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Industry 5.0 and National Development Plans

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Abstract: The Industrial Revolutions, occurring since the 18th century, have constituted some of the most significant milestones in history, fundamentally altering numerous vital domains such as production, economy, transportation, and healthcare through remarkable inventions. The expeditious evolution of the industry has concurrently instigated revisions in the midterm development strategies of nations. This research endeavors to assess the degree to which the attributes delineated in the academic literature about Industry 5.0 have been assimilated by countries that have established national development plans. Specifically, a bibliometric study was conducted by analyzing 545 articles in the Web of Science Core Collection database using the keyword "Industry 5.0". Eight primary concepts, big data, internet of things, artificial intelligence, blockchain, collaborative robotics, digital twins, edge computing, and 6G, were delineated as overarching categories within which a total of 37 keywords were systematically classified. The presence of these keywords in the national development plans of countries was examined and their alignment with the understanding of Industry 5.0 was evaluated. Document analysis, a qualitative research design, was employed in this research. The MaxQda 2020 software package was used to conduct qualitative analyses and development plans were matched with the identified codes. The concepts related to Industry 5.0 were categorized into eight main codes and sixteen sub-codes within the program. For the purpose of clarity and coherence, a comprehensive array of analytical techniques, encompassing frequency analysis, code cloud visualization, comparative analysis, and relationship analyses, were meticulously employed to explain and graphically illustrate the prominent thematic codes and their interconnectedness. The findings of this research identify countries that prominently integrate the attributes of Industry 5.0 into their development plans, thus offering potential contributions to the refinement of nations developmental strategies.

Keywords: Industry 5.0, Development planning, National planning

Introduction

Production has been carried out by humans throughout history; however, this process has undergone significant transformations due to industrial revolutions since the early 18th century (Ok & Kagıtcı, 2023). These revolutions include the emergence of steam power and mechanical machines in Industry 1.0, the advent of electric power and assembly line production in Industry 2.0, the rise of electronic and computer technologies in Industry 3.0, and the integration of technologies such as digitalization, the Internet of Things, and artificial intelligence in Industry 4.0. Industrial revolutions have fundamentally altered the way tasks are performed, resulting in a remarkable increase in production efficiency and quality. The acceleration of economic progress and the widespread adoption of these industrial revolutions across various sectors have given rise to numerous business opportunities. The developmental processes initiated with Industry 1.0 and continued through subsequent phases have led to the emergence of the concept of Industry 5.0 we have today. The term "Industry 5.0" was first introduced by Michael in 2015. Industry 5.0 represents a digital transformation of future industrial eras, although the precise form it will take and the specific technologies it will encompass remain uncertain.

Nevertheless, it is anticipated that sustainability, flexibility (Xu et al., 2021), and a human-centered approach will be key principles (Madsen & Berg, 2021).

Industrialization plays a pivotal role in the economic development of nations and significantly influences the economic disparities among different countries. Each country possesses a unique history, resources, and population structure, which in turn shape their distinct economic landscapes. In the present day, most countries have established development plans with the dual objective of fostering economic growth, closing the gap with more developed nations, and enhancing the overall standard of living (Avcı & Ergen, 2022). The advent of industrial revolutions has further reshaped the national development plans of countries, thanks to the technological innovations and economic policies brought about by these revolutions. This study seeks to analyze the degree to which the attributes of the Industry 5.0 concept have been embraced by countries that are implementing national development plans. We will employ qualitative analysis methods to explore this subject.

Key Features of Industry 5.0

The smart production systems approach, which emerged with Industry 4.0, and the human-oriented, sustainable, and flexible production approach aimed at in Industry 5.0, have underscored the importance of human skills once again. The primary objective of Industry 5.0 is to enhance productivity and efficiency through the collaborative use of humans, robots, and artificial intelligence technologies, while also reintroducing significance to social sensitivities that were sometimes overlooked during Industry 4.0. The core competencies of Industry 5.0 revolve around the development of innovative products and technologies, becoming a crucial concept for the competitiveness of both individual and national economies (Balog & Demirova, 2021). In broad terms, Industry 5.0 is a concept that has emerged to harness human creativity in cooperation with powerful, intelligent, and precise machines (Maddikunta et al., 2022).

The fundamental components of Industry 5.0 are expected to exert significant influences on various professions, depending on the societal changes it generates. It has been projected that by 2030, 400-800 million people around the world may face job displacement (McKinsey, 2017). The primary factor behind this risk is the integration of technologies like artificial intelligence into the workplace. In this context, substantial transformations will be necessary in development plans, serving as a cornerstone of economic transformation, to facilitate the inclusion of individuals into new areas of business. The industrial revolutions experienced thus far have had profound effects on economic transformation, with one of the most notable consequences being the alteration and evolution of existing employment opportunities.

National Development Plans

Considering the development plans of nations, there are no obstacles to commencing the Industry 5.0 process in countries where the Industry 4.0 process has not yet begun or is in its early stages. The most influential catalyst for the transformation to Industry 5.0 is expected to be the rise in consciousness and awareness. In this context, it is essential to assess the interest and awareness levels of countries with respect to industrial revolutions. In pursuit of this objective, it is feasible to scrutinize the developments in the literature, which can be viewed as an outcome of Industry 4.0. As the transition to Industry 5.0 unfolds, varying levels of awareness are likely to emerge in both developed and developing countries. Different levels of awareness are anticipated as an expected outcome.

Method

In this section, which aims to provide information about the main features of Industry 5.0, the Web of Science (WoS) Core Collection database was searched using the Vosviewer program. It includes scientific literature in the WoS database from 2010 to the present. The complete citation network, all cited references, and fully indexed and searchable publications were utilized. Bibliometric analysis offers an overview of the research field (Hood & Wilson, 2001). Bibliometric methods help identify structural aspects and trends in the research topic (Rey Martí et al., 2015). The selected analysis period covers the time when the topic was prominent, resulting in the identification of 545 articles. A cluster analysis was conducted using the software developed by Van Eck and Waltman. Networks of co-occurring keywords were created and visualized based on the number of articles. The visualization presents a network of elements shaped according to the density and strength of relationships between keywords, with links indicating the closeness of the relationship between the elements. The circles'

colors and positions are employed to group the elements. It is expected that the clusters and keywords generated by this program will enhance awareness in the development plans of nations.

This section presents the main results of the bibliometric analysis applied to the records available in WoS, aiming to draw attention to the extent to which the features of Industry 5.0 that garnered the most attention in academic literature between 2010 and 2023 have been incorporated into national development plans. A total of 545 articles were selected for screening, and the analysis was conducted in October 2023. A network visualization of the most frequently used keywords in conjunction with Industry 5.0 trends is presented to assess the topic by scholars from 2010 to 2023 (Figure 1).

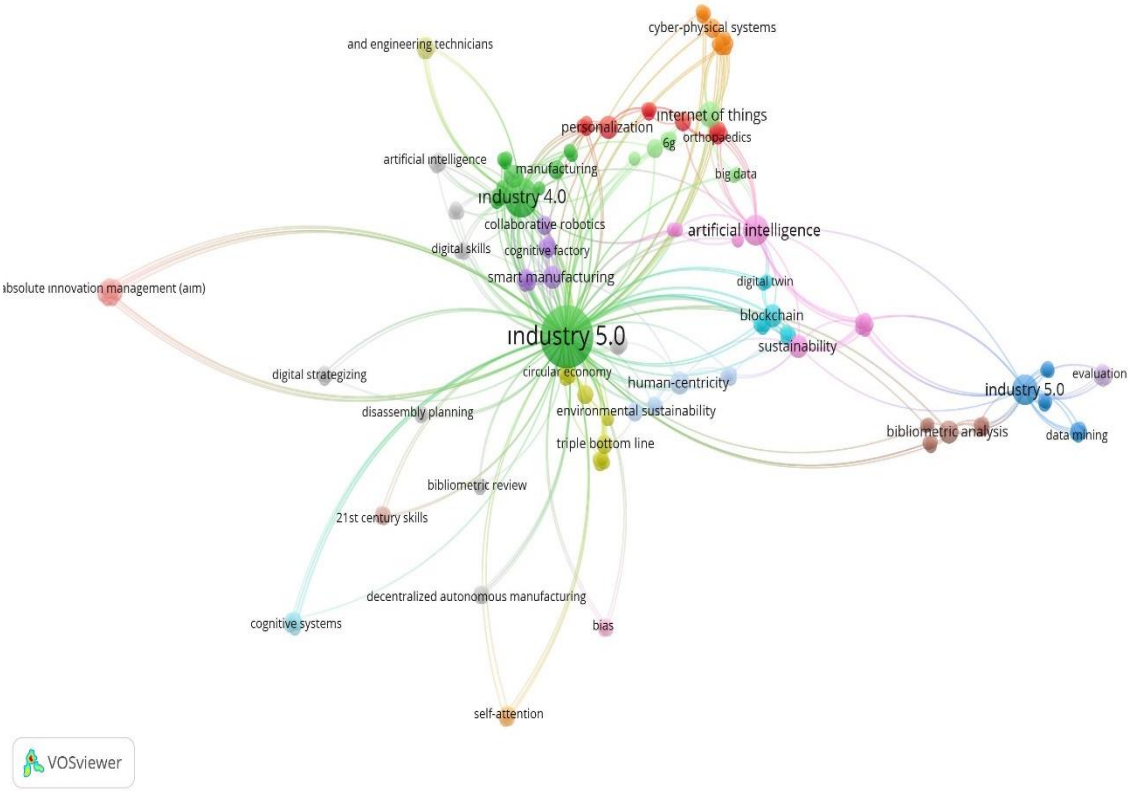

Figure 1. Network visualization of top Industry 5.0 keywords

In the network visualization, items are represented by their labels and, by default, with circles. The size of both the label and the circle of an item is determined by the item's weight. The higher an item's weight, the larger its label and circle. The color of an item is determined by the cluster to which it belongs. The lines between items represent connections. In the visualization, the large circles indicate the most frequently used words, and the lines indicate their associations with other words. Both the thickness of the lines and the size of the circles provide insights into the frequency of usage. Eight clusters related to Industry 5.0 and 37 keywords associated with these clusters were identified. The program used helped identify the clusters based on the most frequently used related keywords. The words within the clusters were grouped according to their most frequent co-occurrence rates. (Table 1.) displays the organized clusters.

Each cluster pertains to a different topic. For example, the first cluster encompasses 6G applications, which represent one of the significant challenges for Industry 5.0. 6G entails a personalized intelligent network that integrates artificial intelligence technologies, transitioning the network from the traditional function-centered model to a user-centric, data-centered, and content-centered one (Chen et al., 2020). The second cluster revolves around topics such as big data analytics. Big data refers to the flow of digital data from various sources in the digital world, including sensors, scanners, numerical modeling, mobile phones, the internet, videos, emails, and social networks (Hsu et al., 2015). The third cluster includes discussions on blockchain technology. Blockchain serves as a ledger that records committed transactions to enable the tracking and security of digital assets in a commercial network (Kumas, 2023). The fourth cluster emphasizes digital twins, which can be described as virtual models created to simulate the behavior of physical systems (Tuegel et al., 2011). These digital twins facilitate the connection of information between the physical reality and its virtual representation. The fifth cluster centers on edge computing, a novel computing model that combines resources close to the user within

network proximity to provide computing, storage, and network services. The sixth cluster encompasses the concept of the Internet of Things, which enables the interconnection between physical devices and virtual worlds. In the seventh cluster, artificial intelligence is the focus, while the eighth cluster pertains to collaborative robotics. These clusters are based on a literature review and the individual opinions and experiences of the authors. Consequently, all eight clusters offer a comprehensive overview of the most emphasized features associated with Industry 5.0. This approach enables a comprehensive perspective on research and theory in the field of Industry 5.0.

Table 1. Keywords related to Industry 5.0

Cluster	Keywords
6G	sensor, robotics
Big Data	data mining, optimization, cloud computing, big data analytics
Blockchain	decentralized learning, decentralized autonomous manufacturing
Digital Twins	digitalization, digital innovation, digital technology, digital product passport, digital transformation, digital strategizing, digital skills, human digital twin, industrial systems, data mining, big data, artificial intelligence, machine learning, smart manufacturing
Edge Computing	network analysis, network automation
Internet of Things	industrial internet of things, sensor, artificial intelligence, big data, cloud computing
Artificial Intelligence	machine learning, smart manufacturing, cobots
Collaborative Robotics	cobots, human-robot collaboration, human-robot intraction, sensor, human machine collaboration

Figure 2. Code list

The analysis of this study is centered around the extent to which nations have incorporated Industry 5.0 features into their development plans. A qualitative research method was chosen as it is a suitable approach for comprehending the nature and structure of the subject matter. Furthermore, qualitative analysis aims to understand and explore both compiled and uncompiled information. In this study, the document analysis method, one of the qualitative analysis techniques, was employed, utilizing information extracted from the national development plans of 92 countries.

The concepts associated with the characteristics of Industry 5.0 within these national development plans were systematically examined. The most recent development plans of each country were considered, and these plans

were accessed from the respective countries' official websites. In the process of data analysis, Industry 5.0 features were coded using the MaxQda 2020 software package. During the data analysis, primary codes were initially identified, and subsequent sub-codes related to the main codes were appended as necessary. While scrutinizing the development plans of each country, identical or closely related expressions were matched with the established codes. The codes and sub-codes pertaining to Industry 5.0 are presented in Figure 2. The frequencies and percentages resulting from this analysis are also displayed.

During the coding process, codes were assigned to paragraphs, sentences, or individual words. In total, there are eight main codes and 37 sub-codes. Once the national development plans were coded, a word cloud and document overview of the Industry 5.0 features were generated. In the subsequent sections of the findings, the codes and the frequencies of the sub-codes are presented in a chart.

Table 2. Countries whose national development plans were analysed

N	Country	Plan timeframe	N	Country	Plan timeframe	N	Country	Plan timeframe
	Africa			Asia			Middle East	
1	Angola	2018-22	33	Bangladesh	2020-25	63	Algeria	2013-30
2	Benin	2018-25	34	Bhutan	2018-23	64	Bahrain	2017-20
3	Botswana	2017-23	35	Brunei	2018-23	65	Egypt	2020-30
4	Burkina Faso	2016-20	36	China	2021-35	66	Lebanon	2016-40
5	Burundi	2018-27	37	India	2012-17	67	Oman	2021-25
6	Chad	2017-21	38	Laos	2021-25	68	Palestine	2021-23
7	Congo	2019-23	39	Malaysia	2021-25	69	Qatar	2018-22
8	Ethiopia	2021-30	40	Myanmar	2018-30	70	Iraq	2018-22
9	Ghana	2022-25	41	Pakistan	2013-18	71	Saudi Arabia	2018-30
10	Guinea	2016-20	42	Papua New Guinea	2008-50	72	Tunisia	2022-25
11	Guinea-Bissau	2020-23	43	Philippine	2023-28		Latin America	
12	Kenya	2018-22	44	Thailand	2023-27	73	Argentina	2023-25
13	Lesotho	2018-23	45	Timor Leste	2011-30	74	Barbados	2013-20
14	Liberia	2018-23	46	Vietnam	2015-35	75	Belize	2010-30
15	Madagascar	2019-23		Europe		76	Bolivia	2021-25
16	Malawi	2017-22	47	Albania	2015-20	77	Chile	2014-18
17	Mali	2019-23	48	Armenia	2014-25	78	Colombia	2018-20
18	Mozambique	2020-24	49	Azerbaijan	2022-26	79	Costa Rica	2023-26
19	Namibia	2017-22	50	Belarus	2018-25	80	Dominica	2020-30
20	Nigeria	2021-25	51	Bosnia	2021-27	81	Ecuador	2023-27
21	Rwanda	2017-24	52	Estonia	2018-20	82	El Salvador	2014-19
22	R. of Congo	2018-22	53	Georgia	2014-20	83	Guatemala	2021-24
23	Sierra Leone	2019-23	54	Kazakhstan	2018-25	84	Haiti	2018-30
24	Somaliland	2023-27	55	Kosovo	2016-21	85	Honduras	2010-38
25	South Africa	2012-30	56	Kyrgyzstan	2018-26	86	Jamaica	2018-21
26	South Sudan	2021-24	57	Lithuania	2011-30	87	Mexico	2019-24
27	Swaziland	2019-22	58	Moldova	2018-30	88	Nicaragua	2019-23
28	Tanzania	2021-26	59	Mongolia	2016-30	89	Panama	2019-24
29	Togo	2018-22	60	Tajikistan	2021-25	90	Peru	2016-21
30	Uganda	2015-20	61	Turkey	2019-23	91	Tobago	2020-30
31	Zambia	2022-26	62	Ukraine	2017-30	92	Venezuela	2020-23
32	Zimbabwe	2021-25						

Results and Discussion

The national development plans of 92 countries were analyzed. Among these countries, 32 are located in Africa, 14 in Asia, 16 in Europe, 10 in the Middle East, and 20 in Latin America. Before delving into the analysis of the Industry 5.0 concept, the 100 most frequently used words in these countries' national development plans were identified and visually presented in a word cloud (Figure 3). Additionally, Table 3 displays the frequency and percentage values for the top 10 words. The word cloud was generated based on the frequency of occurrence within the development plans.

Figure 3. National development plans word cloud

Table 3. Word frequency distributions of development plans

Word	Frequency	Percentage %
Development	45971	1,36
Sector	34192	1,01
National	26773	0,79
Plan	26307	0,78
Economic	24256	0,72
Services	20558	0,61
Strategy	19112	0,56
Public	17128	0,51
Goverment	16542	0,49
Policy	15079	0,45

The code cloud obtained from the concepts related to Industry 5.0 in the national development plans of 92 countries was also created and shown (Figure 4.).

Figure 4. Industry 5.0 code cloud

In the code cloud representing Industry 5.0 concepts, "digitalization" stood out as the most frequently used concept. "Digital technology" ranked second, "digital transformation" took the third spot, followed by "Internet of Things" in fourth place, and "artificial intelligence" in fifth place. Notably, concepts such as "human digital twin," "cobots," and "human-machine collaboration" were not found within the development plans of the analyzed countries. Table 4 presents the frequency and percentage values associated with the characteristics of the Industry 5.0 concept. The total frequency of the codes in the study amounts to 653. When considering the frequency values of the codes, the top five countries with the highest code frequencies are as follows: "Bangladesh" with 93 frequencies, "Malaysia" with 58 frequencies, "the Philippines" with 52 frequencies, "China" with 44 frequencies, and "Azerbaijan" with 36 frequencies, as depicted in Figure 5.

Table 4. Word frequency distributions of Industry 5.0 features

Word	Frequency	Percentage %
Digitalization	70	10,7
Digital Technology	59	9,0
Digital Transformation	56	8,6
Internet of Things	51	7,8
Artificial Intelligence	50	7,7
Digital Skills	46	7,0
Robotics	40	6,1
Blockchain	33	5,1
Big Data	32	4,9
Cloud Computing	28	4,3

Figure 5. Distribution of Industry 5.0 features by country

Conclusion

Today, the world is under the influence of industrial revolutions, and technological advancements have compelled both developed and developing countries to reassess their policies. Since the introduction of the concept of Industry 4.0 in 2011, significant progress has been made in both theoretical and practical applications. These advancements have triggered a swift reorganization of country policies. Some nations have revised their action plans to maintain their competitive advantages, while others have adjusted their strategies not to miss out on the opportunities brought by this new revolution. To cope with the challenges of high labor, raw material, and logistics costs, developed countries have shifted towards technology-oriented production. They have harnessed smart production technologies to reduce manufacturing costs and preserve their economic competitiveness derived from a production-based economy. In this context, this study aims to underscore the significance of national development plans in countries and explore their relationship with the features of the Industry 5.0 concept. Qualitative analysis was conducted by aligning the national development plans of countries with codes using the MaxQda 2020 software package. Within the program, features related to the

concept of Industry 5.0 were categorized into eight main codes and 37 sub-codes. Frequency analysis and code cloud analysis were performed to visually represent the codes. Upon analyzing the collected data, the countries that most prominently featured the Industry 5.0 concept were identified. The research findings revealed that out of a total of 3,384,467 words in national development plans, the word "digitalization" held a predominant position concerning the features of the Industry 5.0 concept. The emphasis on digitalization in these national development plans holds significant implications across various dimensions, including cultural, economic, communication, and international competition among nations. It is worth noting that this study is limited to the latest national development plans of the countries and may be extended by examining similar policy documents where countries outline their strategic objectives. In conclusion, this research aims to determine which countries worldwide have incorporated the features of the Industry 5.0 concept and to what extent. The findings are expected to provide valuable insights for the national development plans of countries in the future.

Recommendations

In future studies, it is advisable to consider the sustainable development plans of nations.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

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