Exploring green energy in economics: conceptual evolution. A literature review based on text mining and sentiment analysis

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Abstract*. Green energy has become one of the most recurrent topics of the last decade, with a clear ascending trend in terms of popularity and strategic relevance. Although the term has been a fundamental element in the energy, environmental science, or engineering domains, we can now observe frequent linkages with the highly dynamic and versatile economic context. With this in mind, in the current paper, we aim to present the related literature approaches that integrated green energy in economics, while also identifying the evolutionary differences of perspectives and frameworks. Therefore, the methodology will start by showcasing the clear evolution of the concept, with statistical overviews that confirm its increasing frequency. Afterward, we will limit the review to the papers that integrated green energy in the title, in an endeavor to illustrate the main connections and synergies found within the economic and business area. A selection of 50 papers will be made, 25 being published in the 2010-2019 period and 25 starting in 2020. Consequently, a classification framework will be constructed to allocate each paper based on the general subject and the main methodology used. After profiling the periods and extracting valuable comparisons, the papers will be curated through the computation of different text-mining techniques, resulting in insightful statistics on the most common words, complementary concepts, and general sentiment. The study's main conclusion will be the observed prevalence of a new economic framework, based on economic growth and sustainability: green growth. Therefore, in terms of contribution, by using data mining and sentiment analysis, we have extracted valuable information from a large volume of text, methodically proving that green energy is frequently linked with economic development, and evolving conceptually throughout the last decades.*

Keywords*: green energy, economics, green growth, text mining, sentiment analysis*
JEL classification*: A12, Q40, Q42, Q50, C80*

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1. Introduction

Recently, the public international agenda frequently integrates concepts such as green revolution, green economy, or green growth, in all actions plans and strategies designed for the future. Therefore, sustainable development has become a clear priority for all the major cooperation institutions, such as the (European Union, 2020), which designed a proposal package entitled *A European Green Deal*, or the (UN Climate Change Conference, 2016) where the Paris Agreement was adopted, one of the most important, legally binding frameworks on climate change. At the same time, green energy will be part of the 17 Sustainable Development Goals created by the (UN Development Programme, 2015), along with complementary domains such as clean water and sanitation, sustainable cities and communities, climate actions, or life on land and below water. We can therefore observe that at the core of all of these strategies is the conversion to a new, renewable type of energy that promises to deliver a more sustainable way of production, consumption and ultimately living. As a consequence, all major states have created national action plans to tackle the transition towards green energy, the Inflation's Reduction Act adopted by (The White House, 2022) being a representative example.

Further on, it will be essential to analyze the impact of green energy on the economy as a whole, since we have seen that we no longer refer to it as a new technology, but as a complex transition that has to deal first with the multiple climate threats. Therefore, the best way to understand the different layers of impact and implications of green energy in the economy is to first look at the related literature, since it approaches the most contemporary issues with an immense level of detail while maintaining its neutrality and diversity of topics. Consequently, in the current paper, the focus will be set on the experts' opinions, in an effort to understand what are the predominant subjects of green energy in the economics area, whether there is an evolution compared to the publication rhythm of the last decades, and what are the main methodologies and approaches.

In order to reach these objectives, we will first study the concept of green energy as a whole, identifying the trends in terms of publishing. On this note, we will see a growing popularity of the notion, a process fueled by the political implications and agendas that we have mentioned earlier. Since it is a universally claimed concern, the interest developed by international institutions, governments, as well as private companies has undoubtedly boosted the research in the domain, a phenomenon that will be demonstrated in quantitative terms throughout the paper. Next, after the main overview of the subject, we will describe our applicative case study, split into two sections: the configuration of a classification framework that can be used to determine the main subjects and methods used for analysis and the insights generated using text mining and sentiment analysis.

Therefore, we consider that the paper contributes to the related field since it brings to light the evolution of an extremely relevant topic, framed in the fervent economic context. By looking at the trends in the literature, we can confirm that green energy has become a key priority for the smart sustainability revolution, being recently analyzed from newer perspectives that clearly impact different aspects of the economy, whether it's the business sector, certain industries, human capital, or the overall economic growth. At the same time, by constructing a classification framework and employing text mining and sentiment analysis, a subdomain of machine learning techniques, we have extracted valuable information from a large volume of text, methodically proving that the term is frequently linked with economic development, evolving conceptually throughout the last decades.

2. Literature review

2.1. General green energy concept

In terms of the general concept and research period, we aimed to showcase the entire evolution of *green energy,* from its first appearance in the related literature in the 1990 decade to the present day. Consequently, we could find a large number of Scopus-indexed papers that included the term either in the keywords or in the title, with a clear ascending trend in terms of popularity. To confirm that, in Table 1 and Figure 1 we can see the evolution of the correlated research, with the observation that in the 2020 period, there were more papers published than in the whole 2010 decade, despite the significantly shorter timeframe. At the same time, in terms of regional evolution, we can see that China and India have become the countries that publish the most papers on the subject, compared with the

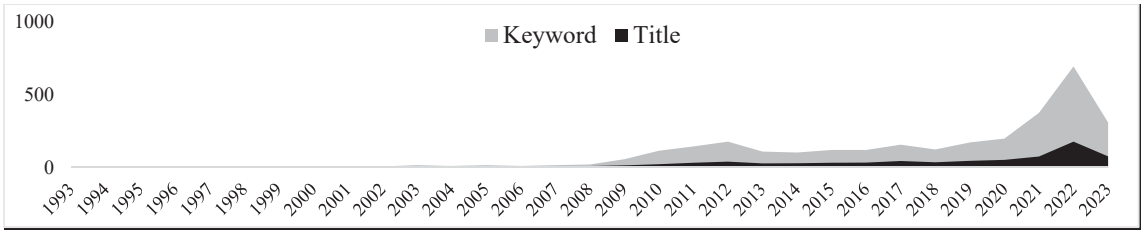
United States and Canada in the 2000s. An interesting fact is that Italy and Romania are also among the countries with the most Scopus-indexed papers throughout the 2010 decade, while Poland has also been growing its presence, proving that South and Central Europe can be an important center for the propagation of essential information on the subject.

Table 1. Number of Scopus-indexed papers integrating the green energy notion

Period	Keyword	Title	Top publishing countries
1990 – 1999	4	4	United Kingdom, Brazil, Japan
2000 – 2009	147	40	United States, Canada, China, Turkey, Taiwan, United Kingdom
2010 – 2019	1.323	330	United States, China, India, Taiwan, Italy, Romania
2020 – 2023	1.566	376	China, India, United States, Pakistan, United Kingdom, Poland
Total	**3.040**	**750**	**China, India, United States, Taiwan, United Kingdom, Poland**

Source: Authors' own processing, using the Scopus platform, May 2023

Figure 1. Number of Scopus-indexed papers integrating the green energy notion



Source: Authors' own processing, using the Scopus platform, May 2023

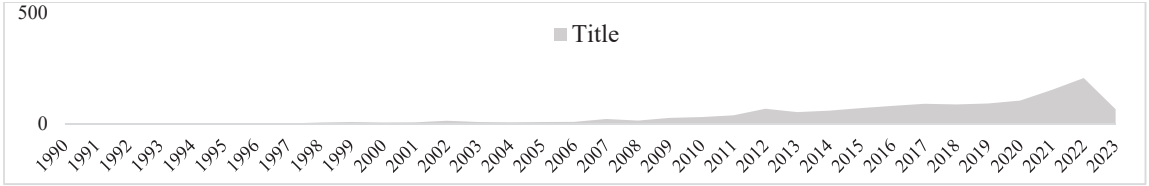
The same observations can be drawn by studying analytics from the Web of Science platform. Although the total number of papers on the subject is lower than the one in Scopus, the same ascending evolution can be observed, as well as the geographical poles represented by China, the USA, India, Taiwan, and Poland (Table 2 and Figure 2).

Table 2. Number of Web of Science-indexed papers integrating the green energy notion

Period	Title	Top publishing countries
1990 – 1999	19	United Kingdom, USA
2000 – 2009	113	United States, Canada, Turkey, China, Germany, Sweden, Japan
2010 – 2019	664	United States, China, India, Taiwan, Canada, Germany, Italy
2020 – 2023	528	China, India, Pakistan, USA, Saudi Arabia, Poland, England
Total	**1.324**	**China, USA, India, Taiwan, Canada, England**

Source: Authors' own processing, using the Web of Science platform, May 2023

Figure 2. Number of Web of Science-indexed papers integrating the green energy notion



Source: Authors' own processing, using the Web of Science platform, May 2023

2.2. Green energy in the economics context

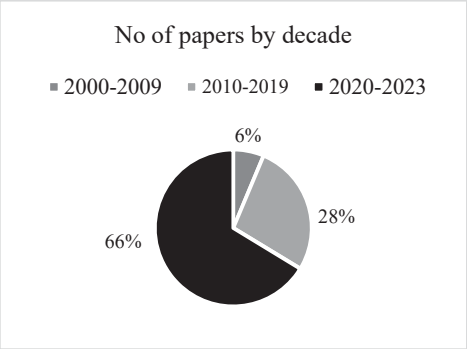
However, circling back to the main objective of the paper, we aim to tackle the question: *how is green energy integrated and correlated with the economic context?* So, as a consequence, we will now study the volume of papers that are classified as part of the economics domain, in the same two

international databases: Scopus and Web of Science. We have also refined and limited the search to the papers that integrated green energy in the title, considering them the most representative of the subject at hand. In regards to the period, we can see that the selection is now framed between 2000 and2023, since we couldn't find any papers that fit all the above criteria in the 1990 decade (as opposed to the general green energy concept described before). Therefore, in both Tables 3 and 4, we can see the number of studies that are part of the broad economic area, such as economics, econometrics, business, or management, the names being different depending on the platform. In actual numbers, the share will be relatively low, 13% and 8%, most of the articles being classified in other sections, such as environment, engineering, or technology.

In terms of the number of papers per period, we can see once again that in each platform, more than half of the studies have been published in the last 4 years, starting in 2020, proving that the subject is extremely recent and there is a great deal of information to be studied and shared.

Table 3. Green energy concept in the economics area – Scopus-indexed papers

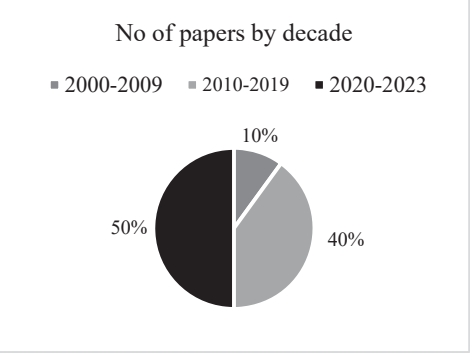
Category	Papers
Economics, Econometrics, and Finance Business, Management, and Accounting	95 (13%)
Total	**750**



Source: Authors' own processing, using the Scopus platform, May 2023

Table 4. Green energy concept in the economics area – Web of Science indexed papers

Category	Papers
Economics Business Management	112 (8%)
Total	**1.328**



Source: Authors' own processing, using the Web of Science platform, May 2023

3. Methodology and data

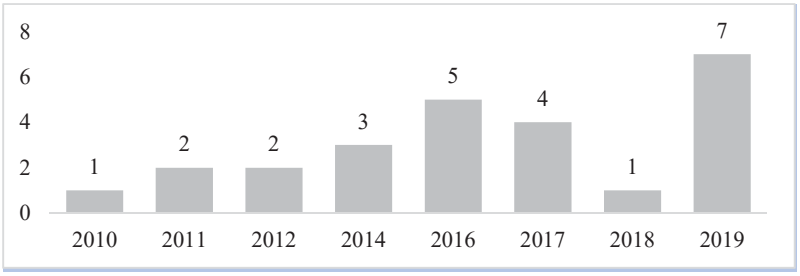
Given the previous observations, the next step in the analysis is represented by the selection of the most relevant articles that include green energy in the title and that are classified as economic research. In terms of the chosen criteria, the periods have been reduced to 2010-2019 and 2020-2023, since they gather more than 90% of the content that we want to explore (Tables 3 and 4). Therefore, a total selection of 50 articles was made, in an equal distribution between the two periods, in order to maintain a good level of comparability, especially in quantitative terms. Also, the fact that the 2020-2023 period is gaining a massive share of the studies on the subject, despite the shorter timeframe, was an extra motive for splitting the datasets equally. All the papers were collected from Scopus and Web of Science databases, two of the most prestigious research platforms. Ultimately, in the selection of those, the number of citations was the deciding factor.

Therefore, before implementing the text mining methods, we will first proceed with designing a classification framework, useful in the allocation of each paper, based on the general subject and the main methodology employed.

3.1. Classification framework. 2010-2019 decade

Therefore, we will start the analysis with the 25 papers published in the period 2010-2019. The yearly distribution of the papers can be seen in Figure 3.

Figure 3. Number of selected papers by year



Source: Authors' own processing, based on the selected papers

In terms of the main methodology, we have identified 5 classes of general methods used in the selected literature. An important mention here is that the papers that integrated social studies are found two times in the table, once in the distinct social-investigative category, and once in the methodological class (theoretical or applicative). At the same time, we must mention the fact that both classification frameworks employed a certain level of simplification, in order to collect valuable insights.

Therefore, regarding the results, we can note that multiple papers explored a descriptive approach, whether purely theoretical, or by illustrating certain statistics and graphical representations. Besides this framework, social studies, or data analysis and statistical models have been found, along with the computation of advanced techniques such as panel data or quantitative modeling. The papers selected and their classification can be seen in Table 5.

Table 5. Main methodology – 2010 - 2019 decade

Type	Methodology	References
Theoretical	Explanatory, Descriptive Statistics, Literature Review	(Li et al., 2011), (Winfield & Dolter, 2014), (Cieslik, 2016), (Oncel, 2017), (Lachapelle, MacNeil & Paterson, 2017), (Chernysheva et al., 2019), (Kim, 2019)
Applicative	Data Analysis, Statistical Models, Regression, Factor Analysis, Decision Theory, Structural Equation Modelling, Statistical Tests	(Datta et al., 2011), (Coley & Hess, 2012), (Hartmann & Apaolaza-Ibáñez, 2012), (Ardito, Petruzzelli & Albino, 2016), (Krishnamurthy & Kriström, 2016), (Sangroya & Nayak, 2017), (Ardito, Petruzzelli & Ghisetti, 2019), (Arroyo & Carrete, 2019), (Stucki, 2019)
	Advanced Statistics and Models (Panel Data, Machine Learning)	(Auer, 2016), (Kruse & Wetzel, 2016), (Ng & Zheng, 2018), (Zandi & Haseeb, 2019)
	Quantitative Macroeconomic, Microeconomic, and Financial Modeling	(Zhou & Tamas, 2010), (Ciarreta, Espinosa & Pizarro-Irizar, 2014), (Eichner & Pethig, 2014), (Anderloni & Tanda, 2017), (Yoshino, Taghizadeh-Hesary & Nakahigashi, 2019)
Social-investigative	Social & Market Studies (Surveys, Interviews,	(Hartmann & Apaolaza-Ibáñez, 2012), (Cieslik, 2016), (Krishnamurthy & Kriström, 2016),

	Pilot Projects)	(Sangroya & Nayak, 2017), (Arroyo & Carrete, 2019), (Stucki, 2019)

Source: Authors' own processing, based on the selected papers

In regard to the main subject, we have identified five broad categories illustrated in Table 6. An area that integrated multiple papers is related to the green energy market, trade, or macroeconomics. At the same time, green energy consumption and purchase behavior were repeatedly found, mainly studied using sociology and qualitative methods, while subjects in the area of policies, projects, and environmental impact will also be frequent. Green energy engineering and technologies topics come next, with a focus on patent data, general knowledge, prices, and description of new systems. Lastly, we have found three articles that approached business and companies-related subjects, such as returns, stocks, or investments.

Table 6. Main Subject – 2010 - 2019 decade

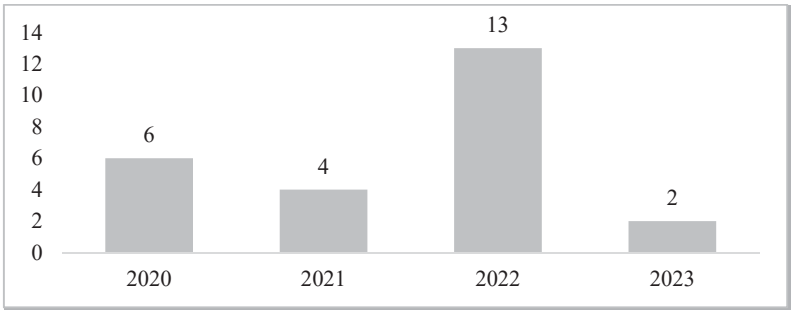
Subject	References
Green energy consumption, adoption, and purchase behavior	(Datta et al., 2011), (Hartmann & Apaolaza-Ibáñez, 2012), (Cieslik, 2016), (Krishnamurthy & Kriström, 2016), (Sangroya & Nayak, 2017), (Arroyo & Carrete, 2019)
Green energy market, trade, and macroeconomics	(Zhou & Tamas, 2010), (Ciarreta, Espinosa & Pizarro-Irizar, 2014), (Eichner & Pethig, 2014), (Yoshino, Taghizadeh-Hesary & Nakahigashi, 2019)
Green energy companies (stock, returns, investments, costs)	(Anderloni & Tanda, 2017), (Ng & Zheng, 2018), (Stucki, 2019)
Green energy engineering & technologies	(Li et al., 2011), (Ardito, Petruzzelli & Albino, 2016), (Kruse & Wetzel, 2016), (Oncel, 2017), (Ardito, Petruzzelli & Ghisetti, 2019)
Green energy policies, projects, regulations, environmental impact – case studies	(Coley & Hess, 2012), (Winfield & Dolter, 2014), (Auer, 2016), (Lachapelle, MacNeil & Paterson, 2017), (Chernysheva et al., 2019), (Kim, 2019), (Zandi & Haseeb, 2019)

Source: Authors' own processing, based on the selected papers

3.2. Classification framework. 2020-2023 period

Reaching the 2020s distribution (Figure 4), a first mention that needs to be made is that the number of citations was clearly limited, given the short period of time, as well as the access to some titles. At the same time, there were plenty of studies on different green technologies, focusing on explaining and illustrating the respective mechanisms, with little focus on the economic effects, so those were excluded from the analysis.

Figure 4. Number of selected papers by year



Source: Authors' own processing, based on the selected papers

In terms of actual results, we have similarities in the classification frameworks, but the overall distribution did face some dynamics (Table 7). For example, we see that advanced methodologies have taken the lead detrimental to the theoretical class. Therefore, explanatory papers, or the ones based on social studies are becoming less sought after, with only 4 articles being classified in this category. Panel data models became the most common method, together with other econometrics and forecasting algorithms. Other new methods will be part of decision theory (TOPSIS), portfolio theory, or structural equation modeling.

Table 7. Main methodology – 2020 - 2023 period

Type	Methodology	References
Theoretical	Explanatory, Descriptive Statistics, Bibliometric Analysis, Text Mining	(Haas, 2021), (Khan, Nasir & Rashid, 2022)
Applicative	Data Analysis, Statistical Models, Regression, Factor Analysis, Decision Theory, Structural Equation Modelling, Portfolio Theory, Statistical Tests	(Bhowmik et al., 2020), (Kaiser et al., 2020), (Mezger et al., 2020), (Cortez, Andrade & Silva, 2022), (Naqvi et al., 2022)
	Advanced Statistics and Models (Panel Data, Forecasting, Econometrics, Supervised and Unsupervised ML methods)	(Chakraborty & Mazzanti, 2020), (Skordoulis, Ntanos & Arabatzis, 2020), (Cheng, Shi & Yu, 2021), (Corrocher & Mancusi, 2021), (Huang, Chien & Sadiq, 2022), (Husain, Sohag & Wu, 2022), (Li, Dong & Dong, 2022), (Liu et al., 2022), (Rachidi et al., 2021), (Saqib, 2022), (Yan et al., 2022), (Yu et al., 2022), (Zakari et al., 2022), (Zhang & Kong, 2022), (Shang et al., 2023), (Zakari et al., 2023)
	Quantitative macroeconomic and microeconomic modeling (CGE)	(Detemple & Kitapbayev, 2020), (Pradhan & Ghosh, 2022)
Social-investigative	Social Studies (Surveys & Interviews)	(Mezger et al., 2020), (Skordoulis, Ntanos & Arabatzis, 2020)

Source: Authors' own processing, based on the selected papers

In terms of subjects (Table 8), the first observation worth mentioning is the fact that we can see an increased diversity, with multiple correlations that were not studied before, such as the impact of certain green aspects on economic growth (*green growth*) and the sustainability revolution. At the same time, different socio-economic aspects have been introduced, with a focus on their impact on CO2 emissions (for example human capital, education, and natural resources). The frequency of China case studies has also increased.

Table 8. Main Subject – 2020 - 2023 period

Subject	References
Green energy engineering, technologies, innovation, new materials, optimization	(Bhowmik et al., 2020), (Chakraborty & Mazzanti, 2020), (Corrocher & Mancusi, 2021), (Rachidi et al., 2021), (Pradhan & Ghosh, 2022)
Green energy consumption, adoption, and purchase behavior	(Mezger et al., 2020), (Skordoulis, Ntanos & Arabatzis, 2020)
Green energy market, trade, green growth**,** financial products, investments	(Detemple & Kitapbayev, 2020), (Cortez, Andrade & Silva, 2022), (Husain, Sohag & Wu, 2022), (Li, Dong & Dong, 2022), (Naqvi et al., 2022), (Yan et al., 2022), (Shang et al., 2023)
Green energy from a sustainability perspective (environmental impact)	(Khan, Nasir & Rashid, 2022), (Saqib, 2022), (Zakari et al., 2022), (Zakari et al., 2023)

Green energy nexus with social-economic aspects (economic growth, human capital, education)	(Huang, Chien & Sadiq, 2022), (Liu et al., 2022)
Green energy policies, regulations, infrastructure – case studies	(Kaiser et al., 2020), (Cheng, Shi & Yu, 2021), (Haas, 2021), (Yu et al., 2022), (Zhang & Kong, 2022)

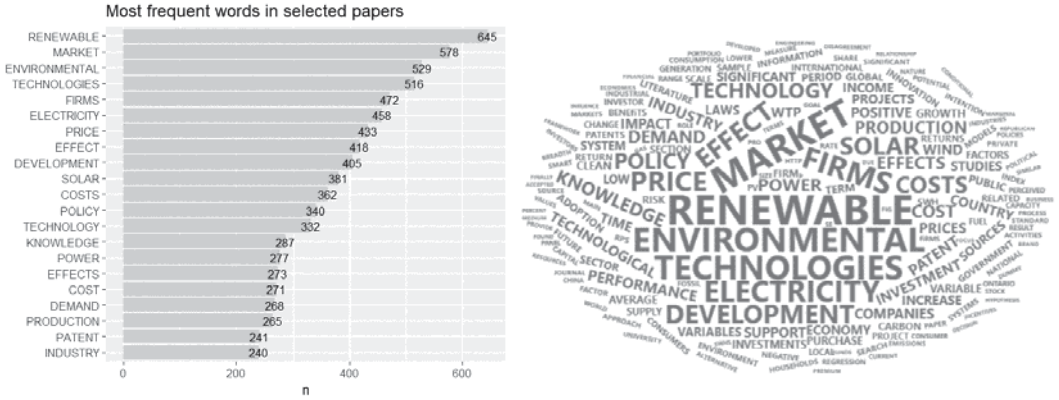
Source: Authors' own processing, based on the selected papers

4. Research results and comments

4.1. Most frequent words

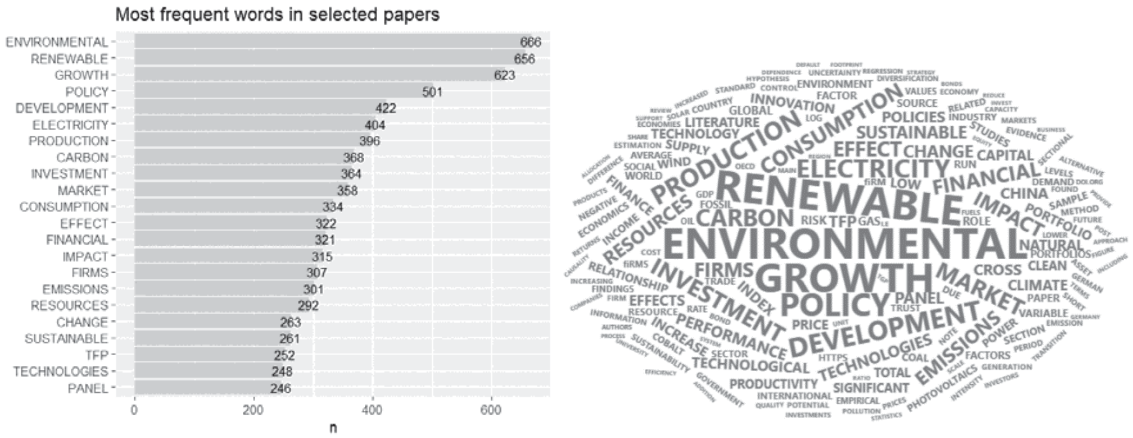
After constructing the classification framework, the next section of the paper will explore different methods that are part of the text-mining family. As a consequence, the first step in this analysis was to curate the papers and tokenize the data structure. We have removed the references, the stop words, and the numbers from the articles, in order to obtain a clean data frame. In the computation of the diagrams below, we have also eliminated key terms such as *green energy* and *economic,* as well as frequently used notions in academia such as *table, figure, data, model, countries, or results* (not limited to those). The results are illustrated in a comparative overview between the two periods, in Figure 5 and Figure 6.

Figure 5. Most frequent words, 2010-2019 decade, various representations



Source: Authors' own processing, based on the selected papers

Figure 6. Most frequent words, 2020-2023 period, various representations



Source: Authors' own processing, based on the selected papers

In both periods, we can profile some keywords that are often linked together with the concept of green energy, such as *renewables, environmental, or technologies.* From the economic area, we can note terms such as *market, firms, price, costs*, *demand, or production*, illustrating a business lexicon, with a focus on the direct microeconomic effect.

To add on that, in order for the comparative view to be complete, we have also illustrated the words with the highest and lowest growth in terms of frequency (Table 9). The insights generated in the classification step are confirmed, with certain dynamics, such as the increase of the *panel and green growth* models, *portfolio and financial* subjects, or *China* case studies. At the same time, the issue of *costs and prices* seems to be losing popularity, similar to the *projects* and *technologies/technology* terms. At the same time, the focus on *sustainable* systems is once again demonstrated, with notions such as *resource, climate, or carbon emissions* showing a growth of over 100%.

Table 9. Words with the highest and lowest frequency growth, in a comparative overview

WORD	2010-2019	2020-2023	Growth%	WORD	2010-2019	2020-2023	Growth%
GROWTH	171	623	264%	**COSTS**	362	83	-77%
FINANCIAL	94	321	245%	**SOLAR**	381	112	-71%
NATURAL	65	217	234%	**PROJECTS**	204	85	-58%
SUSTAINABLE	80	261	226%	**SOCIAL**	326	141	-57%
RESOURCE	95	291	207%	**SUPPORT**	213	93	-56%
CONSUMPTION	113	334	196%	**COMPANIES**	212	93	-56%
EMISSIONS	107	301	181%	**COST**	271	123	-55%
CLIMATE	85	223	162%	**PRICE**	433	206	-52%
PANEL	97	246	154%	**TECHNOLOGIES**	516	248	-52%
POLICIES	96	232	142%	**SYSTEM**	185	89	-52%
CHINA	99	232	134%	**PRICES**	221	115	-48%
CARBON	159	368	131%	**DEMAND**	268	146	-46%
PORTFOLIO	94	205	118%	**MARKET**	578	358	-38%
INVESTMENT	224	364	63%	**TECHNOLOGY**	332	207	-38%

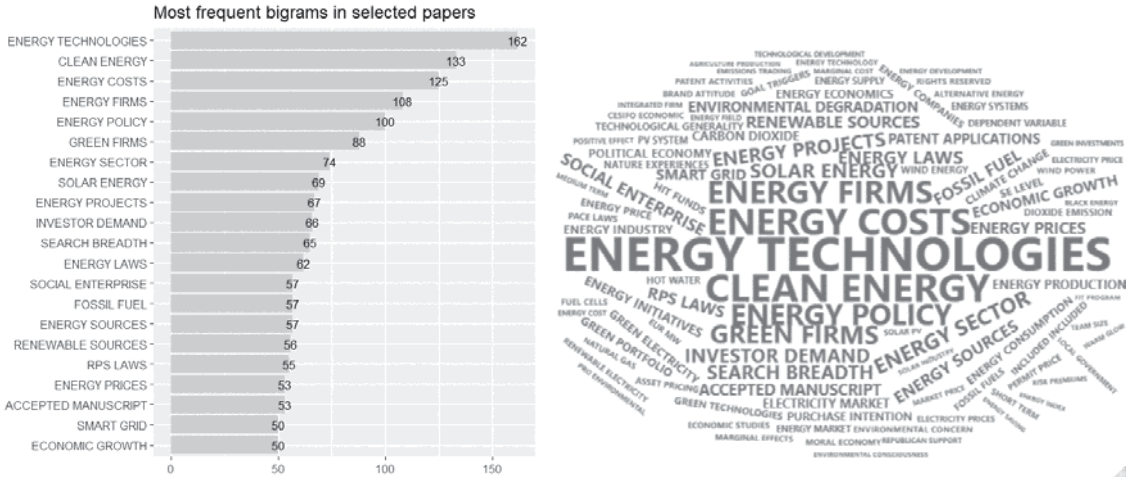
Source: Authors' own processing, based on the selected papers

4.2. Collocations

The next step in the analysis will consist of the analysis of bigrams or the combinations of two words. Therefore, we can identify key concepts that are frequently found in conjecture with the *green energy* concept, in the area of economics. We have computed the comparative frequency diagrams, in the graphical representations available in Figures 7 and 8. In terms of interpretation, in the 2010 decade, a vast majority of collocations will showcase different energy-correlated aspects, such as *technologies, costs, firms, policies, projects, laws, sources, or prices.* Complementary, from the economic area, we have found concepts such as *energy costs, energy firms, green firms, investor demand, social enterprise, energy prices, and economic growth.*

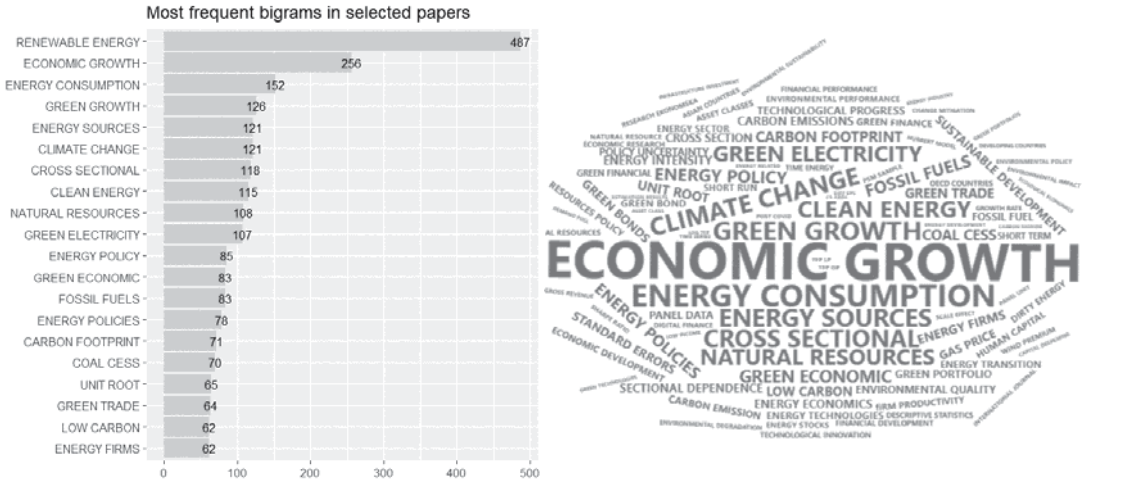
In comparison, starting in 2020, *economic growth* has become the most common collocation (besides green energy and renewable energy), followed closely by *green growth.* At the same time, we can observe new notions such as *green economics, green trade, or energy policy,* all of them gaining new positions in terms of frequency versus the previous decade. More than that, we can also confirm the methodological insight, that of an increase in the use of panel data models, since both *unit root and cross-sectional* collocations are entering the most used expressions (Figure 8).

Figure 7. Most frequent bigrams, 2010-2019 decade, various representations



Source: Authors' own processing, based on the selected papers

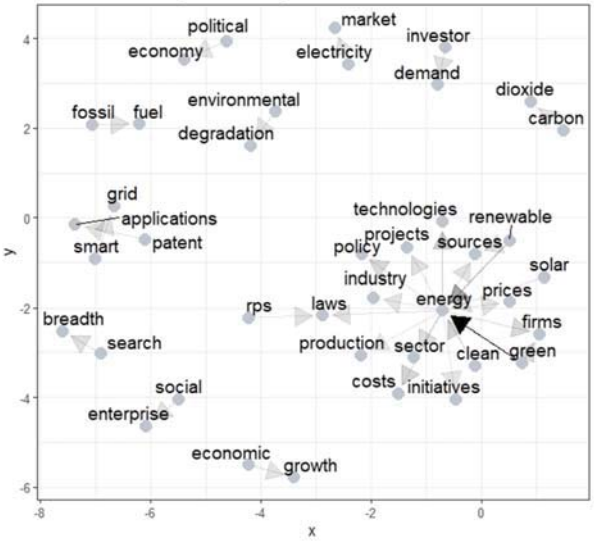
Figure 8. Most frequent bigrams, 2020-2023 period, various representations



Source: Authors' own processing, based on the selected papers

Lastly, in a graph representation available in Figure 9, we can see the network of bigrams and how they are connected. In this case, the results are similar for both periods, so we have illustrated only one perspective. The economic terms such as *prices, industry, firms, sector, costs, and production* will be strongly connected with the energy notion, while economic growth, social enterprise, environmental degradation, or carbon dioxide are between the other links. A mini cluster of technical terms can also be profiled, composed of *grid, applications, smart, and patent* words.

Figure 9. Bigrams network



Source: Authors' own processing, based on the selected papers

4.3. Economy co-occurrence

Next, we will explore the presence of co-occurrences or the most common terms that are associated with the *economy* word. They can be seen both in Table 10 and Figure 10, through the use of dendrograms. The strength of the co-occurrence will show the depth of the relationship, or how common will the two words be found together. We can note that starting in 2020, words such as *circular, greener, transitioning, or sustainability* will be prevalent, compared to *enterprise, community, moral or international*, which will be prevalent in the previous decade. That will confirm once again the fact that green energy is seen as a vector for sustainable economic development, through its transformative characteristics.

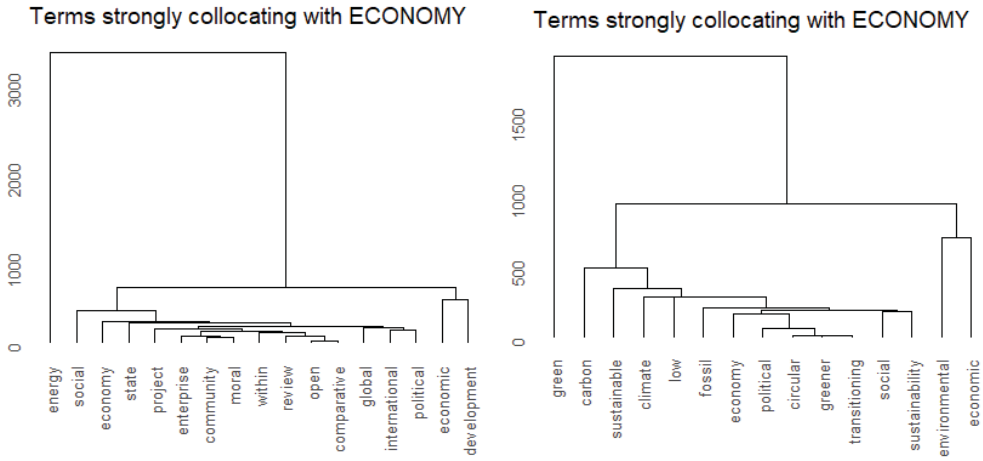
Table 10. Co-occurrences with the economy word, in a comparative overview

2010-2019	
Term	Strength
POLITICAL	216.2
MORAL	183.9
GLOBAL	101.9
ENTERPRISE	50.2
REVIEW	48.9
STATE	43.1
OPEN	40.1
DEVELOPMENT	39.4
COMMUNITY	38.5
INTERNATIONAL	37.8
PROJECT	30.5
SOCIAL	26.8
ENERGY	25.6
COMPARATIVE	25.1

2020-2023	
Term	Strength
CIRCULAR	65
POLITICAL	42.8
SUSTAINABLE	36.5
LOW	34.1
CARBON	31.7
TRANSITIONING	27.9
SUSTAINABILITY	26.6
ENVIRONMENTAL	25
GREEN	24.8
FOSSIL	23.5
GREENER	22.2
CLIMATE	21
DECARBONIZED	19.9
ECO	19.7

Source: Authors' own processing, based on the selected papers

Figure 10. Co-occurrences with the economy word, dendrograms

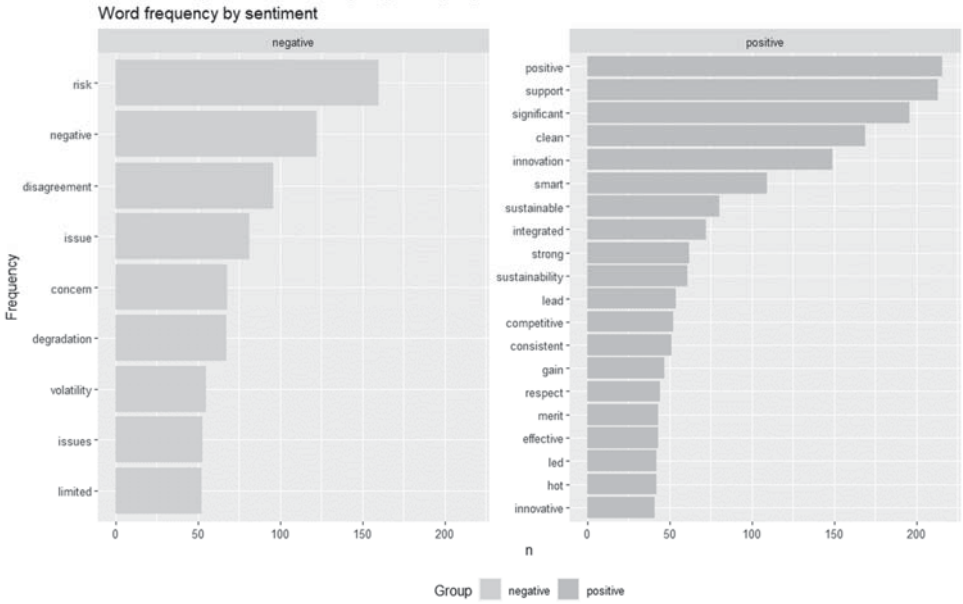


Source: Authors' own processing, based on the selected papers

4.4. Sentiment Analysis

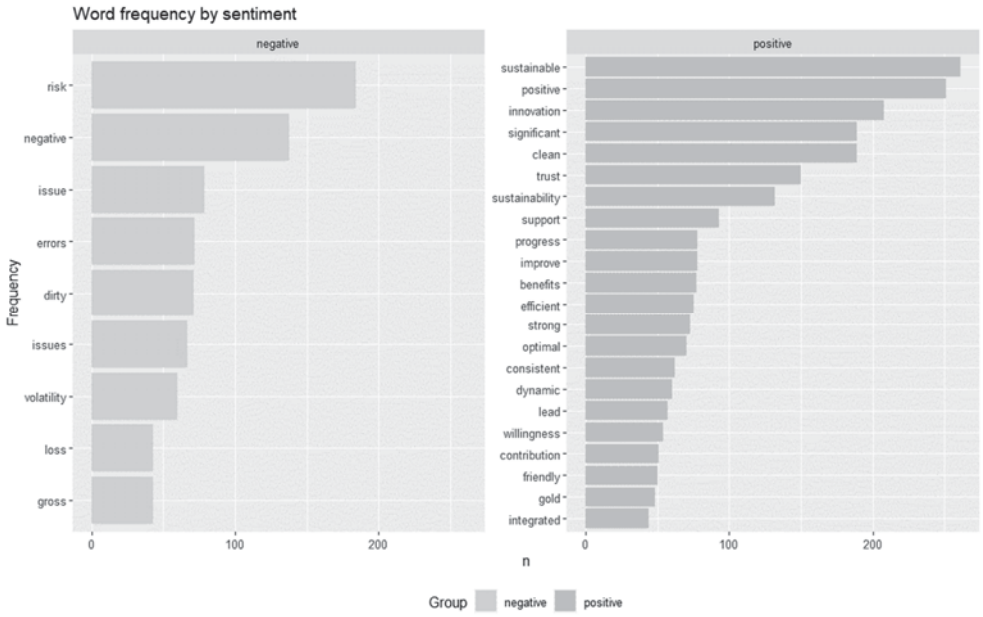
The last method employed will be sentiment analysis, a frequently used model in natural language processing or text analysis, in domains such as social media, marketing, or advertising. When applying this framework to our selection of papers, we aim to identify whether there is a general sentiment in the exploration of the green energy concept, either viewed from a positive perspective, focused on benefits, or a negative, critical one, focused on issues and risks. Therefore, in Figures 11 and 12 we can see the word frequency by sentiment, classified as negative and positive. In 2010, in the first category, words such as *risk, disagreement, degradation, or volatility* are seen as having a negative valence, while the usual terms that describe the new technologies and economic framework associated with green energy will take a positive nuance (*clean, innovation, smart, sustainable, strong, competitive, consistent*). At the same time, we can see that the number of words classified as positive will be higher, considering the criteria of a frequency bigger than 40.

Figure 11. Word frequency by sentiment, 2010-2019 decade



Source: Authors' own processing, based on the selected paper

Figure 12. Word frequency by sentiment, 2020-2023 period

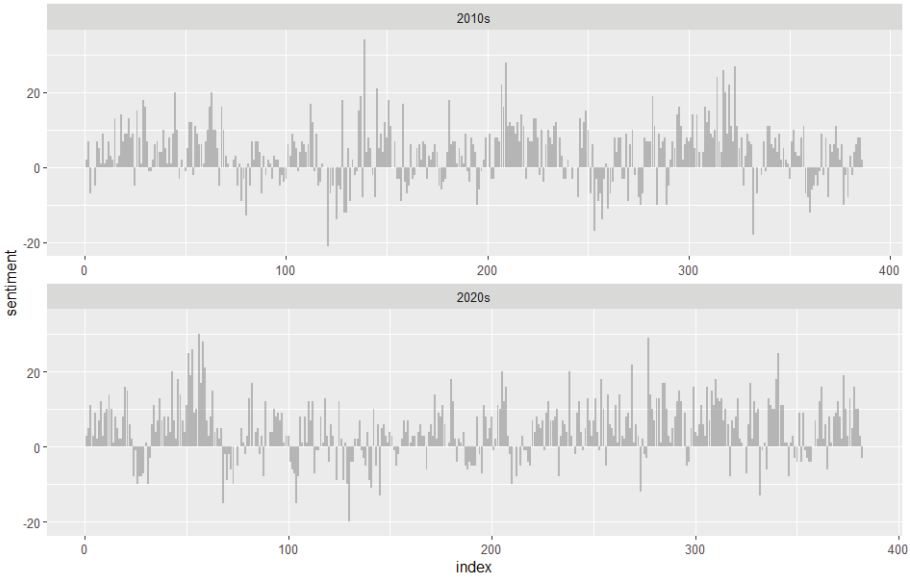


Source: Authors' own processing, based on the selected papers

In regards to the 2020 evolution, we can note that *sustainable* has become the most frequent positive word, along with *innovation*, proving that the sustainability revolution is vastly integrated into the economics area of green energy. Other words that show a positive sentiment and are more frequent than in the last period are *trust, progress, improve, optimal, or dynamic*, all of them showing the aspects that are gaining the stakeholders' interest.

Another view we can use is represented in Figure 13, in which we used a data frame composed of all 25 studies selected in each period. The positive sentiments are represented above the origin, while the negative below, both of them creating an intuitive graphic that follows the content of the papers. We can therefore conclude that a generally positive perspective will be prevalent since the chart will show a more intense trajectory above the origin.

Figure 13. Evolution of the general sentiment, throughout the selected papers



Source: Authors' own processing, based on the selected papers

Lastly, using different lexicons found in the R Studio environment, we calculated the number of words based on the sentiment (Table 11). We can see clearly that in both periods, the positive attitude will be prevalent, almost doubling the number of words specific to the negative sentiment. Other complementary feelings identified are *trust, joy, or anticipation*, proving that green energy can inflict a perspective of enthusiasm and confidence for the economic future. Starting in 2020, we can also see that *fear and disgust* decreased more than other sentiments, which confirms the overall positive view generated in the related literature.

Table 11. Words frequency, based on sentiment, in a comparative overview

SENTIMENT	2010-2019 period No. of words	2020-2023 period No. of words	Evolution
POSITIVE	15.295	15.960	+4%
TRUST	9.144	9.308	+2%
NEGATIVE	7.428	7.057	-5%
JOY	4.689	4.808	+3%
ANTICIPATION	4.057	4.125	+2%
FEAR	3.399	2.799	**-18%**
SADNESS	2.756	2.654	-4%
ANGER	2.440	2.496	+2%
DISGUST	1.938	1.605	**-17%**
SURPRISE	1.521	1.506	-1%

Source: Authors' own processing, based on the selected papers

Therefore, we can conclude that the new green energy framework is presented with the potential to positively impact society, especially in the context of an uncertain and threatened climate and an overall vulnerable economy.

5. Conclusions

In conclusion, the following results can be reiterated. The green energy concept has increased in frequency, with the volume of published papers on the subject growing year after year. Regionally, China and India have become the main producers of studies and articles, with a transition from the American continent. In regards to the economic perspective, the vast majority of the papers will integrate subjects such as green energy consumption and purchase behavior, impact on businesses, markets, or trade, and policy implications. In terms of methodology, recently, more complex models have been described, that integrate panel data, econometrics, or forecasting algorithms.

Subsequently, evolving in 2020 versus the previous period is the interest in a whole new economic framework, with collocations such as green, circular, transitioning, or environmental economy increasing significantly in frequency. We can interpret those as characteristics of the new model that from a simplistic perspective will have two objectives: to generate economic growth (the most common concept in the 2020s) and to integrate sustainable principles that can minimize the climate and environmental threats. Merging the two goals together, we obtain the green growth concept, which will be extremely popular in the related literature of the last few years. Finally, the general sentiment of the papers will be a positive one throughout the studied periods, with the literature focusing on the benefits and constructive characteristics of the new green energy model: sustainable, innovative, strong, smart, and competitive.

Having all of the above in mind, future research directions could focus on breaking down the new green economy and green growth frameworks, describing each element and its impact on the economy as a whole, whether we refer to macroeconomic or environmental effects. At the same time, a great deal of methodologies is found in the related literature, both qualitative and quantitative, so an overview of the extent to which they can be used in the economic analysis could prove to be extremely beneficial for future experts' research, as well as public and international institutions' interests.

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