness Index (NRI) | | | | | | | | | | |
| Political and regulatory environment | | | | | | | | | | |
| Business and innovation environment | | | | | | | | | | |
| Infrastructure | | | | | | | | | | |
| Affordability | | | | | | | | | | |
| Skills | | | | | | | | | | |
| Individual usage | | | | | | | | | | |
| Business usage | | | | | | | | | | |
| Government usage | | | | | | | | | | |
| Economic impacts | | | | | | | | | | |
| Social impacts | | | | | | | | | | |
| Ease of Doing Digital Business (EDDB) | | | | | | | | | | |
| E-commerce platform | | | | | | | | | | |
| Digital media platform | | | | | | | | | | |
| Sharing economy platform | | | | | | | | | | |
| Online freelance platform | | | | | | | | | | |
| European Index of Digital Entrepreneurship Systems (EIDES) | | | | | | | | | | |
| Culture and informal institutions | | | | | | | | | | |
| Formal institutions, regulation, and taxation | | | | | | | | | | |
| Market conditions | | | | | | | | | | |
| Physical infrastructure | | | | | | | | | | |
| Human capital | | | | | | | | | | |
| Knowledge creation and dissemination | | | | | | | | | | |
| Finance | | | | | | | | | | |
| Networking and support | | | | | | | | | | |

1— the relation of a subindex to a certain determinant.
As shown in Table 4, several indicators relate to more than one dimension of digital entrepreneurship. For example, skills or individual usage (NRI) relate to a regional digital business environment, characterizing the availability of human resources with relevant competences, but also to the personal characteristics and competences of entrepreneurs.

5.2. Correlates between the Three Dimensions of Digital Entrepreneurship

Digital entrepreneurship is based on complex mechanisms [22–32] that integrate the various dimensions of the socioeconomic system. We argue that the dynamics within the mentioned determinants (e.g., due to permanent interaction between the key agents) determine the dynamic patterns of digital entrepreneurship. We provide a correlation analysis in order to reach a better understanding of how the three dimensions of digital entrepreneurship are interrelated and how they are integrated within the digital transformation process.

5.2.1. Data and Method

In order to form a dataset for correlation analysis, we chose 13 metrics (one compound indicator and 12 subindices), which were interrelated to specific determinants of digital entrepreneurship (see Table 4). In addition, for the analysis, we chose those countries for which all 13 metrics were available. We also coded the heading of the subindices, mentioning the relevance to a certain compound indicator and dimension of digital entrepreneurship (Table 5). According to the methodology of each compound indicator [17–20], all indices and subindices have different ranges of scales (see Table 5).

| Compound Indicator                  | Subindex             | Range of Scales | Code for Correlation Matrix |
|------------------------------------|----------------------|-----------------|----------------------------|
| Digital Trust                      | Attitudes            | [0;5]           | A_DT                       |
|                                    | Behavior             |                 | B_DT                       |
| Network Readiness Index            | Skills               | [1;7]           | S_NRI                      |
|                                    | Individual usage     |                 | IU_NRI                     |
|                                    | Business usage       |                 | BU_NRI                     |
|                                    | Infrastructure       |                 | I_NRI                      |
| International Digital Economy and Society Index | Human Capital | [0;1]       | HC_I-DESI                  |
|                                    | Business technology integration |         | BTI_I-DESI                 |
| Digital Evolution Index            | E-Commerce           | [0;5]           | EC_EDDB                    |
|                                    | Digital media        |                 | DM_EDDB                    |
|                                    | Sharing economy      |                 | SE_EDDB                    |
| Ease of doing digital business     | Online freelancing   |                 | OF_EDDB                    |

The formed dataset for the correlation analysis contained 13 metrics for 19 countries (see Appendix A). Since the dataset contains only the values of specific sub-indices and relates to the interval scale of values, we applied the Pearson correlation coefficients for the analysis. The critical values for Pearson correlation were calculated for 0.05 and 0.01 significance levels. Using the Excel function T.INV.2T, we calculated Student’s T Critical Values for probabilities 0.05 and 0.01 with 245 degrees of freedom (sample size 247). We obtained 1.97 and 2.596 for probability 0.05 and 0.01 respectively. Further, we calculated the critical values for the Pearson correlation coefficients, which were 0.125 and 0.164 for 0.05 and 0.01 significance levels respectively. Table 6 shows the Pearson correlation coefficient matrix.
Table 6. Pearson correlation coefficient matrix between the indices.

|         | A_DT | B_DT | S_NRI | IU_NRI | BU_NRI | HC_I-DESI | BTI_I-DESI | DEI | I_NRI | EC_EDDB | DM_EDDB | SE_EDDB | OE_EDDB |
|---------|------|------|-------|--------|--------|-----------|------------|-----|-------|---------|---------|---------|---------|
| A_DT    | 1    | 0.105| 0.005 | -0.016 | -0.163 | 0.082     | 0.033      | -0.035| 0.082  | 0.196   | -0.28   | -0.096  | 0.046   |
| B_DT    | 1    | 0.105| 0.005 | -0.016 | -0.163 | 0.082     | 0.033      | -0.035| 0.082  | 0.196   | -0.28   | -0.096  | 0.046   |
| S_NRI   | 0.005| 1    | 0.003 | 0.105  | 0.003  | 0.033     | 0.082      | 0.033| 0.003  | 0.105   | 0.003   | 0.033   | 0.082   |
| IU_NRI  | -0.016| -0.016| 1     | 0.033 | 0.082 | 0.033      | 0.082      | 0.033| 0.003  | 0.105   | 0.003   | 0.033   | 0.082   |
| BU_NRI  | -0.163| -0.163| 0.033| 1     | 0.033 | 0.082      | 0.033      | 0.082| 0.033  | 0.003   | 0.105   | 0.003   | 0.033   |
| HC_I-DESI| 0.082| 0.082| 0.033| 0.082| 1     | 0.105      | 0.033      | 0.082| 0.033  | 0.003   | 0.105   | 0.003   | 0.033   |
| BTI_I-DESI| 0.033| 0.033| 0.082| 0.033| 0.105 | 1         | 0.033      | 0.082| 0.033  | 0.003   | 0.105   | 0.003   | 0.033   |
| DEI     | -0.035| -0.035| 0.082| 0.033| 0.082 | 0.105      | 1         | 0.033| 0.082  | 0.033   | 0.082   | 0.033   | 0.082   |
| I_NRI   | 0.082| 0.082| 0.033| 0.082| 0.033 | 0.105      | 0.033      | 1    | 0.033  | 0.082   | 0.033   | 0.082   | 0.033   |
| EC_EDDB | 0.196| 0.196| 0.033| 0.082| 0.033 | 0.105      | 0.033      | 0.082| 1     | 0.033   | 0.082   | 0.033   | 0.082   |
| DM_EDDB | -0.28 | -0.28 | 0.033| 0.082| 0.033 | 0.105      | 0.033      | 0.082| 0.033 | 1     | 0.033   | 0.082   | 0.033   |
| SE_EDDB | -0.096| -0.096| 0.033| 0.082| 0.033 | 0.105      | 0.033      | 0.082| 0.033  | 0.082 | 1     | 0.033   | 0.082   |
| OF_EDDB | 0.046| 0.046| 0.033| 0.082| 0.033 | 0.105      | 0.033      | 0.082| 0.033  | 0.082 | 0.033 | 1     | 0.033   |

1 Ecosystem dimension
2 Entrepreneurial process dimension
3 Entrepreneurial dimension
4 Entrepreneurial process and Ecosystem dimensions

2 * significant at 0.05, ** significant at 0.01 critical values 0.125 and 0.164 for 0.05 and 0.01 significance levels respectively.

5.2.2. Correlation Analysis

The core aim of the correlation analysis was to define how the different subindices are interconnected within the different dimensions of digital entrepreneurship. Consequently, the implications of the analysis refer to a better understanding of the interrelations between the different determinants of digital entrepreneurship, which provide evidence for the role of a systematic approach for understanding digital business transformations, their part in societal transition patterns and, their impact on the transformation capacity and resilience of the innovation system. The following interconnections may serve as examples:

1) Digital trust affects the development of skills and the usage of digital products, which, in turn, affect the digitalization of business.

The results of correlation did not show a significant interrelation between the trust indicators (A_DT and B-DT) and metrics that characterize digital skills and usage (S_NRI, IU_NRI, and BU_NRI; HC_I-DESI). Nor did the data show a significant correlation between digital trust (A_DT and B-DT) and business technology integration (BTI_I-DESI). Nevertheless, between the IU_NRI and BU_NRI and BTI_I-DESI, direct correlation is rather strong at 0.715 and 0.772, respectively.

2) The digital environment is interrelated with the development of digital infrastructure and the intensity of business digitalization.

A high and direct correlation is observed between the state of digitalization level (DEI) and the infrastructure (I_NRI) at 0.911, as well as with business technology integration (BTI_I-DESI) at 0.844.

3) The digital environment is interrelated with the development and application of digital platforms.

The correlation matrix shows the significant level of direct interconnectedness between DEI and e-Commerce, digital media, and online freelancing platforms (EC_EDDB; DM_EDDB; OF_EDDB) at 0.883, 0.743, and 0.839, respectively. The correlation with the sharing economy platform (SE_EDDB) is the lowest at 0.647.

5.3. Digital Entrepreneurship and Its Resilience and Sustainability Implications

The interrelatedness of various indicators within three core dimensions of digital entrepreneurship provide evidence of the validity of a systematic approach for understanding the impact of digital entrepreneurship on the innovation system as well as its part in societal transitions. Results obtained from previous [16] as well as current research allowed us to contribute to a better understanding of digital entrepreneurship within the complexity of digitally induced transitions. We may define digital
entrepreneurship as a complex mechanism that is, on the one hand, a consequence and, on the other hand, a driver for the transformation of social relations (under the effect of digital technologies) within the different dimensions and levels of the innovation and socioeconomic systems. A specific example for such transformation of social relations concerns the principles of sharing economy (see [33]). Nevertheless, it is crucial to define the interconnection between the transformative and sustainable impacts of digital entrepreneurship. In other words, it is important to understand how certain elements of the digital entrepreneurship mechanism (e.g., intentions, competences, and initiatives) may contribute to sustainable transitions of the innovation system, its viability, and its resilience within complex societal transitions (e.g., contribution to system innovation implications, and influence on the sustainable transformation and transition capacities) (Figure 10).

**Figure 10.** Digital entrepreneurship within the societal transition patterns.

Discussing the role of digital entrepreneurship for sustainable transition patterns, we point also to a particular role of entrepreneurial competences as a crucial element for the development of digital business initiatives. A future research avenue related to applying a systems science approach should include the implications for the development of an entrepreneurial competence portfolio. Such competences should include the ability to apply a systems understanding as a basis for the problem-solving capacity of future entrepreneurs and, consequently, the development of system innovations. In turn, the systems approach in the innovation implications allows dealing with the vulnerabilities within the various systems dimensions (i.e., different dimensions of socioeconomic systems, different time prospects), contributes to the sustainable transition capacity of the innovation system, and becomes a factor of its viability and resilience within complex societal transitions (see [14,15]).
6. Conclusions

The aim of this research was to provide a theory-based systematization of core performance indicators of digital entrepreneurship in order to understand how digital tendencies affect the transformation of business frameworks and how they may further relate to innovation system resilience. As a theoretical basis for such systematization, we applied the results of previous research (i.e., a systematic literature review in the field of digital entrepreneurship). In particular, we based the indicator analysis on 10 determinants of digital entrepreneurship clustered within three dimensions: Entrepreneur, Entrepreneurial process, and Ecosystem. We analyzed the current tendencies of digital entrepreneurship in different countries. In order to understand how the indicators can be applied to evaluate digital entrepreneurship, we analyzed their interrelatedness with the determinants of digital entrepreneurship. Applying the correlation analysis, we examined how the different dimensions of digital entrepreneurship are interconnected. This provided evidence for the role of a systematic approach in the understanding of the digital transformation of socioeconomic systems. Moreover, the overview of the relevant digital entrepreneurship indicators, their strengths, focuses, and possible implications is posited as a supporting consolidation for readers (e.g., policy makers, business agents, and entrepreneurs as well as researchers).

With respect to future research, the results presented in this paper call for the extended study of societal transitions, particularly those brought about by digital transformation. Particularly important is the application of a systems science approach in a field of entrepreneurial transformation and further formation of a competence portfolio. Such an approach would advance the understanding of the interrelatedness of entrepreneurial processes with socioeconomic system dimensions, particularly in terms of global societal transitions [34]. This includes an understanding of how the resilience and sustainability of a socioeconomic system, on the one hand, may be affected by different disturbances and vulnerability factors within its interrelated dimensions. On the other hand, such understanding may define the role of digital entrepreneurs in contributing to the resilience of the innovation system and, consequently, the sustainability of the socioeconomic system in general.

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## Appendix A

Table A1. Dataset for Pearson correlation coefficient matrix.

| Countries    | A_DT | B_DT | S_NRI | IU_NRI | BU_NRI | HC_I-DESI | BTI_I-DESI | DEI | I_NRI | EC_EDDB | DM_EDDB | SE_EDDB | OF_EDDB |
|--------------|------|------|-------|--------|--------|-----------|------------|-----|-------|----------|---------|---------|---------|
| China        | 3.04 | 3.62 | 5.4   | 3.9    | 3.9    | 0.41      | 0.41       | 2.49| 3.3   | 2.04     | 2.24    | 2.51    | 2.06    |
| Estonia      | 2.57 | 2.45 | 5.9   | 6.3    | 4.4    | 0.66      | 0.53       | 3.24| 6.5   | 3.1      | 2.93    | 3.29    | 3.21    |
| Finland      | 2.57 | 2.53 | 6.5   | 6.6    | 5.8    | 0.73      | 0.67       | 3.72| 7     | 3.4      | 2.86    | 3.58    | 3.15    |
| France       | 2.41 | 1.49 | 5.9   | 6      | 5      | 0.62      | 0.53       | 3.25| 6.3   | 3.17     | 2.99    | 2.82    | 2.82    |
| Germany      | 2.73 | 1.93 | 6.1   | 6.2    | 5.8    | 0.62      | 0.59       | 3.36| 6.6   | 3.35     | 3.03    | 2.83    | 2.87    |
| Ireland      | 2.27 | 2.96 | 6.1   | 5.9    | 4.9    | 0.77      | 0.51       | 3.41| 6     | 3.21     | 2.77    | 3.14    | 3.09    |
| Netherlands  | 2.75 | 2.12 | 6.2   | 6.6    | 5.8    | 0.69      | 0.75       | 3.55| 6.4   | 3.63     | 3.06    | 3.7     | 3.35    |
| Spain        | 2.21 | 2.87 | 5.3   | 5.6    | 3.9    | 0.62      | 0.55       | 2.95| 5.4   | 3.17     | 2.85    | 2.88    | 2.9     |
| Sweden       | 3.34 | 2.52 | 5.8   | 6.7    | 6      | 0.69      | 0.65       | 3.79| 7     | 3.44     | 2.89    | 3.24    | 3.17    |
| UK           | 2.29 | 2.4  | 5.8   | 6.6    | 5.2    | 0.65      | 0.68       | 3.67| 6.3   | 3.66     | 3.46    | 3.72    | 3.56    |
| Australia    | 2.9  | 1.85 | 6     | 6.3    | 4.8    | 0.81      | 0.57       | 3.55| 7     | 3.35     | 3.06    | 3.33    | 3.35    |
| Canada       | 2.66 | 1.76 | 6.1   | 5.7    | 4.9    | 0.67      | 0.65       | 3.55| 7     | 3.28     | 3.13    | 3.11    | 3.25    |
| Japan        | 2.25 | 2.16 | 6.1   | 6.4    | 5.9    | 0.7       | 0.53       | 3.52| 6.6   | 3.57     | 3.28    | 2.56    | 3.01    |
| Norway       | 2.41 | 2.8  | 6     | 6.7    | 5.5    | 0.69      | 0.66       | 3.79| 7     | 3.48     | 3.04    | 3.53    | 3.3     |
| New Zealand  | 2.51 | 2.66 | 6.2   | 6.1    | 5      | 0.79      | 0.56       | 3.54| 6.8   | 3.32     | 2.97    | 3.05    | 3.3     |
| South Korea  | 2.4  | 1.73 | 5.6   | 6.5    | 5.4    | 0.76      | 0.64       | 3.68| 7     | 3.05     | 2.75    | 2.51    | 2.84    |
| Switzerland  | 2.65 | 2.38 | 6.4   | 6.6    | 6.1    | 0.65      | 0.8        | 3.74| 6.8   | 3.4      | 3.08    | 3.14    | 3.08    |
| USA          | 2.45 | 1.96 | 5.8   | 6.2    | 5.9    | 0.56      | 0.62       | 3.61| 7     | 3.62     | 3.62    | 3.79    | 3.4     |
| Russia       | 2.58 | 2.24 | 5.4   | 5.3    | 3.6    | 0.64      | 0.3        | 2.44| 4.7   | 1.7      | 2.05    | 2.22    | 2.22    |
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