Structure of REDEE and EJMBE research: a bibliometric analysis

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Abstract

Purpose – Evaluating existing literature can lead to a better understanding of a scientific journal's state of the art. In this sense, this study aims to analyze the global research evolution of the Revista Europea de Dirección y Economia de la Empresa (REDEE) and the *European Journal of Management and Business Economics* (EJMBE).

Design/methodology/approach – A bibliometric analysis was conducted to acknowledge the most contributing authors, impactful articles, publication trends, keyword analysis, co-occurrence networks and collaboration networks. A total of 454 articles published between 2006 and 2022 were analyzed.

Findings – The results suggest that the international strategy set in 2014 has resulted in a steadily growing number of publications and a significant increment in citations. Relationship marketing and the connections between innovation, performance and entrepreneurship are topics of interest for the EJMBE.

Originality/value – Mapping existing EJMBE research through identifying the contributing authors, most impactful articles, publication trends, keyword analysis, co-occurrence networks and collaboration networks is missing to encourage new research projects.

Keywords Journal analysis, Bibliometrics, Ágora, Scopus, REDEE, EJMBE

Paper type Literature review

Introduction

The current *European Journal of Management and Business Economics* (EJMBE) was first published with this new name in 2016, having Professor Enrique Bigné as its editor. This turned out to be a new phase of the journal initially designated as Revista Europea de Dirección y Economía de la Empresa (REDEE), launched in 1991 by the Academia Europea de Dirección y Economía de Empresa, thus when it was commemorating its 25th anniversary. Professor Varela and Professor Barroso were the two previous editors-in-chief of the journal (Bigne, 2016). Digitization and internationalization of this journal were two cornerstone objectives behind embracing English as the written language for all its published articles and extending its editorial board to accommodate more academics from a broader range of countries. In this context, the role of the European Academy of Management and Business Economics (AEDEM; https://redaedem.org/) has been crucial for the success of the EJMBE as it determines the strategic vision of the journal and appoints its editor. This non-profit organization aims to foster the progress of the business economics investigation by organizing two conferences per year,

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specifically an annual scientific conference (since 1987) and an international conference (since 1992). Additionally, this association is responsible for editing three journals, namely the EJMBE, the *European Research on Management and Business Economics* (ERMBE) and the *Journal of Management and Business Education* (JMBE).

EJMBE aims to publish peer-reviewed conceptual, methodological, or empirical investigations in business economics, including strategy, management, organization, corporate governance, human resources, operations, finance, marketing and tourism (Emerald, 2022). Additionally, special issues were released to stimulate new research outputs and foster research on emerging topics (e.g. Huarng and Rey-Martí, 2019; Kozak *et al.*, 2018). Since its revamp in 2016, this journal has almost quadrupled its SJR in Scimago in just five years, from 0.175 in 2016 to 0.665 in 2021 (Figure 1). Note that in seven years (2010–2016), this outlet was only in the range of 0.102–0.175, started to climb in the next two years (0.239–0.354 in 2017 and 2018, respectively) and reached a much higher SJR in the last three years (0.639–0.665 between 2019 and 2021). Furthermore, EJMBE consolidated a position as a Scopus Quartile 2 (Q2) indexed journal in two subject areas ("Business, Management and Accounting", "Economics, Econometrics, and Finance") and six categories ("Business and International Management", "Marketing", "Organizational Behavior and Human Resources Management", "Strategy and Management", "Tourism, Leisure and Hospitality Management", "Finance").

Since the inception of the journal, multiple papers have been published. The high volume of publications is a challenge for researchers to remain aware of the latest developments in EJMBE. Therefore, a systematic review of the journals' extant literature is relevant as it integrates and synthesizes the past, suggests novel research lines and contributes to the journal's evolution (Priyashantha *et al.*, 2022). However, mapping existing EJMBE research through identifying the contributing authors, most impactful articles, publication trends, keyword analysis, co-occurrence networks and collaboration networks is yet to be done. Such synthesis is critical to acknowledge the structure and intellectual base of research published in EJMBE. A retrospective evaluation permits the identification of the leading trends of the past and present of the journal. This is common practice to analyze one journal to provide an overall structure of the knowledge published over the years. For instance, Merigó *et al.* (2015) conducted a bibliometric overview of the *Journal of Business Research* from its origins until

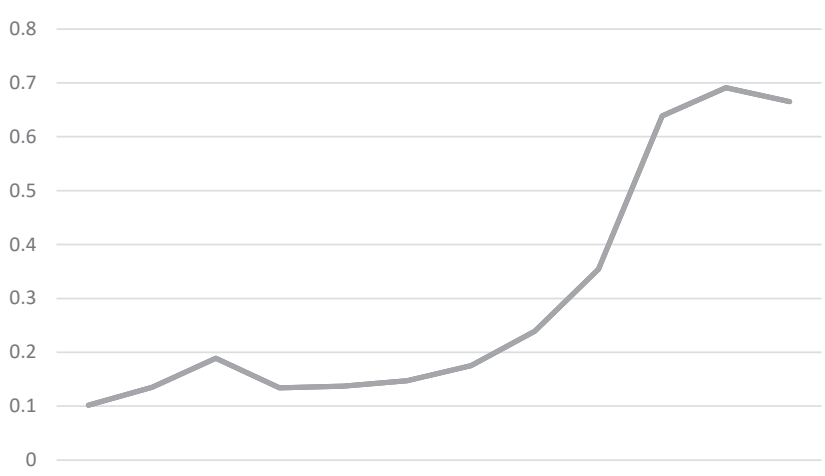


Figure 1.
EJMBE's SJR (Scopus): 2010–2021

Source(s): Figure by authors

2014. Martínez-López *et al.* (2018) performed a bibliometric analysis for the fiftieth anniversary of the *European Journal of Marketing* and Van Fleet *et al.* (2006) analyzed the *Journal of Management*'s first 30 years Autor (2012) examined the *Journal of Economic Perspective*'s first 100 issues.

This study aims to describe the global research evolution, identify the predominant themes and raise awareness for the value of EJMBE. Additionally, it provides a better understanding of the journal's current state of the art by characterizing the footprint left by the journal from 2006 to 2022 that made the journal recognized as it is nowadays. To achieve this aim, a bibliometric analysis was conducted. Bibliometrics, the discipline that studies bibliographic material quantitatively (Broadus, 1987; Quezado *et al.*, 2022), has been used in various studies (e.g. de Diego and Almodóvar, 2022; Martínez-López *et al.*, 2018; Ramos-Rodríguez and Ruíz-Navarro, 2004) from multiple research areas. Unlike other techniques, it provides an objective and reliable analysis (Aria and Cuccurullo, 2017), offering an objective study of the documents published in REDEE and EJMBE. Bibliometrics uses a set of indicators to obtain information collected from research activity. The output can reveal academic productivity and evaluate scientific research performance (Durieux and Gevenois, 2010). Data were collected from Ágora (2021) and Scopus databases. The analysis allows for uncovering the publication and citation structure, the most productive authors, the journal's knowledge structure and the authors' countries. This article is of particular interest to researchers considering publishing in EJMBE.

This paper's structure is as follows: methodology describes the steps followed for data collection and data analysis; the results section details the publication and citation structure, contributing authors, influential articles, characterization of the authors' keywords, analysis of the multiple correspondence evolution map and country collaboration network; finally, the conclusion section entails the top results and how these address the study aims.

Methodology

This study focused on EJMBE, former REDEE, between 2006 and 2022, using the data collected from Ágora (2021) and the Scopus database. By collecting a large set of articles, we aimed to analyze an extensive review of the scientific knowledge published in EJMBE (Paul and Benito, 2018). A bibliometric analysis was used to systematically analyze science networks to acquire knowledge on the evolution and studies of a significant number of researchers (Donthu *et al.*, 2021; Rita and Ramos, 2022).

Data selection

Scopus was the database used for data collection as scholars consider it to be where relevant publications are indexed and one of the most widely accepted bibliographic databases (Ramos *et al.*, 2019). Moreover, it is considered the most well-organized, structured and largest scholar database (Kumar *et al.*, 2020; Tavakoli and Wijesinghe, 2019). Although many other databases exist (e.g. Web of Science/WoS, Google Scholar), the expectation is that the Scopus database data is of the highest credibility and quality standards (Kumar *et al.*, 2020). The use of Scopus is consistent with other bibliometric analyses (Martínez-López *et al.*, 2018; Sharma *et al.*, 2021). Since the REDEE and EJMBE have been indexed in Scopus only since 2009, data included 2006 to 2008 from Ágora's (2021) database for a comprehensive review (Paul and Benito, 2018). Ágora is a database that provides public access to public administration scientific articles written in Spanish to disclose knowledge to foster quality investigation (Ágora, 2021).

In the first stage, data were collected from Ágora's database. This database provided free access to the 114 full texts of the REDEE published articles in the designated period. The

author's name, keywords, affiliation, affiliation country, source and year were extracted from each article.

In the second stage, data were retrieved from the Scopus database on January 16, 2023. We applied the terms "Revista Europea de Dirección y Economia de la Empresa" and "European Journal of Management and Business Economics" in the source title search tool to select and extract the data. The first Scopus-indexed article published by REDEE was in 2009, while the first under the EJMBE journal title was published in 2016. Along with the data collected from each article mentioned above, the number of Scopus citations was extracted. The Ágora database does not provide the number of citations. For this reason, every metric that demands citations was not applied to the articles collected in the Ágora's database. The Scopus dataset comprised 287 papers from REDEE and 167 from EJMBE. A manual analysis attested no duplicates, confirming a total of 454 (114 articles from Ágora; 173 REDEE articles from Scopus; 167 EJMBE articles from Scopus) published between 2006 and 2022. Retrieved data were uploaded into a CSV file and used as input for the bibliometric analysis. Considering the size of the dataset, a bibliometric analysis is considered suitable for conducting this study (Donthu *et al.*, 2021). Before data analysis procedures, the authors' names had to be standardized since some are cited differently (e.g. "Blanco González, A." vs "Blanco-González, A.").

Data analysis

Data were analyzed using the "bibliometrix" package, an R-tool used for science mapping analysis (Aria *et al.*, 2020; Bond and Buntins, 2018; Rita and Ramos, 2022). Other prominently used bibliometric software are VOSviewer, Gephi and Scimat. Each piece of software has pros and cons, and the choice is usually a researcher's decision (Donthu *et al.*, 2021). For instance, Gephi and R's development speed and flexibility are higher than those of UNICET and Pajek. Another example is that VOSviewer does not allow merging different forms of the same word. However, that can be done using Gephi. The R package "bibliometrix" was installed in R, and the CSV file containing the data for analysis was imported. After executing all the package functions, the output provided the bibliometric descriptive and graphical results. The "bibliometrix" package allows for several analyses, such as authors' impact and productivity, citations, publication trends, keyword analysis, or author's indices (*h*-index, *g*-index, *m*-index) (Aria and Cuccurullo, 2017). The Hirsh index (*h*-index) uses the number and citations per article to quantify the authors' productivity and impact (Hirsch, 2005). In turn, the *g*-index measures the performance of the articles (Egghe, 2006). Moreover, the *m*-index considers the h-index and the year of the first publication (*n*). Hence *m*-index = *h*-index/*n* (Halbach, 2011). For the country collaboration network analysis (Secinaro *et al.*, 2022), the authors' affiliation country was used, and the dataset was divided into two parts: articles published in the (1) REDEE and (2) EJMBE.

Although the bibliometric analyses help to summarize and map with objectivity and reliability the research published in EJMBE, they are mainly descriptive (Palmatier *et al.*, 2018; Rita and Ramos, 2022). The analysis of the bibliometric data allowed us to uncover the most productive and impactful authors and most influential articles, identify the most recurrent authors' keywords and their longitudinal evolution, keyword co-occurrence network, multiple correspondence evolution map and country collaboration network. The information provided by such analyses permitted uncovering of the structure of the EJMBE, highlighting its latest developments and suggesting a future research agenda.

Results and discussion

Publication and citation structure of REDEE and EJMBE

The trend of articles in the REDEE and EJMBE is reflected in Table 1. During the 16-year analyzed period, a total of 454 articles were published (287 from 2006 to 2015 in the REDEE

Year	N	TC****	Mean total citations (TC) per document	Mean TC per year	Citable years
2006*	42	–	–	–	–
2007*	37	–	–	–	–
2008*	35	–	–	–	–
2009	38	121	3.18	0.23	14
2010	37	174	4.70	0.36	13
2011	27	76	2.81	0.23	12
2012	16	90	5.63	0.51	11
2013**	21	65	3.10	0.31	10
2014	19	136	7.16	0.80	9
2015	15	146	9.73	1.22	8
2016***	17	338	19.89	2.84	7
2017	20	522	26.10	4.35	6
2018	17	289	17.00	3.40	5
2019	17	317	18.65	4.67	4
2020	27	259	9.59	3.20	3
2021	26	98	3.77	1.88	2
2022	43	61	1.42	1.42	1
Total	454	2,692	5.93	0.42	

Note(s): *There is no Scopus information regarding citations in the articles published in 2006, 2007 and 2008
** There is no Scopus information regarding citations of 14 articles published in 2013
*** There is no Scopus information regarding citations of one article published in 2016
**** Only Scopus citations were considered
Source(s): Table by authors

Table 1.
Publication and citation structure of REDEE and EJMBE

and 167 from 2016 to 2022 in the EJMBE), with an average of 27 papers per year (454 published manuscripts/17 years). The year with fewer publications was 2015, with 15 articles. From 2006 to 2014, REDEE published four issues per year. However, since 2015 the number of annual issues has become three. This can explain the reduced number of articles published in 2015 compared to 2006. Nevertheless, 2022 was the year with the most published articles (43), reflecting a contribution of 9.47% of the total in 2006–2022.

It should be noted that the articles published between 2006 and 2008 and 14 articles from 2013 are not indexed in Scopus. A total of 326 articles were cited 2,692 times, with an average of 5.93 citations per article and 0.42 per year. Remarkably, the years between 2014 and 2020 represent 74.55% of the citations. This indicates the articles' relevance published in this period. The year with the highest total citation (TC) mean per document was 2017, with 26.10, reinforcing the relevance of the articles published in that period.

Contributing authors

It is fundamental to recognize the journal's structure and growth by identifying the most productive authors, institutions and countries (Donthu *et al.*, 2021). In total, 1.042 authors published their work in REDEE and EJMBE. Table 2 reveals the top 10 most productive authors and their impact. The analysis considered the 1.042 authors who published in REDEE and EJMBE. Gázquez-Abad, J., Vázquez-Casielles, R. and Camisón-Zornoza, C. are the most prolific authors, with four articles each. It is interesting to acknowledge that Professor Camisón-Zornoza published four articles between 2008 and 2009, an average of two papers per year. Among the top 10 most productive authors, Universidad de Almeria is the most represented affiliation, with two authors (Gázquez-Abad, J.; Cruz-Rambaud, S.) and seven papers. In an editorial note published in 2015, the Editors Barroso and Bigné (2015) stated multiple measures to facilitate the publication of relevant and rigorous papers. One of

Table 2.
Top 10 most productive authors and author's impact*

Most productive authors			Author's impact (ordered by total citations*)						
Author's name	Affiliation	Total	Author's name	Total citations	No. of cited documents (*n*)	h-index	g-index	m-index	Production year – start
Gázquez-Abad, J.	Universidad de Almeria, Spain	4	Barrena-Martínez, J.	85	1	1	1	0.125	2016
Vázquez-Casielles, R.	Universidad de Oviedo, Spain	4	López-Fernández, M.	85	1	1	1	0.125	2016
Camisón-Zornoza, C.	Universidad Jaume I, Spain	4	Romero-Fernandéz, P.M.	85	1	1	1	0.125	2016
Barba-Aragón M.I.	Universidad de Múrcia, Spain	3	Curras-Perez, R.	84	2	2	2	0.333	2018
Blanco-González, A.		3	Arfaoui, M	80	2	2	2	0.286	2017
Cruz-Rambaud, S.	Universidad de Almería, Spain	3	Rejeb, A.B.	80	2	2	2	0.286	2017
Días-Casero J.C.	Universidad de Extremadura, Spain	3	Andreu, L.	71	1	1	1	0.167	2018
Aguiar-Díaz, N.	Universidad de Las Palmas de Gran Canaria, Spain	3	Biachi, E.	71	1	1	1	0.200	2018
Elrehail, H.	Abu Dhabi School of Management, United Arab Emirates	3	Bruno, J.M.	71	1	1	1	0.200	2019
Rita, P.	Universidade NOVA de Lisboa, Portugal	3	Sarabia-Sanchez, F.J.	71	1	1	1	0.200	2019

Note(s): *There is no Scopus information regarding citations in the documents published in 2006, 2007 and 2008, 14 published in 2013 and one published in 2016. Only Scopus citations were considered
Source(s): Table by authors

them was stimulating authors to publish in English to reflect a new internationalization approach. In 2016, Bigne (2016) reinforced this interest by changing the journal's name from REDEE to EJMBE, assuming the commitment previously stated to internationalize the journal. Since these changes are recent, it is understandable that most of the documents published were from Spanish authors and affiliations before they were applied. However, in the list, there are already two non-Spanish institutions, namely, the Abu Dhabi School of Management from the United Arab Emirates and Universidade NOVA de Lisboa from Portugal.

The number of citations is fundamental to acknowledging the articles' impact (Donthu *et al.*, 2021). According to this metric, it is possible to recognize the most EJMBE impactful author. Barrena-Martínez, J., López-Fernández, M. and Romero-Fernández, P.M., were the authors with the highest number of citations (85) among the most impactful. This result derives from the work entitled "Corporate social responsibility: Evolution through institutional and stakeholder perspectives," published by the three authors (Barrena-Martínez *et al.*, 2016). The fourth most cited author was Curras-Pérez, R., with 84 citations from two papers (Sánchez-García and Curras-Perez, 2019; Stojanovic *et al.*, 2018). It is also interesting to acknowledge that Curras-Pérez, R., Arfaoui, M and Rejeb, A.B., are the authors with the highest productivity and impact (*h*-index) and article performance (*g*-index). However, Curras-Pérez, R., has the highest *m*-index (0.333) since its first paper was published in 2018, one year after Arfaoui, M. and Rejeb, A.B.

Most influential articles

The number of citations is fundamental to understanding the articles' research impact (Donthu *et al.*, 2021) and how they shape future research (Purkayastha *et al.*, 2019; Singh *et al.*, 2022). The journal's most impactful articles are identified through the analysis of TC. The top 10 most impactful documents are represented in Table 3. These documents contributed to 21.66% of the total number of citations. The most cited work is from Barrena-Martínez *et al.* (2016), with 85 citations, followed by Stojanovic *et al.* (2018), with 71. Barrena-Martínez *et al.* (2016) conducted a literature analysis about the evolution of corporate social responsibility (CSR). In the top 10, only the works by Kamazak (2017) and Palaniappan (2017) were single-authored. Of the list, only one article was published in REDEE (Aragón-Sánchez *et al.*, 2015), confirming the effect of the EJMBE internationalization strategic decision on the number of citations. The normalized citation impact compares the performance of a document to the

Documents	Total citations*	Average total c itations per year	Normalized total c itations
Barrena-Martínez *et al.* (2016)	85	10.63	4.28
Stojanovic *et al.* (2018)	71	11.83	4.18
Bianchi *et al.* (2019)	71	14.20	3.81
Kamasak, R. (2017)	68	9.71	2.61
Arfaoui and Rejeb (2017)	57	8.14	2.18
Riera and Iborra (2017)	57	8.14	2.18
Aragón-Sánchez *et al.* (2015)	50	5.56	5.14
Liberato *et al.* (2018)	45	7.50	2.65
Palaniappan (2017)	42	6.00	1.61
Gómez-Cruz *et al.* (2017)	37	5.29	1.42

Note(s): *There is no Scopus information regarding citations in the documents published in 2006, 2007 and 2008, 14 published in 2013 and one published in 2016. Only Scopus citations were considered
Source(s): Table by authors

Table 3.
Top 10 most cited documents

average performance of the documents published in the REDEE and EJMBE (Bornmann and Marx, 2015). This metric helps mitigate the impact of a publication with more citations than a recent one (Rahaman *et al.*, 2022). The work by Aragón-Sánchez *et al.* (2015) has the highest normalized total citations (5.14), while the work by Bianchi *et al.* (2019) has the highest average total citations per year (14.20). These results highlight the relevance of these studies among those published in EJMBE using metrics other than TC.

Author's keywords

The analysis of the author's keywords represents a way to understand the core topic of a research article (Su and Lee, 2010) and explore the existing and future relationships in EJMBE. A total of 2,028 keywords occurred in the 454 analyzed documents. The most prominent keywords that occurred at least ten times were innovation (n = 26), performance (n = 22), trust (n = 15), satisfaction (n = 14) and entrepreneurship (n = 10). These findings confirm the journal's aim to publish research related to business economics. Analyzing the Top 10 keywords, one is associated with the research context (i.e. performance), five with a body of literature (e.g. entrepreneurship or corporate governance) and four is related to theoretical concepts (e.g. trust or satisfaction). In total, these five keywords represent 4.29% of the total. Table 4 depicts the most frequent authors' keywords.

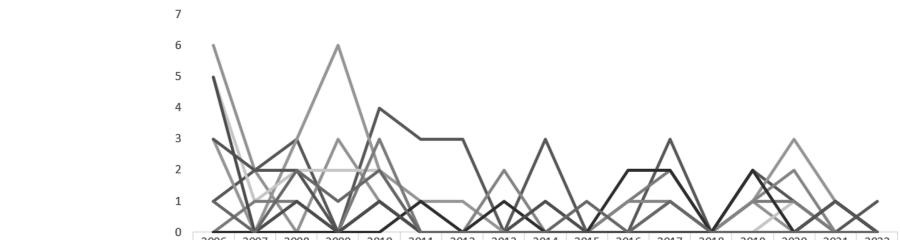
Figure 2 highlights the authors' keywords evolution to reveal the journal's longitudinal interest. This analysis allows us to explore the existence of the future interests of EJMBE (Donthu *et al.*, 2021). Innovation, the most recurrent keyword, had a steady representation in the first eight years, with 19 hits. This result suggests the interest of EJMBE in publishing articles related to innovation in their first years. The 19 articles published using this keyword represent 73% of the total. The remaining seven (27%) were published after 2014. In turn, the CSR keyword has prominence (seven times out of nine) in the second half of the analyzed period (2015/2022), showing a trend. This result suggests the relevance of CSR for the Business Economics research area. In particular, CSR has been a requirement for companies to meet environmental pressures and improve competitiveness (Barrena-Martínez *et al.*, 2016). In 2022, innovation was the sole keyword referred to, which by the way, has been losing relevance over the years. These results may suggest a shift in research trends published in EJMBE.

Figure 3 highlights the author's keyword co-occurrence network. This analysis establishes the relationship and maps the conceptual structure of the articles published (Eduardsen and Marinova, 2020) in REDEE and EJMBE, reflecting their relevance to the journal. It suggests the thematic relationship between the authors' keywords and the published articles (Wang *et al.*, 2012). It makes a conceptual contribution to analyzing the top 10 most recurring keywords (Table 4) by establishing a connection between them. The point

Author's keywords	Frequency	Percentage
Innovation	26	1.64
Performance	22	1.39
Trust	15	0.94
Satisfaction	14	0.88
Entrepreneurship	10	0.63
Corporate governance	9	0.57
Corporate social responsibility	9	0.57
Relationship Marketing	9	0.57
Commitment	8	0.50
Knowledge management	8	0.50

Source(s): Table by authors

Table 4.
Top 10 recurrent authors' keywords



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Innovation	1	2	3	0	4	3	3	0	3	0	0	3	0	2	1	0	1
Performance	3	0	3	6	2	1	1	0	0	0	0	1	0	1	3	1	0
Trust	6	2	0	3	1	0	0	0	1	0	0	0	0	1	0	1	0
Satisfaction	5	1	2	2	2	0	0	0	1	0	0	0	0	0	1	0	0
Entrepreneurship	0	1	1	0	3	0	0	0	0	0	1	2	0	1	1	0	0
Corporate Governance	0	0	1	0	1	0	0	2	0	0	1	1	0	1	2	0	0
Corporate social responsibility	0	0	0	0	0	1	0	1	0	0	2	2	0	2	0	1	0
Relationship marketing	3	2	2	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Commitment	5	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Knowledge management	1	0	2	1	2	0	0	0	0	1	0	1	0	0	0	0	0

Source(s): Figure by authors

Figure 2.
Authors' keywords evolution

Source(s): Figure by authors

Figure 3.
Keyword co-occurrences network in REDEE and EJMBE

size of the edge represents the frequency that a keyword occurs, and the thickness of the line between two-point size edges indicates the keyword's frequency co-occurrence. Confirming the results of Table 4, the point-size edges with the greater dimension are innovation, performance and satisfaction. The keywords in the same color represent a cluster. For instance, organizational learning, organizational performance, transformational leadership and shared vision (brown color) reveal a theme significantly interconnected. The lines between the edges of trust, satisfaction, commitment and loyalty (pink color) suggest that these theoretical concepts are pivotal to relationship marketing and a relevant topic for EJMBE. *Relationship marketing* is a competitive strategy aiming to create, maintain and

develop successful customer relationships (Mahmoud *et al.*, 2018). Trust, satisfaction, commitment and loyalty are fundamental to establishing such relationships (Simões Coelho *et al.*, 2022; Furtado *et al.*, 2022; Moro *et al.*, 2020).

Innovation and performance are concepts strongly linked to entrepreneurship (red color). Innovative entrepreneurship is the basis for economic development, fundamental to achieving and maintaining success (Block *et al.*, 2017; García-Rodríguez *et al.*, 2017). Also, firm performance is critical for survival, growth, or turn profitability. It is a guide to meeting the firm's objectives, such as profit or positive cash flow (Brownell *et al.*, 2021; Rico and Cabrer-Borrás, 2019).

Multiple correspondence analysis evolution map

Multiple correspondence analysis permits the creation of a conceptual structure for the documents published in the REDEE and EJMBE. K-means clustering acknowledges the documents with common concepts (Aria and Cuccurullo, 2017), examining the relationship between the authors' keywords and creating a conceptual map. Through the graphical representation of the data through a homogeneity analysis of the indicator matrix (Gifi, 1990), it is possible to understand the interdependence among a set of variables, identifying new latent variables. Figure 4 shows that the publications in the REDEE and EJMBE are classified into two clusters, showing the intellectual structure of the journal in the past seventeen years. For instance, in the red cluster, the keywords competitive advantage, stakeholder theory, firm performance and CSR reveal that these are used simultaneously in multiple documents. Since these keywords are close to the middle of the map, they represent the core of the research field developed in the journal. In turn, the keywords Perceived Risk and Transformational Leadership are far from each other, suggesting that few articles studied perceived risk in transformational leadership.

Country collaboration network

The social structure reveals the relationship and collaboration between authors from different countries (Figure 5) in the analyzed years. Scholars' collaboration can lead to

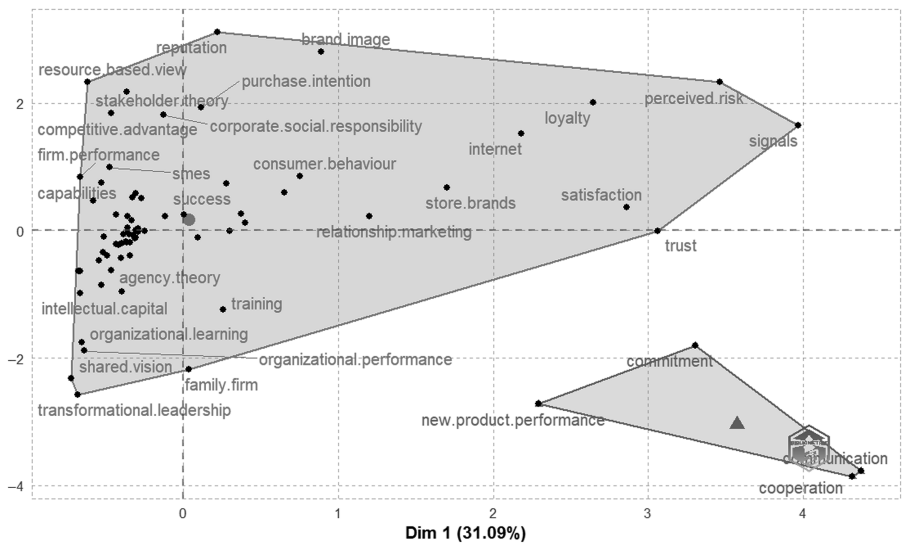


Figure 4.
Conceptual structural map

Source(s): Figure by authors

From	To	Frequency	Percentage
Spain	Argentina	1	11.11
Spain	Canada	1	11.11
Spain	Chile	1	11.11
Spain	Costa Rica	1	11.11
Spain	Mexico	1	11.11

From	To	Frequency	Percentage
Spain	Colombia	7	12.28
Spain	USA	3	5.26
China	Oman	2	3.51
Jordan	Cyprus	2	3.51
Pakistan	Jordan	2	3.51

Source(s): Figure by authors

Figure 5.
REDEE (left) and EJMBE (right) collaboration maps

different contributions and richer insights (Crane, 1977). Identifying the countries from which REDEE and EJMBE authors are affiliated reveals the intensity of the journal's internationalization. It can encourage new research projects among researchers from unrepresented countries (Donthu *et al.*, 2021).

In 2016, EJMBE started an international journey (Bigne, 2016). To highlight the international path, the country collaboration world map among REDEE and EJMBE authors is presented in Figure 5. Additionally, the top five country collaborations are revealed. The author's affiliation country was used as a proxy to acknowledge the authors' nationality (Aria *et al.*, 2021), and only papers in which the collaboration between authors from different nationalities was considered. The blue colors represent the authors' countries, and the color tone reveals the frequency of collaborations. Through the analysis, a growing international trend started since the foundation of EJMBE. The international collaborations of REDEE (world map on the left; nine articles) showed a lower collaboration rate. In turn, EJMBE (world map on the right; 57 articles) showed a radical increase in international collaborations. Since 2016, the collaboration network has spread worldwide. The collaboration network involves authors from Asia, Africa and Australia and has grown stronger in the United States.

From the 287 articles published in REDEE, 9 (3%) articles were developed by a group of authors from different nationalities. In turn, the EJMBE counted 57 (34%) out of 167 articles published. The collaborations at the REDEE involved the collaboration between Spanish authors and authors from Argentina, Canada, Chile, Costa Rica, Mexico, the Netherlands, Oman, Portugal and the USA One example is the work of Oviedo-García *et al.* (2014), which authors produced from the Universidad de Sevilla, Spain and Universidad Autónoma de Chile, Chile. Regarding EJMBE, the top three collaborations among countries are between Spain–Colombia with seven articles, Spain–USA with three articles and China–Oman with two papers. The work of Badillo *et al.* (2017) is an example of a collaboration network conducted by authors from the Universidad Autónoma Latinoamericana (Unaula), Medellín, Colombia and the Universitat de Barcelona, Spain.

Conclusions

This study performed a bibliographic analysis aiming to identify the footprint left by REDEE and EJMBE that made the journal recognized as it is nowadays. As the number of academic studies published in REDEE and EJMBE is increasing rapidly, it is vital to create a sustainable evolution, helping researchers align their focus and meet the journal's aim (Cortez *et al.*, 2018; Moro *et al.*, 2017). Examining the past, present and future of EJMBE research was needed. Hence, this study developed an overview of the studies published in REDEE and EJMBE between 2006 and 2021. The results highlighted that many researchers publish in this journal, showing diversity, especially since the EJMBE foundation.

The bibliometric analysis results indicate a steadily growing number of publications since 2015. The year with the highest number of publications was 2021 (46). Additionally, since 2014, the number of citations has increased significantly, as 66% of the journal's citations were from 2014 to 2019. This output led the journal from a Scopus Quartile 3 (Q3) in the subject area of Business and International Management to an outstanding Scopus Quartile 1 (Q1) in 2019. Simultaneously, these results reflect their relevance and impact on EJMBE. The contribution of Barrena-Martínez *et al.* (2016), Kamazak (2017) and Stojanovic *et al.* (2018) was fundamental, as they were the most cited papers.

The result from the analysis of the most contributing authors revealed that the most prolific authors (i.e. more articles) were Gázquez-Abad, J., Universidad de Almeria, Spain (n = 4), followed by Vázquez-Casielles, R., Universidad de Oviedo, Spain (n = 4). The third most productive author was Camisón-Zornoza, C., Universidad Jaume I, Spain (n = 4). These results demonstrate the diversity of authors publishing in the EJMBE. Among the 988

authors who published in the REDEE and EJMBE, only three published four articles in the 16 years of analyzed publications. These three authors represent 0.4% of the total. Among the top 10 most productive authors (see Table 2), it is possible to acknowledge that all the authors are based in Spain. These results are understandable since changes occurred in the journal only more recently. In 2015, REDEE changed its direction by stimulating authors to publish in English instead of Spanish (Barroso and Bigné, 2015), starting the process of internationalization. In 2015, a step forward was taken by changing the Spanish REDEE designation to EJMBE (Bigne, 2016), an international designation. Due to these recent changes, it is understandable that the most prolific authors still have a Spanish affiliation. Due to the internationalization dynamic that started in 2015 (see Figure 5), these results are expected to change in the following years.

An analysis of the authors' keywords demonstrated the topics that are getting the attention of the EJMBE. Since 2014, the authors have most mentioned the CSR keyword. The keyword co-occurrence analysis (see Figure 3) and the conceptual structural map (see Figure 4) confirmed this result. They suggested that the topic relates to purchasing intention, firm performance, stakeholder theory and reputation. Implementing CSR actions includes the systemic analysis of the environment. From this point of view, the stakeholder theory is critical. The stakeholder theory refers to the effort to establish a positive multilateral relationship among involved parties. This implies achieving sustainable economic development, establishing a connection between employees, the local community and society, and improving the quality of life of others (Barrena-Martínez *et al.*, 2016). These efforts will promote a positive reputation and stimulate the customers' purchase intentions (Baah *et al.*, 2021; Bianchi *et al.*, 2019). Additionally, relationship marketing and the relation between innovation, performance and entrepreneurship are topics of interest for the journal (Cánovas-Saiz *et al.*, 2020; Guei, 2022; Rico and Cabrer-Borrás, 2019).

In summary, three significant implications can be taken from the research topics which received the most attention from the authors who published in EJMBE during the analyzed period. First, innovation is a critical requirement if one wishes to embark on entrepreneurship endeavors (Rehman *et al.*, 2023), which is strongly connected with performance; however, this theme was more emphasized in 2006–2014. On the contrary, CSR achieved prominence between 2014 and 2021, with researchers often using stakeholder theory (e.g. Salam and Ali, 2020) and stressing CSR's influence on purchase intention, firm performance and reputation. Second, concepts like satisfaction, trust, commitment and loyalty were frequently the focus of attention of papers encapsulated by the relationship marketing paradigm (Pinto and Brandão, 2020).

The aims and scope of EJMBE are well formulated, aligned with the name of the journal, at the core of the business and management arena, and matching key subject areas and categories as defined by Scopus, such as business and international management, marketing, organizational behavior and human resources management, strategy and management, finance. Nevertheless, the journal could improve its positioning by developing successful strategies embracing future lines of research or special issues emphasizing the interface between management and information technology. This novel approach could cover hot topics such as digital and social media analytics and social network analysis for business, data science for management and big data analytics, knowledge management and business intelligence, social network intelligence and cybersecurity (Jakubik and Müürsepp, 2022; Kumar and Mallipeddi, 2022; Mariani *et al.*, 2022).

Social media has given businesses a previously unheard-of opportunity to communicate with customers in real-time and access uncharacteristically large and rich consumer information that may be used to revolutionize their business and marketing strategies (Kumar and Sharma, 2022; Stojanovic *et al.*, 2018). Social media analytics can be envisaged as a multidisciplinary strategy that integrates text mining, social network analysis and data

mining to allow firms to take advantage of techniques like sentiment analysis, topic modeling, social network analysis and influencer identification (Ramos *et al.*, 2019, 2022; Rita *et al.*, 2022). Social network analysis enables companies to think about network problems and extract valuable and practical information for various applications, utilizing network science that offers a complete set of approaches, with applications such as personalized targeting and influencer detection (Fuentes-Medina *et al.*, 2018; Rita *et al.*, 2020).

Data science for management uses interdisciplinary methods such as data visualization, database systems and machine learning (Han and Trimi, 2022) to find novel, practical and clear patterns in data. These methods are used to analyze and prepare data to build analytical models, like data characterization/description, recency, frequency and monetary (RFM) value, or association rules (for example, market basket analysis). Big data analytics highlights business challenges brought on by the big data ecosystem's complexity and diversity (Modic *et al.*, 2019; Naeem *et al.*, 2022).

Knowledge management is also a cornerstone area of research since many of the conventional sources of competitive advantage are being swept away by the consequences of digital transformation and other globalizing forces (Machado *et al.*, 2022; Qadri *et al.*, 2021). Business intelligence focuses on procedures giving managerial decision-supporting capabilities (Gupta *et al.*, 2022). Furthermore, social network intelligence addresses the management of social networks, geographic information and technological data, information and knowledge. Finally, cybersecurity covers the function of information and the safety of such information within social and organizational contexts (Kumar and Mallipeddi, 2022).

Although the study gives a complete overall picture of the published documents between 2006 and 2021, it has some limitations. First, the search scope was restrained to the Scopus database. However, every scientific database has limitations (Falagas *et al.*, 2008). Second, the present study was limited to the years between 2006 and 2021. The REDEE was founded in 1991, and to depict the entire history and the general overview of the journal, it would be essential to consider all the documents. The lack of information restrained our scope since the documents published before 2006 are not publicly available. Third, there are 129 documents published that are not indexed in the Scopus Database. This implies limitations in terms of the number of citations. Tables 2–4 should be analyzed considering this limitation. Fourth, recent years have had higher results since it is possible to disseminate the author's work easier than before, resulting, for instance, in a higher number of citations among the scientific community. Although these limitations should be considered, this bibliometric analysis uncovers a general overview of the published documents and identifies the most relevant information published in REDEE and EJMBE.

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Anchor investors and equity crowdfunding for entrepreneurs

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Abstract

Purpose – This empirical study uses herd behavior model to explore the role of anchor investors in ensuring fundraising success and overfunding of crowdfunded ventures.
Design/methodology/approach – Qualitative comparative analysis (QCA) is applied to find the configurational patterns describing how anchor investors' information disclosure leads to successful financing and overfunding.
Findings – Even when the anchor investor's resume is not detailed or the anchor investor has little experience in entrepreneurial investment, success or overfunding can be achieved, provided the anchor investor is a corporation rather than an individual. For individual anchor investors, a detailed resume matters. Overfunding can be achieved even when an individual anchor investor makes a small relative investment, if this small relative investment is compensated for by a detailed resume. Experience in entrepreneurial investment is crucial when individual anchor investors have few previous investments. Regardless of the anchor investor's identity, investment in absolute terms is crucial for crowdfunding success when experience in entrepreneurial investment is low. Such experience must be extensive if the anchor investor's resume is not detailed.
Practical implications – Both entrepreneurs and crowdfunding platforms can benefit from the findings in relation to the design of campaigns that use anchor investors' informational cues to achieve success and overfunding.
Originality/value – The study examines the importance of anchor investors' information disclosure in digital crowdfunding environments, differentiating between individual and corporate anchor investors.

Keywords Anchor investor, Herd behavior, Equity crowdfunding, Qualitative comparative analysis (QCA), Success, Overfunding
Paper type Research paper

1.Introduction

> "It is a far, far better thing to have a firm anchor in nonsense than to put out on the troubled seas of thought."—John Kenneth Galbraith

The mobilization of financial resources in entrepreneurial ecosystems has been identified as one of the major difficulties in the creation of new companies (Ko and McKelvie, 2018). Crowdfunding makes it possible to reach a multitude of potential backers online. The need to

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develop strategies for successful crowdfunding campaigns is becoming increasingly acute (Kraus *et al.*, 2016; Moritz and Block, 2016). The main challenges in fundraising for new ventures lie in mitigating information asymmetries between entrepreneurs and potential backers and in building trust around technologies, products or services whose quality or market demand are unproven or costly to determine (Murray and Marriott, 1998; Nagy *et al.*, 2012; Colombo, 2021; Bahlous-Boldi, 2022).

Crowdfunding success factors (e.g. campaign design and entrepreneur characteristics, motivations, biases, and culture) have been studied using many theoretical approaches. These approaches include information asymmetries, social influence, game theory, cognitive evaluation theory, impression management, signaling theory and herd behavior. Success has also been measured in different ways (Alegre and Moleskis, 2016). One approach to mitigating information asymmetries in crowdfunding is for fund-seeking entrepreneurs, as the better informed party, to convey signals about the quality of their ventures (see Ahlers *et al.*, 2015; Piva and Rossi-Lamastra, 2018; Chakraborty and Swinney, 2021; Huang *et al.*, 2022). Another approach is to use others' behavior to trigger imitation based on observational learning. This imitation is known as herding. In such cases, the crowd's decision-making is influenced by others' decisions to invest. The crowd uses these cues given the cognitive cost of generating a more exhaustive evaluation of the projects available for investment (see Comeig *et al.*, 2020; Petit and Wirtz, 2022). This study focuses on herd behavior by studying the role of anchor investors (also referred to as lead investors) in triggering herding and encouraging potential backers to invest.

The present empirical study uses qualitative comparative analysis (QCA) to establish configurational patterns of anchor investors' informational cues that lead to fundraising success or overfunding in equity crowdfunding campaigns. Here, overfunding is defined as raising at least 10% above the fundraising target. The study focuses on a process of observational learning resulting in herd behavior. The informational cues that trigger herd behavior are evaluated using two models. The first explores the successful achievement of the funding target (Model 1). The second explores the achievement of particularly high levels of funding, referred to here as overfunding (Model 2). The data are from Startupxplore. This equity crowdfunding platform follows a hybrid crowd design. Anchor investors serve as experienced professionals that conduct thorough due diligence on fund-seeking entrepreneurial projects (Chen *et al.*, 2016).

The study is original in its exploration of the role of anchor investors' financial and reputational commitment in securing syndicated equity crowdfunding success and overfunding. It is also original in that it differentiates between information disclosure strategies for individual and corporate anchor investors. This approach not only enriches the possible theoretical implications but also makes it easier to derive practical guidelines to ensure successful entrepreneurial fundraising.

Next, a discussion of the theoretical foundations is provided, building on the literature on information processing, observational learning and herd behavior. Then, the data and method are outlined, with emphasis on the configurational nature of the analysis and the relevance of this approach. The results are then presented, followed by a discussion of the optimal information disclosure strategies identified in the analysis. Conclusions are provided, before the paper closes with the theoretical contributions, limitations and practical implications of the study.

2. Theoretical background

2.1 Investors' cognitive processing in asymmetric informational settings

Credit markets for highly innovative small- and medium-sized enterprises (SMEs), including crowd-based financial environments, have high information asymmetries. These

asymmetries often result in a credit rationing problem (Comeig *et al.*, 2014). When investors are confronted with a catalog of mutually exclusive investment options or independent projects with budget constraints, cognitive processing becomes increasingly complex as more information is added to the decision-making process (Anderson, 2003). This complexity calls for the use of heuristics. Such methods are aimed at streamlining information processing and subsequent decision making under limited cognitive resources (Gigerenzer and Goldstein, 1996; Ferretti *et al.*, 2021). The need for heuristics is extremely acute in equity-based crowdfunding, where Hemer (2011) and Ahlers *et al.* (2015) have found especially high levels of information asymmetries and complexity in information processing (Bade and Walther, 2021).

In equity-based crowdfunding, potential investors possess limited information prior to investing. The most well-informed party is the entrepreneur, who often provides potential investors with information on the venture to mitigate information asymmetries. This disclosure is part of a trust-building strategy (Ahlers *et al.*, 2015). This study does not focus on the role of the entrepreneur in signaling the expected future success of an equity crowdfunding campaign in an attempt to reduce uncertainty and stimulate investment. Instead, it focuses on how the behavior of a quasi-informed party, the anchor investor, triggers a process of observational learning, leading to herd behavior. Ultimately, this process can determine crowdfunding success or overfunding. Research has shown that it is rational to rely on the decisions of others when making one's own decisions in the presence of information asymmetries (Banerjee, 1992).

In syndicated equity crowdfunding, fundraising campaigns are always endorsed by an anchor investor. After a due diligence process, this anchor investor assigns a considerable amount of money to the venture prior to its launch. Anchor investors are considered to have substantial expertise in entrepreneurial investment and due diligence processes (Zhao *et al.*, 2021). They often provide written justification for their decisions to invest in particular projects. Accordingly, anchor investors' access to information is somewhere between the insider information of entrepreneurs and the information provided by entrepreneurs to potential investors.

The involvement of anchor investors in equity crowdfunding campaigns provides two paths to the mitigation of information asymmetries. Before the venture is available for public investment, a sizeable investment by an anchor investor reduces the remaining amount required to reach the funding target. This path lowers the risk that the funding target will not be reached. It therefore reduces the risk that the fundraising campaign will fail and that investors will incur an opportunity cost for the time their funds have been tied up in the unsuccessful campaign (financial commitment). An alternative path to mitigate information asymmetries stems from the anchor investor's personal career and written endorsement of a campaign (reputational commitment). This study focuses on both paths. It explores the role of the anchor investor's monetary contribution in relative and absolute terms (financial commitment) and the anchor investor's information disclosure based on experience and rationale for investment (reputational commitment) in triggering rational herd behavior that ultimately leads to fundraising success and overfunding.

Figure 1 illustrates this dual path to mitigating information asymmetries and generating confidence. Section A exemplifies how, before the campaign (from $t_0 - x$ to t_0), the targeted funding is α, which is reduced once the anchor investor makes a sizeable investment (α/y). This investment lowers the funding required to reach the funding target (t_f) to $\alpha - \alpha/y$ once the campaign starts (t_0). Thus, the chances of not raising the funding target are reduced substantially. Section B shows how the anchor investor's due diligence between $t_0 - x$ and t_0 generates information disclosed from t_0 to t_1. This disclosed information, together with information on the anchor investor's attributes, builds momentum for herd behavior.

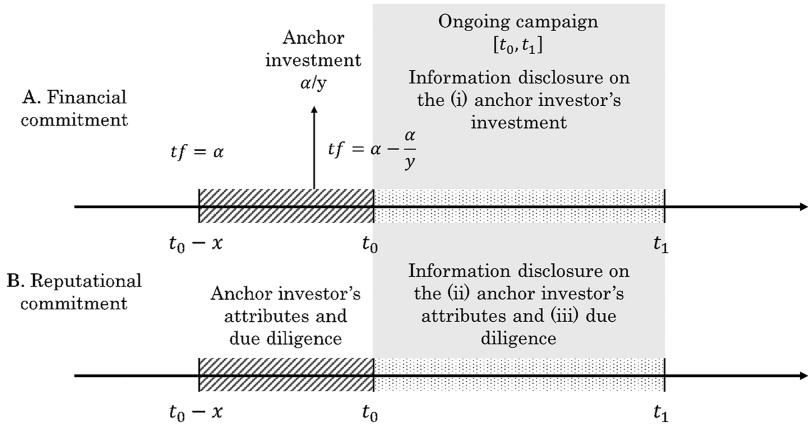

Figure 1.
A dual path to mitigating information asymmetries and generating confidence

The next section describes rational herd behavior dynamics. According to Hoegen *et al.* (2018), these dynamics are a prominent set of heuristics used in financial scenarios with multiple competing investment alternatives.

2.2 Information disclosure and rational herding dynamics

In evaluating the information structure and the awakening of rational herd behavior, this empirical study employs three subsets of cues: (1) informational cues on the investment by the anchor investor, (2) informational cues on the anchor investor's experience and (3) informational cues on the explanation that led the anchor investor to invest. Figure 2 shows that subset (1) of cues comes from the financial commitment path. Subsets (2) and (3) come from the reputational commitment path. In QCA terminology, the first subset has two conditions: absolute investment and relative investment in relation to target funding. These conditions could be used as indicators of the anchor investor's investment. The second subset has three conditions: the number of years that the anchor investor has been investing in startups, the number of investments that the anchor investor has made and the length of the anchor investor's resume displayed on the platform, used as a proxy of detail. The last subset

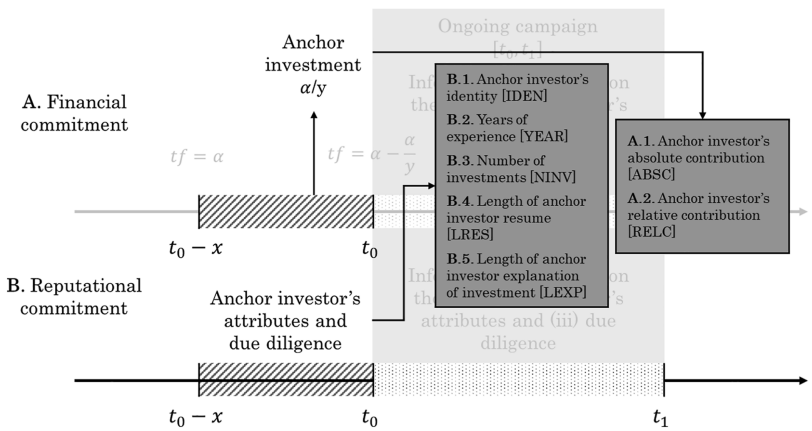

Figure 2.
Disclosure of information on the anchor investor's financial and reputational commitment

consists of a single condition: the detail of the explanation as to why the anchor investor decided to invest. In addition, the anchor investor's identity as either an individual or a corporation is included in the analysis to add further detail to the configurational patterns. The three subsets of conditions are now described in more depth.

2.2.1 Disclosure of information on investments by the anchor investor. Just as the potential buyers in the used car market described by Akerlof (1970) knew little or nothing about car quality, potential crowdfunders require credible signals to combat the information asymmetries in this market. As noted by Pabst and Mohnen (2021), trust building through such signals is critical in crowdfunding platforms. Reputational intermediation, whereby car dealers provide warranties for used cars, was established in the used car market to prevent the "lemons" problem (Ibrahim, 2015). Likewise, in crowdfunding, the main role of such reputational intermediaries is to provide further assurance of fundraising campaign success to mitigate information asymmetries and incentivize investment.

The original lead investor–follower model was introduced by the US equity crowdfunding platform AngelList. Under this model, the crowd invests in the lead's syndicated operations (Agrawal *et al.*, 2016). Shen *et al.* (2020) found that the amount of funds invested by anchor investors in the financing process matters. Thus, anchor investors' decisions trigger more investment from the crowd because these decisions are deemed to be informed and reliable. An analogy is the fact that entrepreneurs' investment in their own ventures or their decisions to retain more equity are seen as an indication of overall venture quality (Brealey *et al.*, 1977; Vismara, 2016; Löher *et al.*, 2018; Shen *et al.*, 2020).

As argued by Agrawal *et al.* (2016), syndicates (i.e. the use of an anchor investor to whom the crowd is syndicated) help mitigate market failures by shifting the focus of the crowd's investment activities from startups (i.e. the entrepreneurs) to anchor investors. Li *et al.* (2016) identified information on lead or anchor investors as a peripheral cue. They observed a positive relationship between the lead investor's identity certification and the number of followers. However, they found a negative link between the percentage of money invested by the lead investor and the number of followers, probably due to the fear of collusion between the lead and the entrepreneur. In contrast, Shen *et al.* (2020) found that the share of the anchor investor's contribution in relation to target funding positively influenced campaign performance. Despite concerns about collusion, which affect the reputational commitment path to mitigating information asymmetries, a higher volume of investment by an anchor investor substantially reduces the amount of money still required to be raised. It thus makes it easier to achieve the funding target. Given these arguments, the following propositions are formulated.

Proposition 1. High monetary contributions are conducive to funding success and overfunding (i.e. exceeding the funding target by at least 10%) in syndicated co-investment campaigns.

Proposition 2. High relative levels of anchor investment with respect to the funding target are conducive to funding success and overfunding (i.e. exceeding the funding target by at least 10%) in syndicated co-investment campaigns.

2.2.2 Disclosure of information on the anchor investor's experience. Entrepreneurs' observable attributes have been recognized as valuable signals for the market (Hsu, 2007; Gimmon and Levie, 2010; Piva and Rossi-Lamastra, 2018). Regarding human capital, Piva and Rossi-Lamastra (2018) noted that entrepreneurial experience is a key factor for fundraising success in equity crowdfunding. Given that human capital is a key factor in funding new ventures, particularly young ones, firms with greater human capital (i.e. with higher expected efficiency) should attract more money (Zacharakis and Meyer, 2000; Colombo and Grilli, 2005; Unger *et al.*, 2011; Barbi and Mattioli, 2019).

Arguably, just as the human capital of entrepreneurs who run fundraising campaigns is relevant to potential backers (Hunter, 1986; Ackerman and Humphreys, 1990; Baum *et al.*, 2001; Ahlers *et al.*, 2015), the human capital attributes of anchor investors are similarly important to trigger observational learning (see Unger *et al.*, 2011). Specifically, in the same way that studies have identified entrepreneurs' crowdfunding experience as a source of credibility for potential backers (Courtney *et al.*, 2017; Davis *et al.*, 2017), anchor investors' experience can perhaps enhance credibility. Anchor investors are often experienced business angels or venture capitalists whose level of expertise in entrepreneurial investment is above the average among crowd investors (Xiao, 2020). Therefore, their judgment indicates venture quality. Investment by business angels and venture capitalists is crucial for startups to develop (Cánovas-Saiz *et al.*, 2020).

As noted by Wang *et al.* (2019), angels' behavior in equity crowdfunding platforms can reduce information asymmetries, thus mitigating possible market inefficiencies. Platforms can enable the flow of information from angels (i.e. experienced individuals) working with such investments (see Maula *et al.*, 2005; Ramadani, 2009; Mason *et al.*, 2016) to the nonprofessional crowd (which is generally less experienced). They can thereby help the former convey information on venture quality (Agrawal *et al.*, 2016). Research has not only confirmed the central role of angels in financing large ventures but also revealed the complementarity between business angels and crowd investors as a source of greater overall efficiency in highly uncertain and asymmetric information environments (Wang *et al.*, 2019). Specifically, Shen *et al.* (2020) found that the lead investor's experience was positively related to fundraising success. Kim and Viswanathan (2019) concluded that experienced early investors within the app development crowdfunding market provide credible informational cues to the crowd regarding the quality of the project. This discussion leads to the following propositions.

Proposition 3. A greater number of years of experience investing in startups are conducive to funding success and overfunding (i.e. exceeding the funding target by at least 10%) in syndicated co-investment campaigns.

Proposition 4. A higher number of previous investments by the anchor investor are conducive to funding success and overfunding (i.e. exceeding the funding target by at least 10%) in syndicated co-investment campaigns.

Proposition 5. A more detailed anchor investor resume (i.e. a longer resume) is conducive to funding success and overfunding (i.e. exceeding the funding target by at least 10%) in syndicated co-investment campaigns.

2.2.3 Disclosure of information explaining investment decisions. The rationale behind an anchor investor's decision to support a funding campaign financially and reputationally is vital for triggering observational learning among potential investors and thus rational herd behavior. Hence, anchor investors offer potential investors a reasoned explanation of their investment decisions. Some authors have found a positive relationship between an optimal word count in the written content displayed in a crowdfunding campaign and investment (Bi *et al.*, 2017; Lagazio and Querci, 2018; Moy *et al.*, 2018). This finding may imply that the word count of the explanation of an investment decision acts as a relevant informational cue. Bi *et al.* (2017) and Lagazio and Querci (2018) found that backers preferred detailed textual descriptions. However, an excessive word count may hinder the assessment of a project, disincentivizing backers (Moy *et al.*, 2018).

Ultimately, it can be argued that an anchor investor's written endorsement of an entrepreneurial project can increase the perceived trustworthiness of the campaign for two reasons. It not only shows that someone has already committed considerable financial resources to that campaign but also provides a detailed justification of this investment

decision. Accordingly, a comprehensive explanation of what motivated an anchor investor to place funds in a project may help build a trusting environment where an anchor investor's endorsement is seen as a credible informational cue.

Proposition 6. A more detailed explanation of the anchor investor's decision to invest (i.e. a longer explanation) is conducive to funding success and overfunding (i.e. exceeding the funding target by at least 10%) in syndicated co-investment campaigns.

2.2.4 Anchor investor identity. One of the key methodological advancements of the current study is to provide configurational patterns of successful equity crowdfunding campaigns with either corporate or individual anchor investors. Previous research has identified the power of peer endorsement in attracting investment in crowd-based environments (Comeig *et al.*, 2020). Hence, it could be argued that individual anchor investors would be deemed as more credible than corporate investors because prospective investors see themselves as more similar to individuals than corporations. Conversely, a corporate anchor investor may be seen as more mature or experienced (i.e. more reputed) by the crowd of potential investors (Lee *et al.*, 2011). However, despite its importance for developing effective fundraising strategies in digital fundraising environments, the anchor investor's identity remains unexplored as an informational cue for imitation. This condition is included in Model 1 and Model 2 (i.e. the models of fundraising success and overfunding, respectively). The models thus explore how to improve the design of informational structures that effectively convey venture quality and informed imitation depending on the anchor investor's identity.

Proposition 7. Both individual and corporate anchor investors are conducive to funding success and overfunding (i.e. exceeding the funding target by at least 10%) in syndicated co-investment campaigns.

3. Data and method

3.1 Data

The data were gathered from the website of the equity crowdfunding co-investment platform Startupxplore, based in Valencia, Spain. Startupxplore is a leading Spanish equity crowdfunding platform. It is legally constituted as Startupxplore PFP, S.L. and is authorized by the Spanish National Securities Market Commission (Comisión Nacional del Mercado de Valores, CNMV). In June 2016, only two years after its launch, Startupxplore became Europe's second largest community. At the time of writing, the platform has raised more than 14 million euros from 60 deals. Of the fundraising campaigns on Startupxplore, 85% have been successful, attracting investment from more than 70,000 investors. This crowdfunding platform was chosen to source the data because of its relevance in terms of the volume of funds it intermediates and the fact that most of its campaigns follow a syndicated crowdfunding model with an anchor investor.

The data covered all campaigns managed until late 2021, representing €9,804,879.06 in requested funding and €10,984,543.65 in raised funding. From this initial data set, campaigns with no anchor investor were discarded (representing 41% of the initial data set), as were those with missing data for any of the conditions included in the analysis (representing 15% of the initial data set). Therefore, the final sample was homogeneous in terms of intermediation by an anchor investor and the information displayed to prospective backers, with the same informational cues provided in all campaigns.

The sample comprised 24 syndicated equity crowdfunding financing operations carried out between 2016 and 2021. Requested funding amounted to €5,141,261.06, and raised funding totaled €5,695,426.90. The anchor investor provided an average share of 23.68% of

the target funding for the sample. In absolute terms, the average funding provided by anchor investors was €51,855.75. In all transactions, the anchor investor was an organization or an individual male investor. No female anchor investors were found in either the sample or the original data set prior to filtering. Hence, gender was not considered in this study.

The data to perform the QCA included both dichotomous (i.e. 0 or 1) and fuzzy (i.e. continuous values ranging from 0 to 1) conditions (Sendra-Pons *et al.*, 2022b). To calibrate fuzzy values, full membership was set at 20% above the mean, the cross-over point was set at the mean value and full nonmembership was set at 50% below the mean (Berné-Martínez *et al.*, 2021). Publicly available data were collected by hand from Startupxplore. The authors processed the data themselves and were fully responsible for the data collection process. Table 1 explains both the outcomes and conditions. All data on the conditions were publicly displayed to all prospective backers.

3.2 Method

The method was based on two QCA models: Model 1 aimed at providing configurations of conditions resulting in campaign success [SUCC]; Model 2 aimed at providing configurations of conditions resulting in overfunding (i.e. raising at least 10% more than the target) [OVER].

$$Model\ 1:\ SUCC = f(IDEN, ABSC, RELC, YEAR, NINV, LRES, LEXP)$$

$$Model\ 2:\ OVER = f(IDEN, ABSC, RELC, YEAR, NINV, LRES, LEXP)$$

QCA was first proposed by Charles Ragin (1987) as a case-oriented methodology leveraging certain valuable aspects of qualitative and quantitative methods. As explained by Marx *et al.* (2014), this methodology is inspired by John Stuart Mill's comparative tradition and is rooted in Boolean logic and set theory. In QCA terminology, the phenomenon under study is the

	Definition	Codification
Outcomes		
Success [SUCC]	Whether campaign is successful (i.e. meets or exceeds target funding)	Crisp value
Overfunding [OVER]	Whether campaign exceeds the funding target by 10% or more	Crisp value
Conditions		
Anchor investor's identity [IDEN]	Identity of anchor investor (1 = corporate anchor investor; 0 = individual anchor investor)	Crisp value
Anchor investor's absolute contribution [ABSC]	Euro denominated amount deposited by anchor investor in campaign	Fuzzy value
Anchor investor's relative contribution [RELC]	Ratio of anchor investor's investment in euros to campaign funding target (relative amount)	Fuzzy value
Years of experience [YEAR]	Years of experience in entrepreneurial fundraising	Fuzzy value
Number of investments [NINV]	Number of investments by anchor investor prior to campaign	Fuzzy value
Length of anchor investor resume [LRES]	Word count of anchor investor's resume	Fuzzy value
Length of anchor investor explanation of investment [LEXP]	Word count of explanation of anchor investor's decision to invest in campaign	Fuzzy value

Note(s): Success [SUCC] was the outcome in Model 1 and overfunding [OVER] was the outcome in Model 2. Anchor investor's relative contribution [RELC] has been employed by Shen *et al.* (2020). Number of investments [NINV] has been employed by Li *et al.* (2021). Word count has been used as a metric numerous times in crowdfunding research (Bi *et al.*, 2017; Lagazio and Querci, 2018; Moy *et al.*, 2018)

Table 1. Outcomes and conditions used in the study

"outcome", and each independent variable is a "condition". A combination of conditions is called a "configuration". QCA allows for the study of configurational patterns leading to a certain outcome (Ragin, 2008; Rey-Martí *et al.*, 2022).

The decision to use this methodology was primarily based on its suitability for the study of phenomena in the social sciences because it allows for equifinality and multifinality (Gerrits and Pagliarin, 2021). It has been widely used in business research and has the advantage of allowing for causal multiplicity (Sendra-Pons *et al.*, 2022a). Hence, it can offer a useful way of studying reality. Moreover, it is particularly well suited to small- and medium-sized data sets ranging from 5 to 50 cases (Rihoux *et al.*, 2013). Figure 3 summarizes the approach in this study by displaying the conditions included in Models 1 and 2.

4. Results

The results were obtained by applying QCA to the aforementioned models. Reporting begins with the analysis of necessary conditions. Table 2 reports this analysis for Model 1, where the outcome is the success of the fundraising campaign [SUCC], and Model 2, where the outcome is overfunding (i.e. raising at least 10% more than the target) [OVER].

The analysis of necessary conditions for Models 1 and 2 (see Table 2) shows that no condition is considered necessary for the presence of funding success [SUCC] and overfunding [OVER] in equity crowdfunding campaigns because consistency is below 0.9 in all cases. Even when these conditions are grouped (see notes to Table 2), the consistency is still less than 0.9. Therefore, the next step is to explore configurational patterns leading to the aforementioned outcomes.

Table 3 shows the parsimonious solution for Models 1 and 2, aimed at exploring funding success [SUCC] and overfunding [OVER]. Raw coverage refers to the percentage of the outcome that can be explained by a specific solution, whereas unique coverage refers to the percentage of the outcome that can be described by each condition within a causal configuration (Florea *et al.*, 2019). The results show four configurations leading to funding success (i.e. achieving the funding goal within the predefined period) [Model 1]. There are also four configurations leading to overfunding (i.e. achieving at least 10% more than the target)

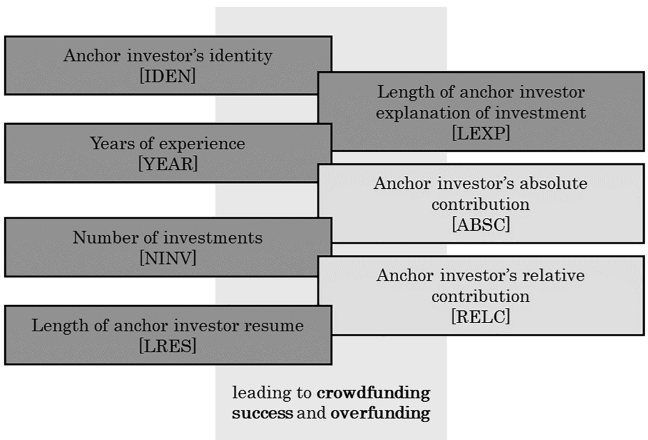

Figure 3.
Conditions included in the study

Note(s): The conditions shaded in dark gray refer to the anchor investor's reputational commitment, and those shaded in light gray to the anchor investor's financial commitment

Condition	Model 1 Outcome: SUCC Consistency	Coverage	Model 2 Outcome: OVER Consistency	Coverage
IDEN	0.611111	0.785714	0.692308	0.642857
~IDEN	0.388889	0.700000	0.307692	0.400000
ABSC	0.532778	0.832465	0.358462	0.404514
~ABSC	0.467222	0.673878	0.641539	0.668269
RELC	0.630000	0.855849	0.497692	0.488302
~RELC	0.370000	0.619535	0.502308	0.607442
YEAR	0.316111	0.729487	0.269231	0.448718
~YEAR	0.683889	0.759877	0.730769	0.586420
NINV	0.298889	0.778582	0.288462	0.542692
~NINV	0.701111	0.73844	0.711538	0.541252
LRES	0.338889	0.604559	0.315385	0.406343
~LRES	0.661111	0.855500	0.684615	0.639827
LEXP	0.344444	0.668103	0.306923	0.429957
~LEXP	0.655556	0.801630	0.693077	0.612092
ENDO	0.642222	0.829268	0.506153	0.472023
~ENDO	0.357778	0.640159	0.493846	0.638171
INFD	0.594444	0.721510	0.576154	0.505057
~INFD	0.405556	0.796074	0.423846	0.600872
EXPE	0.533333	0.818414	0.506923	0.561807
~EXPE	0.466667	0.684597	0.493077	0.522412

Note(s): The symbol "~" refers to the absence of a condition. For example, "~ABSC" corresponds to a low level of absolute investment by the anchor investor [ABSC]. "ENDO", "INFD" and "EXPE" conditions are combinations of various individual conditions. "ENDO" refers to "endowment" and comprises "ABSC" and "RELC"; "INFD" refers to "information disclosure" and comprises "LRES" and "LEXP"; and "EXPE" refers to "experience" and comprises "YEAR" and "NINV"

Table 2.
Analysis of necessary conditions for Models 1 and 2

Causal configuration	Raw coverage	Unique coverage	Consistency
Section A. Model 1 explaining crowdfunding success			
[C1] IDEN*~LRES	0.425556	0.155000	0.998696
[C2] ~IDEN*LRES	0.153333	0.104444	0.734043
[C3] ABSC*~YEAR	0.354444	0.163333	0.864499
[C4] ~LRES*YEAR	0.290556	0.161111	0.984934
Note(s): Solution coverage: 0.903333→Solution consistency: 0.887554			
Section B. Model 2 explaining overfunding			
[C5] IDEN*~LRES*~YEAR	0.435385	0.265385	1
[C6] IDEN*~YEAR*NINV	0.265385	0.095384	0.991379
[C7] ~IDEN*~RELC*LRES	0.135385	0.131539	0.649447
[C8] ~IDEN*YEAR*~NINV	0.147692	0.143846	0.668990
Note(s): Solution coverage: 0.81→ Solution consistency: 0.881171			

Table 3.
Parsimonious solution for Models 1 and 2

[Model 2]. As expected in QCA, most conditions in the configurations are both present and absent (IDEN, YEAR, LRES and NINV). ABSC only appears as present and RELC as absent. Hence, Propositions 2, 3, 4 and 5 are rejected, while Propositions 1 and 7 are corroborated. Proposition 6 could not be tested because the corresponding condition did not appear in the configurations.

5. Discussion

Based on the previous results, this section follows two main lines of discussion. The first explores the configurational patterns resulting in funding success [Model 1]. The second explores the configurations resulting in overfunding [Model 2]. A distinction is made between the corporate versus individual identity of the anchor investor. Overall, the results suggest that there is causal complexity underlying the disclosure of information about the financial and reputational commitment of anchor investors.

5.1 Configurations leading to the success of entrepreneurial fundraising

One of the configurations of logically feasible conditions resulting in entrepreneurial fundraising success applies only to corporate anchor investors, another applies only to individual anchor investors, and the remaining two do not apply to a specific anchor investor identity. The configurations that apply to a particular anchor investor identity (corporate or individual) can be seen in Table 3. The theoretical and practical implications of these configurations differ depending on the identity of the anchor investor.

Finding 1: If the anchor investor is a corporate investor (i.e. a company not an individual), then the entrepreneurial fundraising campaign through equity crowdfunding can be successful even if the length of the anchor investor's resume shown on the crowdfunding website is short.

Finding 2: If the anchor investor is an individual, then the path to a successful fundraising campaign requires a much more extensive explanation of the anchor investor's resume than if the anchor investor is a corporation.

Finding 3: Two alternative paths apply to both corporate and individual anchor investors. When investment experience is low, then the absolute amount invested must be high. Conversely, if experience in entrepreneurial investment is extensive, then less disclosure may be given in the anchor investor's resume. Thus, if experience is limited (i.e. the investor has spent few years in entrepreneurial investment), then this relatively low experience should be complemented by a large absolute investment. If experience is extensive, less information can be provided in the anchor investor's resume.

These findings are especially interesting because they provide clear insights into the role of the anchor investor's identity. Findings 1 and 2 suggest that when the anchor investor is a corporate investor, it is less important to provide details on the anchor investor's curriculum vitae. The fact that the investor is a company has enough informational power to result in the success of the funding campaign. However, this informational power seems to be diluted when the anchor investor is an individual. Hence, more detail is required in the anchor investor's resume.

The raw coverage, which is the percentage of the outcome explained by a specific solution (Florea *et al.*, 2019), implies that more than 40% of the outcome can be explained by Configuration 1. Configuration 2 explains approximately 15% of the outcome, Configuration 3 approximately 35% and Configuration 4 approximately 29%. Thus, most of the outcome is explained when the anchor investor is a corporation (Configuration 1), partly due to the dominance of this type of anchor investor. The next most explanatory configurations are Configuration 3 and Configuration 4, which are independent of the anchor investor identity. Configuration 2, which refers to individual anchor investors, explains the smallest percentage of the outcome (roughly 15%).

5.2 Configurations leading to the overfunding of entrepreneurial ventures

In reference to Model 2, all configurational paths resulting in overfunding (i.e. raising at least 10% more than the target) apply to a certain type of anchor investor (either corporate or individual). The first two (Configuration 5 and Configuration 6) refer to corporate anchor

investors. The next two configurations (Configuration 7 and Configuration 8) refer to individual anchor investors. The configurations associated with corporate anchor investors can be seen in Table 3. Again, the theoretical and practical inferences from these configurations can be stated.

Finding 4: Overfunding in entrepreneurial fundraising (i.e. exceeding target funding by at least 10%) can be achieved even if the anchor investor's resume and experience are limited, as long as the anchor investor is a corporate anchor investor.

Finding 5: Overfunding can also be achieved when experience (number of years) in entrepreneurial investment is limited, as long as the number of previous investments by the anchor investor is high and the anchor investor is a corporation.

Finding 6: When the investor is an individual, overfunding can be achieved even when the relative size of investment by the anchor investor is low, as long as a detailed resume is provided.

Finding 7: Also, when the investor is an individual, overfunding can be achieved even if the anchor investor has made a small number of investments, as long as the anchor investor's experience is extensive in terms of number of years in entrepreneurial investment.

In summary, if the anchor investor is a corporation, overfunding can be achieved even if the resume provides little detail and the investor lacks experience or if experience is limited but the investor has made a large number of investments. If the anchor investor is an individual, the length of resume and experience matter to achieve overfunding, even if the relative size of investment is low or the investor has made few previous investments.

In terms of ranking how much of the outcome is explained by each configuration, the raw coverage again suggests that the configurations relating to corporate anchor investors are the most explanatory. Configuration 5 accounts for more than 40% of the explanation of the outcome, and Configuration 6 accounts for roughly 26%. Configuration 7 (roughly 14%) and Configuration 8 (roughly 15%) explain a smaller percentage of the outcome.

5.3 Visual representation of successful strategies

Overall, three configurations apply to corporate anchor investors, three to individual anchor investors and two to both types. Four configurations explain success in equity crowdfunding [SUCC], and another four explain overfunding in equity crowdfunding [OVER]. Besides investor identity, the most common conditions in the configurations (in terms of both presence and absence) are the number of years in entrepreneurial investment [YEAR] and the length of the anchor investor's resume [LRES]. Each of these conditions appears in five causal configurations (Configurations 3, 4, 5, 6 and 8 and Configurations 1, 2, 4, 5 and 7, respectively). The absence of YEAR and LRES appears three times for each condition, and the presence of each condition appears twice. Additionally, the presence of ABSC and the absence of RELC can be found in one configuration, and each of the presence and absence of NINV can be found in one configuration. LEXP does not appear in any configuration. Table 4 summarizes causal configurations leading to entrepreneurial fundraising success and overfunding.

6. Conclusions and limitations

The present study has certain theoretical and practical contributions. On the theoretical side, based on the theory of information asymmetries (Akerlof, 1970) and herd behavior theory, it contributes to a growing body of academic research on success factors of crowdfunding campaigns. On the practical side, it shows crowdfunding platforms which information is most relevant and informs potential investors about which informational elements to look for when searching for potentially successful investment projects.

To the authors' knowledge, this configurational study is one of the very few investigations exploring funding success and overfunding in online investment campaigns through

Configuration No.	Success in equity crowdfunding [SUCC]				Overfunding in equity crowdfunding [OVER]			
	C1*	C2	C3	C4	C5*	C6*	C7	C8
IDEN	●	○			●	●	○	○
ABSC			●					
RELC							○	
YEAR			○	●	○	○		●
NINV						●		○
LRES	○	●		○	○		●	
LEXP								
Raw coverage	0.425556	0.153333	0.354444	0.290556	0.435385	0.265385	0.135385	0.147692
Unique coverage	0.155000	0.104444	0.163333	0.161111	0.265385	0.095384	0.131539	0.143846
Consistency	0.998696	0.734043	0.864499	0.984934	1	0.991379	0.649447	0.668990
Solution coverage	0.903333				0.81			
Solution consistency	0.887554				0.881171			

Note(s): Configurations marked with an asterisk (*) refer to corporate anchor investors. "●" refers to the presence of a condition within the configuration. "○" refers to the absence of a condition

Table 4.
Causal configurations leading to entrepreneurial fundraising success and overfunding

syndicated equity crowdfunding. Crucially, the study accounts for the identity of the anchor investor (corporate vs. individual) to derive guidelines for campaign design. The study provides several core findings. (1) Corporate anchor investors have considerable power in driving herd behavior. Despite situations where the anchor investor's resume is poorly explained and experience is low, this power enables success or high success (Configurations 1, 5 and 6). (2) There is a need for a detailed resume when the investor is an individual. This situation was observed in Configurations 2 and 7, despite a low relative investment. There is also a need for a high number of previous investments when experience is low (Configuration 8). (3) In cases where the identity of the anchor investor is not specified, absolute investment matters when experience (years in entrepreneurial investment) is low (Configuration 3). When little information is disclosed about the anchor investor, the number of years of experience in entrepreneurial investment should be high (Configuration 4). Overall, disclosing information on an anchor investor's financial and reputational commitment is extremely valuable for reducing information asymmetries in equity crowdfunding.

This study has several limitations. (1) Although the sample was representative, the small sample size means that the results should be validated with larger samples. (2) The information provided in the anchor investor's resume and the explanation of the investment decision were characterized in a simplistic way, relying on word count. (3) The study focused on a specific type of crowdfunding, namely equity crowdfunding. Further research should seek to enlarge the sample and broaden the types of platforms considered, include discourse analysis with text processing techniques, and develop a theoretical model of anchor investor herd behavior in online financial and crowd-based environments for subsequent validation in an experimental setting.

7. Practical implications

The findings from this study have practical implications for entrepreneurs seeking funds through syndicated equity crowdfunding and for intermediary platforms. Financial technology, including crowdfunding, requires the study of information disclosure processes between those involved to ensure the optimal use of tools in digital ecosystems

where there are large information asymmetries. For entrepreneurs, the use of anchor investors can considerably reduce the uncertainty and information asymmetries faced by potential backers (both ex ante or pre-investment and ex post or post-investment). This research sheds light on how anchor investors should manage information disclosure to show both financial and reputational commitment, and effectively attract investment.

Given the range of information disclosure options that can result in success or overfunding in a syndicated equity crowdfunding campaign, intermediary platforms should pay more attention to the anchor investor information they display in campaigns. This research reveals the informational cues that are important for both individual and corporate anchor investors. Active participation of platforms in the design of information displayed by anchor investors is important to maximize success and overfunding in syndicated equity crowdfunding campaigns. However, a word of caution is necessary. Overfunding can lead to cannibalization, whereby some campaigns lose visibility in favor of overfunded campaigns (Li *et al.*, 2020).

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The learning effect on organizational performance during a crisis: a serial mediation analysis with knowledge creation, storage and sharing

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Abstract

Purpose – The aim of this study is to investigate the serially mediating effect of knowledge management (KM) practices (namely, knowledge creation, storage and sharing) on the organizational learning (OL) and organizational performance (OP) relationships during a crisis.

Design/methodology/approach – Based on theories-of-action, knowledge-based and resource-based theories, this study proposed a sequential mediation model where OL underlying mechanisms through which KM practices have facilitated OP during the crisis. The sample dataset contains 440 responses collected from the managers of the software development companies in Pakistan. The authors used Hayes Process macro with SPSS to test the study hypotheses.

Findings – The results of the study reveal that knowledge creation, storage and sharing serially mediate the relationships between OL and OP. These findings strengthen the argument suggesting that OL plays the key role in KM that helps software companies to mend their performance in times of crisis.

Originality/value – This study contributes to the KM literature in two ways: (1) grounded on the study's proposed framework, organizations can improve and manage their businesses in times of crisis and (2) learn how to generate new knowledge in response to business crises.

Keywords Organizational learning, Knowledge management practices, Organizational performance, Theories of action, Covid-19 crisis, Software development industry

Paper type Research paper

1. Introduction

Learning during a crisis (i.e. Covid-19) is a very difficult and challenging task for a firm. A crisis is usually a kind of event for organizations that cannot be planned (Deverell, 2009; Alles, 2021).

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Although the harmful impact of the crisis on organizations has been studied extensively (Olsson, 2014), limited research has examined how companies can deal with these challenges and learn from a crisis, particularly in the software development industry (Boehm *et al.*, 2020). An organization that actively compacts in an uncertain environment should not only create information and knowledge but also process it well. Similarly, successful organizations are those that adapt to changing environments and thrive despite external factors. Accordingly, software development companies are constantly looking for methods to improve quality and productivity (Gopalkrishna *et al.*, 2012; Nguyen-Duc *et al.*, 2015). Knowledge management (KM) processes, such as knowledge creation, storage and sharing, provide a platform for solving problems efficiently. In addition, many researchers have tried to explain how to develop and implement effective crisis management strategies to improve organizational performance (OP) in times of crisis (e.g. Carroll and Hatakenaka, 2001). Despite the growing interest in KM and OP, insufficient attention has been paid to investigating the role of KM practices (i.e., knowledge creation, storage and sharing) in achieving OP, particularly with the aids of organizational learning (OL). In particular, more empirical studies are needed at the company level to determine what factors could interfere with OP during a crisis. With these lines, while handling crises (e.g. Covid-19), organizations need to process and apply a large amount of new data in a timely manner. They need to develop processes that enable them to achieve their goals effectively (Hu *et al.*, 2021). Accordingly, the study of knowledge creation (KC) and OL is "pursued as independent themes in research [. . .] and the links between them tend to be forgotten [. . .] because it is hard to reconcile fundamental assumptions about knowledge, information, environment and learning" (Lyles, 2014, pp. 132–133).

In light of above arguments, this research addresses OL, which has been stated and suggested as a set of organizational values and norms. These days, firms are considered successful if they have the ability to learn and do it quickly. Consequently, this paper adds to extant research by investigating the sequential mediation relationship between OL and OP via knowledge creation, storage and sharing in the software development industry of Pakistan.

2. Literature review and hypothesis development

2.1 Theories

Little is known about how knowledge is encoded in the employees' minds. According to Argyris *et al.* (1985), people create their own "mental maps," the way they act in a particular situation. These include how they plan, execute and review their behaviors. In OL, these mental maps guide the employees' actions rather than their theoretical claims (Argyris *et al.*, 1985; Argyris, 2000). Although very few employees are familiar with the theories or maps they use; theories of action guide them to consider changes in the depth of knowledge. Theories of action are a "mechanism" through which employees associate their thoughts with their actions (Argyris *et al.*, 1985). Argyris and Schon (1974) divided theories of action into two parts that govern employees' actions that affect OL. Accordingly, "espoused theories are those that an individual claims to follow; theories-in-use are those than can be inferred from action" (Argyris *et al.*, 1985, p. 82). In this study, the authors explain that OL's theories focus on KC and the use of that knowledge within the organization.

In addition, this study used theories such as knowledge-based view (KBV) and resource-based view (RBV) to describe the KM processes and organizational performance of software companies. The RBV suggests that organizations can improve their performance and use their resources and capabilities to create a competitive advantage (Singh *et al.*, 2019).

2.2 KM practices

Darroch (2005, p. 211) defines KM as a "management function that creates or locates knowledge, manages the flow of knowledge within organizations and ensures that the

knowledge is used effectively and efficiently for the long-term benefit of the organization." This study uses 3 KM dimensions (namely, knowledge creation, storage and sharing). However, KM varies from study to study. For example, according to Ode and Ayavoo (2020), KM practices are based on knowledge application and use. Early studies of KM such as Addis (2016), focused on the KC process and knowledge transfer with an emphasis on implicit and explicit knowledge. While recent studies identify "knowledge creation, acquisition, sharing and application" as the main components of the KM processes (Ode and Ayavoo, 2020), others have identified the knowledge creation, transfer, storage and application as the key KM processes (Al-Emran *et al.*, 2018). The importance of KM for software development companies is incredible. KM helps improve implementation and coordination across the company, which is a challenge for software companies. Furthermore, KM also helps in delivery speed and execution accuracy for software companies (Khosravi and Nilashi, 2018).

2.3 Hypothesis development

2.3.1 Direct relationship between OL, KM processes and OP. In the times of Covid-19 crisis, the process of learning and KM within organizations is being given much importance (Velásquez and Lara, 2021). Despite a lot being written about OL, little attention is being paid to KM, which is a big issue. Prior to that, most of OL's theories were based on the misconception that "the development of knowledge shapes learning" (Senge, 1990). Later, Nonaka and Takeuchi (1995) expose the fallacy of the idea and state that "a comprehensive view of what constitutes OL has not been developed." According to Mehralian *et al.* (2018), OL has the potential to enhance the efficiency of the learning process and KC in software companies. In other words, there are learning process requirements to enhance the quality of software products (Saha and Annamalai, 2021). Similarly, learning through better information and understanding has led to a change in behavior that helps improve organizational performance (Ullah *et al.*, 2021). In addition, OL is important to the organization's customers because it involves meeting and understanding latent needs through new services, products and ways of doing business (Zhang *et al.*, 2020). Concurrently, OL has proven to be invaluable in improving performance within software companies (Waheed *et al.*, 2019). Therefore, organizations should use OL to generate new knowledge (Pasamar *et al.*, 2019). In addition, several prior studies have suggested significant and positive relationships between OL, KM and OP, as shown in Table 1.

Accordingly, companies with technology capabilities and high-level KC are more efficient and can improve organizations (Abusweilem and Abualoush, 2019). Therefore, knowledge is a key success factor in obtaining competitive advantage in the times of crisis (Mehralian *et al.*, 2018). According to Abusweilem and Abualoush (2019), KM processes (i.e. KC, knowledge storage [KS] and knowledge sharing [KSI]) that enhance intermediate OP will lead to positive financial performance. Consequently, in the essence of RBV theory, we propose that if a company obtains resources and uses them effectively, it may have a major "strategic advantage" that will increase OP. Thus, we suggested that

H1. (a) OL, (b) KC, (c) KS and (d) KSI are effective in improving OP.

In addition, Boella *et al.* (2016) stated that the organization's success is highly dependent on knowledge and KM. From the KM processes, KSI is valuable for organizations as it helps them improve performance (Obeidat and Zyod, 2015). In addition, it is important for organizations to exchange knowledge as it promotes OL (Park and Kim, 2018). In other words, Park and Kim (2018) proposed the positive relationship between OL and KSI. Accordingly, one of the important outcomes of KM is KC (Argote *et al.*, 2003). The value of the KC depends on level of KSI and skills among people across the organization (Oliveira *et al.*, 2020). Subsequently, KC and KS are two vital aspects of KM that play an important role in creating

Table 1.
Critical synthesis literature review on OL, KM and OP

Authors	Research objective	Independent variables	Dependent variables	Mediators	Methodology	Results	Limitations and future studies
Putra and Ruslan (2021)	To analyze the effect of OL on OP	OL	OP	–	This study used the SAQ to collect the data from 221 employees	The results show that OL has a significant positive effect on OP	None reported in this article
Hutagalung *et al.* (2020)	To determine the effect of OL on teacher performance	OL	Teacher performance	Innovation capability	Used SAQs to the collect the data from 327 samples	The indirect effect of OL on teacher performance via innovation capability	Based on the proposed threshold of this study, future studies should find other variables that may affect teachers' performance
Sahibzada *et al.* (2020)	To investigate the mediating effect of OL on the relationship between KM processes and OP	KM processes	OP	Creative OL	This study used SAQs to collect the data from 536 administrative and academic staff	This study found the mediating effect of OL on the relationship between KM processes and OP	This study encouraged the replication of this framework in other cultures to correct the findings. In addition, the indirect link between KM processes and OP should be investigated further via some other mediators
Obeso *et al.* (2020)	To investigate the indirect effect of KM practices on OP via OL	KM	OP	OL	Telephone survey was used to the collect data from employees of 400 SMEs	This study shows that KM practices have an indirect effect on OP via OL	Future research would need to differentiate between different KM practices

(*continued*)

Table 1.

Authors	Research objective	Independent variables	Dependent variables	Mediators	Methodology	Results	Limitations and future studies
Abusweilem and Abualoush (2019)	To investigate the direct effect of KM processes on OP	KM processes	OP	–	Used SAQs to collect the data from 126 staffs	This study concludes that there is a significant positive relationship between KM processes and OP	None reported in this article
Sawaean and Ali (2020)	To identify the mediating effect of innovation capacity on the learning orientation and OP links	Learning orientation	OP	Innovation capacity	SAQs, collected data from 384 owners of the various corporations	This study found the indirect effect of learning orientation on OP via innovation capacity	Future studies should consider other variables that may affect OP
Zaim *et al.* (2019)	To investigate the mediating effect of knowledge utilization on the links b/t KM and OP	KM process	OP	Knowledge utilization	This study used SAQs to collect the data from 1,068 employees	This research found the indirect effect of knowledge utilization on the KM–OP relationships	None reported in this article
Wahda (2017)	To identify the indirect effect of OL on OP via KM	OL	OP	KM	This study used SAQs to collect the data from 138 respondents	This study found that KM mediates the relationships between OL–KM	As this study took KM as a mediating variable, it would be interesting to take KM as exogenous or endogenous variables in the future studies

(*continued*)

Table 1.

Authors	Research objective	Independent variables	Dependent variables	Mediators	Methodology	Results	Limitations and future studies
Tseng and Lee (2014)	To investigate the indirect effect of KM capability on OP via dynamic capability	KM capability	OP	Dynamic capability	SAQs and online survey (e-mail) were used to collect the data from 237 respondents	Results indicated that KM capability increases the dynamic capability of the firms, resulting in an increase in OP	This research used a purposive sampling technique; this study suggested that to increase the generalizability of the results, future studies should apply a random sampling technique
Noruzy *et al.* (2013)	To investigate the relationship between transformational leadership, OL, KM, organizational innovation and OP	Transformational leadership	OP	OL, KM and organizational innovation	This study used SAQS to collect the data from 280 respondents	This study found the significant relationship between constructs	Based on the proposed limits. This study suggested that more studies in this area are required to investigate relationships between these constructs in different organizational setting and culture
Kuo (2011)	To determine the relationship among human resource management, OL, KM capability, organizational innovation and OP	Human-resource management	OP, KM capability, OL and organizational innovation	–	213 surveys were collected from the employees of the technological companies	This study found the significant positive relationship among the variables	This study collected data only from Taiwanese respondents; future studies may apply this framework to other regions or countries whose environment is similar to Taiwan in order to achieve more general results

Note(s): KM = knowledge management; OL = organizational learning; OP = organizational performance; SAQs = self-administered questionnaires; SMEs = small and medium-sized enterprises

organizational value. In KM, KS is a phase to store explicit knowledge. Therefore, most organizations in the software development industry are focused on improving their KSI capability to create new knowledge (Carmeli *et al.*, 2013). This also helps to retrieve knowledge for later usages as well. So, we proposed that

H2. (a) OL, (b) KC and (c) KS are effective in improving KSI activities.

2.3.2 Serial mediation effect of KC, KS and KSI. A number of studies (Calabretta *et al.*, 2017) have examined how KC plays a key role in the success and survival of a firm. In addition, Calabretta *et al.* (2017, p. 392) subsumes the KC process "embedding new ideas, cognitive frames, and manners of thinking in organizations require adaptation (i.e., translation) to the specific practices and socio-cultural context of the target organization." Accordingly, companies can enhance both financial and nonfinancial performance through affected KC methods (Kao and Wu, 2016). Previous research (Sahibzada *et al.*, 2020) proposed the direct relationships between KC, KS and KSI. Contrariwise, none of these studies identified an indirect relationship between them. In addition, Zaim *et al.* (2019), investigate the significant positive association between KM practices and OP. Accordingly, learning has the significant positive effect on KC and KS (Abusweilem and Abualoush, 2019), which in turn lead to increase organizational OP (Kordab *et al.*, 2020). Thus, the following hypotheses are proposed:

H3. (a) KC, (b) KS and (c) KSI mediate the relationship between OL and OP.

H4. (a) KC and KS, (b) KC and KSI, (c) KS and KSI, and (d) KC, KS and KSI serially mediate the relationship between OL and OP.

3. Research design

3.1 Research model and measurement

Based on theory of action, KBV and RBV theories, we proposed that the three mediators – KC, KS and KSI could play the role of sequential mediator between OL and OP. This means that OL affects OP via KC, KS and KSI in a sequential manner (see, Figure 1). Grounded on theoretical framework, the study's questionnaire was prepared, and four items of OL were measured on a five-point Likert-scale ranging from "1 = strongly disagree to 5 = strongly agree" adapted from the study of García-Morales *et al.*, (2008). Furthermore, this study measured the three processes of KM (namely, knowledge creation, storage and sharing)

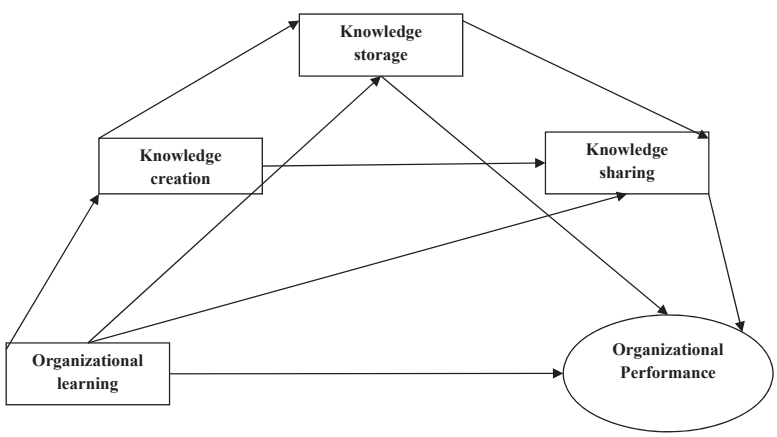

Figure 1.
Research model

through 14 items. In which, five items of KC and six items of KSI were measured through five-point Likert scale adapted from the study of Lee and Wong, (2015) and Holtshouse, (1998). While three items of KS were measured through five-point Likert-scale taken from the study of Hansen *et al.* (1999), four items of OP adapted from the study Cho *et al.* (2008) were measured through five-point scale from 1 (poor) to 5 (excellent) (see Appendix).

3.2 Data collection and sampling

During the second wave of the Covid-19 crisis, we used a self-report cross-sectional survey method to collect the data from the employees of software companies. Through which, we selected 20 companies randomly in the software development industry in Lahore, Multan and Islamabad, which had more than 20 workers. In 20 companies, 17 allowed their employees to participate in the survey. The study survey was written in English because it is the official language of business and higher education in Pakistan. Furthermore, recent research (e.g. Fatima *et al.*, 2020; Qadri *et al.*, 2020) conducted in Pakistan and published in mainstream journals has demonstrated that the survey format is feasible. Consequently, each study questionnaire was accompanied by a cover letter, which explained the purpose of the study and the volunteer nature of the respondents. Therefore, considering our sample, we did not translate the survey into Urdu. After completing the survey format, we met with lower-, middle- and top-level managers of software companies and asked them to participate in the survey.

In addition, this study used purposive sampling techniques as a data collection strategy because it is less expensive and usually requires less time (Etikan *et al.*, 2016). We collected the data between October 2020 and November 2020. The data compilation process lasted for four working weeks. Since our research model had five variables and a total of 22 items, the minimum size of the sample required for our study was 110 ($22 \times 5 = 110$). The size of the sample used in our study (i.e. $N = 440$) is larger than the required sample size and therefore adequate enough for analysis and give more reliable results with greater precision and power (Benner and Waldfogel, 2008).

Consequently, we distributed 610 questionnaires; among them, in which 440 were returned, we selected 425; the rate of response was 72.13%. In the study, we removed 15 surveys that had incomplete answers. Of the respondents, 43% were females. All sampling employees had an average of five years with the company. Of the respondents, 40% belonging to the company have more than 100 employees. The majority of respondents (55%) was lower/first line managers in their companies.

4. Data analysis and finding

4.1 Control variables

This study statistically controlled the effect of gender (1 = Male, 2 = Female), age (1 = 20–35, 2 = 36–50, 3 = 51–65, 4 = 65+), tenure (in years) in the software development company and designation ("1 = first-line manager, 2 = middle manager, 3 = top manager"), we made sure they would not affect other variables of interest.

4.2 Reliability and correlation analysis

The mean, standard deviation, correlation coefficient and discriminant validity values of the study constructs are in Table 2. We have found a positive significant correlation between KSI and KS at ($r = 0.365$, $p < 0.001$), OL and KS at ($r = 0.379$, $p < 0.001$), OL and KSI at ($r = 0.678$, $p < 0.001$), KC and KS at ($r = 0.357$, $p < 0.001$), KC and KSI at ($r = 0.464$, $p < 0.001$), and KC and OL at ($r = 0.633$, $p < 0.001$). In addition, this study uses "Cronbach's alpha" to assess the scales internal reliability. In this study, Table 3 shows that alpha values of OL is 0.868 for four

	Mean	SD	Correlation matrix									
			1	2	3	4	5	6	7	8	9	10
1. Software companies[a]	2.449	1.276	1									
2. Age[b]	1.889	0.553	0.381**	–								
3. Gender[c]	1.372	0.484	0.015	0.013	–							
4. Tenure[d]	2.489	0.727	0.062	0.059	−0.009	–						
5. Designation[e]	2.551	0.878	0.080	−0.001	−0.083	−0.017	–					
6. KS	3.083	1.376	0.034	0.021	−0.029	0.037	0.090	*(0.783)*				
7. KSI	2.922	1.295	−0.048	0.006	−0.061	−0.006	−0.027	0.365**	*(0.830)*			
8. OL	3.143	1.183	−0.043	0.014	−0.008	−0.015	−0.008	0.379**	0.678**	*(0.864)*		
9. KC	3.149	1.186	−0.018	0.025	0.017	−0.039	0.033	0.357**	0.464**	0.633**	*(0.836)*	
10. OP	3.000	1.366	−0.017	−0.061	−0.029	−0.008	−0.063	0.270**	0.612**	0.521**	0.580**	(0.801)

Note(s): *$p < 0.05$, **$p < 0.001$, SD = standard deviation and "Diagonal elements (italic values) are the square root of the AVE"

[a]1 = Small-sized company (21–100 employees), 2 = Medium-sized company (101–200 employees), 3 = large-sized company (200> employees)

[b]1 = 15–30, 2 = 31–45, 3 = 46–60, 4 = 60+

[c]1 = Male; 2 = Female

[d]1 = Less than 5 years; 2 = 6–10 years; 3 = Greater than 10 years

[e]1 = Lower-level manager; 2 = Middle-level manager; 3 = Top-level manager

Table 2.
Means, standard deviations, correlations and validity

Constructs	Scale	Factor loadings (λ)	Alpha	MaxR (H)	CR	AVE	MSV
Organizational learning (OL)	OL1	0.685	0.868	0.981	0.876	0.641	0.531
	OL2	0.859					
	OL3	0.866					
	OL4	0.779					
Knowledge creation (KC)	KC1	0.725	0.881	0.893	0.887	0.613	0.494
	KC2	0.766					
	KC3	0.842					
	KC4	0.755					
	KC5	0.821					
Knowledge storage (KS)	KS1	0.837	0.813	0.930	0.816	0.690	0.206
	KS2	0.819					
	KS3	0.499[a]					
Knowledge sharing (KSI)	KSI1	0.809	0.942	0.977	0.933	0.6990	0.531
	KSI2	0.759					
	KSI3	0.818					
	KSI4	0.860					
	KSI5	0.877					
	KSI6	0.887					
Organizational performance (OP)	OP1	0.722	0.900	0.966	0.921	0.746	0.445
	OP2	0.920					
	OP3	0.897					
	OP4	0.900					

Table 3.
Measurement model reliability and validity

Note(s): [a]Deleted, CR = Composite reliability; MaxR(H) = Maximum reliability; MSV = Maximum shared variance; AVE = Average variance extracted; λ = Standardized regression weights

items, KC is 0.881 for five items, KS is 0.813 for two items, KSI is 0.913 for six items and alpha of OP is 0.900 for four items, which is higher than the threshold, as suggested by Nunnally (1978).

4.3 Confirmatory factor analysis (CFA)

In this study, we run confirmatory factor analysis (CFA) through AMOS version 24 to validate the element structure of a set of observed variables and to ensure that what extent our model fits the data. Table 3 shows that regression weights "λ" of all items range from 0.685 to 0.920, which are in the acceptable range, as suggested by Truong and McColl (2011). In addition, Table 3 shows that AVE > 0.50, and CR > 0.60 for all the variables; this means there is no "convergent validity" issue in the research. Further, AVE square root was greater than its corresponding correlation elements, as shown in Table 3. These findings show that the CFA model meets the criteria for measuring discriminant and convergent validity. This study assessed the measurement model fit by measuring the CCMIN/DF, GFI, RMSEA, AGFI, CFI and NNFI (TLI). The results indicated that all fit indices met the required criteria for determining the goodness fit of the measurement model, as shown in Table 4.

4.4 Hypothesis testing

To test the research hypotheses, this study used Model 6 of the process macro in SPSS version 24, as suggested by Hayes (2013). Table 5 shows the standardized estimate and standard error with lower and upper bounds of the "confidence interval" derived from bootstrap 5,000 resamples. As shown in Table 5, R^2 is (0.4003) which explained 40.03% of the variance of KC, R^2 is (0.1664) that explained the 16.64% of the variance of KS, (0.4735) 47.35% of the variance of KSI and R^2 is (0.4869) that described the 48.69% of the variance of OP. In addition, Table 2

Fit indices	Abbr	Recommended values	Scores	Sources
Chi-square/Degrees of freedom (CMIN/DF)	χ^2/df	≤3.00	2.516[a]	Gefen (2000)
Tucker–Lewis index	TLI	≥0.90	0.954[a]	Bentler (1980)
Adjusted goodness-of-fit index	AGFI	≥0.80	0.886[a]	Joreskog and Sorbom (1993)
Goodness-of-fit index	GFI	≥0.80	0.919[a]	Hu (1998)
Root mean square error of approximation	RMSEA	≤0.08	0.060[a]	Joreskog and Sorbom (1993)
Comparative fit index	CFI	≥0.90	0.964[a]	Bagozzi (1998)

Note(s): [a]Acceptable

Table 4.
Fit indices of the CFA model

Direct/Indirect/Total effect	Estimate	Standard error (SE)	BC 95% CI Upper bounds (BC)	BC 95% CI Upper bounds (BC)
Indirect effect				
OL → KC → OP	0.251	0.040	0.461	0.650
OL → KC → KS → OP	−0.003	0.005	−0.014	0.006
OL → KC → KSI → OP	0.010	0.013	−0.013	0.038
OL → KC → KS → KSI → OP	0.007	0.003	0.002	0.015
OL → KS → OP	−0.007	0.010	−0.030	0.011
OL → KS → KSI → OP	−0.012	0.005	−0.004	0.025
OL → KSI → OP	0.236	0.032	0.172	0.299
Direct effect				
OL → KC	0.634	0.038	0.560	0.708
KC → KS	0.226	0.066	0.096	0.357
OL → KS	0.297	0.067	0.166	0.428
KC → KSI	0.038	0.051	−0.061	0.138
KS → KSI	0.115	0.037	0.043	0.186
OL → KSI	0.667	0.051	0.566	0.768
KC → OP	0.456	0.053	0.352	0.560
KS → OP	−0.027	0.038	−0.102	0.049
KSI → OP	0.483	0.051	0.383	0.583
OL → OP	−0.035	0.063	−0.159	0.090
Total effect of OL → OP	0.601	0.048	0.507	0.695
R-square				
KC				40.03%
KS				16.64%
KSI				47.35%
OP				48.69%

Note(s): "5,000 bootstrap samples were entered"; BC = Bias corrected; SE = Standard error

Table 5.
Direct, indirect and total effects of OL on OP

shows that age and gender, tenure, the software companies and designation were not significantly correlated with the outcomes and predictor variables, therefore not included in the models as covariates.

4.4.1 Direct effect. In Table 5, OL has a positive effect on KC at ($\beta = 0.634$, SE = 0.038; 95% CI = [0.560, 0.708]), KC on KS at ($\beta = 0.226$, SE = 0.066; 95% CI = [0.096, 0.357]), KS on KSI at ($\beta = 0.115$, SE = 0.037; 95% CI = [0.043, 0.186]), OL on KSI at ($\beta = 0.667$, SE = 0.051; 95% CI = [0.566, 0.768]) and KC on OP at ($\beta = 0.456$, SE = 0.053; 95% CI = [0.352, 0.560]). Although

the effect of KC on KSI at (β = 0.038, SE = 0.051; 95% CI = [−0.061, 0.13]), KS on OP at (β = −0.027, SE = 0.038; 95% CI = [−0.102, 0.049]), OL on OP at (β = −0.035, SE = 0.063; 95% CI = [−0.159, 0.090]) were not significant, the effect of OL on OP before mediators inserting was significant at (β = 0.601, SE = 0.048; 95% CI = [0.507, 0.695]). Thus, all direct hypotheses are accepted, except H1b and H2b.

4.4.2 Indirect effect. As shown in Table 5, the indirect effect of KC at (β = 0.251, SE = 0.040; 95% CI = [0.461, 0.650]) and KSI at (β = 0.236, SE = 0.032; 95% CI = [0.172, 0.299]) between OL and OP was significant. But, the indirect effect through KS was not significant at (β = −0.007, SE = 0.010; 95% CI = [−0.030, 0.011]). Consequently, H3a and H3c, were accepted, whereas H3b was rejected.

4.4.3 Serial/sequential mediation. In Table 5, the results present that the indirect effect of OL on OP through the serially mediating effect of KC, KS and KSI at (β = 0.007, s.e = 0.003; 95% CI = [0.002, 0.015]) was significant. It provides support for the serial mediation model. On the other hand, the indirect effect through KC and KS at (β = −0.003, SE = 0.005; 95% CI = [−0.014, 0.006]), KC and KSI at (β = 0.010, SE = 0.013; 95% CI = [−0.013, 0.038]) and KS and KSI at (β = −0.012, SE = 0.005; 95% CI = [−0.004, 0.025]) was insignificant. Therefore, H4d was accepted, whereas H4a, H4b and H4c were rejected.

5. Discussion

5.1 Theoretical contribution

This study extends KM research by investigating the serially mediating effect of KC, KS and KSI between OL–OP relationships. Previous studies have shown that companies face significant difficulties in learning from the crisis (Broekema *et al.*, 2019). In this study, we examine the variables that lead OL out of crises (i.e. Covid-19). We applied "multiple regression analysis" through process macro to test the study's hypotheses. The study proposes that (1) OL and KM processes have the positive relationship with OP, (2) OL, KC and KS have the significant positive relationship with KSI and (3) KM processes serially mediate the relationship between OL and OP. These theoretical predictions are supported by our empirical findings.

First, the results of hypothesis H1a and H2a show that OL has a positive effect on KSI and OP. Results are consistent with the past studies (Ricciardi *et al.*, 2020; Noruzy *et al.*, 2013). Second, the accepted hypotheses H1b, H2c and H1cshow the significant positive effect of KC on OP, KS on KSI and KSI on OP in the software development industry of Pakistan. This result is linked to the findings that companies use information to create context, generate knowledge and make decisions in times of crisis (Sahibzada *et al.*, 2020). The result of H3a and H3c shows the significant indirect effect of OL on OP via KC and KSI respectively. Third, the result of H4d shows that the association between OL–OP is sequentially mediated by KC, KS and KSI. Findings are consistent with the earlier research, where indirect effects of OL on OP via KC, KS and KSI have been reported (Hutagalung *et al.*, 2020; Kordab *et al.*, 2020; Wahda, 2017).

5.2 Practical implications

The study has the following implications: First, by using the proposed framework, organizations can gauge their ability to learn from their experiences in a rapidly changing environment and to gain critical knowledge of how to better perform KM practices to strengthen OP during crises. Second, this study will provide new insights into the managers and policy makers, and how OL and KM work together to enhance OP during crisis. Third, the relationships between OL, KM and OP may provide a guideline as to how firms can enhance their performance by using OL to develop KM. Fourth, understanding the effect of

OL and KM on OP would assist top-, middle- and first-line (lower) managers of the companies to identify their strategies in future development. The companies should be aware that OL and KM are crucial for success to operate in an environment of turbulence and uncertainty.

6. Conclusion

Consistent with our expectations, the findings show that the link between OL–OP is mediated by KC, KS and KSI. This result reinforces the argument that OL and KM play a key role in improving the performance of organizations during the Covid-19 crisis. To tackle the coronavirus crisis, software development companies' managers should consider OL and KM practices significantly when focusing on efforts or planning to improve OP. In addition, for software companies it adds credence to the role played by KM in mediating the link between OL and OP, which potentially enables managers to create and maintain a conducive learning environment. KM is vital because it increases the decision-making capacity of the company. All level managers within the companies should ensure that all technical and nontechnical workers have access to the overall skills available within the companies and a better workforce is developed that are more capable of making quick, informed decisions that benefit the company. During crises (e.g. Covid-19), there is a strong consensus that the core strategic advantage of an organization lies in its ability to learn and respond to challenges. Certainly, more attention needs to be paid to the development of OL to improve OP. This will only be possible when organizations create an environment where employees can learn and share information on a regular basis.

7. Limitations and further research avenues

Despite the promising findings, there are some limitations to this study, which provide opportunities for future research: First, the cultural differences in the companies or among managers that might influence the perceptions of learning and KM practices. In terms of generalizability and attain a broader view, it would be interesting to replicate the research by using the cross-culture samples. Second, this study adopts a cross-sectional approach, but a longitudinal research study would be more appropriate to establish the fundamental paths of the studied variables. Third, from a theoretical viewpoint, this study tests KM as a moderator between OL and OP. Future studies can test the mediating effect between transformational leadership and innovation performance. In addition, the future studies should consider the component variables of KC (i.e. externalization, socialization, combination, and internalization) for obtaining more comprehensive results.

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Appendix

The supplementary material for this article can be found online.

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The rise of online food delivery culture during the COVID-19 pandemic: an analysis of intention and its associated risk

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Abstract

Purpose – This study aims to understand consumer behaviour in the context of online food delivery (OFD), especially given the mandatory lockdown imposed in some countries that have modified the behaviour of consumers. Using model goal-directed behaviour (MGB), this study was conducted to investigate consumer perceived risk on the use of OFD services.

Design/methodology/approach – Responses of food delivery services users were collected online throughout April 2020 to understand their risk profile and behaviour. A total of 339 responses were collected and subsequently analysed using partial least square (PLS). Both measurement and structural model were evaluated to ensure that the structural equation modelling (SEM) is valid.

Findings – The results revealed that attitude (ATT), subjective norm (SN), positive anticipated emotion (PAE) and negative anticipated emotion (NAE) and perceived behavioural control (PBC) significantly influenced users' desire. It was also found that PBC significantly influenced users' intention. The empirical result suggests that performance, privacy, financial, physical and the risk of contracting COVID-19 negatively influenced users' desire. In contrast, only physical and the risk of contracting COVID-19 negatively influenced users' intention to use OFD services.

Practical implications – These findings provide OFD service providers and scholars with significant insights into what compels urbanites to adopt OFD services amid a health pandemic. It also allows OFD companies to realign their operation in addressing these concerns and changes in consumer behaviour.

Originality/value – Against the backdrop of the pandemic, this study provides insights for OFD providers in developing new strategies and approaches for business development and consumer retention in a post-pandemic world.

Keywords Food delivery culture, Perceived risk, Consumer behaviour, COVID-19 pandemic

Paper type Research paper

1. Introduction

The rapid growth of the Internet and wireless technologies has substantially impacted online shopping. Cheaper smart devices, rapid improvement in telecommunication infrastructure, coupled with the increase in purchasing power, lack of time and convenience has forced the food and beverage (F&B) industry to adapt and provide new offerings to cater to the growing demands of consumers (Bezerra *et al.*, 2013). Consumers are attracted to shopping online since

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it is much more convenient, comfortable and at their leisure (Jiang *et al.*, 2013). Online shopping has enabled consumers to reduce their decision-making efforts by offering more comprehensive options to choose from, screen information and compare products (Alba *et al.*, 1997). Das and Ghose (2019) observed these changes in consumer behaviour, noting that the working population has less time due to the work-life culture in big cities. This busy lifestyle contributes to the rise of online shopping as consumers are too busy to enter shopping malls physically. Similarly, on-demand food and grocery delivery services quickly flourish among the urban working community.

Over the past year, the popularity of online food delivery (OFD) has been on the rise worldwide. Cho *et al.* (2019) argues that OFD is an innovative way that allows consumers to purchase a wide range of food selection via platform(s). OFD platforms collect orders from consumer and pass on the information to restaurants and delivery personnel (Troise *et al.*, 2021). This opens up new opportunity for restaurants to reach new market while increasing their revenues and consumers the convenience of having food delivered to their home. In the past, researchers have mainly focused on traditional retail, e-commerce behaviours, characteristics of mobile application (Cho *et al.*, 2019), not much discussion around OFD consumers (Yeo *et al.*, 2017; Suhartanto *et al.*, 2019) and even lesser on the use of mobile application to order food from a restaurant (Rodríguez-López *et al.*, 2020).

In 2020 and 2021, due to strict lockdown order, OFD had cemented itself as the most significant trend around the world (Durai, 2020), representing a significant shift from frequenting restaurant to ordering food online. According to Statista (2021), the estimated market size for OFD worldwide is around 107.44 billion U.S. dollars for 2019 and projected to be 154.34 billion U.S. dollars by 2023. Before the COVID-19 pandemic, majority of urban consumers are warming up to the concept of OFD. However, this trend had a major shift with multiple regions reporting a surge in OFD services, such as an increase 65% for Asia Pacific region, 21% for North America, 23% for Europe and 150% for Latin America region (Statista, 2021; Hussey, 2021). The new behaviour imposed upon due to the pandemic will most likely remain as long-term behaviours, altering consumer's behaviours permanently. The present study coin this new phenomenon as food delivery culture. Food delivery culture refers to the consumer shift of practices and attitude (ATT) from the traditional model (i.e. dine-in or take-away) to delivery services enabled by the rise of technology. Nevertheless, with the rise of food delivery culture, little is known regarding this new behaviour and decision-making process. These changes were more evident as COVID-19 causes significant economic disruptions often up-ending years of traditional practices among consumer and companies worldwide. Faced with major disruption, it is relevant to focus on behavioural change among existing and new OFD consumer in response to the uncertainty.

A significant increase in OFD services resulted in a huge number of first-time users, but they also have concerns about the adoption of a new technology because they perceive unforeseen negative outcome before, during or after use, which is also known as "perceived risk" (Hwang and Choe, 2019). The change in consumer behaviours shifted some risks traditionally that are not associated to dine-in to the consumers such as financial risk, privacy risk and performance risk. Business and consumers are expected to incur an additional cost when engaging in commission-based OFD services (e.g. signup fees, commission, packaging fees and delivery charges). In contrast, a patron is not subjected to additional fees while dining in the restaurant and businesses are not required to invest in new technology to cater for OFD. In this light, while pivoting to OFD may be the logical choice for the business's survival, the adoption of OFD is entirely dependent on the consumers due to the cost and risk posed by the adoption. More importantly, such risks are negatively associated with the adoption of a new technology. Even though studies related to perceived risk in e-commerce and hospitality industry is not uncommon (Lutz *et al.*, 2018; Yi *et al.*, 2020), studies related to perceived risk in the domain of mobile application for food deliveries is extremely limited.

OFD represents a significant innovation in food delivery that is changing consumers' habits (Troise *et al.*, 2021). Hence, the present study examines the consumer's intention to use OFD and its associated risks to address the research gap. More specifically, this study proposes evaluating consumer's desire and intention in engaging with OFD using the model goal-directed behaviour (MGB), which is an extension of the theory of planned behaviour (TPB). The application of MGB could elicit meaningful insight in examining consumers' behavioural intention and decision-making as MGB focuses on areas overlooked by TPB, which are desire, affect and habit in providing more accurate OFD user prediction of behaviour and decisions (Perugini and Bagozzi, 2001, 2004). Furthermore, this study incorporates the influence of perceived risk on desire and behavioural intention to use OFD. The investigation of perceived risk's role would reveal the hurdles preventing users from engaging with OFD and assisting OFD service provider in formulating relevant strategies to target their market and mitigate consumer risk profiles.

2. Theoretical framework and hypothesis development

According to the first lacuna, this study developed a conceptual model that revisited the intention theory – theory of planned behaviour (TPB) (see Figure 1). TPB was first proposed by Ajzen (1991), who claims that when behaviour is rational, the best predictor of that behaviour is intention. This theory postulates that intentions are a fundamental antecedent of actual behaviour. TPB posits the link between subjective norm (SN), ATT and perceived behavioural control (PBC) influencing intention and subsequent behaviour. Likewise, Fishbein and Ajzen (2010) also suggest that once intentions have been formed, individuals will be highly inclined to act on such intentions once the opportunity arises. TPB has been widely applied in numerous research such as health-related studies (Cooke *et al.*, 2016), marketing (Rehman *et al.*, 2019) and e-commerce (Dakduk *et al.*, 2017).

TPB has been criticised recently due to concerns over its validity and utility, with some arguing that the theory should be retired (Sniehotta *et al.*, 2014; Erasmus *et al.*, 2010). Esposito *et al.* (2016) argues that TPB fails to capture people really *want* to do something and the emotions after they have done it. Due to these shortcomings, researchers have sought to extend and improve upon TPB by establishing new constructs and new relationships (Sutton, 1998; Perugini and Bagozzi, 2001; Tommasetti *et al.*, 2018), such as MGB (see Figure 2). MGB accounts for significantly more variance, parsimonious and prediction in studies regarding intention and behaviour in comparison to the TPB (Perugini and Bagozzi, 2001).

In the MGB, the intention to perform a behaviour is primarily motivated by the desire to perform the behaviour, and this desire is assumed to reflect the effects of ATT, SN, PBC, anticipated emotions (AEs) and frequency of past behaviour and to mediate their influence on

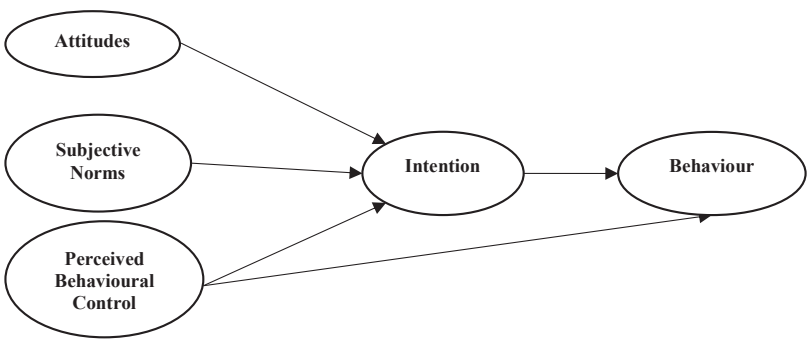

Figure 1.
The theory of planned behaviour

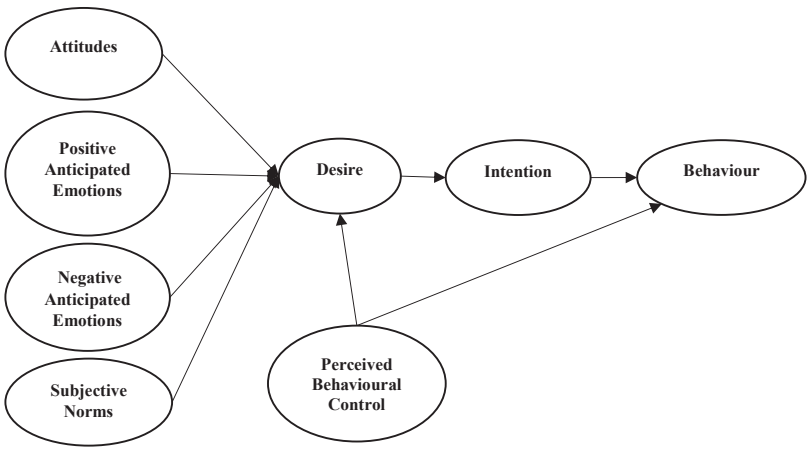

Figure 2.
The model of goal-directed behaviour

intention (Perugini and Bagozzi, 2001). The concept of desire is defined as "a state of mind whereby an agent has a personal motivation to perform an action or achieve a goal" (Perugini and Bagozzi, 2004, p. 71). This desire represents a motivational state of mind where the reasons to act are translated into motivation. Desire is a state in which an individual is eager to take a particular action through internal stimulation (e.g. achievement, curiosity and shortage) (Perugini and Bagozzi, 2004). One of the crucial causes of desire formation is individuals' previous experiences (Leone *et al.*, 2004). Therefore, the construct of desire is to capture whether people want to do something, out of joy or a feeling of satisfaction, instead of out of obligation (Esposito *et al.*, 2016). Meanwhile, AE evaluates one's emotional state in the decision-making process (Perugini and Bagozzi, 2001). Desire is presumed to mediate the influence of ATT, SN and PBC on intention, while AE appear in the model as a factor influencing desire. Thus, the MGB explained significantly greater amount of variance in intention in comparison to the TPB (Esposito *et al.*, 2016).

Ample of evidence in the literature that supports the significant relationship rooted in TPB. TPB argues that an individual's beliefs about their ability to perform the behaviour in question influence whether or not they engage in the behaviours. ATT represents the degree to which a person has a favourable or unfavourable evaluation of the behaviour. At the same time, SN refers to the belief that whether the majority of people approve or disapprove of the behaviour while, PBC reflects a persons' perception of the ease or difficulty of performing a given behaviour (Ajzen, 1991). An individual with a positive evaluation of the behaviour will increase the likelihood that the behaviour will be performed. Consumer's ATTs toward buying food online have a significant positive effect on their behavioural intentions (Chen *et al.*, 2020). Mosunmola *et al.* (2018) argued that ATT has a significant positive effect on engaging in online purchases. Behavioural intentions are also influenced by important people in the consumers' lives, such as their family and friends (Bhattacherjee, 2000). Bui and Kemp (2013) argued that consumers' ATTs, emotion regulation, SN and PBC influence repeat purchase intentions. In the field of marketing, a recent study has applied MGB to the purchase of sporting goods online (Chiu *et al.*, 2018), and Yi *et al.* (2020) applied MGB in the field of tourism.

In this light, one's intention to perform the behaviour is strongly weighted by available resources and opportunity (Ajzen, 1991). An individual will be subjectively affected by external factors, such as past experiences or expectations which may hinder or encourage them, individual acknowledgement of self-competence (ability), awareness of critical needs

(resources) and the awareness of convenience (opportunity) (Chen *et al.*, 2020). Consumers' past experiences will significantly influence their behavioural intention toward online food services (Liang and Lim, 2011). Hence, PBCs are essential factors influencing online purchases (Yang *et al.*, 2018). MGB assumes that PBC bolsters an individual's desire and intention of a specific behaviour (Perugini and Bagozzi, 2001). Drawing similarities from consumer online purchase intention, ATT, SN and PBC would, therefore, have similar influence on OFD users. When consumers have favourable views towards OFD services, they substantially improve a person's motivation that would result in lesser resistance in ordering food online, triggering a higher level of desire to use OFD services. Therefore, the present study posited that individuals' behavioural, normative and control belief are key factors influencing their desire and intention towards OFD services. Based on these discussions, the following hypotheses have been developed.

H1. ATT positively influences the desire to use OFD services

H2. SN positively influences the desire to use OFD services

H3. PBC positively influences the desire to use OFD services

H4. PBC positively influences behavioural intention to use OFD services

A long-held belief is that individuals tend to avoid discomfort or pain while seeking pleasure or happiness. Many, if not all, of our decisions are bias towards pursuing happiness or avoiding unhappiness. Emotions play a significant role in persuading consumer's intention. External stimuli such as restaurant ambience, customer-employee relationship, virtual reality simulation, aromas and service failures influence their satisfaction and intention (Rodríguez-López *et al.*, 2020). Additionally, emotions were found to be a significant predictor of online shopping behaviours in numerous studies (Szymkowiak *et al.*, 2020; Poon and Mohamad, 2020b; Cinar, 2020). Emotions are dynamic and heavily influenced by our surroundings, current happenings and other people who affect our decision-making, resulting in impulsive buying. Affirming the importance of emotions in affecting an individual's online shopping behaviours, the underlying assumption of AE is that individuals anticipate that the emotional consequences of their action or inaction post decision-making (Bagozzi *et al.*, 2016). Positive anticipated emotions (PAEs) are related to emotions felt when the individual succeeds in accomplishing the behaviour. These emotions, such as pleasure or arousal post–purchase, are important as they positively affect users' behaviour to use a particular online service (Kim *et al.*, 2007; Menon and Khan, 2002). Meanwhile, negative anticipated emotions (NAEs) constitute regret, angry or guilt related to action or inaction after the purchase (Bagozzi and Dholakia, 2002). These emotions relate to emotions one fell when failing to achieve the desired behaviour. Wang *et al.* (2011) found both PAE and NAE affect intention depending on customers' reasons for engaging in the process. A recent study by Chiu *et al.* (2018) found that both PAE and NAE significantly influence consumers' purchase intention. Bagozzi and Dholakia (2002) argued that the effect of AEs is based upon an individual's argument when deciding to act or not in goal-directed situations, taking into account emotional consequences or both action and inaction. As such, AEs play a role in shaping an individual's behaviour towards the use of OFD services. With the rise of technology enabled services such as OFD, external stimuli such as ambience, aroma or meaningful relationship with customer that are traditionally used to stimulate consumer emotions are no longer effective. Consumer instead draws upon experience of past purchases to shape their emotions. In summary, consumers will intend to order food from mobile application if the emotions they anticipate from doing so are positive, which in turn will drive their desire. Hence, based on the discussion, the following hypotheses have been developed.

H5. PAE positively influences the desire to use OFD services

H6. NAE positively influences the desire to use OFD services

Desire functions as a motivator. Desires are thought to be very important in the first step of human actions and argued to lead to intentions to perform a behaviour (Perugini and Bagozzi, 2001, 2004). Perugini and Bagozzi (2004) argue that desire is the motivational state of mind in which internal assessment to carry out a particular behaviour are transformed into a motivation to do so. Desires act as a stimulus of decisions when individual consider their desires and endorse them as motivators to act (Bagozzi and Dholakia, 2002). Since humans naturally want to satisfy their desires for a gratifying self-image, they tend to believe, intuit and act in certain ways to achieve their goals (Perugini and Bagozzi, 2001). Han *et al.* (2018) investigate the effect of desire to engage in pro-environmental action on green loyalty. The results suggest that desire to engage in such action was an integral factor affecting green loyalty. Therefore, the desire to engage in OFD services will be a vital determining factor in an individual's intention to engage in OFD services. Based on previous studies on desire as a strong motivator for intention, the following hypothesis has been developed.

H7. Desire positively influences behavioural intention to use OFD services

2.1 Perceived risk

Consumers are notably more anxious when using new technology-based services (e.g. OFD applications), especially in providing personal information, such as their full name, identification number and credit card details. The uncertainty of unpleasant consequences can result in perceived risk (Yang *et al.*, 2015). Suppose the intention and desire to make a certain purchase goal are not met. Consumer will experience negative consequences such as negative view toward the service, financial losses, violation of privacy, product or service delivery failure, anxiety, discomfort or wasted time. The higher the perception of negative consequences among consumers, the more it would deter consumers' purchasing intention. Hence, building consumer confidence and the mitigation of such risk influences consumers' purchasing intentions.

Since the 1960s, perceived risk theory has been used to explain consumers' behaviour. Perceived risk is a kind of expected loss (Schierz *et al.*, 2010) to pursue the desired outcome, which plays a significant role in dictating consumer purchase intention. Consumers' perceived risk is higher in online purchases compared to traditional in-store purchases. As such, perceived higher risk behaviours would hinder the individual's motivation to act a certain way. Zhao *et al.* (2017) and Kim and Lennon (2013) posit that if a consumer perceived that it is risky to purchase from online retailers, it is less likely for the consumer to purchase from the online retailer. The majority of scholars agreed that consumers' perceived risk is a multi-dimensional construct and may vary according to its product, service, industry or situation. Five constructs or component of perceived risks have been identified that could influence online purchasing habits: performance risk, financial risk, time risk, physical risk and privacy risk (Featherman and Pavlou, 2003; Han and Kim, 2017). Furthermore, the pandemic's abrupt behavioural change causes' anxiety and stress among the OFD users. Hence, the present research investigated five types of risk: performance risk, privacy risk, financial risk, physical risk and COVID-19 risk and its influence on the desire and intention to use OFD services.

The first concern of OFD is performance risk. Performance risk refers to the potential loss incurred when the service does not perform as expected (Kushwaha and Shankar, 2013). Compared to an established traditional in-dining service restaurant or take-away option, OFD services are more likely to be managed by an amateur delivery person resulting in sub-par or failed delivery service. On top of that, purchasing a product or service online without touching, smelling, seeing or feeling the product may increase the level of perceived

performance risk (Forsythe and Shi, 2003). Previous studies have commonly suggested that OFD consumers are more likely to have a negative experience. Unable to make correct decision, order prepared wrongly by the restaurant, delayed in delivery or stolen food would significantly impact the performance of OFD services resulting in higher performance risk for the consumer. Privacy risks are concerned with the possibility of a consumer's personal information, such as name, email address, phone number, credit card information, leaked or misused by an unscrupulous individual (Forsythe and Shi, 2003). OFD companies might store sensitive information through their mobile applications, making them likely target of hackers. Fortes and Rita (2016) found that the privacy concern negatively impacts trust, behaviours and online purchase intention. As all OFD transactions are conducted online, OFD users are more likely to be concerned about any unauthorised access of information that could cause harm to the owner. Thus, privacy risk could hinder consumer's intention and desire to engage in OFD services.

The financial aspect also poses a risk to the consumer. Financial risk refers to the possibility of consumer's loss of money due to inappropriate purchases of product and services online (Forsythe and Shi, 2003). If consumer's perception of value towards the online product or service is low, they are more likely to perceive that it is financially risky for them to engage in OFDs (Kim *et al.*, 2005). Such risk is more significant for first-time OFD users, where consumer expectations are not met in reality (Hwang and Choe, 2019). In short, OFD users could suffer from potential financial losses when using OFD services. Lastly, the physical risk is directly related to physical safety, while COVID-19 risk is concerned with an individual's perception of contracting COVID-19. Consumer engaging in OFD services is exposed to some form of physical risk. Consumer's physical location must be shared in real-time via a mobile application; with this, they are more likely to be concerned about their safety. Additionally, contacts with delivery persons might increase the likelihood of contracting COVID-19 if the recommended safety measures are not being adhered to. It was found that more than sixty percent of food delivery workers in Hanoi, Vietnam display mildly ill or presymptomatic while working (Nguyen and Vu, 2020). This raises the concern that food delivery workers may infect other riders and their customers as more and more people are adhering to shelter-in-place order. Altogether, consumers that decides to use OFD services are directly or indirectly exposing themselves to potential physical harm and risk of contracting unwanted illnesses from the delivery person. Hence, the following hypotheses have been developed based on the literature.

H8. Performance risk negatively influences the desire to use OFD services.

H9. Performance risk negatively influences behavioural intention to use OFD services.

H10. Privacy risk negatively influences the desire to use OFD services.

H11. Privacy risk negatively influences behavioural intention to use OFD services.

H12. Financial risk negatively influences the desire to use OFD services.

H13. Financial risk negatively influences behavioural intention to use OFD services.

H14. Physical risk negatively influences the desire to use OFD services.

H15. Physical risk negatively influences behavioural intention to use OFD services.

H16. COVID-19 risk negatively influences the desire to use OFD services.

H17. COVID-19 risk negatively influences behavioural intention to use OFD services.

3. Research method

3.1 Data collection and sample

The study's respondents are customers with OFD experience. The non-probability convenience sampling method was applied to examine the proposed framework (Figure 1) due to the unknown total population and the absence of a sampling frame for the customer of OFD. This study adopted Kline's (2015) recommendation to estimate the minimum samples size using the G*Power 3.1 program (Faul *et al.*, 2009). This program is designed to analyse the statistical power commonly used in social behavioural studies. It provides power analysis options for frequently used analysis, including correlation and regression. In terms of sampling, this study adopted the sample size calculation by Poon *et al.* (2018). The minimum estimated sample size is 208 respondents with the power at 95%, with an alpha set at 0.05 and a medium effect size of 0.15. The convenience sampling method was used in this study. Potential respondents were contacted online (messaging application) enclosed with an online survey link. In a bid to encourage respondents to complete the survey, important information such as the study's introduction and purpose guarantee data confidentiality, option to decline and progress bar. A total of 355 respondents recruited for the study; 349 responses were gathered from OFD customer residing in Selangor and Kuala Lumpur over two weeks in April 2020. After data cleaning, ten responses were discarded due to poor data quality and only 339 useable responses were included in the data analysis.

3.2 Scale measurement

The proposed research model (see Figure 3) consists of 12 variables-ATT, SN, PAE, NAE, PBC, desire, intention and five constructs of perceived risk (performance risk, financial risk, privacy risk, physical risk and COVID-19 risk). The items for MGB were adapted and contextualised from Perugini and Bagozzi (2001) and Bagozzi and Dholakia (2002) to represent OFD behaviours. The constructs of perceived risks were adapted from Murray and Schlacter (1990) and Yi *et al.* (2020). All items were assessed on a five-point Likert scale from strongly disagree (1) to strongly agree (5). The English language questionnaire was pre-tested on 30 OFD customers to ensure that the questions and instructions are well comprehended.

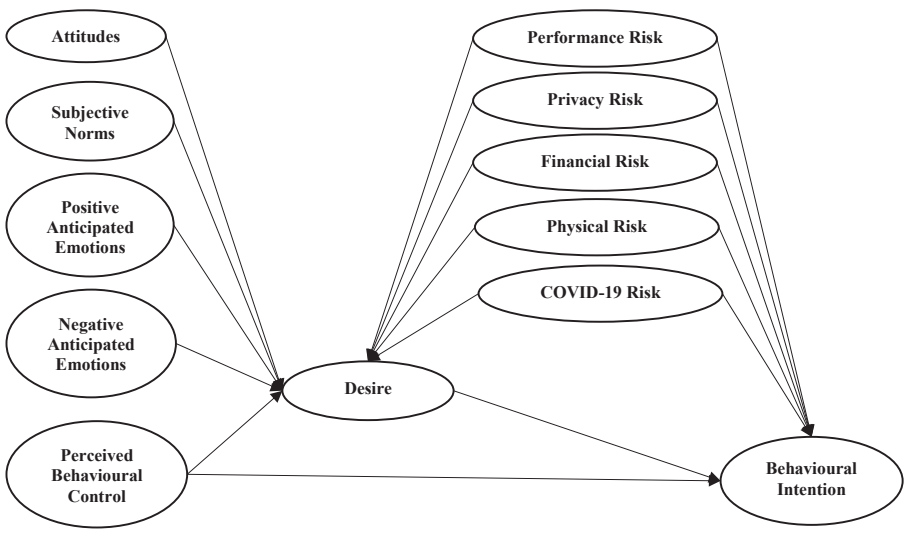

Figure 3.
Proposed research model

Minor amendments were made to the questionnaire based on the feedback from the pre-testing.

3.3 Analysis and results

To better understand the characteristics of respondents, the frequency distribution method was presented. In all, 62.2% of the respondents are female, 49.9% of them are aged between 20 and 29, 71.6% of the respondents are college or university graduates, and a majority earn a monthly income between RM 4,000 and RM 7,999 (34.5%). The summary of the demographic data is presented in Table 1.

As suggested by Cain *et al.* (2016), this study assessed the multivariate skewness and kurtosis. The results indicated that the data was not multivariate normal, Mardia's multivariate skewness ($\beta = 12.982, p < 0.01$) and Mardia's multivariate kurtosis ($\beta = 191.807$, $p < 0.01$). Thus, to analyse the data, the partial least squares structural equation modelling (PLS-SEM) technique was adopted using SmartPLS 3.3.2 (Ringle *et al.*, 2015). The present study employed PLS-SEM due to the prediction-oriented variance-based approach compared with covariance-based structural equation modelling (CB-SEM), which is more confirmed-orientated (Hair *et al.*, 2017a). PLS-SEM was chosen to examine the predictability of exogenous variable (ATT, SN, PAE, NAE, PBC and perceived risk) on the endogenous variable (desire and behavioural intention). Furthermore, the two-stage analytical procedures by Gerbing and Anderson (1988) validity and goodness of the measurement model were first tested to evaluate the proposed research model (Poon and Mohamad, 2020a). For reflective constructs, item factor loading, construct reliability, composite reliability (CR) and average variance extracted (AVE) are evaluated (Hair *et al.*, 2017a). The minimum cut-off value for item factor loadings are above 0.70, AVE in each construct exceeds 0.50 and CR in each construct exceeds 0.708 (Bagozzi and Yi, 1988; Hair *et al.*, 2013). As can be observed, the MacDonald's Omega reliability indices exceed 0.70 which indicates satisfactory reliability (Hayes and Coutts, 2020). The model satisfies all of these criteria, as depicted in Table 2.

Henseler *et al.* (2009) suggested the use of heterotrait-monotrait (HTMT) ratio, which is the average of the heterotrait-heteromethod correlations (i.e. the correlations of indicators across constructs measuring different phenomena) relative to the average of the monotrait-heteromethod correlations (i.e. the correlations of indicators within the same construct). Thus, this study used the most conservative criterion HTMT to examine discriminant validity at the cut-off value of 0.85. A value is greater than 0.85 signifies an issue with discriminant validity (Henseler *et al.*, 2009; Voorhees *et al.*, 2016). As depicted in Table 3, the measurement

Table 1.
Demographic profile of respondent and SMEs

Variable	Description	Frequency	%
Gender	Male	128	37.8
	Female	211	62.2
Age	Below 19 years old	9	2.7
	20–29 years old	169	49.9
	30–39 years old	120	35.4
	40–49 years old	34	10.0
	50–59 years old	7	2.1
Highest education level	High/secondary school	10	2.9
	College/university	329	97.1
Monthly income	No fixed monthly income	67	19.8
	Less than RM 4,000	97	28.6
	RM 4,000 to RM 7,999	117	34.5
	RM 8,000 and above	58	17.1

Item	Loadings	ω	CR[a]	AVE[b]	Item	Loadings	ω	CR	AVE
ATT1	0.712	0.805	0.867	0.621	PBC1	0.816	0.776	0.868	0.686
ATT2	0.759				PBC2	0.821			
ATT3	0.848				PBC3	0.848			
ATT4	0.826				PER1	0.818	0.829	0.872	0.632
BI1	0.900	0.924	0.945	0.813	PER2	0.735			
BI2	0.938				PER3	0.899			
BI3	0.940				PER4	0.714			
BI4	0.823				PPR1	0.869	0.839	0.901	0.752
DE1	0.800	0.851	0.899	0.689	PPR2	0.876			
DE2	0.838				PPR3	0.856			
DE3	0.836				PR1	0.835	0.892	0.925	0.755
DE4	0.846				PR2	0.922			
FR1	0.880	0.632	0.751	0.511	PR3	0.855			
FR2	0.545				PR4	0.862			
FR3	0.680				SN1	0.896	0.930	0.949	0.822
NAE1	0.912	0.925	0.946	0.815	SN2	0.934			
NAE2	0.900				SN3	0.923			
NAE3	0.889				SN4	0.873			
NAE4	0.911				PAE1	0.856	0.858	0.907	0.710
COR1	0.865	0.885	0.920	0.793	PAE2	0.890			
COR2	0.907				PAE3	0.816			
COR3	0.899				PAE4	0.805			

Note(s): [a] Composite reliability (CR) = (square of the summation of the factor loadings)/ [(square of the summation of the factor loadings) + (square of the summation of the error variance)
[b] Average variance extracted (AVE) = (summation of squared factor loadings)/(summation of squared factor loadings) (summation of error variances)
ω = Omega, CR = Composite reliability, AVE = Average variance extracted, ATT = attitude, BI = behavioural intention, DE = desire, FR = financial risk, NAE = negative anticipated emotions, PAE = positive anticipated emotions, PBC = perceived behavioural control, PER = performance risk, PPR = privacy risk, PR = physical Risk, COR = COVID-19 risk, SN = subjective norms

Table 2.
Loadings, McDonald's Omega, composite reliability and average variance extracted

	1	2	3	4	5	6	7	8	9	10	11	12
1. Attitude												
2. Behavioural intention	0.733											
3. COVID-19 risk	0.220	0.157										
4. Desire	0.718	0.848	0.173									
5. Financial risk	0.218	0.175	0.424	0.219								
6. NAE	0.346	0.287	0.062	0.461	0.092							
7. PBC	0.388	0.375	0.263	0.243	0.123	0.092						
8. Performance risk	0.204	0.129	0.522	0.110	0.607	0.058	0.114					
9. Physical risk	0.218	0.167	0.675	0.071	0.353	0.064	0.256	0.475				
10. PAE	0.623	0.537	0.144	0.618	0.247	0.485	0.145	0.198	0.090			
11. Privacy risk	0.089	0.164	0.362	0.146	0.355	0.117	0.093	0.595	0.447	0.111		
12. Subjective norms	0.631	0.477	0.148	0.532	0.190	0.360	0.143	0.124	0.075	0.588	0.077	

Note(s): NAE = Negative anticipated emotions, PAE = Positive anticipated emotions, PBC = Perceived behavioural control

Table 3.
Heterotrait-monotrait (HTMT) ratio analysis

model attains discriminant validity based on HTMT analysis. In assessing the model fit, the present study adopts standardised root mean square residual (SRMR). As suggested by Hu and Bentler (1999), the cut-off value of less than 0.08 for SRMR indicates a good fit. In this light, the present study's SRMR value is 0.07, indicating a good model fit.

Following the recommendation from Hair *et al.* (2017a, b), the bootstrapping method of 5,000 resampling procedures was applied to determine the level of significance of each indicator weight. Bootstrapping is a resampling technique that draws a large number of subsamples from the original data (with replacement) and estimates models for each subsample. Table 4 summarises the results from the PLS path analysis for structural model evaluation. ATT ($\beta = 0.374, p < 0.001$), SN ($\beta = 0.088, p < 0.10$), PBC ($\beta = 0.096, p < 0.10$), PAE ($\beta = 0.192, p < 0.05$), and NAE ($\beta = 0.169, p < 0.05$) have positive effect on desire. The result indicates that individual ATT, SN, PBC, PAE and NAE influences desire. PBC ($\beta = 0.154$, $p < 0.001$), and desire ($\beta = 0.738, p < 0.001$) have a positive effect on intention.

Performance risk ($\beta = -0.119, p < 0.05$), privacy risk ($\beta = -0.133, p < 0.05$), financial risk ($\beta = -0.088, p < 0.05$), physical risk ($\beta = -0.150, p < 0.05$) and COVID-19 risk ($\beta = -0.105$, $p < 0.10$) have a negative effect on desire. The findings indicate that performance risk, privacy risk, financial risk, physical risk and the risk of contracting COVID-19 negatively influence the desire of OFD users. Physical risk ($\beta = -0.147, p < 0.05$) and COVID-19 risk ($\beta = -0.106$, $p < 0.05$) have a negative effect on intention. The result implies that users' intention is influenced by their physical risk and the risk of contracting COVID-19. However, the results indicate the insignificant relationship between performance risk ($\beta = -0.012$, $p > 0.10$), privacy risk ($\beta = -0.020, p > 0.10$), financial risk ($\beta = -0.013, p > 0.10$) and intention. Table 4 presents the value of R^2 for endogenous variables. The R^2 values are 0.626 for desire and 0.491 for intention. The R^2 value indicates that 62.6% of the variance explained for desire and 49.1% of variance explained for intention (see Table 4).

PLS predict was used to examine the model's predictive relevance. Shmueli *et al.* (2019) described the method comprises training and holdout sample-based procedure generating case-level predictions on the item or construct level using the PLS-predict with a 10-fold procedure to identify predictive relevance. According to Shmueli *et al.* (2019), the PLS model offers predictive performance if the Q^2 prediction value is positive. There is a strong predictive power and vice versa if all the item differences linear regression model (LM) are lower than the PLS model. There is moderate predictive power when the majority item

	β	Std. Error	*t*-value	Hypothesis testing	R^2
H1 ATT → desire	0.374	0.059	6.376***	Supported	0.626
H2 SN → desire	0.088	0.052	1.694*	Supported	
H3 PBC → desire	0.096	0.049	1.939*	Supported	
H4 PBC → BI	0.154	0.038	4.026***	Supported	0.491
H5 PAE → desire	0.192	0.063	3.051**	Supported	
H6 NAE → desire	0.169	0.050	3.353**	Supported	
H7 desire → BI	0.738	0.028	26.578***	Supported	
H8 PER → desire	−0.119	0.056	2.138**	Supported	
H9 PER → BI	−0.012	0.045	0.262	Rejected	
H10 PPR → desire	−0.133	0.043	3.093**	Supported	
H11 PPR → BI	−0.020	0.040	0.505	Rejected	
H12 FR → desire	−0.088	0.040	2.178**	Supported	
H13 FR → BI	−0.013	0.034	0.379	Rejected	
H14 PR → desire	−0.150	0.059	2.524**	Supported	
H15 PR → BI	−0.147	0.048	3.094**	Supported	
H16 COR → desire	−0.105	0.058	1.825*	Supported	
H17 COR → BI	−0.106	0.046	2.308**	Supported	

Table 4.
Standard beta, standard error, *t*-Value and variance explained

Note(s): *$p < 0.10$, **$p < 0.05$, ***$p < 0.001$, ATT = attitude, SN = subjective norms, BI = behavioural intention, FR = financial risk, NAE = negative anticipated emotions, PAE = positive anticipated emotions, PBC = perceived behavioural control, PER = performance risk, PPR = privacy risk, PR = physical risk, COR = COVID-19 risk

differences in LM are lower than the PLS model, while there is low predictive power if the minority item differences in LM are lower than the PLS model, then. As shown in Table 5, using ten folds and ten repetitions, all PLS models' items were lower than the PLS LM model; thus, the result concludes that the model has strong predictive power for behavioural intention and desire.

Following the guideline by Ringle and Sarstedt (2016), all outer weights of the measurement model are positive. The importance performance matrix (IPMA) revealed that PBC appears as the most important influencing factor for behavioural intention to use OFD with a score of (0.225; 75.336). The second most influential factor for behavioural intention with a score of (0.276; 68.128) was the ATT towards OFD. Interestingly, the result revealed that financial risk as the third most influential factor for behavioural intention with a score of (0.276; 67.259). Desire with a score of (0.738; 62.366) appears to be the fourth most influential factor for behavioural intention (see Table 6).

4. Discussion and implications

Little attention was paid to OFD consumer's behaviour and the decision-making process of OFD users. This study's objective is to use MGB to investigate the relationship between consumer's intentions towards OFD services to address the gap in the literature. Perugini and Bagozzi (2001) hypothesised that desire reflects the ATT, SN, PBC and AEs. Consistent with expectations, ATT, SN, PBC and AEs positively influence desire and intention. This study's results have further demonstrated the validity of the theoretical foundation used. The addition of desire and PAE and NAE guided by the literature suggests that what people want

	PLS RMSE	LM RMSE	PLS - LM RMSE	Q^2_predict
BI1	0.709	0.729	−0.020	0.360
BI2	0.761	0.783	−0.022	0.343
BI3	0.746	0.750	−0.004	0.338
BI4	0.818	0.877	−0.059	0.292
DE1	0.930	0.968	−0.038	0.258
DE2	0.769	0.789	−0.020	0.342
DE3	0.871	0.929	−0.058	0.298
DE4	0.881	0.929	−0.048	0.318

Note(s): BI = behavioural intention, DE = desire, LM = Linear Regression Model, RMSE = root mean squared error

Table 5. PLS predict

	Desire	Behavioural intention	
	Total effect	Total effect	Performances
Attitude	0.374	0.276	68.128
COVID-19 risk	−0.105	0.028	49.101
Desire	–	0.738	62.366
Financial risk	−0.088	−0.077	67.259
Negative anticipated emotions	0.169	0.125	33.029
Perceived behavioural control	0.096	0.225	75.366
Performance risk	0.119	0.076	54.642
Physical risk	0.150	−0.037	27.136
Positive anticipated emotions	0.192	0.142	54.970
Privacy risk	−0.133	−0.118	55.268
Subjective norms	0.088	0.065	58.568

Table 6. Performance and total effects

to do is an essential variable in explaining intention. On top of that, the study contributes to our understanding of various types of perceived risk that have not been explored in-depth in previous literature and their effects on the desire and intention to use OFD. OFD users would be more open towards continuance adoption of food delivery services when they are sure that it is safe to do so. Addressing specific concerns among OFD users would lead to an increase in desire. Subsequently, the desire will influence the intention to use OFD services.

Consumer's favourable ATT towards OFD suggests that consumers are comfortable with the concept of purchasing products or services online, given that the e-commerce industry had more than a decade to educate and build trust among OFD user. Such favourable ATTs could be attributed back to policies by e-commerce players, such as a 100% authenticity or money back warranty. The entry of branded and luxury items into the online platform is a signal of consumers' willingness to spend money on big-ticket items. These trends indicate the increasing level of trust among consumers towards online purchases, positively impacting OFD services. Therefore, capitalising on this trend, restaurant operators should introduce high-ticket items that could generate a higher margin. Currently, offerings available on OFD for consumers are largely cheaper options that are design to entice first-time users to try out the delivery service. Current restaurant operators could offer family meal menu or monthly subscription meal plan that could provide a better financial stability long-term. As ATT towards OFD changes, Michelin-starred chef and high-end restaurants could venture into the food delivery space and offer higher ticket items. Conversely, OFD operators would need to revamp its deliver processes taking into account the need of these high-end restaurants such as timeliness of delivery or the use of temperature-controlled storage boxes.

Apart from having a favourable ATT, PAE and NAE forms the desire to use OFD services. AE influences the decision-making process (Bagozzi *et al.*, 2016); hence OFD users are more motivated to engage with OFD services in anticipation of a positive outcome from the delivery service. To leverage on these emotions, platforms could also employ promotional strategies such as "Refer-a-Friend" campaign after each successful transaction. Having succeeded in achieving the desired goal-directed behaviour, consumers are more likely to become platform ambassadors offering vouchers or cash rebates to entice new users. It is worthy to note that PBC had significant influences on consumer's desire and intention to use OFD services. In the performance of behavioural intention to engage with OFD services, PBC emerged as the most critical factor. OFD users who are capable of using mobile application to make purchases and past experiences, will likely contributed to an increase in the usage of OFD services. Therefore, OFD operators ought to focus on removing obstacles that would inhibit consumer's intention to use OFD services. These improvements will undoubtedly improve consumer's overall experience. On top of that, due to a number of reasons, the delivery service could be delayed. OFD operators should consider appropriate action in ensuring that the consumer's experience and emotion remains positive as these favourable perspective influences consumer's desire and subsequently their intention. These findings provide a more complex view in understanding consumers" intention to use OFD services that both OFD operators and restaurant managers must consider in their decision-making.

The present study had also explored the influences of perceived risks on desire and intention to use OFD services, and the results indicated interesting results. Performance, privacy, financial physical and COVID-19 risk negatively affect consumer's desire, while only physical and COVID-19 risk negatively affect consumer intention to engage in OFD services. These findings are consistent with previous studies on perceived risk and consumer behaviour research (Han and Kim, 2017; Kamalul Ariffin *et al.*, 2018; Bashir *et al.*, 2018; Lăzăroiu *et al.*, 2020). An intricate mechanism influences one's motivation to act a certain way. The results suggest that OFD users consider different critical risk factors (i.e. performance risk, privacy risk, financial risk, physical risk and COVID-19 risk) in determining one's motivation.

Issues ranging from poor delivery service, food being stolen, wrong order, leak of personal information, financial dispute, potential physical harm and the risk of contracting COVD-19 from the delivery person could reduce users' desire to engage with OFD services. In a physical restaurant, issues such as delivery service, stolen food, wrong order or financial dispute could have been quickly addressed. However, with OFD, consumers need to contact the OFD service provider online to ask for a refund, and this could take up to a week to resolve or longer. Therefore, managerial actions should specifically consider improving consumer complaint process and establish hiring guidelines along with appropriate key performance index for delivery person. Clear procedures should be developed to manage simple issues faced by users. However, for more complicated issues, an independent third party should be appointed to manage it effectively and efficiently. Apart from performance issues, financial concerns could be mitigated through a money-backed guarantee scheme introduced by OFD companies. OFD operators that introduces a guaranteed scheme gain a competitive edge, develop loyal customers over time, and this information be used to provide useful feedback to the restaurant if ordered were wrongly completed, eventually improving both OFD and F&B operators' performance.

Another concern among OFD users is that their credentials (i.e. banking details, credit card information, house address, hand phone number, email address and password) are not sufficiently secured, and their online behaviour data could be leaked or sold to third-party advertisers. Practitioners, such as OFD companies, should continuously seek to reassure consumers that their data and private information are managed and stored securely according to the government's countries' regulation and guideline. Apart from that, government too plays an active role in regulating all businesses, including OFD operators, by enacting relevant data protection regulation to protect its citizen from exploitation, such as General Data Protection Regulation (GDPR) in the European Union. While such moves could incur additional cost to some industries, consumers' privacy concern would be alleviated, prompting higher consumption in data-driven industries such as e-commerce, healthcare, insurance services and financial services.

Furthermore, the physical risk and risk of contracting COVID-19 negatively influence consumer's desire and intention to use OFD services. Undoubtedly, all consumers would not subject themselves to any physical harm or potential exposure to diseases regardless of physically patronising a restaurant or purchasing food online. With COVID-19 risk looming in the back of mind, the introduction of contactless delivery, pick-up, or unmanned last-mile delivery would make it more comfortable among OFD customer and F&B operators significantly reduce the risk of transmission. F&B operators could designate an area in the restaurant as a contactless pick-up area for both walk-in customers and delivery personnel. Apart from that, OFD platform could implement "Just-In-Time" concept where delivery personnel would only enter the restaurant once the food is ready for collection. These steps are deemed necessary to protect essential workers, such as delivery personnel, by preventing overcrowding, enforcing strict standard operating procedures (SOPs) and upholding high safety standards throughout the entire F&B industry. It is worth noting that while this study was conducted during the height of the COVID-19 pandemic, consumers might be more biased towards health-related issues. However, contracting any transmittable diseases or hygiene issues would naturally be the top concern of many consumers, primarily when it comes to food. Traditional take-away option offered by restaurants, consumers that do so are more likely to be in contact with other people if they were to leave their houses. If health advisories such as physical distancing, wearing of face mask or washing of hands are not adhered to religiously by the community at large, consumers that leaves their home are more likely to contract COVID-19 (World Health Organization, 2020) or other types of transmittable diseases. Conversely, if consumers were to use OFD services, it would pose a lower risk if compared with take-away option. With that said, necessary precaution would need to be

practised by the OFD users and workers to reduce the risk of transmission. OFD operators raise awareness for OFD users and workers on the latest health advisors by health experts and secondly, to introduce a feedback system for the public to raise concerns if food delivery riders are seen flaunting these SOPs.

Continuous real-time tracking via Global Position System (GPS) or geolocation allows for unscrupulous actors the ability to pinpoint the exact location of consumer and delivery personnel, hence exposing them to unnecessary physical risk. As OFD requires a location-based tracking system, the application developer should introduce a method to quickly disable location tracking in food delivery applications if the user felt that their life is threatened. On top of that, OFD operator should introduce a panic button alert would allow users to report any issues quickly. OFD and F&B operators could not afford to overlook these risks as concerns on physical safety would ultimately steer the customer away from the OFD provider. As OFD and F&B operators are in the service sector, poor performance would create a bad image of the service resulting in lower purchases (Hwang and Choe, 2019). As such, both physical risk and risk of contracting COVID-19 would influence consumer's decision-making process.

All in all, any of these concerns show that consumers' desire and intention to use OFD services are impaired. Consumers tend to be more motivated to engage with OFD services if they perceived it would bring minimal adverse effects. Hence, it falls on the OFD operators and restaurants to be ambidextrous in managing and mitigating these risks through new policies and strategies. This study postulates that the food delivery culture worldwide is set to grow in the coming years. With the rise of ghost kitchen coupled with efficient operation and lowering cost, the food delivery culture is set to transform the F&B industry. All stakeholders need to come together to create a new sustainable framework in addressing these dynamic changes.

4.1 Limitation and future research

While this study offers important implication for practitioners, it has several limitations. The first concern is related to external validity. As the data were only collected from Malaysian consumers, the data might offer a narrow perspective and could differ from other countries. Future studies are recommended to collect data in other parts of Malaysia and other countries to provide a broader view of perceived risk among OFD consumers. Another limitation is that the study was conducted during the pandemic, and the responses might only be relevant to the current scenario. Thus, future studies should consider conducting the research post-pandemic and compare the findings with the current results. The convenience sampling method was used for data collected in the current study, which can cause selection biases (Wright, 2005). It is recommended to use another type of sampling method to reduce biases. In this study, the respondent may be biased towards the looming threat of a pandemic, which may skew their overall risk perception. Thus, future studies could use longitudinal data to assess the perceived risk profile more accurately as the relationship may change over time.

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Appendix
The supplementary material for this article can be found online.

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Interlinkages of cryptocurrency and stock markets during the COVID-19 pandemic by applying a QVAR model

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Abstract

Purpose – This paper aims to study the interlinkages between cryptocurrency and the stock market by characterizing their connectedness and the effects of the COVID-19 crisis on their relations.

Design/methodology/approach – The author employs a quantile vector autoregression (QVAR) to identify the connectedness of nine indicators from January 1, 2018, to December 31, 2021, in an effort to examine the relationships between cryptocurrency and stock markets.

Findings – The results demonstrate that the pandemic shocks appear to have influences on the system-wide dynamic connectedness. Dynamic net total directional connectedness implies that Bitcoin (BTC) is a net short-duration shock transmitter during the sample. BTC is a long-duration net receiver of shocks during the 2018–2020 period and turns into a long-duration net transmitter of shocks in late 2021. Ethereum is a net shock transmitter in both durations. Binance turns into a net short-duration shock transmitter during the COVID-19 outbreak before receiving net shocks in 2021. The stock market in different areas plays various roles in the short run and long run. During the COVID-19 pandemic shock, pairwise connectedness reveals that cryptocurrencies can explain the volatility of the stock markets with the most severe impact at the beginning of 2020.

Practical implications – Insightful knowledge about key antecedents of contagion among these markets also help policymakers design adequate policies to reduce these markets' vulnerabilities and minimize the spread of risk or uncertainty across these markets.

Originality/value – The author is the first to investigate the interlinkages between the cryptocurrency and the stock market and assess the influences of uncertain events like the COVID-19 health crisis on the dynamic interlinkages between these two markets.

Keywords Stock market, COVID-19 pandemic, Cryptocurrency, QVAR, Dynamic connectedness

Paper type Research paper

1. Introduction

More than a decade after Bitcoin (BTC) was introduced; cryptocurrencies are now regarded as attractive investments. Many scholars have even emphasized that futures markets play an important role in risk hedging. There is a distinct difference between the price fluctuations experienced by cryptocurrency (a new type of exchange asset) and those experienced by other financial assets (Corbet *et al.*, 2019), in part due to the uncertainty caused by shocks such as the current COVID-19 epidemic (Wang *et al.*, 2022). Besides, based on Sharif *et al.* (2020), COVID-19 has caused unprecedented volatility in the stock market and a surge in uncertainty

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in US. economic policy. Since the beginning of 2020, circuit breakers were frequently activated on the major United States (US) stock market indices (such as the Dow Jones industrial average index, the S&P 500 Index, and the National Association of Securities Dealers Automated Quotations Stock Market (NASDAQ) 100 Index). Furthermore, in the meantime, Ethereum (ETH) prices dropped by approximately 44%, while BTC prices dropped by up to 50% in one day, making it the worst one-day decline ever. The first bear market since active BTC trading started in COVID-19 has generated significant losses (Conlon and McGee, 2020). The cryptocurrency market exhibited idiosyncratic characteristics of higher irregularity and instability than the equity market in the aftermath of the COVID-19 epidemic, according to Lahmiri and Bekiros (2020).

A number of recent studies have shown that there are asymmetric spillover effects between the stock market and the cryptocurrency market (Corbet *et al*., 2019; Gil-Alana and Claudio-Quiroga, 2020; Kristjanpoller *et al*., 2020; Lamothe-Fernández *et al*., 2020). There have been contrasting conclusions regarding crypto currency's role and inconsistent findings regarding the relationship between cryptocurrencies and stock markets. Similarly, our paper contributes to the literature by extending its scope. Initially, we examine the interaction between cryptocurrencies and stock markets and determine the influence of unforeseen circumstances, such as the COVID-19 outbreak, on these dynamic relationships. In order to achieve this, we collect daily market capitalization data of the three most valuable cryptocurrencies (BTC, ETH and Binance coin (BNB)) and six stock indexes from global markets. Aside from New York Stock Exchanges and Shanghai Stock Exchanges (SSEs), Hong Kong Stock Exchanges (HSKEs), Japan Exchange Groups (JPXGYs) and Euronext, (London Stock Exchange Groups (LSEs) are also listed.)). The data in this study were collected between January 1, 2018, and December 31, 2021.

This article's primary research objective is to assess the uncertainty shock's severe effects on the dynamic connectedness between the volatility of the cryptocurrency and stock markets in order to provide important information to policymakers in order for them to accurately comprehend the contagion effects of the pandemic shock and design and implement policies to limit the volatility of these two markets. Our paper highlights how the COVID-19 crisis negatively impacted cryptocurrencies and stocks, which is the first time anyone has investigated this issue. Since the first, second and third waves of the COVID-19 pandemic, an analysis of changes in the stock market and the cryptocurrency market has become increasingly important as both production and investment activities have been curtailed as well as all investments have turned out to be highly risky. Cryptocurrencies are safer assets under these circumstances. Our study used an up-to-date database to reveal novel findings regarding uncertain events, whereas previous studies examined the impacts of global economic recession. Second, we employ a quantile vector autoregression (QVAR) to study this dynamic connectedness. Due to its various advantages, we choose this empirical approach. First, we do not lose any insight with this practical approach. Thus, it can be performed in cases of short data spans, though that is not the case here. Second, outliers do not significantly affect our results, whereas this approach allows us to adjust for parameter changes more effectively. As part of our strategy, we computed a pairwise connectedness metric, which helps identify transmission mechanisms between these financial and commodity markets. Through the use of daily data, this paper explores the impacts of cryptocurrency market changes on stock volatility in various regions, providing critical, insightful knowledge and warnings for investors and authorities.

Our results demonstrate that the pandemic shocks appear to influence the system-wide dynamic connectedness, which peaked during the Covid-19 pandemic. Dynamic net total directional connectedness implies that BTC is a net short-duration shock transmitter during our sample. BTC is a long-duration net receiver of shocks during the 2018–2020 period and turns into a long-duration net transmitter of shocks in late 2021. ETH is a net shock

transmitter in both durations. Binance turns into a net short-duration shock transmitter during the COVID-19 outbreak before receiving net shocks in 2021. The US stock market transmits net shocks in both durations before 2021 and turns into a net short-duration shock receiver from 2021. The role of the US stock market in the long duration is opposite to the short duration from 2021. Asian stock markets (including Hong Kong, Japan and Shanghai) are net receivers in both duration during our sample. Europe stocks (including Euronext and London) are net receivers of shocks during the 2018–2020 period before turning to net transmitters of shocks from 2021 in both durations. During the COVID-19 pandemic shock, pairwise connectedness reveals that cryptocurrencies can explain the volatility of the stock markets with the most severe impact at the beginning of 2020.

Following is the structure of the remainder of the study. Related works are analyzed in Section 2. A summary of statistics and data is presented in Section 3. During Section 4, we will present the analytical results or analyses of the empirical results, while Section 5 will present conclusions.

2. Literature review

BTC market fluctuations become erratic and unpredictable during the health crisis. Unlike stocks and the US dollar, cryptocurrencies (such as BTC) present superior hedging opportunities compared to other financial assets (Bouri *et al.*, 2019; Hu *et al.*, 2019; Kostika and Laopodis, 2019; Miglietti *et al.*, 2019; Sahoo, 2021). In response, investors diversified their portfolios throughout the outbreak of the virus to find short-term investments that were safe and profitable. Cryptocurrencies were used as a means of payment during COVID-19, which spread quickly around the world. Majdoub *et al.* (2021) and Umar *et al.* (2021) assert that cryptocurrencies can be used as investment options during unstable economic times like the COVID-19 economic crisis due to their potential link between foreign exchange and cryptocurrency markets. This plan profoundly affects managing portfolio risk, allocating strategic assets and pricing financial instruments (Umar and Gubareva, 2020). BTC's value plummeted, as well as the value of other cryptocurrencies in 2020, causing investors to change their decisions (Chen *et al.*, 2020). This has resulted in a more volatile and unpredictable crypto market during the COVID-19 crisis (Lahmiri and Bekiros, 2020) and neither did Conlon and McGee (2020). There has been significant research on BTC markets during the epidemic (Umar *et al.*, 2021). However, a small number of studies have focused explicitly on or paid close attention to cryptocurrencies due to the scattered research interests. For example, Bouri *et al.* (2021) use the daily price data of seven leading cryptocurrencies from August 8, 2015, to December 31, 2020, to indicate the connectedness measures in the left and right tails are much higher than those in the mean and median of the conditional distribution. There is evidence that return connectedness increases with shock size for both positive and negative shocks, indicating that return shocks propagate more intensely during extreme events than during calm periods. Naeem *et al.* (2022) calculate the spillover effects among seven cryptocurrencies to explore the spillover characteristics of seven cryptocurrencies, namely, BTC, ETH, Ripple, Litecoin, Monero, Stellar and New Economy Movement (NEM). The connectedness networks of returns are based on standard Vector Autoregression (VAR) and quantile VAR spillovers. In addition, the framework focuses on intact, pre-, and post-COVID-19 crisis subsample periods. They highlight that BTC, Litecoin and Ripple are the dominant transmitters to return spillover. During the outbreak of COVID-19 in Europe and the United States of America (USA), Ali *et al.* (2020) examined financial market volatility, concluding that global markets collapsed in March 2020 as the outbreak of the U.S. pandemic had significant implications on even safer commodities.

In their 2020 paper, Corbet *et al.* discuss how COVID-19 might contagiously affect gold and cryptocurrency, suggesting cryptocurrencies might serve the same purpose during economic

downturns as precious metals. Gharib *et al.* (2021) demonstrated a bilateral contagion effect on gold and oil prices when COVID-19's economic effects modified the relationship between these two markets. Abakah *et al.* (2023) investigate the distributional and directional predictabilities among Fintech, BTC and artificial intelligence stocks from March 2018 to January 2021 using nonparametric causality-in-quantile and cross quantilogram approaches. They reveal the existence of bidirectional causality-in-variance between the variables in a normal market.

The eight economies' financial industries are impacted by COVID-19, according to Rizwan *et al.* (2020). It has been found that the correlation between price volatility shocks in the oil market, geopolitical risks and economic policy uncertainty is closely related to the spread of COVID-19 in the USA, according to Sharif *et al.* (2020). The researchers have identified COVID-19 as a geopolitical threat. COVID-19 is associated with cryptocurrency markets in such a way. Despite the fact that the current literature focuses primarily on the relationship between gold and cryptocurrencies, or oil and cryptocurrency markets, the authors have sought to examine the relationship between COVID-19 and the cryptocurrency market in light of the lack of research focusing entirely and mainly on this market's fluctuation.

The COVID-19 spread has also been associated with the cryptocurrency market in previous studies (Salisu and Ogbonna, 2022; Umar *et al.*, 2021). This relationship is revealed to be inconsistent, which is a concern of the authors. The literature has revealed empirical evidence of an asymmetric spillover effect between the stock market and the cryptocurrency market in regard to the correlation between the two markets. In an article published in April 2020, Lamothe-Fernández *et al.* (2020) argue that cryptocurrency price volatility is caused partly by the halving of the supply and the hash rate each year. There is a risk of spillovers occurring when there is a severe economic, financial or public health crisis, and there is also no circuit breaker on the BTC market, unlike the stock market in the USA. Therefore, there may be an end to the decline of US stocks in some manner. Unlike conventional stock markets, cryptocurrencies have maintained a downward or upward trend, increasing asymmetry. Hence, it is possible to include cryptocurrencies in investment portfolios to provide diversification of risks. This observation is supported by Corbet *et al.* (2019) and Gil-Alana and Claudio-Quiroga (2020). In most cases, cryptocurrency, however, does not provide useful hedging strategies for stock markets due to the positive correlations found in most cases (Kristjanpoller *et al.*, 2020). It is found from these analyses that cryptocurrencies' price fluctuations differ over time from those of US market indices. The spillover influences between conventional financial markets and cryptocurrency markets were investigated by Matkovskyy and Jalan (2019) using a regime-switching model. Clearly, spillover effects exist between these markets based on their results. López-Cabarcos *et al.* (2021) reported similar results.

Our paper differs from previous work by studying the dynamic interconnectedness between cryptocurrency and various global stock markets by applying the QVAR approach. We also highlight the shift in each market's role during extreme events like the COVID-19 pandemic. Our empirical approach reveals novel findings and mechanisms for the interaction between two important markets, especially during uncertain times.

3. Data and methodology

3.1 Data sample

The present article utilizes the daily data of the three largest cryptocurrencies based on market capitalization, including *BTC*, *ETH* and *BNB*, and six stock indices from the global stock market, including SP500 stock index of the U.S. (*SP500*), *SSE*, *HSKE*, *JPXGY*, Euronext (*EURONEXT*) and *LSE*. Our data is collected from January 1, 2018, to December 31, 2021. Our paper studies the dynamic interlinkages between cryptocurrency and stock markets. Since the cryptocurrency market does not close at the end of the day, we collect the daily price data,

which specialized crypto companies and websites proxy cryptocurrency daily prices by using weighted prices (Vidal-Tomás, 2021). This price type represents the average of the prices across the 24-h period. We also use a similar approach to compute the weighted prices of the stock market. It is widely known that trading times for cryptocurrency markets are 24/7, and the trading day is mostly defined as 12:00 am–11:59 pm Universal Time (UTC), while conventional stock exchanges trade roughly 9/5 local time. Therefore, we must merge cryptocurrency market data (high-frequency data) with stock exchange trade data (low-frequency data). Missing data for stock market trading due to weekends, holidays and asynchronous trading times, while a similar issue does not happen for the cryptocurrency market. Merging data in this way can solve this issue. Since we used the average of the prices across the 24-h period, the difference in closing time between various stock markets (SP500 stock index of the U.S., SSE, HSKE, JPXGY, Euronext and LSE).

In terms of whole observations, all series in Table 1 are reported with a positive average return. The BNB and ETH markets have the highest variance, making the two markets the riskiest assets throughout the sample periods, as indicated in Panel A. Figure 1 demonstrates the volatility of these series. Furthermore, this research finds that all of the series are leptokurtic, which means the distributions have fatter tails than a normal distribution. According to Jarque and Bera (1980), all assets are substantially non-normally distributed. All results are at least on the 1% significance level when using the unit root test by Elliott *et al.* (1996). Finally, Fisher and Gallagher (2012) found that the returns and squared returns are autocorrelated, implying that the interlinkages of the series may be modeled using a QVAR method with a time-varying variance-covariance structure. Since the research aims to find the linkages between cryptocurrencies and the stock market, we examine the interconnectedness of these two markets before and during the COVID-19 pandemic.

Panel B and Panel C highlight the main statistics of two subsamples, each having identical statistics as Panel A. The data used to split the two periods (before and post-COVID) is based on the Public Health Organization's (WHO, 2020) set timeframe, which publicly revealed the coronavirus pandemic of 2019 (COVID-19) to the world for the first time on December 31, 2019. As a result, we divided the two periods into classifications: pre-COVID-19 (from January 1, 2018, to December 31, 2019) and post-COVID-19 (from January 1, 2020, to December 31, 2021). Table 1 highlights considerable distinctions in statistics of these included series in two periods. Surprisingly, a positive average return in the post-COVID-19 period is reported for all included variables except for LSE. Moreover, the mean return of *BTC, ETH* and *BNB* increased from the start of the COVID-19 health crisis, while the value of BTC and ETH changed from negative in return to positive. In addition, except for SSE, other markets became volatile during the post-COVID-19 period as all variances increased. The results of the Elliott, Rothenberg and Stock (ERS) unit root test and the weighted portmanteau test on these variables during these two periods are more likely to be the same as those obtained from tests on the entire sample, leading us to believe that modeling the interconnectedness of the series using a QVAR approach with a time-varying variance-covariance structure is a well-supported.

3.2 Empirical methodology

We use the quantile connectedness technique (Chatziantoniou *et al.*, 2021) to investigate the spreading structure between cryptocurrency volatility and renewable energy volatility. We begin to estimate a QVAR(p), and then compute all connectedness metrics using this model.

$$\mathbb{z}_t = \boldsymbol{\mu}_t(\tau) + \mathbf{d}_1(\tau)\mathbb{z}_{t-1} + \mathbf{d}_2(\tau)\mathbb{z}_{t-2} + \ldots + \mathbf{d}_p(\tau)\mathbb{z}_{t-p} + \boldsymbol{u}_t(\tau). \quad (1)$$

Table 1.
Summary statistics

	BTC	ETH	BNB	SP500	SSE	EURONEXT	JPXGY	HSKE	LSE
Panel A: Whole sample									
Whole sample									
Mean	0.1349	0.1697	0.4562	0.062	0.0093	0.0597	0.0251	0.0654	0.0695
Variance	25.2293	43.3539	56.5131	1.9764	1.4571	3.2521	3.5031	3.588	3.6577
Skewness	−0.893***	−0.617***	0.221***	−1.004***	−0.346***	0.226***	−0.135*	0.084	−0.144*
	(0.000)	(0.000)	(0.007)	(0.000)	(0.000)	(0.006)	(0.096)	(0.300)	(0.075)
Kurtosis	10.049***	7.281***	11.495***	16.649***	5.399***	9.681***	2.289***	2.761***	10.738***
JB	3928.192***	2056.557***	4989.956***	10604.336***	1117.402***	3541.961***	200.300***	288.542***	4351.433***
ERS	−10.929***	−4.286***	−5.420***	−8.933***	−9.586***	−13.690***	−5.723***	−12.724***	−13.300***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Q(20)$	35.375**	31.439**	23.780*	286.692***	37.583***	40.319***	17.265	20.572	41.702***
	(0.018)	(0.050)	(0.252)	(0.000)	(0.010)	(0.005)	(0.636)	(0.423)	(0.003)
$Q^2(20)$	18.992**	23.390***	97.652***	1083.912***	25.756***	319.568***	31.974***	90.537***	58.800***
	(0.026)	(0.004)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Panel B: Pre-COVID-19 Pandemic									
Pre-COVID-19 Pandemic									
Mean	−0.1616	−0.423	0.097	0.0399	−0.0205	0.0739	5e-04	0.0025	0.1604
Variance	23.8119	39.2743	55.1085	0.9635	1.5171	2.2228	2.6536	2.6598	2.4219
Skewness	−0.259**	−0.218*	0.256**	−0.426***	−0.301***	−0.691***	−0.265**	−0.193*	1.731***
	(0.024)	(0.057)	(0.026)	(0.000)	(0.009)	(0.000)	(0.021)	(0.091)	(0.000)
Kurtosis	3.260***	2.266***	9.807***	4.401***	2.719***	4.950***	1.648***	1.617***	15.529***
JB	206.117***	100.754***	1824.155***	380.153***	146.746***	499.570***	56.690***	52.256***	4788.632***
ERS	−7.096***	−2.824***	−3.537***	−5.544***	−6.852***	−9.659***	−3.891***	−8.840***	−10.663***
	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Q(20)$	36.766**	22.740	22.067	15.604	39.750***	22.188	19.413	23.196	15.173
	(0.013)	(0.302)	(0.337)	(0.741)	(0.005)	(0.330)	(0.495)	(0.279)	(0.766)
$Q^2(20)$	30.927***	23.409***	46.610***	78.484***	28.712***	14.344	13.452	30.831***	10.945
	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.152)	(0.202)	(0.000)	(0.407)
Panel C: Post-COVID-19 Pandemic									
Post-COVID-19 Pandemic									
Mean	0.4408	0.7718	0.8312	0.0827	0.037	0.0405	0.0473	0.1225	−0.0205
Variance	26.568	46.9366	57.8382	3.0048	1.3985	4.2932	4.3713	4.5155	4.9033

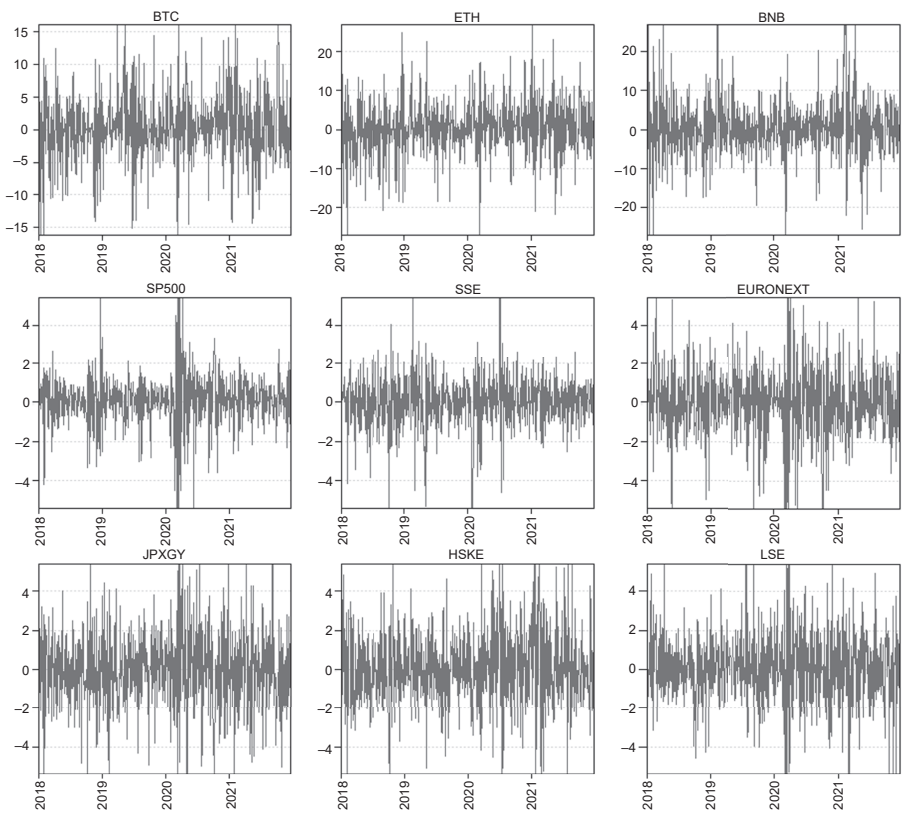
(*continued*)

Table 1.

	BTC	ETH	BNB	SP500	SSE	EURONEXT	JPXGY	HSKE	LSE
Skewness	−1.466***	−0.980***	0.179	−1.024***	−0.387***	0.574***	−0.079	0.174	−0.733***
	(0.000)	(0.000)	(0.118)	(0.000)	(0.001)	(0.000)	(0.486)	(0.128)	(0.000)
Kurtosis	15.902***	11.162***	13.145***	13.410***	8.580***	9.541***	2.114***	2.672***	7.615***
JB	4902.485***	2408.121***	3242.086***	3450.172***	1391.426***	1731.673***	84.261***	136.153***	1127.532***
ERS	−4.358***	−5.550***	−6.278***	−6.063***	−10.164***	−10.721***	−8.071***	−4.004***	−7.190***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Q(20)$	30.159*	25.804	29.320*	236.510***	18.789	33.751**	23.144	27.757	39.520***
	(0.067)	(0.172)	(0.082)	(0.000)	(0.536)	(0.028)	(0.282)	(0.115)	(0.006)
$Q^2(20)$	9.270	11.324	88.582***	544.370***	15.512	190.787***	15.250	45.970***	39.520***
	(0.586)	(0.370)	(0.000)	(0.000)	(0.102)	(0.000)	(0.111)	(0.000)	(0.000)

Note(s): ***,**,* denote significance at 1%, 5% and 10% significance level; Skewness: D'Agostino (1970) test; Kurtosis: Anscombe and Glynn (1983) test; JB: Jarque and Bera (1980) normality test; ERS: Elliott *et al.* (1996) unit-root test with constant; $Q(10)$ and $Q2(10)$: Fisher and Gallagher (2012) weighted portmanteau test

Source(s): Authors' calculations



Source(s): Authors' calculations

Figure 1.
Changes in volatility degrees in the cryptocurrency and stock market

where $\mathbb{z}_t$ and $\mathbb{z}_{t-i}$, $i = 1, \ldots, p$ are $N \times 1$ dimensional endogenous variable vectors, τ is between [0, 1] and describes the quantile of indicator, p illustrates the lag length of the QVAR model, $\boldsymbol{\mu}(\tau)$ is an $N \times 1$ dimensional conditional mean vector, $\mathbf{d}_j(\tau)$ is an $N \times N$ dimensional QVAR coefficient matrix, and $\boldsymbol{u}_t(\tau)$ demonstrates the $N \times 1$ dimensional error vector, which has an $N \times N$ dimensional variance-covariance matrix, $\sum(\tau)$. The approach of Wold is employed to convert the QVAR(p) to its Quantile Vector Moving Average (QVMA)(∞) description: $\mathbb{z}_t = \boldsymbol{\mu}(\tau) + \sum_{j=1}^{p} \mathbf{d}_j(\tau)\mathbb{z}_{t-j} + \boldsymbol{u}_t(\tau) = \boldsymbol{\mu}(\tau) + \sum_{i=0}^{\infty} \mathbf{Z}_i(\tau)\boldsymbol{u}_{t-i}$.

Consequently, our research estimate the generalized forecast error variance decomposition (GFEVD) (Koop *et al.*, 1996; Pesaran and Shin, 1998), which is the center of the connectedness technique [1]. The GFEVD, which has the general structure, may be used to determine the effect that a shock in series j has on variable i with regard to the variance of its forecast error:

$$\Upsilon_{ij}(\breve{\mathrm{U}}) = \frac{(\boldsymbol{\Sigma}(\tau))_{jj}^{-1} \sum_{\breve{\mathrm{u}}=0}^{\breve{\mathrm{U}}-1} ((\mathbf{Z}_h(\tau)\boldsymbol{\Sigma}(\tau))_{ij})^2}{\sum_{\breve{\mathrm{u}}=0}^{\breve{\mathrm{U}}} (\mathbf{Z}_h(\tau)\boldsymbol{\Sigma}(\tau)\mathbf{Z}_h'(\tau))_{ii}} \tag{2}$$

$$\widetilde{\Upsilon}_{ij}(H) = \frac{\Upsilon_{ij}(\breve{\mathrm{U}})}{\sum_{k=1}^{N}\Upsilon_{ij}(\breve{\mathrm{U}})} \tag{3}$$

where $\widetilde{\Upsilon}_{ij}(\breve{\mathrm{U}})$ illustrates the effects of the j th series on the variance of the forecast error of the i th series at horizon $\breve{\mathrm{U}}$. We must standardize the rows of $\widetilde{\Upsilon}_{ij}(\breve{\mathrm{U}})$ because they do not even add up to one, which yields $\widetilde{\Upsilon}_{ij}$. We achieve the next identities by standardization: $\sum_{i=1}^{N}\widetilde{\Upsilon}_{ij}(\breve{\mathrm{U}}) = 1$ and $\sum_{j=1}^{N}\sum_{i=1}^{N}\widetilde{\Upsilon}_{ij}(H) = N$.

All connectedness metrics can be calculated in a subsequent phase. We begin by computing the net pairwise connectedness as follows:

$$NPDC_{ij}(\breve{\mathrm{U}}) = \widetilde{\Upsilon}_{ij}(\breve{\mathrm{U}}) - \widetilde{\Upsilon}_{ji}(\breve{\mathrm{U}}). \tag{4}$$

If $NPDC_{ij}(\breve{\mathrm{U}}) > 0$ ($NPDC_{ij}(\breve{\mathrm{U}}) < 0$, it denotes that series j impacts series i more (less) than the other way around.

The effect of a shock in indicator i transmitted to all other indicators j is described by the *total directional connectedness TO others:*

$$TO_i(\breve{\mathrm{U}}) = \sum_{i=1, i\neq j}^{N}\widetilde{\Upsilon}_{ji}(\breve{\mathrm{U}}) \tag{5}$$

The effect of a shock in indicator i receiving to all other indicator j is described by the *total directional connectedness FROM others:*

$$FROM_i(\breve{\mathrm{U}}) = \sum_{i=1, i\neq j}^{N}\widetilde{\Upsilon}_{ij}(\breve{\mathrm{U}}) \tag{6}$$

The *net total directional connectedness* may be considered the impact series i has on the system under study since it is the difference between TO others and FROM others.

$$NET_i(\breve{\mathrm{U}}) = TO_i(\breve{\mathrm{U}}) - FROM_i(\breve{\mathrm{U}}) \tag{7}$$

If the $NET_i > 0$ ($NET_i < 0$), all other series i have a greater (lesser) impact on them than they have on us. As a result, it is regarded as a net shock transmitter (receiver).

The following formulas can be used to determine the total connectedness index (TCI), which gauges the degree of network interconnectedness:

$$TCI(\breve{\mathrm{U}}) = N^{-1}\sum_{i=1}^{N}TO_i(\breve{\mathrm{U}}) = N^{-1}\sum_{i=1}^{N}FROM_i(\breve{\mathrm{U}}) \tag{8}$$

This metric, then, shows the average effect of a shock in one series on all others. The risk associated with the market increases as its value increases, and vice versa.

Our research has been concentrating on the time domain connectedness assessment so far. In a similar vein, we keep up with the connectedness evaluation in the frequency area. We may investigate the connectivity connection in the frequency domain by employing a spectral decomposition technique. We start by exploring function: $Z(\boldsymbol{e^{-i\omega}}) = \sum_{\breve{\mathrm{u}}=0}^{\infty}e^{-iwh}Z_{\breve{\mathrm{u}}}$, where $i = \sqrt{-1}$ and ω illustrates the frequency to keep up with the spectral density of x_t at frequency ω which can be illustrated as a Fourier transformation of the QVMA(∞):

$$\boldsymbol{S}_{\mathbb{z}}(\omega) = \sum_{\breve{\mathrm{u}}=-\infty}^{\infty}E(\mathbb{z}_t\mathbb{z}'_{t-h})\,e^{-iwh} = Z(e^{-i\omega h})\sum\nolimits_t Z(e^{+i\omega h}) \tag{9}$$

Combining the spectral density and the GFEVD yields the frequency GFEVD. Similar to the time domain situation, the frequency GFEVD has to be normalized. This may be done by formulating it regards:

$$\Upsilon_{ij}(\omega) = \frac{(\Sigma(\tau))_{jj}^{-1}\left|\sum_{ŭ=0}^{\infty}(Z(\tau)(e^{-iwh})\Sigma(\tau))_{ij}\right|^2}{\sum_{ŭ=0}^{\infty}(Z(e^{-iwh})\Sigma(\tau)Z(\tau)(e^{iwh}))_{ii}} \tag{10}$$

$$\widetilde{\Upsilon}_{ij}(\omega) = \frac{\Upsilon_{ij}(\omega)}{\sum_{k=1}^{N}\Upsilon_{ij}(\omega)} \tag{11}$$

where $\widetilde{\Upsilon}_{ij}(\omega)$ denotes the portion of the ith variable's spectrum at a certain frequency ω that may be assigned to a shock in the jth series. As a within-frequency indication, it may be understood.

Instead of measuring connectedness at a single frequency, we combine all frequencies within a certain range to evaluate both short-duration and long-duration connectedness, $d = (a, b) : a, b\,\epsilon\,(-\pi, \pi), a < b$:

$$\widetilde{\Upsilon}_{ij}(d) = \int_a^b \widetilde{\Upsilon}_{ij}(\omega)d\omega \tag{12}$$

From this point, we can compute the accurate same connectedness estimates as Diebold and Yilmaz (2012, 2014), which may be evaluated the same way. Nevertheless, in this instance, frequency interconnectedness estimates provide details on spread within a specific frequency range d:

$$NPDC_{ij}(d) = \widetilde{\Upsilon}_{ij}(d) - \widetilde{\Upsilon}_{ji}(d) \tag{13}$$

$$TO_i(d) = \sum_{i=1, i\neq j}^{N}\widetilde{\Upsilon}_{ji}(d) \tag{14}$$

$$FROM_i(d) = \sum_{i=1, i\neq j}^{N}\widetilde{\Upsilon}_{ij}(d) \tag{15}$$

$$NET_i(d) = TO_i(d) - FROM_i(d) \tag{16}$$

$$TCI(d) = N^{-1}\sum_{i=1}^{N}TO_i(d) = N^{-1}\sum_{i=1}^{N}FROM_i(d) \tag{17}$$

All measurements offer data on the precise range but not on the overall impact. In accordance with the overall methodology, Baruník and Křehlík (2018) recommend weighing all contribution metrics of each frequency band by, $\Gamma(\mathrm{d}) = \sum_{i,j=1}^{N}\widetilde{\Upsilon}_{ij}(d)/N$.

$$\widetilde{NPDC}_{ij}(d) = \Gamma(\mathrm{d})\cdot NPDC_{ij}(d) \tag{18}$$

$$\widetilde{TO}_i(d) = \Gamma(\mathrm{d})\cdot TO_i(d) \tag{19}$$

$$\widetilde{FROM}_i(d) = \Gamma(\mathrm{d})\cdot FROM_i(d) \tag{20}$$

$$\widetilde{NET}_i(d) = \Gamma(\mathrm{d})\cdot NET_i(d) \tag{21}$$

$$\widetilde{TCI}(d) = \Gamma(\mathrm{d})\cdot TCI(d) \tag{22}$$

Finally, we demonstrate the correspondence between the Baruník and Křehlík (2018) frequency-domain measurements and the Diebold and Yilmaz (2012, 2014) time-domain estimates:

$$NPDC_{ij}(\breve{U}) = \sum_{d} NPDC_{ij}(d) \tag{23}$$

$$TO_i(\breve{U}) = \sum_{d} TO_i(d) \tag{24}$$

$$FROM_i(\breve{U}) = \sum_{d} FROM_i(d) \tag{25}$$

$$NET_i(\breve{U}) = \sum_{d} NET_i(d) \tag{26}$$

$$TCI(\breve{U}) = \sum_{d} TCI(d) \tag{27}$$

4. Results

The average and dynamic results for the connectedness metrics are shown in the next section. The TCI average value is calculated based on the whole sample of data. TCI is first presented, after which a dynamic evolution of the TCI over time is demonstrated. Understanding how the TCI responds to different economic scenarios requires the latter approach. Political patterns are also seen within the time frame of our investigation. We evaluate net pairwise and net total connectedness data in our suggested framework. This relationship improves our understanding of the market for four indicators, including the geopolitical risks index and prices of corn, wheat and rice. Remembering that each indication can act as either a transmitter or receiver of net shocks is crucial. Finally, we employ the dynamic spillover index created by Chatziantoniou *et al.* (2021) and Diebold and Yilmaz (2012, 2014). These results might be used to investigate the reasons for changes in the networks connecting various measures.

4.1 Variation in average dynamic connectivity over time

Table 2 shows the average outcomes for the interlinkages of various indicators inside the network using the entire data set from January 1, 2018, to December 31, 2021. The diagonal part of this table describes the change of a single indicator driven by its own shocks. In comparison, the off-diagonal components describe how the instability of this indicator influences that of other indicators (FROM) and how other indicators impact the instability of this indicator (TO). The columns display the independent effects of each type of indicator on one another, whereas Table 2 specifically displays the influence of each indicator on the forecast error variance of each other.

The TCI average value for the entire set of data is 40.95%. It is proven that changes to this network might be responsible for 40.95% of the volatility in the network of indicators under investigation. This shows that idiosyncratic causes cause about 60% of the system's error variation. The contribution of each indicator is displayed in the last row of Table 2. The transmission of shocks and volatility to other system indicators is significantly influenced by ETH, SP500. Many previous studies also reached the same conclusion as our paper, such as Shahzad *et al.* (2021), Sui *et al.* (2022). Moreover, BTC, BNB and LSE are net shock transmitters in the network. In contrast, *JPXGY* is the most susceptible to shocks. It is worth noting that the *JPXGY, SSE, EURONEXT* and *HSKE* absorb the net of shocks in our network. Most cryptocurrencies play a major role in transmitting shocks to the stock market.

Table 2.
Averaged Joint connectedness

	BTC	ETH	BNB	SP500	SSE	EURONEXT	JPXGY	HSKE	LSE	FROM
Panel A: Total										
Whole sample										
BTC	45.10	29.10	19.22	2.77	0.53	0.70	0.90	0.34	1.34	54.90
ETH	28.43	44.15	20.43	2.76	0.59	0.81	1.09	0.82	0.92	55.85
BNB	20.56	22.39	49.14	2.78	0.90	0.96	1.32	0.77	1.19	50.86
SP500	3.46	3.80	3.31	62.64	3.90	5.47	7.77	3.75	5.91	37.36
SSE	1.42	1.61	1.58	5.47	62.45	2.21	1.60	20.48	3.18	37.55
EURONEXT	1.19	1.62	1.47	6.29	2.06	67.40	1.65	3.76	14.56	32.60
JPXGY	1.86	2.54	2.58	11.04	2.37	2.25	72.75	2.28	2.33	27.25
HSKE	0.68	1.47	1.09	6.98	19.68	3.94	2.33	60.22	3.62	39.78
LSE	1.75	1.39	1.63	7.40	2.02	14.31	1.33	2.56	67.60	32.40
To	59.35	63.92	51.32	45.49	32.04	30.63	17.98	34.77	33.05	TCI
NET	4.45	8.07	0.46	8.13	−5.51	−1.97	−9.27	−5.02	0.65	40.95
Panel B: 1–5										
1–5										
BTC	39.11	25.37	16.67	2.40	0.44	0.59	0.79	0.28	1.20	47.75
ETH	25.18	38.55	17.94	2.42	0.50	0.65	0.97	0.65	0.82	49.13
BNB	18.00	19.59	42.54	2.48	0.76	0.79	1.17	0.59	1.04	44.42
SP500	3.20	3.45	3.11	55.40	3.59	4.93	7.09	3.28	5.31	33.96
SSE	1.24	1.32	1.22	4.21	53.94	1.77	1.32	17.32	2.57	30.96
EURONEXT	0.98	1.36	1.21	5.35	1.82	57.90	1.42	3.17	12.74	28.05
JPXGY	1.63	2.19	2.34	9.82	2.16	1.85	62.88	2.04	1.95	23.97
HSKE	0.58	1.15	0.89	5.41	17.31	3.19	1.89	51.96	2.88	33.30
LSE	1.51	1.24	1.44	6.16	1.92	12.46	1.12	2.34	58.78	28.19
To	52.32	55.68	44.81	38.25	28.50	26.22	15.77	29.68	28.51	TCI
NET	4.57	6.54	0.39	4.30	−2.46	−1.84	−8.20	−3.62	0.32	35.53
Panel C: 5-inf										
5-inf										
BTC	5.99	3.73	2.56	0.37	0.09	0.11	0.11	0.05	0.13	7.15
ETH	3.25	5.60	2.49	0.34	0.09	0.16	0.12	0.18	0.10	6.72

(*continued*)

Table 2.

	BTC	ETH	BNB	SP500	SSE	EURONEXT	JPXGY	HSKE	LSE	FROM
BNB	2.56	2.80	6.60	0.30	0.14	0.17	0.15	0.18	0.15	6.44
SP500	0.27	0.35	0.20	7.24	0.31	0.54	0.67	0.47	0.60	3.40
SSE	0.18	0.28	0.36	1.27	8.51	0.44	0.28	3.16	0.61	6.59
EURONEXT	0.22	0.26	0.26	0.94	0.24	9.49	0.23	0.59	1.82	4.55
JPXGY	0.23	0.35	0.24	1.22	0.21	0.40	9.87	0.23	0.39	3.27
HSKE	0.09	0.32	0.20	1.57	2.37	0.75	0.44	8.26	0.74	6.48
LSE	0.24	0.15	0.20	1.23	0.11	1.85	0.21	0.22	8.82	4.22
To	7.03	8.24	6.51	7.24	3.54	4.42	2.21	5.09	4.54	TCI
NET	−0.11	1.52	0.07	3.84	−3.05	−0.13	−1.07	−1.39	0.32	5.42

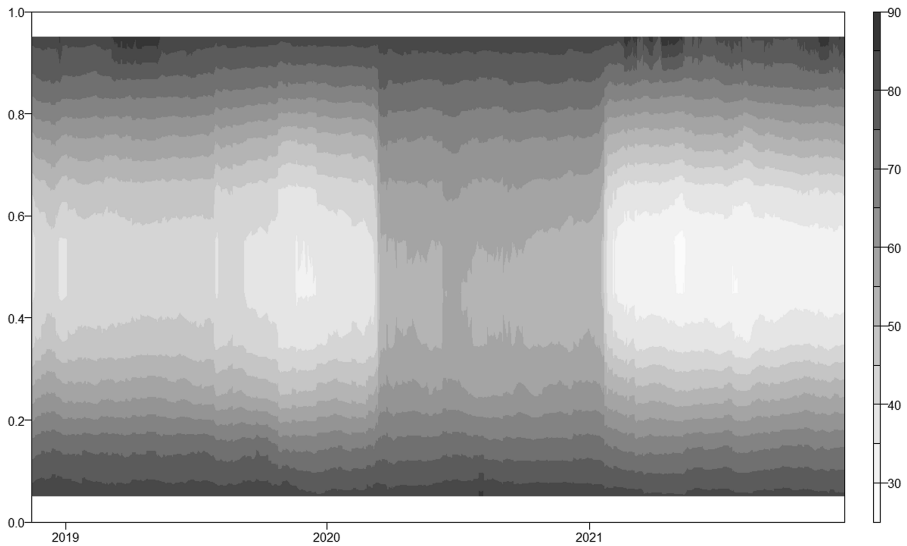
Note(s): Results are based on a QVAR model with a lag length of order one (Bayesian Information Criterion (BIC)) and a 20-step-ahead generalized forecast error variance decomposition. Panel B and C are the results of the fluctuation in the system's forecast uncertainty in the short run and long run

Source(s): Authors' calculations

This analysis explores the notion that each indicator has a varied role throughout various times by dividing the observational portions into short duration and long duration. The system of all indicators (TCI is 35.53%) can partially explain the short-duration history of the system. Similarly, idiosyncratic effects can account for around 65% of the system's forecast uncertainty fluctuation in the short duration. Long-term, nevertheless, this number has significantly dropped to 5.42%. These findings support the notion that these indicators commonly move in lockstep, especially for short-duration or long-term. *SSE, EURONEXT, JPXGY* and *HSKE* have been net receivers of network shocks in both durations, respectively. On the contrary, *ETH, BNB, SP500* and *LSE* are net transmitters of shocks in both two durations. In the long term, BTC changes from a net transmitter of shocks in short duration to a net receiver of shock. We can empirically show that, except for BTC, the connectedness of cryptocurrency and stock markets in short duration is similar to long duration. Moreover, cryptocurrency helps to describe the erratic nature of the stock markets.

4.2 Dynamic total connectedness

Figure 2 displays the findings for total dynamic connectedness over a quantile. Warmer colors on the graph indicate larger levels of interconnectedness. An intense correlation occurs between changes in the geopolitical risks and the commodities market that are strongly negative and those that are strongly positive (below the 20% quantile and above the 80% quantile). In other words, it appears that the impact is symmetrical. Additionally, 50% is the median quantile of connectedness throughout the whole time. Colors along the vertical axis represent times when there is greater uncertainty across quantiles, indicating a generalized financial and economic crisis. In our situation, it is easy to distinguish between the COVID-19 epidemic. Additionally, we find that market risk is higher since the start of the COVID-19 epidemic when market interconnection dramatically increased across all quantiles. The interconnectedness around the y-axis is interestingly quite symmetric, suggesting that spillovers between very positive and negative returns behave similarly.



Source(s): Authors' calculations

Figure 2.
Dynamic net total directional connectedness over a quantile

The findings about the net spread shocks of each indicator are of great importance in the literature on connectedness. In this particular instance, it carries crucial data for risk managers and investors. The long-duration dynamics are fully accountable for the roles of nine indicators, being a net shock transmitter or receiver, while the short-duration net spread mechanism paints a helpful overview. Our article analyses the net total directional connectedness in both two durations in Figure 3. For BTC, we notice that its role depends on the study period. BTC is a net short-duration shock transmitter during our sample. BTC is a long-duration net receiver of shocks during the 2018–2020 period and turns into a long-duration net receiver of shocks from late 2021. ETH is a net shock transmitter in both durations. BNB turns into a net short-duration shock transmitter during the COVID-19 outbreak before receiving net shocks in 2021. SP500 transmits net shocks in both durations before 2021 and turns into a net short-duration shock receiver from 2021. The role of SP500 in long duration is opposite to short duration from 2021. SSE, HSKE and JPXGY are net receivers in both duration during our sample. Specifically, TCI values of JPXGY and HSKE reach a peak at the beginning of the COVID-19 epidemic. EURONEXT and LSE are net receivers of shocks during the 2018–2020 period before turning to net transmitters of shocks from 2021 in both durations.

Then we focus on net total directional connectedness over a quantile. As illustrated in Figure 4, this. On these graphs, a currency net transmitter is indicated by warmer colors. Figure 4c demonstrates that, among all the indicators, the geopolitical risks index has had the most consistent reaction. The incident between 2020 and 2021 (COVID–19) is significant. BTC and ETH are significant transmitters of shocks all over quantiles during the outbreak of COVID-19. BNB is a net shock transmitter during 2020 in the median quantile, while BNB has almost no impact on the system in other periods. SP500 is a net transmitter of shocks before 2021 and turns into a net shock receiver from 2021 all over quantiles. SSE, HSKE and Japan Exchange Group (JPXGX) are net shock receivers during the COVID-19 outbreak over all quantiles. EURONEXT is a net shock receiver from 2020 all over quantiles and turns into a

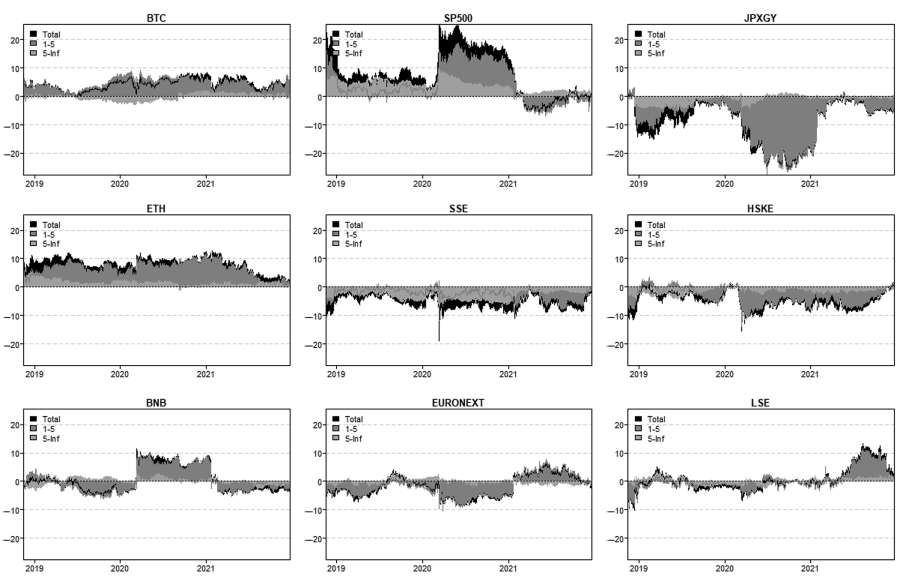
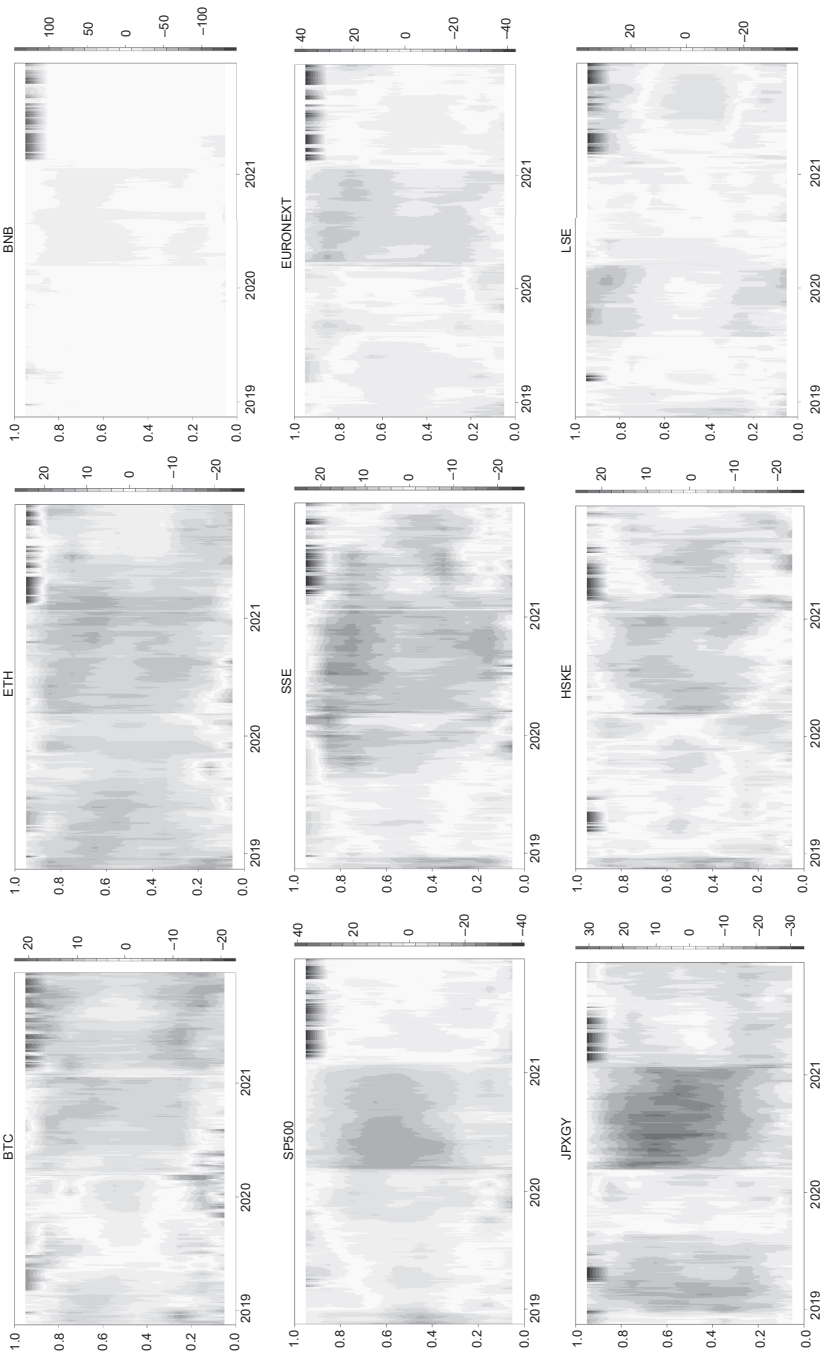


Figure 3.
Dynamic net total directional connectedness: QVAR

Source(s): Authors' calculations



Source(s): Authors' calculations

Figure 4.
Dynamic net total directional connectedness: QVAR

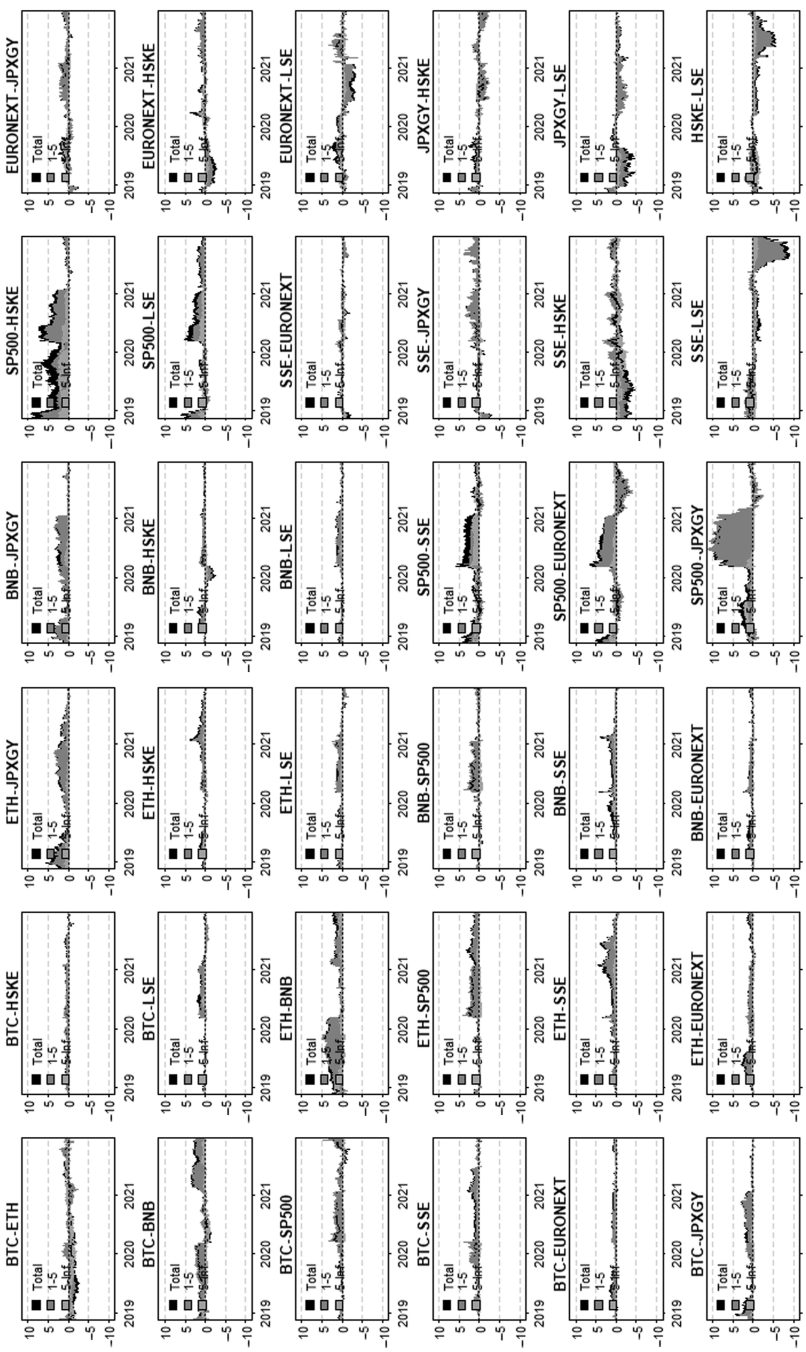
net transmitter of shocks from 2021 below 60% quantile. LSE is a net shock transmitter of shocks during 2020 below the 20% quantile and over 80% quantile.

Finally, to fully comprehend the dynamics of volatility in cryptocurrency and stock markets, we display the pairwise dynamics in Figure 5 and discuss the results in detail. All the stock markets have had an important interaction with cryptocurrency during the COVID-19 outbreak. The short-duration and long-duration net pairwise connectedness emphasize the dominance of cryptocurrency during the COVID-19 outbreak. BTC and ETH dominated SSE, EURONEXT, JPXGY and HSKE during the COVID-19 outbreak in both durations, while the effect of BTC and ETH on these stock markets decreased at the end of our sample. BTC and ETH dominate SP500 for a short duration from 2020, while their role in a long duration is the opposite. BTC and ETH were significant net transmitters of shocks to LSE at the beginning of COVID-19 and turned into net shock receivers in 2021. The domination of ETH is more preponderant than BTC. BNB dominated SSE, EURONEXT, JPXGY and LSE during the COVID-19 outbreak in both durations, while its effect on these stock markets decreased at the end of our sample. BNB dominates SP500 in short duration during the COVID-19 outbreak, while their role in long duration is the opposite. Regarding HSKE, BNB is a net transmitter of shock during our sample except at the beginning of COVID-19. Therefore, it can be indicated that the volatility of the stock markets can be explained by cryptocurrencies, with the impact most severe at the beginning of 2020. The pairwise dynamics between cryptocurrency and stock markets in a short duration are more preponderant than in a long duration. In other words, the dominance of cryptocurrency in a crisis has little impact on stock markets for a long duration. Our results are consistent with the findings in the literature. The growth of some commodity markets has been noted before in conjunction with various financial crises (2007–2009), as indicated by Balcilar *et al.* (2021) and Zhang and Broadstock (2020).

5. Conclusions and policy implications

Our study includes a QVAR framework to measure the network connectedness of nine indicators, including *BTC*, *ETH*, and *BNB*, and six stock indices from the global stock market, including SP500 stock index of the U.S. (*SP500*), *SSE*, *HSKE*, *JPXGY*, Euronext (*EURONEXT*) and *LSE*, in a time-varying manner. We also use the strategy proposed by Baruník and Křehlík (2018), which offers greater flexibility and lets us achieve the net pairwise connectedness measurements. These indicators are among the daily datasets we gathered for this study. Our time series covers from January 1, 2018, to December 31, 2021.

Our findings demonstrate that all the investigated indicators are just marginally related when considering the entire set of data. This research specifically demonstrates the existence of a temporal variation of systemic connectedness driven by the COVID-19 outbreak. According to the dynamic net total directional connectedness, BTC is a net short-duration shock transmitter during our sample period. From 2018 to 2020, BTC was a long-duration net receiver of shocks and became a long-duration net transmitter of shocks in late 2021. In both durations, ETH acts as a shock transmitter. During the COVID-19 outbreak, Binance became a net short-duration shock transmitter before receiving net shocks in 2021. Before 2021, the US stock market transmits shocks of both durations and then becomes a net short-duration shock receiver from 2021. The U.S. stock market plays a different role in the long term than in the short term, beginning in 2021. Stock markets in Asia (including Hong Kong, Japan and Shanghai) are net receivers of both durations during our sample. Stocks in Europe (including Euronext and London) are net recipients of shocks during the period 2018–2020 before becoming net transmitters of shocks from 2021. Following the COVID-19 pandemic shock, pairwise connectedness revealed that cryptocurrencies explained the most severe impact on stock markets at the beginning of 2020.



Source(s): Authors' calculations

Figure 5.
Dynamic net pairwise directional connectedness: cryptocurrency to other indicators

5.1 Theoretical contributions

In our research, we are the first to offer a unique deep explanation of the interconnectedness between these indicators, namely cryptocurrency and stock markets, specifically in chaotic events like the COVID-19 epidemic on the dynamic connectedness over quantile among these indicators. The special method uses the net pairwise connectedness over a quantile estimate spread channels between cryptocurrency and stock markets. We contribute crucial information and warnings about the spread of uncertain occurrences and policies for regulators and investors.

5.2 Practical applications

As a result of the interconnections between the various determinants and their spillover effects, our findings have significant policy repercussions for investors and authorities. We also provide suggestions based on these interactions. By being well-informed about the primary sources of the spillovers between cryptocurrency and stock markets, policymakers can develop the most effective policies to lessen the vulnerabilities of these indicators and minimize how widely the market is exposed to risk or uncertainty. By showing the substantial linkages between nine variables, our findings indicate the risk of either insufficient or excessive variety in evaluations of authorities. Our analysis draws attention to the rising relationships between unanticipated and wildly unpredictable events, such as the COVID-19 outbreak. Our research suggests that cryptocurrency promotes the volatility of stock markets since a shock to one typical indication impacts the entire network. Additionally, it is meant that crises like the COVID-19 outbreak will affect cryptocurrency movements and stock markets in the short duration with little impact on their trend in the long duration. Clarifying the connectedness between cryptocurrency and stock markets in short and long duration enables the authorities to establish policies to stabilize cryptocurrency and stock markets. The results of this study may also benefit politicians in improving social welfare, which is directly influenced by cryptocurrency and stock markets. In order to promote the welfare of society, it is crucial to incorporate them while creating policies for disadvantaged groups.

5.3 Limitations and directions for future research

The outcomes of the research still have three limitations. Prior to all else, it is important to highlight that we cannot find any general principle or pattern that applies to all cases on how risk occurrences impact total, net or pairwise spillovers over a quantile. Second, the extent of the spread is significant from the standpoint of indicator association. If the spread is large, changes and shocks brought on by other indicators will majorly influence a particular market system. The government must take a variety of steps to lessen the negative consequences of outside shocks. Authorities should concentrate on frequency-specific danger sources. In the integration of global regulatory guidelines for different metrics, more focus should be made on reducing the negative consequences of long-duration fluctuation spread and short-duration return spread. Last but not least, considering that many researchers consider the spillover influence across several metrics, evaluating the portfolio advantages of diversity is a substantial extension. In the meanwhile, we placed it on the back burner.

Note

1. Because the recovered results are entirely independent of the variable ordering, the GFEVD is preferable to its orthogonal equivalent. Furthermore, Wiesen *et al.* (2018) emphasize that the GFEVD is able to be used in the absence of a theoretical framework that would make it possible to detect the error pattern.

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Are gold and cryptocurrency a safe haven for stocks and bonds? Conventional vs Islamic markets during the COVID-19 pandemic

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Abstract

Purpose – This study aims to identify the ability of gold and cryptocurrency (Cryptocurrency Uncertainty Index (UCRY) Price) as safe haven assets (SHA) for stocks and bonds in both conventional (i.e. stock indices and government bonds) and Islamic markets (i.e. Islamic stock indices and Islamic bonds (IB)).

Design/methodology/approach – The authors employed the nonadditive panel quantile regression model by Powell (2016). It measured the safe haven characteristics of gold and UCRY Price for stock indices, government bonds, Islamic stocks, and IB under gold circumstances and level of cryptocurrency uncertainty, respectively. The period spanned from 11 March 2020 to 31 December 2021.

Findings – This study discovered three findings, including: (1) gold is a strong safe haven for stocks and bonds in conventional and Islamic markets under bearish conditions; (2) UCRY Price is a strong safe haven for conventional stocks and bonds but only a weak safe haven for Islamic stocks under high crypto uncertainty; and (3) gold offers a safe haven in both emerging and developed countries, while UCRY Price provides a better safe haven in developed than in emerging countries.

Practical implications – Gold always wins big for safe haven properties during unstable economy. It can also win over investors who consider shariah compliant products. Therefore, it should be included in an investor's portfolio. Meanwhile, cryptocurrencies are more common for developed countries. Thus, the governments and regulators of emerging countries need to provide more guidance around cryptocurrency so that the societies have better literacy. On top of that, the investors can consider crypto to mitigate risks but with limited safe haven functions.

Originality/value – The originality aspects of this study include: (1) four chosen assets from conventional and Islamic markets altogether (i.e. stock indices, government bonds, Islamic stock indices and IB); (2) indicator countries selected based on the most used and owned cryptocurrencies for the SHA study; and (3) the utilization of UCRY Price as a crypto indicator and a further examination of the SHA study toward four financial assets.

Keywords Conventional assets, Cryptocurrency, Gold, Islamic assets, Safe haven, UCRY price

Paper type Research paper

1. Introduction

The beginning of the COVID-19 pandemic in 2020 was reported as the highest recorded instance of global uncertainty based on the world uncertainty index (WUI) (Ahir *et al.*, 2022). Hence, risk aversion continues to have a significant influence on investors in seeking safe haven assets (SHA) (Aharon *et al.*, 2021) due to infectious diseases (Ali *et al.*, 2022). SHAs move in the opposite direction of other assets in times of a market crisis (Shahzad *et al.*, 2019a).

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In that case, investors take a long position on SHAs when uncertainty increases to preserve their wealth (Kaul and Sapp, 2006).

Gold is still the most popular and most used SHA. It is proven by the average annual prices for gold worldwide from 2015 to 2021, which increased from United States (US)$ 1,161 to 1,795 (per troy ounce) [1]. Even before the COVID-19 pandemic, gold was found to be a SHA against conventional stocks and/or bonds (Baur and Lucey, 2010; Baur and Mcdermott, 2010; Lucey and Li, 2015; Li and Lucey, 2017; Shahzad *et al.*, 2019a, 2020). Yet a very limited study of gold as a SHA against Islamic stock markets (Tirosh and Barkai, 2007; Chkili, 2017). Meanwhile, during the COVID-19 pandemic, most of the literature examined and confirmed gold as a SHA against conventional stock indices (Akhtaruzzaman *et al.*, 2021; AlAli, 2020; Kristoufek, 2020; Chemkha *et al.*, 2021; Lahiani *et al.*, 2021; Esparcia *et al.*, 2022).

Based on the above studies, gold has clearly been a favorable SHA throughout history. However, attention from gold has shifted to cryptocurrency. Bitcoin, the most popular digital cryptocurrency, is claimed to be "digital gold" (Disli *et al.*, 2021; Koutmos *et al.*, 2021). Cryptocurrencies have similar hedging and safe haven characteristics to gold (Antonakakis *et al.*, 2019; Shahzad *et al.*, 2019a). Before the COVID-19 pandemic, the studies only focused on Bitcoin which served as a safe haven against conventional stock indices (Kang *et al.*, 2020; Shahzad *et al.*, 2019a; Stensås *et al.*, 2019). It was further studied during the COVID-19 pandemic by investigating more cryptocurrencies (i.e. Bitcoin and Ethereum) and revealed SHA properties against conventional stock indices (Mariana *et al.*, 2021). Będowska-Sójka and Kliber (2021) conducted a comprehensive study and the results revealed that gold serves as a strong SHA, while Bitcoin and Ether have weak SHA properties against conventional stock indices. Disli *et al.* (2021) also investigated both gold and Bitcoin, but against Islamic equity indices, it was revealed that gold and Bitcoin do not possess safe-haven properties.

Notably, we identified that studies on investments which rely on Islamic faith are scarce, while this study has attracted scholars during a subprime crisis (Umar and Gubareva, 2021). It interests more investors' attention because of the ethical and social responsible features and can be highly considered by both conventional and faith-based investors (Umar *et al.*, 2022a). Regarding the prior works above, we discovered several research gaps, including: (1) there is a dearth of SHA studies on conventional and Islamic bonds (IB) during the COVID-19 pandemic for both gold and cryptocurrency; (2) there are no SHA studies of cryptocurrency against Islamic stock indices during the COVID-19 pandemic; (3) most of the prior works were benchmarking to big stock markets and world-wide indices; and (4) the studies utilized price or return as the cryptocurrency indicator and only focused on the top two cryptocurrencies (i.e. Bitcoin and Ethereum).

Recently introduced by Lucey *et al.* (2021), the Cryptocurrency Uncertainty Index (UCRY) (UCRY Price) measured the size of unpredictable moves in the price of cryptocurrency. Bitcoin – the leading cryptocurrency – experienced an approximate 500% price hike since COVID-19 was declared as a pandemic [2]. However, it also could broadly decline by 30% in an hour [3]. Therefore, we conjecture that the UCRY price is an effective indicator of cryptocurrency volatility in determining SHAs when markets were in turmoil due to the COVID-19 pandemic. To our knowledge, there were only two recent studies discussing SHA by utilizing UCRY Price (Hassan *et al.*, 2021; Karim *et al.*, 2022).

Therefore, our study fills the research gap by contributing to the literature in threefold: (1) it covers four financial assets at once from both conventional and Islamic markets (i.e. stock indices, government bonds, Islamic stocks and IB); it provides better and more comprehensive portfolio investment strategies for investors, especially during market turbulence; (2) it takes a panel setting (i.e. countries' level over a period); of a SHA study for gold and cryptocurrency which are categorized as the highest cryptocurrency owners and users based on a Statista Global Consumer Survey [4]; hence, it represents a more reliable

depiction of the cryptocurrency market; and (3) it uses UCRY price as the crypto indicator and further examines the SHA properties of those four financial assets.

The rest of the paper is structured as follows. Section 2 provides the literature review. Section 3 describes the data and explains the research methodology. Section 4 presents and discusses the results. Section 5 presents the conclusion and recommendations.

2. Literature review

2.1 Conventional and Islamic markets

The conventional market disregards the "halal-haram" aspects [5] and does not align with the principles of *Shariah* or Islamic law. It uses the concept of interest containing usury, and speculative/manipulative transactions (Nurhayadi and Rito, 2019). Contrarily, the Islamic market follows the principles of *Shariah* or Islamic law, prohibiting the "halal-haram" aspects. It also applies asset-backed security and equity participation and limitations of investments on assets that are in accordance with Islamic law (Jawadi *et al.*, 2014).

2.2 The theory of safe haven assets

Markowitz (1952) pioneered the modern portfolio theory with the aim to create the most efficient portfolio possible reducing volatility and the risk of losses by choosing assets that are negatively correlated. Conceptually, a SHA is negatively correlated with another asset under extreme market pressure (Baur and Lucey, 2010). Therefore, investors tend to seek SHAs to minimize losses during critical periods such as the COVID-19 pandemic (Akhtaruzzaman *et al.*, 2021; AlAli, 2020; Haddad and Trabelsi, 2021). As a safe haven, an asset must hold its value during market turbulence to limit its exposure to extreme losses (Disli *et al.*, 2021). Apart from being a safe haven, an asset also can be a hedge if it is negatively correlated with another asset on average and a diversifier if it shows a positively correlation to another asset (Kliber *et al.*, 2019).

2.3 Gold as a safe haven asset

Gold has been considered as the most dependable SHA throughout history. For example, before the COVID-19 pandemic, gold was a SHA for the US, the United Kingdom (UK) and German stock indices but not a SHA for bonds in any market based on the GARCH (Generalized AutoRegressive Conditional Heteroskedasticity) model (Baur and Lucey, 2010). Using the cross-quantilogram, this depicted gold as a weak SHA in developed and emerging stock markets (Shahzad *et al.*, 2019a). Based on the MGARCH DCC (Multivariate GARCH Dynamic Conditional Correlation) model, gold performs as a SHA against the US stocks and bonds during most economic crisis events (Lucey and Li, 2015). Using an OLS (Ordinary Least Square) regression resulted in gold acting as a SHA for stocks (the US, the UK, Germany, Italy, Japan and India) and bonds (the UK, France, Italy and Canada) (Li and Lucey, 2017). The Islamic market was examined using the Markov switching approach and suggested gold as a SHA against the Islamic stock market at high volatility (Chkili, 2017). Another study also using the MGARCH DCC model found that gold is a SHA for Shariah-compliant equities (Tirosh and Barkai, 2007). Contrarily, a revisited study using the novel VAR (vector autoregressive) for the value at risk (VaR) approach and the cross-quantilogram method revealed that gold does not act as a SHA for the G7 stock and bond markets (Shahzad *et al.*, 2019b).

Gold has always been a superior SHA during periods of economic uncertainty and crisis (Hasan *et al.*, 2021; Huang and Chang, 2021; Ji *et al.*, 2020; Liu, 2020). The existing studies have scrutinized the role of gold as a SHA using the DCC GARCH model during two distinct phases of the COVID-19 pandemic. It was found that gold was a SHA for stock indices (i.e. S&P500, equity indices of the Eurozone (EURO) STOXX50, Nikkei225 and China FTSEA50) in Phase I (31 December 2019 to 16 March 2020), but it lost its SHA potential in Phase

II (17 March to 24 April 2020) (Akhtaruzzaman *et al.*, 2021). Moreover, using an OLS regression, gold was a SHA for the S&P 500, Shanghai SE, Nikkei 225, Germany stock index (DAX), Australia stock index (ASX) and UK stock exchange (FTSE) 100 over the period of 12 February to 9 April 2020 (AlAli, 2020). Another result applied an A-DCC model and found that gold served as a weak SHA for the S&P 500, EURO STOXX 50 and FTSE 100, except for the Nikkei 225 (Chemkha *et al.*, 2021). Another finding by applying an nonlinear ARDL (autoregressive distributed lag) (NARDL) model has confirmed gold as a SHA against the S&P 500 during the COVID-19 pandemic period (31 December 2019 to 25 June 2021) (Lahiani *et al.*, 2021). By scrutinizing several methodologies (i.e. VaR, wavelet methods and performance assessment), indeed, gold was remarkable as a safe haven property during a recession (Esparcia *et al.*, 2022). An opposite finding using a wavelet coherence analysis found that gold did not exhibit safe haven characteristics against Islamic equity indices during the COVID-19 crisis (Disli *et al.*, 2021). Additionally, new findings using the DCC-Multivariate Stochastic Volatility (MSV) model revealed that gold did not act as a SHA against several indices (i.e. S&P 500, DAX, STOXX 600 and FTSE 250) during the COVID-19 outbreak (Będowska-Sójka and Kliber, 2021).

2.4 Cryptocurrency as a safe haven asset

The emergence of Bitcoin, as the first and largest cryptocurrency, has shifted investors' attention (Bouri *et al.*, 2020; Shahzad *et al.*, 2020). Recently, researchers have started to question whether cryptocurrency (i.e. Bitcoin and Ethereum) is a better SHA than gold (AlAli, 2020; Kristoufek, 2020; Będowska-Sójka and Kliber, 2021; Chemkha *et al.*, 2021; Disli *et al.*, 2021). Before the COVID-19 pandemic, by using a Dynamic Equicorrelation Fractionally Integrated GARCH (DECO-FIGARCH) model, Bitcoin was an effective SHA for the case of the stock market (S&P 500) (Kang *et al.*, 2020). Moreover, by addressing a cross-quantilogram approach from 19 July 2010 to 22 February 2018, Bitcoin was a weak SHA for China stock indices (Shahzad *et al.*, 2019a).

Meanwhile, during the COVID-19 pandemic, cryptocurrency was claimed to be a SHA against several stock indices (i.e. S&P 500, DAX, FTSE 250 and STOXX 600). Using the DCC-MSV model, cryptocurrencies can be considered as SHAs occasionally; (1) Ether SHA against DAX, and S&P 500, and (2) Bitcoin SHA against FTSE 250, STOXX 600, and S&P 500 (Będowska-Sójka and Kliber, 2021). Another finding using the DCC model showed that Ethereum was a SHA against the S&P 500 from 1 July 2019 to 6 April 2020 (Mariana *et al.*, 2021). In contrast, during the COVID-19 pandemic, opposite findings using wavelet coherence revealed that Bitcoin was not a SHA against Islamic equity indices (Disli *et al.*, 2021). Apart from this, similar findings using a DCC model claimed that Bitcoin was not a safe haven property (Lavelle *et al.*, 2022). In addition, Bitcoin did not act as a SHA against the S&P 500 (Conlon and McGee, 2020). Also, a study focused on VaR, conditional value at risk (CVaR), modified value-at-risk (MVaR) and modified CVaR (MCVaR) showed that Bitcoin and Ethereum did not act as a SHA for international equity markets (Conlon *et al.*, 2020).

3. Data and methodology

3.1 Data and sources

This study selected 10 out of 56 countries who owned and used the most cryptocurrencies for the independent variables (i.e. Stock Indices (SI), Government Bonds (GB) and Islamic Stock (IS)) as there was an unavailability of data as detailed in Table 1. Meanwhile, we employed

No	Criteria	Countries
1	Countries with the most used and owned cryptocurrencies	56
2	Countries with unavailable data of Islamic stocks	46
	Countries selected as the sample of this research	10

Table 1.
Selection countries

global data for IB (i.e. Dow Jones Sukuk World) (see Table A1). The conventional stock indices and government bond variables were proxied as the most common financial assets. For the Islamic stocks and bonds variables, they were also chosen as they were suggested to be invested along with cryptocurrency (Rehman *et al.*, 2020) in addition to functioning well during the COVID-19 pandemic (Nomran and Haron, 2021).The first declaration of COVID-19 as a global pandemic was announced by WHO (2020) on 11 March 2020. Therefore, the period of work spanned from 11 March 2020 to 31 December 2021 (i.e. until the paper being studied). Considering the availability of data, we used the weekly frequency prices for all variables. The asset prices used in this study were either given in United States dollar (USD) or converted to USD using applicable exchange rates. Thus, these prices were calculated into the return series $((p_1 - p_0)/p_0)$. As seen in Table 2, it portrays the overview of variables and descriptive statistics.

3.2 Quantile regression for panel data

Referring to prior works of safe haven studies (Jareño *et al.*, 2020; Kang *et al.*, 2020; Liu, 2020; Hasan *et al.*, 2021; Mokni *et al.*, 2021), we employed a panel quantile regression model to estimate between market and SHA assets. The panel quantile regression method has advantages to examine the various responses of the dependent variable to changes in the independent variables using their various quantiles instead of focusing on the mean effect (Cepoi, 2020; Khalid *et al.*, 2021; Liu, 2020) and is more robust when outliers and fat tails exist (Huang *et al.*, 2017; Jareño *et al.*, 2020). Therefore, the underlying model of the panel quantile regression is:

$$Q_{y_{i,t}}(\tau | x_{i,t}) = \alpha_i + x_{i,t}^T \beta(\tau), \tag{1}$$

Most quantile panel data estimators by Galvao (2011), Koenker (2004), and Ponomareva (2011) include the additive fixed effect (α_i). They provide estimates about the distribution of $(Y_{it} - \alpha_i)$ given $\boldsymbol{D}_{it}$ instead of Y_{it} given $\boldsymbol{D}_{it}$. According to Powell (2016), it is undesirable in many empirical studies because observations close to the top of $(Y_{it} - \alpha_i)$ distribution may be close to the bottom of the Y_{it}. In other words, the additive fixed effect model only shows information about the effect of the policy on the outcome relative to the fixed effect distribution because the disturbance term has been separated.

Hence, Powell (2016) proposed a panel quantile regressions estimator with the nonadditive fixed effect to uphold the nonseparable disturbance term linked with the quantile estimation that may be interpreted similarly to those obtained from a cross-section regression. The equation is as follows

$$Y_{i,t} = D'_{i,t}\beta U^*_{i,t} \text{ with } U^*_{i,t} \sim U(0,1), \tag{2}$$

where $D'_{i,t}\beta(\tau)$ is strictly escalating in quantile τ, and $U^*_{i,t}$ serve as the function of the disturbance term and proneness for the outcome (Doksum, 2007). In equation (2),

Variable	Obs	Mean	Std. Dev	Min	Max	CD-test	CADF	Westerlund
Gold	950	0.002	0.0236	−0.0587	0.1063	65.3835***	309.6210***	−2.3524***
UCRY Price	950	0.0003	0.0125	−0.0322	0.0401	65.3835***	355.9230***	−3.4083***
SI	950	0.0035	0.0333	−0.2072	0.2019	33.8250***	304.0610***	
GB	950	−0.0008	0.0178	−0.1624	0.1413	14.4747***	218.5160***	
IS	950	0.0038	0.0343	−0.2135	0.1773	25.9048***	297.9690***	
IB	950	0.0006	0.0062	−0.0677	0.0457	49.3389***	173.6580***	

Table 2. Summary statistics, cross section dependency, panel unit root and Westerlund tests

Note(s): Data for Gold, SI, GB, IS, and IB are from www.investing.com, while UCRY price from https://brianmlucey.wordpress.com/; *** stands for 1% level of significance

the structural quantile function (SQF) outlines the quantile outcome variable $Y_d = d'\beta(U^*)$ for randomly selected $U^* \sim U(0,1)$. This SQF is similar to Chernozhukov and Hansen's (2008) terminology which can be illustrated by the following specification:

$$S_Y(\tau|d) = d'\beta(\tau) \text{ with } \tau \in (0,1), \quad (3)$$

Consequently, this study designates the panel quantile regression to estimate the response of Gold and UCRY Price against SI, GB, IS and IB under the different market conditions and uncertainties. Thus, the enhancement of equation (1) becomes:

$$(Gold|UCRY\ Price)_{i,t}(\tau|\alpha_i, \delta_i, x_{i,t}) = \alpha_i + \delta_i + \beta_{1,\tau}SI_{i,t} + \beta_{2,\tau}GB_{i,t} + \beta_{3,\tau}IS_{i,t} + \beta_{4,\tau}IB_{i,t}, \quad (4)$$

where α_i signifies "the non-adaptive fixed effects" and $x_{i,t}$ signifies the matrix of the regressors at individual countries i and time t.

Considering the quantile, we followed previous research (Das *et al.*, 2020; Zhu *et al.*, 2020) and classify them into three phases: lower (5%–25%), middle (50%) and upper (75%–95%) quantiles. As for gold, it represents the bearish, normal and bullish markets, respectively (Das *et al.*, 2020). A negative significant (insignificant) coefficient signifies (1) a strong (weak) safe haven under bearish, (2) a strong (weak) hedge under normal and bullish condition. A positive coefficient signifies a diversifier. Meanwhile, it represents low, normal and high uncertainty, respectively for UCRY Price (Hasan *et al.*, 2021). Therefore, it has a reverse meaning to gold circumstances. A positive significant (insignificant) coefficient signifies (1) a strong (weak) safe haven under high uncertainty, (2) a strong (weak) hedge under low and normal uncertainty. A negative coefficient signifies a diversifier. This will be able to study the heterogeneous responses of gold return and UCRY Price uncertainty to changes in SI, GB, IS and IB at diverse points of the conditional distribution of Gold and UCRY Price.

Accordingly, the implementation of the panel quantile regression approach required that first we applied the cross-section dependency test based on Pesaran (2004) to ensure that there was cross-sectional dependency. Second, we checked the panel unit root test following Pesaran (2007) for each variable whether they were stationary at the level or first difference. Third, we estimated the cointegration test to identify the long-run relationship among the variables using a Westerlund (2005) test. Overall, the three required tests indicated there was cross-section dependency within the data sets across the countries, the unit root was not present on all of the variables, and both panels (i.e. gold and UCRY Price), showing that the variables had a long-run relationship (see Table 2). Finally, we ran the panel quantile regression using the nonadditive fixed effect model of Powell (2016) to analyze the potential SHA, especially during a bearish market (lower quantile) and high uncertainty (upper quantile) for gold and UCRY price, respectively.

4. Results and discussion

4.1 Panel quantile regression results

4.1.1 Results on gold. In referring to Table 3, we found negative gold coefficients to SI in all market conditions (5%–95%) but these were not significant under bearish (5%) and bullish (90%) markets. This signifies that gold offered a strong safe haven in bearish conditions (10% and 25%) and a weak safe haven in extremely bearish conditions (5%), while there was a strong hedge on normal and bull markets (50%, 75% and 95%). This confirmed Baur and Lucey's (2010) results. The coefficient of gold was significantly negative under bearish (5% and 10%) markets that proved a strong safe haven for GB. It was consistent with the results of Lucey and Li (2015). Meanwhile, there was a strong hedge under a bullish (90%) market. Besides that, it could function as a diversifier on average, reflecting positive results under distinct conditions (i.e. bear: 25%; normal: 50%; bull: 75% and 95%).

Table 3.
Panel quantile result of gold and UCRY price

	DV: Gold				DV: UCRY price			
Quantiles	SI	GB	IS	IB	SI	GB	IS	IB
0.05	−0.0001	*−0.0854****	*−0.0039****	*−0.4539****	−0.0594***	−0.0674***	0.0542***	0.4817***
0.1	*−0.1305****	*−0.1238****	0.0659***	−0.0843	−0.8872***	−0.0252***	0.071***	0.5561***
0.25	*−0.3187****	0.0685***	0.1830***	0.5262***	−0.0310***	0.0503***	0.0050***	0.3082***
0.5	−0.1997***	0.0063***	0.1853***	0.1036***	0.0024***	0.0093***	−0.0017***	0.0069**
0.75	−0.2736***	0.0031***	0.2417***	0.1951***	*0.0010****	*0.0003****	−0.0019***	−0.1663***
0.9	−1.1085	−0.0798**	0.902	−0.9777**	0.0191	−0.3842	0.0094	−0.3189**
0.95	−0.8001***	0.2613***	0.6311***	−0.6864***	0.0552	−0.1098	−0.2058	−0.8272***

Note(s): ***, ** stands for 1% and 5% level of significance; The significance in italics implied safe haven assets

For IS, it was found that gold outlines a negative significant coefficient in an extremely bearish (5%) market. Other conditions showed positive significant coefficients, excluding the bullish (90%) market. This implied that gold acted as a safe haven and diversifier against IS as found earlier by Chkili (2017) and Raza *et al.* (2016), respectively. As for IB, gold was negative and significant under bearish (5%) and bullish (90% and 95%) markets. It implied that gold could be a safe haven for IB in market crises and a hedge on average. Gold was also presented as a diversifier to IB during the various gold market conditions (25%, 50% and 75%), as evidenced by Maghyereh *et al.* (2019).

4.1.2 Results of the UCRY price. Based on Table 3, UCRY price exhibited positive coefficients to SI from normal (50%) to high (75%–95%) uncertainty. UCRY Price could act as a strong hedge during normal times. It also could be a strong (weak) safe haven against SI under high (extreme high) crypto uncertainty, confirming the findings of Mariana *et al.* (2021). Furthermore, we found that UCRY Price had a negative significant coefficient at low (5%–25%) uncertainty, acting as a diversifier against stock indices which was similar to Kristoufek (2020). Regarding the UCRY price-GB relationship, it was likely to be a positive and significant coefficient under various cryptocurrency levels (i.e. low: 25%; normal: 50% and high: 75%). This suggested that UCRY Price could function as a safe haven for GB during high uncertainty. It was also in line with Mokni *et al.* (2021), in which the cryptocurrency also offered a hedge on average. Moreover, the linkage was negative when uncertainty was low (5% and 10%) and high (90% and 95%) implying cryptocurrency could act as a diversifier as it moved in the same direction as bonds (Baur *et al.*, 2018).

In the case of IS, UCRY price had a positive coefficient under low (5%–25%) and high (90%) uncertainty. Thus, the results corroborated Chkili *et al.* (2021) who showed that Bitcoin offered a strong hedge on average and could perform as a weak safe haven at high uncertainty. Additionally, UCRY price revealed a negatively significant coefficient to IS at normal (50%) and high (75%) uncertainty, suggesting cryptocurrency could function as a good diversifier against IS. If we considered the coefficients of UCRY Price to IB, we noted significance at all levels of uncertainty. Meanwhile, it was positive on lower (5%–25%) to normal (50%) uncertainty while negative in high (75%–95%) uncertainty. The coefficient also decreased as UCRY Price moved from low to high uncertainty. This finding exhibited that UCRY price served as a strong hedge on average instead of being a SHA against IB, confirming the results of Mensi *et al.* (2020).

4.2 Robustness analysis

We estimated the results for (1) different periods by separating the full sample into two subsample periods: 2020 and 2021 (2) different country categories for emerging (i.e. Nigeria, Thailand, Indonesia, Malaysia, India and China), and developed countries (i.e. United States, Canada, Taiwan and Japan) [6], and (3) the utilization of CRYPTO CURRENCIES INDEX 30 (CCI30) index to examine whether or not the results changed compared to UCRY Price.

4.2.1 Results of different periods. In the case of Gold, it was consistent with the full sample result (see Table 4). Specifically, it was negative to SI, GB, IS and IB in the bearish market in 2020, denoting a SHA characteristic. However, the dependence of gold and GB in 2021 has changed as it does not show any safe haven characteristics. As for UCRY Price, it had a positive and significant coefficient to GB and SI under high cryptocurrency uncertainty both in 2020 and 2021 (see Table 5). Meanwhile, we found UCRY Price also provided a SHA to IS in 2020 by exhibiting a positive coefficient. This confirmed the above results which offered a potential safe haven role.

4.2.2 Results of different country categories. Gold behaved negatively toward SI, GB, IS, and IB during the downside conditions of emerging countries which pointed it out as a SHA (see Table 6). This was contrary to Baur and Mcdermott's (2010) findings, who found a minor

Table 4.
Results of gold in 2020 and 2021

	2020				2021			
Quantiles	SI	GB	IS	IB	SI	GB	IS	IB
0.05	*−0.1637****	*−0.1736****	0.0772***	0.0051***	*−0.0019****	0.0843***	0.0084***	*−2.2011****
0.1	*−0.0549***	*−0.0726****	*−0.0219****	*−0.1044****	−7.497	5.2484	4.0636	5.954
0.25	*−0.2895****	*−0.0204****	0.1393***	1.1285***	0.0017	0.1071***	*−0.0069****	0.5875***
0.5	−0.3588***	0.0019	0.2864***	−0.0533***	0.0874***	0.0501***	0.0018	−0.9891**
0.75	−0.1198***	−0.2450***	0.0737***	−1.8785***	−0.0095***	0.0338***	−0.0070***	1.2900***
0.9	−37.3179	−7.1728	27.4871	−59.1972	−0.0078***	0.0446***	−0.0640***	1.0366***
0.95	−0.2070***	−0.2675***	0.1828***	−0.2743***	−1.1718	0.9815	3.8437	−20.5905

Note(s): ***, **stands for 1% and 5% level of significance; The significance in italics implied safe haven assets

	2020				2021			
Quantiles	SI	GB	IS	IB	SI	GB	IS	IB
0.05	−0.0214***	0.0247***	−0.0014***	0.0787***	−0.0135***	−0.1055***	−0.0569***	0.6862***
0.1	−0.0024***	0.0067***	−0.0006***	0.0278***	−0.9155**	−0.1119**	0.0149	0.6820
0.25	0.0005***	0.0021***	−0.0003***	0.0588***	−0.0809***	−0.0350***	0.0152***	0.1599***
0.5	−0.0214***	−0.0006	−0.0014***	0.0787***	−0.0393***	−0.0255***	−0.0066***	0.2802***
0.75	−0.0009***	*0.0009***	*0.0003***	−0.1917***	−0.0062***	−0.0035***	−0.0020***	−0.6926***
0.9	*0.0063***	*0.0128***	*0.0047***	−0.1752***	*0.0647***	−0.1610***	−0.0032	−4.6093***
0.95	*0.0313***	*0.0119***	0.0006	−0.2416***	*0.1379***	*0.5275***	−0.0524***	−4.4943***

Note(s): ***, ** stands for 1% and 5% level of significance; The significance in italics implied safe haven assets

Table 5.
Results of UCRY price in 2020 and 2021

Table 6.
Results of gold in emerging and developed countries

	Emerging				Developed			
Quantiles	SI	GB	IS	IB	SI	GB	IS	IB
0.05	0.0049***	0.0447***	*−0.0416****	*−0.4198****	*−0.0251****	*−0.3755****	0.1577***	*−0.8651****
0.1	*−0.0178****	*−0.0185****	*−0.0473****	*−0.0428****	*−0.1255****	*−0.1341****	0.0548***	0.8777***
0.25	*−0.0685****	*−0.0056****	*−0.0190****	0.6779***	*−1.3250****	0.1306***	0.1739***	1.0561***
0.5	−1.2582	0.4952	1.478	0.6771	−0.3444	0.0478	0.3001	0.6738
0.75	−0.2569***	−0.0004	0.2325***	0.2956***	−0.2561***	−0.1953***	0.1745***	0.0982***
0.9	0.4540***	−0.0484***	0.4410***	−1.0211***	−0.1355***	−0.3808***	0.0963***	−1.2963***
0.95	−0.5574	0.0483	0.4352	−2.1872***	−0.0529***	−0.1735***	0.1230***	−2.0225***

Note(s): ***, **stands for 1% and 5% level of significance; The significance in italics implied safe haven assets

SHA ability of Gold in emerging markets. Gold also acted as a SHA to SI, GB and IB except for IS in developed countries. We determined that UCRY Price reacted positively under high uncertainty (1) to SI in emerging and developed countries, and (2) to GB, IS and IB in developed countries (see Table 7). However, it performed as a strong (weak) safe haven for SI in emerging (developed) countries. This denoted that UCRY Price could only offer a better SHA to GB, IS and IB in the developed countries compared with emerging countries during uncertain times.

4.2.3 Results of the CCI30 index. Compared to UCRY price, we employed the CCI30 index as another representative of the cryptocurrency market (Rivin and Scevola, 2017). It represents the growth as well as daily and long-term movement of the blockchain sector [7]. This index has also been utilized in prior works (Jalal *et al.*, 2020; Dutta and Bouri, 2022; Vidal-Tomás, 2022). The results exhibited that the CCI30 index performed negatively significant to GB under a bearish condition, implying it as a SHA (see Table 8) which is in line with the UCRY price results, but contrary with Lavelle *et al.* (2022). For the rest of the results under a low quantile (i.e. bearish), it only showed crypto as a diversifier.

4.3 Discussion

Our findings consisted of gold and UCRY price results. Gold was a SHA against stocks and bonds for conventional and Islamic markets during the COVID-19 pandemic because risk-averse investors prefer gold in their portfolios. This was predictable because gold has maintained its value throughout various critical times. Uncertain times triggered gold demand and hence price increase since more investors would be searching for safer options (Gubareva *et al.*, 2022).

For UCRY Price, we discovered that cryptocurrency can serve as a strong (weak) SHA for conventional stocks and bonds (Islamic stocks) under high crypto uncertainty. The beginning of the COVID-19 pandemic caused lower returns or even losses to most conventional assets (Nomran and Haron, 2021) and Islamic stocks (Chkili *et al.*, 2021). Meanwhile, the pandemic also impacted cryptocurrency to gain positive media attention. Positive sentiment toward the crypto market increased crypto prices (Gurdgiev and O'Loughlin, 2020). Thus, if the assets decreased in price under high uncertainty, investors could get a higher return from cryptocurrency to cover their losses. Moreover, UCRY Price qualified to serve as a weak SHA for Islamic stocks during the high uncertainty of crypto states.

Our robustness check confirmed that both gold and UCRY Price could serve more potential SHA characteristics during the pandemic in 2020 than 2021. Notably, the world faced the greatest economic damage in the year 2020 at a time which plunged most countries into a recession due to the spread of the COVID-19 pandemic [8]. UCRY price faded in its ability as a SHA in 2021 as the global economy started to recover. Additionally, we inferred gold could be used as a SHA for conventional and Islamic markets in both emerging and developed countries as proven earlier by Baur and Mcdermott (2010). Historically, gold is the most trustable asset for world-wide investors in times of a crisis. Next, UCRY price had more potential to be a SHA for conventional (i.e. GB) and Islamic markets (i.e. IS and IB) in developed (i.e. China, Canada, the US and Japan) than emerging countries, supporting the results of Stensås *et al.* (2019). Developed countries have higher literacy in utilizing the cryptocurrency than emerging countries. In addition, both UCRY price and the CCI30 index provide a SHA for conventional bonds (i.e. GB) in times of a market crisis, while the rest of the results revealed dissimilar findings. This may be caused by having divergence in the index's base construction; UCRY price is constructed based on news, while the CCI30 index is constructed based on the top 30 cryptocurrencies by market capitalization.

Table 7.
Results of UCRY price in emerging and developed countries

	Emerging				Developed			
Quantiles	SI	GB	IS	IB	SI	GB	IS	IB
0.05	−0.1760***	0.0149***	0.1060***	0.2437***	−0.0141***	−0.0428***	−0.0029***	1.1229***
0.1	−0.0684***	−0.0017***	0.0286***	0.3436***	0.0064***	−0.0762***	0.0116***	0.7584***
0.25	−0.0231***	0.0375***	0.0025***	0.2535***	−0.0141***	−0.0372***	−0.0040***	0.4149***
0.5	0.0041***	0.0107***	−0.0020***	0.0193***	0.0664	−0.5571	−0.0646	−0.4204
0.75	*0.0166***	−0.0004***	−0.0297***	−0.1106***	−0.0129***	*0.0051***	−0.0039***	−0.1102***
0.9	*0.1338***	−0.1318***	−0.1278***	−0.3766***	0.001	−0.0044***	*0.0135***	−1.0061***
0.95	4.9393	−0.6334	−4.1953	−7.9924	−0.5192***	*0.3278***	*0.4848***	*0.3745***

Note(s): *** stands for 1% level of significance; The significance in italics implied safe haven assets

5. Conclusion and future research

We found that gold was a SHA for conventional and Islamic investors during the COVID-19 pandemic period. Gold was preferable as it was a stable asset in times of a crisis as well as Shariah-compliant. Besides that, cryptocurrency could be another strong safe haven option for conventional assets but only a weak safe haven for Islamic assets (i.e. IS) under high uncertainty. High crypto uncertainty often leads to highly volatile prices which allow investors to potentially have a higher reward (return). In that sense, conventional investors are likely to invest in crypto as they are more open to speculative elements compared with Islamic investors. We confirmed the safe haven characteristics of the results that the assets were negatively correlated during a market crash but could be positively or negatively correlated on average (Baur and Lucey, 2010) by distinguishing between the first and second year of the COVID-19 pandemic. In addition, gold offered a SHA for emerging and developed countries because it was the most popular choice for safe investments. Despite cryptocurrencies being widely used in emerging countries, cryptocurrency was a better SHA for developed countries as there are more developed countries whose governments classify cryptocurrency as legal [9].

Overall, our results could benefit investors in diversifying their portfolios to mitigate losses as the COVID-19 pandemic has an inconclusive end. Our findings suggest implications for conventional and Islamic investors to add gold and consider cryptocurrency as their SHA during uncertain conditions. For policymakers, regulators and the government, they could provide more discussions on cryptocurrency as an alternative investment opportunity. Notably, it is still essential for them to stay aware and devise guidelines as cryptocurrency has speculative and fluctuating aspects. Specifically, it must warn amateur investors who are more attracted to invest in cryptocurrency during high volatility (Jalal *et al.*, 2020).

We provide recommendations for future studies. First, our method disregards the dependency between the quantile of independent (i.e. financial assets) and dependent (i.e. gold and crypto market) variables. Therefore, future studies could use a quantile-on-quantile method as the quantiles of the independent variable may have different impacts on the quantiles of the dependent variable which has been applied in previous research (Hasan *et al.*, 2021; Bossman *et al.*, 2022). They can benefit from seeing more accurate and clearer relationships between the variables in certain conditions. Second, instead of utilizing only one cryptocurrency index, future studies can compare the SHA ability in various crypto indexes: CCI30, UCRY Price, UCRY Policy and cryptocurrency environmental policy index (ICEA) for different countries or regions in conventional and Islamic markets. Therefore, it can capture different perspectives from each index. It can also be extended to other financial markets: NFTs that show a significant increase of interest among investors recently (Umar *et al.*, 2022b, c; Vidal-Tomás, 2022) and fiat currencies (Umar and Gubareva, 2020; Umar *et al.*, 2021).

	DV: CCI30 index			
Quantiles	SI	GB	IS	IB
0.05	0.3118***	0.3505***	0.3457***	8.8046***
0.1	0.7711***	0.7528***	0.6157***	1.8627***
0.25	0.4544***	*−0.0936***	0.4752***	1.1259***
0.5	128.8496	−59.1893	18.4729	−339.8276
0.75	0.2817***	−0.4286***	0.1548***	−4.2725***
0.9	0.2320***	−1.2036***	0.1326***	−3.5178***
0.95	0.8861***	−1.0370***	−0.4560***	−5.9591***

Note(s): ***, **stands for a 1% and 5% level of significance; interpretation is similar with gold; The significance in italics implied safe haven assets

Table 8. Results of the CCI30 index

Third, many predictions have stated that in the year of 2023, it is heading towards a recession. As a result, it would be interesting for future studies to forecast whether gold or crypto can still potentially be SHAs during the recession.

Notes

1. For the average prices for gold worldwide from 2014 to 2025, see: https://www.statista.com/statistics/675890/average-prices-gold-worldwide/
2. When the pandemic emerged, Bitcoin could be purchased at $7,900 but today it costs $46,000 based on https://coinmarketcap.com/
3. See: https://www.forbes.com/sites/nicolelapin/2021/12/23/explaining-cryptos-volatility/
4. See: https://www.statista.com/statistics/675890/average-prices-gold-worldwide/
5. It includes interest rates from lending money or investments in businesses which are engaged in alcohol production, pork-related products and ammunition.
6. We categorize the countries by the gross national income (GNI) per capita per year. An upper high-income country (GNI >$12.695) is classified as a developed country and a middle to lower-income country (GNI<$12.695) is listed as a developing country. See: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups
7. See: https://cci30.com/
8. See: https://www.worldbank.org/en/news/feature/2020/06/08/the-global-economic-outlook-during-the-covid-19-pandemic-a-changed-world
9. See: https://www.thomsonreuters.com/en-us/posts/wp-content/uploads/sites/20/2022/04/Cryptos-Report-Compendium-2022.pdf

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Appendix
The supplementary material for this article can be found online.

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Disruptive human resource management technologies: a systematic literature review

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Abstract

Purpose – The disruptive human resource management (HRM) technologies are now considered a significant facilitator to change and benefit the entire HRM landscape. This view needs to be further verified by reviewing the knowledge on the subject in the empirical research landscape. Thus, the study's objectives were to find (1) the current knowledge and (2) the areas where empirical research is lacking in disruptive HRM technologies.
Design/methodology/approach – The article is a literature review that was followed by the systematic literature review and the preferred reporting items for systematic reviews and meta-analyses (PRISMA). The review considered 45 articles published during the 2008–2021 period extracted from the Scopus database, and bibliometric analysis was performed to achieve the research objectives.
Findings – The results found that scholarly attention has been given to electronic HRM (E-HRM) rather than the disruptive HRM technologies. The areas investigated include the determinants of intention, adoptions and use of E-HRM and the outcomes of E-HRM adoptions and use. These outcomes can be further divided into general outcomes and HRM outcomes.
Research limitations/implications – The findings reveal gaps in E-HRM research and disruptive HRM technologies remain untapped in the empirical research landscape. Hence, the study findings provide some implications for future research and applications.
Originality/value – The study found empirically proven determinants of E-HRM intention, adoptions and use and E-HRM adoptions and use outcomes. These were found in the studies conducted during the 2008–2021 period.

Keywords Disruptive human resource management technologies, Systematic literature review, PRISMA
Paper type Research paper

1. Introduction

Disruptive technologies involve continuously creating new technologies (Aghion and Howitt, 1990) by constantly destroying existing ones (Buhalis *et al.*, 2019; Rodriguez, 2016). Current disruptive technologies include Artificial Intelligence (AI), Robotics, Internet of Things (IoT), Autonomous Vehicles, 3D Printing, Nanotechnology, Biotechnology, Materials Science, Energy Storage and Quantum Computing (Schwab, 2016). These are treated as powerful driving forces for business activities (Gupta and Saxena, 2012), and they have significantly changed the ways of doing business. Practitioners believed they could affect billions of consumers, millions of workers, and trillions of economic activities across industries (Manyika, 2017; Schwab, 2016).

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Disruptive technologies are now incorporated into a variety of concepts. Disruptive human resources management (HRM) technologies are the disruptive technologies embedded in HRM (Gupta and Saxena, 2012). It is also termed as electronic HRM (E-HRM) (Chandradasa and Priyashantha, 2021a, b; Thite, 2018), digital HRM (Halid *et al.*, 2020; Strohmeier, 2020; Thite, 2018), smart HRM (Strohmeier, 2018) or smart human resources 4.0 (SHR 4.0) (Liboni *et al.*, 2019). Major disruptive HRM technologies are social media, cloud computing, big data/data analytics, mobile technologies and the IoT (Waddill, 2018).

HRM is a strategic and coherent approach for managing organisations' people (Armstrong and Taylor, 2020) and helping increase performance. When disruptive technologies are combined with HRM, its strategic relevance for improved corporate performance grows (Stone and Dulebohn, 2013). It is viewed that it can change the entire HRM landscape (Bondarouk *et al.*, 2016; Strohmeier, 2020). Social media is currently used for candidate recruitment and selection (Bersin, 2017). It has made it much easier for vacancy notifications, skill assessments and profile checking (Bersin, 2019). Internal communications, team collaboration, training, learning and employee development are also facilitated by social media (Waddill, 2018). Big Data/Data Analytics can be used for job seeker tracking at hiring, employee tracking for various kinds, employee performance evaluations and career path modelling (Waddill, 2018). They can predict employee satisfaction levels, engagement patterns, and learning and development levels (Waddill, 2018). The succession planning, health, safety and well-being levels are also facilitated by big data/data analytics (Waddill, 2018). Cloud-based technologies give greater automation for almost all HRM activities through human capital software systems (Waddill, 2018). IoT helps with employee tracking, performance management, health, safety, well-being and job designing (Aronica, 2014). Mobile technologies drive all these functionalities of Social Media, Big Data/Data Analytics, Cloud Computing, and the IoT (Waddill, 2018). Industry experts and analysts view such disruptive HRM technologies create greater efficiency in managing human resources, enhanced employee experience (Barman and Dass, 2020) and more accessibility to HRM practices than ever before (Bersin, 2019; Thite, 2018).

Rationale: Thus, disruptive HRM technologies' benefits may encourage the interested parties to adopt such technologies. HRM technology adoption has been much researched, including the benefits and barriers of HRM technology adoption (Bondarouk and Ruël, 2009; Strohmeier and Kabst, 2009). However, a synthesis of empirical studies is limited. A review study by Bondarouk *et al.* (2017) covered four decades of E-HRM adoption research. It has not included the disruptive HRM technologies, and no review study after 2017 has been conducted. Given the much evidence of conceptual clarifications (Ma and Ye, 2015; Strohmeier, 2020), bloggers' perspectives (Barman and Das, 2018; Joshi, 2018), and industry experts', vendors' and book authors' views (Strohmeier, 2018) on disruptive HRM technologies, the extant literature has empirical gaps. Other than that, empirical researchers may have found other phenomena than those found in Bondarouk *et al.* (2017). Hence, looking up the current empirical knowledge on disruptive HRM technologies is imperative.

Objective: Therefore, the objectives of this research were to find (1) the current knowledge and (2) the areas where empirical research is lacking in disruptive HRM technologies.

We were capable of accomplishing these objectives by conducting a systematic review of 45 articles published between 2008 and 2021. These articles were picked from the Scopus database according to the PRISMA article selection guidelines. Keyword co-occurrence analysis was one of the bibliometrics analyses performed with VOSviewer. Findings reveal that E-HRM was studied rather than disruptive HRM technologies. They also demonstrate that the empirical research for disruptive HRM technology remains largely unexplored. The key areas of E-HRM that have been studied include factors of intention, adoptions and use of E-HRM, as well as the outcomes of E-HRM adoptions and use. However, limited research into

such findings reveals the inadequacy of existing knowledge. Thus, the findings point to new possibilities for future research.

The following sections of this manuscript provide a complete overview of the study's methodology and findings. The methodology outlines how the literature review was carried out and analysed systematically. The results and findings section outlines the significant findings of the study. It is split into four subsections: study selection, study characteristics, results of studies and reporting biases. Next, one after the other, the discussion, conclusion, practicality and research implications are outlined.

2. Methods and methodology

2.1 Study selection process and methods

The SLR was used in the research. It used a more objective method of article selection, inclusion criteria and analysis methods. Regarding the article selection procedure, the PRISMA article selection steps, known as PRISMA flow diagram, were followed, as is recommended for SLRs (Liberati *et al.*, 2009). The steps include the "Identification," "screening," and "included." Figure 1 depicts how these steps were followed in this study.

The identification stage includes determining the search terms, search criteria, databases and data extraction method. The key search term was "Disruptive Human Resource Management Technologies." The search criteria were developed by including the terms "Disruptive Human Resource Management Technologies," "Disruptive HRM Technologies," "EHRM," "Electronic HRM," "E-HRM," "Virtual HR" and "Digital HRM." They were typed in the Scopus database with the "OR" operative between each term.

According to the PRISMA 2020 flow diagram, the articles identified must be screened. The screening, retrieval, and assessment of the eligibility of each article were the tasks performed at the screening. In each task, the articles that did not match the inclusion criteria were eliminated (Meline, 2006; Priyashantha *et al.*, 2021a, b, c). The inclusion criteria for screening the articles were the "empirical studies" published in "English" in "Journals" from "2008 to 2021." Reasons for choosing the final empirical journal articles include that they are recommended for SLRs (Tranfield *et al.*, 2003), and they ensure sufficient homogeneity in methodological quality to derive relevant findings (Okoli and Schabram, 2010) which satisfy internal validity (Petticrew and Roberts, 2006).

This screening was done through automation and manually. We included articles satisfying the inclusion criteria "empirical studies" published in "English" "journals" from "2008 to 2021" by using Scopus' automatic article screening functions by study type, language, report type and publication date. The other publication types (e.g. research notes, editors' comments, books, book chapters, book reviews, conference proceedings and unpublished data), non-English articles and articles published out of the considered year range were excluded. Then the full versions of the screened articles were retrieved for the next stage of screening; the eligibility assessment.

The eligibility assessments were done manually by the authors. It requires assessing methodological quality by setting a minimum acceptable level (Meline, 2006). Articles that meet the minimum acceptable level are included, while those that do not meet the minimum acceptable level are excluded (Meline, 2006). Accordingly, the minimum acceptable level was "the empirical studies that employed quantitative techniques."

2.2 Study risk of bias assessment

Review quality is reduced due to researcher bias in article selection and analysis (Kitchenham and Charters, 2007). Using a review protocol, following a systematic, objective article selection procedure and analysis methods (Kitchenham and Charters, 2007; Xiao and

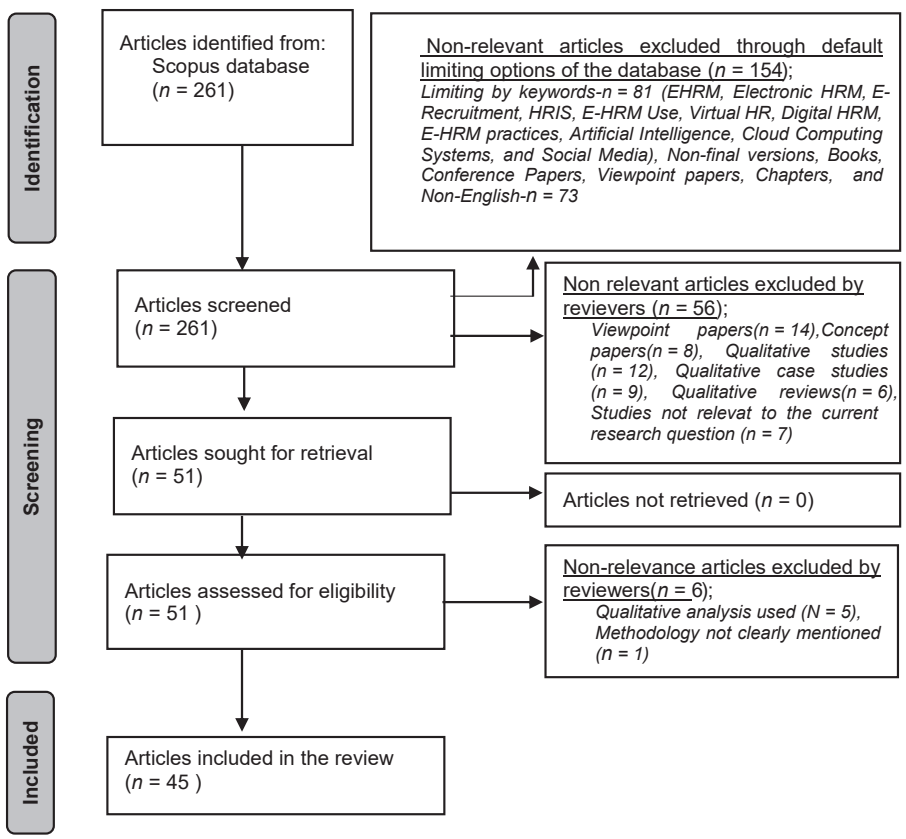

Figure 1.
PRISMA article selection flow diagram

Watson, 2019) and performing a parallel independent quality assessment of articles by two or more researchers (Brereton *et al.*, 2007) avoid bias in article selection and analysis. Thus, the articles' risk of biases was avoided by following all such requirements.

2.3 Methods of analysis

The analysis method was the bibliometric analyses performed using Biblioshiny and VOSviewer. It is a mathematical technique to examine scientific activity in research (Aparicio *et al.*, 2019; Paule-Vianez *et al.*, 2020). In particular, it provides two types of analysis; (1) evaluation, performance, and scientific productivity analysis, and (2) scientific maps (Cobo *et al.*, 2012). The scientific map analysis provides the research's structure, evolution and key players (Noyons *et al.*, 1999). Different information in an article, called a unit of analysis, is used to create such maps, commonly called bibliometric networks (Callon *et al.*, 1983). The keywords that signify an article's primary content are amongst the most widely used units of analysis for such bibliometric networks. Various links can be created using the co-occurrence relationship of the keywords in an article (Aparicio *et al.*, 2019). The VOSviewer visualises such relationships in a map, called "keyword co-occurrence network visualisation."

The normalisation of the network visualisation is required to relativise the relationships between the keywords to gain important information about the area of investigation. Thus, the VOSviewer, by default, applies the association strength normalisation and creates a

network in a two-dimensional space. In that space, the strongly related keywords are indicated by nodes close to each other, whereas the weakly related nodes are located far away (van Eck and Waltman, 2014). Then the VOSviwer assigned the nodes into a network of clusters where the nodes with a high correlation with other nodes tend to be put into the same cluster (Chen *et al.*, 2016). VOSviewer uses colours to indicate the cluster assigned to a node. Thus, a cluster may represent a common theme. Since one of our objectives was to find the current knowledge of disruptive HR technologies, this keyword co-occurrence analysis was utilised.

Another analysis is the density visualisation derived from the keyword co-occurrence analysis. It was used to achieve the study's second objective: to find the areas where empirical research is lacking in disruptive HRM technologies. VOSviewer manual states that keywords' density at each position in the item density visualisation map is denoted by colour range from blue to green to red by default. The closer a position's colour is red, the greater the number of items in its proximity and the higher its weight. If the fewer items in a certain point's proximity and the lower the weights, the closer the point's colour is to blue. If items in a point are average, the colour is green. Thus, we searched what keywords have fallen into the blue or green area to achieve the study's second objective.

Additionally, "annual article publications," "average citations received," "most relevant sources articles published," and "country-wise article publications" were generated by the software. They were to explain the article set profile in the review. The first three outputs were generated from Biblioshiny of *R*, and the VOSviewer generated the final output.

3. Results and findings

3.1 Study selection

According to the PRISMA flow diagram, we identified 261 articles during the identification stage. Articles published outside of the 2008–2021 time frame were excluded. The articles did not contain the keywords E-HRM, Electronic HRM, E-Recruitment, HRIS, E-HRM Use, Virtual HR, Digital HRM, E-HRM practices, Artificial Intelligence, Cloud Computing Systems and Social Media were excluded. The total number of articles then remained at 180. We further tried to include the articles on empirical studies in final versions published in journals in English. It was performed through automation with the database's limiting options. Then 107 articles were retained. These were retrieved to an MS Excel sheet with their essential information: the article's title, abstract, keywords, authors' names and affiliations, journal name, cited numbers and year of publication.

Next, the authors of the study independently went through each article. They excluded 56 articles based on the criteria "viewpoint papers," "concept papers," "qualitative studies," "qualitative case studies," "qualitative reviews," and "studies not relevant to the current research." Then 51 articles were retained for the next step, the eligibility checking.

The eligibility check revealed five "qualitative analyses" and one "methodology not clear" article. They were excluded. Finally, 45 articles were retained for the review. This entire article selection process is shown in Figure 1. Then, the MS Excel sheet was modified to fit the analysis requirements to achieve the research objectives.

3.2 Study characteristics

This research looked at 45 studies conducted by 100 authors in 27 countries. They have been published in 36 journals. The average number of citations each article obtained was 10.4. There were 171 keywords and 2,400 references in total. Table 1 presents that information in detail.

Figure 2 depicts the annual article publication, showing a gradual increase. It also shows that the majority of studies were completed in 2021. Figure 3 shows the average citations

received by each article. The citations received for a study indicate the popularity of the field that the study represents. Therefore, the increasing trend in Figure 3 demonstrates that the disruptive HRM technology field is getting increased attention from scholars.

Figure 4 shows the most relevant sources of the articles. It summarises the 20 journals which have published the highest number of articles. Thus, the *International Journal of Human Resource Management* has published the highest number of articles (4). The *Asian Social Science and Employee Relations* have published three articles each. Two articles have been published in the *International Journal of Business Information Systems* and the *Journal of Asian Finance Economics and Business*. The rest of the journals have published one article each.

Figure 5 shows the country-wise article publications and how countries are interdependent on citations. Since the larger nodes in the figure denote the number of occurrences, Jordan has the highest publications. As some nodes in the figure are unclear in size to examine the second and third places in publications, we created a Table 2 using the VOSviewer. It summarises and ranks the countries with publications and their citations. Accordingly, Jordan, India, Malaysia and the United Kingdom ranked first, second and third. However, concerning the citations, the first, second, and third places go to Taiwan, the UAE and Bahrain, indicating that they are famous for disruptive HRM technology research.

Description	Results
Timespan	2008:2021
Journals	36
Countries	27
Journal articles	45
Average citations per article	10.4
References	2,400
Author's keywords	171
Authors	100

Table 1.
The primary information of the article set

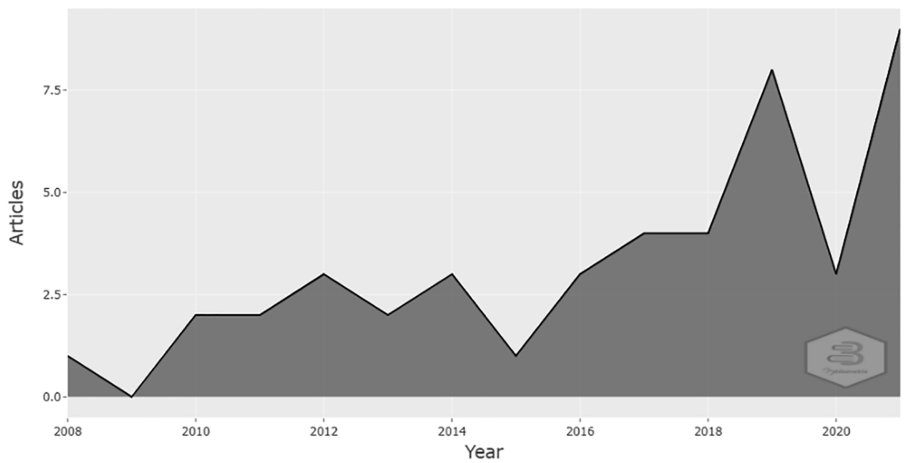

Figure 2.
Annual article publication

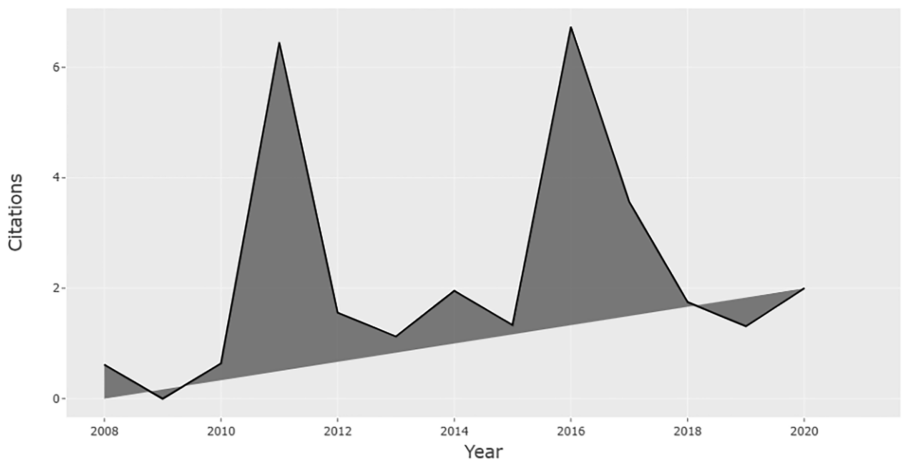

Figure 3.
Average citations received for the articles

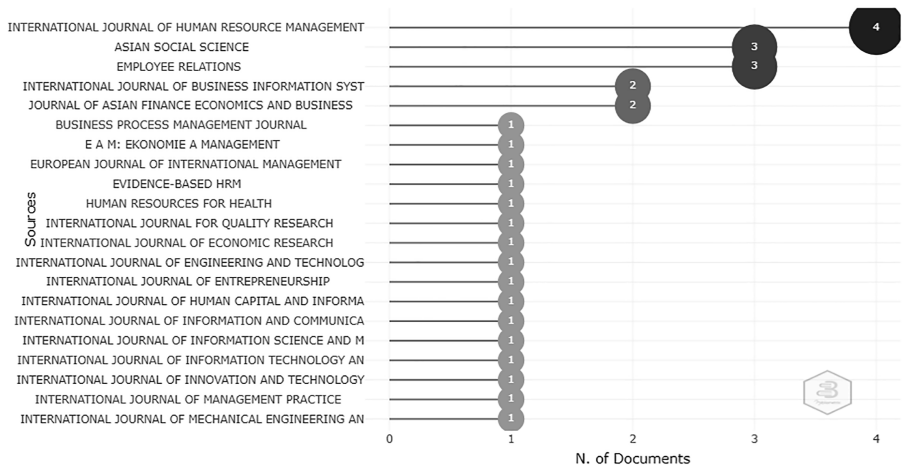

Figure 4.
Most relevant sources of the article publications

3.3 Results of studies

This section reports the findings complying with research objectives. The findings were developed using keyword co-occurrence analysis. The two forms of "keyword co-occurrence; network visualisation" and "density visualisation" were utilised in the analysis. The keyword co-occurrence network visualisation, in particular, addressed the first objective: finding the current knowledge of disruptive HRM technologies. The keyword co-occurrence density visualisation addressed the second objective, finding the areas where empirical disruptive HRM technology research is lacking.

3.3.1 The current empirical knowledge in disruptive HRM technologies. Using the minimum keyword occurrences functionality of VOSviewer software, we discovered that 19 keywords frequently occurred in the studies. It was achieved by gradually increasing the number of times a keyword occurred, starting with one, until the threshold keyword level reached a level that covered more keywords (Table 3). We chose 19 threshold keywords at the two minimum keyword occurrences since very few threshold keywords (e.g. three) were generated at a

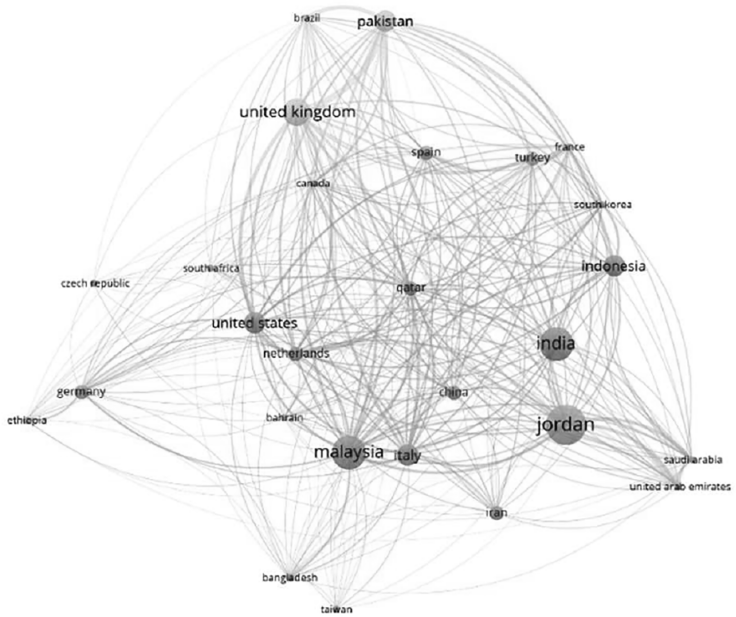

Figure 5.
Country-wise article publications

higher number of minimum keyword occurrences (e.g. five or six). We did so because we thought it was clear enough to understand the areas investigated in the studies. Figure 6 depicts those 19 keywords and their relationships, while Table 4 shows their frequency.

As shown in Table 4, the highest number of keyword occurrences was observed for E-HRM. A larger red node is shown in Figure 6 to demonstrate it further. Even though our focus was on disruptive HRM technologies in the empirical research landscape, we discovered that the current empirical research has focussed on E-HRM, implying that disruptive HRM technologies have not been empirically tested.

The keyword co-occurrence network visualisation in Figure 6 shows the connections of keywords shown in nodes. The connection represents the relationship between each keyword. Specifically, the strength of a relationship is characterised by the thickness of the line. Therefore, Figure 6 shows that E-HRM and the HRM are linked by a thicker line indicating that E-HRM is highly related to HRM. Moreover, the link of HRIS and information technology with HRM indicates their relationship to HRM.

The nodes in Figure 6 are in three clusters: red, green and blue. Those clusters have keywords which are denoted in Table 5. As shown in Figure 6, the different clusters indicate that disruptive HRM technologies varied by different areas of investigation. Grouping the keywords in one cluster means that the keywords are highly likely to represent the same topic. Hence, as shown in Table 5, the red, green and blue clusters reflect common themes as "adoption and outcomes of E-HRM," "use of E-HRM and HRM outcomes," and "intention to use the E-HRM," respectively.

3.3.1.1 E-HRM adoption and outcomes – red cluster. *Adoption and E-HRM:* The E-HRM adoption is determined by perceived usefulness, HRM strength (Wahyudi and Park, 2014), top management support, employee attributes, system complexity, IT infrastructure and industry pressure (Masum *et al.*, 2015).

Employee performance and E-HRM: The successful E-HRM implementation helps for increased labour productivity (Iqbal *et al.*, 2018) and employee performance (Ajlouni *et al.*, 2019;

Rank	Country	Journal articles	Rank	Country	Citations
1	Jordan	6	1	Jordan	1
2	India	5	2	Taiwan	172
3	Malaysia	5	3	United Arab Emirates	111
4	The United Kingdom	4	4	Bahrain	74
5	Indonesia	3	5	Saudi Arabia	48
6	Italy	3	6	Brazil	42
7	Pakistan	3	7	Qatar	41
8	The United States	3	8	Bangladesh	31
9	China	2	9	Turkey	17
10	Germany	2	10	Iran	17
11	Iran	2	11	Ethiopia	15
12	The Netherlands	2	12	China	12
13	Qatar	2	13	Spain	9
14	Spain	2	14	Netherlands	9
15	Turkey	2	15	Italy	9
16	Bahrain	1	16	Pakistan	8
17	Bangladesh	1	17	India	8
18	Brazil	1	18	Malaysia	7
19	Canada	1	19	Indonesia	3
20	The Czech Republic	1	20	United Kingdom	2
21	Ethiopia	1	21	Czech Republic	1
22	France	1	22	United States	0
23	Saudi Arabia	1	23	South Korea	0
24	South Africa	1	24	South Africa	0
25	South Korea	1	25	Germany	0
26	Taiwan	1	26	France	0
27	The United Arab Emirates	1	27	Canada	0

Table 2.
Country-wise publications and citations received

Minimum keywords occurrences	Threshold keywords level
1	171
2	19
3	4
5	3
6	3

Table 3.
Occurrences of keywords

Nurlina *et al.*, 2020) through HR service quality (Iqbal *et al.*, 2018; Nurlina *et al.*, 2020). Thus, the increased employee performance is an outcome of the E-HRM implementation.

HRIS and E-HRM: HRIS supports all HRM functions (Ukandu *et al.*, 2014). Web-enabled access (Strohmeier and Kabst, 2012), Internet access, availability of separate HR sections, basic computer skills and fear of unemployment (Dilu *et al.*, 2017), influence successful HRIS implementation. Additionally, organisational support (literacy, technical and technology involvement support) influences successful HRIS implementation (Ibrahim *et al.*, 2019).

Information technology (IT) and E-HRM: Researchers have found that IT use, virtual organisations adoptions (Lin, 2011) or E-HRM use (Zareena, 2018) can contribute to organisational innovation (Lin, 2011), cost and time savings, comfort, convenience, increased communication and data accuracy (Zareena, 2018). All of these outcomes point to more favourable outcomes.

Innovation and E-HRM: The adoptions of IT and virtual organisations help organisational innovations (Lin, 2011). Instead, the E-HRM implementation has been

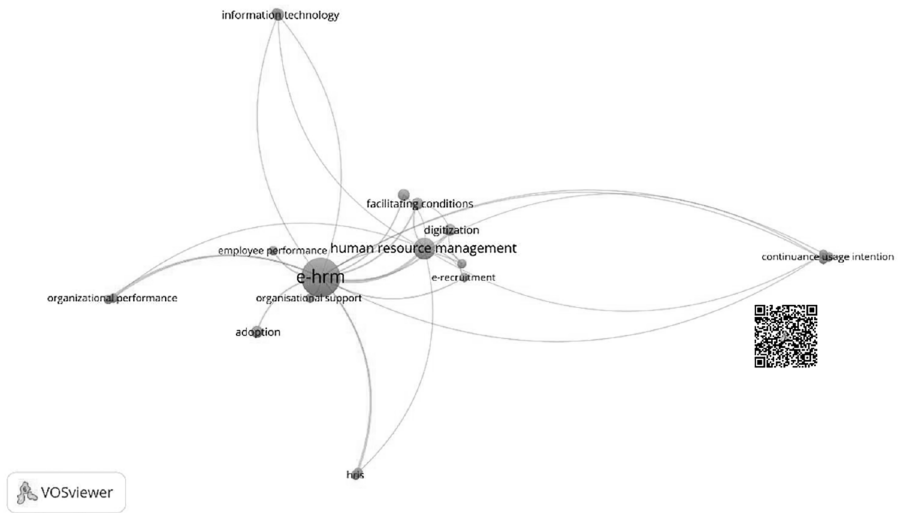

Figure 6.
The keyword co-occurrence network visualisation

Keyword	Occurrences
E-HRM	38
Human resource management	9
Human resource information systems (HRIS)	4
Adoption	3
HRM effectiveness	3
Facilitative conditions	2
Information technology	2
Continuance usage intention	2
Digitisation	2
E-Recruitment	2
Employee performance	2
Innovation	2
Organisational support	2
Organisational performance	2
Perceived ease of use	2
Perceived usefulness	2
Social media	2
Strategic HRM	2

Table 4.
The keywords with a minimum of two occurrences

researched as an innovation in the organisation (Roy and Jegan, 2019). Findings imply that conventional practices can be done innovatively with the technology.

Organisational support and E-HRM: Organisational information system-related support (literacy support, technical support, and technology involvement support) help the end-user satisfaction for E-HRM-related applications (Ibrahim *et al.*, 2019) and effective implementation of E-HRM (Rathee and Bhuntel, 2021). Therefore, organisational support is a factor for successful E-HRM implementation and employee satisfaction.

Organisational performance and E-HRM: The E-HRM moderates the influence of high-performance work practices on organisational performance (Obeidat, 2016). Thus, E-HRM is a factor for organisational performance. Additionally, E-HRM mediates impersonal trust and

HR service quality, resulting in employee productivity (Iqbal *et al.*, 2019). Thus, employee productivity and organisational performance are outcomes of E-HRM.

Strategic HRM and E-HRM: E-HRM is a strategic HRM initiative that modifies the influence of high-performance work systems on organisational success (Obeidat, 2016). Moreover, strategic HR involvement is reciprocally related to higher E-HRM capability (Marler and Parry, 2016). Therefore, E-HRM is treated as a strategic HRM initiative for organisational success.

3.3.1.2 Use of E-HRM and HRM outcomes- green cluster. *Digitalisation and E-HRM:* Some researchers have referred to the E-EHM as the "digitalisation of HRM." They have found determinants (performance expectations, ease of use, social influence and facilitating conditions) affecting E-HRM use (Vazquez and Sunyer, 2021).

E-Recruitment and E-HRM: E-recruitment is another area researched. Social media, particularly social network sites' qualities (easily navigate, secure process, eminence proficiency, candidate's attraction and network expedition) contribute to effective E-recruitment (Waheed *et al.*, 2019). Moreover, it is a factor in SMEs' corporate sustainability (Alkhodary, 2021).

Facilitating conditions and E-HRM: The facilitating conditions are factors for E-HRM use (Vazquez and Sunyer, 2021). Thus, creating more facilitative conditions aids E-HRM use.

HRM effectiveness and E-HRM: HRM effectiveness results from E-HRM implementation (Al-Harazneh and Sila, 2021; Obeidat, 2016; Sanayei and Mirzaei, 2008).

HRM and E-HRM: The E-HRM has changed the HR manager's role from administrative expert to the strategic agent (De Alwis, 2010). Because all the administrative HRM functions (planning, recruitment, selection, performance, compensation, communication, training and development) can be done by the E-HRM (Ukandu *et al.*, 2014). Thus, HRM value creation (Ruël and van der Kaap, 2012), internal efficiency, employee commitment (Bissola and Imperatori, 2013), HRM effectiveness (Al-Harazneh and Sila, 2021; Obeidat, 2016; Sanayei and Mirzaei, 2008) and labour productivity (Iqbal *et al.*, 2018, 2019) are outcomes of E-HRM. Other than that, HRM service quality (Iqbal *et al.*, 2018; Nurlina *et al.*, 2020), impersonal trust (Iqbal *et al.*, 2019) and increased employee performance (Nurlina *et al.*, 2020) are also consequent of E-HRM adoption. Moreover, social media as part of E-HRM use has been found to influence achieving the relational HRM objectives (better internal communication, collaboration and personnel engagement) and management of operational and transformational HR functions (e.g. personnel administration, training, performance management and skill assessment) (Martini *et al.*, 2021).

Social media and E-HRM: Social media is a good tool for E-HRM. Specifically, it is being used for E-recruitment (Waheed *et al.*, 2019). Thus, researchers have found that the E-recruitment's effectiveness is determined by the quality of social media sites (Waheed *et al.*, 2019). Social media use in HRM can also increase HRM performance and organisational performance (Vardarlier and Ozsahin, 2021). Moreover, social media is used for relational and

Table 5.
Keywords categorised into clusters

Cluster	Common theme	Keywords
Red (10 items)	E-HRM adoption and outcomes	Adoption, E-HRM, Employee Performance, HRIS, Human Resource Information Systems, Information Technology, Innovation, Organisational Support, Organisational Performance, Strategic HRM
Green (6 items)	E-HRM use and HRM outcomes	Digitalisation, E-Recruitment, Facilitating Conditions, HRM Effectiveness, Human Resource Management, Social Media
Blue (3 items)	Intention to use the E-HRM	Continuance Usage Intention, Perceived Ease of Use, Perceived Usefulness

extended relational purposes in the organisation resulting in greater HRM success (Martini *et al.*, 2021).

3.3.1.3 Intention to use the E-HRM – blue cluster. *Continuance usage intention and E-HRM:* The users' attitude and satisfaction determine the intention for E-HRM (Yusliza *et al.*, 2018). Besides, the users' perceived usefulness and perceived ease of use also determine the intention for E-HRM (Rawashdeh *et al.*, 2021). Then the E-HRM usage intention, in turn, results in successful E-HRM implementation (Rathee and Bhuntel, 2021).

Perceived ease of use and E-HRM: Perceived ease of use of E-HRM influence the intention of E-HRM (Yusoff and Ramayah, 2012). Besides, the perceived ease of use helps E-HRM user satisfaction, which in turn helps the intention of E-HRM (Rawashdeh *et al.*, 2021). Instead, perceived ease of use contributes to E-HRM implementation (Rathee and Bhuntel, 2021; Vazquez and Sunyer, 2021). These findings reveal that perceived ease of use determines E-HRM intention and adoption.

Perceived usefulness and E-HRM: The perceived usefulness of E-HRM impact E-HRM usage intention (Rawashdeh *et al.*, 2021; Yusliza *et al.*, 2018) and effective E-HRM implementation (Rathee and Bhuntel, 2021). Other than that, the perceived usefulness of E-HRM is a factor for E-HRM user satisfaction that results in E-HRM intention (Rawashdeh *et al.*, 2021).

3.3.2 Areas where empirical research is lacking. This section covers the study's second objective. E-HRM is the most commonly used keyword in studies, as seen in Table 4, indicating that it has been extensively researched. The density visualisation map created by the VOSviewer shows it in the node with the red background (Figure 7). According to the VoSviewer manual, a node in the red background indicates sufficient research for established knowledge. However, keyword nodes with a green background indicate that there has been less study on those keywords. Thus, all other keywords in Figure 7 are in the green background, indicating insufficient research. The empirically tested determinants of E-HRM intention, adoption and use, and the outcomes of E-HRM adoption and use, emphasised in 3.3.1, can be viewed as insufficient for established knowledge.

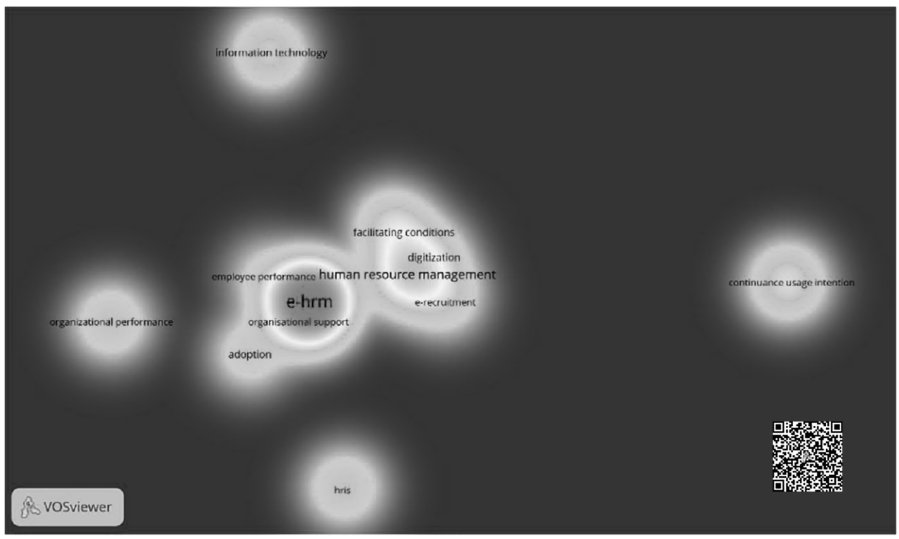

Figure 7.
Keyword density visualisation map

Additionally, as the keywords were investigated more than twice and explained under 3.3.1, it is essential to find them tested only once. Thus, Table 6 shows the keywords investigated only once. It mainly highlights two areas as determinants and outcomes of E-HRM.

As determinants, decision-making responsibility given to the user (HR staff) and the technical (IT) department cause the HRM technology usage intensity (Lujan and Florkowski, 2010). Additionally, E-HRMs' ability for; strategic execution, playing the strategic partners' and administrative expert's roles, management of people, transformation and change, and the regulatory pressures are the determinants for E-HRM adoption (Poba-Nzaou *et al.*, 2020). Besides, the perceived behavioural control (Noerman *et al.*, 2021) and the social influence determine the E-HRM intention and use.

As outcomes of E-HRM, HRIS success (Strohmeier and Kabst, 2012), employees' affective commitments resulting from the relational and transformational aspects of E-HRM (Bissola and Imperatori, 2013) and improved employee retention (Allumi Nura and Hasni Osman, 2013) are evidenced. Additionally, organisational agility (Hamidianpour *et al.*, 2016), better talent attraction, acquisition and development (Vazquez and Sunyer, 2021), and corporate sustainability (Alkhodary, 2021) are outcomes of E-HRM.

These determinants and outcomes investigated only once can be treated as insufficient for established knowledge.

3.4 Reporting bias assessment

The PRISMA guidelines required the assessment of biases due to missing the results in reporting. No systematic assessment was performed for this task; however, we followed systematic and objective software tools and PRISMA guidelines to avoid bias in reporting the results.

4. Discussion

Each article's results and synthesis were mainly reported under "the current empirical knowledge in disruptive HRM technologies" and "areas where empirical research is lacking." That was done to represent the two objectives of the study. In sum, both these sections have reported the same thing: "determinants" and the "outcomes" of E-HRM. Only these two areas have been subject to empirical research during the period. The determinants have been investigated relating to the intention, adoption, and use of E-HRM. The theory of planned behaviour postulates that intention leads the behaviour (Ajzen, 1991). Thus, the intention to use the E-HRM results in E-HRM adoption, which ultimately causes E-HRM use. The E-HRM intention is the desirability or willingness for E-HRM (Davis and Davis, 1989; Moghavvemi, 2017). The E-HRM adoption refers to the decision-making process to initiate HR-related technologies. It is a strategy to transfer traditional HRM techniques to E-HRM systems and their acceptance by the users (Bondarouk *et al.*, 2017). Other than that, E-HRM use is the application of E-HRM functionalities in day-to-day activities (Obeidat, 2016). Finding the

Table 6.
Areas tested only once in studies

Affective commitment	E-performance management
Cognitive absorption	Employee retention
Corporate sustainability	HR technology intensity
Design characteristics	Motivations
E-learning	Social influence
E-payment of human resources	Talent
E-performance appraisal	Top management support

different determinants relating to each element in that process is essential for smooth E-HRM use behaviour. Our study results revealed many determinants relating to intention, adoption and E-HRM use. Those have been tested only in minimal studies.

Two types of outcomes were found concerning the E-HRM outcomes: general outcomes and HRM outcomes. The general outcomes were discovered through E-HRM adoption, whereas the HRM outcomes were discovered through E-HRM use. Since these outcomes have been tested in minimal studies, finding more outcomes is missed. Moreover, no outcomes were found except for determinants for intention to E-HRM.

Moreover, the focus of this study was to find empirical research on disruptive HRM technologies. The books' authors and practitioners cited that the major disruptive HRM technologies are social media, cloud computing, big data/data analytics, mobile technologies and the IoT (Bersin, 2017; Waddill, 2018). They have used synonyms for disruptive HRM technologies as digital HRM Waddill (2018), (Halid *et al.*, 2020; Strohmeier, 2020), smart HRM (Strohmeier, 2018), or SHR 4.0 (Liboni *et al.*, 2019), etc. Except for social media, these areas were not found in the two analyses done under 3.3.1 and 3.3.2. Thus, our results found gaps in the empirical research landscape. They indicate that the areas are still untouched for empirical research.

One limitation of the study is the minimal empirical research accessible, found in only 45 articles. That may be because the articles for the review were chosen from only one database. Furthermore, we looked at only empirical studies, ignoring other types. This omission leaves out a significant amount of relevant literature.

4.1 Practicality and research implications

Regarding the practicality of the findings, the determinants of E-HRM intention, adoption and use, and the outcomes of E-HRM adoption and use imply the policymakers and the practitioners for their E-HRM adoption decisions.

Implications for future researchers include various aspects. One such is the absence of empirical data on disruptive HRM technologies. As stated in the introduction, disruptive HRM technologies have many uses today. The industry experts view that disruptive HRM technologies have caused a change in the entire HRM landscape. However, almost all the components of disruptive HRM technologies (cloud computing, big data/data analytics, mobile technologies, and the IoT) remain untouched for empirical research except for social media. Even though we found the application of social media influence for recruitment, the finding is not enough for established knowledge. Also, many other uses of social media for HRM functions have not been investigated. As a whole, more uses of disruptive HRM technologies for HRM must be empirically investigated.

As the current study found only 45 articles for the review, another significant implication is the limitedness of the available research. More research needs to be done on the (1) investigated determinants for intentions, adoptions and use of E-HRM and (2) the outcomes of E-HRM adoptions and use. There were no outcomes resulting from E-HRM intentions other than the E-HRM adoptions or use.

The current realities indicate employee disengagement globally (80%) and workplace stress like role conflicts and health and safety issues (Gallup, 2013, 2021). Mitigating those issues is a timely requirement. There is a notion that the application of HRM technologies into employment setup can mitigate these issues (Turner, 2020; Waddill, 2018). Our review did not find any study investigating such sociological aspects with disruptive HRM technologies or E-HRM.

Besides, the E-HRM is designed to carry out all HRM functions (Omran and Anan, 2019). However, we noticed gaps in the empirical research landscape concerning specific E-HRM functions. For example, one or two studies have investigated e-recruitment, e-learning,

e-payment, e-performance appraisal and e-performance management. Specifically, e-selection, e-health and safety, e-team work and e-collaboration are yet to be investigated.

Additionally, as some studies emphasised, the code of ethics for any system implementation is essential. Therefore, gaps were found in the roles of ethical codes in E-HRM implementation (Delgado-Alemany *et al.*, 2022). Moreover, E-HRM implementation requires checking whether the new system fits the organisational legitimacy. However, gaps were found in effect produced by E-HRMs on organisational legitimacy. Future research could examine whether E-HRM provides or removes legitimacy from an organisation? Whether organisations or society deem E-HRMs legitimate or whether E-HRMs' legitimacy aids their implementation (Díez-Martín *et al.*, 2021). Besides, although the E-HRM has been researched in different institutional settings, there are gaps in its application in educational institutions. Thus, future research could focus on how education influences E-HRM or how educational institutions incorporate EHRM into higher education (Almahameed *et al.*, 2020; Gómez-Martínez *et al.*, 2020). What types of competencies should be taught to enable EHRM? Therefore, we hope all these implications may be on the agendas of future researchers.

5. Conclusion

Disruptive technologies are seen as a critical factor in HRM. This viewpoint must be supported by the empirical research landscape's knowledge of disruptive HRM technology. We conducted an SLR to find (1) current knowledge and (2) areas where empirical research on disruptive HRM technology is lacking. We used inclusion criteria to review 45 articles published during the 2008–2021 period. The articles were found using Scopus, and PRISMA guidelines were applied to select articles and report the findings.

The study's first objective was to find the current knowledge on disruptive HRM technologies. Accordingly, the study discovered that E-HRM was examined rather than disruptive HRM technologies. It demonstrates that the empirical research landscape for disruptive HRM technology is still largely untouched. The primary areas as determinants of intention, adoption or usage of E-HRM and the outcomes of E-HRM adoptions or use have been tested.

Perceived usefulness, ease of use, attitude towards the E-HRM, performance expectancy, effort expectancy, social influence and satisfaction with the E-HRM have been investigated as determinants for E-HRM intention. Determinants for E-HRM adoptions include perceived usefulness, HRM strength, top management support, employee attributes, system complexity, IT infrastructure and industry pressure. Moreover, web-enabled access, Internet access, availability of separate HR sections, basic computer skills, fear of unemployment and organisational support are also determinants for such adoptions. The determinants of E-HRM use are performance expectations, ease of use, social influence and facilitating conditions.

The outcomes of E-HRM found can be classified as general outcomes and HRM outcomes. The general outcomes were found from E-HRM adoptions, whereas the HRM outcomes were discovered from E-HRM use. The general outcomes of E-HRM adoptions include labour productivity, increased employee performance, organisational performance, organisational innovation and organisational success. Moreover, cost and time savings, comfort, convenience, improved communication and data accuracy are also the outcomes of E-HRM adoption. The HRM outcomes of E-HRM use include effective recruitment, HRM effectiveness, changes in the HR manager's role from the administrative expert to the strategic agent, HRM value creation, internal efficiency, employee commitment and labour productivity. Besides those, improved HRM service quality, impersonal trust, increased employee performance, relational HRM objectives achievement, operational and transformational HR functions management and increased HRM performance are the HRM-related outcomes resulting from E-HRM use.

The study's second objective was to find the areas where empirical research is lacking in disruptive HRM technologies. There was no article found for disruptive HRM technologies. Instead, we found E-HRM articles that have investigated determinants and outcomes. The determinants were for E-HRM intention, adoption, and use. The perceived behavioural control, social influence and top management support are determinants for E-HRM intention. E-HRMs' ability for; strategic execution, playing the strategic partner and administrative expert roles, management of people, transformation and change and the regulatory pressures are the determinants for E-HRM adoption. The level of decision-making responsibility of the user (HR staff) and the technical (IT) staff cause the HR technology usage intensity.

Under the second objective, the outcomes we found were related to E-HRM use. They can be divided into organisational and general outcomes. The general outcomes of E-HRM use include organisational agility and corporate sustainability. The HRM outcomes of E-HRM use are the HRIS success, employees' affective commitments, improved employee retention, better talent attraction, acquisition and development and corporate sustainability.

Thus, this study found determinants of E-HRM intention adoption and use and the outcomes of E-HRM adoptions and use.

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