



Unveiling commodities-financial markets intersections from a bibliometric perspective

Imen Mbarki^a, Muhammad Arif Khan^b, Sitara Karim^c, Andrea Paltrinieri^{d,*}, Brian M. Lucey^{e,f,g}

^a Department of Management, Esprit School of Business, Ariana, Tunisia

^b Department of Business and Law, University of Siena, Italy

^c Department of Economics & Finance, Sunway Business School, Sunway University, Selangor, Malaysia

^d Università Cattolica del Sacro Cuore, Milan, Italy

^e Trinity Business School, Trinity College Dublin, Ireland

^f University of Economics Ho Chi Minh City, Ho Chi Minh City, Viet Nam

^g Jiangxi University of Finance and Economics, China

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ABSTRACT

The prominence of commodity markets within the domains of empirical finance and energy economics is well established, largely due to oil's importance and its relationship with other commodities and financial markets. In this study, we present a bibliometric examination of 437 journal articles addressing the phenomenon of commodity connectedness, spanning the period from 1994 to 2022. The research methods include a blend of qualitative and quantitative approaches, incorporating bibliometrics and content analysis. Based on the findings of the analysis, four primary research streams have been identified within the literature concerning commodity connectedness, namely (1) commodity interconnectivity, (2) the relationship between traditional commodities, renewable energy, and cryptocurrencies, (3) the relationship between oil and stock markets, and (4) studies utilizing copula methods to examine the interconnectivity between oil and financial markets. We proposed 15 future research questions for further investigation in the domain of commodity connectedness, including topics such as the impact of the post-COVID era and global uncertainties on commodity markets, how commodities can address the issue of climate change, the exponential growth of cryptocurrencies as a new financial asset, and the impact of the ongoing Russia-Ukraine conflict on commodity and financial markets.

1. Introduction

Commodities hold a central place in the global economy and financial world. They are essential for the industrial processes of both advanced and developing economies, contributing greatly to economic growth and development. Crude oil futures and other fossil energy markets gained popularity in the 1970s, transforming commodities from mere industrial inputs and trade assets to financial instruments, hence the rise of what is referred to as the “financialization of commodities” (Lin and Su, 2020; Dahl et al., 2020; Boyd et al., 2018; Karim et al., 2022a, 2022b; Naem et al., 2022a, 2022b). Commodities are becoming more popular among investors as a way to diversify their investments and manage risk (Nguyen and Prokopczuk, 2019; Carter et al., 2017).

Since commodities are increasingly recognized as financial assets, there is a growing interest in understanding their price and risk

dynamics and their interactions with other financial assets, especially in uncertain economic times. As commodities play a crucial role in imports and exports, analyzing the links between commodities and financial markets can provide valuable insights into commodity price behavior and assist policymakers in making informed decisions regarding price stability and international trade.

Investors and fund managers must understand commodity connectedness in order to develop portfolio composition strategies that achieve the optimal balance between return and risk (Farid et al., 2023; Arfaoui et al., 2023). In order to achieve this objective, returns are maximized while global portfolio risk is minimized. To gain insight into the interactions between commodities, external factors that affect their dynamics and financial markets, we conducted a bibliometric analysis.

In this bibliometric study, we examine commodity connectedness in terms of price and volatility, both within and between commodities.

* Corresponding author.

E-mail addresses: imenmbarki@yahoo.com (I. Mbarki), muhammad.khan2@unisi.it (M.A. Khan), sitarakarim.malik@gmail.com (S. Karim), andrea.paltrinieri@unicatt.it (A. Paltrinieri), brian.lucey@tcd.ie (B.M. Lucey).

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This includes not only the interrelationships between prices, but also factors that have a substantial impact on their dynamic movements, such as uncertainties, geopolitical risks and various crises. In addition, we examine the relationship between commodities and other financial markets.

To ensure the rigor and relevancy of our study, we have meticulously selected a sample of the premier journals in the fields of commodities, energy and finance, such as the Journal of Commodity Markets, Energy Economics, Applied Energy, International Review of Financial Analysis and Finance Research Letters. A significant proportion of the studies reviewed revolve around oil as the paramount strategic commodity, but other noteworthy commodities are also within the purview of our examination.

Our study contributes to the field in several crucial ways that make it stand out from previous studies. Firstly, we have conducted a rigorous and systematic literature review of research on the nexus between commodities and financial markets, covering a diverse range of topics such as market manipulation, commodity risk management, speculation, financialization, crude oil prices, commodity futures, and oil prices and stock markets. While previous studies have adopted a descriptive and qualitative methodology, we adopt a hybrid approach that combines content analysis with bibliometric analysis, allowing hence for a more in-depth understanding of the knowledge domain, by identifying core research streams and assessing the impact of the published works through co-citation, the contributions of the authors and universities, and the research trend mapping the global structure of the field.

Secondly, given the prominent role of commodities in the global economy, there has been a growing interest among researchers in conducting commodity related bibliometric studies. Zhang et al. (2022) aims to analyze the commodity price fluctuation while Balcilar et al. (2021) focus their review on commodities connectedness, either in one single commodity market or in cross-commodity markets. Lin and Su (2020) study the oil price nexus with stock markets. Comparing to these existing bibliometric studies, our second contribution is that we rather provide a comprehensive bibliometric review of commodities connectedness that also includes connectedness of commodities with other assets like stock markets, bonds, exchange rates or also cryptocurrencies and uncertainties. One more important contribution is that in furtherance to the identification of four research streams, we suggest relevant future research questions to be investigated for each stream. Notably, our review involves a wide range of commodities that involves either fossil energy, renewable energy, and other categories of commodities, while analyzing not only price connectedness, but also return, risk and volatility connectedness of commodities with other assets and uncertainties.

By reviewing existing studies on both within commodities connectedness or interconnection between commodities and other assets or even uncertainties, our bibliometric study provides interesting trading and risk management implications for investors and policy makers as well as insightful directions for academicians. For the policy makers, the discussion of the different conclusions drawn from these works help them to enhance their analysis of business cycle and have a full picture on the drivers of economic or financial shock spillovers in the economy. For the investors and portfolio managers, this review provides a broad range of alternatives to manage and hedge portfolio risks, as well as better strategies to diversify portfolios. For the academicians, the critical review of the existing studies sheds light on the research gaps to be conducted in the future that involve proposing new methodologies, focusing on unexplored markets or also investigating new features of connectedness between commodities and other assets and factors.

The rest of the paper is organized as follows: Section 2 sheds light on data and methodology, Section 3 illustrates the findings of the bibliometric analysis, Section 4 highlights future research avenues, and Section 5 concludes the study.

2. Data and methodology

2.1. Data

2.1.1. Step 1: sample selection

The citation data is an integral part of any bibliometric analysis. We aim at collecting citation data from the ISI Web of Science Core Collection (WoS) since its database recognizes highly impactful journals from 1985.

To extract the data, we use a two-step process to extract the relevant literature using suitable keywords (Chiaromonte et al., 2022). In the first step, we incorporate very generic keywords that most likely explain the interconnectedness among various commodities. To this end, we use the keywords of (“Commodity” OR “Energy”) AND (“connectedness” OR “spillover” OR “contagion”) and search them in the title which resulted in 206 articles. Using VOSviewer, we, then, run the analysis of the keyword to extract the most relevant alternative keywords that would explain the literature on interconnectedness among commodities. In the second step, we use the broader set of following keywords (“Energy” OR “Oil” OR “natural gas” OR “coal” OR “Precious metals” OR “gold” OR “silver” OR “platinum” OR “palladium” OR “Industrial metals” OR “aluminum” OR “cobalt” OR “nickel” OR “zinc” OR “Agriculture” OR “Wheat” OR “corn” OR “sugar” OR “soybean” OR “coffee”) AND (“connectedness” OR “spillover” OR “Contagion” OR “co-movement” OR comovement) and search them in Title, Abstract and Author’s keywords. This exercise yields us total of 3968 articles (published up to January 2022).

2.1.2. Step 2: data cleaning

The second step is to exclude the unrelated articles from an initial search of 3968 articles as reported in Table 1. We apply mainly three filters, (1) The studies should be published within the subject area of economics, environmental sciences, energy fuels, environmental studies, business finance, management, and business, and (2) All the studies should be published in English language and in peer-reviewed journals which includes articles, reviews, and early excess and (3) lastly, to ensure the quality of published literature, we include only

Table 1
Query description.

Query description		
Category	Criteria	No. of refined documents
	Query outcomes before search refine	3968
Access	Types including both open access and other journals.	0
Years	Including all years (1900–2021)- removed articles from 2022	(48)
Subject area	Limit the search to the following subjects: Economics Environmental Sciences Energy Fuels Environmental Studies Business Finance Management Business We excluded International Relations, Political science, History and other subjects.	(1834)
Document type	Limiting the documents to Articles (1970), Early Access (71) and Review Articles (39) while exclude Proceedings Papers (111) Book Chapters (11) Corrections (2) Editorial Materials (1) and Notes (1) We exclude all book series	(73)
Language	We excluded all languages other than English.	(9)
	ABS ranking 2 and above	(8)
		(1241)
	Final number of documents (After search refine)	755
	After careful examination of all articles by two independent researchers, we left with 436 articles	436

those articles which are published in Association of Business Schools (ABS) ranking 2 or above. Consequently, we are left with 755 articles.

The final step involved careful examination of each article i.e., an article must have to deal with a topic as direct content. To ensure the relevance and reliability of the data, we exclude all those articles where connectedness among the commodities is cursory and marginally discussed. Our final dataset includes 436 articles.

2.2. Methodology

We carry out this study, by applying a hybrid analysis of the literature (Mukherjee et al., 2022). This method is mixed in nature since it includes a quantitative “bibliometric citation analysis” and a qualitative “content analysis” (Khan et al., 2020, 2021; Paltrinieri et al., 2019; Alon et al., 2018). To conduct this analysis, we propose the following bibliometrics and content analyses.

1. Bibliographic Coupling analysis: the articles which cite each other belong to the same topic or discipline (Khan et al., 2021; Mukherjee et al., 2022). This analysis identifies the research streams.
2. Content analysis (Bahoo et al., 2020; Donthu et al., 2021): we content analyze all the articles, and quantitative results to present streams and future research directions related to the topic.
3. Cartography/Trend analysis: similar keywords also reflect the same topic or discipline (Van Eck and Waltman, 2010). We identify the growth under each stream through cartography analysis coupled with trend analysis.

4. Citation analysis (Khan et al., 2021): we identify the impactful perspective of literature through citations (authors, institutions, countries, journals, influential and trending articles/topics).

We use analytical tools “Bibliometrix” package of RStudio, along with “Biblioshiny” (Aria and Cuccurullo, 2017) and VOSviewer for the visualization networks within the sample data (Khan et al., 2020, 2021; Van Eck and Waltman, 2010). Both analytical tools are recognized and best-known software among the researchers conducting bibliometric reviews (Khan et al., 2020). Fig. 1 provides the graphical description of the overall study.

Fig. 2 showcases a steady research interest growth in the number of papers and their citation impact. Researchers start producing papers on commodity and financial markets in 2010. Particularly, there is a clear upward trend after 2015, with a peak of about 70 research papers in 2018 that decreased slightly during 2019 to pursue increasing during 2020, which is probably associated with the COVID-19 outstanding crisis (Naeem et al., 2022c, 2022d, 2022e, 2023, 2022c, 2022d; Karim et al., 2022c, 2022d, 2023). Accordingly, the citation trend increases steadily since 2012, with an upward trend since 2018 that is consistent with the intensive research production since that date. Appendix 1A provides the main description of the overall data.

2.3. Top journals

Table 2 exhibits the top journals publishing research papers on connectedness within commodity markets and between commodity and financial assets. The major proportion of journals falls in the domain of economics, including those that are not classified as economic journals

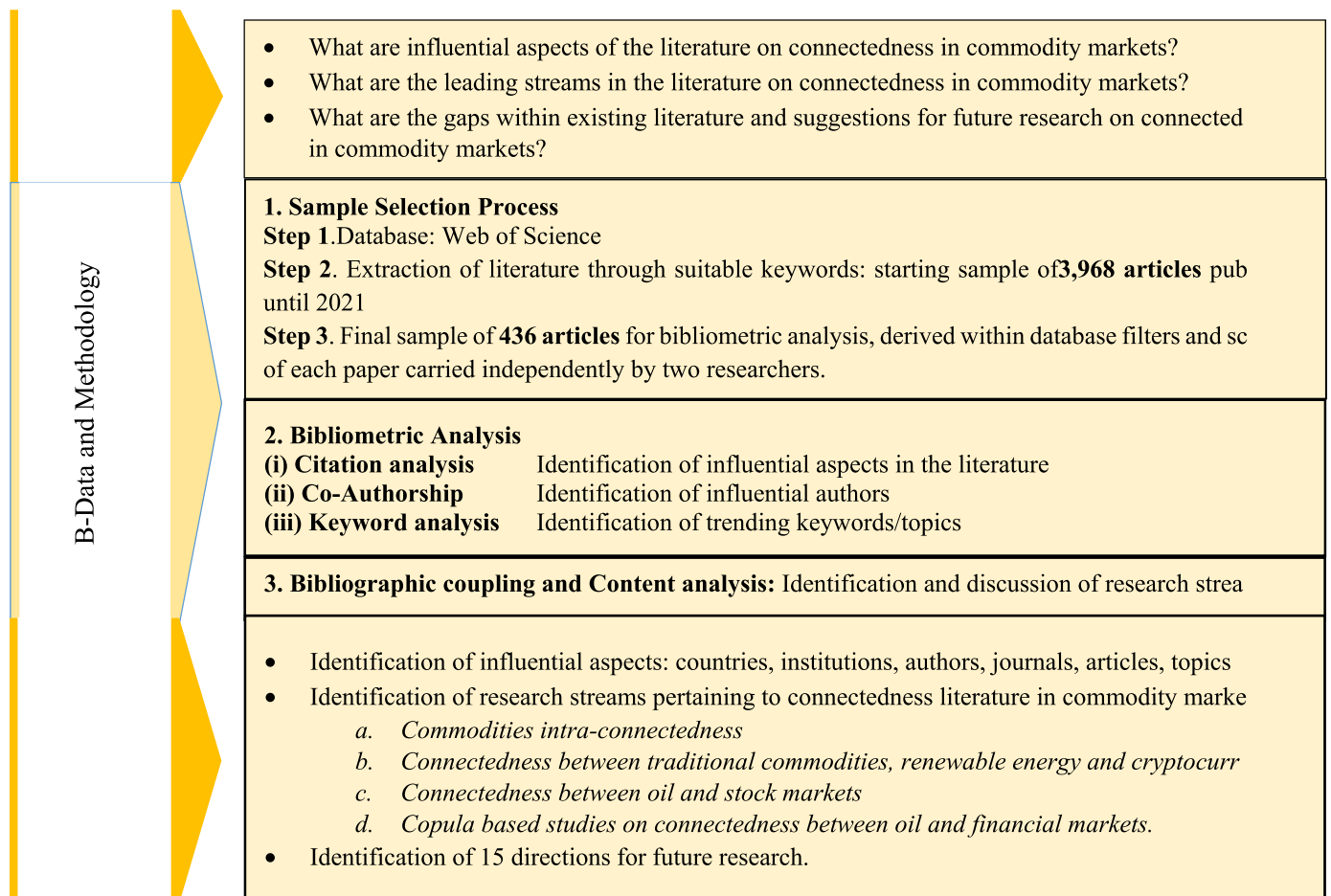


Fig. 1. Methodological approach.

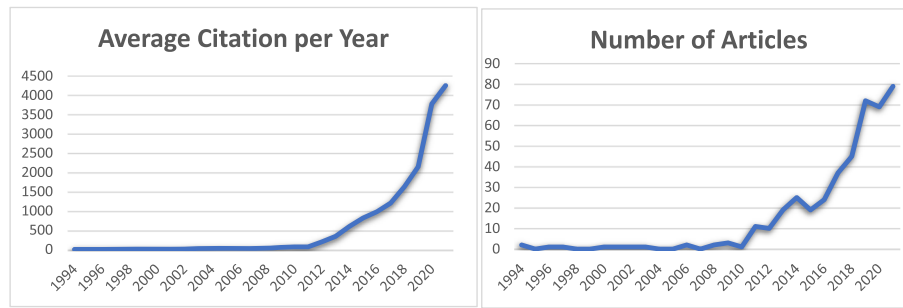


Fig. 2. Publication growth of Commodity Literature.

Table 2
Top journals in commodity literature.

Sources	Articles	% of Total Sample	Economics Journal	Publisher	IF	ABDC Ranking	ABS Ranking	WOS Research Categories (JCR Quartile)
Energy Economics	162	37.16	Yes	Elsevier	7.42	A*	3	Economics and Econometrics (Q1), Energy (Q1)
International Review of Financial Analysis	35	8.03	No	Elsevier	5.37	A	3	Economics, Econometrics and Finance(Q1)
Economic Modelling	27	6.19	Yes	Elsevier	3.127	A	2	Economics and Econometrics (Q2)
Applied Economics	25	5.73	Yes	Taylor & Francis	1.835	A	2	Economics and Econometrics (Q2)
International review of Economics & Finance	24	5.50	No	Elsevier	2.52	A	2	Economics and Econometrics (Q2)
Finance Research Letters	20	4.59	No	Elsevier	5.596	A	2	Finance (Q1)
Journal of Cleaner Production	17	3.90	No	Elsevier	9.297	A	2	Strategy and Management(Q1), Renewable Energy, Sustainability and the Environment (Q1), Industrial and Manufacturing Engineering (Q1), Environmental Science (Q1)
Energy Policy	14	3.21	Yes	Elsevier	6.142	A	2	Management, Monitoring, Policy and Law (Q1), Energy(Q1)
Energy Journal	12	2.75	No	International Association for Energy Economics	2.414	A	3	Economics and Econometrics (Q1), Energy (Q1)
Applied Energy	9	2.06	No	Elsevier	9.746	A	N/A	Management, Monitoring, Policy and Law (Q1), Energy(Q1), Building and Construction (Q1)

like “Energy Journal” or “Applied Energy”. In this particular field of economics in energy, about 38% of the papers of our sample are published in the journal “Energy Economics”. This is consistent with the specific scope of this prestigious journal, highly ranked 3 in ABS and with a 7.42 Impact factor, suggesting it the main best destination for researchers for high quality papers on commodities. The following publishing journal, although far less than the former, concerns a leading finance journal, the “International Review of Financial Analysis” that is ranked 3 in ABS and with an IF of 5.37. Other energy journals with either high rank in ABS like “Energy Journal” or a high IF like “Energy Policy” publish as well from 9 to 25 papers. Among finance journals, 20 to 25 papers are published in ABS 2 rank journals, namely the “International Review of Economics and Finance” and the “Finance Research Letters” with a higher IF for the latter. Some commodity papers can also target the “Journal of Cleaner Production” that stands out with 17 papers, which is a multidisciplinary journal with 9.2 IF. While finding about the papers on commodity connectedness and financial markets, the Journal of Commodity Markets lack sufficient number of articles on this subject area.

Overall, it appears that high ranked journals based on ABS, publish the most of papers on connectedness of commodity markets, while few papers are published by high IF either in energy or multidisciplinary area, which might reflect the necessity of the commodity area in ABS ranking.

2.4. Influential countries, institutions, and authors

Tables 3 and 4 provide an overview of the leading countries, institutions, and authors participating in this area of research. According to an analysis of 437 papers, China was the most influential country, with 139 papers, followed by the United States with 42 papers, and France with 34 papers. Montpellier Business School had the most papers with 29, largely due to its affiliated authors, such as Syed Shahzad Jawad, IPAG Business School, and Paris School of Business. There are three universities that are most influential in China: the Chinese Academy of Science, Hunan University, and Xiamen University.

Dr. Qiang Ji from China, Juan C. Reboredo from Spain, Aviral Kumar Tiwari from India, and Elie Bouri from Lebanon were the most influential authors. It is evident from a closer examination of the tables that influential authors play an instrumental role in enhancing the reputation of their institutions and countries as leading players in commodity research. Spain, for instance, ranked sixth in terms of the number of papers with 20 papers, 15 of which were written by Juan C. Reboredo, who is considered to be the second most prominent researcher. In consequence, his institution, the University Santiago De Compestela, became one of the most prestigious universities. Similarly, Drexel University in the United States was ranked as one of the most influential institutions, with thirteen papers written by Shawkat Hammoudeh, the sixth-most influential author.

Table 3
Most Influential Countries and Institutions in Commodity literature.

Rank	Countries		Institution	
	No. Of Articles	Share in Total Articles	No. Of Articles	Share in Total Articles
1	China	139	31.88%	Montpellier Business School, France
2	USA	42	9.63%	Pusan National University, South Korea
3	France	34	7.80%	University of Chinese Academy of Science, China
4	United Kingdom	21	4.82%	Hunan University, China
5	Korea	20	4.59%	IPAG Business School, France
6	Spain	20	4.59%	Xiamen University, China
7	Australia	14	3.21%	Institute of Science & Development, China
8	India	13	2.98%	Southwestern University of Finance & Economics, China
9	Japan	11	2.52%	University Santiago De Compostela, Spain
10	Germany	9	2.06%	Drexel University, United States

Table 4
Most influential Authors in Commodity literature.

Rank	Authors	Institute	Country	No. of Articles	Total Citation
1	Dr. Qiang Ji	Chinese Academy of Sciences	China	23	1357
2	Juan C. Reboredo	Universidade de Santiago de Compostela	Spain	15	1546
3	Aviral Kumar Tiwari	Rajagiri Business School	India	15	325
4	Elie Bouri	Lebanese American University	Lebanon	14	826
5	Sang Hoon Kang	Pusan National University	Republic of Korea	14	435
6	Shawkat Hammoudeh	Drexel University	USA	13	567
7	Khaled Guesmi	Paris School of Business	France	11	356
8	Syed Shahzad Jawad	Montpellier Business School	France	10	427
9	Walid Mensi	Sultan Qaboos University	Oman	9	553
10	Yue-Jun Zhang	Hunan University	China	9	594

2.5. Top-cited articles

Table 5 reported the number of the most cited papers and their citation per year, reflecting the most citations in absolute and in relative

Table 5
Trending Articles in Commodity literature.

Article	Journal Name	Total Citations	TC per Year
Sharif et al. (2020)	International Review of Financial Analysis	337	112
Arouri et al. (2011)	Journal of International Money and Finance	319	27
Mensi et al. (2013)	Economic Modelling	240	24
Wang et al. (2013)	Journal of Comparative Economics	236	24
Du et al. (2011)	Energy Economics	226	19
Vacha and Barunik (2012)	Energy Economics	225	20
Arouri et al. (2012)	Energy Economics	218	20
Nazlioglu et al. (2013)	Energy Economics	210	21
Zhang et al. (2008)	Journal of Policy Modeling	198	13
Corbet et al. (2020)	Finance Research Letters	196	65

terms, respectively. In absolute terms, Sharif et al. (2020) is the most cited paper; it deals with the connectedness between oil, stock markets and economic and political risk along with the COVID crisis impact. Similarly, Arouri et al. (2011) highlighted volatility spillover between oil and stock returns with portfolio implications. In relative terms, Sharif et al. (2020) followed by Corbet et al. (2020) are the most cited papers, dealing with the impact of COVID on connectedness between oil and stock markets along with uncertainties, and the impact of COVID on connectedness of Gold and cryptocurrencies. We may conclude that the most cited papers in commodity connectedness are centered on oil and gold and their connectedness with stock market and also new financial asset like cryptocurrencies. Therefore, they are published in Top Finance journals (International Review of Financial Analysis, Journal of International Money and Finance and Finance Research Letters). Notably, the COVID crisis, as an ongoing crisis has the most significant role in trending papers on commodities, particularly those related to stock markets or new related financial assets like cryptocurrencies. The other trending papers regard correlations between commodities and stock markets, focusing on energy, food and gold (Mensi et al., 2013) or agricultural commodity markets (Nazlioglu et al., 2013), distinguishing between oil importing and oil exporting countries (Wang et al., 2013), diversifying empirical models like Bayesian analysis (Du et al., 2011) or wavelet (Vacha and Barunik, 2012), focusing on European equity markets (Arouri et al., 2012) and also spillover between US dollar exchange rate and oil (Zhang et al., 2008).

3. Network visualization of bibliometric literature in finance

3.1. Keyword/trend analysis

WoS classifies papers' topics according to both journal categories and overall research categories. The distribution of 436 papers in our sample (Fig. 3), on connectedness in commodity markets, ranges into the main category of the WoS category "Economics" (255 articles) followed by "Finance" with 123 published articles. The remaining articles are assigned by order to Energy & Fuels and Environmental Sciences and a few papers in the "Management" research category. That classification reflects the nature of the commodity class mainly as an economic asset before its recent migration to a financial asset due to portfolio diversification by investors and portfolio implications as induced by research papers on connectedness in commodity markets with each other and with other financial assets.

With regards to journal categories, most papers of our sample are published in economic journals specialized in energy, commodities, and agriculture commodities and modeling in these fields, followed by finance and multidisciplinary journals.

Referring to existing bibliometric studies (Bahoo et al., 2020; Zhang

Bouri et al., 2020). Unsurprisingly, despite its recent occurrence, the unprecedented COVID crisis was also well studied in commodity papers, particularly that the oil market was the most hit hard during the pandemic (Naem et al., 2022a, 2022b; Rubbiany et al., 2021; Chemkha et al., 2021).

3.2. Visualization of research streams and content analysis

We examine the commodity connectedness studies through co-citation mapping provided by VOS viewer Software. Articles are presented through networks and classified by color according to their interrelatedness. Each article is represented by a circle, with a color identifying its cluster and a size that reflects the number of its citations. The spatial grouping of research streams into colored clusters is plotted in Fig. 6 while the explanation of the main keywords that might define each research stream is summarized in Table 6. Overall, we identify four noticeable clusters.

3.2.1. Cross-commodity connectedness

The red cluster of studies (41 articles) dealing with commodity prices and financial markets is characterized by its well-diversified and evolving nature over time. In the early years, from 1996 to 2009, the focus was primarily on studying co-movements across commodity prices using various methodologies (Deb et al., 1996; Ai et al., 2006; Lin and Tamvakis, 2001; Fan et al., 2008). During this period, some researchers also investigated how factors such as the US dollar exchange rate could affect these co-movements (Zhang et al., 2008).

From 2011 to 2013, multiple studies were published on the spillover of crude oil to food prices and other non-energy commodity markets, notably agriculture commodities (Du et al., 2011; Natanelov et al., 2011; Esmaeili and Shokoohi, 2011; Mensi et al., 2013; Nazlioglu et al., 2013;

Byrne et al., 2013). Du et al. (2011) conducted Bayesian Markov Chain Monte Carlo methods to examine the volatility spillovers between oil and agriculture commodity futures, such as wheat and corn. A stimulus effect of oil prices on agricultural commodity prices was found, which they attributed to ethanol production.

Byrne et al. (2013) expanded this research by investigating factors that drive the co-movements of commodity prices. Their findings confirmed the importance of interest rates and indicated that monetary policy should take into account the impact of interest rates on commodity prices in order to maintain policy stability. Byrne et al. (2013) also emphasized the importance of diversification in stock-diversified portfolios. In contrast, Mensi et al. (2013) examined the return and risk spillovers between the stock market and selected commodities, such as energy and food, and determined the optimal weights and hedge ratios.

A recent study by Nazlioglu et al. (2015) investigated the link between financial stress and oil prices in order to examine how oil shocks can affect contagion. In their study, significant return and risk spillovers were found across energy and financial markets, suggesting that oil shocks and financial stress can have an indirect impact on the economy. Therefore, policymakers must take into account not only each factor's direct effect but also their mutual connection.

This topic was further explored by Ding et al. (2017) by focusing on the investor sentiment channel. Investors' energy awareness could be boosted by oil prices.

Anwer et al. (2022) study connectedness between energy commodities and non-energy commodities and assess the impact of COVID on this connectedness. They apply a new methodology of the neural network and two firm firm-specific risk measures, the VaR and the CoVar. One important advantage of this methodology is to rank commodities in terms of degree of vulnerability to systemic risk and the

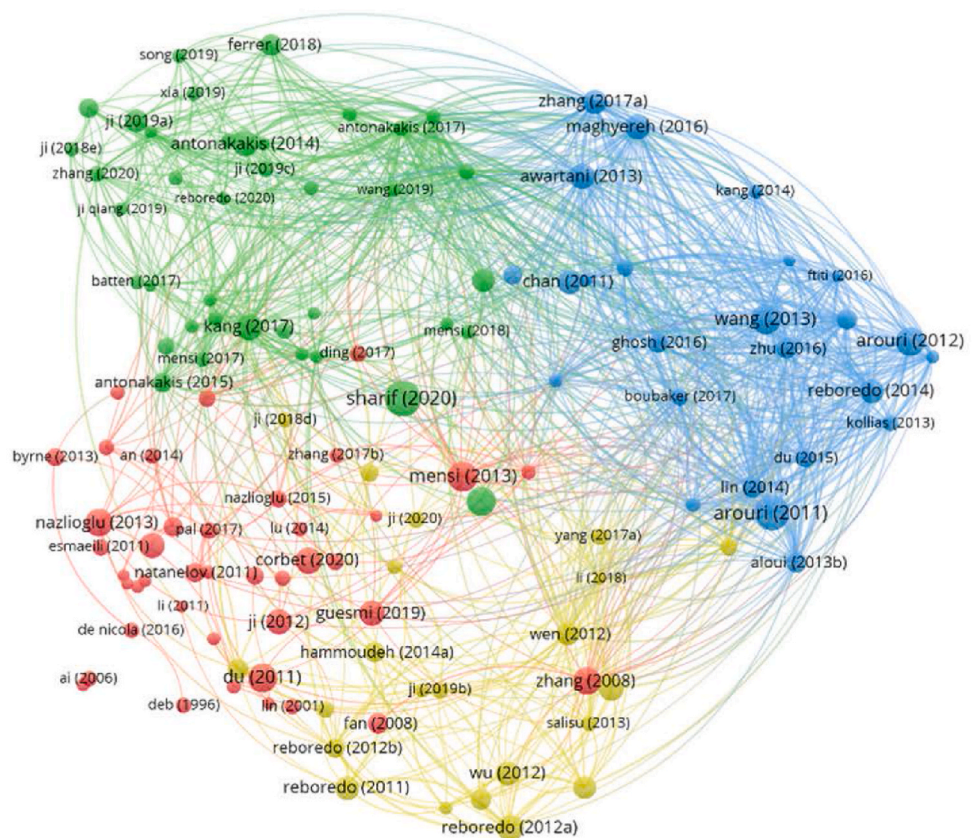


Fig. 6. Network visualization of research streams.



Table 6

Keyword summary of key papers in each stream.

Research Streams	Most frequent keywords	References
Commodities intra-connectedness	Chinese stock market, Chinese agriculture commodity, real estate investment trusts (REITs), complex network, time varying causality tests, stock markets, investor sentiment, agriculture commodity, bitcoin, gold, cryptocurrencies, contagion risk, portfolio implications.	(Deb et al., 1996; Fan et al., 2008; Du et al., 2011; Natanelov et al., 2011; Esmaeili and Shokoohi, 2011; Mensi et al., 2013; Nazlioglu et al., 2013; Byrne et al., 2013; Ding et al., 2017; Guesmi et al., 2019; Corbet et al., 2020; Corbet et al., 2020)
Connectedness between traditional commodities, renewable energy and cryptocurrencies	Oil, precious metals, agriculture futures, natural gas, stock markets, currency markets, renewable energy, green bonds, cryptocurrencies, global financial crisis, geopolitical risk, economic policy uncertainty, financial stress, COVID, fossil energy, investor sentiment, oil-financial stress, oil-stock market, investor sentiment, wavelet, dynamic network, time varying, time frequency,	(Kang et al., 2017; Batten et al., 2017; Antonakakis et al., 2017; Antonakakis and Kizys, 2015; Mensi et al., 2017; Ferrer et al., 2018; Song et al., 2019; Sharif et al., 2020; Antonakakis et al., 2017; Antonakakis et al., 2014; Ji et al., 2019a)
Connectedness between oil and stock markets	oil-Europe; oil-GCC; oil-global stock markets; oil-transition economies, oil-BRICS, oil-China, oil-Saudi Arabia, diversification, hedging, portfolio management.	Salisu and Oloko, 2015; Kang et al., 2014; Zhang, 2017; Arouri et al., 2012; Boubaker and Raza, 2017; Wen et al., 2014; Zhu et al., 2016; Ghosh and Kanjilal, 2016; Jouini, 2013; Lin et al., 2014)
Copula based studies on connectedness between oil and financial markets	oil-stock market, energy-stock market, oil-exchange rate, copula wavelet, VAR-GARCH	(Wen et al., 2014; Li and Wei, 2018; Reboredo, 2011, 2012; Wu et al., 2012; Yang et al., 2017; Salisu and Mobolaji, 2013)

contribution to the global risk. The results document an increase in systemic risk during the pandemic and show that in the post COVID-19 period, gold, silver, copper, and zinc are the most fragile commodities while wheat and sugar are the least fragile commodities. In pre- and post-crisis, based on the systemic hazard index, the top five contributors to the systemic risk are oil and gasoline in energy commodities and only sugar as non-energy commodity. Other non-energy commodities make a moderate contribution.

Bouri (2023), among others consider limiting spillover analyses in commodity markets to the first and second order a drawback in empirical literature that need to be resolved. Instead, using higher order moment like Kurtosis and skewness is preferred to better capture the non-Gaussian distribution of commodities and the asymmetric risks related to tail events. Recognizing this fact, Bouri et al. (2023) analyze the time frequency connectedness in implied higher order moment of precious metals and energy commodities, using data on commodity exchange traded funds (ETFs). The results show a weakening system-wide connectedness when the moment order becomes higher, higher spillovers in all implied moments at a lower frequency and significant time variation during turbulent periods. Generally, gold is the net transmitter and the most influential source, but gold and oil still have the prominent role, when excluding the 2020 crisis period.

3.2.2. Trend research studies on connectedness between traditional commodities, cryptocurrencies, renewable energy and COVID

The green cluster of research papers indicates that commodity connectedness has been gaining traction in recent years. There is a wide range (39 articles) of topics and markets covered in this cluster, including the nexus between crude oil and precious metals, agriculture futures and natural gas (Kang et al., 2017; Batten et al., 2017). The research has expanded from just studying the oil market to also exploring the relationships between oil and other markets, including the stock market (Antonakakis et al., 2017), currency markets (Antonakakis and Kizys, 2015; Mensi et al., 2017; Anwer et al., 2022a,b), as well as trend assets like renewable energy, green bonds, and cryptocurrencies (Ferrer et al., 2018; Song et al., 2019; Naeem and Karim, 2021; Ren and Lucey, 2022; Karim and Naeem, 2022). Furthermore, the studies examined the effect of different uncertainties, such as the global financial crisis, geopolitical risk, economic policy uncertainty, financial stress, and COVID-19, on the interconnectedness between commodities and other markets (Antonakakis et al., 2014; Sharif et al., 2020; Naeem et al., 2021a,b).

The green cluster consists of three sub-streams, each focusing on a different aspect of the interconnectedness between commodities and other markets. The first sub-stream focuses on the relationship between traditional commodities and stock markets. Using multivariate DECO-GARCH models and spillover indices, researchers such as Kang et al. (2017) and Liu and Gong (2020) have found that during times of crisis, commodities such as gold and silver serve as information transmitters to other commodity futures markets, implying a flight to quality for investors. Lin et al. (2019) study risk transmission between natural gas and stock markets in the USA and China and examine the hedging strategies. Using a multivariate GARCH methodology with regime switching, the findings show evidence of risk transmission from natural gas to the Chinese stock market and a vulnerability of the dynamic correlations (Chinese and American) to natural factors like extreme weather and macroeconomic factors like government policies and financial crises. Likewise, Dai and Zhu (2022) conduct a similar study, but adding the crude oil and focusing on different Chinese stock markets that are related to belt and road initiative. The findings show that on average, crude oil, gas and the stock markets of ferrous metals, agriculture and communication sectors are the net receivers of systematic shocks, while the stock markets of electric utilities, high-speed railway and infrastructure are the net transmitters of systematic shocks. As to hedging effectiveness, crude oil and gas reveal to be cheap hedging tools.

The second sub-stream examines the relationship between commodities and renewable energy. Several studies have been conducted, such as Ferrer et al. (2018), Ji et al. (2018b), and Xia et al. (2019), which have indicated that oil plays a significant role in the development of renewable energy companies, and that the renewable energy market is competitive with the traditional energy market. The results of these studies provide valuable insight into the relationship between carbon and energy markets, as well as the impact of fossil fuel prices on renewable energy stocks.

The third sub-stream focuses on the relationship between commodities and cryptocurrencies. Ji et al. (2019c) found that cryptocurrencies are being integrated into the commodities markets, although their connection to energy commodities is weak. Apart from the three sub-streams, a recent study by Sharif et al. (2020) examined the impact of uncertainty such as economic policy uncertainty, geopolitical risk and COVID-19 on the connection between traditional assets, such as oil price shocks, and stock prices.

In conclusion, these research papers provide valuable insights into the complex relationships between commodities and other markets, and how various uncertainties can affect them.

3.2.3. Between oil and stock markets

The blue cluster of papers (25 articles) examines the relationship between oil prices and various regional and individual stock markets. It

encompasses a range of studies conducted between 2011 and 2019. During the period 2011–2016, research production in this field, was about four papers per year. But in the subsequent years, only one paper was published per year.

In the early literature, the relationship between oil and stock markets has been well documented to study how oil is connected to various regional markets as US, Europe, GCC, BRICS, and G7 countries, while analyzing the portfolio implications in terms of diversification and hedging.

The models used in this stream include wavelets, time-frequency, regime-switching, VARMA-BEKK-GARCH (Arouri et al., 2011, 2012) and time-varying copulas. As stock markets are too vulnerable to every economic shock that is related to corporate cashflows or investors' required rate of return, it was essential to take into account the impact of several and diverse shocks particularly financial crises (e.i., the global financial crisis) or also terrorism, on the connectedness between oil and stock markets.

As regards to oil, a particular interest is given to whether it is a demand or a supply shock as oil-exporting and oil-importing countries react often asymmetrically to these shocks as was distinguished for the first time by Wang et al. (2013). Subsequent studies analyze then the impact of oil shocks on the structure and the intensity of the connectedness between oil and the stock markets taking into account this particular distinction.

In Maghyreh et al. (2016), spillovers were used to examine the connection between implied volatility and oil in eleven global stock markets. According to the study, oil and implied volatility have a strong connection, implying reduced diversification benefits when added to a derivative portfolio. Using a wavelet approach, Ftiti et al. (2016) studied the relationship in G7 countries and found that demand oil shocks have a more significant impact on stock markets than supply oil shocks in the short term. Based on a global perspective, Zhang (2017) found that oil shocks trigger uncertainty in international markets, which in turn impacts stock markets. A multivariate approach and wavelet analysis were used by Boubaker and Raza (2017) to examine the risk transmission between oil and BRICS stock markets.

To conclude, international markets and stock markets can be affected by oil price shocks, causing investors to revise their expectations and settle a new equilibrium. Understanding how oil supply shocks affect stock markets requires a differentiation between oil-exporting and oil-importing countries, since oil-importing countries are more susceptible to oil supply shocks. It is important to consider oil as part of portfolio diversification and hedging strategies because of its strong connection to implied volatilities.

3.2.4. Connectedness between oil and financial markets based on copula models

Studies in the yellow cluster (21 articles) examine the relationship between oil markets and various financial markets, not only the stock markets but including also exchange rates or green bonds. Moreover, papers in this stream are more focused on copula models (Wen et al., 2019; Yang et al., 2017; Ji et al., 2019b; Reboredo, 2018). Earlier in this cluster, Reboredo (2011), examined how crude oil prices are interconnected, using different symmetric tail dependence copulas (i.e., the Gaussian copula, the student-t copula, the Clayton copula, the Gumbel copula) and an asymmetric tail dependence copula (the Joe–Clayton (SJC) copula). The main conclusion of the findings is to reject the idea of regionalized markets in favor of “one great pool.” Subsequently, using a similar combination of copulas, Reboredo (2012) has examined the extreme connectedness between oil and agricultural commodities (corn, soybean, and wheat). The results show an increasingly strong co-movement over the last three years of the sample, but any significant dependence in the higher tail.

Salisu and Mobolaji (2013) examine the nexus between oil and exchange rate. They use a VAR-GARCH methodology with structural breaks in the data series to empirically test the interconnection between

oil prices and US-Nigeria exchange rates. The results show evidence of bidirectional return and risk transmission while confirming the hedging effectiveness of adding oil to improve the risk-return foreign exchange portfolio. Ji et al. (2018a) use time varying copula models to examine risk spillovers between oil and US-China exchange rate, from extreme risk perspectives. To do this, they extend previous works by involving four types of upsides and downside CoVaR that better capture the negative extreme dependence (i.e. lower-upper tail, upper tail, lower tail, and upper-lower tail). Six time varying copula models are used according to their tail dependence: the normal copula with no tail dependence; the t copula with symmetric tail dependence and four asymmetric dependence copulas: asymmetric positive dependence with lower tail dependence (Clayton); asymmetric negative dependence with upper-lower tail dependence (R1 Clayton); asymmetric positive dependence with upper tail dependence (R Clayton) and asymmetric positive dependence with lower-upper tail dependence (R2 Clayton). The results confirm a structural change of dependence for USD-oil, a weakly positive dependence between the Chinese yen and oil while a negative dependence between the USD and oil. There has been evidence of significant risk spillovers from oil to exchange rates of both China and the US. Likewise, Li and Wei (2018) examine the copula dependence between oil and the Chinese stock market and found an asymmetric dependence across the short and long-run, but a symmetric dependence in the upper and lower tails. A number of methodologies, including structural VAR models and copula-GARCH-based CoVaR approaches have been used to study the relationship between the BRICS stock markets and oil prices (Billah et al., 2022; Naeem et al., 2022c; Ji et al., 2020). According to these studies, there is a dynamic relationship between BRICS stock returns and oil prices, which varies with shock types and each country's market situation.

Copulas methodology has also been used to study within commodities connectedness. For instance, Yahya et al. (2019) apply a combined methodology that mixes a wavelet approach when decomposing returns, into short, medium and long-run, with a student-t copula to study connectedness between oil and ten agricultural commodities. While confirming conclusions of previous studies on an increase of connectedness between oil and agricultural products post-2006, Yahya et al. (2019) findings add a higher connectedness for long-run return movements, implying lower commodities diversification benefits for longer investment horizons.

Considering the same problem as Ji et al. (2018a) examining the dependence structure between different oil shocks (supply-side shocks; aggregate demand shocks or precautionary demand shocks) and stock market returns in BRICS countries, Kielmann et al. (2022) revisit the research question applying a CoVar analysis and dynamic vine copulas models that allow for a multivariate copula.

The relationship between oil and exchange rates has also been examined using alternative methodologies, such as time-frequency models. As an example, Yang et al. (2017) examined the connectedness between crude oil prices and exchange rates applying wavelets and found that the relationship deviates over time, especially during the global financial crisis. Jiang and Yoon (2020) used the same methodology to study the co-movement between oil and stock markets in oil-related countries. Using wavelet coherence and time-frequency domains, Cui et al. (2021) found profound risk connectedness between oil, oil-importing and oil-exporting stock markets during the global financial crisis and COVID-19.

Based on the results of these studies, it appears that there is a dynamic dependence between oil and various financial markets, which may vary over time and be influenced by various types of oil shocks. The use of a wide range of methodologies, including copula models and time-frequency models, may be beneficial to effectively address the potential impacts of these relationships. Furthermore, when developing policy, it may be beneficial to take into account the different market conditions and local strategies of different countries.

4. Future research avenues

The bibliometric analysis along with content analysis help us to highlight and identify possible gaps within the commodities connectedness literature as reported in Table 7, suggesting hence future research questions.

4.1. Cross-commodity connectedness

The effect of market sentiment on the interdependence of commodities may provide valuable insight into the transmission of information (Ding et al., 2017). Despite previous studies examining returns and risk across commodities, further research is needed to examine risk spillovers across spot, futures, and forward markets. Recent years have seen a growing interest in studying China due to its rapidly expanding economy. Its progress has not been without challenges, however, as Chinese oil dependency remains high despite its wealth of natural gas and technology resources. Therefore, it is imperative to examine the interaction between China’s fossil fuel reliance, its burgeoning natural gas industry, and technological advancements (Ding et al., 2017). Economists believe that models that analyze financial market shocks and oil price shocks individually are not adequate, so it is necessary to include both variables in the analysis simultaneously (Nazlioglu et al., 2015).

Regarding cross-commodities connectedness research works that are mainly focusing on spillovers in the first and second order moments, future studies are needed to empirically examine spillovers in higher order moments (Bouri et al., 2023; Cui and Maghyereh, 2023).

Assessing the system risk of global commodities across both past crises and new crises would be insightful to investigate the similarities and divergences among the different crises (Anwer et al., 2022a,b).

4.2. Connectedness between traditional commodities, renewable energy and cryptocurrencies

Several future studies could be guided by this research stream. The present knowledge suggests three key areas for future research, which encompass the connection between (i) traditional commodities and renewable energies; (ii) commodities and cryptocurrencies; and (iii) commodities, financial assets, and multiple uncertainties.

The urgent need to protect the environment and to achieve sustainable development goals has inspired researchers to explore the mechanisms and factors that reduce climate change risks. Carbon-energy relationships have become more complex due to the European Union Emissions Trading System (EU ETS), especially when it comes to the limitations imposed on renewable energy development by traditional fossil fuel prices (Foglia et al., 2022; Liu et al., 2023) and the establishment of carbon markets. Accordingly, the attention of investors and portfolio managers regarding carbon-energy finance risk management and optimal portfolio strategy is increasingly growing particularly with the increased number of carbon markets (Liu et al., 2023). Nevertheless, despite previous studies examining the linkages between fossil fuels and renewable energy, further research is needed to understand the key factors driving their interconnectedness (Xia et al., 2019). In line with this idea, it is worth noting that among the three prominent fossil energies (oil, coal and natural gas), natural gas is the cleanest burning fuel as it emits the least amount of carbon dioxide when combusted. However, comparing to extensive research works on oil and other financial markets, little effort, has so far been devoted among researchers to disentangling how natural gas is connected with other financial assets. In line with the recent research of Pham et al. (2023) on quantile connectedness between natural gas and US utility sector, more research is needed on the nexus of this clean fossil energy with other sectors and in other countries. Particularly, distinguishing natural gas producers countries from natural gas importers would be an interesting research idea. Meanwhile, the clean energy industry has grown rapidly

Table 7
Future research direction.

Research Streams	Q No.	Research Questions	References
Commodities intra-connectedness	1	More studies on connectedness between market sentiment and commodity markets are required.	(Ding et al., 2017)
	2	Volatility spillovers between commodities and stock markets across spot, forward and futures.	(Mensi et al., 2013)
	3	Connectedness between fossil energies, new energies based on natural gas and technology development in China needs a future investigation.	(Ding et al., 2017; Guesmi et al., 2019)
	4	Models analyzing the effects of financial market shocks and oil shocks on the economy separately are likely to be flawed and needs to simultaneously incorporate these variables in the model.	Nazlioglu et al. (2015)
Connectedness between traditional commodities, renewable energy and cryptocurrencies	5	How would recent multiple uncertainties of pandemic, economic policy uncertainty and Russia-Ukraine war shape connectedness between commodities and financial markets?	Author's Suggestion
	6	Does the Ripple-US\$ exchange rate uncertainty affect commodity connectedness?	Author's Suggestion
	7	What are the most important influencing factors that drive connectedness between fossil and renewable energies?	Xia et al. (2019)
	8	The issue of the information spillovers and system integration of various energy and non-energy commodities and leading digital currencies remains a puzzle that requires further deep investigation in the future.	(Ji et al., 2019c; Guesmi et al., 2019)
	9	Whether bitcoin is a diversifier or a hedging tool for other financial assets or otherwise, should be examined in future studies, before and after major changes in cryptocurrency regulation around the world, as compared to the traditional hedging alternatives (Oil and Gold).	(Corbet et al., 2020)
	10	It is interesting to study the relationship between business sentiment or market sentiment and oil shocks	(Antonakakis et al., 2014)

(continued on next page)

Table 7 (continued)

Research Streams	Q No.	Research Questions	References
	11	Additional channels of spillovers could be investigated to show whether spillover from economic policy uncertainty in one country can have knock on effects in another country	Antonakakis et al. (2014)
	12	More research on the link between investor sentiment and renewable energy market is required	Ji et al. (2019b)
Between oil and stock markets	13	What is the impact of Russia-Ukraine war on the connectedness between oil and BRICS stock markets	Author's Suggestion
	14	How would be the connectedness between the Ripple-US exchange and commodities?	Author's Suggestion
Copula based studies on oil and financial markets	15	The extreme dependence between oil and stock markets in other regions like the MENA region or African individual markets using copula models is not yet studied	Author's Suggestion

over the past decade and is predicted to be the fastest-growing energy source in the next two decades. Such fact has then sparked an interest in how green energy firms' stock market performance correlates with crude oil prices and other significant financial indicators.

Progressively, there is a growing interest to study the relationships between commodities and digital assets. Several factors are plausible to drive such relationship like the legitimization of some large cryptocurrencies as financial assets and the possibility that certain commodities, including gold and crude oil, have a lot in common with leading cryptocurrencies, such as Bitcoin. The interconnections between commodities and cryptocurrencies are crucial, especially when it comes to sustainable development and climate protection. In the post-pandemic era, it is vital to focus on the interdependence of these assets with sustainability, climate protection, and risk. Consequently, further extensive research in the future, is needed on the phenomenon of information spillovers and system integration among various commodities and leading digital currencies (Ji et al., 2019c). Indeed, it is still unknown whether Bitcoin can be used as a hedging or diversification tool, particularly before and after significant changes in cryptocurrency regulation and new shocks in the cryptocurrency market, notable the collapse of FTX. Oil, gold, and other traditional hedging alternatives should be compared as well to hedging ability of cryptocurrencies (Guesmi et al., 2019; Corbet et al., 2020; Le, 2023; Arfaoui et al., 2023; Siddique et al., 2023; Pham et al., 2022).

More importantly, we think that based on extensive existing empirical evidence, both researchers in economy and digital finance areas, are called for a consistent collaboration to develop theoretical models that allow predicting how commodities are related to cryptocurrencies or digital assets in general and investigate the implications.

With regard to new uncertainties and crises affecting the global economy, future research should consider how would recent multiple uncertainties of pandemic, economic policy uncertainty and Russia-Ukraine war shape connectedness between commodities and financial

markets? (Cui and Maghyereh, 2023; Le, 2023), how does the RUB/USD exchange rate uncertainty affect commodity connectedness?

Alongside the earlier main areas for future research, market sentiment and oil shocks is another topic of interest (Antonakakis et al., 2014). The relationship between investor sentiment and the renewable energy market still requires more research, despite the recent attention paid to behavioral factors (Ji et al., 2019b). Hence, it is a compelling research opportunity to combine high-frequency data with big data related to sentiment extraction from textual analysis or cryptocurrencies.

4.3. Connectedness between oil and stock markets

The issue of oil and stock markets has been widely researched in the earlier literature (Ederington et al., 2019; Costola and Lorusso, 2022). However, on account of connectedness techniques and methodologies, further investigation can be carried out as stated in the following questions.

What is the impact of Russia-Ukraine war on the connectedness between oil and BRICS stock markets? To answer this question, it is always interesting to diversify the connectedness methodologies, for instance, spillover effects under time and frequency domains (Jain and Maitra, 2023), tail-dependence structures (Karim & Naeem, 2021; Liu et al., 2017), quantile neural networks (Keilbar and Wang, 2022; Anwer et al., 2022a,b; Foglia et al., 2022), while not limiting the study to the first and second order of moments, but including also connectedness in higher order moments (Bouri et al., 2023; Cui and Maghyereh (2023).

4.4. Copula based studies on connectedness between oil and financial markets

The use of copula models to investigate the relationship between oil and financial markets is common, but these models may be more useful for analyzing the current situation. As noted by Sharif et al. (2020), it is of considerable importance to study the connectedness of commodities in light of recent uncertainties, such as climate risk and geopolitical risk. After COVID, we saw the trade war between China and the US (Ji et al., 2018a), the recent conflict between Russia and Ukraine. As the Russia-Ukraine conflict has a strong correlation not only with commodities, but also with other financial assets, future research will likely focus on its impact. Hence, Copula models have yet to thoroughly explore the interdependence not only between oil and stock markets but within commodities across countries or regions as well as connectedness of commodities with other financial markets. In line with existing works that combine copula models with other methodologies like time frequency, wavelet or TVP-VAR models, combining copula models with machine learning and artificial intelligence models is likely to figure out to what extent do different methodologies lead to different conclusions.

5. Conclusion

We provide a bibliometric study on commodity connectedness, based on a sample of 437 studies between 1994 and 2022. We adopt a meta-literature analysis that combines bibliometric and co-citation analysis through influential countries and authors and cartography analysis, along with a content analysis. The content analysis findings of our bibliometric review reveal four research streams. The red stream deals with commodity connectedness within a single market or between cross-commodity markets. The green stream comprises several papers that discuss three main sub-topics, which are currently in trend. The last two streams are relatively less explored yet important, and both focus on oil as the main comment commodity with different dimensions such as connectedness between oil and stock markets, financial markets, utilizing various methodologies such as copula models and time frequency models. Lastly, we have identified various areas in the literature that require further exploration and have recommended potential directions

for future research.

Our paper provides interesting implications for academicians, research scholars, and upcoming graduates. By identifying the leading journals in this area with the main keywords and the future directions, researchers are more guided towards the research gaps to be filled in the future on the intersections of commodities-financial markets nexus. The current bibliometric study is helpful for research scholars to identify the most influential research topics in this area that have the most useful implications and reap the highest citations that allow it to be among top universities. Managers and policymakers may find good insights through the mining analysis of the conclusions and the implications of the existing studies on this filed, to better understand the price and risk dynamics of commodities and their abilities to diversify their portfolios. Policymakers may be guided with our outputs when implementing their monetary, international trade and sustainability policies. Investors and portfolio managers can also find this study useful in terms of mitigating their risk and identifying potential markets through various connectedness studies. On the grounds of volatility in the commodity markets, the current study also provides fresh insights by highlighting key distressed events, for example, global financial crisis, oil crisis, COVID-19. However, following the Russia-Ukraine war, researchers need to explore

a plethora of evidence on the dynamics of commodity-financial markets nexus.

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Author statement

All the authors equally contributed to the manuscript.

Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

Data availability

Data will be made available on request.

Appendix 1A

Description	Results
<i>Main information about data</i>	
Timespan	1994:2022
Sources (Journals, Books, etc)	50
Documents	437
Average years from publication	4.65
Average citations per documents	40.23
Average citations per year per doc	6.434
References	10275
<i>Document types</i>	
Article	418
article; early access	10
article; proceedings paper	6
Review	2
<i>Document contents</i>	
Keywords Plus (ID)	707
Author's Keywords (DE)	1116
<i>Authors</i>	
Authors	825
Author Appearances	1295
Authors of single-authored documents	28
Authors of multi-authored documents	797
<i>Authors collaboration</i>	
Single-authored documents	34
Documents per Author	0.53
Authors per Document	1.89
Co-Authors per Documents	2.96
Collaboration Index	1.98

References

- Ai, C., Chatrath, A., Song, F., 2006. On the comovement of commodity prices. *Am. J. Agric. Econ.* 88 (3), 574–588.
- Alfeus, M., Nikitopoulos, C.S., 2022. Forecasting volatility in commodity markets with long-memory models. *Journal of Commodity Markets*, 100248.
- Alon, I., Anderson, J., Munim, Z.H., Ho, A., 2018. A review of the internationalization of Chinese enterprises. *Asia Pac. J. Manag.* (1), 573–605.
- Antonakakis, N., Kizys, R., 2015. Dynamic spillovers between commodity and currency markets. *Int. Rev. Financ. Anal.* 41, 303–319.
- Antonakakis, N., Chatziantoniou, I., Filis, G., 2014. Dynamic spillovers of oil price shocks and economic policy uncertainty. *Energy Econ.* 44, 433–447.
- Antonakakis, N., Chatziantoniou, I., Filis, G., 2017. Oil shocks and stock markets: dynamic connectedness under the prism of recent geopolitical and economic unrest. *Int. Rev. Financ. Anal.* 50, 1–26.
- Anwer, Z., Naeem, M.A., Hassan, M.K., Karim, S., 2022a. Asymmetric connectedness across Asia-Pacific currencies: evidence from time-frequency domain analysis. *Finance Res. Lett.*, 102782.
- Anwer, Z., Khan, A., Naeem, M.A., Tiwari, A.K., 2022b. Modelling systemic risk of energy and non-energy commodity markets during the COVID-19 pandemic. *Ann. Oper. Res.* 1–35.
- Arfaoui, N., Naeem, M.A., Boubaker, S., Mirza, N., Karim, S., 2023. Interdependence of clean energy and green markets with cryptocurrencies. *Energy Econ.* 120, 106584.
- Aria, M., Cuccurullo, C., 2017. bibliometrix: an R-tool for comprehensive science mapping analysis. *Journal of informetrics* 11 (4), 959–975.
- Aroui, M.E.H., Jouini, J., Nguyen, D.K., 2011. Volatility spillovers between oil prices and stock sector returns: implications for portfolio management. *J. Int. Money Finance* 30 (7), 1387–1405.
- Aroui, M.E.H., Jouini, J., Nguyen, D.K., 2012. On the impacts of oil price fluctuations on European equity markets: volatility spillover and hedging effectiveness. *Energy Econ.* 34 (2), 611–617.

- Awartani, B., Aktham, M., Cherif, G., 2016. The connectedness between crude oil and financial markets: evidence from implied volatility indices. *Journal of Commodity Markets* 4 (1), 56–69.
- Bahoo, S., Alon, I., Paltrinieri, A., 2020. Corruption in international business: a review and research agenda. *Int. Bus. Rev.* 29 (4), 101660.
- Balciar, M., Usman, O., Agan, B., 2021. On the connectedness of commodity markets: a critical and selective survey of empirical studies and bibliometric analysis. *J. Econ. Surv.* 00, 1–40.
- Batten, J.A., Ciner, C., Lucey, B.M., 2017. The dynamic linkages between crude oil and natural gas markets. *Energy Econ.* 62, 155–170.
- Benlagha, N., Karim, S., Naeem, M.A., Lucey, B.M., Vigne, S.A., 2022. Risk connectedness between energy and stock markets: evidence from oil importing and exporting countries. *Energy Econ.* 115, 106348.
- Billah, M., Karim, S., Naeem, M.A., Vigne, S.A., 2022. Return and volatility spillovers between energy and BRIC markets: evidence from quantile connectedness. *Res. Int. Bus. Finance* 62, 101680.
- Boubaker, H., Raza, S.A., 2017. A wavelet analysis of mean and volatility spillovers between oil and BRICS stock markets. *Energy Econ.* 64, 105–117.
- Bouri, E., 2023. Spillovers in the joint system of conditional higher-order moments: US evidence from green energy, brown energy, and technology stocks. *Renew. Energy* 210, 507–523.
- Bouri, E., Shahzad, S.J.H., Roubaud, D., Kristoufek, L., Lucey, B., 2020. Bitcoin, gold, and commodities as safe havens for stocks: new insight through wavelet analysis. *Q. Rev. Econ. Finance* 77, 156–164.
- Bouri, E., Lei, X., Xu, Y., Zhang, H., 2023. Connectedness in implied higher-order moments of precious metals and energy markets. *Energy* 263, 125588.
- Boyd, N.E., Harris, J.H., Li, B., 2018. An update on speculation and financialization in commodity markets. *Journal of Commodity Markets* 10, 91–104.
- Byrne, J.P., Fazio, G., Fliess, N., 2013. Primary commodity prices: Co-movements, common factors and fundamentals. *J. Dev. Econ.* 101, 16–26.
- Carter, D.A., Rogers, D.A., Simkins, B.J., Treanor, S.D., 2017. A review of the literature on commodity risk management. *Journal of Commodity Markets* 8, 1–17.
- Chemkha, R., BenSaïda, A., Ghorbel, A., Tayachi, T., 2021. Hedge and safe haven properties during COVID-19: evidence from Bitcoin and gold. *Q. Rev. Econ. Finance* 82, 71–85.
- Chiaramonte, L., Dreassi, A., Piserà, S., Khan, A., 2022. Mergers and Acquisitions in the Financial Industry: a bibliometric review and future research directions. *Res. Int. Bus. Finance*, 101837.
- Corbet, S., Larkin, C., Lucey, B., 2020. The contagion effects of the COVID-19 pandemic: evidence from gold and cryptocurrencies. *Finance Res. Lett.* 35, 101554.
- Costola, M., Lorusso, M., 2022. Spillovers among energy commodities and the Russian stock market. *Journal of Commodity Markets*, 100249.
- Cui, J., Goh, M., Li, B., Zou, H., 2021. Dynamic dependence and risk connectedness among oil and stock markets: new evidence from time-frequency domain perspectives. *Energy* 216, 119302.
- Cui, J., Maghyereh, A., 2023. Higher-order moment risk connectedness and optimal investment strategies between international oil and commodity futures markets: insights from the COVID-19 pandemic and Russia-Ukraine conflict. *Int. Rev. Financ. Anal.*, 102520.
- Dahl, R.E., Oglend, A., Yahya, M., 2020. Dynamics of volatility spillover in commodity markets: linking crude oil to agriculture. *Journal of Commodity Markets* 20, 100111.
- Dai, Z., Zhu, H., 2022. Time-varying spillover effects and investment strategies between WTI crude oil, natural gas and Chinese stock markets related to belt and road initiative. *Energy Econ.* 108, 105883.
- Deb, P., Trivedi, P.K., Varangis, P., 1996. The excess co-movement of commodity prices reconsidered. *J. Appl. Econom.* 11 (3), 275–291.
- Diebold, F.X., Liu, L., Yilmaz, K., 2017. *Commodity Connectedness* (No. W23685). National Bureau of Economic Research.
- Ding, Z., Liu, Z., Zhang, Y., Long, R., 2017. The contagion effect of international crude oil price fluctuations on Chinese stock market investor sentiment. *Appl. Energy* 187, 27–36.
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., Lim, W.M., 2021. How to conduct a bibliometric analysis: an overview and guidelines. *J. Bus. Res.* 133, 285–296.
- Du, X., Cindy, L.Y., Hayes, D.J., 2011. Speculation and volatility spillover in the crude oil and agricultural commodity markets: a Bayesian analysis. *Energy Econ.* 33 (3), 497–503.
- Ederington, L.H., Fernando, C.S., Hoelscher, S.A., Lee, T.K., Linn, S.C., 2019. A review of the evidence on the relation between crude oil prices and petroleum product prices. *Journal of Commodity Markets* 13, 1–15.
- Esmaili, A., Shokoohi, Z., 2011. Assessing the effect of oil price on world food prices: application of principal component analysis. *Energy Pol.* 39 (2), 1022–1025.
- Fan, Y., Zhang, Y.J., Tsai, H.T., Wei, Y.M., 2008. Estimating 'Value at Risk' of crude oil price and its spillover effect using the GED-GARCH approach. *Energy Econ.* 30 (6), 3156–3171.
- Farid, S., Karim, S., Naeem, M.A., Nepal, R., Jamasb, T., 2023. Co-movement between dirty and clean energy: a time-frequency perspective. *Energy Econ.* 119, 106565.
- Ferrer, R., Shahzad, S.J.H., López, R., Jareño, F., 2018. Time and frequency dynamics of connectedness between renewable energy stocks and crude oil prices. *Energy Econ.* 76, 1–20.
- Foglia, M., Angelini, E., Huynh, T.L.D., 2022. Tail risk connectedness in clean energy and oil financial market. *Ann. Oper. Res.* 1–25.
- Ftiti, Z., Guesmi, K., Abid, I., 2016. Oil price and stock market co-movement: what can we learn from time-scale approaches? *Int. Rev. Financ. Anal.* 46, 266–280.
- Gajurel, D., Chawla, A., 2022. The oil price crisis and contagion effects on the Canadian economy. *Appl. Econ.* 54 (13), 1527–1543.
- Ghosh, S., Kanjilal, K., 2016. Co-movement of international crude oil price and Indian stock market: evidences from nonlinear cointegration tests. *Energy Econ.* 53, 111–117.
- Guesmi, K., Saadi, S., Abid, I., Ftiti, Z., 2019. Portfolio diversification with virtual currency: evidence from bitcoin. *Int. Rev. Financ. Anal.* 63, 431–437.
- Hoang, K., Nguyen, C.C., Poch, K., Nguyen, T.X., 2020. Does Bitcoin hedge commodity uncertainty? *J. Risk Financ. Manag.* 13 (6), 119.
- Ivanovski, K., Hailemariam, A., 2021. Forecasting the dynamic relationship between crude oil and stock prices since the 19th century. *Journal of Commodity Markets* 24, 100169.
- Jain, P., Maitra, D., 2023. Is there commodity connectedness across investment horizons? Evidence using news-based uncertainty indices. *Econ. Lett.*, 111025.
- Ji, Q., Bouri, E., Roubaud, D., 2018a. Dynamic network of implied volatility transmission among US equities, strategic commodities, and BRICS equities. *Int. Rev. Financ. Anal.* 57, 1–12.
- Ji, Q., Bouri, E., Roubaud, D., Kristoufek, L., 2019c. Information interdependence among energy, cryptocurrency and major commodity markets. *Energy Econ.* 81, 1042–1055.
- Ji, Q., Li, J., Sun, X., 2019b. Measuring the interdependence between investor sentiment and crude oil returns: new evidence from the CFTC's disaggregated reports. *Finance Res. Lett.* 30, 420–425.
- Ji, Q., Liu, B.Y., Fan, Y., 2019a. Risk dependence of CoVaR and structural change between oil prices and exchange rates: a time-varying copula model. *Energy Econ.* 77, 80–92.
- Ji, Q., Liu, B.Y., Zhao, W.L., Fan, Y., 2020. Modelling dynamic dependence and risk spillover between all oil price shocks and stock market returns in the BRICS. *Int. Rev. Financ. Anal.* 68, 101238.
- Ji, Q., Zhang, D., Geng, J.B., 2018b. Information linkage, dynamic spillovers in prices and volatility between the carbon and energy markets. *J. Clean. Prod.* 198, 972–978.
- Jiang, Z., Yoon, S.M., 2020. Dynamic co-movement between oil and stock markets in oil-importing and oil-exporting countries: two types of wavelet analysis. *Energy Econ.* 90, 104835.
- Jouini, J., 2013. Return and volatility interaction between oil prices and stock markets in Saudi Arabia. *J. Pol. Model.* 35 (6), 1124–1144.
- Kang, S.H., Lee, J.W., 2019. The network connectedness of volatility spillovers across global futures markets. *Phys. Stat. Mech. Appl.* 526, 120756.
- Kang, S.H., McIver, R., Yoon, S.M., 2017. Dynamic spillover effects among crude oil, precious metal, and agricultural commodity futures markets. *Energy Econ.* 62, 19–32.
- Kang, W., Ratti, R.A., Yoon, K.H., 2014. The impact of oil price shocks on US bond market returns. *Energy Econ.* 44, 248–258.
- Karim, S., Naeem, M.A., 2022. Do global factors drive the interconnectedness among green, Islamic and conventional financial markets? *Int. J. Manag. Finance* 18 (4), 639–660.
- Karim, S., Naeem, M.A., Shafiqullah, M., Lucey, B.M., Ashraf, S., 2023. Asymmetric relationship between climate policy uncertainty and energy metals: evidence from cross-quantilegram. *Finance Res. Lett.*, 103728.
- Karim, S., Lucey, B.M., Naeem, M.A., Uddin, G.S., 2022a. Examining the Interrelatedness of NFTs, DeFi Tokens and Cryptocurrencies. *Finance Research Letters*, 102696.
- Karim, S., Lucey, B.M., Naeem, M.A., Vigne, S.A., 2022b. The dark side of Bitcoin: do Emerging Asian Islamic markets help subdue the ethical risk? *Emerg. Mark. Rev.*, 100921.
- Karim, S., Naeem, M.A., Mirza, N., Paule-Vianez, J., 2022c. Quantifying the hedge and safe-haven properties of bond markets for cryptocurrency indices. *J. Risk Finance* 23 (2), 191–205.
- Karim, S., Naeem, M.A., 2022. Clean energy, Australian electricity markets, and information transmission. *Energy Research Letters* 3 (3).
- Karim, S., Naeem, M.A., Hu, M., Zhang, D., Taghizadeh-Hesary, F., 2022d. Determining dependence, centrality, and dynamic networks between green bonds and financial markets. *J. Environ. Manag.* 318, 115618.
- Keilbar, G., Wang, W., 2022. Modelling systemic risk using neural network quantile regression. *Empir. Econ.* 62 (1), 93–118.
- Khan, A., Goodell, J.W., Hassan, M.K., Paltrinieri, A., 2021. A bibliometric review of finance bibliometric papers. *Finance Res. Lett.*, 102520.
- Khan, A., Hassan, M.K., Paltrinieri, A., Dreassi, A., Bahoo, S., 2020. A bibliometric review of takaful literature. *Int. Rev. Econ. Finance* 69, 389–405.
- Kielmann, J., Manner, H., Min, A., 2022. Stock market returns and oil price shocks: a CoVaR analysis based on dynamic vine copula models. *Empir. Econ.* 62 (4), 1543–1574.
- Le, T.H., 2023. Quantile time-frequency connectedness between cryptocurrency volatility and renewable energy volatility during the COVID-19 pandemic and Ukraine-Russia conflicts. *Renew. Energy* 202, 613–625.
- Li, X., Wei, Y., 2018. The dependence and risk spillover between crude oil market and China stock market: new evidence from a variational mode decomposition-based copula method. *Energy Econ.* 74, 565–581.
- Lin, B., Su, T., 2020. Mapping the oil price-stock market nexus researches: a scientometric review. *Int. Rev. Econ. Finance* 67, 133–147.
- Lin, B., Wesesler Jr., P.K., Appiah, M.O., 2014. Oil price fluctuation, volatility spillover and the Ghanaian equity market: implication for portfolio management and hedging effectiveness. *Energy Econ.* 42, 172–182.
- Lin, L., Zhou, Z., Liu, Q., Jiang, Y., 2019. Risk transmission between natural gas market and stock markets: portfolio and hedging strategy analysis. *Finance Res. Lett.* 29, 245–254.
- Lin, S.X., Tamvakis, M.N., 2001. Spillover effects in energy futures markets. *Energy Econ.* 23 (1), 43–56.

- Liu, B.Y., Ji, Q., Fan, Y., 2017. A new time-varying optimal copula model identifying the dependence across markets. *Quant. Finance* 17 (3), 437–453.
- Liu, C., Naeem, M.A., Rehman, M.U., Farid, S., Shahzad, S.J.H., 2020. Oil as hedge, safe-haven, and diversifier for conventional currencies. *Energies* 13 (17), 4354.
- Liu, T., Gong, X., 2020. Analyzing time-varying volatility spillovers between the crude oil markets using a new method. *Energy Econ.* 87, 104711.
- Liu, J., Man, Y., Dong, X., 2023. Tail dependence and risk spillover effects between China's carbon market and energy markets. *Int. Rev. Econ. Finance* 84, 553–567.
- Maghyereh, A.I., Awartani, B., Bouri, E., 2016. The directional volatility connectedness between crude oil and equity markets: new evidence from implied volatility indexes. *Energy Econ.* 57, 78–93.
- Mensi, W., Beljid, M., Boubaker, A., Managi, S., 2013. Correlations and volatility spillovers across commodity and stock markets: linking energies, food, and gold. *Econ. Modell.* 32, 15–22.
- Mensi, W., Hammoudeh, S., Shahzad, S.J.H., Al-Yahyaee, K.H., Shahbaz, M., 2017. Oil and foreign exchange market tail dependence and risk spillovers for MENA, emerging and developed countries: VMD decomposition based copulas. *Energy Econ.* 67, 476–495.
- Mukherjee, D., Lim, W.M., Kumar, S., Donthu, N., 2022. Guidelines for advancing theory and practice through bibliometric research. *J. Bus. Res.* 148, 101–115.
- Naeem, M.A., Karim, S., 2021. Tail dependence between bitcoin and green financial assets. *Econ. Lett.* 208, 110068.
- Naeem, M.A., Balli, F., Shahzad, S.J.H., de Bruin, A., 2020. Energy commodity uncertainties and the systematic risk of US industries. *Energy Econ.* 85, 104589.
- Naeem, M.A., Farid, S., Balli, F., Hussain Shahzad, S.J., 2021a. Hedging the downside risk of commodities through cryptocurrencies. *Appl. Econ. Lett.* 28 (2), 153–160.
- Naeem, M.A., Karim, S., Hasan, M., Lucey, B.M., Kang, S.H., 2022a. Nexus between oil shocks and agriculture commodities: evidence from time and frequency domain. *Energy Econ.* 112, 106148.
- Naeem, M.A., Karim, S., Uddin, G.S., Junttila, J., 2022b. Small fish in big ponds: connections of green finance assets to commodity and sectoral stock markets. *Int. Rev. Financ. Anal.* 83, 102283.
- Naeem, M.A., Iqbal, N., Lucey, B.M., Karim, S., 2022c. Good versus bad information transmission in the cryptocurrency market: evidence from high-frequency data. *J. Int. Financ. Mark. Inst. Money* 81, 101695.
- Naeem, M.A., Yousaf, I., Karim, S., Yarovaya, L., Ali, S., 2022d. Tail-event driven NETWORK dependence in emerging markets. *Emerg. Mark. Rev.*, 100971
- Naeem, M.A., Pham, L., Senthilkumar, A., Karim, S., 2022e. Oil shocks and BRIC markets: evidence from extreme quantile approach. *Energy Econ.* 108, 105932.
- Naeem, M.A., Appiah, M., Karim, S., Yarovaya, L., 2023. What abates environmental efficiency in African economies? Exploring the influence of infrastructure, industrialization, and innovation. *Technol. Forecast. Soc. Change* 186, 122172.
- Naeem, M.A., Rabbani, M.R., Karim, S., Billah, S.M., 2021b. Religion vs ethics: hedge and safe haven properties of Sukuk and green bonds for stock markets pre-and during COVID-19. *Int. J. Islam. Middle E Finance Manag.* 16 (2), 234–252.
- Natanelov, V., Alam, M.J., McKenzie, A.M., Van Huylenbroeck, G., 2011. Is there co-movement of agricultural commodities futures prices and crude oil? *Energy Pol.* 39 (9), 4971–4984.
- Nazlioglu, S., Erdem, C., Soytaş, U., 2013. Volatility spillover between oil and agricultural commodity markets. *Energy Econ.* 36, 658–665.
- Nazlioglu, S., Soytaş, U., Gupta, R., 2015. Oil prices and financial stress: a volatility spillover analysis. *Energy Pol.* 82, 278–288.
- Nguyen, D.B.B., Prokopczuk, M., 2019. Jumps in commodity markets. *Journal of Commodity Markets* 13, 55–70.
- Paltrinieri, A., Hassan, M.K., Bahoo, S., Khan, A., 2019. A Bibliometric Review of Sukuk Literature. *International Review of Economics & Finance.*
- Peng, X., 2020. Do precious metals act as hedges or safe havens for China's financial markets? *Finance Res. Lett.* 37, 101353.
- Pham, S.D., Nguyen, T.T.T., Do, H.X., 2023. Natural gas and the utility sector nexus in the US: quantile connectedness and portfolio implications. *Energy Econ.*, 106632
- Pham, L., Karim, S., Naeem, M.A., Long, C., 2022. A tale of two tails among carbon prices, green and non-green cryptocurrencies. *Int. Rev. Financ. Anal.* 82, 102139.
- Reboredo, J.C., 2011. How do crude oil prices co-move?: a copula approach. *Energy Econ.* 33 (5), 948–955.
- Reboredo, J.C., 2012. Modelling oil price and exchange rate co-movements. *J. Pol. Model.* 34 (3), 419–440.
- Reboredo, J.C., 2018. Green bond and financial markets: Co-movement, diversification and price spillover effects. *Energy Econ.* 74, 38–50.
- Ren, B., Lucey, B., 2022. A clean, green haven?—examining the relationship between clean energy, clean and dirty cryptocurrencies. *Energy Econ.* 109, 105951.
- Rubbaniy, G., Khalid, A.A., Syriopoulos, K., Samitas, A., 2021. Safe-haven properties of soft commodities during times of COVID-19. *Journal of Commodity Markets*, 100223.
- Salisu, A.A., Mobolaji, H., 2013. Modeling returns and volatility transmission between oil price and US–Nigeria exchange rate. *Energy Econ.* 39, 169–176.
- Salisu, A.A., Oloko, T.F., 2015. Modeling oil price–US stock nexus: a VARMA–BEKK–AGARCH approach. *Energy Econ.* 50, 1–12.
- Sharif, A., Aloui, C., Yarovaya, L., 2020. COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: fresh evidence from the wavelet-based approach. *Int. Rev. Financ. Anal.* 70, 101496.
- Siddique, M.A., Nobanee, H., Karim, S., Naz, F., 2022. Investigating the role of metal and commodity classes in overcoming resource destabilization. *Resour. Pol.* 79, 103075.
- Siddique, M.A., Nobanee, H., Karim, S., Naz, F., 2023. Do green financial markets offset the risk of cryptocurrencies and carbon markets? *Int. Rev. Econ. Finance* 86, 822–833.
- Song, Y., Ji, Q., Du, Y.J., Geng, J.B., 2019. The dynamic dependence of fossil energy, investor sentiment and renewable energy stock markets. *Energy Econ.* 84, 104564.
- Vacha, L., Barunik, J., 2012. Co-movement of energy commodities revisited: evidence from wavelet coherence analysis. *Energy Econ.* 34 (1), 241–247.
- Van Eck, N., Waltman, L., 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 84 (2), 523–538.
- Wang, Y., Wu, C., Yang, L., 2013. Oil price shocks and stock market activities: evidence from oil-importing and oil-exporting countries. *J. Comp. Econ.* 41 (4), 1220–1239.
- Wen, D., Wang, G.J., Ma, C., Wang, Y., 2019. Risk spillovers between oil and stock markets: a VAR for VaR analysis. *Energy Econ.* 80, 524–535.
- Wen, X., Guo, Y., Wei, Y., Huang, D., 2014. How do the stock prices of new energy and fossil fuel companies correlate? Evidence from China. *Energy Econ.* 41, 63–75.
- Wu, C.C., Chung, H., Chang, Y.H., 2012. The economic value of co-movement between oil price and exchange rate using copula-based GARCH models. *Energy Econ.* 34 (1), 270–282.
- Xia, T., Ji, Q., Zhang, D., Han, J., 2019. Asymmetric and extreme influence of energy price changes on renewable energy stock performance. *J. Clean. Prod.* 241, 118338.
- Yahya, M., Oglend, A., Dahl, R.E., 2019. Temporal and spectral dependence between crude oil and agricultural commodities: a wavelet-based copula approach. *Energy Econ.* 80, 277–296.
- Yang, L., Cai, X.J., Hamori, S., 2017. Does the crude oil price influence the exchange rates of oil-importing and oil-exporting countries differently? A wavelet coherence analysis. *Int. Rev. Econ. Finance* 49, 536–547.
- Zhang, D., 2017. Oil shocks and stock markets revisited: measuring connectedness from a global perspective. *Energy Econ.* 62, 323–333.
- Zhang, D., Zhang, Z., Managi, S., 2019. A bibliometric analysis on green finance: current status, development, and future directions. *Finance Res. Lett.* 29, 425–430.
- Zhang, Q., Hu, Y., Jiao, J., Wang, S., 2022. Exploring the trend of commodity prices: a review and bibliometric analysis. *Sustainability* 14 (15), 9536.
- Zhang, Y.J., Fan, Y., Tsai, H.T., Wei, Y.M., 2008. Spillover effect of US dollar exchange rate on oil prices. *J. Pol. Model.* 30 (6), 973–991.
- Zhu, H., Guo, Y., You, W., Xu, Y., 2016. The heterogeneity dependence between crude oil price changes and industry stock market returns in China: evidence from a quantile regression approach. *Energy Econ.* 55, 30–41.