Review

Market Connectedness and Volatility Spillovers: A Meta-Literature Review

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Abstract: Evaluation of market connectedness and asymmetric volatility spillover has recently seen a surge in financial risk analytics and portfolio diversification. We carried out a meta-literature review on connectedness and spillovers, providing solid insight into the research field and robust guidelines for future investigation. The review consists of a quantitative bibliometric analysis of 594 papers and a qualitative content analysis of 77 papers covering 1991 to 2021. The results of the meta-citation analysis show that *Diebold's Spillover index* (2007) is the predominant method in most works as far as market connectedness and spillover are concerned. With an extensive review, we achieved the following objectives: (1) Analyze the most influential authors, journals, and publications. (2) Understand the research streams and most studied streams. (3) Understand the theme's structure, thematic evolution, and keyword trends. (4) Examine the pattern of collaboration and most productive affiliations. (5) Explore future research directions and untapped areas. The content analysis revealed the following important research streams in the current literature: (1) Asymmetries in market connectedness. (2) Influence of macro factors in market connectedness and spillover. (3) The role of oil in market spillovers and hedging portfolios. (4) Dynamic cross-market connectedness and spillovers. Our study is the first to employ a meta-review to assess the domain of market connectedness; thus, our work will significantly contribute to macroeconomic policymakers, researchers and hedging investors.

Keywords: integration; bibliometric analysis; meta-analysis; content analysis; asymmetric information; portfolio diversification

1. Introduction

The past decade has exhibited a significant perturbation of the markets, with consequent international crises. This has led to research, as reported in the literature, on financial market integration, connectedness, and co-movements, and there is a spillover of this research, with implications for policy and portfolio diversification. While financial turmoil threatens the market's stability, it also threatens the stability of the country's economic activities. Two of the main non-trivial problems decision-makers and investors face are managing optimal portfolios and asset allocations and adopting policies that will stabilize the economy and markets [1].

Ref. [2] defined financial shocks and transmissions, or causality in the variance between markets and volatility spillovers. Ref. [3] called this variance contagion, usually detected during events or crises as they increase cross-market linkage or co-movements. Later, studies [1,4,5] explored the information dissemination and asymmetries surrounding market connectedness and spillovers, which pose another non-trivial problem, as there is a lack of knowledge on the market's reaction towards these asymmetries.

Ref. [6] proposed that the increase in volatility converges from innovation and development, investor protection, financial openness, and the country's level of risk. Studies have addressed determinants of why and how these volatility transmissions occur. Most triggering factors are macro- and economic-policy-based, and some are potentially due to

the firm's origin or country of origin [7–11]. Thus, market connectedness and volatility spillovers grabbed researchers' interest in market information dissemination and how to help this behavior bear fruit, so to speak, from markets, through hedging and diversification.

Although there have been several studies concerning market integration, and there is also literature regarding linkage, our study tried to delve into a specific field, rather than a broad review: connectedness and volatility spillover across the market. We tried to address these research areas from the evolutionary point of view. For this, we conducted a review with the following objectives: (1) Analyze the most influential authors, journals, and publications. (2) Understand the research streams and most studied streams. (3) Understand the theme's structure, thematic evolution, and keyword trends. (4) Examine the pattern of collaboration and most productive affiliations. (5) Explore future research directions and untapped areas. To examine the above questions to the fullest, we have adopted the meta-literature review method, comprising a bibliometric analysis and content analysis from 1991 to 2021 with the keywords given in Figure 1.
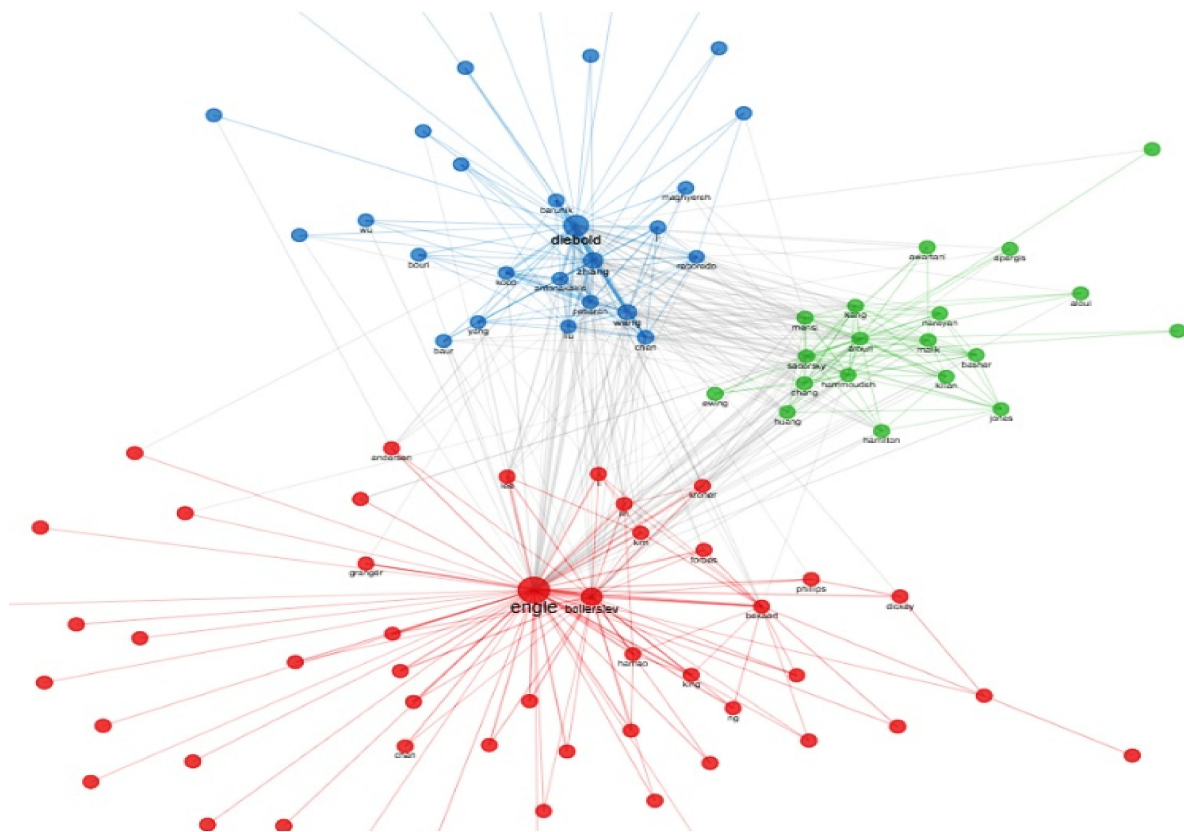

Figure 1. Results of co-citation analysis. Source: Produced by the author using Biblioshiny.

We identified four streams in the current literature on connectedness and spillover: (1) Asymmetries in market connectedness. (2) The influence of macro factors in market connectedness and spillover. (3) The role of oil in market spillovers and hedging portfolios. (4) Dynamic cross-market connectedness and spillovers. We also identified key research questions and future research directions, which will be of great interest to researchers, policymakers, and potential investors.

The paper is presented as follows. In Section 2, the methodology and analysis conducted are discussed. Sections 3 and 4 present significant aspects of connectedness, spillover, and visualization, as well as the results of the co-citation analysis and word analysis, respectively. In Section 5, we provide an extensive content analysis of the core papers of the literature, and in Section 6 we discuss potential research streams and future directions. In Section 7, we concluded the paper.

2. Methodology

A meta-analysis is an excellent tool for extracting multiple explorations of a subject matter from numerous pieces of work [12]. The systematic review of the literature has grown in popularity, evidently, and become an ideal method to deliver evidence on the meta-level and disclose which area needs more research contributions [13]. Our study used bibliometric analysis to assess statistical properties and content analysis to assess the validity and reliability of the research.

Bibliometric analysis has evolved considerably, and is aligned with many software updates for the mapping and visualization of research. Bibliometrix, an R package, allowed us to evaluate various statistical parameters and perform mapping. Content analysis is a text-mining method that systematically reviews and assesses the validity of research knowledge—an outline of the methodology is provided in Figure A1 in the Appendix A.

2.1. Data Collection and Sample Selection Process

Our sample selection comprised the following steps: first, we extracted the data using keywords and refined the final ones using the most used author's keywords in the data from the Scopus database. Ref. [14] mentioned that Scopus is quite comprehensive as it includes expansive publications, houses, and fields of study.

We useed Bibliometrix to examine the metadata (bibliographic information) for the most used keywords to refine our data to the core papers. The final keywords used to refine the extraction of articles from the database are stated in Figure A1 in the Appendix A, in which also appear the title, abstracts, and keywords. Secondly, we filtered the journals based on their score on the SJR. For quality papers, we selected only the journals that scored one and above in the SJR.

2.2. Data Analysis and Visualization

2.2.1. Meta-Literature Review

Our research is centered on two methods: bibliometric analysis for quantitative and empirical analysis and content analysis for qualitative analysis. Following [12,15–19], the subsequent analyses are conducted: (1) co-citation analysis, (2) co-authorships, and (3) co-word and thematic evolution analyses.

We predominantly utilize the RStudio package 'Bibliometrix' provided by [20]. Bibliometrix is an R tool for comprehensive science mapping analysis that uses the metadata (bibliographic information) as input and provides networks, clusters and themes for the input data. The software is utilized to conduct (1) co-citation analysis, (2) co-authorship analysis, and (3) co-word analysis and thematic evolution. The tool captures the intellectual, conceptual and social network of the specified research field. Our study design is described in the following subsections.

2.2.2. Co-Citation Analysis

Co-citation analysis investigates the cited documents, examines the connections, and infers the shift in the apex and schools of thought. Depending on the scope of analysis, the co-citation network attempts to depict the connection between sources, articles and authors. Thus, it assists us in capturing the impact of these various actors in the field and their influence on the research area [12,20,21]. Even though numerous citation analyses exist to improve the literature research, we employ co-citation analysis in our study due to its prospective and dynamic nature as well as its efficacy across multiple time segments.

2.2.3. Co-Authorship Analysis

Using co-authorship and collaboration analysis, a social network framework among various affiliations and countries is constructed. Future global and regional collaboration and research directions can be inferred. Consequently, a comprehensive structure of the research pyramids is attained by evaluating the domain's social structure and leading scholars, as well as capturing the total knowledge production in the field.

2.2.4. Co-Word Analysis

Co-word analysis provides a framework for conceptual structure by mapping and clustering the keyword co-occurrences. The software provides us with the conceptual structure by means of multiple correspondence analysis, which identifies the cluster of related concepts [22,23].

2.2.5. Word Trend and Thematic Analysis

We performed a keyword analysis to identify the key streams in the literature. We used the word trend and thematic analysis in the software. We illustrated the significant shifts in keyword usage over time and evaluated the pertinent change in the streams through thematic analysis.

2.2.6. Content Analysis

We conducted content analysis to add a qualitative dimension to the empirical research from [17,24]. We verify and categorize the research stream and explore in greater depth the origins and evolution of the concepts, research topics, significant findings and research gaps in more detail.

3. Identification of Significant Aspects of Connectedness and the Spillover Literature

The general information about our sample is presented in Table 1.

Table 1. Main information about the data.

Description	Results
Timespan	1991–2021
Sources (Journals, Books, etc.)	66
Documents	594
Annual Growth Rate %	16.14
Document Average Age	7.41
Average citations per doc	42.79
References	23,501
Document Contents	
Keywords Plus (ID)	1073
Author's Keywords (DE)	1428
Authors	
Authors	1104
Authors of single-authored docs	85
Authors Collaboration	
Single-authored docs	87
Co-Authors per Doc	2.63
International co-authorships %	37.21
Document Types	
article	585
conference paper	2
erratum	2
review	5

Source: Author's calculation using Biblioshiny.

We have also provided a comprehensive summary of key papers in each stream in Appendix A.

3.1. Most Studied Countries

We provided the list of most studied countries in Table 2 based on the total number of articles the and MCP ratio.

Table 2. Most studied countries.

Country	TC	Average Article Citations
USA	4483	75.98
China	2579	31.07
United Kingdom	1604	34.13
Australia	1427	43.24
France	1151	46.04
Czech Republic	828	118.29
Greece	824	45.78
Korea	769	36.62
Spain	725	31.52
Japan	591	59.1

Source: same as Table 1.

It is evident that the top three countries studied in the literature are the United States, China, and the United Kingdom, while the remaining top 10 countries are predominantly European. Based on the content analysis, we determined that extensive research must be conducted on the frontier countries and specific Asian countries. Examining the most- and least-researched nations assists in directing future research. Cross-market portfolio diversification can be explored effectively by the inclusion of frontier countries. However, few effective studies have been conducted on the dynamics of frontier markets and it appears that the focus of the research will transfer from developed markets to the emerging and frontier markets.

3.2. Most Influential Journal

We identified top journals based on three parameters—number of articles, impact scores, and Bradford's law. The results are shown in Table 3.

Table 3. Influential journals.

Panel 1: As per Bradford's law				
Sources	Rank	Freq	cumFreq	Zone
Energy Economics	1	88	88	Zone 1
International Review of Financial Analysis	2	63	151	Zone 1
Research in International Business and Finance	3	58	209	Zone 1
Resources Policy	4	56	265	Zone 2
Economic Modelling	5	54	319	Zone 2
Journal of International Financial Markets, Institutions and Money	6	51	370	Zone 2
Finance Research Letters	7	31	401	Zone 2
Journal of Banking and Finance	8	30	431	Zone 3
Journal of International Money and Finance	9	30	461	Zone 3
Journal of Empirical Finance	10	13	474	Zone 3

Table 3. *Cont.*

	h_index	g_index	m_index	TC	NP	PY_start
Panel 2: As per the impact scores						
Energy Economics	41	72	2.278	5400	88	2005
Economic Modelling	25	44	1.087	2041	53	2000
International Review of Financial Analysis	23	47	0.92	2324	63	1998
Journal of Banking and Finance	22	30	0.846	1965	30	1997
Research in International Business and Finance	22	36	1.158	1434	57	2004
Journal of International Financial Markets, Institutions and Money	21	34	0.808	1246	51	1997
Journal of International Money and Finance	21	30	0.7	2312	30	1993
Resources Policy	21	32	2.333	1176	55	2014
Finance Research Letters	16	25	1.067	689	31	2008
Emerging Markets Review	10	10	0.588	358	10	2006

Sources	Articles
Panel 3: As per the articles.	
Energy Economics	88
International Review of Financial Analysis	63
Research in International Business and Finance	58
Resources Policy	56
Economic Modelling	54
Journal of International Financial Markets, Institutions and Money	51
Finance Research Letters	31
Journal of Banking and Finance	30
Journal of International Money and Finance	30
Journal of Empirical Finance	13

Source: same as Table 1.

It is essential to note that *Energy Economics* is the leading journal based on all the analyses. We analyzed total citations, citations per year, and impact scores (h index, g index and m index to avoid discrepancies between these metrics). The extensive contribution of the *Energy Economics* journal makes it a notable publication in the connectedness and spillovers literature.
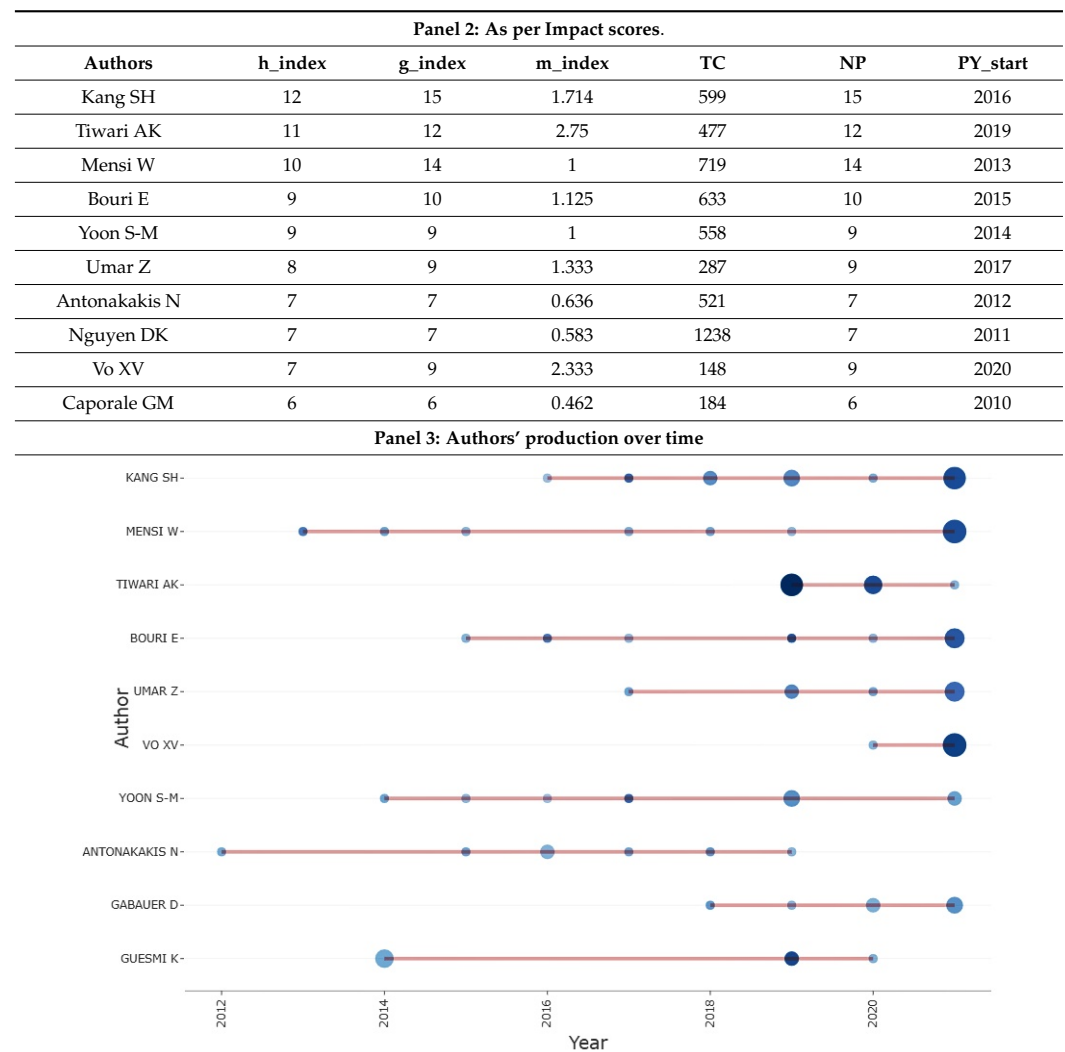
3.3. Influential Authors and Articles

We conducted an extensive analysis to identify the core authors based on their local citations (among our sample), impact scores (h index, g index and m index) and their production over time (where the circle denotes the number of articles and shade intensity denotes the number of citations over the time), as shown in Table 4.

Table 4. Influential authors.

Authors	Articles	Articles Fractionalized
Panel 1: As per Local Citations.		
Kang SH	15	4.32
Mensi W	14	3.73
Tiwari AK	12	3.25
Bouri E	10	3.37
Umar Z	9	2.92
Vo XV	9	2.62
Yoon S-M	9	3.03
Antonakakis N	7	3.2
Gabauer D	7	2.2
Guesmi K	7	2.2

Table 4. *Cont.*

Panel 2: As per Impact scores.						
Authors	**h_index**	**g_index**	**m_index**	**TC**	**NP**	**PY_start**
Kang SH	12	15	1.714	599	15	2016
Tiwari AK	11	12	2.75	477	12	2019
Mensi W	10	14	1	719	14	2013
Bouri E	9	10	1.125	633	10	2015
Yoon S-M	9	9	1	558	9	2014
Umar Z	8	9	1.333	287	9	2017
Antonakakis N	7	7	0.636	521	7	2012
Nguyen DK	7	7	0.583	1238	7	2011
Vo XV	7	9	2.333	148	9	2020
Caporale GM	6	6	0.462	184	6	2010
Panel 3: Authors' production over time						

Source of Panels 1 and 2: Same as Table 1; Source of Panel 3: Produced by author using Biblioshiny.

The identification of core authors facilitates us explore how these authors directs a research stream in the field and how their future collaboration will develop. We discovered the influential articles based on their local citations, as shown in Table 5. Diebold's work is clearly the most cited article, and the content analysis also revealed that the spillover index is the most utilized methodology in the literature.

Table 5. Most influential articles.

Document	DOI	Year	Local Citations
Diebold FX, 2009, *Econ J*	10.1111/j.1468-0297.2008. 02208.x	2009	125
El Hedi Arouri M, 2011, *J Int Money Financ*	10.1016/j.jimonfin.2011.07.008	2011	44
Baruník J, 2018, *J Financ Econom*	10.1093/jjfinec/nby001	2018	41
Sadorsky P, 2012, *Energy Econ*	10.1016/j.eneco.2011.03.006	2012	38
Mensi W, 2013, *Econ Model*	10.1016/j.econmod.2013.01.023	2013	35
Arouri MEH, 2012, *Energy Econ*	10.1016/j.eneco.2011.08.009	2012	31
Ng A, 2000, *J Int Money Financ*	10.1016/S0261-5606(00)00006-1	2000	30
Du X, 2011, *Energy Econ*	10.1016/j.eneco.2010.12.015	2011	30
Hong Y, 2001, *J Econom*	10.1016/S0304-4076(01)00043-4	2001	30
Baele L, 2005, *J Financ Quant ANAL*	10.1017/s0022109000002350	2005	29

Source: same as Table 1.

4. Citation Analysis and Visualization

4.1. Co-Citation Mapping

We conducted the co-citation analysis using Bibliometrix. The minimum citation threshold was set to 12 and the walk trap algorithm was implemented for citation networking. We obtained three main clusters—red, blue and green—corresponding to asymmetries in market connectedness, major determinants and macroeconomic variables or factors that influence the market connectedness and spillovers, and dynamic market spillover among different markets and sectors, respectively (presented in Figure 1).

To add the element of thematic evolution and to identify the primary focus of research for each cluster, we conducted a content analysis; we extracted the core papers using the PageRank metric and evaluated them to corroborate their linkages and integrity [25]. The content analysis revealed that extensive studies have been conducted on oil, which should be given special consideration; thus, we treated them as a distinct stream in this paper. The identified streams consist of (1) asymmetries in market connectedness, (2) macro factors that impact market connectedness and spillovers, (3) the role of oil in spillover and hedging portfolios and (4) dynamic cross-market connectedness and spillovers.

4.2. Co-Authorship Visualization

We conducted the co-authorship analysis, with the minimum threshold of three co-authored papers. This provides a unique perspective on the evolution of these research streams over time with these authors [26]. The authors do not constitute a vast network; however, the network is pertinent, and the affiliations are strengthening over time. The analysis outcome is depicted in Figure 2.
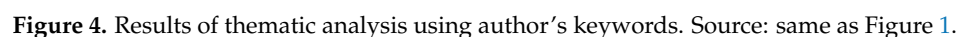

Figure 2. Results of Co-authorship analysis. Source: same as Figure 1.

4.3. Co-Word and Thematic Analysis

We performed co-word analysis followed by thematic analysis to illustrate the evolution of keywords and themes within each stream. Figure 3 depicts the outcome of the keyword analysis, which provides the evolution of keyword usage by the authors and the growth of the current literature over time.

We employed concepts of centrality and density to identify core keywords. We analyzed their evolution across time and the entire sample period, categorizing the themes into base, motor, isolated, and declining or emerging themes, as shown in Figure 4.

Figure 3. Results of co-word analysis. Source: same as Figure 1.

Figure 4. Results of thematic analysis using author's keywords. Source: same as Figure 1.

5. Content Analysis of the Four Clusters

5.1. Asymmetries in Market Connectedness

Ref. [27] analyzed the asymmetries in the forex market of AUD, GBP, CAD, EUR, JPY, and CHF during the 2007–2015 period. The Global Financial Crisis (GFC, 2008) mainly induced good volatility, and Japan became the primary receiver. Ref. [28] conducted ARMAX-GARCH to investigate the volatility spillover of the commodity market (energy, industrial metals, precious metals, oil seeds) to the sovereign CDS of 23 emerging and

frontier markets and noticed significant but inconsistent transmission over time. However, the results vary over time and commodities that are considered.

Ref. [29] verified the statistical properties of asymmetries in return connectedness between the Asian currencies from 1994 to 2019. They proposed that considering the size of the return shock is proportional to connectedness and crucial for the development of rigorous portfolio diversification and policies. The study argues that planning policies and schemes should take into account the prospects of the market's potential positive and negative asymmetries. According to Ref. [30], policymakers should exercise caution when simultaneously investing in currency and energy markets. Assessment of structural breaks improves a deeper comprehension of the persistent behavior of the market [30,31].

Large asymmetric transmission exists between oil and equities, whereas bilateral transmission is negligible. Instead of using historical volatility, Ref. [32] argued that implied volatility provides additional information on the connectedness and risk transmission between different markets and countries. Ref. [33] demonstrated that China's and global oil prices are asymmetries. According to Ref. [9], the Asian stock market co-moves without discernible asymmetry between them.

Ref. [34] defined asymmetries in OPEC's announcement as the cut, maintain, and hike decisions and investigated their influence on cereal products. They confirm a significant asymmetric effect of oil and gasoline on cereals over a continuous period, disregarding economic fundamentals and the prices of the commodities; they referred to decisions to make cuts as bad news and decisions to maintain the status quo as good news.

Refs. [32,35,36] argued that market volatility spillover and asymmetries are crucial when constructing hedge ratios and optimal portfolios. However, in accordance with Ref. [37], market connectedness is not extremely susceptible to information spillover among the ASEAN markets.

5.2. Macro Factors Impact on Market Connectedness and Spillovers

Ref. [37] demonstrated that market size does not play a significant role in market integration. After removing the effects of the global market, they discovered that the level of connectedness drops drastically. Refs. [8,37] showed that capital account restrictions, exchange restrictions, and capital control play a unique role in the integration and information dissemination among the markets. Different regimes (tax, size, stability, technological advancements) have distinct effects on connectedness.

Ref. [31] supported the notion of flight-to-quality, i.e., shifting to safe haven assets during times of crisis. In his study, VIX is considered the ideal hedging instrument and unconditional against developed markets where currency treasuries (likely Yen and USD) are contingent on the market conditions. For developed markets, the safe haven assets exhibit relatively low-risk exposure, less than unity; however, this exposure increased during the GFC. As per Ref. [38], the macroeconomic developments in the European Economic and Monetary Union (EMU) initiates the bond–stock market integration.

Ref. [33] asserted that arbitrage plays a vital role when the oil market's prices are below the threshold level by using the threshold VECM, and defined these threshold effects as originating from the transaction cost. Ref. [8] advocated four linkages, which are economic, financial, information capacity, and industrial similarity, and revealed that information capacity and industrial similarity are highly prone to developed markets whereas economic and financial integration are crucial in developing and developed markets.

Ref. [7] provided evidence that future trading impacts the spot stock prices but not the futures spreads, and the impact is not due to the exogenous factors but rather to broad market factors. Ref. [10] added that during extreme events, the currency carry trade and stock markets affect each other, i.e., a bilateral spillover exists in times of events.

EPU has an enormous impact when the stock market confronts downside risk. When stimulative schemes are enacted, the upside risk is sensitive to the EPU but shifts in the opposite direction regarding disputes or contagion [39]. However, Ref. [40] observed that EPU's effect on dynamic connectedness is regime-dependent.

5.3. Role of Oil in Market Spillovers and Hedging

Ref. [41] stated that the influence of natural gas has not received less attention compared to crude oil, despite the former having environmental benefits. They found an optimal hedging ratio between stocks and oil and natural gas, i.e., a dollar invested in stock should be hedged with a cent in natural gas futures or short selling of the oil futures. When equities possess significant asymmetries, they found that Indian investors tend to favor natural gas over oil for hedging. Similarly, as per [42], a dollar in Brent crude oil should be hedged with 10 cents in DJASIA and 30 cents in Italy stocks. In this regard, the hedging is contingent on the time horizon, and the uncertainty depends on the contingents. They observed that during ESDC, hedging is more costly than during the GFC and oil price bursts. Higher oil prices can affect vulnerable economies, break the exchange rates, and deteriorate the performance of the stock returns. It is also emphasized that higher oil prices improve the oil-exporting countries' fiscal stability.

Ref. [43] enriched the literature by filling the gap by examining the impact of the oil volatility on the stocks of heavy oil importing countries; he found that oil played a significant role post-crisis (GFC). The oil volatility had little effect on Lebanon, a country which is dominated by banking and services, whereas Jordan has shown a significant response to the oil shocks. The presence of foreign investors influenced small countries such as Morocco and Tunisia.

Ref. [44] analyzed the oil and exchange rate connectedness and spillover of the major oil exporting and importing countries. He segregated the oil shocks into demand, supply and risk following [41] segregation. The study found that the demand and risk shock significantly affect the exchange rates and increase after the crisis; the author asserts these phenomena possess potential forecasting advantages that can be used to construct an international hedging portfolio. He states that it is also important for policymakers to pursue oil shocks for trade balance as part of macro-level regulation and policing.

Ref. [45] tried to capture the role of exogenous shocks on the information transmission of the oil–equity uncertainty index. They figured that the exogenous shocks impacted the volatility spillovers between the oil and equity uncertainty index post-crisis but was insignificant pre-crisis. Ref. [46] found that the exchange rates and interest rates and the oil prices co-move over time, and the important oil importing and exporting countries' exchange rates were affected by the crude oil, and importing countries were affected relatively higher than exporting countries in their study. They noted that the rise in oil prices results in exchange rate appreciation.

5.4. Dynamic Cross-Markets Connectedness and Spillover

Ref. [37] found that the level of cross-market integration within the ASEAN market is not as high as is commonly perceived when considering the global market influence; the interconnectedness is relatively low. They noticed that the cross-market connectedness decreases when the world market factors are filtered out. Ref. [41] demonstrated that the dynamic model (DCC) captures the asymmetries in the market better compared to the constant model (CCC). In their sample, oil serves a crucial role in cross-market spillovers. Studies have considered the dynamic models for cross-market analysis to incorporate the geopolitical risk that transits into the world market systems [47]. In addition, they analyzed the geopolitical risks of BRICS, oil, and gold and found that they varied over time and frequency frame and intensified in the short term. For short-term investors, the impact of the geopolitical risk has to be the main focal element, as the study stated that the GFC and the Ukrainian crisis caused numerous spikes in the spillover. They have stated that gold and oil have a hedging function during geopolitical events, and the oil–gold nexus has to be the main concern for the hedgers.

In the crypto market, investors are not only acclimated to positive returns. Ref. [48] noticed that the general notion of Bitcoin does not apply to crypto market connectedness, and Bitcoin has transitioned from a net contributor to a net receiver over time. At the same time, other significant currencies entered the market, and Litecoin became the epicenter of

connectedness. Studies have observed that if return and trading volumes are connected, there is a significant linkage between the return connectedness and the trading volume; however, Ref. [49] asserted that the volatility of Bitcoin exchange markets depends on the asset's withdrawal rather than the trading volume. Ref. [50] demonstrated that the LME nonferrous metal futures impact SFE nonferrous metal and added that the GFC intensified the impact pattern. Ref. [38] observed bond and stock integration and discussed the reason why it is happening. They pointed out that international bond and stock integration are typically characterized by dynamism. In the event that monetary policies play a role in these linkages, bonds usually have the upper hand.

Ref. [51] found shreds of evidence in the spillover from the developed stock market to the emerging market; however, the linkage is tenuous. Studies found that Asian countries' stock markets exhibit co-movements and strengthened after the impact of the GFC. However, the interaction between Asia and the US was minimal, and hardly any co-movements ensued. Ref. [52] found that the asymmetry transmission can be discerned as stabilizing unit between the stock markets and should be regarded as a hedging tool. He found a degree of transmission between the developed markets and the emerging Asian markets.

6. Discussions and Future Directions

6.1. Asymmetries in the Market Connectedness and Spillover

With a growing profundity in asymmetry studies, research increasingly focuses on information dissemination in terms of good and bad news in the market. Rarely do studies explore the geopolitical risks of various institutional unions, macro variables, and investing tools. One should also account for the geographical setting and the time difference between regions when addressing cross-country asymmetries. Ref. [53] argued that social and cultural factors can also influence market information dissemination. Although there are comprehensive studies on cross-country, cross-listed, and cross-market analysis, they focus on large markets, ignoring the frontier and small countries. Structural reversals are often observed in the risk spillovers from the oil nexus which differs at different quantiles and spikes at both tails against the median [54]. Contrary to the findings of the content analysis, a study found that Asian markets are strong negative spillers in the major international stock market network [55]. Thus, a broad study must be conducted on these frontier markets and small countries (potentially growing ones).

The methodologies for connectedness and spillover have been upgraded from basic GARCH models to frequency analysis and other significant techniques. However, in our study, the DY or spillover index, DCC-GARCH, and variants of GARCH models are the most prevalent techniques. At the same time, Barunik's SAM and frequency asymmetric index have contributed considerably to the asymmetry hypothesis analysis [4,5]. The usage of high-frequency data is stagnant in this particular framework. Other financial methods and tools had to be examined under the connectedness literature.

6.2. Macro Factor Influence on Market Connectedness and Spillover

We have already mentioned that the studies focus on developed markets while ignoring small markets, despite the fact that few studies have shown that the size effect does not play a significant role in connectedness. Small markets have to be considered to determine the bilateral spillover or whether they were acting as primarily net receivers only. Policy creation, global speculation, and anticipation must be indexed in terms of connectedness, and the same criteria must be indexed with the frontier and emerging markets. Ref. [56] found that the effects of macro and economic policy uncertainty (EPU) are time-varying, asymmetric, and non-linear. The immunity of the aggressive and defensive sectors in the markets towards the macroeconomic policy would help us to construct their structural breaks and linearity patterns. Globalization, market openness, innovation in trading, and monetary unions must be thoroughly examined for their contributions to the volatility transmission between markets. Country-specific determinants have yet to be explored. The

time-varying nature of these determinants, as well as their functions and dynamics in times of contagion, must be addressed.

6.3. Role of Oil in Market Spillovers and Hedging Portfolios

Prior studies did not consider the role of oil in the market linkages in terms of the geopolitical risk it holds; we explored the oil impacts in market spillover and its effect on hedging. Oil is the subject of the majority of investigations. The notion of small countries that are large oil importers has to be explored in terms of their contributions to the oil volatility fluctuation. Oil futures must be investigated from a country-specific perspective to demonstrate how hedging can be made possible, given that the markets are connected. Analysis of the GCC countries reveals that with the exception of Qatar, all other countries are prone to global geopolitical risk [57]. This has to be evaluated using empirical methods to quantify the network of the GCC's impacts and their long-term behavior. The connectedness between large oil-importing and oil-exporting Asian countries must be evaluated to determine how the oil volatility influences their net spillovers. The safe haven properties of the oil–gold nexus and oil–crypto nexus will be crucial in the upcoming years as the study disputes the absence of safe haven properties in the oil–gold–Bitcoin nexus [58]. The impact of green alternatives and green energy on oil volatility and oil spillovers should be assessed in the context of the current literature.

6.4. Dynamic Cross-Market Connectedness and Spillovers

Lately, the time-varying spillover between and across different markets and sectors has been examined. Numerous studies have documented the stock and bond market connectedness; however, the influence and network with the commodity market remain understudied. In the current literature, the time-varying integration of the feedback trading of cross-listed shares and the intensity of foreign investors is largely unexplored. Methods-based cross-quantile studies reveal that the crypto-currency market possesses a heterogeneous pattern [59]. However, this pattern varies based on the market sizes as opposed to the main findings in the content analysis. G10 countries are affected to varying degrees by financial contagions, with the most prominent finding of this study being that the Eurozone was able to contain the shock transmission from Brexit by adopting effective measures [60]. As previously stated, currency, monetary union, and liquidity effects on the stock–bond connectedness have yet to be made for a number of countries.

Thus, we outline the gaps from the identified streams from the literature and present them as future research questions in Table 6.

Table 6. Future research questions.

Research Stream Clusters	Question	Research Questions
Asymmetries in market connectedness	1	What are the variables that pose a geopolitical risk to the markets?
	2	How does information dissemination happen between Frontier and Emerging markets and developed markets?
	3	What do the asymmetries in the currency market propose in the large oil-importing small countries?
	4	How do the asymmetries differ when high-frequency data are used from different markets?
	5	How do the asymmetries differ in economic integration and financial integration?
	6	Can asymmetry in connectedness be quantified?
	7	How does the country-specific asymmetry differ among the sectors?
	8	Do structural breaks in volatility play a significant role in asymmetry prediction?
	9	Does volatility asymmetry follow a mean reverting process?
	10	Does the US contribute most of the asymmetry to the world market?
	11	Does the EMU have an impact on the Asian markets?
	12	Do social and cultural factors play any role in volatility asymmetry fluctuations?
	13	Do political and policy tie-ups between countries direct market connectedness?
	14	Are there any potential benefits from good volatility spillovers?
	15	Is there a bilateral spillover between Asia and the US and EMU? Moreover, how much net good and bad contribution happens between them during the tranquil and contagion periods?
	16	What are the major determinants of the volatility asymmetries in developed and emerging markets?

Table 6. *Cont.*

Research Stream Clusters	Question	Research Questions
Macro factor's influence on market connectedness and spillovers	17	Does the market size indicate the level of integration?
	18	How to derive the EPU index between the frontier and emerging markets? How do their economic conditions behave about this index?
	19	Does the technologically advanced stock market dominate international markets?
	20	What are the country-specific determinants of the connectedness and spillovers?
	21	How do dollar currency and exchange rates trigger the connectedness among specific Asian countries?
	22	What is the role of information capacity in the volatility spillovers in country-level sectors?
	23	Does international economic integration trigger financial integration among the countries?
	24	What is the degree of impact of oil volatility fluctuation in the macroeconomic variables in oil-importing countries?
	25	What is the long-term behavior between emerging and developed nations' economic and financial integration?
	26	Does EDC affect specific Asian markets? Why is there not much political or terrorism spillover from the US and EU to the East Asian markets?
	27	Does good economic performance from a country or firm shield them from bad volatility spillovers?
Role of oil in the spillovers and hedging	28	Do the Asian markets have the upper hand in the oil futures as a hedging tool?
	29	What is the degree of connectedness between the large oil-importing and exporting EU and Asian countries?
	30	What is the impact of green alternatives and green energy products on oil price fluctuations?
	31	What is the role of oil in connecting the commodity and financial markets in specific EU and Asian Countries?
	32	What is the degree of change in geopolitical risk from oil among different countries?
	33	Does the oil–gold nexus pose an effective hedging tool for emerging countries?
	34	What is the spillover effect of oil on the safe haven assets?
	35	Are high-natural-gas-using countries well-off from oil spillovers?
	36	What are the substantial hedging values for oil futures and exchange rates for the Asian sub-countries?
	37	What is the optimal international diversification for oil futures in the tranquil and event periods?
	38	What is the directional spillover of oil to the Asian sub-countries during crises?
	39	Does oil integrate the financial markets across countries during crises?
Dynamic cross-market connectedness and spillover	40	How do the dynamic spillover changes differ in the high-frequency data?
	41	Do structural changes pose a constraint in the dynamic analysis?
	42	What is the level of integration among firms?
	43	What are the changes in dynamics in the short and long run?
	44	What is the intensity of short- and long-term connectedness and directional spillovers between commodity, stock, and bond markets?
	45	Does connectedness shift when the market's foreign investors percentage is high?
	46	What are the time-varying changes in feedback trading of cross-listed shares?
	47	Do market openness and information capacity transform the directional spillover in developed and emerging markets?

7. Conclusions

We wanted to investigate the prominent literature on market connectedness and spillovers. We followed some of the previous studies' footprints in a meta-literature review in order to derive a set of quantitative and qualitative structures for the literature, for which we conducted bibliometric analysis for the former and content analysis for the latter. We utilized the Bibliometrix package for various bibliometric analyses including co-citation, co-authorship, co-word, and thematic analysis. The advantages of the study are co-word analysis, which introduces an element of thematic analysis that was absent from previous works of literature, and the extraction and purging of 40 years (1991–2021) of data from the Scopus database in accordance with the structure of the study.

The paper contributes in two ways. First, it extracts the most influential facets of the connectedness literature including the most studied countries, top collaborations, sources, authors, and articles. Then, we examined the themes in the field and categorized them according to the most compelling topics and the base, motor, and emerging themes. With an extensive content analysis of 75 papers comprised of core and secondary papers, we identified four major streams in the connectedness in the literature, which are (1) asymmetries in the market connectedness, (2) macro factors' impact on the connectedness and spillovers across markets and countries, (3) the role of oil in market spillovers and portfolio hedging, and (4) dynamic cross-market connectedness and spillovers. We analyzed and summarized the key findings from the abovementioned streams, as well as mapped the essential methodologies and authors. We contributed by identifying the literature gaps, then outlined and discussed the future directions of the research field.

The growing globalization and interactions between markets and countries have made the market co-movements more complex in analytics; with the ongoing innovations and contagions or crises, the literature on connectedness and spillover would be of outstanding contribution and interest to the policymakers, investors, and hedgers for portfolio diversification and risk management. Nonetheless, the study is restricted to citation analysis which can be expanded by interpreting the empirical form by undertaking a meta-regression on the study domain and how the changes are recorded accordingly.
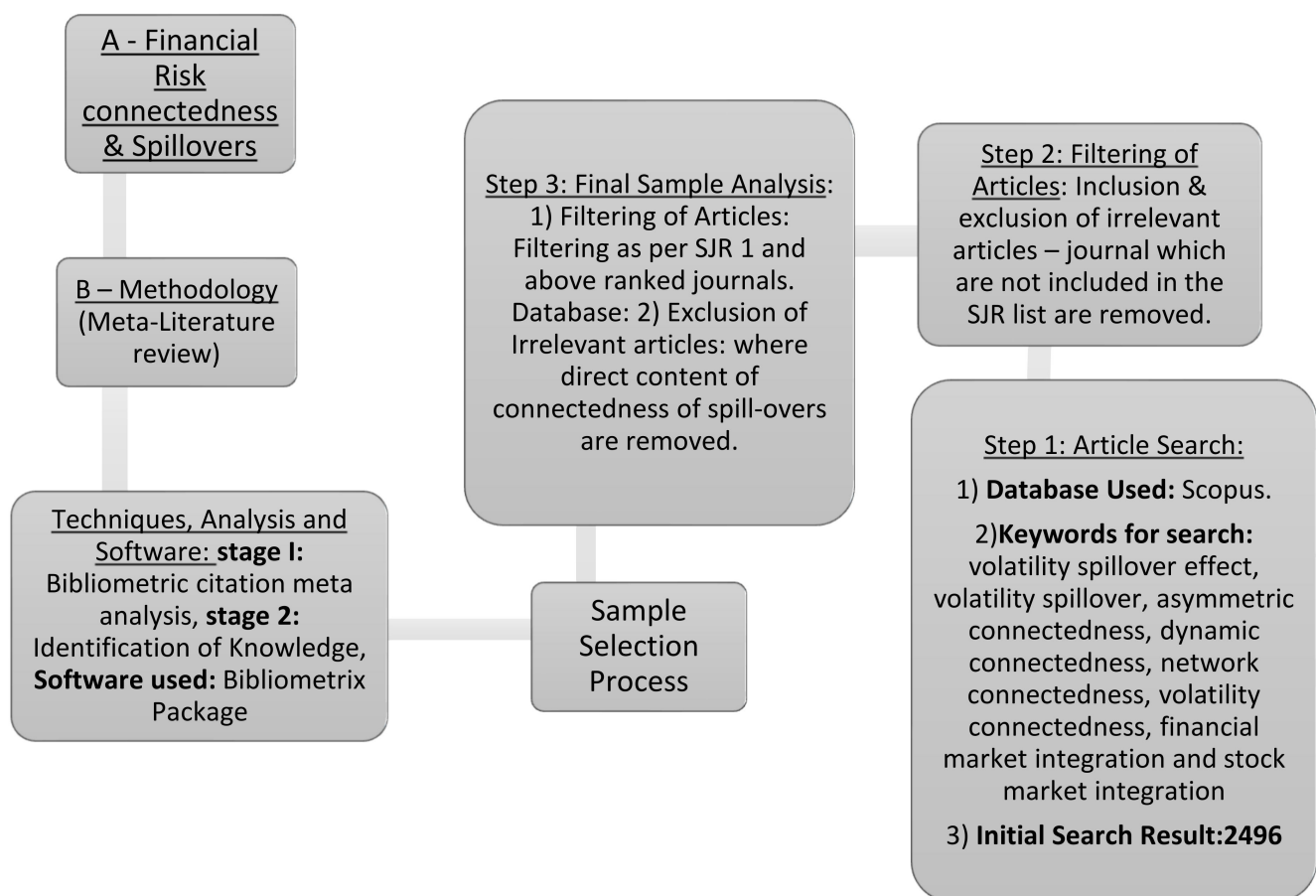
Appendix A

Figure A1. Outline of Methodology.

Table A1. Summary of the core literatures in each stream.

Authors (Year)	Type of Paper (Empirical or Qualitative)	Title of Study	Objective/Research Question	Methods (Technique/Sample of Study/Data Questions	Main Findings
Engle, 2012	Empirical	Volatility spillovers in east Asian financial markets: A mem-based approach	Volatility spillover during the Asian Currency Crisis	MEM-GARCH	Hong Kong was a major transmitter and build-up of volatility transmission during the currency crises in 1997 but few in the 9/11 attack.
Baillie R.T., Bollerslev T., Redfearn M.R. 1993	Empirical	Bear squeezes, volatility spillovers and speculative attacks in the hyperinflation 1920s foreign exchange	Co-movements between exchange rates during 1920 and their behavior to present exchange rate connectedness	QMLE and Robust Wald test for causality, 7 Country 162 Weekly exchange rates	Even though there is a significant relationship during events, there is no clear evidence of transmission between exchange rates.
Bekaert, 2019	Empirical	On the global financial market integration "swoosh" and the trilemma	Analyzing the pattern in Financial Market Integration	Factor Model and CAPM 17 country's 1554 monthly equity portfolio of 1885–2014	There is no significant regional cointegration, but the cointegration among countries follows a swoosh pattern as opposed to the previous findings.
Lin B. 2014	Empirical	Oil price fluctuation, volatility spillover and the Ghanaian equity market: Implication for portfolio management and hedging effectiveness	Hedging and portfolio diversification during oil shocks in west Africa and Nigeria stocks	VAR-GARHC, VAR-AGARCH &DCC-GARCH,574 weekly Ghana stock, oil from 2000–2010	There is significant volatility spillover between oil and the two stock markets, and the information shocks intensified the spillovers and predictability.
Suk-Joong Kim, Fariborz Moshirian, Eliza Wu 2006	Empirical	Evolution of international stock and bond market integration: Influence of the European Monetary Union	EMU influence on stock-bond integration	EGARCH, PCA&GLS, the eurozone and non-eurozone total of seven countries of 1994–2003.	The introduction of EMU impacted the eurozone stock-bond co-movement but not the non-euro countries; it led to a flight to quality phenomena.
Jong-Min Kim and Ho-jin Jung 2018	Empirical	Dependence Structure between Oil Prices, Exchange Rates, and Interest Rates	What is the co-movement nature of the oil, exchange rate and U.S. interest rate	TGARCH and Asymmetric ARCH, APRCH and Copula, weekly data 1998–2017	There is a negative relationship between oil and the U.S. interest rate; Oil fluctuations are transported to the Exchange rate of oil exporting countries.
Lei Li, Libo Yin, Yimin Zhou 2016	Empirical	Exogenous shocks and the spillover effects between uncertainty and oil price	Examining the information spillover between oil and stock pre- and post-GFC	Bi-variable EGARCH, VIX, ted spread, S&P 500 index and gold future oil price as exogenous shocks, daily data of 2004–2014	There was no information transmission between the oil and stock pre crises, but it became significant after the crises, and the exogenous shocks intensified the transmission.
Yingli Li, Jianbai Huang, Wang Gao, Hongwei Zhang 2021	Empirical	Analyzing the time-frequency connectedness among oil, gold prices and BRICS geopolitical risks	Examining the interaction between oil, BRICS, gold and geopolitical risk index.	Asymmetric Frequency Index, 2000–2019, Gold, Geopolitical risk index, BRICS risk index and Oil price.	There is a clear presence of spillover among the variables.
Jozef Baruník, Evžen Kočenda, Lukáš Vácha (2017)	Empirical	Asymmetric volatility connectedness on the forex market	Do asymmetries exist in the volatility of the currency market, and if they do, what is their uniformity?	BK (2016) & DY (2012) & SAM	GFC triggers good volatility spillover, and JPY is the receiver mainly, and macro variables play their role in monetary policies and bank interventions.
Elie Bouri (2015)	Empirical	Oil volatility shocks and the stock markets of oil-importing MENA economies: A tale from the financial crisis	AVS between oil and MENA countries (Jordan and Lebanon Stock markets).	L.M. test & ARMAX-GARCH	Oil volatility impacts Jordan's stock post-GFC, whereas oil volatility does not predict Lebanon's volatility. There is a heterogeneity in the comparison between Tunisia and Morocco (small and heavy oil-importing countries).
Elie Bouri, Maria E. de Boyrie, Ivelina Pavlova (2016)	Empirical	Volatility transmission from commodity markets to sovereign CDS spreads in emerging and frontier countries	AVS from commodity to sovereign CDS, sector-wise, and country-wise analysis.	L.M. test & AR-GARCH	10 out of 17 emerging, four frontier markets are affected by commodity price volatility, whereas the energy and precious metals sectors are large contributors.
Elie Bouri, Brian Lucey, Tareq Saeed, Xuan Vinh Vo (2020)	Empirical	Extreme spillovers across Asian-Pacific currencies: A quantile-based analysis	AVS between Asian currency markets.	Quantile based VAR	Return spillovers vary between periods of appreciation and depreciation and extreme events.
Elie Bouri, Xiaojie Lei, Naji Jalkh, Yahua Xu, Hongwei Zhang	Empirical	Spillovers in higher moments and jumps across U.S. stock and strategic commodity markets	AVS in the higher moment and jumps between	TVP-VAR, GIRF & GFEVD	U.S. (RV&RK), oil (R.S. & jumps) main transmitter, and gold is the primary receiver.
Jing Chen, Yizhe Dong, Wenxuan Hou, and David G McMillane (2017)	Empirical	Does feedback trading drive returns of cross-listed shares?	Analyze feedback and information volatility spillover among cross-listed shares, whether the same market segmentation information gives volatility of the same stock and how exogenous shocks affect the price discovery.	Feedback Model- VAR, VECM, VAR-MV-GARCH	Cross-listed shares have long-run co-movements and bi-directional causations; a dynamic exists between volatility and liquidity.
Qiang Jia, Elie Bouric, Ladislav Kristoufekd, Brian Luceye	Empirical	Realized volatility connectedness among Bitcoin exchange markets	To determine the integration degree of the crypto market.	Realized Volatility, FEVD, D.Y. Connectedness	Coinbase is the most influential exchange, although not in the top 3 in trading volume, and Binance is the no. 1 in terms of trading volume but not influential.
Qiang Ji, Elie Bouri, Chi Keung Marco Lau, David Roubaud	Empirical	Dynamic connectedness and integration in cryptocurrency markets	Return connectedness and volatility spillover between six cryptocurrencies.	FEVD, D.Y. Connectedness	The largest net transmitter is Bitcoin and receivers are Ethereum and Dash. A negative return is more potent than a positive, dynamically, moved Bitcoin from net transmitter to net receiver, and trading volume might be a significant determinant given that return and trading volume have linkages.
Min Hu, Dayong Zhang, Qiang Ji, Lijian Wei	Empirical	Macro factors and the realized volatility of commodities: A dynamic network analysis	Analyzing macro factors' impact on commodity volatilities.	Realized Volatility, FEVD, D.Y. Connectedness	Gold is the net information transmitter. Gold and crude oil show significant time-varying characteristics over macro information; gold influenced mainly from the sentiment index and volatility index and crude oil for default spread and volatility index.
Jian Yang, Meng Tong, Ziliang Yu	Empirical	Housing market spillovers through the lens of transaction volume: A new spillover index approach	Analyzing the determinants and the pattern of housing information transmission.	Directed Cycle Graph (DAG) and Spillover index. Eight Chinese provinces' daily housing index, from Nov 2009 to Feb 2018	Hierarchy in the cities is the primary determinant and propounds different dynamic information transmissions. The usage of high- and low-frequency results in different daily fluctuations housing sector.
Chia-Lin Chang a, Michael McAleer, Roengchai Tansuchat, 2010	Empirical	Analyzing and forecasting volatility spillovers, asymmetries and hedging in major oil markets	Crude oil price volatility.	CCC, VARMA–GARCH, VARMA–AGARCH	Conditional correlation forecasts exhibited both upward trend and downward trends, and optimal portfolio weights suggest holding the light sweet grade category in a more significant proportion than the heavier and less sweet-grade category.
Farooq Malik, Zaghum Umar	Empirical	Dynamic connectedness of oil price shocks and exchange rates	Different sources of oil price shocks are connected to the exchange rates of major oil-dependent countries.	ARMA, VAR, SVAR	Oil price shocks resulting from changes in demand and risk significantly contribute to variations in exchange rates, while supply shocks have virtually no impact.

Table A1. *Cont.*

Authors (Year)	Type of Paper (Empirical or Qualitative)	Title of Study	Objective/Research Question	Methods (Technique/Sample of Study/Data Questions	Main Findings
• Sang Hoon Kang, Ron McIver, Seong-Min Yoon	Empirical	Dynamic spillover effects among crude oil, precious metal, and agricultural commodity futures markets	Spillover effects among six commodity futures markets.	multivariate DECO-GARCH, Spillover Index	Hedging strategies depend on market conditions, with a higher value for the hedge ratios during episodes of financial turmoil.
• Walid Mensi, Shawkat Hammoudeh, Duc Khuong Nguyen, Seong-Min Yoon,	Empirical	Dynamic spillovers among major energy and cereal commodity prices	Examining the impacts of three types of OPEC news announcements on the volatility spillovers and persistence	VAR-BEKK-GARCH, VAR-DCC-GARCH	Empirical models are flexible enough to capture the dynamic structure of the return interactions, volatility spillovers, and conditional correlations.
• Sang Hoon Kanga, Aviral Kumar Tiwari, Claudiu Tiberiu Al-bulescud, Seong-Min Yoone	Empirical	Exploring the time-frequency connectedness and network among crude oil and agriculture commodities V1	frequency domain connectedness between oil and agriculture commodity prices.	frequency domain spillover method, D.Y. Spillover Index	vegetable oil prices are net volatility transmitters at any frequency band.
• Sang Hoon Kanga, Seong-Min Yoonb	Empirical	Dynamic spillovers between Shanghai and London nonferrous metal futures markets	Examines the dynamic return and volatility spillovers between the Shanghai Futures Exchange (SFE) and the London Metal Exchange (LME).	new spillover index of Diebold and Yilmaz	LME nonferrous metal futures have a more significant impact on SFE nonferrous metal futures.
• Walid Mensi, Shawkat Hammoudeh, Xuan Vinh Vo, Sang Hoon Kang	Empirical	Volatility spillovers between oil and equity markets and portfolio risk implications in the U.S. and vulnerable E.U. countries	Frequency dynamics of volatility spillovers between Brent crude oil and stock markets in the U.S., Europe, Asia, GIPSI, Ireland, Portugal, Spain and Italy.	Methods by Diebold and Yilmaz, and Barunik and Krehlik, AR (1)-FIGARCH	Spillover effect between the oil and the stock markets is conidered time-varying, crisis-sensitive, and frequency-dependent.
• Mohamed El Hedi Arouri, Amine Lahi-ani, Duc Khuong Nguyen	Empirical	Return and volatility transmission between world oil prices and stock markets of the GCC countries	Return links and volatility transmission between oil and stock markets in the Gulf Cooperation Council (GCC) countries.	VAR-GARCH, GCC-GARCH	Oil stock return and volatility linkages could compare their causality across GCC countries and other oil-exporting and oil-importing countries.
• Walid Mensi, Shawkat Hammoudeh, Idries Mohammad Wanas Al-Jarrah, Khamis Hamed Al-Yahyaee, Sang Hoon Kang	Empirical	Risk spillovers and hedging effectiveness between significant commodities and Islamic and conventional GCC banks	Dynamic risk spillovers and hedging effectiveness between two important commodity markets (oil and gold).	DECO-FIGARCH, spillover index of Diebold and Yilmaz	Gold offers the best hedging effectiveness for UAE, Qatar and Saudi Arabia, which are major oil exporters, while oil provides the highest hedging effectiveness for Bahrain, which is a minor oil producer.
• Perry Sadorsky	Empirical	Correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies	Analyze the volatility spillovers between oil prices and the stock prices of clean energy companies and technology companies.	MGARCH, BEKK	Stock prices of clean energy companies correlate reasonably highly with the stock prices of technology companies. Portfolio of clean energy stocksand oil futures can be built, and oil futures can be used to hedge an investment in clean energy stock prices.
• S. Narayan, S. Sriananthakumar, S.Z. Islam	Empirical	Stock market integration of emerging Asian economies: Patterns and causes	Patterns and causes of stock market integration of selected emerging Asian nations against the U.S., Australia, China, and India.	GARCH-DCC, EGARCH	Monthly correlations were least influenced; six Asian markets were relatively more correlated with the Chinese stock market than those of India, Australia, or the U.S.
• Walid Mensi, Shawkat Hammoudeh, Seong-Min Yoon	Empirical	Structural breaks, dynamic correlations, asymmetric volatility transmission, and hedging strategies for petroleum prices and USD exchange rate	Influence of structural changes on the asymmetry of volatility spillovers, asset allocation and portfolio diversification between the USD/euro exchange market and each of six major spot petroleum markets, including WTI, Europe Brent, kerosene, gasoline and propane.	Bivariate DCC-EGARCH Model	Volatility spillovers from the petroleum prices to the dollar/euro exchange rate have implications for import inflation and the general price level; portfolio strategies are sensitive to the petroleum-currency nexus.
• Aktham I. Maghyereh, Basel Awartani, Elie Bouri	Empirical	The directional volatility connectedness between crude oil and equity markets: new evidence from implied volatility indexes	Directional connectedness between oil and equities in eleven major stock exchanges.	VAR, KPSS H-Step	The study exploited newly introduced implied volatility indices and directional connectedness measures to study the risk transfer between the oil market and a group of global equity markets.
• Chia-Lin Chang, Chia-Ping Liu, Michael McAleer	Empirical	Volatility spillovers for spot, futures, and ETF prices in agriculture and energy	Relationship and the interactions on price and volatility, and on the covolatility spillover effects for agricultural and energy industries.	Full BEKK and DCC,	Volatility spillovers exist for all four financial assets in three different markets, though there are some differences in the quantitative results.

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