

Article

# Conceptualisation of the Three-Dimensional Matrix of Collaborative Knowledge Barriers

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**Abstract:** Nowadays, collaborative knowledge management (CKM) is well accepted as a decisive asset in the field of networked enterprises and supply chains. However, few knowledge management initiatives have been performed successfully because, in most cases, the barriers that hinder the CKM process are unknown and misunderstood. Currently, the research reveals different uni- and bi-dimensional barriers' classifications, however multi-dimensional approaches provide a better view of the complexity in the area of CKM. Therefore, this paper proposes the three-dimensional matrix of collaborative knowledge barriers taking into account: (i) perspectives; (ii) levels and (iii) barriers blocks to provide a reference way to audit the CKM barriers, and thus, in further research, focus on the corrections and adjustments to guarantee the success while implementing a CKM project.

**Keywords:** collaborative knowledge; barriers; framework; three-dimensional matrix; perspectives; levels; blocks

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## 1. Introduction

Globalisation has led organisations to form alliances and to develop partnerships with other entities (customers, suppliers, distributors, government, and even competitors) which have different experiences, languages, cultures, strategies and contexts to respond to changes in the environment in an agile and flexible way, to reduce costs and save time, and to deliver customer-oriented products and services in a sustainable way. Rajabion et al. [1] state that effective organisations are those who can create and distribute the knowledge rapidly and can use the created knowledge for designing new products for consumers. However, not only the design of new products, collaborative knowledge (CK) is instead a strategic asset that contribute to expand the cognitive capacities of individuals, organisations and supply chains to solve complex problems.

Nowadays, CK management (CKM) is well accepted as a decisive asset in all the enterprises [2] for business survival and sustainability [3]. However, according to the literature, few knowledge management initiatives have been performed successfully in the field of networked enterprises and supply chains because, in most cases, the barriers that hinder the CKM process are unknown and misunderstood. This is also corroborated by [1] who state that designing a strong system to improve performance and facilitate relationships in supply chains is a challenge, and the authors suggest that future studies should address barriers in networked enterprises and supply chains. For this reason, the objective of this paper is the identification of the barriers involved in the CK process, considering four level (individual, intra-, inter- and extra-), from five different perspectives (human, organisational, technological, contextual and informational) and aggregating the identified barriers

into four blocks (trust, management, environment and means). With this, the paper aims at proposing the three-dimensional matrix of collaborative knowledge barriers (CKB) to provide a practical framework for academics and professionals wishing to diminish the CKB impact and enhance the CKM process.

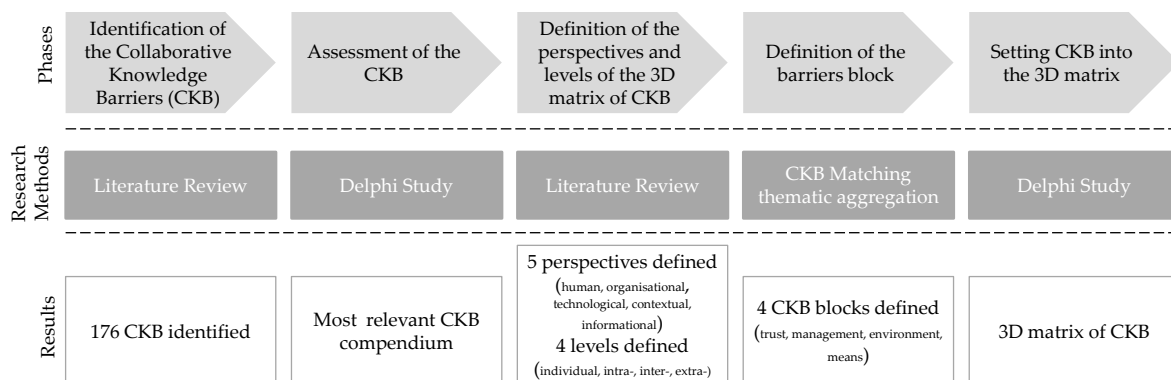
The paper is structured as follows: Section 2 presents the research procedures adopted in this paper. Section 3 describes the main dimensions of the three-dimensional matrix of CKB based on the literature review. Section 4 proposes the three-dimensional matrix of CKB describing each of the identified and framed barriers in detail. Finally, Section 5 presents the main conclusions of this paper and proposes the following steps in the research.

## 2. Research Methodology

The first methodological step of this research was a literature review. Sets of keywords were defined to perform searches in the Web of Science database. The terms used were: “collaborative knowledge”, “knowledge transfer”, “knowledge sharing” and “barriers”. With this literature review 176 barriers were identified based on the works of [2,4–11]. However, some of them were repeated or very similar and then they were aggregated making a total of 96 barriers. Once that the barriers formulation was concluded, and in order to frame these findings, a Delphi study was performed. Based on the Delphi phases defined by [12], the choice of experts was performed. To do so, the selection was mainly driven by the experts’ experience in knowledge management in collaborative contexts. Besides this, the choice attempted to involve different profiles (academia, industrial, consultants...), countries, knowledge domains and background. The experts’ identity was treated anonymously during the study to guarantee the respondents autonomy. This phase was based on the preparation and launching of questionnaires. Experts had to assess the importance of each barrier in a 5 point-Likers scale. In three iterative rounds, the compendium of the most relevant CKB was performed.

The following phase was to define the perspectives and levels of the framework to classify the different CKB identified in the previous phase. This was based on an exhaustive literature review. The missing dimension of the three-dimensional framework is the CKB Blocks. To perform this phase, an analysis of similitudes (based on thematic matching) was developed with the objective of aggregating the barriers into different blocks to have an organised and holistic framework in form of a three-dimensional (3D) matrix. Section 3 shows a more detail description of the three dimensions considered in the framework proposed (perspectives, levels and barriers blocks). As aforementioned, the first two dimensions were identified based on an exhaustive literature review while the barriers blocks were defined based on the barriers aggregation study according to thematic matching.

With the definitive collection of barriers, in a second Delphi study, experts proposed and assessed the CKB setting into the 3D matrix. Figure 1 shows an outline of the research phases, methods and results of the methodology used.



**Figure 1.** Research methodology for the conceptualisation of three-dimensional matrix of CKB.

It is worth mentioning that some of the CKB could affect different levels, however, they have been located according to the three-dimensional matrix of CKB in the most representative level based on the Delphi study results. For example it is the case of the organisational perspective of the barriers' block of management and which the main barrier is related to the self-interest. At the individual level, the self-interest is focused on the relationships among the personnel of a company while at intra-collaborative, this barrier is related to the fulfilment of functional units' objectives instead of the company's objective. In the same line, at the inter-collaborative level, each entity of the supply chain is focused on its objectives regardless of the overall objective of the supply chain. In the case of extra-collaborative level, this barrier is characterised by the dilution of interests that prevent different supply chains from consensus on common objectives.

### 3. CKM Dimensions

A great deal of controversy has been generated in relation to the definition, description and characteristics of CK. Many authors use different terms as an equivalent form such as knowledge transfer, knowledge induction, knowledge sharing, knowledge communication [13], knowledge exchange [14], among others. For instance, some authors define the knowledge transfer concept similarly to the way they do with CK, and they define it as the transfer of knowledge between its origin and destination within a specific context [15–17]. In this case, however, it is generally perceived that knowledge transfer only comprises the uni-directional field. Knowledge induction [18] is another form of defining CK, which is understood through observation and experience as the way to obtain the general principle that it is implicit. This definition has an intrinsic meaning which is related to the need for a leader who has certain conviction or influence to bring collaboration to a successful conclusion. In this research therefore it was considered appropriate to use the term CK, which is defined as efforts made between two entities (people, organisations, supply chains, etc.) and which takes place when a group of autonomous participants have a common problem and operate synergistically in a process to create and apply knowledge [19]. In this case, the term CK encompasses the idea of operating collectively and willingly to share knowledge, especially for the purpose of accomplishing a common goal both bi-directionally and reciprocally, and without the persuasive power of any participant who is in complete control. This definition is also aligned with the term knowledge sharing and in this study, they have been treated synonymously. A detailed review about the differences among knowledge transfer, knowledge sharing and knowledge barriers could be found in [20].

Yet in the collaborative process of knowledge management, we come across a large number of barriers which complicate and hinder the collaboration process from being accomplished. The main objective of this work is an in-depth study of each and every associated barrier to obtain a better understanding, so that once all the main barriers are known in a CKM project, the appropriate measures can be taken to avoid their negative effects. To go about this, a classification matrix using the following dimensions has been developed:

- Perspectives in CKM.
- Levels of CKM, including the extra-collaborative level among the various supply chains as an innovative element.
- Blocks of general barriers which encompass the different problems associated with collaborative management.

#### 3.1. Perspectives of CKM

Diverse disciplines such as cognitive anthropology, cognitive and behavioural science, and psychology [21], organisational management, sociology, philosophy and information science, have studied the different perspectives of the CK process, where the most important are the human and technological ones. While the human perspective is not a matter of discussion among the scientific community, since a consensus has been reached that knowledge resides in people, the technological perspective presents certain discussion. Some authors state that one of the most common errors that

occurs in CK is to confuse knowledge barriers as purely technological problems. In general, the first intention to manage knowledge is to generate technical solutions for a problem that has a real factor of human dependency. The vast majority of the references in the literature, argue that technology is merely the enabler of knowledge management, but it cannot provide an optimal way to manage the knowledge by itself. Therefore, it is vital to balance both perspectives.

In the present-day scenario which, characteristically, is highly dynamical and where knowledge chains are the genuine trend by stressing CK, other perspectives are required to be able to analyse the problems from all viewpoints. In this way, it is possible to go deep into their characteristics and properties with a view to being able to attack their causes and, in this way, to eradicate their effects.

The classification of intra-and inter-organisational barriers developed by Brandt and Hartmann [22] is based on three perspectives called Technology, Organisation and People (TOP). Therefore, apart from the two perspectives related to CKM which are par excellence, technological and human perspectives, the TOP approach adds a third dimension, this being the organisational perspective. Factors such as organisational structure, communication flows, strategy, etc., are the main agents which greatly influence CKM and, depending on the organisational perspective characteristics, they present a typology of one problem or another [4]. A characterisation of the different perspectives from which the CKM process could be analysed is presented in Table 1.

**Table 1.** Perspectives of the CKM.

Perspectives	Description
<b>Human</b>	This perspective involves the personnel being part of the entities involved in the CKM process. Aspects such as the skills, abilities, fears, among others define this perspective.
<b>Organisational</b>	This perspective concerns the factors that shape an ordered and structured system such as funding, investment opportunities of income. equipment, facilities, employees, target audiences, patents, copyrights, trademarks, programs, software systems, and department hierarchies of an organisation.
<b>Technological</b>	This perspective refers to tools, strategies, mechanisms and machines that may be used to facilitate (i) the real-world problems solving; (ii) the decision-making procedures and (iii) the CKM process.
<b>Contextual</b>	This perspective considers the facts and events that surround the CKM system. Aspects such as: environmental issues, competitors, regulations, among others are factors influencing the CKM process from this perspective.
<b>Informational</b>	This perspective concerns relevant data that has meaning in some context for its receiver. Some aspects such as accuracy, opportuneness, relevance, appropriateness, comprehensiveness, explicitness, impartiality are part of this perspective.

Human resources and technology are the main perspectives used in the field of knowledge management. Based on [22] the organisational perspective is also considered as an important view from the CKM. However, it is important also to pay attention to other perspectives such as the context in which entities operate and the information characterisation of the CK process.

The informational perspective covers the organised collection of data and information which constitute the knowledge of a particular entity or phenomenon. Davenport and Prusack [23] point out that most people have an intuitive sense about knowledge being wider, deeper and richer than data or information. Nonaka and Takeuchi [24] state that information is a flow of messages, while knowledge is created by the same flow of information, based on the beliefs and the commitment of its possessor. Considering the joint collection of data-information-knowledge, the last dimension emerges from the effective management of the two previous ones, and it is the informational perspective which encompasses such concepts [25].

Finally, it is worth mentioning that enterprises and supply chains are not individual and isolated entities, they work under circumstances and conditions which surround them. Nonaka and Takeuchi [24] stated that knowledge is context specific and relational. Consequently, it is important

to consider the context as an additional perspective [26] to include political, social, historical, and cultural factors, among others, that shape the way enterprises know and understand reality.

### 3.2. Levels of CKM

It is very important to manage CK at all levels in networked enterprises. Segmentation at levels is done to facilitate the study of the different characteristics of each segment. The CK levels are related to the different segments in which the management is performed.

Numerous references about different knowledge level divisions have been found in the literature. Nonaka et al. [27] classify knowledge management resistance into individual impediments and organisational obstacles. Argote et al. [28] state that knowledge transfer/distribution occurs at various levels: transfer of knowledge between individuals, from individuals to explicit sources, from individuals to groups, between groups, across groups and from a group to the organisation at large. Gupta et al. [29] suggest that the CKM process takes place at five different organisational levels: individual-dyadic, project/team, community of interest/practice, organisational and inter-organisational.

The most basic form of knowledge management within an organisation occurs internally on an individual level. At the same time, these individuals reflect the effort that one individual has to make to overcome oneself in order to face new challenges, obligations, changes, and even personal insecurity.

The intra-collaborative level refers to the knowledge management-related activities done within an organisation's limits. In this research, it is considered that teams must be included within this level. This is justified by the works of Gray and Wood [30] and Roberts and Bradley [31], who state that teams belong to a specific domain with shared objectives, and that they are formed during predefined periods of time to accomplish a particular goal. Knowledge management at the intra-collaborative level is defined as joint organisational structure management, whose aim is to fulfil a mutual mission in which all the participants are immersed in management planning and work with well-defined communication channels. Resources collectively act and operate as a 'whole', and share the resulting profits [32].

Presently, the trend to be followed by those organisations which attempt to be agile and flexible to swiftly respond to customers' requirements and to properly adapt to the changes imposed by the dynamism, is knowledge management at the inter-collaborative level. At this level, cooperation is voluntary and organisations combine resources to face uncertainty, to create new products, among others [33,34].

Yet the future trend does not merely boil down to CK among organisations, rather it extends beyond these limits and includes whole supply chains. The hypothesis of this research is based on defining the level when two supply chains, which operate independently, need or wish to collaborate voluntarily to achieve a mutual purpose. Would this be the inter-level? Or would another level need to be defined? After thoroughly studying the literature, we came to the conclusion that the characteristics of a superior collaboration level would differ from the properties of the inferior levels, and all this has led to the definition of a superior level being necessary to be able to study the supply chains' future collaboration trend. This level has been named the extra-collaborative level based on the initial research performed by [35]. However, a holistic framework to frame the complete views is necessary. The reason for the name of this level is due to the progressive use of the prefixes in the two previous cases, as indicated in Table 2.

**Table 2.** Prefixes of the CKM levels.

Intra-	Inter-	Extra-
Interior	Among	Exterior

Therefore, this research work encompasses the following levels of collaboration: individual, at which CKM is established among individuals; the intra-collaborative level of knowledge management (interior), at which collaboration is carried out in an organisations' functional limits

(examples of this level are the management among departments, business units, functional areas, teams, projects, etc.); inter-collaborative level (among), at which different organisations are understood to be a whole, that is, those that promote CKM (examples of this level are the relationships established among the firms that form part of supply chains). Finally the new level, known as extra-collaborative (exterior), defines the relationships among the different supply chains, where supply chain is understood as a whole (examples of these collaboration relationships are supply chain-supply chain, supply chain-end customers, supply chain-public administrations, etc.).

### 3.3. CKB Blocks

Many existing organisational, political, and technical factors may posit serious barriers to the effectiveness of CK [4]. For Wunram et al. [36], a barrier of knowledge management is anything related to human, organisational and/or technological issues that obstructs the intra- and inter-organisational management of knowledge. Based on the previous levels defined before, this definition is extended with a superior level of collaboration and two additional perspectives, thus our definition of a CKB is anything related to human, technological, organisational, informational and contextual perspectives that obstructs the individual, intra-, inter- and extra-collaborative levels of knowledge management.

In addition, given the large number of barriers found in a CKM process, the different barriers have been divided into blocks which will, in turn, be divided for further study and better understanding. Based on an analysis of the thematic uniformities among the compendium of barriers identified, and based also in the literature review, four blocks were defined to aggregate the most representative barriers. A summary of the four barrier blocks proposed with the common thematic features is presented in Table 3.

Therefore, the main purpose of the present paper is to identify and frame the most significant barriers in the process of CKM in networked enterprises by using three aspects (i) perspectives in the CKM process; (ii) levels of CKM, including extra-CK level as an innovative concept, and (iii) barrier blocks that obstruct the CKM process.

**Table 3.** Aggregation characteristics by barrier block thematic matching.

Block	Thematic Characteristics
Trust [29,37]	Fear, disbelief, apprehension, scepticism, copy and imitation, inflexibility and complexity
Management [4]	Vulnerability, doubtful attitude, self-interest, incompatibility, demotivation, disorder, leadership, misalignment
Environment [38–41]	Instability, imbalance, limitations, blindness, rivalry
Means [42]	Invisibility, wastage, obsolescence, unstructuredness, unavailability

In the field of CKM in networked enterprises, the first form of action is to increase the awareness of the causes and effects of CKM barriers. All entities involved in a CKM network might feel truly motivated and recognize the real benefits of a CKM process. Once firmly convinced that the results will be excellent and that they confer a competitive advantage over the competitors, it is vital to carry out a successful CKM project. Moreover, an identification and a comprehensive knowledge of all the issues hindering this process will help to avoid their effects. Networked enterprises should foster an innovative vocabulary, the search for a common climate, behaviour patterns in tolerance with all the proposals, and a host with no limits of time and space, in order to overcome CKB.

## 4. Three-Dimensional Matrix of CKB

Researching the literature, KARE Project [43], CORMA Project [44], Szulanski [45] and Riege [5], reveals different uni- and bi-dimensional barriers' classifications, however multi-dimensional approaches provide a better view of the complexity in the field of CK.

Therefore in this paper, the Cartesian perspective that provides orthogonal dimensions, evolves to a three-dimensional perspective of the CKM problems. Examples of three-dimensional classifications are depicted in the literature, like the case of CIMOSA with its 4×3×3 graphical representation which provides one of the most popular enterprise modelling architectures [46]. For example, Garlasu et al. [47] represent their studies related to e-learning with a three-dimensional cube based on the CIMOSA reference architecture.

Based on the previous three-dimensional structures, a distribution of the three CKM dimensions is developed to build the three-dimensional matrix of CKB (Figure 2).

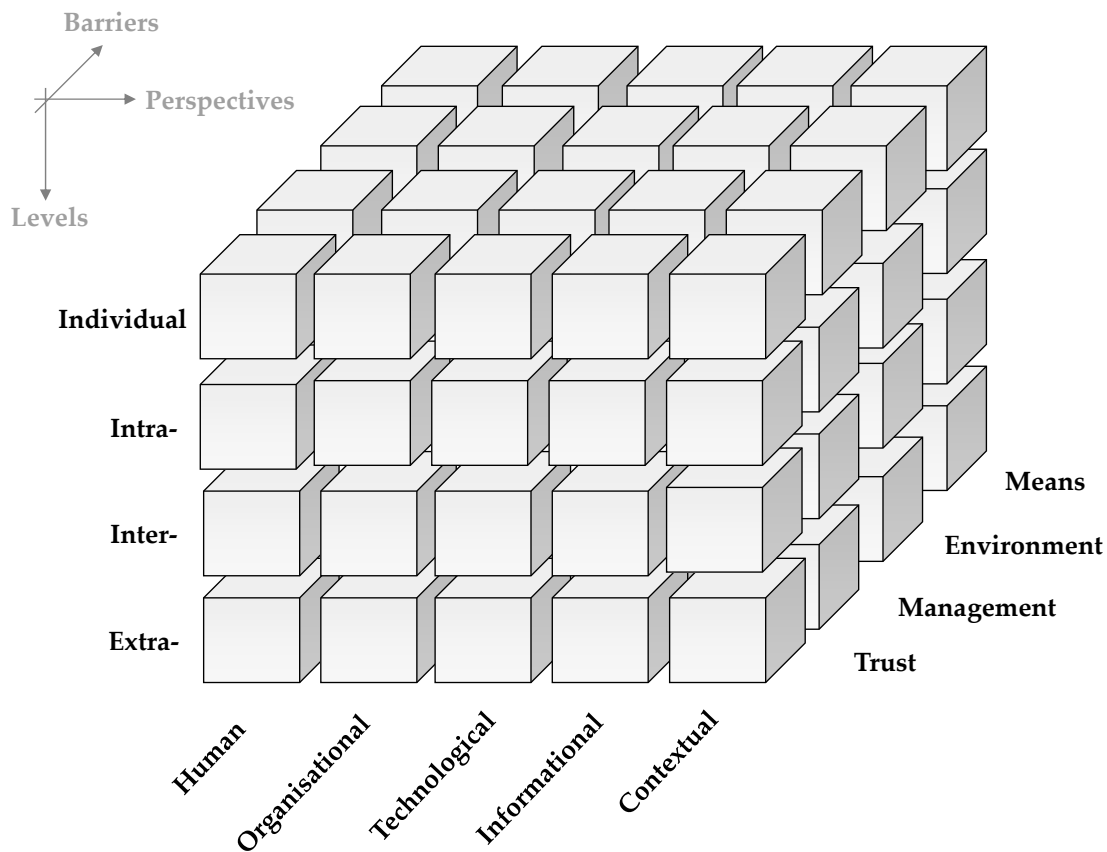


Figure 2. Three-dimensional matrix of the CKB.

This matrix is neither a rigid framework nor a mere classification, quite the opposite as it can be expanded with new levels, perspectives or CKB blocks. The advantage of the matrix is that, depending on the future needs of organisations, new dimensions can be integrated in order to study each cell of the matrix in detail. In addition, it is important to stress the differences depending on the perspectives because, for example, the characteristics of the lack of trust block will not be the same from the technological perspective as from the human one. Therefore, the development of a detailed description of each barrier is necessary to recognise what their impacts at each level and for each perspective are.

#### 4.1. Trust Barriers Block of CK

The trust barriers block, represented in Table 4, is one of the most intangible blocks since it is characterised by fears, insecurities, doubts and suspicions.

**Table 4.** Description of the trust barriers block.

	<b>Individual</b>	<b>Intra-</b>	<b>Inter-</b>	<b>Extra-</b>
<b>Human</b>	Fear of the unknown and non-recognition.	Organisational resistance to change. Fear of non-recognition.	Fear of copying and imitation.	Lack of the network organisation/management.
<b>Organisational</b>	Disbelief of expected results.	Lack of confidence in the CK process.	Fear of losses of time and unsuccessful results.	Greater complexity in relationships. Chaos.
<b>Technological</b>	Invisible dimension.	Overrating technological solutions.	Unrealistic expectations of the technological systems' functions.	Uncertainty about security aspect of the technological solutions of other entities.
<b>Contextual</b>	Differences in age, gender, level of education, etc.	Rigid hierarchical system. Propriety of knowledge.	Propriety of knowledge.	Widespread scepticism
<b>Informational</b>	Fear of sharing information.	Differences in mental models among the different departments and information accuracy.	Fears of information veracity. Dissipation of intellectual rights.	Apprehension about information credibility. Problems related to confidentiality and knowledge protection.

#### 4.1.1. Trust/Human

Fear of the unknown is a common characteristic of individuals when they face new challenges. Considering the CKM as a new target to achieve, individuals wonder why the current management system must change if this system works more or less well for another system in which the benefits obtained or the means to achieve them remain unclear. For most individuals, having to incorporate changes into their work involves an important adjustment in their identity. Given the close link between identity and knowledge, individuals often oppose new or unknown aspects [27]. Moreover, the fear of not receiving just recognition and accreditation from managers and colleagues is also an important barrier at this level [5].

This fear is translated also into the intra-CKM level with the suspicion that the contribution of a functional unit is not recognised by the global enterprise and, therefore, the efforts implemented in the development of a CKM model are diluted [48]. Moreover, Zhang et al. [4] state that CK initiatives represent a new way of thinking, and require radical process and organisational behaviour changes. Commonly, organisations resist change what discourages the CK process [10].

Barriers at the inter-CKM level are also based on mistrust of the loss of competitive positioning in the market due to fears about their best practices, knowledge and know-how being copied or imitated by ones competitors. Because of the knowledge transfer taking place from some organisations to others within a CKM project, organisations are exposed to their competitors acquiring skills from their key processes and, therefore, from acquiring their know-how that sets them apart and which confers them competitive advantages [49–51]. This has been defined by [52] as opportunistic behaviour and appropriability hazards [53] and it is one of the most important barriers at this level since mistrust translates into a tremendous resistance to collaboration between organisations.

Finally at a superior level, doubt focuses on the fundamentals of the CKM process. The extra-CKM level is characterised by a network of entities, organisations, end customers, other supply chains, public administrations, etc., and its orderliness is difficult to organize appropriately. The complexity of the network relationships is a threat for a successful CKM project.



#### 4.1.2. Trust/Organisational

From the organisational perspective, barriers focus on the individuals' disbelief of the benefits resulting from implementing a CKM process that is supported by [5].

Lack of confidence, openness and complicity between the different business units and/or departments will jeopardize the CKM project at the intra-CKM level [54] due to the atmosphere of distrust about the CK outputs.

The fear characteristic moves to a superior level and is characterised by a feeling of loss of time and control. If an entity does not comply with the prerequisites established, the contributions of the other entities will not be those expected, and they will not achieve the initially expected global targets.

Finally, the extra-CKM level is characterised by the summation of the barriers encountered at inferior levels, and in addition, the great complexity of the relationship among the different networks leads to a chaotic situation in which the necessary confidence to bring the collaboration to fruition is severely damaged [55,56]. Balle et al. study's main contribution highlights the complexity of inter-organisational knowledge sharing regarding the nodes and ties in knowledge networks [57] what is even more complicated in the extra CK level.

#### 4.1.3. Trust/Technological

The technological perspective has a twin barrier. First of all, it is acknowledged that technological systems only complement personal networks of those who seek solutions to their problems. No matter how robust the searches or how personalised the databases, the human relations network often determines the knowledge that it contains [58]. Secondly, the invisible dimension characteristic of the technological systems means that individuals are reluctant to make their knowledge explicit.

At a superior CKM level, there is a tendency to overestimate the technological solutions implemented. When the results are not those expected, lack of motivation and incentives affect the CKM process.

Mistrust in the unrealistic expectations of the technological systems functions makes organisations feel disappointed with their investments, and they reject the new solutions implemented to return to their traditional systems [59]. At the extra-CKM level in many cases, insecurity of technological applications, focused on security aspects, means that the CKM initiatives do not exceed the emerging stages of implementation [48]. Current technologies such cloud computing facilitates the process of CK, however it implies to be more exposed to technological threats. At this extra-collaborative level, all the entities involved in a CK process should guarantee and protect the confidentiality, availability, and integrity of the knowledge [60].

#### 4.1.4. Trust/Contextual

Differences in age, gender, level of education, are a major barrier at the individual CKM level of the contextual perspective. Such differences make some participants of the CKM project feel uncomfortable with their workmates [5]. Therefore, feelings of mistrust and apprehension emerge during the process.

The literature review revealed that there are two types of organisational structure: mechanistic and organic [61]. The results show that in a relatively stable environment, organisations tend to have a mechanistic conception. This type of organisation has a highly hierarchical structure, that is, formal management operations with centralised authority, a large number of rules and procedures, a precise division of labour, and formalised coordination. While organisations operate in an unstable environment that is full of uncertainty, they usually acquire an organic design which is characterised by a less formal structure and hierarchy. Their organisational design has a less precise concept of the division of labour, more decentralised authority, and fewer rules and procedures [62]. Therefore according to the mechanistic organisational structure, the characteristics of a rigid hierarchical system raise barriers at the intra-CKM level because of the inflexibility of the relationship among the

strategic, tactical and operational levels. This concept was studied by [63] and is called 'tight coupling'. Rigid hierarchical structures, highly centralised decision-making and extremely formal rules and procedures produce tight coupling what threaten the CKM. This type of organisations is excessively inflexible and their adaptation is minimum. Moreover, the internal competition, related to the proprietary information among the different functional units, has been also ranked as a relevant barrier. It is related to the strain arising when a functional unit needs information from another department. Then internal competence-related problems emerge as far as the propriety of information and knowledge is concerned, which will lead to certain reluctance when it comes to facilitating this information.

The inter-CKM level is considered by insecurity of knowledge propriety. The transfer relationships among organisations causes mistrust about the owner who has the rights to exploit information and knowledge. Organisations feel insecure when they consider the possibility that their skills can be internalised by other organisations. Moreover, the intangible relationship among the different entities can lead to undesired knowledge transfers [53]. Finally at the extra-CKM level, scepticism is the predominant trend. A widespread mistrust of the accuracy and efficiency of CKM prevails.

#### 4.1.5. Trust/Informational

Fear of sharing knowledge from the informational perspective is typical at the individual level. The participants of a CKM project feel insecure about their capabilities and whether their knowledge is relevant. The prevalent opinion is that their colleagues may acquire their knowledge and thus be promoted while they would be relegated to a lower status. This is supported by [2] who summarise this barrier as idea robbery.

The mental models of people, who belong to the different functional units, are the most significant barrier at the intra-CKM level given the logical differences caused by individual's psychological tendency to reject those ideas, which are inconsistent with the existing mental models of their functional unit. If new ideas are incoherent with the *modus operandi* of the business unit, these ideas will be ignored, and only the knowledge that is integrated into the mental structure of the department or business unit will be considered [64]. This lack of trust also involves the accuracy of the information of the collaborative process [6].

Given the property insecurity and the fear of being copied and imitated by competitors, the inter-CKM level from the informational perspective is also characterised by mistrust of the authenticity, accuracy, sincerity, frankness and clarity of the knowledge that is being transmitted [5,48,65]. Solli-Sather et al. [7], state that the risk of the dissipation of intellectual property holds for any inter-organisational collaboration in which knowledge is shared. In the same way as the extra-CKM level, mistrust increases because of the diversity in the composition of knowledge exchanges caused by susceptibility to the credibility of knowledge [7,53,65–68].

#### 4.2. Management Barriers Block of CK

The management barrier block that hinder the CKM process is related to all the issues related to organizing, planning, controlling, and directing resources in order to achieve the objectives of a defined policy. This barrier block involves aspects such as skills and abilities, objectives pursued, coordination, leadership, among others. Table 5 shows the general characteristics of the different barriers of this block.

**Table 5.** Description of the management barriers block.

	<b>Individual</b>	<b>Intra-</b>	<b>Inter-</b>	<b>Extra-</b>
<b>Human</b>	Differences in ability and skills. Lack of motivation.	Differences in knowledge and fields.	Great contrasts in knowledge, fields and skills.	Disorder in knowledge, fields and skills.
<b>Organisational</b>	Self-interest. Incompatibility.	Prevalence of functional objectives to organisational ones.	Predominant interests of each organisation as opposed to the global objectives.	Dilution of interest. Strategic misalignment.
<b>Technological</b>	Lack of technological training strategies.	Lack of technological coordination and management.	Technology imbalance. Lack of common technological initiatives.	Lack of technological culture network. Lack of technological coordination, leadership and management.
<b>Contextual</b>	Fear of becoming redundant. Lack of awareness of knowledge strategies and instruments.	Conflict of interests. Weak CK culture.	Difference in the size of enterprises. Control by a leader	Confusing interests. Lack of feedback on performance.
<b>Informational</b>	Lack of knowledge registers.	Lack of policy documentation management.	Insufficient management to externalize knowledge.	Complex and great density of management externalisation strategies.

#### 4.2.1. Management/Human

When a CKM process is performed, the individuals involved possess similar knowledge from the application field point of view, but have different capacities. Sometimes assumptions are made that everyone shares the same background and that we speak from that shared background [54]. The field in which the collaborative process is developed is usually very similar, but the differences in the individuals' experience and skills present a twofold problem; on the one hand the learning curve, as the least qualified person will have to cope with the new challenges, and on the other hand, the suspicion to share knowledge given the fear of losing an important position in the company and being absorbed by the organisation [5]. This is translated into lack of motivation what is justified by individuals as lack of time to perform the CK process.

The characteristics at the intra-collaborative level differ considerably as we come across marked differences in both the field of knowledge and capacities. Each business unit has specific assigned tasks within an area of application. Therefore, lack of knowledge exists of the duties or tasks corresponding to other sections or functional units. If to this, we also add the difference in individuals' capacities, we obtain a barrier which is difficult to manage. When the CKM process is performed among different business units, and even though the same language is spoken among them, the fact that skills assemble in different fields means that there is no understanding among them because of the specificity of the information since the underlying meaning may be interpreted differently [69]. The organisations' tendency to direct themselves around business processes and to abandon the traditional view for functional units, was used in an attempt to solve the aforementioned series of problems. The intention of such an arrangement directed toward business processes was for all those involved to have knowledge of the complete system, and even though they are specialists in a specific field, they also have notions of everything that occurs at the intra-collaborative level.

Normally multidisciplinary teams are formed at the inter-collaborative level to carry out the CKM project. However, great contrasts in knowledge, fields and skills may cause difficulties in understanding [11]. Abou-Zeid [56] highlights that the more habituated individuals are to collaborate within and outside companies' boundaries, the more efficient is the CK process.

Finally, there is genuine chaos at the extra-collaborative level as far as the different shareholders involved in a project of this kind are concerned. This barrier is closely related to differences in background, experience [70] and cultural aspects.

#### 4.2.2. Management/Organisational

From the organisational perspective at the individual level, those participating in the CKM process are more interested in obtaining their own benefits than obtaining those of a mutual kind. Besides, problems related to incompatible characters often arise among the personnel involved [4].

As for the intra-collaborative level, problems centre on the excessive emphasis on optimizing the results at a functional level, and this leads to the results becoming under-optimised at the organisational level. Frequently, the functional structure does not take customers into account and it does not describe how the workflow, with which the firm supplies customer requirements. All this implies pursuing functional and individual objectives and forgetting the firm's global objective, and this problem increases when organisations become larger and more complex, and even more so when the changing environments in which they are run use more complex technology [11,65,67].

Exactly the same problems occur at the inter-collaborative level, but at a superior level as the interests of each organisation prevail when faced with the global interests of the whole supply chain. Organisations attempt to accomplish their own objectives, missions and priorities as they are self-interested entities and tend to forget the remaining partners of the organisational structure. Adding to such complexity, inter-organisational knowledge sharing initiatives may involve large numbers of organisations with diverse missions, goals and priorities. Organisations are self-interested entities. Achieving agreement on common objectives can be really difficult, and may not even be achieved if misaligned priorities are involved [71].

The most important barrier at the extra-collaborative level is the dilution of interests and the conflict among them. This occurs at a complex level where the *strongest survive*. Therefore, if no unified structure exists, in which each participant understands the problems, needs and objectives of the rest, neither the lack of solidarity barrier nor the search for a unique and single benefit will be overcome. Moreover, the strategic misalignment [72,73] is also a relevant barrier at this level.

#### 4.2.3. Management/Technological

The lack of training policies in technology for personnel at an individual level turns into lack of motivation and loss of interest. Individuals feel satisfied with their work when they are perfectly aware of how to carry it out, and when they know the benefits that doing a specific task produces. However, if individuals neither know the duties they must do from the information and communication technologies (ICTs) perspective given their lack of preparation, nor the purposes of the tasks that they do, they will not opt to not carry out works related to knowledge management from the technological perspective [4,5,67,74].

Lack of leadership and management in terms of communication systems at the intra-collaborative level is the most relevant characteristic of this level since a policy to report the benefits and values of knowledge management is needed. From superior levels, it is necessary to encourage and establish training policies with new tools in order to form an excellent all-inclusive communications network. In this way, all participants should have enough training to include their information in the system and to obtain feedback with which they learn about not only the destination of this knowledge and its use, but also the benefits obtained by the receivers as a result of its use [75,76]. Moreover, technological coordination is also important to guarantee that the input data needed by a functional unit is available in the appropriate format and at the right time by another department.

Lack of strategic technological-level initiatives at the inter-collaborative level leads to gaps forming among the different organisations because, while some entities own advanced, organised, structured and all-inclusive systems of all the business knowledge and information from having established and implemented CKM methodologies, others own nothing of this kind. The root of the problem arises in two perspectives. The first in the firm's strategic unit, which is not totally convinced about the benefits that it may obtain from knowledge management versus the investment it must make. The second arises in the lack of technological resources which hinders the coordination of communication among the various entities involved. This second root is also related to the technological imbalance among the different entities of the supply chain [54].

Finally a network culture could exist at the extra-collaborative level, although it is difficult that this structure provides an adequate support for activities given the lack of management [7] coordination and leadership, lack of technological resources, incompatibility of systems, lack of compromises, lack of training..., among others [54]. Moreover, it is worth mentioning the barrier of the rapid technology life-cycle that affects all levels. The speedy development of new technological tools leads to a continuous learning curve and investments that individuals and companies are not willing to do [4].

#### 4.2.4. Management/Contextual

From the contextual perspective, and on an individual level, the management barrier block is related to fear of losing the job should a recognition and rewards scheme not be managed properly, thus individuals are very reluctant to collaborate [5]. The desire to save face can constitute a significant barrier to active participation in a CK process [7,77]. Moreover, the lack of awareness of knowledge management strategies and instruments [2] and the lack of employee willingness to share knowledge [37] are also important barriers to be considered, as Thoben et al. [2] declare that only few companies have an explicit knowledge management strategy implemented, nor determined corresponding responsibilities.

The conflict of interests among the various functional units is one of the most relevant barriers at the intra-collaborative level. This will lead to a complex management of the collaborative process. Moreover, the lack of executive support [4,10] and a weak CK culture [37] have been also identified as an important aspect that hinders the collaboration at this level.

The most important barrier at the inter-collaborative level is the difference in how resources are distributed because of the firms' size. Supply chains are made up of small- and medium-sized enterprises (SMEs) with limited resources if compared with large-sized firms. Levy et al. [78] conclude that SMEs, apart from lacking resources, infrastructures and technology, do not own a systematic knowledge management strategy as they focus on the day-to-day feasibility of their operations. It is of vital importance that no one takes the control or complete leadership of the supply chain knowledge management because, if this were the case, the process will become intimidating and persuasive. There must be a coordinating entity, but one whose role is not domineering in the overall supply chain group.

The problems at the extra-collaborative level are very similar to the previous level, although confusing interests between supply chains and entities, and between some supply chains and others, will hinder collaboration from progressing in knowledge management. Moreover, the lack of feedback about the CK process results' performance has been identified as a critical barrier [37]. Feedback promotes critical reflection and brings new approaches [79] and although this barrier has been considered relevant in the Delphi study at this level, it is worth mentioning that this also affects to all the three dimensional matrix levels.

#### 4.2.5. Management/Informational

The most significant barrier at the individual level from the informational perspective is not recording the knowledge, in general, and specifically the one that has been transmitted in the collaboration process. In most cases, information is verbally transmitted and is not stored, so when this knowledge is required another time, it will only be available in a tacit form [5].

Not only is registering information necessary at the individual level but at intra-collaborative level, this knowledge must be well documented to be registered and stored in order to be reused whenever required [76].

Barriers at the inter-collaborative level are more in line with the lack of the management policies and appropriate methodologies [10] at the strategic levels of the formalities and mechanisms required to make knowledge explicit [75,76].

This barrier increases in complexity at the extra-collaborative level as, besides the great density of management externalisation strategies coexisting, it is also affected by other barriers such as mistrust, adversity, hostility and fear of transferring knowledge propriety.

#### 4.3. Environment Barriers Block of CK

The barriers belonging to the environment block are related to the situation, circumstances and conditions which corresponds to, and encompasses, the CKM process as shown in Table 6.

**Table 6.** Description of the environment barriers block.

	<b>Individual</b>	<b>Intra-</b>	<b>Inter-</b>	<b>Extra-</b>
<b>Human</b>	Reluctance and prejudices because of cultural differences.	Rivalry and background differences.	Important cultural differences. Lack of environmental monitoring.	Lattice of different views, perspectives and opinions.
<b>Organisational</b>	Fear of contamination.	Robust organisational memory.	Blindness.	Weakness of adequate conditions to encourage CKM.
<b>Technological</b>	Imbalance of users' requirements and technological systems. User-unfriendly IT systems.	Difficulty of integration.	Incompatibility among different entities' systems.	Lack of web systems to exchange information.
<b>Contextual</b>	Informal relations.	Lack of a suitable space.	Time and geographic Limitations.	Long time and geographic differences.
<b>Informational</b>	Reduced communication skills.	Inappropriate channels for communication. Losses of information.	Differences in languages and terminology.	Significant linguistic differences. Gaps in understanding.

##### 4.3.1. Environment /Human

Cultural differences are related to the tastes, preferences, customs and experiences of a given community, and they typically exert more power on superior levels [80]. At the individual level, these differences prevent individuals from engaging regular and frequent reciprocal cross-cultural exchange of ideas and the creation of new collaborative solutions [81]. Besides this, at the intra-collaborative level, the rivalry is also considered an important factor that hinders the collaboration among business units of an enterprise. This rivalry may be related to the "Not-Invented-Here" syndrome [82]. Based on the Gupta et al. study [83], this syndrome has two drivers: (i) ego-defence mechanisms [84,85] which can make that some individuals some managers reject the information coming from others who seem to be more capable than they are, and (ii) power struggles within organisations [86] which can lead some executives to try to downgrade the potential knowledge of peer business units by advertising that the knowledge of these peer units is not as relevant.

At the inter-collaborative level, where the number of entities involved in the knowledge management process is higher, differences between cultures mean that problems of an

incomprehensibility type arise [87]. Hofstede [88] analysed in his conceptual model the differences among countries related to five cultural dimensions: (i) power distance, (ii) individualism, (iii) masculinity, (iv) uncertainty avoidance, and (iv) long-term orientation. Moreover, not monitoring the environment conditions in the sense that organisations are not watchful of the threats and opportunities that the environment may present, will lead to not make the best use of such situations and not swiftly and flexibly react in the face of dangers. This barrier is related to the enterprise and supply chain resilience concept [89] that it is defined as the capacity to absorb changes and disruptions, both internal and external, without affecting their profitability, and even though, developing a flexibility, through the rapid adaptation to the new context that may get extra benefits, whether they are pecuniary or intangible, arising from adverse and/or unforeseen circumstances [90].

Vaara et al. [91] state that the effects of cultural differences lead to ‘us versus them’ thinking characterised by incompatibilities in the beliefs, values, and norms that may turn out to be significant impediments to successful CK project. However, the authors also maintain that the same cultural differences can contribute to learning in terms of CK due, in fact, to such differences.

Culture covers numerous aspects such as ideas learnt, values, knowledge, norms and customs shared by members of a collectivity [80], which is much more worrying at the extra-collaborative level as the number of relationships and collaborations established with different cultural points of views increases exponentially. Richards et al. [92] pointed out the need for training with a view to acquiring a better understanding of the different cultural characteristics and behaviours for the purpose of lowering and minimizing the effects of these cultural differences.

#### 4.3.2. Environment /Organisational

In the organisational context, the fear noted on an individual level is possibly due to contamination [93]. Fear of contamination comes about when an individual who commences and establishes CK relationships with another individual of a lower status, hierarchically speaking, and feels somewhat nervous that he or she is seen in disrepute by the rest of society through its associationism.

Despite organisational memory often being an element of competitive advantage at the intra-collaborative level, it brings about certain problems in CKM processes. Organisational memory is motivated by the wish to preserve and share experiences and knowledge which lie within an organisation’s functional limits [94]. Organisational memory is seen as a cognitive system which includes meanings, terminology, practices, understandings, cultural rules and values shared among an organisation’s different functional units [95]. But a common understanding in the way matters are run sometimes acts as obstacles in individuals to express diverging ideas.

Blindness is the most relevant barrier at the inter-collaborative level, and is understood as organisations’ being incapable of properly assessing environmental opportunities and threats. Neither the external environment is analysed nor opportunities and problems sought, there is no active attitude to find or create new markets, and long-term threats and opportunities are not perceived [63].

Lack or the nonexistence of the right conditions at the extra-collaborative level to promote CKM, and the complexity of the factors that affect networks of different nature, will make the management of this barrier difficult.

#### 4.3.3. Environment/Technological

In the technological perspective, the imbalance between the users’ requirements and the functional properties of the technological systems will mean that in many cases, implementing a CKM system will be depleted. Moreover, the lack of user-friendly IT systems will make individuals averse to use technological solutions to facilitate the CKM process [9].

The intra-collaborative level is characterised by the lack of integration between the systems of the various functional units.

Incompatibility between the organisations' different legacy systems is a very common and generalised problem in projects of this kind at the inter-collaborative level.

Meanwhile at the extra-collaborative level, the lack of information exchange systems will be a genuine threat for the transfer of records, documents and information. Moreover, in intergovernmental and inter-organisational knowledge sharing projects that rely on IT, the lack of knowledge about technology for policy staff and the lack of knowledge about public service programs for technical staff create difficulties for effective communication and CK exchange and negatively impact potential success [4,96].

#### 4.3.4. Environment/Contextual

The contextual perspective focuses on a large amount of relations and informal communications which take place on an individual level, but where none of this knowledge is recorded. Neither mechanisms to make knowledge explicit nor a solid structure exist, which leads to knowledge being lost and badly distributed.

At the intra-collaborative level, we introduced the *Ba* concept which has been widely studied in the literature. This concept was initially proposed by a Japanese philosopher [97], and was developed by [98]. Nonaka et al. [99] adapted this concept for the purpose of elaborating his knowledge creation model. *Ba* may be defined as an integrating and orientating space of shareholders interaction with their useful environments. So, *Ba* may be considered to be a space as a basis for knowledge creation and sharing. According to Nonaka et al. [99], *Ba* may be considered a space to establish new relationships. This space may be physical (an office, for example), virtual (for instance, electronic mail, teleconferences), mental (transferring experiences, ideas and ideals) or any combination of these. *Ba* provides a platform for the individual and group promotion of knowledge. So, the lack of a contextual environment of this kind will limit CKM [76].

Limitations at the inter-collaborative level are imposed by the different time zones and geographical distances [2]. Whereas communication is normally synchronous within the organisation's functional limits, information transfer at superior levels must be done in an asynchronised way as the enterprises tend to be located in different time zones. This is one of the main problems which the European firms in supply chains are faced with where Asian organisations operate [67,70,100]. In addition, at this level, it is also worth mentioning the humans' imperative need to share our problems. In this sense, knowledge flowing out the boundaries of the organisation on the basis of individual decisions can represent critical breaches of confidentiality in an organisation's view [101].

At the extra-collaborative level, differences in time zones may even be higher, although the main barrier is not the wide margin of differences in time, but the large number of shareholders involved in the different enterprise networks. With geographical distance, the effects are highly similar, as in the previous barrier. Nonaka [27] acknowledged that "face-to-face" communication, when knowledge providers and knowledge receivers are actually in direct contact with each other, is the most efficient communication method to obtain the best results in the CKM process. Therefore, and even though the current technologies facilitates information and communication transfer to a great extent, the effects of the various entities' locations at the inter- and extra-collaborative levels make the process difficult because of gaps in understanding, loss of information, etc.

#### 4.3.5. Environment/Informational

The informational perspective presents barriers on an individual level because of the individuals' poor skills to communicate information [5]. Lack of expressiveness and aptitudes to explain concepts, ideas or initiatives, will slow down the collaborative management process

At the intra-collaborative level, organisations must fight against the problems which arise from using inadequate communication channels [2]. Preferring one channel to another depends on whether the message is routine or not. Routine messages tend to be direct and very slightly ambiguous, whereas non routine messages are complicated and tend to confuse. So, using a poor



channel for a non-routine message can lead to loss of information, and the knowledge management process is not fruitful [75].

At the inter-collaborative level, linguistic differences may be added to the aforementioned problems at inferior levels [102]. Even when a common language is being used, quite often problems arise in understanding as words mean different things for different people, that is, the so-called differences in terminology [4]. But difficulties considerably increase if the language being used is different. Communication at the extra-collaborative level does not flow smoothly and skilfully as it should. This causes nervousness as a result of a lack of understanding [70].

#### 4.4. Means Barriers Block of CK

The means barriers block (Table 7) is related to the means by which a CKM project is implemented and developed. It is related the channels, inputs and resources used for a CKM project.

**Table 7.** Description of the means barriers block.

	<b>Individual</b>	<b>Intra-</b>	<b>Inter-</b>	<b>Extra-</b>
<b>Human</b>	Reservations about the terms of use. Inadequate learning opportunities. Lack of job rotation. Lack of time.	Lack of a Chief Human Resource Officer (CHRO).	Lack of a responsible for each entity. Insufficient processing of past mistakes.	Lack of social network.
<b>Organisational</b>	Lack of awareness about the individual needed knowledge container.	Lack of CKO. Lack of budget to support CK. Management.	Insufficient resources and structure.	Important differences between distribution of resources and means.
<b>Technological</b>	Lack of technical support.	Lack of CIO. Lack of intraoperability.	Systems obsolescence. Lack of interoperability.	Lack of extraoperability.
<b>Contextual</b>	Neglect contextual opportunities.	Immaturity of means and resources.	Misuse and misalignment of contextual resources.	Lack of a common networked infrastructure.
<b>Informational</b>	Unavailability/inaccessibility of information sources.	Inappropriate information sharing.	A large quantity of unstructured information.	Confusing distribution and assignment of information.

##### 4.4.1. Means/Human

As far as the terms of explicit knowledge use are concerned, there are reserves at the individual level of collaborative management. Individuals have doubts regarding who will use the knowledge that has been made explicit and whether it will be of real use [93]. Moreover, Yih-Tong et al. [6] also point to at this level, the fear about the knowledge being inadequate or unimpressive. Maitlo et al. [37] found in their study that the lack of opportunity for employees to learn about CK was one of the major barriers. In addition, job rotation is vital for the enhancing the knowledge of individuals [103] specially in jobs that involve dealing with changing conditions in a turbulent environment [37]. Finally, it is worth noting that individuals are immersed in on-site demands and daily multi-task what prevent them to invest time to devote to the CK process [54].

At the intra-collaborative level, the most relevant barrier is related with the lack of a key role to carry out the CKM project. This figure, in most the companies defined as the Chief Human Resource Officer (CHRO), plays an essential role to align human resources policies, the organisation strategy,

and the appropriate means to make the CKM process to be implemented through people. In most of the companies, among the CHROs responsibilities, it is highlight the assessment of the chances of meeting the business goals using the intra-knowledge of the personnel.

Evolving to a superior level, the inter-collaborative one, this role is also necessary to act as the intermediary between the entity to which this role belongs and the other entities of the supply chain. Moreover, at this level it has been also considered as a relevant barrier the insufficient capture, evaluation, feedback, communication, and tolerance of past mistakes that would enhance the inter-CK relationships [5]. Learning lessons from past mistakes affects best practices in the future, and it seems that at the inter-CK level, the mistakes, due to the complexity of the collaboration, are common.

Lack of social network [5] at the extra-collaborative level is a barrier that limits the rapid knowledge flow between people working across different entities, supply chains and geographical areas [104].

#### 4.4.2. Means/Organisational

From the organisational perspective on the individual level, the lack of awareness about the appropriate individual mean containing the needed knowledge is complex and time-consuming. Frequently, when a need is detected, knowing who would be the best person to ask is difficult [2].

When we move to the intra-collaborative level, a new strategic role is required to plan, control, guide and manage the collaborative process. This figure, defined as the Chief Knowledge Officer (CKO), is in charge of starting, promoting and coordinating knowledge management programs [105] to maximize the return of investments made in knowledge, for example, new contracts, processes and intellectual capital, exploiting intangible assets like know-how, patents and customer relations, repeating past successes and sharing better practices, improving innovation (commercializing ideas), and avoiding loss and drains of knowledge by organisational restructurings [106]. Moreover, Mazorodze et al., [10] identified the lack of budget to support CKM as an important barrier, as companies prioritise other business aspects instead of knowledge.

In light of this, the inter-collaborative level is also characterised by the lack of clear return on investment [10,107] what decreases the participation of supply chain entities in a CK process.

Finally at the extra-collaborative level, the improper distribution of resources and means causes a serious imbalance of resources and means coordination, what also hinders to obtain the expected results with the CKM project.

#### 4.4.3. Means/Technological

The technological perspective at an individual CKM level is characterised by lack of technical support for the technological solutions adopted. Individuals feel they are not properly trained and do not receive suitable support. Riege [5] points also to the reluctance of individuals to use IT systems due to lack of familiarity and experience with them, what it is related to the lack of training.

At the intra-collaborative level, a need for a new figure is presented, the so-called *Chief Information Officer* (CIO). The nature of the CIO's responsibilities is established around the strategy, operations and functions of the technologies. Previously, we explained the need for a CKO to promote and coordinate knowledge management programs, but the presence of a CIO is equally vital to coordinate these activities from the technological perspective. On numerous occasions, the CKO will act as the CIO, although the corollary is not right. The fundamental difference between the CKO and the CIO is that while the CKO focuses on maximizing the creation, discovery and diffusion of knowledge within the organisation, the CIO's objective is to supervise the development of the technologies as a support for the CKM process [105].

Obsolescence of systems is considered a potential problem by many software engineers [108]. One of the main reasons in the collaboration context is the lack of capacity to interoperate in other systems. The term used within an organisation to describe this capacity to interact with other systems within the organisation's functional limits is intraoperativity.

At the inter-collaborative level, this capacity is known as interoperability, that is, the capacity or aptitude for two systems to operate jointly with total understanding [109]. The term interoperate implies that a system does an operation that is destined for another system. From the technological viewpoint, it is defined as the capacity of two heterogeneous computer systems to work jointly and which allows access to their resources reciprocally. From the enterprise network perspective, interoperability refers to capacity of interaction between the different organisations' systems within an enterprise network.

However, another superior level of difficulty exists, the extraoperability barrier, which is defined as the incapacity to operate systems together which belong to different supply chains. In the bibliographic review, no studies have covered this series of problems. It might be thought that extrapolating the developed solutions to improve the interoperability of the systems is sufficient, but this situation needs to be studied as the extra-collaborative level is highly complex. Interoperability capacity must advance toward an extraoperability vision, which is the main property to overcome the understandable and compatible interaction of networked systems.

#### 4.4.4. Means/Contextual

In the contextual perspective, failure is seen at an individual level if the opportunities that the context offers are not taken into account. Quite frequently, explicit information and knowledge is available in the environment, but the lack of attention and monitoring is almost like having to reinvent the wheel [110]. Borowiecki et al. [9] highlights the failure to use market opportunities as one of the most reported barriers in their study.

Along with this barrier, we find that immature means and resources at the intra-collaborative level make the CKM process difficult. In such circumstances, immaturity is understood as the insufficient degree of development of resources (training, CKM principles, CKM benefits awareness...) to undertake the project [111].

Even though a great deal of resources is available at the inter-collaborative level, they are not made full use of because they are not correctly organised and aligned in the net grid.

The extra-collaborative level is characterised by the lack of a common networked infrastructure [37], that is to say, a structure which includes all the means to accomplish the expected results by means of the knowledge management project.

#### 4.4.5. Means/Informational

Finally the informational perspective presents difficulties at the individual level as sources of information or access to these sources are not available. In so many cases, the impediment of collecting information or knowledge about a particular aspect needed for the proper development of the work is due to not being aware of the sources of information that are accessible. In this light, access rights policies should be dimensioned accordingly because a restricted access to information sources will lead to the misuse of potential valuable information sources [42].

At the intra-collaborative level, and following the same stream line than at the individual level, sometimes the information generated by a functional unit is necessary for another functional unit to take decisions. However, in most cases, some needed data is missing or the format of such data is not the appropriate one for the receiving functional unit and it needs to be reprocessed what is time-consuming and source of errors. Sieber [112] highlighted that the greatest impediment to data sharing is likely to be practical problems of preparing an archive suitable for sharing from information that was collected without data sharing in mind.

The amount of information that is collected and stored increases exponentially from the individual level to superior levels. Thus at the inter-collaborative level, a large amount of useful information to be used and transformed into knowledge exists. But the problem centres on this information remaining as an unstructured form, and large amounts of time are lost performing searches, which are often unprofitable. Thus the need to have relevant information available when required and for adequate resources is one of the most relevant impediments at this level. This barrier has been also considered related to the big data concept. In this case, current studies indicate

that further research should be addressed to how knowledge management can conceptually and operationally use and integrate big data to foster individual, intra-, inter- and extra-organisational knowledge for better decision-making and value creation [113]. Finally, the confusing distribution and assignment of information at the extra-collaborative level is due to the complexity of the networks, and knowledge does not reach the resources that require it.

## 5. Conclusions

The barriers hindering the CKM process have their own characteristics, depending on the level of study, considering the individual, intra-, inter- and extra-collaborative levels. Besides the classification by levels, an analysis of the identified barriers has been considered in this research work from the various perspectives which embrace CKM. The most representative perspectives are the human, organisational, contextual, informational and technological ones.

Knowledge barriers increase in complexity when the level of collaboration advances from the individual to the extra-collaborative level since the latter presents the addition of all the barriers of all the inferior levels plus the particular ones of its level. With all this in mind, it is necessary to know and understand these barriers in each collaboration level and from each perspective to propose the most adequate mechanisms to overcome their effects. To this end, the three-dimensional matrix of the four barriers blocks is attempted to be a useful reference model for individuals, enterprises, supply chains, public administrations, and organisation of any nature while implementing a CKM project. This matrix is expected to provide a convenient way to audit the CKB, and thus, focus on the corrections and adjustments to guarantee the success while implementing a CKM project. The matrix is an open system, with which future barriers may be included or even new blocks or levels could be added, depending on the future conditions and needs.

Supply chains must advance from a CK perspective to a collaboration-oriented knowledge arrangement. CKM is based on formalizing and processing knowledge among individuals, functional areas, organisations and supply chains. But as we have seen throughout this paper, barriers often hinder this process from being properly established. To this end, knowledge management oriented toward collaboration from the individual level to the extra-collaborative level, covering all the previously analysed perspectives, will not only favour leaving behind problems from inferior levels, but will also direct management toward collaboration. This process of orienting knowledge management toward collaboration must commence at the individual level in order to be subsequently extrapolated at the intra-collaborative level. At the inter-collaborative level, a global strategy oriented to a concurrence of all an organisation's knowledge is required. If these objectives are fulfilled at the three first levels, the way forward to promote collaboration at the extra-collaborative level will be more efficient due to the experience acquired throughout the process of aligning knowledge toward collaboration. This process will be more familiar to supply chains, which will therefore be more capable of overcoming knowledge barriers and of suitably managing collaboration-oriented knowledge.

Further research lines are addressed to analyse potential solutions to overcome each of the identified barrier proposing, in this case, the three-dimensional matrix of CK solutions. Moreover, the optimisation of the solutions' choice taking into account different input data such as needed effort to implement the solution, budget restrictions, expected utility of the results obtained by the implementation of such solution,... among others, is another future line of research that could be of utmost interest for the actual applicability in the business world.

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