













“SDG 4 and SDG 8 in the knowledge economy: A meta-analysis in the context of post-COVID-19 recovery”

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SDG 4 AND SDG 8 IN THE KNOWLEDGE ECONOMY: A META-ANALYSIS IN THE CONTEXT OF POST-COVID-19 RECOVERY

Abstract

Almost all human activity spheres, from the health care system to the education system, were unprepared for the pandemic. This, in turn, has slowed down the progress in achieving sustainable development goals. The Sustainable Development Goals 4 "Quality Education" and 8 "Decent Work and Economic Growth" were particularly vulnerable. In addition, the widespread concern was caused in the context of the transition to a "knowledge-based economy". This paper analyzes the readiness of the scientific community to provide preconditions for the acceleration of these SDGs achievements. To do this, a meta-analysis of the academic literature on SDG 4, SDG 8, and the knowledge-based economy during 2015–2021 was conducted. Several special methods and instruments were used, including Scopus, WoS, VosViewer, Publish or Perish, Google Trends, and Google Books Ngram Viewer. The results show the inability of the modern academic community to provide a theoretical and empirical framework for a successful transition to a knowledge-based economy, taking into account the need to achieve sustainability. This is partly due to the relative subject novelty and the lack of academic attention. The challenges posed by the pandemic (lockdowns, unemployment, closing of educational institutions, financial flows reorientation, etc.) together with potential threats (new pandemic, climate change, population displacement, armed conflicts, etc.) necessitate a radical intensification of academic activity in economics to achieve SDGs.

Keywords

sustainable development goals, knowledge-based economy, knowledge sharing, decent work, quality education

JEL Classification

D83, A20, H75, P36

INTRODUCTION

The economic system transformation into the so-called knowledge-based economy began in one line with the transition to the information age. As a result, knowledge and its applied aspects play a key role in economic development. From 70% to 85% of the GDP growth in developed countries is provided by using and implementing new knowledge in education, production technology, etc. (Jones, 2016).

One of the elements ensuring a successful transition to the knowledge-based economy is the achievement of sustainability.

Several of the 17 Sustainable Development Goals can be characterized as the accelerator goals. Their implementation is the key to the successful reaching of others. SDG 4 "Quality Education" and SDG 8 "Decent Work and Economic Growth" are necessary for other goals and crucial in forming the knowledge-based economy, which should become a new paradigm of human development and the fundamental of post-pandemic recovery.

The World Bank notes that the availability of skilled labor and a quality education system, together with academia and institutional structures that ensure the use of knowledge, is the basis of the knowledge-based economy (Chen & Dahlman, 2006).

Accordingly, the role of SDG 4 “Quality Education” in the implementation of SDG 8 “Decent Work and Economic Growth” reaches a qualitatively new level. It means a smooth transition from one goal to another based on their total symbiosis. SDG 4 generates a resource for the development of SDG 8, providing quality education. At the same time, SDG 8 provides resources and an appropriate material base for the functioning of SDG 4.

The transition to a knowledge-based economy is impossible without ensuring the effective exchange of knowledge and innovation. With this aim, Global Partnership for Education (GPE) has set up a special KIX (Knowledge and Innovation Exchange) mechanism to involve 67 developing countries in creating knowledge, innovation, and capacity building. The KIX mechanism includes a common learning platform and funding for knowledge and innovation. However, its effectiveness will depend on the availability of academic support in theoretical and methodological bases, empirical patterns, and econometric models.

1. LITERATURE REVIEW

The paradigm step in shaping the vectors of human development towards sustainability is the adoption of 17 SDGs (United Nations) in 2015. These goals require significant efforts, both financial and organizational, involving all stakeholders at various levels (business, government, society) to ensure progress. The total value of achieving the Goals by 2030 was 6.3 trillion USD (OECD, 2017) annually. However, under the influence of COVID-19, investment in SDGs decreased by a third (UNCTAD, 2021).

The pandemic currently threatens the achievements of SDG 4 and SDG 8. Its beginning caused a powerful economic shock, the scale of which is difficult to overestimate. According to the UN, the world economy is experiencing the worst crisis since the Great Depression. It is accompanied by the loss of hundreds of millions of jobs, and the economic sectors decline, such as tourism and air transport (UN, 2021a).

For example, only in April 2020, the United States lost more than 20 million workplaces (Trading Economics, 2021).

In total, according to the UN, the global loss of workplaces due to the pandemic amounted to 255 million. Moreover, COVID-19 took about 20 years of the education system’s achievements (UN, 2021b).

According to the Bank of England, the economic crisis in Great Britain was the worst since 1706. The country’s GDP lost about 20% in the second quarter (Statista, 2021a). US GDP fell by 30% over the same period (Statista, 2021b).

In economic terms, the pandemic has brought the world back for several years in the past. Furthermore, despite the rapid economic recovery after the start of vaccination campaigns, the problem is still unresolved. Instead, they move to a new level in the form of sharp increases in inflation (inflation rates are many times higher than Central Bank targets in the USA, Eurozone, UK), as well as problems in logistics chains and shortages of goods, including semiconductors, which in turn slows down economic recovery.

However, the shock to the economic system was much less than to the education system, which was unprepared to abandon traditional learning mechanisms. As a result of school closures, 90% of students did not attend school. Distance learning remained inaccessible to up to 500 million students at all levels (UN, 2021c). As a result, the UN described the pandemic effects on the education system as a “catastrophe of generations” (UN, 2021b).

Despite the severe pandemic consequences for the world economic system, they will not be able to stop the evolutionary processes of development. This refers to the transition of economic systems

to the “knowledge-based economy”. The knowledge-based economy is such an organization of the economy, in which most of the gross domestic product is provided by the production, processing, storage, and dissemination of information and knowledge.

SDGs are benchmarks for the transition to a knowledge economy and contribute to the development of human capital and industrial technology through innovation, which together contributes to sustainable economic growth.

The deployment of the COVID-19 pandemic has necessitated intensified progress in achieving the SDGs, especially given the existing financial needs. One of the biggest financial gaps, as well as the scale of the recession, can be called gaps in SDG 4 and SDG 8. Back in 2019 at the High-Level Political Forum on Sustainable Development (HLPF, 2019) progress in SDG 4 was described as battling a “global learning crisis”, progress on SDG 8 is “slow and uneven”.

To restore the pre-pandemic level of achievement of the SDGs 4 targets, it is necessary to overcome the deficit of funding by 2030. For low-income countries and low-middle-income countries, this deficit is 148 billion USD. The additional costs of closing schools through COVID-19 could increase this deficit by almost a third, or 30–45 billion USD for a year. However, immediate funding for programs to restore students’ lost knowledge and skills, as well as their return to school, could reduce additional costs by at least 75% (Global Education Monitoring Report Team, 2020).

For SDG 8, the UN estimates that incomes of informal employment and migrant workers have fallen by 60% globally in the first month of the crisis, and by 81% in some regions (UN, 2020).

In addition, in the light of pandemic challenges, the transition to sustainable development seems difficult and requires states and regulators to prioritize goals and form the basis for the knowledge economy and its post-pandemic recovery.

At the same time, special attention of regulators should be paid to those goals, the progress of which can lead to an increase in progress for other goals

or cumulative for all 17. Thus, ILO (2019) argues in favor of multiplying progress from SDG 8 to SDGs 9, 7, 1, 5, and 16 as a basis for enhancing a society’s knowledge base through learning and experience.

Academic research on the relationship between the goals of sustainable development is quite small. However, Vladimirova and Le Blanc (2015) based on content analysis of 40 sample reports from the organization of the UN system postulated the closest and most complex comprehensive relationship between SDG 4 and SDG 8. Signs of such influence of SDG 4 on SDG 8 were found in 21 reports out of 40 both at the level of challenges and prospects for joint achievement of these goals and at the level of political discussions. Modeling of interaction between SDGs at the target level was conducted by Lawrence et al. (2020) who showed that SDG 4 is primary to ensure progress in 7 SDGs (3, 12, 13, 14, 16, 17, and in particular SDG 8). Lawrence and Lawrence (2019), Nilsson et al. (2016), and Zhou et al. (2017) also investigated the interaction of SDGs, but SDG 4 and SDG 8 are analyzed implicitly.

Thus, in addition to the analysis of exemplary UN reports conducted by Vladimirova and Le Blanc (2015) and selected works of scientists on the relationship between the CSW system and their targets for all 17 goals, studies on CSW 4 and 8 are insufficiently presented in academic circles. The study of the scientific landscape in relation to these goals, their synergetic effects in the light of pandemic challenges, and prospects for the formation of the knowledge economy is an important task that can be solved based on the tools of meta-analysis.

This paper aims to study the current academic landscape on the role and origin of the transferring impact of SDG 4 “Quality Education” on SDG 8 “Decent Work and Economic Growth”, their role in forming the knowledge-based economy as a basis for post-pandemic recovery and assessing the readiness of academia to support the implementation and achievements of SDG 4 and 8.

2. METHODOLOGY

This paper uses several specific meta-analysis instruments, including inbuilt Scopus and Web of Science instruments and Publish or Perish soft-

ware version 8.1.3625, VosViewer version 1.6.16, Google Trends, and Google Books Ngram Viewer.

The data period starts from 2015 when the New York Summit and adoption of 17 SDGs took place. Description of each method, specific of their use for the current study, and periods available per each instrument are provided in Table 1.

Table 1. Key methodology instruments and their usage in the current study

Instrument	Description	Current study features
In-built Scopus instruments by Elsevier	Instruments of browsing in Scopus publications with preliminary analysis tools	Preliminary analysis of publications in each subject area, creation of bibliometric maps with further import in VosViewer
In-built Web of Science instruments by Clarivate Analytics	Instruments of browsing in WoS publications with preliminary analysis tools	Preliminary analysis of publications in each WoS category, creation of bibliometric maps with further import in VosViewer
Publish or Perish	Instruments of browsing in Scopus, WoS, Google Scholar, PubMed, and other databases Publications with preliminary analysis tools	Preliminary analysis of publications in Google Scholar within the most cited publications, creation of bibliometric maps with further import in VosViewer
VosViewer	Software tool for constructing and visualizing bibliometric networks, for example, based on bibliography parameters of papers indexed in Scopus	Co-occurrence and co-authorship cluster analysis and visualization map in the close of the links and chronology mode
Google Trends	An analytical instrument for comparing searching terms with internet requests in different counties and different languages	Regional and dynamic comparative analysis of internet requests concerning defined keywords in each area (SDG 4 and SDG 8)
Google Books Ngram Viewer	Instrument to analyze the frequency of terms appearance in Google Books	Ngram is constructed for each defined searched term. Linguistic corpus "English 2019" is used

Multivariate research in meta-analysis is achieved by reviewing the three largest scientometric databases: Google Scholar (PoP), Scopus (in-built Scopus instruments), Web of Science (in-

built WoS instruments). They present academic achievements.

Each search and request within the meta-analysis of above-mentioned instruments was formed using logic operator AND as of November 25, 2021, for 2015–2021, besides Google Books Ngram Viewer. These requests were conducted for 1950–2021 when the first studies in the field of knowledge economy appeared and concerned main SDGs in the sphere of knowledge sharing with COVID-19 context:

- SDG 4;
- SDG 4 and knowledge economy;
- SDG 4 and COVID-19;
- SDG 8;
- SDG 8 and knowledge economy;
- SDG 8 and COVID-19
- SDG 4 and SDG 8.

3. RESULTS

3.1. SDG 4 and SDG 8 analysis based on in-built Scopus, Web of Science instruments, and Publish or Perish

Search queries for SDG 4, SDG 4 and knowledge economy, SDG 4 and COVID-19, SDG 8, SDG 8 and knowledge economy for Scopus and WoS databases were pre-filtered exclusively by the paper parameter, period (2015–2021), and the broadest categories of WoS (including economics) and subject areas in Scopus.

In particular, the syntax of the search query created by the in-built Scopus instruments is as follows: TITLE-ABS-KEY (sdg 8) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015)) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "ENER") OR LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "ECON")).

Table 2. Static analysis of SDG 4 and SDG 8 in academic literature over the period 2015–2021 as of November 25, 2021

Source: Compiled by authors via WoS, Scopus in-built instruments, and Publish or Perish.

Searched term	Results found			Sum of the times cited		Average citations per item		h-index		
	Scopus	PoP	WoS	PoP	WoS	PoP	WoS	Scopus	PoP	WoS
SDG 4	287	151	325	437	2638	2,89	8,12	25	9	24
SDG 4 and knowledge economy	8	25	10	311	30	12,54	3,00	2	8	4
SDG 4 and COVID-19	27	38	32	56	136	1,74	4,52	4	4	6
SDG 8	161	268	194	865	1907	3,23	9,83	13	14	24
SDG 8 and knowledge economy	5	18	4	227	23	12,61	5,75	2	4	2
SDG 8 and COVID-19	10	7	19	1	144	0,14	7,58	3	1	5
SDG 4 and SDG 8	59	34	63	251	545	7,38	8,65	14	14	14

The results of the static analysis made by instruments of WoS, Scopus in-built instruments, and Publish or Perish on the analyzed terms are presented in the Table. 2.

According to the static analysis results of both SDGs 4 and 8, they are the parent categories and have the largest number of publications in the analyzed 6 years. At the same time, SDG 4 is a more researched goal, characterized by more articles in WoS and Scopus databases, as well as higher citations rates per year, citations by article, and h-index.

The SDG 4 and 8 analyses in the context of the knowledge-based economic development in the academic literature are presented rather narrowly. WoS, Scopus in-built instruments, and Publish or Perish unanimously show the small number of publications on the subject, its low citation rates, and scientific significance.

The same situation with the results of static analysis of the search terms SDG 4, SDG 8, and COVID-19,

which, however, have a logical explanation – a short horizon of research (the last 2 years).

A cross-sectional study of SDG 4 and 8 in articles show the formation of this topic in academia due to the small number of publications compared to the parent categories: 59 (Scopus), 34 (PoP), and 63 (WoS). However, the h-indexes for this topic are quite high for each basis (14), which indicates its importance and relevance.

Dynamic analysis (Tables 3 and 4) of the search terms was carried out based on articles indexed in WoS and Scopus, including the fact that articles from these databases are additionally presented in Google Scholar.

According to both databases, the research dynamics on SDG 4 and SDG 8 of both parent categories and derived search terms as SDG 4, 8 and knowledge economy, SDG 4, 8 and COVID-19 is upward. Currently, terms such as SDG 4, 8 and knowledge economy, SDG 4, 8 and COVID-19 are beginning

Table 3. Dynamic analysis of SDG 4 and SDG 8 in academic literature indexed in WoS over the period 2015–2021 as of November 25, 2021

Source: Compiled by authors via WoS in-built instruments.

Searched term	Parameters	2015	2016	2017	2018	2019	2020	2021
SDG 4	Output	4	6	17	28	54	95	121
	Citation	1	2	31	112	275	776	1409
SDG 4 and knowledge economy	Output	0	0	3	0	2	1	4
	Citation	0	0	2	0	4	11	11
SDG 4 and COVID-19	Output	0	0	0	0	0	6	26
	Citation	0	0	0	0	0	7	123
SDG 8	Output	4	4	8	16	33	57	72
	Citation	0	3	16	54	131	576	1099
SDG 8 and knowledge economy	Output	0	0	0	0	0	2	2
	Citation	0	0	0	0	0	7	15
SDG 8 and COVID-19	Output	0	0	0	0	0	7	12
	Citation	0	0	0	0	0	9	131
SDG 4 and SDG 8	Output	0	0	3	5	11	19	25
	Citation	0	0	6	16	35	149	331

Table 4. Dynamic analysis of SDG 4 and SDG 8 in academic literature indexed in Scopus over the period 2015–2021 as of November 25, 2021

Source: Compiled by authors via Scopus in-built instruments.

Searched term	Parameters	2015	2016	2017	2018	2019	2020	2021
SDG 4	Output	5	5	15	25	44	87	106
	Citation	0	0	39	93	245	672	1420
SDG 4 and knowledge economy	Output	0	0	1	0	0	1	6
	Citation	0	0	0	0	1	2	2
SDG 4 and COVID-19	Output	0	0	0	0	0	7	20
	Citation	0	0	0	0	0	5	79
SDG 8	Output	1	2	5	9	21	52	71
	Citation	0	5	3	20	84	422	1169
SDG 8 and knowledge economy	Output	0	0	0	1	0	1	3
	Citation	0	0	0	0	1	9	13
SDG 8 and COVID-19	Output	0	0	0	0	0	3	7
	Citation	0	0	0	0	0	2	52
SDG 4 and SDG 8	Output	1	2	3	4	5	20	24
	Citation	0	0	14	23	43	101	326

to be studied in scientific community only in the last two years. Several articles were published in 2017 and 2018 on these SDGs and the knowledge-based economy.

At the same time, the required parent categories are actively studied. For six years, the average growth rate of works on SDG 4 in Scopus was

79.0%, and in WoS – 62.0%. For SDG 8 in Scopus, the growth rate was 100.0%, in WoS – 76.0%.

Characterizing the subject areas of the studied terms (Figures 1 and 2), it should be mentioned that there is a specific incompatibility of WoS categories and Scopus subject areas, which are narrower.

Source: Compiled by authors via WoS in-built instruments.

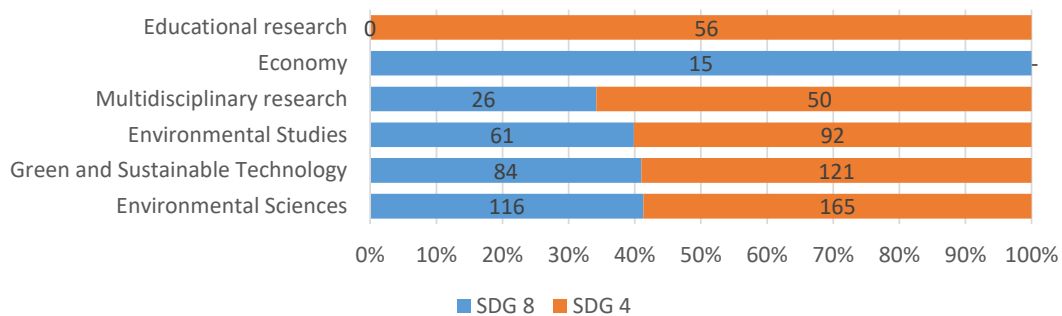


Figure 1. Structural analysis of SDGs 4 and 8 subject areas in academic literature indexed in WoS over the period 2015–2021 as of November 25, 2021

Source: Compiled by authors via Scopus in-built instruments.

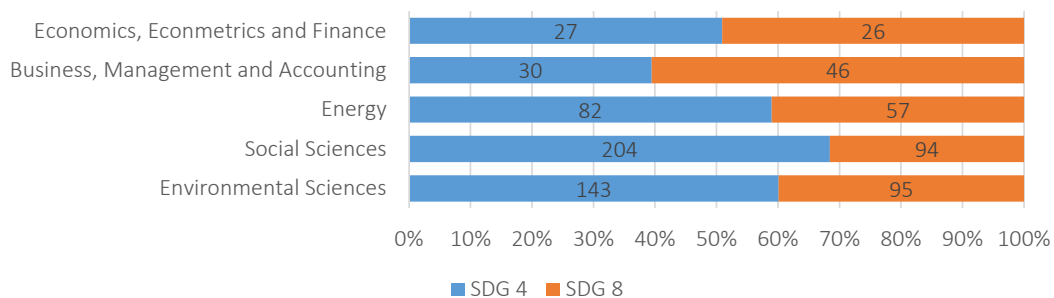


Figure 2. Structural analysis of SDGs 4 and 8 subject areas in academic literature indexed in Scopus over the period 2015–2021 as of November 25, 2021

A comparison of categories shows the predominance of the economic context in the study of search terms in the Scopus database in comparison with WoS. In particular, the articles indexed by the Scopus database for both SDG 4 and SDG 8 and their related terms are presented in two economic subject areas relatively equally. The distribution of works in other subject areas is also even. The exception is for the social sciences, where SDG 4 topic is predominant. At the same time, in the WoS categories, SDG 4 is foremost and fully covered by such a category as Educational research. The only category where SDG 8 studies completely dominate is Economy, but the number of these studies is insignificant.

3.2. SDG 4 and SDG 8 analysis based on VosViewer

Cluster analysis by keywords and authorship of publications through VOS Viewer instruments was made by aggregating all publications lists on SDG 4 and SDG 8 by all tools used (Table 5).

Table 5. Systematization of publications by search terms through scientometric instruments for 2015–2021

Source: Compiled by authors with WoS, Scopus in-built instruments, and Publish or Perish.

Searched term	Results found			Total
	Scopus	PoP	WoS	
SDG 4	287	151	325	763
SDG 8	161	268	194	623
Total	448	419	519	1386

Thus, for the bibliometric maps' construction on SDG 4 (in terms of keywords and authors), bibliographic data of 763 articles were used. As for SDG 8, 623 articles were used to identify network links between topics and potential research schools.

The bibliometric map and its identified clusters based on publications within the SDG 4 research area and related terms (Figures 3a, 3b, 3c) allow identifying the largest red cluster. It covers the research of ensuring sustainability according to the 2030 agenda. Meanwhile, educational topics and

Source: Compiled by authors via VosViewer.

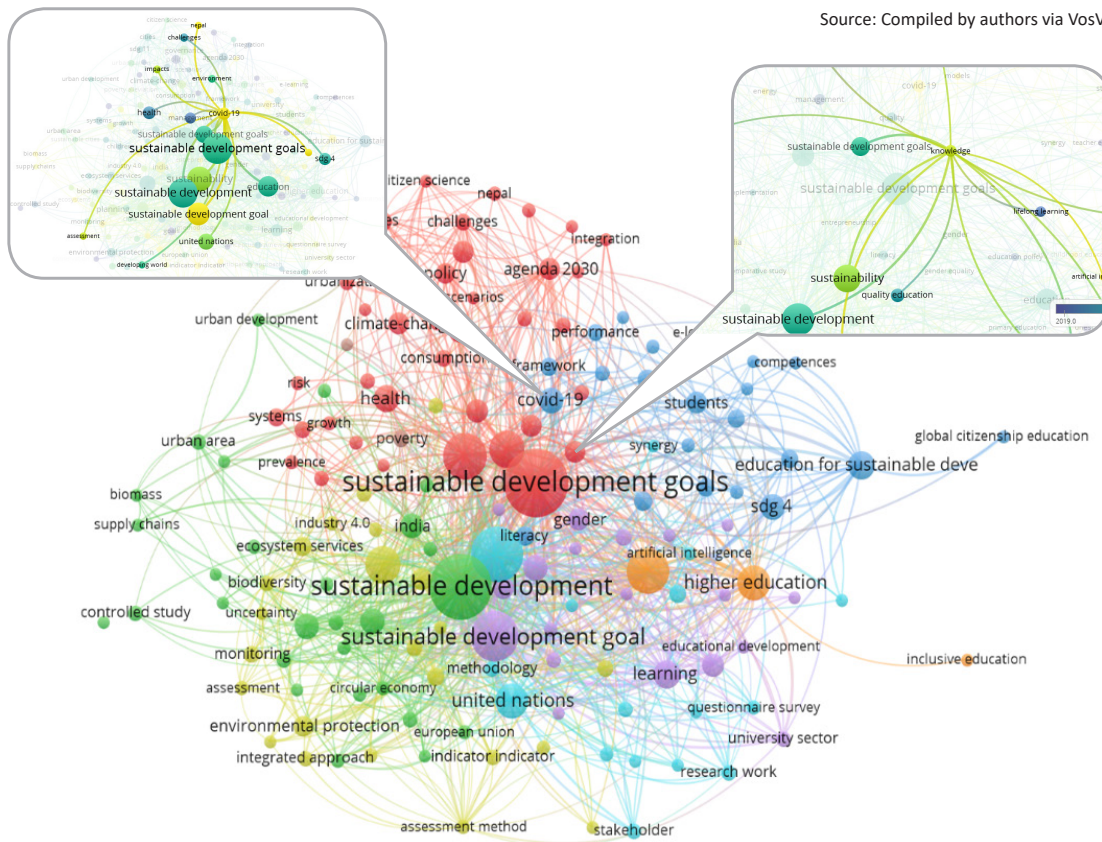


Figure 3a. Bibliometric map of publications on SDG 4 and other relevant terms imported from WoS, Scopus in-built instruments, and Publish or Perish by keywords co-occurrence (mix mode)

Source: Compiled by authors via VosViewer.

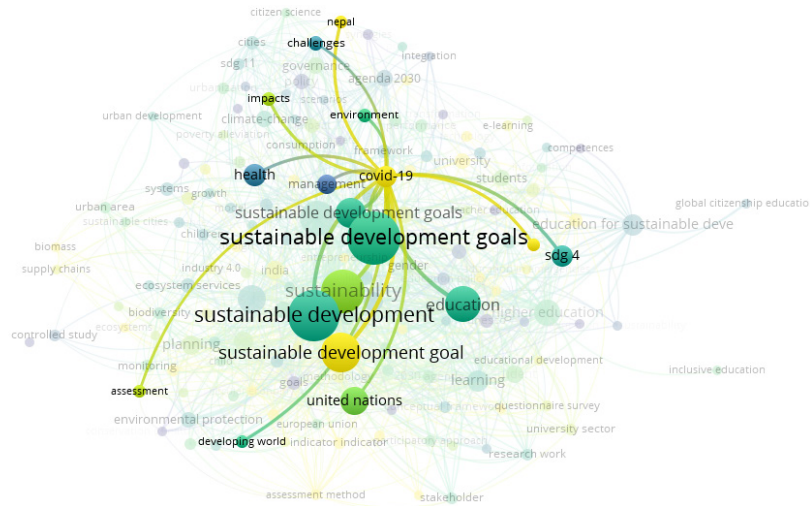


Figure 3b. Network connections with the term COVID-19

Source: Compiled by authors via VosViewer.

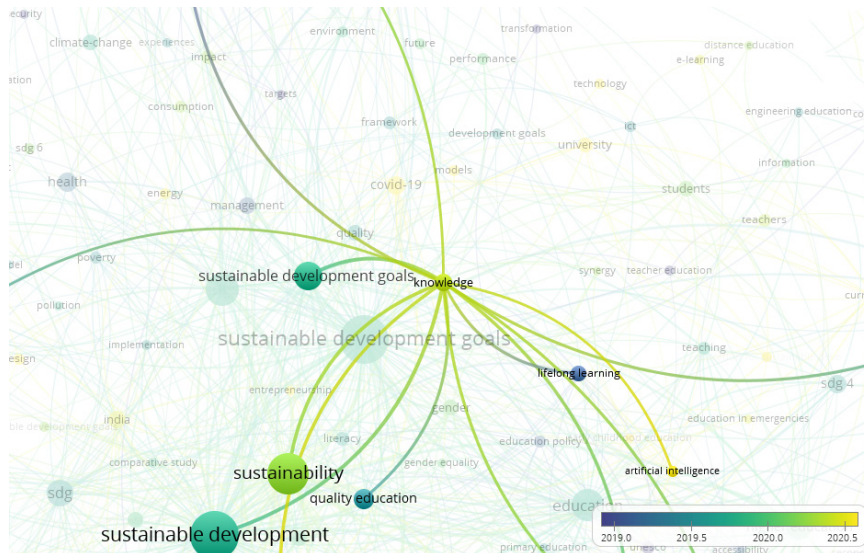


Figure 3c. Network connections with the term knowledge

SDG 4 are closely interconnected and linked with the term “knowledge” which stands for the red cluster. This red cluster combines the research of SDG 4 with the knowledge-based economy. The COVID-19 theme is also within this cluster.

The intersection of SDG 4 and SDG 8 is achieved within the articles presented in the yellow cluster. It aggregates works focused on the study of Industry 4.0, the circular economy, and the economy based on an integrated approach.

The mixed mode of displaying network links between keywords within the search queries means overlay visualization mode on the network visualization mode. The use of such a regime allowed confirming that the knowledge-based economy and COVID-19 challenges are the most relevant areas in the study of SDG 4, as evidenced by the yellow color of keywords in the footnotes.

Figure 4 presents a bibliometric map visualizing the scientific achievements of SDG 8 and other required terms. In the context of the knowledge-based economy, this goal is not considered, but within the prevailing red cluster, there is the theme regarding overcoming the pandemic challenges (footnote) and providing employment and economic recovery in such difficult conditions.

Source: Compiled by authors via VosViewer.

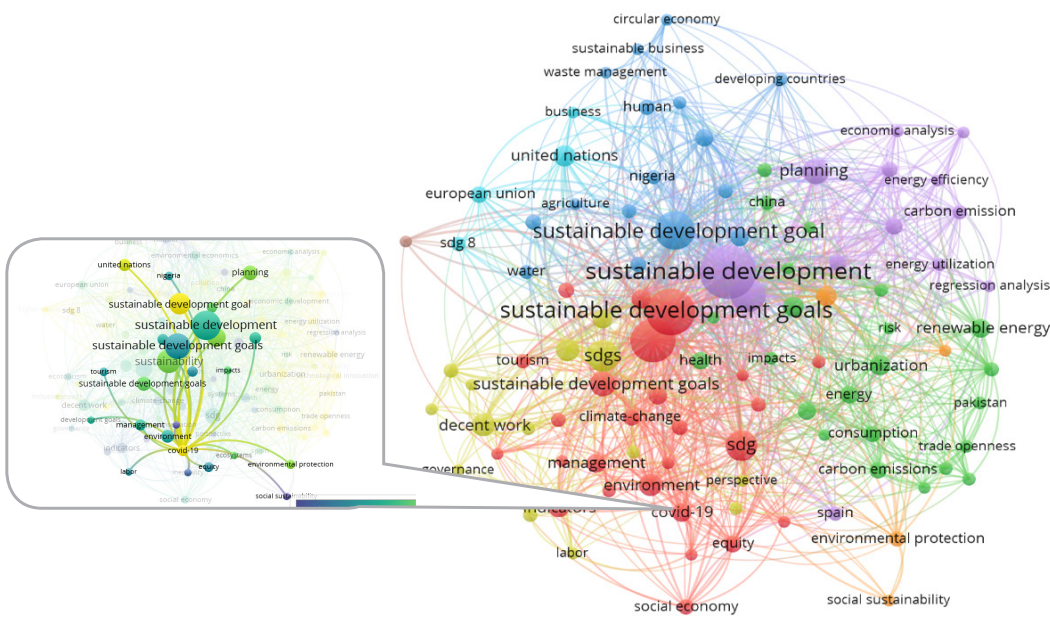


Figure 4. Bibliometric map of publications on SDG 8 and other relevant terms imported from WoS, Scopus in-built instruments, and Publish or Perish by keywords co-occurrence (mix mode)

The mentioned subject on the footnote is marked by the program in yellow color, which confirms the novelty of the investigation.

The aggregate work analysis for both purposes in terms of the authors is presented on bibliometric maps (Figures 5 and 6).

Source: Compiled by authors via VosViewer.

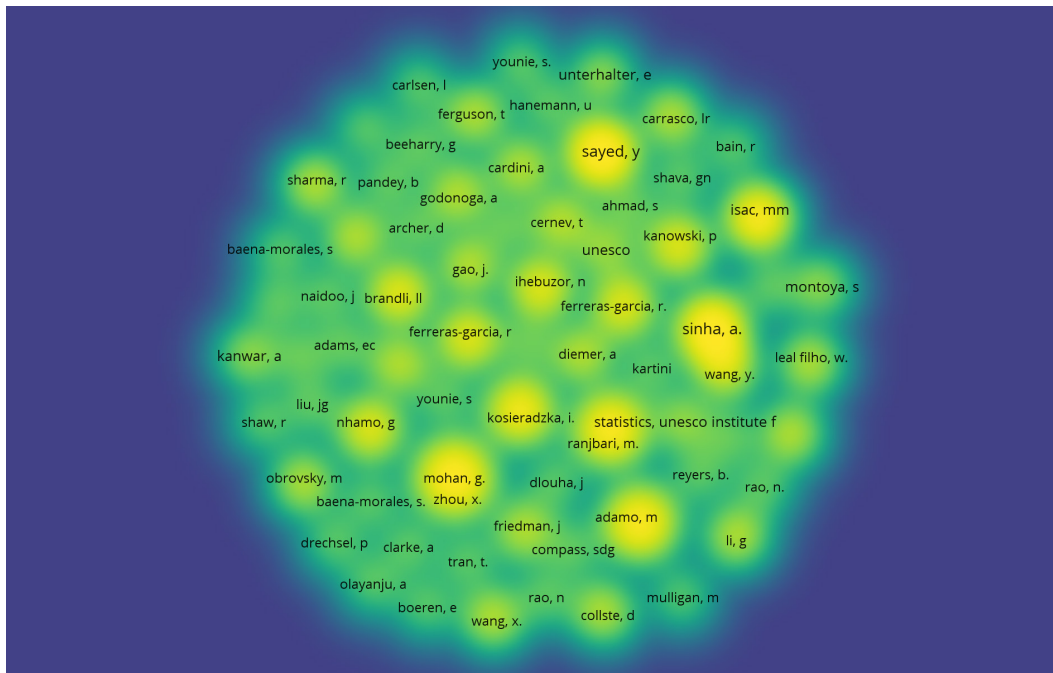


Figure 5. Bibliometric map of publications on SDG 4 and other relevant terms imported from WoS, Scopus in-built instruments, and Publish or Perish by authors (density mode)

Source: Compiled by authors via VosViewer.



Figure 6. Bibliometric map of publications on SDG 8 and other relevant terms imported from WoS, Scopus in-built instruments, and Publish or Perish by authors (density mode)

The use of bibliometric analysis instruments allowed identifying the most relevant works by the search terms SDG 4; SDG 4 and knowledge economy; SDG 4 and COVID-19; SDG 8; SDG 8 and knowledge economy; SDG 8 and COVID-19 SDG 4 and SDG 8. Relevance was largely due to the importance of the scientific work and scientific cluster presented in Figures 5 and 6, as well as the article citations (Tables A1 and A2 of Appendix A).

Based on these publications, the paper further presents their key theses.

Nhamo et al. (2020) explore the SDG implementation as an opportunity to solve the problem of the ongoing environmental degradation, especially climate change, gender inequality, and energy. With a special focus on local government, funding at all levels was identified as the main challenge to achieving sustainability.

Janetschek et al. (2020) demonstrate that climate action of countries' Nationally Determined Contributions (NDC) provides synergies with the Sustainable Development Goals. The study also

identifies sustainability issues directly addressed through climate action and issues not currently present in the NDC.

Weitz et al. (2018), examining the interaction of different SDGs and their targets, identify those whose implementation provides maximum synergistic effect, and those aspects with cross-sectoral interaction should be enhanced. Frey (2017) points to the duality of targets regarding employment in the frame of SDG 8. This, on the one hand, provides full employment (the business component), and on the other hand, ensures the defense of human rights.

Baffoe et al. (2021) investigated the nuances of the impact of gender integration (SDG 5) on other SDGs. In particular, the positive influence on poverty eradication (Goal 1), hunger reduction (Goal 2), health improvement (Goal 3), access to quality education (Goal 4), and basic services such as water (Goal 6) has been demonstrated.

Brandli et al. (2020) explored the role of green zones in universities' campuses that promote and integrate SDGs 4 and 15.

Lafortune et al. (2020) concluded that there is no “correct” way to assess the level of achievement of sustainable development goals. In addition, the differences in the methodologies determine the distinctions in the results. This necessitates the development of a unified methodology for assessing progress in achieving sustainability.

Kreinin and Aigner (2021) proposed new indicators to measure society’s dependence on economic growth to ensure SDG 8 achievement. Sandoval-Hernández et al. (2019) proposed approaches to measuring the global SDG 4 indicator.

Sinha et al. (2020) examined the impact of technological progress on environmental degradation and concluded that industrialization-oriented countries will hardly achieve sustainability. Chien et al. (2021) studied the effect of information and communication technologies, economic growth, and financial development on carbon emissions. They showed that economic growth and financial development contribute to carbon dioxide emissions, while information and communication technologies significantly reduce carbon emissions.

Ferguson and Roofoe (2020) explored the role of higher education in achieving SDG 4 and concluded that integrated higher education is needed for SDG 4 implementation. Wang et al. (2021) investigated the impact of COVID-19 on the Sustainable Development Goals, in particular on SDG 4 (education). Empirical results have shown that developing countries could achieve SDG 4 by increasing student satisfaction and further enhancing their e-learning practices.

Chabbott and Sinclair (2020), analyzing the impact of COVID-19 on education, concluded that the education system is not ready for existing challenges and new forms of learning, including home learning. The future of SDG 4 directly depends on the ability of education systems to evolve and adapt. Regarding potential threats in the future, a new global pandemic, mass population displacement caused by climate change, armed conflicts, and natural disasters were highlighted.

Roy et al. (2021) have shown that trade support contributes to sustainable economic growth in de-

veloping countries, but it is effective and important only for countries with low- and below-average income levels. At the same time, the positive and significant effect in countries with above-average incomes level depends on their political stability.

Ribeiro-Duthie (2020) assessed the potential social benefits in the context of sustainability by the Fair-Trade model. It was concluded that multilateral trade agreements and the development of agricultural policies are feasible.

Firoiu et al. (2019) analyzed the achievements of the SDG in Romania and concluded that the level of implementation is insufficient, and there is a need to intensify efforts aimed at the country’s sustainability.

Anholon et al. (2021) studied the COVID-19 impact on achieving SDG 8 targets in Brazil. Pradhan et al. (2021) investigated the pandemic effect on the SDG completion for Nepal and concluded that it has a negative impact on most SDGs, including targets 1, 4, 5, 8, 9, 10, 11, and 13. The key negative factors were lockdown, unemployment, the closure of facilities, the deflection of attention and resources to non-pandemic issues, and the expected reduction in supporting the development.

3.3. SDG 4 and SDG 8 analysis based on Google Trends and Google Books Ngram

Within Google Books and Google Trends resources, public Google tools have been used to analyze the popularity of search terms among Internet users.

During the analysis of Google Trends, the search was performed in a comparative mode according to terms SDG 4, SDG 8, Knowledge economy. The term “COVID-19” is characterized by inquiries statistics, limited to a period of 2 years. It is incomparable with the queries on dynamics for SDG 4, SDG 8, Knowledge economy; the results are presented in Figure 7.

The analysis of the popularity of Internet users’ requests in 2015–2021 shows the predominance of the knowledge-based economy over the topic of SDGs 4 and 8, despite the growing interest

Source: Compiled by authors via Google trends.

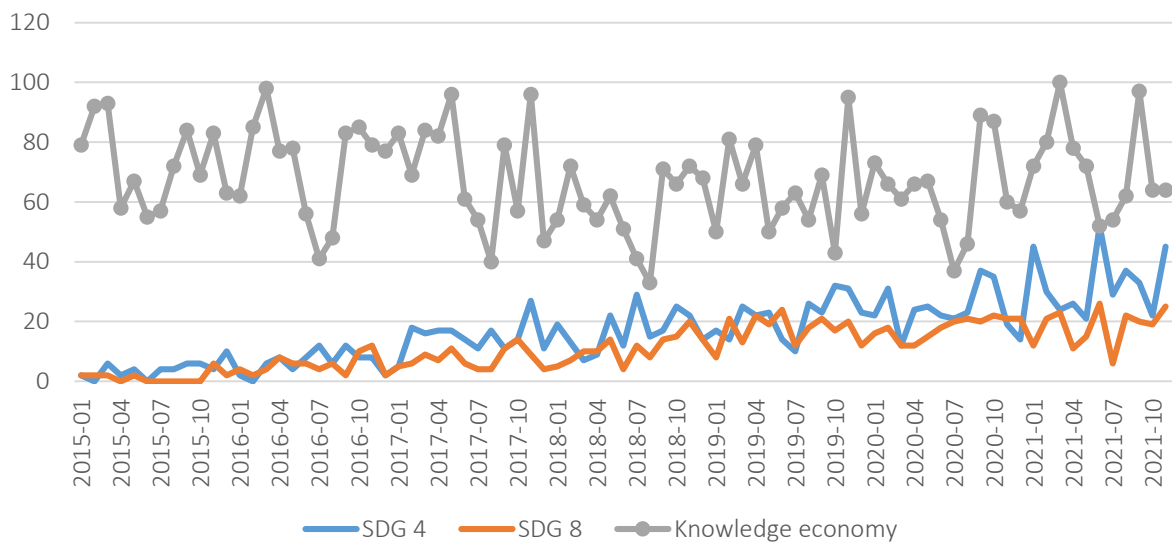


Figure 7. Internet queries concerning SDG 4, SDG 8, “Knowledge economy”

in studying these global landmarks in human development.

It can be explained by the fact that the knowledge-based economy began to be discussed in a scientific environment in the 50s of the 20th century. The topic of sustainable development started to be popular in the late 80s of the 20th century, and the SDG replaced the Millennium Development Goals only in 2015. It is also worth noting that SDG 4 is more actively sought than SDG 8.

The geographical context of the study of Internet users’ interest in search queries SDG 4, SDG 8,

Knowledge economy by countries of the world (Figure 8) also shows in favor of the prevalence of knowledge-based economy, rather than sustainability topic. Only in 3 developing countries (Bangladesh, Ghana, and Indonesia), users are more interested in the subject of SDGs, in particular SDG 4 (100, 85, and 47% of all inquiries for all terms within the country).

At the same time, it cannot be said that the subject of the knowledge-based economy dominates only in developed countries as the share of search queries for it ranges from 40% in Germany to 78% in Pakistan.

Source: Compiled by authors via Google trends.

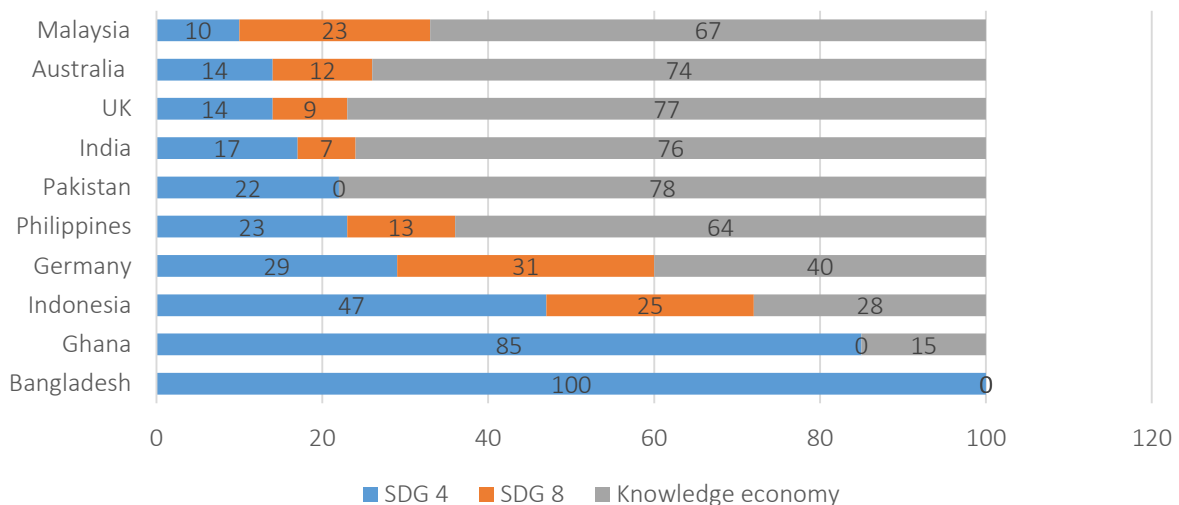


Figure 8. The level of Internet users’ interest in search queries on SDG 4, SDG 8, Knowledge Economy in 2015–2021: Top 10 countries, %

Source: Compiled by authors via Google Books Ngram Viewer.

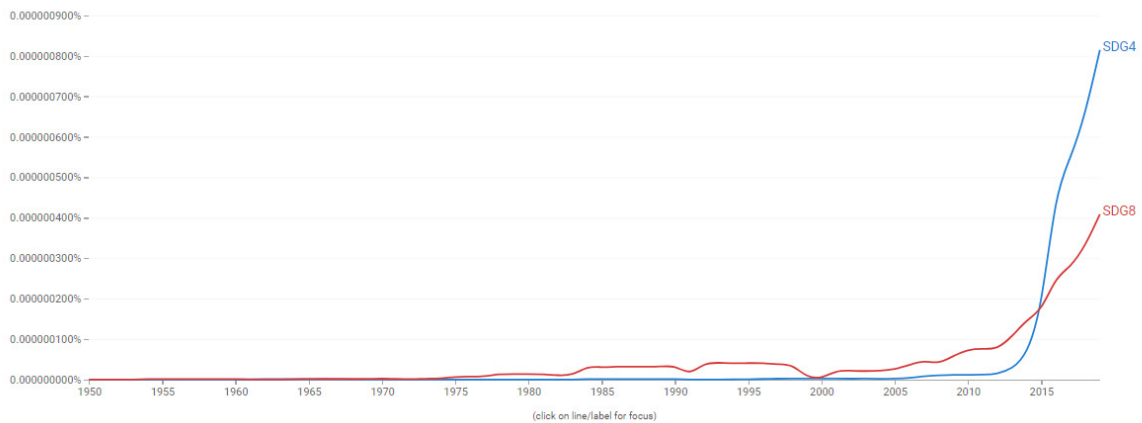


Figure 9. Ngram analysis of SDG 4 and SDG 8 in 1950–2019

Source: Compiled by authors via Google Books Ngram Viewer.

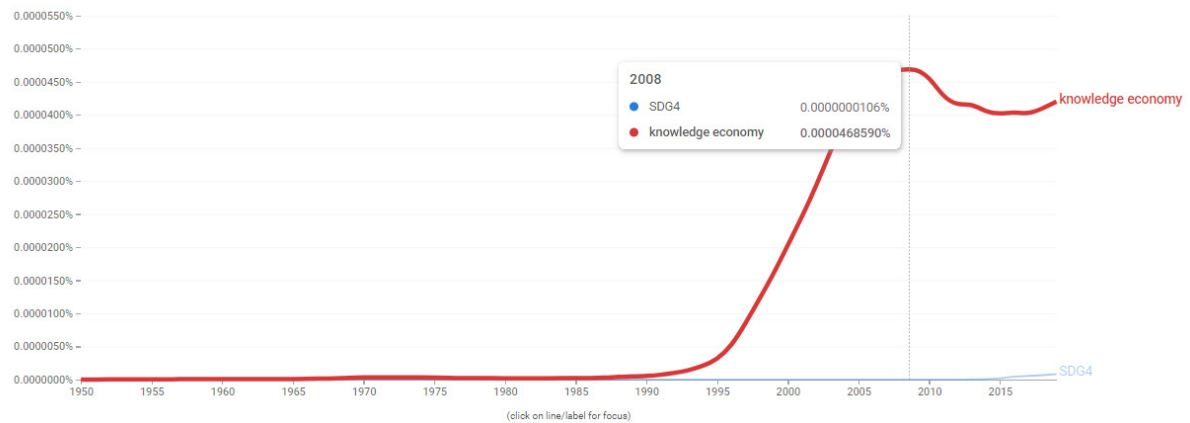


Figure 10. Ngram analysis on SDG 4 and Knowledge economy in 1950–2009

Source: Compiled by authors via Google Books Ngram Viewer.

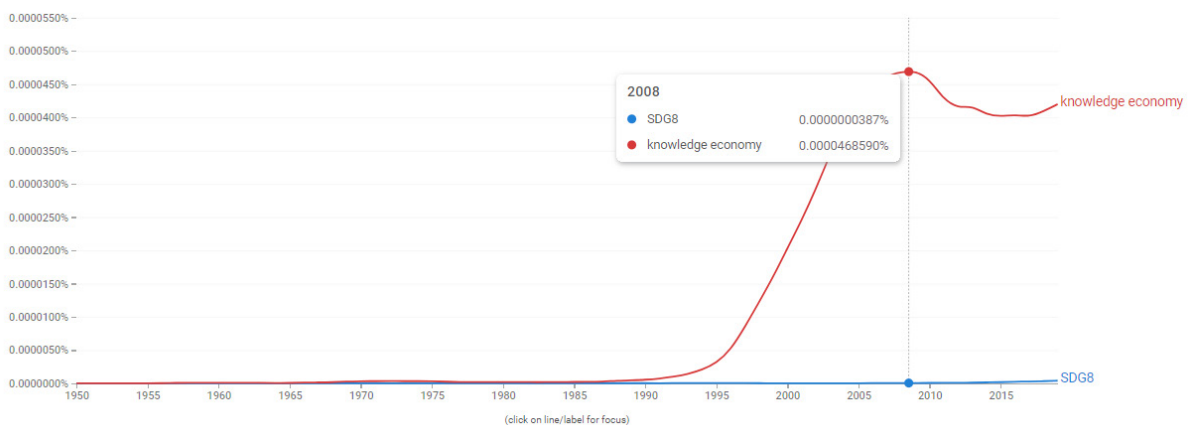


Figure 11. Ngram analysis on SDG 8 and Knowledge economy in 1950–2009

Analysis of the frequency of mentions in Google Books on the research topic (SDG 4, SDG 8, Knowledge economy, COVID-19) using Google Books Ngram Viewer is presented in Figures 9 to 12.

A comparative analysis of the frequency of mentions of SDG 4 and SDG 8 in Google Books sources shows a significant scholars’ interest in the subject of these SDGs only since 2015. The degree of

Source: Compiled by authors via Google Books Ngram Viewer.

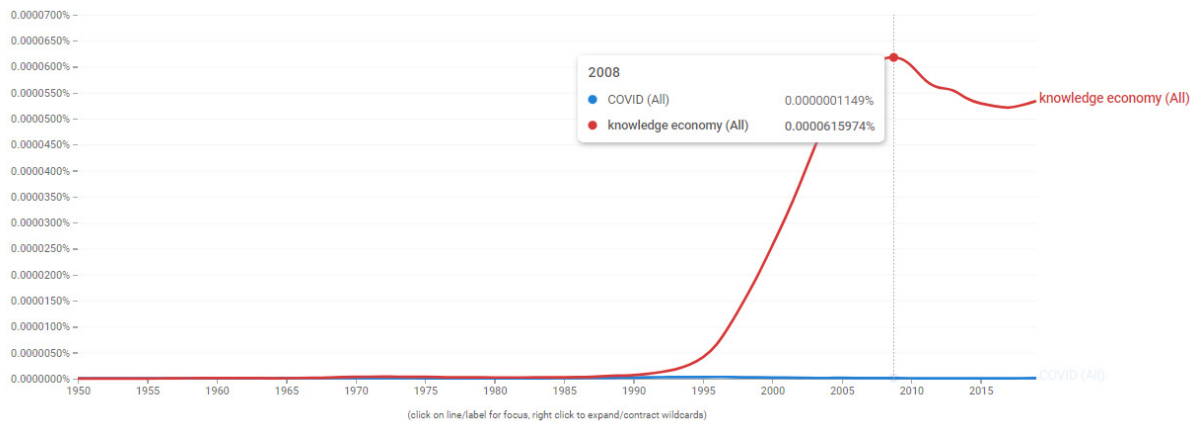


Figure 12. Ngram analysis on Knowledge economy and COVID-19 in 1950–2009

SDG 4 research is much higher than SDG 8, especially in recent years.

The pairwise comparison of the frequency of mentions of SDG 4 and Knowledge economy, as well as SDG 8 and Knowledge economy, convincingly shows more attention to the research development in the field of a knowledge-based economy and their representation in digital Google Books than in the field of sustainable development (Figures 10 and 11).

It is noteworthy that the peak value of references frequency of the “knowledge economy” is observed in the context of pairwise comparisons with SDG 4 and SDG 8 in 2008. A significant upward trend in its study has been observed since 1995.

The frequencies asynchrony of mentioning the subject of the knowledge-based economy and COVID-19 illustrates that COVID-19 in the Google Books sources has a short period of presentation. It comprises the period of the last two years (Figure 12).

CONCLUSIONS

The pandemic is an unexpected challenge not only to the global health system but also to the global economy and education system. As a result, the progress made on several Sustainable Development Goals has been partially lost, and the achievement of sustainability by 2030 is now in great question.

This paper analyzes the readiness of the scientific community to provide preconditions for the progressive acceleration in achieving the SDG 8 “Decent Work and Economic Growth” based on the development of the SDG 4 “Quality Education”, because in the modern model of “knowledge-based economy” education is the basis of growth.

With this aim, a meta-analysis of the scientific literature on SDG 4, SDG 8, and the knowledge-based economy for 2015–2021 was conducted. The paper used several special methods and tools, including Scopus and WoS, VosViewer, Publish or Perish, Google Trends, Google Books Ngram Viewer, and Google Public Data Explorer.

The analysis results showed that SDGs 4 and 8 in the context of the knowledge economy development is presented rather narrowly in the academic literature. It is evidenced by the small number of publications, low citation rates, and scientific significance. This is partly because SDGs 4 and 8 in the context of the knowledge economy have been studied actively only in the last two years. In contrast, the study of SDGs 4 and 8, in general, has been going on for more than six years. As for the knowledge-based economy in general, its study began in the 50s of the twentieth century.

Studies of the SDG 4 impact on SDG 8 as a component of the transition to a knowledge-based economy are unsystematic and fragmentary. An important problem of the sustainability study is assessing progress in SDGs achievement, as there are different indicators and methodologies for their evaluation. Altogether, it creates the preconditions for obtaining different results.

The general conclusion is the unwillingness of the modern academic environment to provide a theoretical and empirical basis for a successful transition to a knowledge-based economy, considering the need to achieve sustainability. The challenges posed by the pandemic (lockdowns, unemployment, closures of educational institutions, change financial flows direction, etc.), as well as potential threats (new pandemic, climate change, population displacement, armed conflict, etc.), necessitate the need to radically intensify the scientists' efforts in the field of the knowledge-based economy.

AUTHOR CONTRIBUTIONS

Conceptualization: Inna Makarenko, Alex Plastun, Yuriy Petrushenko.

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Writing – original draft: Anna Vorontsova.

Writing – review & editing: Inna Makarenko, Alex Plastun, Yuriy Petrushenko.

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APPENDIX A

Table A1. List of the manually selected most cited papers based on Bibliometric map of publications concerning SDG 8 and other relevant searching terms

No.	Study	Bibliometric data
1.	Sinha, A., Sengupta, T., & Saha, T. (2020). Technology policy and environmental quality at crossroads: Designing SDG policies for select Asia Pacific countries.	(MPRA Paper No. 104249). University Library of Munich.
2.	Chien, F., Anwar, A., Hsu, C.-C., Sharif, A., Razzaq, A., & Sinha, A. (2021). The role of information and communication technology in encountering environmental degradation: Proposing an SDG framework for the BRICS countries.	<i>Technology in Society</i> , 65, 101587.
3.	Lafortune, G., Fuller, G., Schmidt-Traub, G., & Kroll, C. (2020). How Is Progress towards the Sustainable Development Goals Measured? Comparing Four Approaches for the EU.	<i>Sustainability</i> , 12(18), 7675.
4.	Weitz, N., Carlsen, H., Nilsson, M., & Skånberg, K. (2018). Towards systemic and contextual priority setting for implementing the 2030 Agenda.	<i>Sustainability Science</i> , 13, 531-548.
5.	Firoiu, D., Ionescu, G. H., Băndoi, A., Florea, N. M., & Jianu, E. (2019). Achieving Sustainable Development Goals (SDG): Implementation of the 2030 Agenda in Romania.	<i>Sustainability</i> , 11(7), 2156.
6.	Anholon, R., Rampasso, I. S., Martins, V. W. B., Serafim, M. P., Leal Filho, W., & Quelhas, O. L. G. (2021). COVID-19 and the targets of SDG 8: reflections on Brazilian scenario.	<i>Kybernetes</i> , 50(5), 1679-1686.
7.	Frey, D. F. (2017). Economic growth, full employment and decent work: the means and ends in SDG 8.	<i>The International Journal of Human Rights</i> , 21(8), 1164-1184.
8.	Kreinin, H., & Aigner, E. (2021). From "Decent work and economic growth" to "Sustainable work and economic degrowth": a new framework for SDG 8.	<i>Empirica</i> (2021).
9.	Roy, C. K., Xiaoling, H., & Banik, B. (2021). Achieving SDG target 8.1 (sustain economic growth) in developing countries: how aid for trade policy and regulations can assist?	<i>Journal of Chinese Economic and Foreign Trade Studies</i> , 14(3), 257-276.
10.	Ribeiro-Duthie, A. C. (2020). SDG 8 Decent Work and Economic Growth.	In I. Franco, T. Chatterji, E. Derbyshire, and J. Tracey (Eds.), <i>Actioning the Global Goals for Local Impact</i> (pp. 117-133) Science for Sustainable Societies. Singapore: Springer.

Table A2. List of the manually selected most cited articles based on Bibliometric map of publications concerning SDG 8 and other relevant searching terms

No.	Study	Bibliometric data
1.	Baffoe, G., Zhou, X., & Moinuddin, M. (2021). Urban-rural linkages: effective solutions for achieving sustainable development in Ghana from an SDG interlinkage perspective.	<i>Sustainability Science</i> , 16, 1341-362.
2.	Nhamo, G., Odularu, G. O. A., & Mjimba, V. (Eds.). (2020) <i>Scaling up SDGs implementation: emerging cases from state, development and private sectors</i> .	Berlin: Springer.
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