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A Bibliometric Analysis of Knowledge Dynamics in Managerial Decision Making

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Abstract: The *purpose* of this paper is to present a bibliometric analysis of the literature, focusing on knowledge dynamics in managerial decision making. The motivation of our research is based on the new theory of knowledge fields and knowledge dynamics and its influence on decision making in business and management. The *methodology* used is based on a bibliometric analysis performed with the specialized software VOSviewer. The analysis graphically presents a series of semantic clusters which show the co-citation distances between different concepts related to the search expressions used like "knowledge dynamics", "managerial decision", and "decision making". As a database, we used the papers published in journals indexed in Web of Science. The *outcomes* of our analysis are some graphical representations of semantic clusters for the expressions "knowledge dynamics" and "managerial decision making", and a series of tables with the content analysis of the clusters and some other data concerning publications and authors. The findings demonstrate that there is a consistent link between knowledge dynamics and the managerial decision making process. The *contribution* of the paper comes from the fact that it is a first bibliometric analysis of the correlations between knowledge dynamics and managerial decision making as reflected in papers indexed in Web of Science. Also, the analysis includes for the first time the topic of entropic knowledge dynamics as reflected in papers indexed in Web of Science.

Keywords: knowledge dynamics; knowledge fields; managerial decision making; cultural intelligence; bibliometric study

1. Introduction

In knowledge management, *knowledge* constitutes a critical intangible resource. It is composed of *explicit* knowledge and *tacit* knowledge [1–3]. Explicit knowledge is a result of rational thinking, and it is expressed using natural or symbolic language [4]. It is the knowledge used in science, technology, education, and all the fields of social life when people use a natural or symbolic language to express their thoughts. Tacit knowledge is experiential [5] and it is processed in the cognitive unconscious zone of our brain [6–8]. "Tacit knowledge is deeply rooted in an individual's action and experience, as well as in the ideals, values, or emotions he or she embraces" [1] (p. 8). Tacit knowledge is worldless, and it can be expressed using body language and facial expressions [9,10]. The dyad explicit knowledge–tacit knowledge can be further developed into the triad rational knowledge–emotional knowledge–spiritual knowledge based on the Theory of Knowledge Fields (TKF) [11]. Rational knowledge is the result of rational thinking, and it is practically equivalent to explicit knowledge. Emotional knowledge is a component of tacit knowledge and contains the result of our perception. Emotional knowledge is supported by neuroscience, and it is processed by emotional intelligence [6,9,10,12–14]. Spiritual knowledge refers to moral and ethical values people acquire from their education and culture [15–17].

Knowledge dynamics (KD) refers to the variation of knowledge in time or in space within a given organizational context. Knowledge dynamics manifests at individual, team, and organizational levels. The variation in time is a result of the learning, unlearning, and re-learning processes, which may change both the quantity and the quality of knowledge at the individual and organizational levels [18–20]. Variation in space generates *knowledge flows* [21,22]. As Nissen [23] remarks, "To the extent that organizational knowledge does not exist in the form needed for application or at the place and time required to enable work performance, then it must flow from how it exists and where it is located to how and where it is needed. This is the concept of *knowledge flows*" (p. XX). Going beyond the Newtonian logic towards thermodynamics, we discover that *knowledge dynamics* can very well reflect a *transformation* from one form of knowledge into another one, like the transformation of mechanical work into heat [24]. Nonaka and Takeuchi [1,17] developed the theory of knowledge creation dynamics that is represented by the SECI—Socialization, Externalization, Combination, and Internalization—cycle. Practically, there is a sequential transformation of tacit knowledge into explicit knowledge and of explicit knowledge into tacit knowledge, at a different level. However, Nonaka and Takeuchi [1] do not show how knowledge dynamics influences decision making.

Bratianu and Bejinaru [11,25] revealed the transformations between rational, emotional, and spiritual knowledge within the theory of knowledge fields, based on the thermodynamics perspective. That explains why the authors called this phenomenon entropic knowledge dynamics to distinguish it from the Newtonian dynamics. Knowledge dynamics is important in the dynamics of organizational intellectual capital [26,27], a critical point in understanding how to manage intellectual capital in order to achieve competitive advantage. Within the theory of knowledge fields, knowledge dynamics play a significant role in the managerial decision (MD) process [8,9,13,28]. There are authors who consider managerial decision making as a purely rational process based on economic principles [29,30], while others focus on the role of intuition in decision making [31,32]. The first category of authors is dominant, especially in economic domains like banking and finance [33]. Also, rational decision making is used in creating algorithms for cognitive systems and technologies based on deterministic thinking patterns [34,35]. The second category is emerging especially in creative domains and when there is a certain pressure of time in making decisions in conditions of uncertainty [36,37].

Researchers coming from neurosciences show that decision making is a result of knowledge dynamics containing rational, emotional, and spiritual components [6,8,13,28,38]. Decision making is a complex process, and that explains the difficulties met by researchers in creating comprehensive models able to reveal the influence of nonlinearity and of continuous transformations between different forms of knowledge on the dynamics of decision making. Those difficulties explain the scarce literature focusing on the influence of knowledge dynamics on the decision making process. Even if some authors indicate the influence of emotional knowledge on the decision making [9,39–41], they do not consider the connection between emotional knowledge and knowledge dynamics, and that between knowledge dynamics and decision making.

The motivation of this paper comes from the need to search the literature and to find how it reflects the influencing power of knowledge dynamics, especially that based on the theory of the knowledge fields, on the managerial decision making process. Identifying a knowledge gap between knowledge dynamics and the complexity of managerial decision making in the literature dedicated to this topic, we formulate the following research question:

RQ: What are the topical structure and the semantic connections between the main concepts and ideas in the literature concerning the influence of knowledge dynamics on managerial decision making?

Thus, our research is based on a semantic literature review and on a bibliometric analysis using VOSviewer [42,43] as specialized software for such type of research. After this introductory part, the structure of the paper, we will present a semantic literature review, the methodology used, results and discussions, and conclusions.

2. Literature Review

Knowledge is a complex concept used in many research domains with different meanings and interpretations [1,44–47]. Aristotle [44] defined three types of knowledge: *episteme*, *techne*, and *phronesis*. *Episteme* refers to scientific knowledge that is everlasting and constitutes a state of the soul. *Techne* refers to craft knowledge that is concerned with production and how to do something. *Phronesis* refers to prudence or practical wisdom in making decisions and implementing them. Prudence is the capacity to grasp the truth and reflect on it, making decisions and initiating actions in concordance with what is good or bad for people. For Plato, knowledge is a result of thinking. "Knowledge consists of reflection, not in impressions, and perception is not knowledge" [48] (p. 153). This line of thinking led Descartes to develop the dualism theory between mind and matter, synthesized in his famous assertion, *Cogito, ergo sum* [48] (p. 564). According to that theory, knowledge is a result of reasoning and not of our senses.

Although there were many philosophers following Aristotle's arguments for explaining the concept of knowledge [1,48], it was Polanyi [49] who argued that perception should be included in the process of knowing. He concluded: "I shall reconsider human knowledge by starting from the fact that *we can know more than we can tell*" [49] (p. 4). Experiential learning [5] and cognitive sciences [50,51] enriched our understanding of the concept of knowledge. Today, it is generally accepted that *knowledge is a justified true belief* if the following conditions are satisfied: "we know something only if we believe it, it is true, and our belief of it is justified" [47] (p. 247). Nonaka and Takeuchi [1] adapted this formulation to their theory of knowledge management, suggesting that *justification* should be considered within an organizational context instead of a theoretical framework.

One of the first seminal papers addressing the issue of *knowledge dynamics* was published by Nonaka [52]. The author proposed a new paradigm for the dynamics of organizational knowledge creation based on the idea of serial conversions of tacit knowledge into explicit knowledge and of expended explicit knowledge into tacit knowledge through the processes of socialization, externalization, combination, and internalization (SECI). Knowledge is created by individuals and then expanded at the team and organizational level through socialization and combination. Socialization is a process of tacit knowledge exchange between individuals. Externalization is a process of transforming tacit knowledge into explicit knowledge at the individual level by using natural or symbolic language. The combination is the process of expanding an individual's explicit knowledge through discussions at the team and organizational levels. Internalization is the reverse transformation of explicit knowledge into tacit knowledge. The SECI model was further developed by Nonaka and Takeuchi [1], and Nonaka, Toyama, and Hirata [53]. The central idea of the SECI model is that "organizational knowledge is created through a continuous dialogue between tacit and explicit knowledge" [53] (p. 14).

Szulanski [54], and Jensen and Szulanski [55] remark that knowledge dynamics implies not only driving forces but also inertial forces, which can be called stickiness metaphorically. "Organizations do not necessarily know all that they know. To a large extent, this is because internal transfers of knowledge, rather than fluid, are often 'sticky' or difficult to achieve" [54] (p. 10). That stickiness contributes to the nonlinear behavior of knowledge transfer processes [56]. Nissen [23] promoted the idea of knowledge flows by extending the SECI method introducing two new dimensions: life cycle and flow time. Although Nissen suggests a connection between knowledge flows and the managerial decision making process, he did not analyze that connection.

Based on literature research, Kianto [34] performs a detailed analysis of the intellectual capital dynamic dimension showing the difficulty of explaining it because most of the authors

have their background in finance and accounting. They see intellectual capital as a stock that is a static interpretation. Kianto [26] shows that in a dynamic perspective, "knowledge is understood as emerging from the ongoing interactions between the organizational members, and the focus is not on the intangible assets per se but on the organizational capabilities to leverage, develop and change intangible assets for value creation" [26] (p. 344).

Although the concept of *knowledge flows* contributed to the theory of knowledge dynamics, it should be observed that the metaphor is based on fluid mechanics and Newtonian logic that is dominated by the idea of linearity and tangibility. Knowledge is not a tangible object, and it does obey linear equations. A new direction of research was opened by Bratianu and Bejinaru [11,25], who conceive knowledge as a field composed of rational, emotional, and spiritual knowledge. Thus, they overcome the limits of tangibility and linearity imposed by all the previous metaphors used in explaining the knowledge concept. Instead of dealing with knowledge flows, we now consider knowledge transformations from one form of knowledge into another. It is much more difficult to explain and understand these transformations, but they reflect in a better way the interactive process between cognition and emotions [6–9,51]. "We have feelings about everything we do, think about, imagine, remember. Thought and feelings are inextricably woven together" [13] (p. 52).

Decision making is the kernel task of any manager. When the activities are well-known and well-structured, decision making follows some rational models based on economic criteria [57,58]. However, when there are new situations or a high level of uncertainty and managers are under the pressure of time, their rational models cannot be used anymore. Managers must use their intuitive minds to provide good enough solutions [31,32,36,38]. In real life, problems have fuzzy formulations, and finding solutions implies both rational and intuitive approaches. As Simon [59] remarks, "intuition is not a process that operates independently of analysis; rather, the two processes are essential complementary components of effective decision making systems. When the expert is solving a difficult problem or making a complex decision, much conscious deliberation may be involved" (p. 61). Intuition is based on a series of patterns developed in time as a result of experience and reflection on it [37,60]. Gladwell calls it the power of thinking without thinking [54]. Intuition is an individual competence, and its distribution within a given organization is a random phenomenon. Knowledge management should be aware of such a distribution to stimulate knowledge sharing and to increase the organizational knowledge entropy [39].

Decision making remains a complex thinking process that needs further research based on the new directions opened by neuroscience and advanced knowledge dynamics models. The key question remains how the decision making process is influenced by rational, emotional, and spiritual knowledge, and by their continuous dynamics. All these aspects less known from the extant literature motivated us to perform a bibliometric analysis of what is known and how they help us to understand the semantic links between the main concepts and ideas related to the connection between knowledge dynamics and managerial decision making.

3. Methodology

We performed a bibliometric analysis of the literature focusing on the influence of knowledge dynamics on managerial decision making using the specialized software VOSviewer developed by Van Eck and Waltman at Leiden University, The Netherlands [42]. The largest part of the research is routed in the co-occurrence investigation procedure, as the method that finds connections and links among concepts and notions that co-occurred in documents' titles, keywords and abstracts, as the only approach that leverage the actual content of the writings to build a resemblance measure [61].

The VOSviewer mapping function creates a two-dimensional map in which items are placed at distances that reflect the similarity between them. The program defines the similarity S_{ij} between two items i and j using the formula:

$$S_{ij} = C_{ij}/W_iW_j,\tag{1}$$

where C_{ij} denotes the number of co-occurrences of items i and j; W_i and W_j denote the total number of occurrences of the items i and j. For instance, if we refer to co-citation analysis, then co-citation is defined as "the frequency with which two units are cited together. A fundamental assumption of co-citation analysis is that the more two items are cited together, the more likely it is that their content is related" [61] (p. 431).

The data retrieval is based on the Web of Science (WoS) core collection, the world's leading information, analytical, and scientific citation search platform [62]. We selected Web of Science as a research database because this paper is a part of a larger research project that uses Web of Science. However, we observed that most of the papers indexed in Web of Science are indexed as well in Scopus.

The retrieval was performed on 05 February 2022, for KD and 30 August 2022, for DM, via an advanced search model, while the retrieval time span was the standard one: 1974/75–2022. The first publications to contain the concept of "decision making" in our search was dated in 1974. We made use of the default and standard values of Web of Science on all the rest of the retrieval settings, while in terms of the document types, we have not excluded any.

We have searched our main and core article expressions: "knowledge dynamics" and "decision making". "Knowledge dynamics", as a research expression, was first captured by WoS in 1991, and the year 2021 represents 4% of the total KD-related publications. However, the "decision making" search on WoS returned 489,250 results, while "decision" brought 1,431,857 outcomes. In this context, we have narrowed the analysis, focused it on its managerial aspect, and researched the expression "managerial decision" (MD) with 1846 results, which was first introduced in 1975 and had, in 2021, a 6.3% share of total related publications (see Table 1). Our further research for this article will be based on KD and MD.

Table 1. Main concepts frequencies and weight on WoS (Source: authors' own research).

Researched Labels	The First Year of Appearance on WoS	Total Number of Publications to Date—on WoS	Weight of 2021 Publications with the Selected Theme within All Years—on WoS
"knowledge dynamics" (KD)	1991	377	4%
"managerial decision" (MD)	1975	1846	6.3%
"decision making"	1974	489,250	10.2%
"decision"	1974	1,431,857	9.2%

The above analyses show the extreme actuality of our research as "decision" and "decision making" drivers are in 2021 at their maximum shared visibility (9.2% and 10.2%).

The literature format for all searches was defined as "all type". The most frequent document type is the article: 241, 64% for KD, and 1299, 70% for MD. At the second position, we have the proceedings paper: 103, 27% for KD, and 440, 24% for MD. The table below lists the numbers and shares of various document types while all data were downloaded on 5 February 2021, and 30 August 2022, in tab separator format (see Table 2).

In terms of the literature origins, the leading analyzed publications came from Romania for KD (64, 17%) and from the USA for MD (32, 4%); however, our study has a global approach relying on the published specialized literature from more than 55 countries for KD and more than 25 for MD. More details are given in Figure 1.

Table 2. Types of retrieved documents for KD and managerial decision on WoS (Source: authors' own research).

| Knowledge Dynamics		
Type of Document	**Frequency**	**Share in total**
Article	241	64%
Proceedings paper	103	27%
Others (books chapters, editorial materials, review articles, early accesses and book reviews)	33	9%
Total	377	100%
Managerial decision		
Type of Document	**Frequency**	**Share in total**
Article	1299	70%
Proceedings paper	440	24%
Others (books chapters, editorial materials, review articles, early accesses, book reviews, letters, notes and meeting abstracts)	107	6%
Total	1846	100%
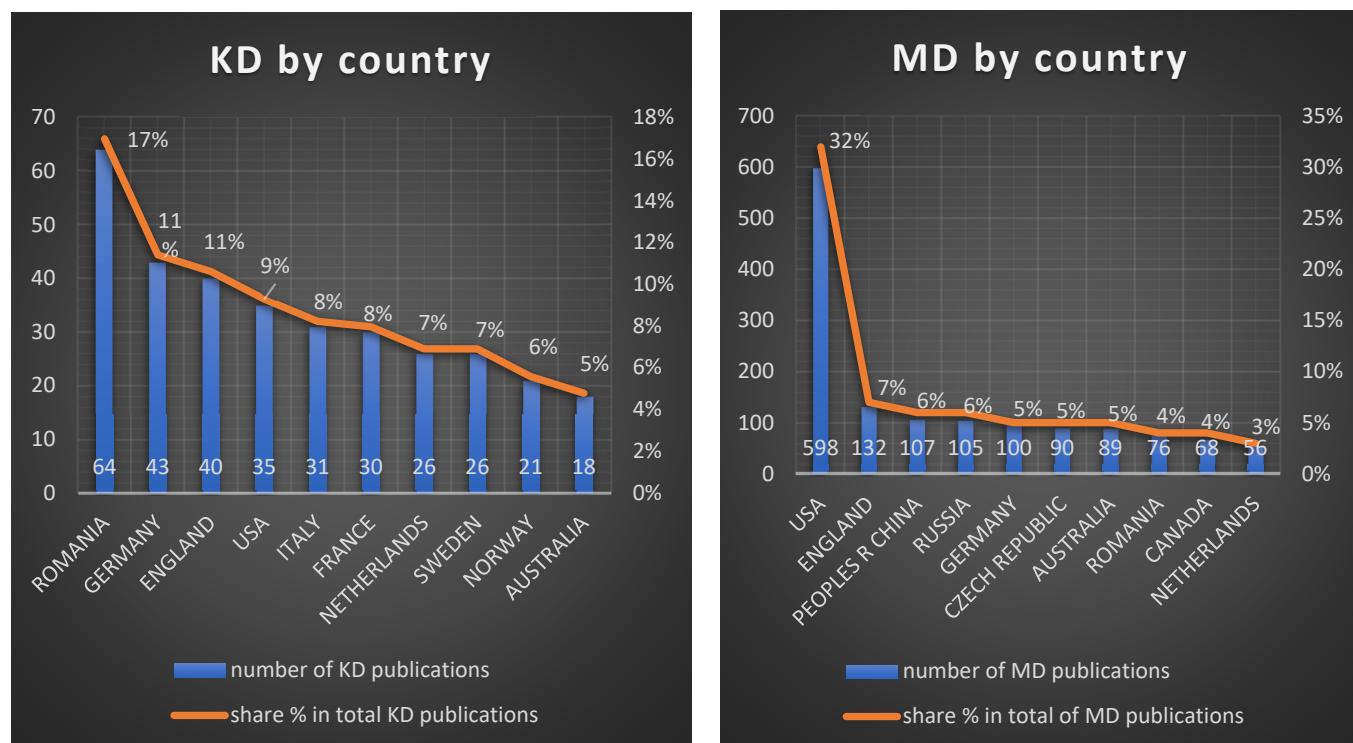
Figure 1. Top 10 KD and MD by country with shares in related publications—by VOSviewer (Source: au-thors' own research).

The most relevant research area is Business Economics for both KD (189; 50%) and MD (1066: 58%), while the main language used is English (accountable for more than 95% of all research on KD and MD). For KD the most influential authors (related to economic fields) are Constantin Bratianu, Ruxandra Bejinaru and Pierre Alexandre Balland, with top publishers: Taylor & Francis, Springer and Elsevier. The most MD relevant authors, also linked to economic topics, are Jeffrey Yi-Lin Forrest, Jeananne Nicholls, Kurt Schimmel,

with Elsevier and Springer as most connected publishers. The tendency shows an increasing number of papers considering the theory of knowledge fields and the knowledge dynamics based on that theory.

A succinct summary of the research protocol is introduced below in Table 3.

We have exported from WoS *complete records and cited references* utilizing *Other Reference Software,* while the bibliometric software VOSviewer (Visualization of Similarities), developed by van Eck and Waltman, was used to process the systematic literature review and to analyze and visualize the co-occurrence of keywords by generating maps embedded on the mentioned bibliographic data and grounded on a *full counting methodology.*

Table 3. Research protocol and characteristics and types of KD and MD research samples *(Source: authors' own research).*

Research Protocol	Description/Explanations
Search expressions	"Knowledge dynamics"; "managerial decision"; "decision making" or "decision";
Search database	Web of Science;
Search fields	All fields;
Type of publications	All types of publications indexed in the Web of Science database;
Subject Areas	All subject areas included in Web of Science, up until 5th of February 2022 for KD/up until 30th of August 2022 for DM;
Timespan	1974/75–2022;
Language	All languages;
Techniques for the bibliometric study	Research field charting (descriptive and performance matrixes via advanced search model) embedded in network analysis;
Software for bibliometric research	VOSviewer

4. Results and Discussions

We were interested in seeing how many papers were published with the focus on the influence of KD on DM. As the query KD + MD returned only five results in WoS, we decided to analyze via VOSViewer KD and MD independently in order to reveal their connections and interdependencies. The keyword's co-occurrence presents the research hotspots in the researched KD and MD fields. The 377 KD-related publications generated 1560 keywords altogether; among them, 92 keywords materialized a minimum of 5 times, accounting for 5.90%. Table 4 presents the keywords for KD and MD, which meet the threshold.

Table 4. KD and MD's keywords meet the threshold (Source: authors' own research).

Searched Expression	Results [WoS]	Number of Keywords [VOSViewer]	Keywords Meeting the Threshold for a Minimum Number of Occurrences of a Keyword of 5	Keywords Meeting the Threshold for a Minimum Number of Occurrences of a Keyword of 2
KD	377	1560	92	358
MD	1846	7007	392	1547

The network graphics are made using VOSviewer software. The size of the nodes and words on the graph represents their weight. The greater the node and word frequency, the larger the weight. The colors represent how closely two keywords are related to one another, and the nodes with the same colors are regrouped into a cluster. The distance between two nodes reflects the strength of the relationship between them. The length of the line describes the relationship between two words and the thickness of the line underlines their co-occurrences level. VOSviewer portrays the keywords of KD-related publications into seven clusters. The green cluster (Figure 2, cluster 2, center-left, 18 items) focused on the main concept of "knowledge dynamics", its model, and its attributes. Below Table 5 exposes this representative second cluster, in green color, to acknowledge the structure and relevant information provided by VOSViewer.

Table 5. KD: Cluster 2 (Knowledge Dynamics): most relevant 14 expressions by VOSviewer (Source: authors' own research).

Term	Links	Total Link Strength	Occurrences
knowledge dynamics; knowledge sharing	82; 13	343; 21	121; 7
knowledge management; knowledge economy	47; 15	106; 17	34; 5
knowledge creation	25	37	11
knowledge strategies	9	11	5
tacit knowledge	37	77	18
explicit knowledge	12	24	8
emotional knowledge	5	20	11
cognitive knowledge	5	16	7
firm; business	43; 13	76; 18	17; 5
learning organization; organizational learning	14; 8	20; 5	5; 5
competitive advantage	20	28	8
intellectual capital	20	29	10
model	34	62	18
strategy	19	27	7

The red cluster (Figure 2, cluster 1, center-left, 20 items) is focused on the knowledge of "geography" and "networks", while the dark-blue cluster (Figure 2, cluster 3, center-up, 16 items) enhances on the "framework" KD matrix as well as on "value creation". The yellow cluster (Figure 2, cluster 4, center, 14 items) regroups the "performance" as KD outcome with "innovation"; while the purple cluster (Figure 2, cluster 5, center-left up, 12 items) combines "technology", "innovation systems" concepts with "entrepreneurship". The sapphire blue cluster (Figure 2, cluster 6, down-left, ten items) focuses on the impact of KD on "collaboration" and "inter-organizational collaboration", while the last cluster in light brown (Figure 2, cluster 7, center-up right, two items) emphasizes on the "education"– "knowledge" relationships.

Analyzing Figure 2 and Table 6, we see that KD is tight to "performance" (link strength 10) and to "management" (cumulated link strength of 25), which are also the most powerful connections of cultural intelligence (CQ). The strong link with CQ was shown previously in similar analyses performed with VOSviewer [63,64]. A more direct link of KD to CQ is, however, underlined by the direct link connection of KD with CQ's attributes in regards to "intellectual capital" (link strength 10) and various "geographies" (cumulated link strength of 7). Nevertheless, the direct link of KD with multicultural leadership's attributes (4) is reflected by a cumulated specific massive link strength of (63): "innovation" (with a cumulated link strength of 37),

"technology" (cumulated link strength 12), "emotional knowledge" (8), "entrepreneurship" (2) and "trust".
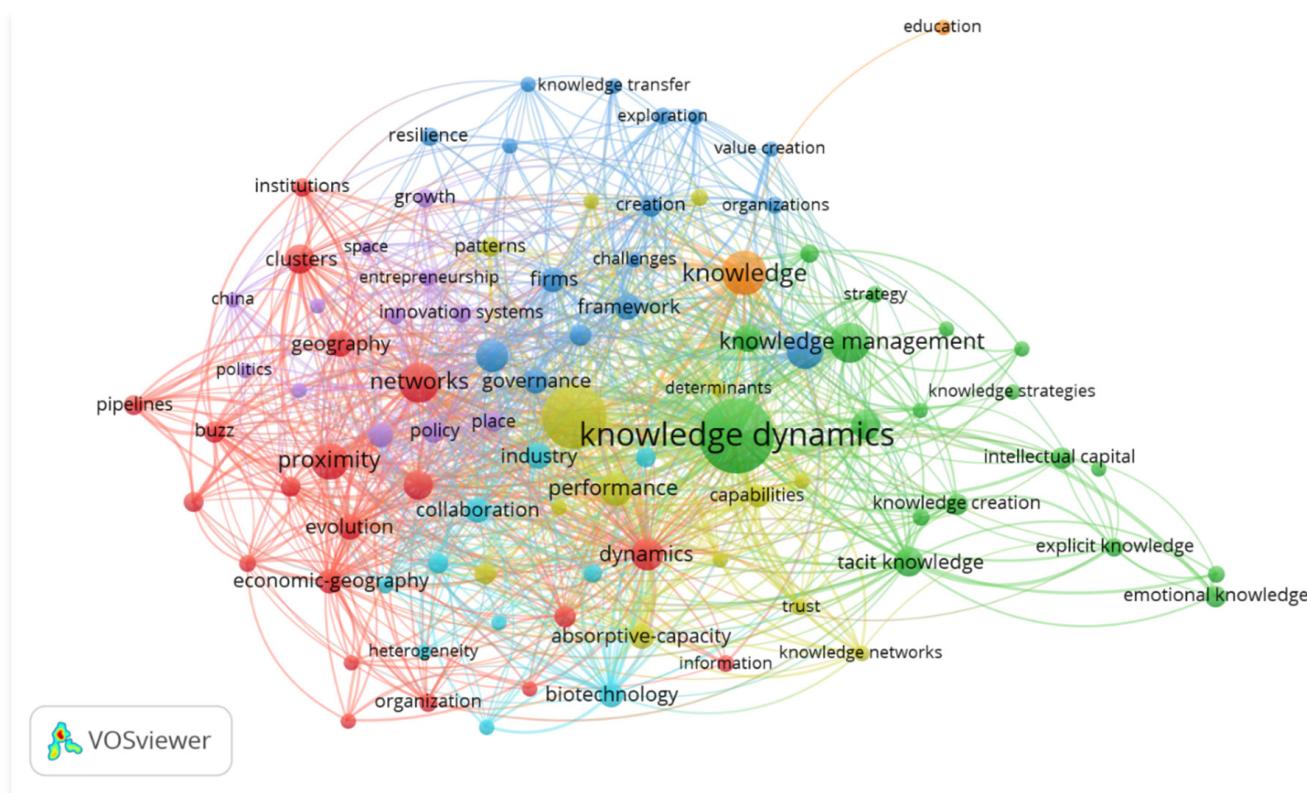

Figure 2. KD: Keyword's co-occurrence network-related publications—by VOSviewer (92 items meeting threshold of 5 occurrences of keywords) (Source: authors' own research).

Table 6. Keyword's co-occurrence network of KD-related publications/Direct links to KD—by VOSviewer (Source: authors' own research).

Item 1	Item 2		Fields	Links Strengths	Cumulated Links Strength
KD	■	innovation	multicultural leadership's competencies	26	63
	■	innovation systems; regional innovation systems; technological-innovation systems		11	
	■	emotional knowledge		8	
	■	entrepreneurship		2	
	■	technology; technological-innovation systems; biotechnology		12	
	■	trust		4	
	■	performance	performance	10	
	■	management; knowledge management	leadership and management	25	25
	■	Intellectual capital	Cultural intelligence (CQ)	10	17
	■	geography; economic-geography; territorial knowledge dynamics		7	
	■	Competitive advantage		2	

VOSviewer presents the keywords of MD-related publications into nine clusters. The orange cluster (Figure 3, cluster 7, center-down, 41 items) is concentrated around "knowledge" "strategy", "innovation" and "dynamic capabilities" as a direct connection with MD. Table 7 presents this seventh representative cluster, in orange color, resulting

from VOSViewer deployment. We have also underlined the common items with KD's cluster 2 (focused on knowledge dynamics) in Table 7 below.

Table 7. MD: Cluster 7 (Knowledge): most relevant ten expressions by VOSviewer—embedded with top items from KD's cluster 2 (Knowledge focused) (Source: authors' own research).

Term	Cluster's Number	Links	Total Link Strength	Occurrences	Same Items/Expressions as in KD's Cluster 2 (Centered on Knowledge Dynamics)	Same or Similar Items/Expressions as in KD's Cluster Number/s:
knowledge	7	166	287	49	Y	N/A
knowledge management;	7	59	83	17	Y	N/A
strategy; business strategy	7	147; 29	275; 34	53; 6	Y	N/A
strategies (cluster 4)	4	116	205	39		
innovation; product innovation; open innovation; radical innovation; technological innovation	7	164; 44; 26; 34; 29	355; 67; 27; 37; 34	65; 11; 5; 5; 5	N	Y (clusters 4 and 5)
perspective	7	123	203	35	N	Y (cluster 1)
business	7	81	102	22	Y	N/A
firm; firms	4	130; 96	226;154	40; 30		
capabilities; dynamic capabilities; organizational capabilities	7	86; 76; 25	152; 122; 35	22; 18; 6	N	Y (cluster 4)
competitive advantage	7	79	148	24	Y	N/A
resource-based view	7	67	119	19	N	Y (cluster 3)
intellectual capital	3	27	32	8	Y	N/A
integration	7	83	135	29	N	N
model; models	6; 3	264	725	157	Y	N/A

This emphasis on the direct connection of these two main notions, KD and MD, underlines the fact that *managerial decisions* are rooted and based on "knowledge" "models", "strategies" and "intellectual capital". Kianto et al. [20,26] studied these connections between knowledge dynamics, decision making and intellectual capital. Nonaka and Takeuchi [1] focus on the wise companies and how knowledge creation dynamics is a key driving force of knowledge management, especially for the Japanese companies. Liu [2] and Massingham [3] analyze knowledge dynamics from the perspective of knowledge management and making decisions. Bratianu et al. [28] focused their research on the entropic knowledge dynamics and its influence on decision making. It is one of the first papers to apply the theory of knowledge fields based on thermodynamics to the managerial decision making process.

The red cluster (Figure 3, cluster 1, center-left, 70 items) is concentrated on the "management" "design" and framework" in relation with MD, while the green cluster (Figure 3, cluster 2, center-right up, 54 items) emphasizes "decision making" and its associated "behaviors". The dark-blue cluster (Figure 3, cluster 3, center-up, 54 items) underlines the "efficiency" of the MD "model". The fourth and yellow cluster (Figure 3, cluster 4, center, 50 items) regroups around "performance" as KD's both trigger and consequence; while the purple cluster (Figure 3, cluster 5, center-left down, 50 items) strengthens the "impact" of "managerial decisions" on existing "systems". The sixth and sapphire blue cluster (Figure 3, cluster 6, center-left, 50 items) focuses on the MD's "model", while the eight cluster in light brown (Figure 3, cluster 8, center-up left, 12 items) emphasizes the "complexity" and "perspectives" of decision making processes. The last cluster in pink (Figure 3, cluster 9,

center-up, 11 items) underlines the "risks" of "failure", the "costs" and the importance of an agile MD "strategic planning".
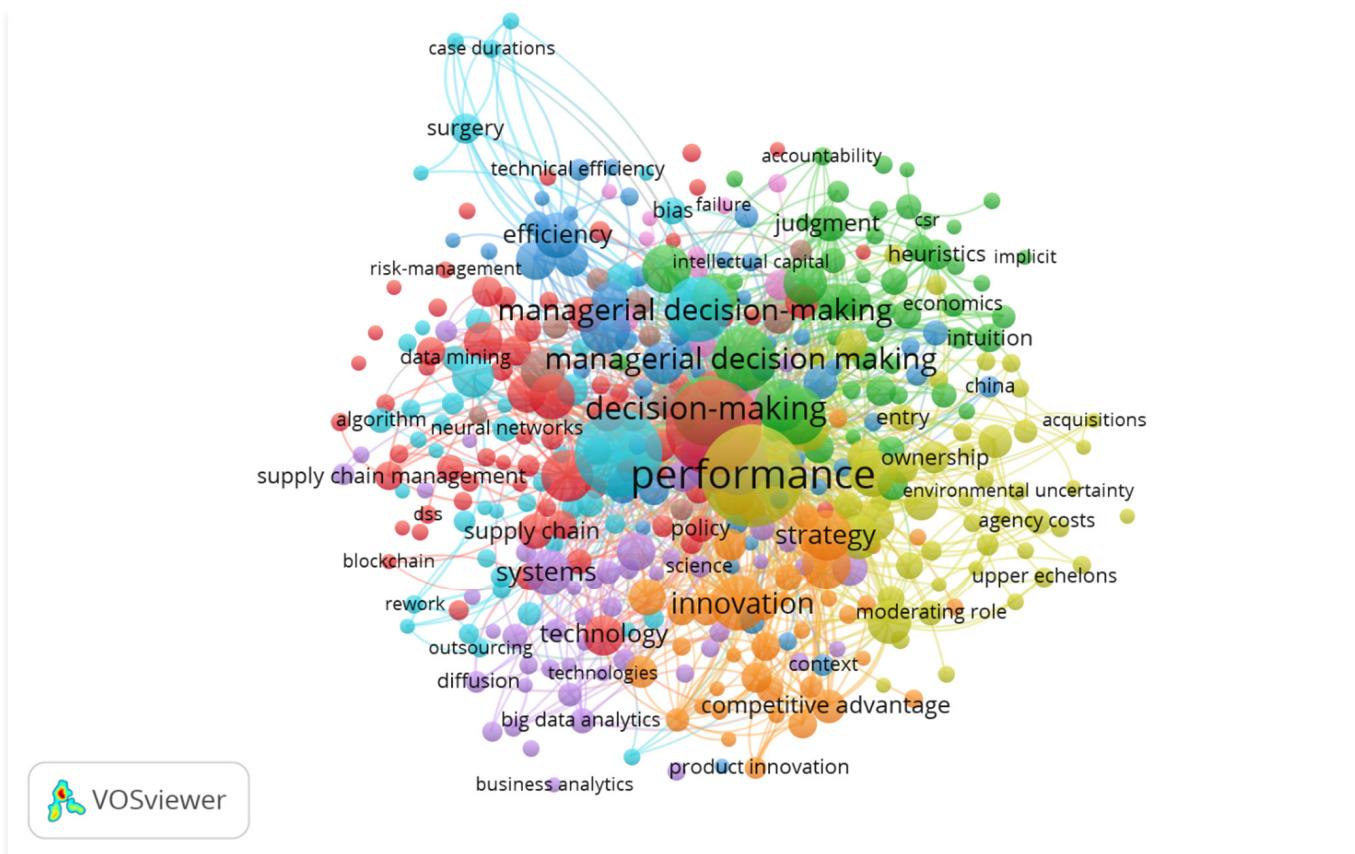

Figure 3. MD: Keyword's co-occurrence network-related publications—by VOSviewer (392 items meeting threshold of 5 occurrences of keywords) (Source: authors' own research).

In the table below, we present the most relevant expressions for MD, as rendered by VOSviewer, in parallel with the top items from KD's map.

KD's number 5th most representative item is "performance" (with a cumulated links strength of 167). Alternatively, "performance" is the number one item in MD (2156). As "performance" is also the main item for cultural intelligence, we can conclude that knowledge dynamics and cultural intelligence are the main performance drivers for managerial decision making processes. All this, in the context in which "management" and "leadership" are occupying the 3rd position in MD and 8th in KD with direct impact on "firms" results (4th place in KD and 10th in MD). As expected, "knowledge" and its synonyms expressions are the first items in KD and the 5th in MD.

"Innovation" ranks 2nd in KD and 7th in MD, while"technology" is in the 7th place in KD and 11th in MD. This underlines the fact that "innovation" and "technology" are embedded into KD and a significant part of the MD processes. Despite a shared "uncertainty", the "trust" remains an essential facilitator in KD and MD (4), and "sustainability" with 9th position in MD starts to be more and more embedded in any managerial decisions. Links strengths are given in Table 8.

This analysis demonstrates the fact that KD is deeply rooted in any MD, and all change processes should contain "data analysis", "knowledge management", "strategic planning", "risk" assessments, and "sustainability". All of these concepts may define the complexity of the decision making in conditions of uncertainty and of its key role in strategizing [65–67].

Table 8. Most relevant MD's expressions, by VOSviewer—embedded with top items from KD's maps (Source: authors' own research).

Rank In MD's Results	Most Representative Results for MD	Field/s (MD)	Total Link Strength (for MD Search)	Cumulated Links Strength	Rank In KD's Results	Most Representative Results for KD	Cumulated Links Strength (KD)
1	performance; firm performance; organizational performance; financial performance; business performance; environmental performance; performance evaluation; performance measurement; performance-measurement	Performance—efficiency—productivity	1174; 257; 88; 92; 22; 51; 24; 65; 32	2156	5	performance; productivity	167
	efficiency; technical efficiency; operating-room efficiency		175; 32; 27				
	productivity		117				
2	network; networks; network design; network idea; analytical network process; neural network; neural-networks	network—system—framework—model	35; 53; 21; 38; 24; 33; 32	1986	3	network; knowledge network; framework; model; systems	414
	system; systems; decision support system; decision support systems		138; 199; 15; 60				
	framework		329				
	model; models; business model; modeling		725; 242; 22; 20				
3	management; operations management; project management; evidence-based management; human resource management; management accounting; total quality management; top management teams; strategic management; earnings management; management-practices; supply chain management; risk-management; risk management; environmental-management; crisis management; manager; managerial; CEO	management—leadership	962; 77; 27; 21; 21; 30; 25; 42; 86; 48; 54; 86; 28; 81; 54; 14; 15; 31; 32	1818	8	management	108
	leadership		84				

Table 8. *Cont.*

Rank In MD's Results	Most Representative Results for MD	Field/s (MD)	Total Link Strength (for MD Search)	Cumulated Links Strength	Rank In KD's Results	Most Representative Results for KD	Cumulated Links Strength (KD)
4	decision making; decision making; ethical decision making; group decision making; decision analysis; decision support; multi-criteria decision making; decisions; management decisions; managerial decision making; managerial decisions; management decision making; managerial decision; managerial decision making	decision making	270; 454; 22; 25; 16; 17; 24; 79; 4; 256; 36; 2; 50; 368	1623	-		
5	knowledge; knowledge management	knowledge—information—data	287; 83	1302	1	knowledge dynamics; territorial knowledge dynamics; knowledge management; cognitive knowledge; emotional knowledge; explicit knowledge; knowledge creation; knowledge economy; knowledge sharing; tacit knowledge; knowledge transfer; knowledge flows; knowledge basis; information	811
	information; information systems; information-systems; information technology; information-technology		365; 25; 49; 44; 60				
	data mining; data analysis; data envelopment analysis; data envelopment analysis idea; big data; big data analytics		34; 26; 141; 26; 65; 97				
6	strategy; strategies; business strategy; strategic planning; strategic change	strategy	275; 205; 34; 11; 45	570	N/A	strategy; knowledge strategies	38
7	innovation; open innovation; product innovation; radical innovation; technological innovation	innovation	355; 27; 67; 37; 34	520	2	innovation; innovation systems; regional innovation systems; technological innovation system	440
8	impact	impact	499	499	N/A	impact	31
9	sustainability; sustainability development	sustainability—CSR	184; 48	485	-		
	CSR		39				
	corporate social responsibility; corporate social-responsibility		70; 144				

Table 8. *Cont.*

Rank In MD's Results	Most Representative Results for MD	Field/s (MD)	Total Link Strength (for MD Search)	Cumulated Links Strength	Rank In KD's Results	Most Representative Results for KD	Cumulated Links Strength (KD)
10	firm; firms	firm—business	226; 154	482	4	firm; firms; business	179
	business		102;				
11	technology; technologies; technology adoption; cloud computing; mechanisms	technology	181; 34; 49; 34; 37	335	7	technology; biotechnology	148
12	risk; risk perception; risk-taking; risk analysis	risk	209; 28; 61;10	308	-		
13	behavior	behavior	291	291	-		
14	determinants	determinants	277	277	N/A	determinants	22
15	competitive advantage; competitiveness; competition	competitive advantage	148; 27; 92	267	N/A	competitive advantage	28
16	uncertainty; environmental uncertainty	uncertainty	200; 50	250	-		
N/A	dynamics; system dynamics;	dynamics	100; 68	168	6	dynamics	149
N/A	trust	trust	118	118	N/A	trust	42

5. Conclusions

The present paper has two main objectives: (a) to search the literature in order to understand the evolution of the semantic spectrum of the concept knowledge dynamics and its influence on managerial decision making; (b) to perform a bibliometric analysis to reveal the attention paid by researchers to this topic and how they explored the connection between knowledge dynamics and managerial decision making. The first objective showed an interesting evolution of the knowledge dynamics semantic from the Newtonian interpretation of dynamics to the thermodynamics understanding. From a Newtonian's perspective, knowledge dynamics is defined in terms of knowledge flows and knowledge stock's variation in time. Both interpretations are very simple and intuitive, but they transfer from the meanings of the physical objects related to linearity and tangibility, which create serious limitations in knowledge management decision making. The theory of knowledge fields and knowledge dynamics based on neuroscience and thermodynamics overcomes those semantic barriers. Knowledge dynamics is not conceived in terms of knowledge variation in time and space but as a transformation from one form (i.e., rational, emotional, and spiritual) into another one. This interpretation sheds light on the fact that decision making is not purely rational, but emotions and values influence it. However, the number of papers indexed in Web of Science analyzing these phenomena is very low for a deeper analysis.

To overcome this difficulty, we defined a second objective focusing on the bibliometric analysis of the papers dealing with knowledge dynamics, decision making, managerial decision making, and all possible connections between their attributes. The bibliometric analysis was carried out with the specialized software VOSviewer and offered interesting data concerning the evolution of research and its distribution in time and within main geographies. Although the number of papers focusing directly on the influence of knowledge dynamics on decision making is very low, by searching the two topics separately, we analyzed how their attributes link together and how strong these links are. The data presented synthetically in tables and illustrated in some significant figures show strong links between knowledge dynamics and managerial decision making.

The contribution of the present study comes from the fact that it is the first one to review the literature dedicated to knowledge dynamics that includes the recent development

of the entropic model of knowledge dynamics based on the theory of knowledge fields. Also, the bibliometric analysis shows the distribution of papers on countries, publishers and authors in this domain. The graphical illustrations offer a better view of the clusters constructed within the semantic ecosystems of the concepts "knowledge dynamics" and "managerial decision making".

The main limitation of the present research comes from using only Web of Science as a database. Further research should include Scopus and Google Scholar to enlarge the area of publishing papers in international journals and proceedings of conferences, as well as books.

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