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Knowledge Management Strategies and Applications

Edited by Muhammad Mohiuddin, Norrin Halilem, SM Ahasanul Kobir and Cao Yuliang

KNOWLEDGE MANAGEMENT STRATEGIES AND APPLICATIONS

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Meet the editors

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SM Ahasanul Kobir was born in Bangladesh in 1978. He received the BSc (Hons) degree in Biochemistry from Aligarh Muslim University, India, in 2001; MSc degree in Nutrition and Food Science from Dhaka University, Bangladesh, in 2004; MSc degree in Molecular Genetics and Physiology from Linkoping University, Sweden, in 2007; and MSc degree in Biotechnology from AgroParisTech and PhD degree in Molecular Genetics from the University of Paris XI in Paris, France, in 2008 and in 2012, respectively. In 2013, he joined as a postdoctoral researcher at the Department of Biotechnology and Microbiology at the Universidad Autonoma de Madrid, Spain; in 2014, he started his career as a research associate at the Department of Experimental Medicine at the Scripps Research Institute, San Diego, California, USA; and since 2015, he has been working as a postdoctoral fellow in the School of Medicine at the University of Pittsburgh, Pittsburgh, USA. His main areas of research interests are molecular mechanism of pulmonary hypertension and its drug designing, molecular detection and live cell imaging in cancer biology, molecular mechanism of HIV and its drug discovery, biotechnological interest of signaling and regulation in bacterial cells, etc. He is a member of the American Thoracic Society and also received the best abstract award from ATS Conference in 2016. Dr. Kobir published in top journals in his field.

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Contents

Preface

Since the use of Knowledge work by the management guru of all time Peter Drucker (1994), the world economy has gone through more structural changes and transformations. The globalization, digitalization and accelerated servitization of the economy have created a formidable context of accelerated competition and coopetition and the role of "knowledge management" becomes fundamental for organizations to survive and sustain in a dynamic competitive world. Rise of information and communication technologies (ICT) and social media have accelerated flow of information and data to such extent that it becomes challenging for managers to retain, read and keep organized of all those knowledge flows. A set of behaviors, processes and technologies are needed to efficiently manage the accelerated flow of information in order to improve learning, decision-making and innovation for business successes. The objective of knowledge management (KM) is to effectively use, develop and mobilize the expertise of the organization and apply them for achieving organization's strategic goals such as competitive advantage. Knowledge management involves with knowledge creation, knowledge retention and knowledge transfers. It can help to improve operational excellence by improving internal practices and processes of the organization to make it better, faster, cheaper, safer and cleaner. It can also help to improve innovation capability and growth of the organization. There are different kinds of knowledge such as tacit and explicit knowledge in organization. There are also different purposes of knowledge management in different kind of organizations from resource economy, industrial organizations as well as service economy including knowledge intensive business services (KIBS). The context of these different organizations for knowledge creation, retention and dissemination differs from one another and requires cross-disciplinary approaches. This book on "Knowledge Management Strategies and Applications" addresses the cross-disciplinary approaches of knowledge management of various kinds of organizations by proposing 14 chapters divided into two parts. The first part of the book proposes 8 chapters addressing knowledge management strategies and the second part of the book addresses the knowledge management application in different sector of activities.

In part 1, the first chapter addresses the tacit knowledge sharing strategies. Author Jose Roberto Ferretti and Maria da Conceicao L. Afonso conclude that organizations are moving from traditional approach of tangible assets toward intangible such as tacit knowledge, which is becoming an increasingly generator of growth and innovation. The second chapter explores the way organizations can become more innovative by developing capabilities of its human resources. Authors Michael Beyerlein, Rachele Collins, Shinhee Jeong, Christi Phillips, Suravee Sunalai and Lei Xie propose a model that ties human resource development practices to knowledge management strategies for developing innovation capabilities. The third chapter addresses the strategies on how the influence of network market orientation (NMO) on born global (BG) competitiveness is mediated by absorptive capacity. Authors Diego Monferrer Tirado and Marta Estrada Guillen conclude that absorptive capacity positively influences the firm's capacity to exploit the new relational knowledge and improve the competitiveness and international performance of born global firms. The fourth chapter examines three major KM pillars, including people, process and technology for effective KM deployment. Authors Ivy Chan shows that a hybrid KM strategy is more effective than a strategy focusing on any particular pillar. The fifth chapter presents the challenges and strategies of KM in informally structured domains that need "Requirements Elicitation (RE)" approach. Authors Karla Olmos-Sánchez and Jorge Rodas-Osollo propose an integrated approach to face challenges posed by "Requirement elicitation (RE)" issue. Chapter 6 deals with "causal mapping" approach of knowledge management for performance management (PM) of organizations. However, Causal mapping offers a low quality of the identified causal structures of success factors (SFs). Authors Sarah Kölbel, Wolfgang Ossadnik and Stefan Gergeleit propose to apply DEMATEL in the mapping context to minimize subjectivity by a systematic and transparent pairwise evaluation of the SFs. Chapter 7 explores the strategies of intelligent knowledge retrieval from industrial repositories. Authors Antonio Martin, Mauricio Burbano, and Carlos León present a model that supports efficient retrieval knowledge from digital repositories. Chapter 8 attempts to understand knowledge workers' behavioral intention to use the knowledge sharing tools (KS tools) in their day-to-day tasks. By using affective technology acceptance model, authors Angela Lee Siew Hoong, Tong-Ming Lim, Lip Sam, and Thi, Mee Hua, Lin conclude that negative affect (NA) does not have any impact on perceived usefulness (PU). However, NA has negative influence on behavioral intention (BI) but very significant negative influence on perceived ease of use (PEOU). The outcomes also highlight that PA has very significant positive influence on PU, PEOU and BI with impact on PEOU being the greatest.

In part 2, Chapter 9 explores the knowledge management application in industry 4.0 in an era of Internet of Things (IoT) and how IoT influence organizational changes in knowledge intensive organizations. Authors Maja Meško and Vasja Roblek show the knowledge sharing applications within the organization and with the external partners such as suppliers and customers. Chapter 10 explores knowledge management trends and applications in biotechnology field in Brazil. Author Maria de Fatima Ebole Santana finds that KM applications in biotechnology in Brazil are focused on its local context as well as follow the world trends. Chapter 11 explores the KM applications in online clinical guidelines and how the use of online clinical guidelines influences individual knowledge management behaviors and the net benefits. Authors Chung-Hsien Chan, Tain-Junn Cheng, and Shofang Chang demonstrate different influential models of online clinical guidelines between physicians and physician assistants. Chapter 12 addresses the application of knowledge-based assignment model for allocation of employees in Engineering-to-Order production system. Authors Matjaz Roblek, Maja Zajec, and Benjamin Urh studied an option for adjusting processes to available knowledge. Chapter 13 addresses the application of KM in hotel industry. Authors Tommy Wong, Linda French and Mark Wickham present an analysis of the KM issues and processes experienced in hotel industry in China. Chapter 14 explores the meaning of "risk" from across the disciplines. Authors Gabriele Berg-Beckhoff, Peter Wiedemann, Balázs Ádám, Joachim Schüz; Kristian Breum Ølgaard, Pernille Tanggaard Andersen, Steven Ndugwa Kabwama, Arounda Jesper and Bo Nielsen conclude that discipline differences are mainly connected to the terminology and interpretation of key concepts but the differences are based on different tasks and perspectives.

The proposed 14 articles constitute an important body of knowledge (BoK) on KM strategies and applications. These articles promote both emergent and managerial approach of KM in the organization. KM strategies' applications in both production and knowledge intensive business service (KIBS) firms demonstrated the context and applications of KM strategies and highlighted differences in applying KM in different sector of firms. We believe our reader will enjoy reading these timely chapters on KM strategies and applications.

We acknowledge the contributions of and indebted to anonymous reviewers of this book.

With warmest regards,

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Section 1

Knowledge Management Strategies

Tacit Knowledge Sharing: A Literature Review Applied to the Context of the Brazilian Judiciary

José Roberto Ferretti and
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Additional information is available at the end of the chapter

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Abstract

Knowledge has been occupying the center of studies and research for some time, and this chapter seeks to contribute to the depth of this collection and aims to offer articles that deal with tacit knowledge and the sharing of that knowledge. The observed understanding with this literature review was that organizations are moving from a traditional model that is attached to physical and tangible assets to another, where knowledge, especially tacit, is treated as an organizational asset that, despite being immaterial, becomes valuable and a generator of wealth.

Keywords: tacit knowledge sharing, knowledge management, intangible assets

1. Introduction

The aim of this chapter is to present a review of literature on the phenomenon of tacit knowledge sharing (TKS). Knowledge represents such a critical feature for the modern dynamics of organizations that Grant [1] interprets it as a central element in the search for a competitive advantage.

This work is the product of a study done between the years of 2012 and 2016 on the exchange of tacit knowledge among judges of the Small Claims Federal Courts of Brazil.

TKS will be addressed within the context of a new era of knowledge or learning society [2], where efficiency gaps are still present [3] and when sharing is assessed as an organizational process. During this research, TKS was seen and treated as a phenomenon, i.e.,: (a) "an established fact that is a science field" [4], characterized by its social interactions, in person or

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remotely; (b) a display of human knowledge that appears under specific conditions [5]; and (c) "knowledge flow" [6], and "relational phenomenon" [7].

The literature review was structured following an epistemological process defined by the following questions: what historical background has been recorded in the literature that showed an investigative awakening about organizational knowledge? How are tacit knowledge and its sharing registered in the literature? And are there any theoretical propositions that deal with TKS as a significant process within the organizational context? To answer these questions, organizational knowledge was understood as the union of two types of knowledge, explicit and tacit [8], or codified knowledge and personal knowledge [2].

Explicit knowledge is understood as information, also referred to knowledge that has already been expressed, taken from the individual's mind, and materialized into any medium (rock, paper, plastic, electronic), established in any media (radio, television, press, publishing, adhesive, photo, film, internet and its content, Whatsapp, Twitter, homepage, blog). In this sense, according to Wolf [9], explicit knowledge is thus expressed and characterized in physical media (clay, papyrus, paper, plastics, CD, DVD); and digital, in bits. The second type of knowledge, tacit knowledge, the main substance of this study, is the content that is stored in human memory, where it exists and from where stories, moods, images, questions, and answers arise [10].

Besides the introduction and conclusion, this article is divided into five sections, which seek to answer the questions previously expressed. The first section discusses the knowledge society, seeking a better understanding of the handling of knowledge in the context of today's society. The second involves the theory of organizational growth, the resource-based view (RBV), and the emergence of the theory based on knowledge. The third introduces studies done on tacit knowledge. The fourth discusses the sharing of tacit knowledge. The last section points out some works where the TKS is the central topic of discussion.

Lastly, some aspects related to the practice within the judicial system are cited, in part because this work is derived from a doctoral thesis where the locus of the research was the Federal Small Claims Courts of Brazil. Thus, this review can extend its application to scholars and practitioners of the judicial system, albeit as a starting point, of some examples of TKS in the judicial context.

2. The knowledge society

It seems to be more reliable to name the current society, less as the information society and more as a society (or era) of knowledge [11, 12]. It is argued that a transition is underway for an economy and society based on knowledge [13].

The knowledge society that serves as a parameter for the development of this research in the Brazilian Judiciary was designed as a spiral of webs, where each web represents the meeting of networks or groups of people that share their tacit knowledge regardless of organizational boundaries or technological tools. This knowledge has been revived, especially since the 1990s, by knowledge management as a source of competitive advantage and intellectual capital [14].

The appearance and the intensive use of new digital technologies led to new and important mechanisms for the political and social development of nations and individuals [15]. Thus, it progresses society toward an increase in its activities based on knowledge, where the organization and sharing of ideas occur simultaneously [16].

The organizational environment, within the context of this new society, is based more on knowledge than on the societies that represented the Modern Era and the industrial society [17] does not differentiate between public and private entities. In both cases, the development of social relations, among others predetermines the willingness to transfer knowledge. With the increasing interconnectedness and the need for rapid change, people and organizations are forced to share what they know and learn from each other [18].

This transit ends up causing an exchange of intangible assets (knowledge), among people and organizations, it is what Van Caenegem treats as "intangible market" [19] that, although relevant, has not yet found the appropriate space within some organizations.

In the case of the Brazilian Judiciary, especially in the Federal Small Claims Courts, there is still a greater concern in dealing with the visible flow of knowledge (information) than with the invisible flow, or its tacit format. The first encompasses what is produced by the parties, what is stated in the sentences and jurisprudence, in the legal codes and norms that regulate the law, and is registered in some type of media. The second mainly covers all the content that is in the minds of the judges and their staff, in other words, fodder for the first. In general terms, in the judicial rite, the author (or advocate) uses tacit knowledge to explain his initial request and the judge in turn uses "[his] tacit knowledge to analyze the law and give the sentence" [20]. This flow is the most critical process, and, at the same time, the "judicial business" axis. **Table 1** below reflects some of these particularities.

In the interchangeable socialization of knowledge, new ideas are offered and foundation is created for the development of new products and services with the possibility of developing innovative mechanisms and workflows. For this reason, Casselman and Samson [21] point out that the use of tacit knowledge maintains a significant relationship with innovative products and financial performance. Similarly, Gomes [22] while studying the Brazilian judiciary claimed knowledge as being the main organizational asset.

New knowledge and sharing redefine problems and solutions and give new form to the organization and its surroundings. Exchanges alter the amount of prior knowledge and increase the permeability of the institutional fabric, allowing for the movement of knowledge from the inside out and vice versa, by causing individual, sectoral, organizational, or inter-organizational exchanges [8].

In the era of knowledge, there is a diminishing emphasis on the tangible flow of information and the emergence of a new worldview where uniqueness, flexibility, and performance, redirect organizations toward a market that is increasingly closer and more related to the intangible knowledge [23].

Present times require a management style that is aligned with a knowledge flow stemming from a new atmosphere created and developed by organizations to enable the recovery and

Industry paradigm	Knowledge paradigm	SCFC context
People under supervision	People mutually linked as a network	Intense TKS
Information control	Accessible information	Integrated electronic process systems
People process tangible resources into products	Knowledge workers convert knowledge into intangible structures	Judges and servants who, at certain stages of the procedural rite, gather knowledge of the parties and of the lawyers as aids to the (mental) decision-making process of the judge
Flow of information via organizational hierarchy	Network flow among co-workers	Network flow among servers, judges, lawyers, experts, doctors, social workers, judicial units, located in the same city or not
Process bottlenecks arising from lack of capital	Process bottlenecks arising from lack of knowledge	There are judges who practice and create an atmosphere of TKS
Production related to tangible products	Production recognizes the importance of intangible assets	In the SCFC, the relationship of judges with the parties, with lawyers and with the servers is stimulated for exchanging knowledge
Unilateral relationship with customers via the market	Relationship according to personal interaction	Judges and servants' relationship with the parties and with lawyers takes place face-to-face (during hearings and over-the-counter visits to provide information and resolve doubts). The relationship of the judges with the servers happens daily, in person and, almost always, without "scheduled time"

Source: adapted from Sveiby [68].

Table 1. Comparative paradigm of principles of a knowledge organization within the context of Small Claims Federal Courts (SCFC).

use of this knowledge, especially the more effective personal knowledge [24], this tacit knowledge favors the emergence of new processes and innovation [12, 25].

Studies done in six organizations of the Asian public sector [16] showed concern for a better understanding of the handling of knowledge. Those organizations opted for increasing efficiency according to the knowledge shared by the most experienced to improve the operational and strategic excellence. The new approach adopted by these six organizations required a rediscussing on how individual and organizational knowledge was (or not) being created and shared, since they saw this knowledge as a fundamental stage of any process that aimed at dealing with change in mentality and behavior.

When analyzing knowledge management carried out at the Department of National Defense in Canada, Girard and McIntyre [26] argued that this process is not characterized as a novelty. However, the significant results highlight what knowledge sharing continues to generate in terms of socialization and an elevated degree of cooperation and learning, something similar to what Kerckhove [27] treated as connected intelligence.

This century, more than others, has compelled organizations to associate their internal structure and work processes to a new asset of intangible nature–knowledge [28]. However, it seems that some organizations, despite being surrounded by information, lack this resource [29, 30].

3. The valuable immateriality: tacit knowledge

In search of the background of what today is referred to as (with relative comfort and understanding) "organizational knowledge", this research took into consideration studies done by Penrose [31][1] when she analyzed companies in the 1950s.

Organizational knowledge is knowledge that is registered in the media under the control of organizations and especially the one that lies within the people minds and flows according to social, formal, or informal interactions [76]. This type of knowledge is composed of personal knowledge, translated by their experience, know-how, and practices developed individually or from within an environment provided by the organization [32].

Penrose sought to find out if there was something that could differentiate organizations regarding its growth or setbacks. In her studies, she assessed and questioned the possibility of there being something else in the firm's growth that was beyond the organization's traditional view on handling human resources (labor) and products (supply chain). She found out that the administrators' experiences translated by their knowledge were revealed as the differentiating factor from one organization to the other. This experience had been transformed into tacit knowledge; it was not available in the form of a manual or coded; in other words, it was not explicit, to be physically incorporated by the organization; she pointed out that this knowledge could not be acquired in the market and concluded that those professionals could bolster or hinder the development of the company. Penrose [31], consequently, asserted knowledge held by more experienced professionals as a particular resource that could be associated with the growth in firms, especially one's individual knowledge, subsequently treated as tacit [8, 33] that if accumulated over time, is capable of providing more efficient opportunities for organizational growth [34].

Penrose [31] developed one of the fundamental assumptions of this theory that the growth of an organization "is essentially an evolutionary process and is based on the cumulative increase of the collective knowledge." Something that Inkpen [3] referred to as 'collaborative knowledge,' and Nonaka and Takeuchi [8] would later represent it as the 'spiral' of the epistemological and ontological knowledge.

In the early 1990s, within the field of strategic management and economics, the theory of 'resource-based view (RBV)' is established and the work of Penrose [31] as a notable

[1]The original work dates from 1959.

contribution [35]. For Bierly et al. [36], such theory almost superseded the traditional view related to industrial organizations (I/O approach)[2] dealt by Porter 10 years earlier [38].

This RBV theory associates the performance of the organization to the combination of two elements, Resources and Capabilities (R & C),[3] it highlights skills and expertise in dealing with knowledge, already showing an early interest in tacit knowledge. This theory seeks to explain and predict why some organizations are able to sustain a competitive advantage and achieve better financial returns.

Considering knowledge as a usable resource in order to improve efficiency and organizational effectiveness [39], RBV appears as a precursor to a new theory, the 'knowledge-based view (KBV)' where this asset, knowledge, is regarded as the most strategically important of the resources in a company [40] and the organization as a vehicle, for creation, sharing, storage, and implementation of this source [41].

Kogut and Zander [42], oriented by the KBV, associate organizational growth with knowledge sharing, defining firms as social communities specialized in the fast and efficient transfer of knowledge, especially knowledge that represent know-how, i.e., tacit knowledge [43].

If we live in a society or knowledge era, where tacit knowledge is seen as strategic in the business field and public organizations, what has the literature offered to conceptualize it?

4. Sharing the intangible

Knowledge is the core element of an emerging production model whose most important process is learning [2]. Through this, it is granted by the use of a sensory organ, the description, calculation or verifiable prediction of any entity, fact, thing or reality [5]. Knowledge consists of a "set of ideas and principles that a person acquires through study, observation, or experience and that can be an integral part of one's abilities" [44] and in this sense, it is related to the cognitive processes where assimilation, association, construction, and deconstruction of concepts occur [45].

Kofman [46] sees knowledge as a product of itself, that is, by acting in the search of results, each stage adds more knowledge, as the spiral spinning of "eternal" growth proposed by Nonaka and Takeuchi [8], taking into account all types of processes, including the most basic, such as, hunting, fishing, farming, and weaving [47].

In the framework of organizations, authors have emphasized the knowledge of the individual, tacit, since Taylor's [48] work in the early twentieth century. This interest is intensified

[2]The approach (I) Industrial/(O) Organizational refers to a business model valued by Porter [33] in his work: Competitive Strategy, where, to ensure a good performance, the organization should resemble the structure of an industry using one of the following strategies: leadership by cost (selling cheap); leadership by distinction (doing something different); or leadership by focus (focuses on meeting specific segments and markets). Later, Porter [37] through another work, Competitive Advantage, analyzes the introduction of concepts already flagged by RVB, such as the importance of internal skills and human expertise as critical to the good performance of the essential activities of the organization.

[3]The literature uses the binomial as "Resources & Capabilities".

when there is a perception of the transition of wealth from that of natural resources to another, provided by brainpower [49], as well as the diversity of concepts and applications within and outside academia[4] [50].

For Davenport and Prusak [51], tacit knowledge "is a fluid mixture of condensed experience, values, and insight,[5] experimented […] originates and is applied in the minds of connoisseurs."

Tacit knowledge, or that which accumulates in the mind of the individual in the form of ideas and experiences [53], has been on the agenda, in some way or the other, in the last 40 years [54]. It presents itself as a knowledge that escapes the formality and materiality; therefore, not captured in licenses and patents [55]. It is an attribute of those who know what they are doing and better understand the needs to be met, as a skilled craftsman whose knowledge is highly personal and deeply rooted in his experiences, values, and emotions [56]. It is of a highly personal nature [57–59], better shared through conversation [60], and with a more pronounced fluidity in informal environments [61].

Alavi and Leidner [62] understand it as something rooted in the actions and experiences of individuals and categorized it as cognitive (mental maps, beliefs, paradigms and viewpoints) and technical (know-how, skills) that allows for thinking and examining a problem and its solutions by a variety of perspectives [63]. Others treat tacit knowledge as "things that originate in someone's brain: electronic programming, trademark, and marketing force" [64]. Lemos and Jóia [65] translate it as a direct result of experiences, reflections, and dialogue.

Most of the organizational knowledge is tacit and includes intuition, perspectives, beliefs, and values [66]. It is estimated at 80% of the useful knowledge of an organization [67] and when not shared brings more problems or difficulties than useful results [33].

Although it seems like a minor issue for some managers, it must be observed that all the practical knowledge is, in almost all its extension, tacit [68] whose most common application is to solve problems [56]. According to Martins et al. [69], these sets of "tacit knowledge" remain scattered throughout the organization and arise from the professional practical activity.

Tacit knowledge is dynamic, nonquantitative, inherent to the practice, and know-how of people [70]. As a brand of organizational knowledge, it is something created in a complex interaction between people [71].

This intangible asset whose origin is directly related to the creative agents of organizations generates economic value [72] and can lead them to competitive advantages [73].

Leonard and Sensiper [74] linked tacit knowledge to innovation, when the capacity of the human mind (worker's expertise) creates new products, services, and processes. Other authors associate it to organizational performance [56, 75–78].

[4]Study conducted taking into account the period between 1958 and 2002, mapped out 149 different meanings for tacit knowledge, among them, skills, know-how, communities of practice (CoP), best practice and mental models.
[5]Insight is the result of a mental process of analyzing complex situations or problems, featuring accurate and deep understanding of them [52].

Tacit knowledge is like an intangible mental product, susceptible to sharing and in constant reformulation, comprised of abstract elements (ideas, reasonings, know-how, skills, allegories, models, constructs, insights, experiences, memories, sounds, images, smell, taste, touch, etc.) capable of generating new knowledge and innovative practices.

Considering the existence of this “available” asset, one must also note the importance of its sharing, given that this dynamic has its own peculiarities, such as that tacit knowledge is best shared through conversation [60], has a more noticeable fluidity in informal settings [61], and, in some organizations, its flow is neglected [79, 80].

Table 2 below summarizes key concepts from this section and cited authors.

Key points relating to TK	References
Ability	[44]
Cognitive process	[45, 49, 62, 64]
Competitive advantage	[73]
Experience, ideas, emotions, beliefs	[51, 53, 56, 62, 65, 66]
Informality, imateriality, intangibility	[55, 61, 72]
Innovation	[74]
Interaction	[71]
Organizational performance	[56, 75–78]
Personal nature	[57–59]
Practical activity, know-how	[50, 62, 69, 70]
Process of learning	[2]
Process relating	[47]
Product of itself	[46]
Sharing	[33, 60, 79, 80]
Solution of problems	[56, 63]
Spiral spinning	[8]
Topic in agenda of firms	[54]
Transferring	[48]
Utility	[67]

Table 2. Summary table of the literature and key points relating to tacit knowledge (TK).

5. Tacit knowledge: the invisible asset

Krogh [81] argues that TKS is the main vector when firms want to raise their own value. He highlights the (invisible) transit of experiences and practices of members in the organization that can leverage knowledge creation, increase TKS, and, as result, provide a higher organizational value.

Bierly et al. [36] argue that the wisdom of each employee can be transformed into an organizational wisdom through knowledge sharing, and what Eraut [82] defines as a type of learning.

The essence of tacit knowledge is its sharing and not its control [83]. Any unilateral displacement from tacit knowledge, when only one party is benefited, is not characterized by an interactive action among people [84], and it does not constitute tacit knowledge transfer, which requires intense interpersonal contact [51]. When interviewing a contributor to the Sematech Company about sharing ideas, Davenport and Prusak [51] registered the comment: "We have documents, databases, intranet, web, groupware, whatever you can think of. But representatives and face to face meetings that we have are by far the most important transfer channels."

Taylor [48] in his book *Principles of Scientific Management*, although seeking a rational, precise, formal, and mathematical model, the best way, also stated the importance of ferreting out the most efficient knowledge, tacit [85], which was found lodged in craftsmen in order to transmit it to engineers, the current scientists and managers of knowledge. This flow has increased over the past decades [86] and positively affected the development of business innovation [87].

Understanding the nature of knowledge as being more tacit than explicit, as well as representing multidirectional and intangible inter-relations, can serve as a source of advantage for the organization, in the transfer, for example, of best practices and lessons learned [37, 83, 84, 88].

Transmission occurs most effectively when set amidst informal and unscheduled conversations, or through structured meetings and actions that enable the free movement of knowledge [67]. In "an economy governed by knowledge, to chat is to work" [51].

Vieira [89] contextualizes one of those moments when he quotes an experience seen as successful by the civil servants of Justice in the city of Casca.[6] "Regular meetings: breakfast held in the dependencies of the Forum, with all civil servants and the Judge, followed by a meeting with a predefined agenda and open to suggestions from staff throughout the group, in order to have functional issues addressed (…) First they all enjoy a delicious breakfast with casual conversations and then the meeting is held. In these meetings solutions to improve judicial services are addressed" [89].

Regarding the public, Carvalho et al. [67] highlight that sharing may lead to a delay of organizational deterioration and an improvement in performance. Caution, however, must be taken in order that this phenomenon is not held down by bureaucratic assumptions of management or personal presumption to understand knowledge as individual property [27].

Van Caenegem [19] when dealing with a possible 'regulation' for sharing through a migration of people between companies, he draws attention to the fact that the socialization of knowledge is less of a normative protocol of relationship and more of a free act between people who have valuable knowledge and desire to share it. Leading organizations often encourage the use of tacit knowledge of their workforce [54], considering crucial its transfer within the organization [65].

[6]A town in the state of Rio Grande do Sul in Brazil.

Although little studied and understood in the Brazilian judiciary, TKS can increase the chances of diffusion of knowledge [90], especially where, "in general, there is no dialogue or exchange of experiences" [91]. Taal et al. [92], however, when examining the phenomenon in the European judiciary, notes that many judges declared that sharing is not a new activity and meetings, seminars, symposiums, and learning events provide the environment conducive to sharing. This phenomenon thus encourages the formulation of policies contrary to the permanence of outdated or dysfunctional routines.

The observation of the existence of a prior knowledge (good practices and lessons learned), for example, can prevent the occurrence of errors of repetition [93], as state judge reported: "In fact, we learn from situations as they arise, we have no strategy (…) errors may occur and occur frequently, hence the difficulty of getting it right from errors" [94]. Even from the perspective of administrative modernization, the transferability of knowledge and management practices gain in sharing a relevant factor and an increasingly intensified practice [95].

The importance of knowledge sharing by tacit means ("face to face" interactions) was reaffirmed by Stefanovitz [96] when dealing with innovation in product development processes. Von Hippel [97] reported that rapid transfers of knowledge actually increase a company's ability to benefit from its own know-how.

From the literature, aspects related to not sharing are also present. Amabile [98] argues that the immobility or inertia of tacit knowledge may be related to lack of motivation of the holder to share. Szulanski [99] analyzed, from the organization's level, its inability to create an atmosphere for TKS; and from the personal level, the lack of interest in the receiver and his/her low absorption capacity, as well as relationship problems with the transmitter. The author perceived an association between these aspects and a possible loss of a firm's ability to build competitive advantage. In communities of practice some causes were identified: fear of misuse; the possibility for personal attacks, and little objectivity concerning the shared knowledge [100].

When dealing with successful companies, Choo [101] pointed out that organizations that have demonstrated ability to adapt to constant change, innovate continuously, and to make decisions that lead toward their goals demonstrate ability to handle knowledge. He noted that an organization with a properly harnessed knowledge has a differentiated ability from others to perceive, discern, and act smart. Thus, the performance of an organization in the era of knowledge is associated with a continuous learning process, generating a model where creativity, innovation, and sharing of tacit knowledge are integrated and reveal themselves in the form of experience.

The United Nations (UN) in recognizing the importance of sharing, points out in its study on innovation in governance the importance of governments working together and better, and so, "knowledge sharing is the first step" [102]. Knowledge sharing can modify the installed mental baggage [103], allows for the creation of new knowledge [104], boosting the organization in its ability to innovate [105], and even grants a greater market value for the organization [106].

With impetus, sharing of tacit knowledge enables the formation of new ideas and knowledge, food for innovation [13]; this sharing being essential to the organization's intelligence [107].

As the whirlwind holds dust immobilizing it, the sharing phenomenon brings stimuli to the knowledge flow. Examples of this dynamic are: the conversation that transfers knowledge [51], the spiral structure [8], and "interpreting communities" [108], which provide new channels, spaces, and organizational arrangements to knowledge.

The sharing terminology encompasses other words such as transfer, distribution, communication, collaboration, diffusion, dissemination, allocation, network, cooperation [109], passing [106], interaction, exchange, and socializing. Because it is a growing challenge for most organizations [18] and because it provides for an opportunity of interpretations [35], there is a growing interest in studying the sharing process, even under the warning of being difficult to transfer [88].

Itami [110] addressing knowledge and the ability to pass it as an invisible organizational asset, points out that, although they are very important ingredients for the development of a successful strategy, they are difficult to measure. Christensen [111] denotes that there are few references in the literature and few companies that include sharing as a key component to increase organizational performance, due to the difficulty of measuring this phenomenon.

Since, it involves intangibles internalized in beliefs, experiences, and personal values, Inkpen [3] stated that the formalization of tacit knowledge becomes complex in certain contexts and difficult to share. Ruschel [90], while researching the Labor Court, found that, although precious, tacit assets were restricted only to the minds of the judges.

The results from the research on knowledge management in public administration [112] follow in the same direction when evaluating the intangible assets (intellectual property assets), and although available in the institutional environment, they are difficult to be qualified and measured. Alvarenga Neto [12] endorses such views, stressing that for being innate to human beings, one cannot share tacit knowledge with ease and spontaneity, however, it is suggested in his conclusion the "urgency to create a set of indicators for measuring the benefits of knowledge management." Likewise, Sveiby [68] supports the considerations of Alvarenga Neto [12]. Noting that a focused strategy on knowledge can be quantified if an organization seeks something beyond measuring monetary flows, but also flows related to intangible assets such as knowledge.

Longanezi et al. [113] presented some nonnumeric indicators based on idea generation: brainstorming sessions, specific training, number of submitted ideas, and the identification of best practices. Another tool that according to the authors encompasses a continuous measuring process is benchmarking. Regarding this topic, however, they pointed out a limitation that restricts its use, "the unwillingness of leaders to share real relevant indicators" [113].

The TKS concept proposed in this chapter is an interpersonal exchange phenomenon describable and measurable. Represents the interaction of tacit knowledge flows established between people. Can occur within organizations or among them, requires a social environment of trust, and promotes the incorporation of new content with multilateral gains of aggregating nature [114].

The following **Table 3** shows some key points concerning TKS and their respective references.

Key points relating to TKS	References
Communities of practices (CoP)	[100, 108]
Competitive advantage	[99]
Crucial	[54, 65]
Difficulty relating to TKS	[12, 88, 110–112]
Firms value	[81, 106]
Indicator to TKS	[12, 68, 113]
Individual property	[27, 90]
Informality	[3, 51, 67, 89]
Innovation	[13, 86, 87, 101–105]
Interactive action, socialization	[19, 48, 51, 84, 96, 114]
Learning	[37, 82–84, 88]
Management practices	[95]
Motivation	[98]
Organization intelligence	[107]
Organizational deterioration, performance	[67, 97]
Organizational wisdom	[36, 90]
Other words to TKS	[106, 109]
Prevention of errors	[93, 94]
Sharing as essence of TK	[83, 90–92]
Spiral structure	[8]

Table 3. Summary table of the literature and key points relating to tacit knowledge sharing (TKS).

6. Some models that have TKS as its core

Ikujiro Nonaka, Japanese organizational theorist, in contextualizing the creation of knowledge in an organizational environment, understood that the interaction between tacit and explicit knowledge was the main dynamic generator of knowledge. He conceptualized tacit knowledge as something difficult to visualize and express, particularly in regards to the actions and experiences of the individual, as well as emotions, values, or ideals. His model gives emphasis to personal interaction, where the key is in the sharing of knowledge [8].

Sveiby [68] introduces his model dealing with visible and invisible knowledge structures. He details among the intangible goods (assets), the competence of employees, customer relationships, brands, management mode, knowledge, and experience. He defines some organizations as 'organizations of knowledge,' featuring its employees as 'knowledge workers.'

In these organizations, intangible assets have more value than its tangible ones, knowledge gains value when it is shared and those that take action in the TKS process end up having an increase in their stock of knowledge through interaction.

Leonard and Sensiper [74] highlighted that collaborators' individual and collective expertise is the source of innovation and a competitive base for most organizations They suggested three applications to the tacit knowledge to leverage the innovation (problem solving, problem finding, prediction, and anticipation future occurrences). They stressed that creative ideas “do not arise spontaneously from the air,” but they are originated by a mental process by social interactions where the tacit knowledge are sorted, grouped, matched, and melted. Still, they emphasized that new solutions are rarely constructed in an isolated fashion and that cooperative productions are essential to organizational development.

Choo [101] states that the construction of knowledge is achieved when one recognizes the synergistic relationship between tacit and explicit knowledge, and organizations need to learn how to convert tacit knowledge into explicit knowledge, becoming capable of promoting innovation and the development of new products. For Choo [101], there are four ways of converting knowledge: through a process of socialization (tacit knowledge into tacit), in other words, allowing the acquisition of tacit knowledge through the sharing of experiences; through externalization (tacit knowledge into explicit) a process in which tacit knowledge is translated into explicit concepts through the use of metaphors, analogies, and models; by combination (what is the word that the author used? Combination, blending, mixing, mixture, matching, hybrid… choose whichever is original) (explicit knowledge into explicit), a process that builds explicit knowledge through the gathering of explicit knowledge from various sources; through internalization (explicit knowledge into tacit) a process in which the experiences acquired in other ways of building knowledge are internalized by the individual in the form of mental models or common work routines.

Davenport and Prusak [51] stressed the importance for knowledge-based organizations to adopt sharing as one of the essential elements. They alerted to the fact that the existence of large numbers of individual tacit knowledge does not necessarily lead the organization to use this knowledge. The importance of organizations turning their attention to the spontaneous and unstructured sharing of knowledge strengthens and encourages the emergence of social movements in favor of TKS. Regarding the inherent informality of sharing, they stressed that conversations around water coolers or in restaurants are sharing opportunities and to designate these moments as a ‘waste of time,’ is part of an outdated theory on the nature of work. They stress, however, that it would not be a sensible attitude to wait around the breakroom for an answer to a specific knowledge, but, they reaffirm that ‘spontaneous meetings of minds’ (unstructured transfers) have demonstrated a capacity to generate new ideas or solve old problems unexpectedly. In the culture of knowledge transfer, the authors pointed out, some friction can slow or even block the communication flow:

- Lack of mutual trust;
- Lack of time and of places to meet;

- 'Not invented here' syndrome'[7];
- Intolerance toward mistakes or for needing assistance.

Miranda and Simeão's model [108] proposes the existence of elements, not so discernible (such as, technological communication systems), but of high value for the transfer of knowledge, such as, "a set of knowledge and practices"; the practice of "Granting specific know-how," or the sharing of "how-to-do". The authors point out to the irrevocability of human interaction in the transfer of tacit knowledge, setting up an 'extensive model of communication.' They argue that in TKS, the process occurs in an interpersonal way, developing increasingly complex structures, such as communities of practice and invisible colleges.

Tonet and Paz [106] consider the knowledge sharing process as composed of four phases: initiation, which are actions that seek to identify and analyze the needs of knowledge, the existing opportunities to employ different or new knowledge, and the tracking of sources where this knowledge can be found; implementation, actions that seek to promote integration between sources and recipients of knowledge; support, actions that seek to create opportunities to exercise shared knowledge and that promote the guidance of its practice with the objective of assimilating knowledge and the development of the necessary skills for a proficient use; and incorporation, actions aimed at making that shared knowledge can flow freely among those who should use it.

7. Conclusion

Knowledge has been occupying the center of studies and research for some time, and this chapter seeks to contribute to the depth of this collection and aims to offer articles that deal with tacit knowledge and the sharing of that knowledge.

This work aimed to bring a review of the literature regarding TKS and to contribute with some definitions related to the topic. The observed understanding with this literature review is that organizations, and to a lesser degree, The Small Claims Federal Courts, are moving from a traditional model that is attached to physical and tangible assets to another, where knowledge, especially tacit, is treated as an organizational asset that, despite being immaterial, becomes valuable and a generator of wealth.

In this trajectory and encouraged by initial questioning, this chapter depicts the search for different references in which the sharing of tacit knowledge was related to a range of organizational vectors covering definitions that go from understanding it as an innovation factor to a strategic component for leveraging organizational performance. Seen by some as difficult to transfer, tacit knowledge is accepted by others as a component of communication flows, where dialogues, social networks, communities of practice, invisible colleges, and even 'TKS

[7]In the literature 'not invented here' (nih) is described as an idea or innovation that was not developed within the company's workplace environment or that was not conducted by their own internal members, so the solution does not have the 'necessary characteristics or identity of the organization' and thus should not be considered.

points' cease to be mere expectations and become powerful channels and knowledge transmission arrangements. Although organizations find themselves inserted into a knowledge society, increasingly tacit, an unequal measure of attention seems to be given to information to the detriment of tacit knowledge.

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Chapter 2

Knowledge Sharing and Human Resource Development in Innovative Organizations

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Abstract

Global competition and rapid changes in technology demand more innovation in organizations. Such an increase in innovation depends on developing the capabilities of employees and providing them with knowledge management support that accelerates learning and discovery. Leading companies have been creating work environments that emphasize learning and knowledge management since the turn of the century. This chapter presents profiles of practices in five such companies and draws conclusions that result in a model that ties human resource development (HRD) practices to knowledge management practices as a guide for other organizations.

Keywords: innovation, human resource development, knowledge management, knowledge sharing, learning and development, collaboration, communities of practice

1. Introduction

Innovation is a key driver of economic growth. New and improved products, processes, and services account for the bulk of trade and industry advancement since the Industrial Revolution. Technology innovations receive a lot of the credit for economic growth. However, modifications in organizational design, infrastructure, policy, and other factors in the organizational ecosystems also deserve significant credit. All these changes depend on generation of new knowledge and its application. In recognition of the central role of knowledge in organization performance, the field of knowledge management (KM) emerged as a focus on improved understanding of the processes and their links to organizational performance

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in modern organizations [1, 2]. Simultaneously, the field of human resource development (HRD) emerged with a focus on improved understanding of the processes of learning and development (L&D) in organizations and their links to performance [3]. KM and HRD seem to intertwine naturally in their approaches to organizational effectiveness.

HRD processes change the competencies of employees at all levels in an organization and thereby play major roles in driving innovation and economic growth. People competencies and the way those competencies are leveraged across the organization due to changes in organizational design occur largely because of innovations in the HR, human resource management (HRM), and human resource development (HRD) departments—the people development functions in the organization. In that trio of special functions, HRD focuses on learning and development at the individual, team, and organizational levels. Innovation inside an organization occurs when employees have the knowledge, skills, and attitudes for learning, taking thoughtful risks, sharing knowledge, and thinking creatively, and the organization's systems provide needed support [4]. Ishak et al. [5] suggest KM is essential for developing the human resource. We further suggest HRD is essential for growing the knowledge that flows through the KM system.

1.1. Applicable literature

Although many definitions of innovation have been published, we will select the following: innovation is executing new ideas to create value [6]. Crossan and Apaydin [7] refer to innovation as both a process and an outcome. Using a complex adaptive systems framework, Harkema [8] linked learning and knowledge generation when he defined innovation as a knowledge process for generating new knowledge, so it drives incremental or radical change.

This chapter focuses on KM and HRD practices that enable innovation within some of the world's most innovative companies. Examples from these innovative organizations will facilitate an understanding of the way enablers and critical success factors of innovation, KM, and learning are implemented for competitive advantage.

A learning organization consists of formal and informal systems that facilitate learning by its members and rapid change in adapting to the environment—a culture where learning drives proactive change. Knowledge sharing benefits from developments in any part of the learning organization that improves the flow of knowledge. For example, HRD work in the organization can build up the communication-related competencies of employees, upgrade organizational design to reduce silo effects, and develop employees' ability to effectively utilize technology, all of which contribute to knowledge-sharing capability within the organization. HRD plays a pivotal role in leading innovative activities with responsive guidance [9]. HRD practitioners increase learning effectiveness from individual, group/team, and organizational levels. Through continuous learning and improving, HRD fosters a culture that favors innovation [10]. In addition, HRD offers diverse solutions to explore challenges by analyzing the organization from the organization development standpoint [11]. Finally, HRD creates reward mechanisms that motivate employees to challenge the status quo and embrace change.

We view KM as "an iterative process of handling actionable knowledge that results from individual, group, and organizational learning to improve organizational performance" [12]. In this context, knowledge consists of individuals' insights, experiences, know-how, and values that are justified through social interactions among participants [13] to make knowledge actionable and embedded in organizational repositories [14]. Consequently, KM functions so organizations can use their actionable knowledge effectively to improve their performance [12]. Generally, HRD can contribute to innovation by promoting organizational activities that better manage the flow of knowledge (i.e., to acquire, create, store, share, use, and assess) throughout an organization [15].

Formal, informal, and incidental learning drives innovation in industry [16–18]. Practitioners in HRD develop learning systems that include an emphasis on career development, training and development, and organizational development. The field of HRD has been changing rapidly over the past two decades and finds itself in a special role in companies of all sizes that make its tools and processes highly valuable in the rapidly changing organizations of the twenty-first century.

In this chapter, we profile five organizations where HRD provides the kind of support that makes learning and development central to the strategic development of knowledge-based organizations. Based on interviews of HRD staff members in these organizations and a study of their Websites, publications, and company reports, we present ways in which HRD creates conditions for enabling knowledge sharing and learning and the processes that enable innovation within these organizations. The five innovative organizations discussed in this chapter include Air Liquide based in France, Krungthai Card Public Company Limited (KTC) in Thailand, and Rockwell Collins, FMC Technologies Inc. (FMC Technologies), and Praxair in the USA (**Table 1**). This sample of innovative organizations was intentionally selected to represent a diverse set of countries and industries as a way of illustrating ways that HRD can promote learning and change inside organizations that stimulates their ability to innovate.

Sustainable organizations are complex, adaptive systems [19]. The challenges that organizations and their employees face today in turbulent market conditions demand an internal environment of continuous learning and knowledge creation, transfer, and sharing as keys to adaptation and innovation and a culture that stimulates a risk-taking mindset. The interrelated processes of learning and knowledge creation occur within a social and a cognitive system embedded in a hierarchy of complex systems. Many hurdles to effective learning and knowledge creation, transfer, and sharing in those systems impede the processes that promote problem solving and utilization of process outputs. Few aspects of the work environment effectively promote those processes. HRD professionals develop the required human capital and create a work environment that unleashes and leverages its human capital for continuous innovation. The same types of HRD tools and methods may be at use in several organizations, but their application depends on the local culture. The next section presents five profiles of innovative organizations using tools and methods of HRD to create more effective knowledge management systems (KMSs). The profiles are necessarily brief and so provide only a small slice of the dynamic processes of human capital development in these companies.

	Praxair	Air Liquide	Rockwell Collins	FMC Technologies Inc.	Krungthai Card PCL.
Industry	Industrial gas & chemicals	Industrial gas & chemicals	Avionics & IT systems	Oil & gas	Consumer finance
Country	USA	France	USA	USA	Thailand
Year founded	1907	1902	2001	1928	1996
Core values	1. Safety; 2. Governance; 3. Energy and climate change; 4. Eco portfolio; 5. Sustainable productivity; 6. People development	Rely on operational excellence, selective investments, open innovation, a network organization	Access, connect, transcend	1. Safety & sustainability; 2. Collaboration; 3. Innovation; 4. Valuing people; 5. Integrity; 6. Customer-centered; 7. Quality	1. Modern; 2. Dynamic; 3. Professional; 4. Simple; 5. Fun
Corporate cultural areas of focus	Diversity, employee, community, and stakeholder engagement	Innovation, new product development; expand and develop new markets	Accelerate knowledge, create value enterprise-wide	Living corporate values; put customers and clients first	Mission-based projects; employee satisfaction

Table 1. General company characteristics.

The companies were selected from the Fortune 500 list but also had to be recognized for their innovativeness. They represent a variety of industries and locations.

2. Case studies

Five case studies of twenty-first century organizations are presented below to illustrate how they have found ways to use HRD practices to improve innovation capability in their organizations. Each case shows unique features as the search for ways to increase innovation capability is tailored to the business context.

2.1. Praxair

Praxair, a Fortune 500 company based in the USA, was selected because of its ranking by *Forbes Magazine* on the list of the "World's Most Innovative Companies" [20] and the Achievers 50 Most Engaged Workplaces™ in North America for 2016 [21]. Praxair is one of the largest industrial gas companies in the world. The organization's primary products are atmospheric and process gases for industrial customers in approximately 50 countries.

The vision for Praxair is "to be the best performing industrial gases company in the world" [21]. This performance culture is driven and reinforced by six priority factors: (1) safety; (2) governance, ethics and compliance; (3) energy and climate change; (4) eco portfolio (environmental innovation and product stewardship); (5) sustainable productivity; and (6) people development. The sixth priority involves four key performance indicators: diversity, employee engagement, community engagement, and stakeholder engagement. Additionally, Praxair's mission is "making our planet more productive," as the company serves customers and the planet for economic and environmental improvements. Success with that mission is reflected in Praxair's consistent placement on the Dow Jones Sustainability World Index for 13 consecutive years [22].

Development of human capital inside Praxair has involved continuous investment for decades. To create a culture based on the core values and achieve performance goals, senior leadership decided to have HR play a more strategic partnership role in 1999 [23]. The mandate for HR was to

1. develop the next generation of Praxair leadership,
2. accelerate employee development and new talent acquisition, and
3. improve integration of business and HR activities.

These three goals for HR operationalized the vision of the firm as it entered the twenty-first century.

The HR team chose eight avenues to pursue these goals:

1. Promote diversity and the core of talent management [24].
2. Create a global mindset.
3. Develop leadership at all levels of the organization—"blended executives" as professionals with subject matter expertise [25].
4. Build a high level of employee engagement.
5. Align HR process with the business via rewards and recognition, goal setting, and team design.
6. Warehouse HR and customer information for data analytics to drive intelligent decision making [26].
7. Develop a more effective knowledge management system.
8. Create a more comprehensive approach to training and development.

Early success with the Praxair program was reflected by the inclusion of the company as the focus of one of 17 chapters in Carter et al.'s [27] book *Best Practices in Leadership Development and Organization Change* which profiled leading innovators in leadership and organization development. The programs for HRD have continuously evolved at Praxair as exemplified by the following sample of topics.

2.1.1. Job autonomy

Based on clear communications around corporate vision, goals, and mission, Praxair gives enough autonomy to all business units to run their own business. Compared to other companies in the chemical industry, Praxair has fewer controllers, commanders, or instructors who regulate or monitor employees' job-related behaviors. Praxair encourages employees to be creative thinkers, to accept and explore different or new perspectives to solve problems, and to expand conceptual frameworks. The flexibility and the absence of rigid job design can be also exemplified with these five principles representing careers at Praxair: "explore your possibilities; build your skills; enjoy your challenge; make your mark; and own your future" [21].

2.1.2. Learning and development

Learning and development (L&D) provides formally structured and informal learning opportunities to facilitate employees pushing the limits of knowledge and experience. Praxair regards every aspect of employees' actual job performance as a part of L&D. A special emphasis has placed knowledge sharing through mentoring at the center of the L&D process. The social support of learning emerges from mentoring relationships. Mentoring of women and by women leaders represents an important part of that emphasis. Praxair formally trains technical personnel in mentoring skills to accelerate the sharing of both technical and soft skills knowledge. The rapid development of new hires in both hard and soft skills prepares them for filling the gap created by retiring senior employees through mentoring relationships. Mid-career employees with advanced degrees may leave for other opportunities, so Praxair uses job shadowing and cross-training for all employees and internships, and job transfers for invited employees to achieve continuous development. Because of the risk involved in manufacturing processes, safety training and safety culture become a primary goal of L&D. The most knowledgeable employees in each work group earn the title of subject matter expert (SME) or corporate fellow [28]. Furthermore, Praxair puts a great emphasis on leadership development, not only for current leaders but also for the next generation of leaders. For example, Praxair uses simulations to develop leadership capability in technical staff with three levels of challenge—early career, mid-career, and longer service—where teams work together to solve problems of a fictional enterprise with ever-changing circumstances [29].

2.1.3. Knowledge management

Firmly grounded in the corporate mission/vision, Praxair operates productivity programs by sharing the best practices. Each employee is mandated to contribute to productivity goals that are measured in hard dollars. A sense of urgency is created to emphasize personal accountability balanced with the skills for teamwork. Furthermore, the company, especially the global engineering business unit, runs communities of practice (CoP) for knowledge creation and dissemination. Praxair launched an on-demand video system in 2010 and an ask-an-expert system in 2011 [30] to facilitate the sharing of knowledge between senior employees on the verge of retirement and less experienced employees. Viewing of the videos increased exponentially because of leadership support. One key has been easy access to videos through such mechanisms as links embedded in E-mails. The technology for the ask-an-expert system has evolved from SharePoint to a customized system to increase effectiveness. Requiring every community of practice to participate with one or more questions per month increased participation and value [31].

2.1.4. Summary

Innovation involves the ideas and efforts of organizational employees. As their knowledge, empowerment, and engagement grow, so does innovation capability. Praxair has made a number of deliberate changes over recent years to build that capability.

2.2. Air Liquide

Headquartered in Paris, France, Air Liquide was founded in 1902 by a group of French scientists and engineers seeking to develop and commercialize a new process for air liquefaction (thus leading to the name of the company). During this period, Paris was considered a beacon of the arts, scientific research, instrument and tool manufacturing, banking, and venture capitalism and "an incubator for technological innovation and for the formation of high-tech start-up companies, not unlike what Boston/Cambridge and Silicon Valley would become in the United States in the late twentieth century" [32]. Smith refers to primary founder of Air Liquide, Georges Claude, as "Frances's leading industrial scientist of the last 100 years" (p. 51). Claude's inventions, creativity, and persistence were key drivers of innovation and success throughout the organization's early years.

Since its founding in the early 1900s, the organization has grown to be one of the world's top two industrial gas suppliers, providing oxygen, helium, nitrogen, carbon dioxide, and argon to business customers in the automotive, chemicals, food and beverage, semiconductor, and healthcare industries. Today, Air Liquide employs approximately 51,500 people across 80 countries and generated over $18 billion in sales revenue in 2015 [33] (these figures do not include the May 2016 acquisition of Airgas).

2.2.1. The importance of innovation at Air Liquide

Innovation has been a key part of the corporate identity since the organization's founding. An excellent history of Air Liquide's early years of innovation can be found in Smith's [32] article "Product Innovation and the Growth of the Large Firm: The Case of Air Liquide, 1902–1930." New product development and innovation are important parts of Air Liquide's strategy as the organization endeavors to continuously improve its production technology, expand existing markets, and develop new markets.

2.2.2. Role of HRD and KM in facilitating innovation

Air Liquide leverages employee development programs, such as technical career pathing, mentoring, and high potential programs, along with more traditional KM approaches such as communities of practice, to facilitate knowledge sharing, transfer technical knowledge, and foster a culture of innovation throughout the organization.

From a developmental standpoint, human resources has established a Technical Career Leaders (TCL) dual career ladder, created in 2003, that serves to identify, develop, recognize, reward, and retain key technical expertise within the organization as well as facilitate the transfer of their knowledge. The TCL program includes six levels: two local levels and four international levels. The program offers structured, yet flexible, career tracks where technical talent has the option to develop and progress in their careers within either the technical or the managerial path, and the flexibility to move between career tracks during their careers. Each track includes mentoring, training, networking, and other developmental opportunities for participating employees.

TCL is a worldwide program covering all Air Liquide business lines. As of June 2016, there were approximately 2500 experts representing 67 nationalities participating in the TCL. Technical areas encompassed in the TCL program include electronics, engineering and technology, healthcare, industrial merchant (cylinder, bulk, and onsite; and applications and services), large industries, and research and development, and each of these areas has its own domain of expertise. Employees are selected to participate in the TCL program based on criteria such as their participation in knowledge transfer activities, their leadership and influence abilities, and their capacity to communicate and deliver on their technical vision and innovative ideas.

Within the Large Industries Business Line in North America, Air Liquide also engages select early- to mid-career high potential technical talent in a LEAP (learning, experiencing, and progressing) developmental program in order to accelerate time to competency of these employees and retain and engage this key employee population. An analysis of this technical population revealed that there was insufficient pipeline to fill anticipated gaps in technical roles due to attrition of technical experts. Therefore, the LEAP program was instituted in 2013 in order to provide early- to mid-career high potential technical talent with the practical, technical training and experiences that they need to quickly advance in their careers at the organization. The LEAP program began with 24 employees; today there are approximately 75 employees participating (45 protégés, and the reminder coaches, trainers, and managers). Each protégé is assigned a coach (some coaches have more than one protégé). The program consists of 10, three-day classes, supplemented with computer-based training, to cover technical content as well as soft skills training. Protégés are assigned a set of technical objectives at various points throughout the program to complete over the next 12 months, under the guidance of their coach. The program offers participating employees a variety of experiences and learning opportunities in an accelerated fashion in order to speed their developmental process, and help transfer technical knowledge from the coaches to their assigned protégés.

From a knowledge management perspective, Air Liquide has established technical communities of practice (CoPs) at a worldwide level, the business line level, as well as at the more regional hub level. For example, as of June 2016, the company has 7 worldwide technical CoPs established and 10 technical CoPs within the large industries business line in Europe. Hubs for the Americas, Asia Pacific, and Middle East Africa are in the process of establishing their own CoPs. The intent of the technical worldwide CoPs is to set standards, establish technical vision, and identify technical best practices. The hub CoPs, in turn, focus on implementing the best practices identified in the worldwide CoPs and people development. All communities facilitate knowledge sharing and transfer within the organization. Within the Americas zone, both formal and informal communities leverage Google Plus Sites as the enterprise platform to facilitate and enable virtual collaboration, content sharing, and Q&A amongst site members.

2.2.3. Summary

Programs such as TCL and LEAP facilitate innovation on an individual level by presenting employees with multiple and diverse opportunities for learning and growth and on a collective level by enabling employees to learn from one another and build on the ideas of others. Similarly, CoPs at Air Liquide provide forums for networking, knowledge sharing, and employee development, ultimately fostering individual and organizational learning and innovation.

2.3. Rockwell Collins

Rockwell Collins, Inc., headquartered in Cedar Rapids, Iowa, provides avionics and information technology systems and services to governmental agencies and aircraft manufacturers. The organization went public in 2001 as a spin-off from Rockwell Automation and has been experiencing tremendous growth over the past decade. Rockwell Collins runs operations in 60 locations with nearly 20,000 employees around the globe (Rockwell Collins, 2014). Its aircraft electronics are installed in the cockpits of nearly every airline in the world, and its airborne and ground-based communication systems transmit nearly 70% of all U.S. and allied military airborne communication. The organization also provides flight simulation and training, MRO (maintenance, repair, operations) services, navigation, and surveillance systems [31].

2.3.1. Innovation culture and knowledge management

Since 2001, Rockwell Collins has undergone a period of rapid growth. The unprecedented growth was a primary driver of its KM system. With the rapid expansion of the organization, the necessity to connect new employees with existing knowledge and expertise worldwide became increasingly urgent [31].

The history of Rockwell Collins' KM system can actually be traced back to 1999. In order to fulfill the mission of "access, connect, and transcend," corporate leaders developed a KM system to "accelerate knowledge, and create value" enterprise-wide [34]. Over the past 10 years, each department of Rockwell Collins has been closely connected by the KM system. Currently, many KM approaches and tools, such as communities of practice (organized groups for employees to share and learn), Epedia (companywide Wikipedia), Lessons Learned (a reflection tool in Epedia), and Enterprise Tools Integrated Forum (questions and answers forum) are used daily [35–37]. Rockwell Collins has promoted a learning culture by combining its formal training and development processes with these industry leading KM programs [34, 38]. The five to ten awards won by Rockwell Collins each year, include Blue Ribbon winner for Innovation by *Military Training Technology* magazine in 2014 [39].

2.3.2. HRD's role in innovation

There are several strategies that HRD leverages to support innovation at Rockwell Collins. For example, a virtual university (Rockwell Collins University) functions as the catalyst for innovation. The University employs highly developed e-learning systems to offer courses efficiently. Technology enables employees to access learning anytime and anywhere. Within the learning culture at Rockwell Collins University, e-learning is a richer source for learning beyond videotapes or online tools only. Employees seek answers actively instead of being offered solutions. For example, learning and development specialists regularly assess the need to retain the core knowledge that senior employees may take away when they retire. Learning and development specialists worked with the Performance Engineering Group (PEG) to invent "QuickLearns," computer-based tutorials featuring subject-matter experts performing key tasks [40].

At Rockwell Collins, a learning culture that emphasizes sharing has been formed with HRD's assistance. For example, HRD specialists facilitate ad hoc meetings with engineering-group leaders who have suggestions and feedback regarding training programs at Rockwell Collins. As a group, HRD specialists use such venues as one mechanism to identify training needs [40].

2.3.3. Summary

One pervasive risk to many technical organizations is employees leaving the organization with critical technical, cultural, and social knowledge that is difficult to replace. As a learning organization, Rockwell Collins leverages the HRD strategies and the well-established KM system described above to create a culture that recognizes inquiry, feedback, and creative thinking. The KM system helps the organization navigate both planned and unplanned organization change.

HRD at Rockwell Collins leverages training and development and knowledge sharing through KM tools to support organizational learning on each level (individual, team, and organizational). As a result of HRD's efforts to facilitate innovation, the organization has experienced several positive changes. First, the creation of a learning culture fosters innovation and out-of-the box thinking. Second, the implementation of KM programs facilitates knowledge sharing at the company more freely and efficiently. Finally, the company has created healthy recognition and reward mechanisms that encourage knowledge sharing and innovative behaviors by employees. In Rockwell Collins' case, formal and informal learning programs are complemented by a firmly established KM system, which makes the company a learning organization that encourages employees to think and work innovatively.

2.4. FMC Technologies, Inc.

Headquartered in Houston, Texas, FMC Technologies is a publicly traded oil and gas equipment services company, specializing in subsea, surface technology, and energy infrastructure. It was originally founded in 1884 as the Bean Spray Company, but then changed in 1928 to the Food Machinery Company, which is where the FMC initials originate. FMC Technologies was recognized by Forbes on its list of most innovative companies in 2013 [20]. At that time, FMC

Technologies ranked 17th on Forbes' international list of innovative organizations, based on their innovation premium. The innovation premium is the difference between a company's market capitalization and a net present value (NPV) of cash flows from existing businesses [20]. Companies with a market cap above NPV of cash flows are ranked in order of the most market cap above NPV to the least. FMC Technologies had a market cap of $12.4 billion USD.

Foss et al. [41] provide a solid definition of knowledge sharing, which is "…the provision or receipt of task information, know how, and feedback on a product or a procedure" (p. 458). The core beliefs espoused by early HRD practitioners and theorists include the notions that HRD itself is the process and practice of developing, harnessing, or releasing of human expertise through individual and organizational development in order to improve performance [42]. This is evidenced in these platforms of knowledge sharing at FMC Technologies: The Women's Leadership Program, a comprehensive program for the development of women as leaders; the Edge, a formal knowledge management system (KMS); WellLinked, a quarterly employee publication; and a business model of formalized internationally based centers of excellence (COEs). The HRD-specific function each of these platforms is discussed in the next section.

2.4.1. Knowledge sharing, innovation, and HRD

Knowledge sharing supports organizational productivity and also enriches its credibility with the marketplace and stakeholders [41]. HRD enhances knowledge exchange at FMC Technologies in three key internal areas that drive external value:

1. Leadership and talent development—Sustainment of success and mindfulness is critical in the leadership and talent development disciplines within FMC. The strategic purpose of the Women's Leadership Program is to support employee's potential and also to attract and retain top talent. Women learn about leadership roles, behaviors, styles, and leading teams, as well as focus on career development and leadership skills necessary for them to be successful. The company monitors the career advancement of the participants to ensure their success and that of the program [42].

2. Team learning and expertise development—A web-based application called the edge allows technical staff to post issues to a single location to receive electronic suggestions, responses, and answers from other knowledge workers within FMC Technologies. Technical staff make use of this global technology knowledge-sharing platform that enhances team learning, giving people opportunities to problem solve with others around the world. If a team member is having an issue or experiencing a challenge, another employee anywhere in the world can provide expertise from a virtual community with thousands of members. In addition to sharing expertise, employees learn about the various working conditions of their colleagues [42].

   One of the most prominent features about this organization is consistent messaging about its internal organizational and operational expertise. FMC Technologies publishes a quarterly global employee publication called WellLinked highlighting the success of employees, teams, and organizational plans. The magazine's purpose is to inform all employees on the forward progress of the organization and any updates in organizational strategy [42].

(3) Networking—FMC boasts 50 online networks established to focus on different parts of the business. Any employee can read content shared within a network, but the people who work in the specific area of the operation run or manage the network. One of the networks, the New Hire Network, helps new hires get their questions answered. Team members welcome them, provide responses, and let them know how to find necessary resources [42].

2.4.2. Summary

HRD's role in innovation at FMC Technologies is to support collaboration and community building that contributes to performance through knowledge sharing. The work of HRD is an antecedent to this organization's ability to support its customers' success. FMC Technologies' stance on innovation is girded by formal organizational structures that ensure knowledge sharing, which makes their customers and the company, in turn, successful.

2.5. Krungthai Card PCL (KTC)

Krungthai Card Public Company Limited (KTC), a consumer finance service provider in Thailand founded in 1996, represents one of the Thai companies, recognized from the Stock Exchange of Thailand, as an innovative organization. KTC was the first Thai financial firm to reform itself into an innovative organization in order to make a difference in its corporate identity.

The company's core values (modern, dynamic, professional, simple, and fun) help KTC build a new corporate identity that differentiates it from its competitors [43]. To manage its identity, the company aligns the five core values with innovation infrastructure capability. The innovation infrastructure capability, which includes the organization structure, the organizational culture, and leadership style, supports the development of creativity and innovation. KTC's structure is characterized by low levels of hierarchy, high levels of cross-functional collaboration, and decentralization of decision making. The KTC corporate culture involves team mission-based projects, modern and dynamic working styles, and a workplace orientation focused on employee satisfaction. KTC leaders emphasize a people-oriented management approach and play an important role in managing organizational change related to creative and innovative capabilities.

2.5.1. Learning and innovation

Regarding KTC's corporate identity, the organization encourages employees to become dynamic and collaborative in order to cope with change in its business markets. KTC assumes that if the company sustains a relaxing learning environment, employees are able to generate a high degree of creativity and innovation.

At KTC, creativity in employees is developed through a lively and collaborative learning climate. The learning climate is shaped by the five core values that align with the organization's processes and practices. The company primarily focuses on collaborative learning in which employees share their knowledge and skills with their peers through a social community. KTC uses this collaborative learning through interactive working processes, such as knowledge sharing within a mission-based team and a specific learning program titled "KTC Knowledge Sharing." These learning activities are delivered via face-to-face and online media (i.e., KTC Mind Intranet) communications. Various employees acquire knowledge from each other when they are placed collectively in their communities.

Creativity and innovation are facilitated by a culture of the learning organization [10] and knowledge management [44]. This culture requires an alignment of organizational policies, procedures, and practices that foster a dynamic interaction of individuals, groups, and an organization that creates knowledge.

2.5.2. Role of HRD and knowledge management

HRD is a bridge between personal creativity and organizational performance through KTC policies, procedures, and practices. HRD strategically supports KTC's identity through the development of employee competencies that are aligned with creativity. KTC uses the knowledge-based organization concept to enhance individuals' competency development and create knowledge sharing within the firm [45]. Consequently, HRD at KTC contributes to innovation through a variety of learning perspectives: active training, social learning, as well as coaching and mentoring.

KTC facilitates many active training programs to enhance employees' competence through dynamic learning.The firm provides classroom training and e-learning programs to develop core, functional, and managerial competencies for its employees. These programs are designed with regard to a dynamic of learning activities and a degree of learners' participation. For example, the HR function implemented a grooming, acting, and voice training program for call center representatives to change their attitudes and make them aware that voice and facial expressions affect their performance when they talk with their clients on the phone [45]. The trainers designed a fun and relaxing environment through demonstration, practice, and a singing contest. KTC applied an aesthetic concept to design fun and dynamic training to develop individuals' creativity as well as to enhance morale and work engagement.

Social learning is about learning from others. The most recognized KTC social learning program is "KTC Knowledge Sharing." This program has succeeded with a large number of participants [46]. KTC employees were invited to be speakers who share their knowledge regarding their specialized areas. The knowledge shared focuses not only on the business-related content but also on the non-related business content (e.g., mind-map writing, health and safety, and fashion).

At KTC, coaching and mentoring are used as informal learning practices, not only to develop individuals' work skills, but also to help them in career and personal enhancement. The former CEO, Niwatt Chitalarn, believed that the most important responsibility in managing his employees was to build a leadership team at KTC [47]. His management philosophy was "my control and your control" by performing as a captain pilot who coaches co-pilots. A captain pilot must function as a leader to provide direction and coordination for his crew. At the right time, a captain pilot should allow co-pilots to make a decision. He believed that a leader had a responsibility, not only to oversee an organization's performance, but also to develop the leadership team. In consistency with the previous CEO's philosophy, the current CEO, Srimongkol, coaches his executive teams by asking opinions, giving suggestions, then monitoring their performance, and providing feedback on their actions [45].

Under the knowledge-based organization concept, KTC focuses on learning and development to enhance individuals' capabilities and create practical knowledge sharing within the organization [46]. The firm creates a climate of team learning to move toward its corporate goals.

2.5.3. Summary

KTC uses a dynamic workplace approach in unleashing individuals' creativities in order to update its corporate identity to one that is more vibrant and creative. Senior leadership at KTC assumes that organizational creativity and innovation rely on learning. The knowledge, experiences, and cultural familiarity that each individual employee embodies can be delivered through social learning. The company creates and sustains a creative and innovative culture through leadership and management activities by leveraging actions across the organization. HRD at KTC encourages employees to improve their work through a lively learning environment and a climate of team work and knowledge sharing.

3. Conclusions

Throughout the chapter, examples were provided of organizations that are considered to be innovative. The conclusion of the chapter focuses on specifying commonalities between innovative organizations. We believe themes emerge in the five profiles highlighting linkages between HRD, KM, and innovation. The identification of similar practices and processes may not make it easier for organizations to be innovative, but it does facilitate understanding by practitioners and researchers of some organizational antecedents necessary for innovation to flourish.

We hope this chapter also accomplishes a secondary goal to solidify and clarify where the presence of HRD together with KM establishes conditions necessary for innovation. HRD looks to develop and unleash human expertise and creativity with its focus on career development, training, and organizational development. HRD at these five cases contribute to facilitating a learning culture, providing a broad spectrum of learning and development (L&D) opportunities, and providing employees a broad spectrum of opportunities and encouraging diversity of thought and new ideas. On the other hand, KM focuses on the development of communities of practices, organizational knowledge sharing through lesson learned process, and the utilization of technology to create infrastructure for storing and sharing expertise and best practices. These KM processes facilitate and sustain individual and collective activities to help manage the flow of knowledge (to acquire, create, store, share, use, and assess) throughout the organization. When and where there is expertise and creativity coupled with methods of harnessing, sharing, and growing knowledge and ideas, we believe an organizational environment or culture can exist for innovation. **Figure 1** captures the relation between HRD, KM, and innovative organization.

3.1. Themes of innovative organizations

Several themes emerged from examination of the five company profiles, which are depicted in **Figure 1**. The themes represent facets of organizing that enable the generation and sharing of new knowledge that relates to improved organizational performance. The themes are matched to the profiles of the five companies shown in **Table 2**.

3.1.1. Vision and core values

Many organizations begin with their vision statement as a starting point to motivate organizational performance. In their vision statements, Praxair and FMC Technologies insist on the long-term view of the organization as one of the global preeminence—a key to organizational sustainability. Core values occupy a supporting role in an organization's vision. With KTC its value-based perspective initiates the development of the resulting learning climate.

3.1.2. Autonomy

While organizational leadership may seem to exert control over its business, technology, and products, each organization demonstrates times when internal self-sufficiency provided flexibility for the organization [48]. Flexibility and agility are what allow organizational systems to

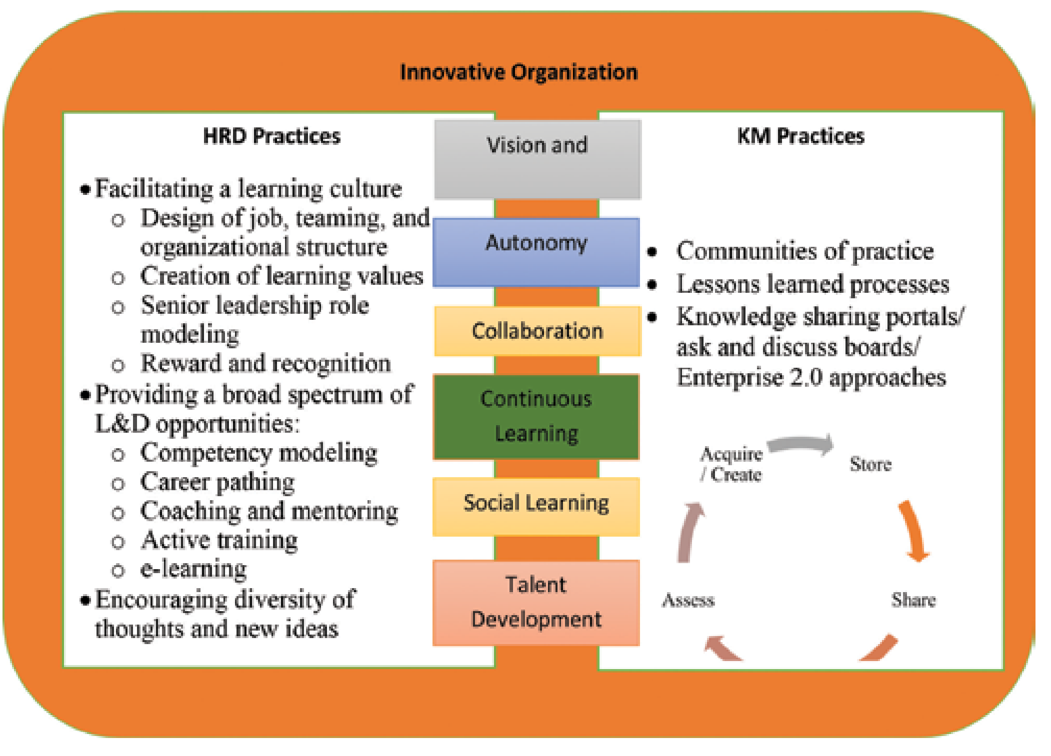

Figure 1. Relationship between HRD and KM practices.

	Praxair	Air Liquide	Rockwell Collins	FMC Technologies Inc.	Krungthai Card PCL.
Vision & core values in daily life	Make the planet more productive	Invent, design, produce high quality solutions for customers and patients	Establish a culture that recognizes inquiry, feedback, and creative thinking	Organizational focus on living the core values	Alignment of corporate policies and practices to enhance employee competency and organization culture
Autonomy	1. Business-unit level autonomy flattens the hierarchy 2. Flexible job design		Employees empowered to seek solutions	Team-based problem solving and solution implementation	
Collaboration	Communities of practice	Communities of practice	1. Communities of practice; 2. Institutionalized cross-functional training	Communities of practice for each business unit, and department	3. Collaborative learning environment; 4. Team-based knowledge sharing
Continuous learning	Simulation-based learning for at all career stages	Focus on continuous learning of succession planning	1. Company-based Wikipedia 2. Formalized lesson-leaned processes	Employee-focused quarterly communication	Leader-directed corporate culture
Social learning	Rapid development of new hires			1. International centers of excellence 2. New hires integrated socially through online and face to face platforms	Engagement-based learning
Talent development	1. Engage HR for next generation leadership, talent acquisition, and business integration; 2. Women mentoring other women; 3. Mid-career talent development	1. Technical career paths; 2. Mentoring & coaching; 3. Early & mid-career talent development	Corporate university	1. Corporate university 2. Women's leadership development program	Coaching & mentoring

Table 2. Company findings mapped to conceptual model.

adapt quickly within their markets and ever-changing business environments. Job autonomy and the self-rule provided in the communities of practice are examples of internal self-governance.

3.1.3. Collaboration

Across each of the companies profiled in this chapter, collaboration in team learning enhances competence by allowing employees to learn from one another. An effective KM system supports the collaborative learning.

3.1.4. Continuous learning

Within the communities of practice, constant dialogue by employees results in continuous new learning with processes improving and adaption occurring.

3.1.5. Social learning

As organizations are largely social systems, learning within their communities reinforces desired knowledge and behavior. These communities reflect learning and collaboration. Rockwell Collins and FMC Technologies communities of practice use technology to share knowledge across their internal teams.

3.1.6. Talent development

Whether the need for talent is within the technical sphere, such as with Air Liquide, Rockwell Collins, and Praxair, or in the leadership area, such as with FMC Technologies, internal programs whose focus is to hone specific competencies identify and guide both expertise and knowledge sharing within the organization. Early, middle, and end of career development supports internal career development and the life cycle of the organization. As talent and the organization mature, the needs of both individual and company are met.

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Network Market Orientation, Knowledge Management and Born Globals' Competitiveness

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Abstract

This chapter studies the influence of network market orientation (NMO) on Spanish Born Globals' (BGs) competitiveness. The study analyses the contribution of a specific knowledge-based dynamic capability, namely absorptive capability, as a key mediator variable between NMO and competitiveness, finally influencing the international performance achieved by this particular type of firm. Results from testing the structural equation model proposed confirm that NMO facilitates the development of an absorptive capability in BGs and that this capability, in turn, influences the firms' capacity to exploit the new relational knowledge, thus improving their competitiveness and international performance.

Keywords: Born Globals, network market orientation, absorptive capability, competitiveness, international performance

1. Introduction

Muchof the previous research on internationalisation behaviour concludes that firms become involved in international markets gradually [1]. However, in the last 20 years, a new kind of business has emerged that does not follow a gradual internationalisation pattern, but is characterised by rapid commitment to international activity. Oviatt and Dougall [2] called these businesses 'Born Globals' (BGs), and they have given rise to a new line of research known as international entrepreneurship centred on the study of how new ventures are committed to developing the processes of 'discovery, enactment, evaluation, and exploitation of opportunities across national borders to create future goods and services' ([3], p.7). Past research in this area has centred on determining the factors that might explain the exceptional speed with

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which certain new ventures can internationalise [3–10]. However, several authors consider that to be able to advance our understanding of BGs, we need to analyse the factors that can affect their competitiveness after their creation, particularly from a marketing perspective [11–17].

Traditionally, lack of market knowledge has been regarded as one of the biggest impediments small businesses have to overcome in their internationalisation process [18–20] in that it constitutes a key variable for proactively seeking international opportunities [21, 22]. McNaugthon [23] shows that companies concerned to expand their knowledge of foreign markets have a broader perspective and there is a greater chance that they will seize the opportunities that appear in them.

If we attempt to identify the main source of this knowledge, we observe that traditional gradualist models attribute a fundamental role in knowledge generation—and, therefore, in the internationalisation process—to the firm's experience (at home and abroad) [1]. However, in the case of BGs, knowledge based on experience cannot be considered the only source of knowledge about foreign markets that these firms use, as their experience is minimal. For this reason, it becomes necessary to investigate how BGs manage to acquire and interpret information about markets and how they translate it into specific actions that affect the development of skills that help them to remain dynamic in international markets [22, 24, 25].

Many marketing scholars argue that market orientation plays a determining role in the international success of new businesses due to its contribution to effective knowledge management [26–30]. In this line, Knight and Cavusgil [31] point out that the market orientation of new international ventures enhances their understanding of their customers' present and future needs and optimises the development of distinctive actions that can meet these needs by providing a more valuable offer than that of their rivals.

In addition, based on the social perspective, the study of entrepreneurship has also highlighted the importance of the links entrepreneurs develop with members of their networks as they facilitate rapid access to the information and knowledge associated with the latest trends in the new markets, and with certain key resources that are not initially available to these firms [32–36].

However, although from the theoretical viewpoint there seems to be a strong complementarity between market orientation and membership of business networks, as shown in certain studies [13, 37, 38], little is known about the way these factors combine. In this vein, Loane and Bell [18] highlight the need for research attention to the mechanisms and routines that enable new international ventures to generate and manage knowledge through relationships they establish in networks. In turn, Evanschitzky [38] highlights the importance of studying their influence on competitiveness and firm performance, in light of the scarce knowledge to date.

In this respect, this study covers the mutually complementary nature of both factors in a single construct known as network market orientation (NMO). Thus, although previous studies have emphasised the importance of MO in the context of relationships between firms, they have not analysed it as an inter-business phenomenon in itself, but rather as the sum of the market orientations of the various individual firms [22, 37, 39, 40]. The present work analyses the role of NMO differently, understanding it as an orientation established jointly by the different members making up the network.

However, the effect of any organisational factor is usually subject to significant causal ambiguity regarding the way firms maintain their capacity to use the knowledge generated in order to continue seizing the market opportunities that arise [41]. Adopting an NMO that promotes a cognitive effort and collective approach to learning can help to overcome this ambiguity by improving understanding of the new and changing links between action and performance and, in this way, recognising the need to face changes in existing routines [22, 40, 42, 43]. In line with this idea, it is essential that BGs complement their adoption of an NMO with the generation of dynamic absorptive capability in order to ensure continuing commitment to construct new resources and capabilities and reconfigure existing ones, thereby adapting to new market demands [22, 44–48].

Specifically, this absorptive capability is related to the assimilation of external information into the firm's internal knowledge base [4, 49]. It is crucial for each firm to develop this capability individually, since it enables the external knowledge generated in the network context to be perfectly understood and assimilated internally by the firm and put to use successfully [50–54].

Ultimately, this study aims to contribute to the existing literature by analysing the way in which BGs start by adopting an NMO in order to access and systematically manage information from foreign markets and the way this orientation contributes to generating a dynamic absorptive capability that helps them to capitalise on the knowledge generated, thus facilitating their consolidation abroad.

In order to meet this objective, we first present the theoretical frame used to formulate hypotheses on the influence of NMO on BGs' international competitiveness and performance. The empirical study carried out to test the hypotheses is then reported, with an analysis of the results obtained and the main conclusions. Finally, limitations and future research lines associated with this study are described.

2. Theoretical development

2.1. The relevance of NMO for BGs

The international entrepreneurship literature has increasingly emphasised the role of business networks in the process of learning and knowledge generation in BGs [36, 55–57]. The relationships an entrepreneur builds with the other network members (family members, customers, distributorsand providers) can be crucial in (1) generating more differential and valuable knowledge on new clients' needs and the business environment conditions, (2) knowing how to exploit the positive conditions and avoid the negative ones and (3) accessing the capabilities and resources required to do it [34]. Networks, therefore, offer BGs a way of compensating for their limitations of newness [58], smallness [59] and foreignness [60] by providing the opportunity to access valuable supplementary knowledge on aspects such as technology, distribution channels and customer bases [61] and to improve other knowledge-related aspects such as information exchange and coordination [62] and the speed of know-how and technology transfer [63]. Thus, networks are key for BGs to develop a broader knowledge base beyond what they could achieve alone [64], abandoning the idea that the generation of new knowledge is a purely internal process [19, 25, 56, 65]. This is particularly so if we bear in mind that BGs are characterised by their lack of necessary resources.

The processes that contribute to relational information management in adopting an NMO are presented in the theoretical proposal of Helfert et al. [37]. These authors define four relational knowledge management mechanisms developed jointly by the members of a network: knowledge exchange processes, in order to satisfy clients' requirements; coordination processes, aimed at synchronising the network ties through formal and informal routines; coupling processes, necessary to adapt the particular features of a network member and conflict resolution mechanisms designed to solve unexpected contexts. The work of Helfert et al. [37] represents a significant step forward in the study of this construct. In fact, previous research was limited to considering the sum of market orientations in individual companies [66] or adapting the original market orientation models (behavioural and cultural) to the network setting.

Following the work of Helfert et al. [37], Monferrer et al. [22:p.388] defined NMO as 'a strategic orientation established jointly by the different members in the business relations network. This strategic orientation involves, in a climate of trust, collaboration and commitment, engaging in certain activities and fundamental shared behaviours (adaptation, coordination, conflict resolution and exchange) based on the generation of an extended intellectual capital'. These activities seek to increase the competitiveness of the network and its individual members in an attempt to provide superior value to end customers by satisfying their needs.

2.2. NMO and absorptive capability in BGs

Absorptive dynamic capability is related to the processes developed in the company to seek new information, internalise it and integrate it into the firm's existing knowledge base [49]. Developing this capability is vitally important for BGs' survival, since their business opportunity has not yet been consolidated. Furthermore, given that BGs compete in a global market segment [2, 3], the nature of the factors that influence the conditions of their business environment come from a greater diversity of sources. This variety of sources has the effect of increasing the complexity associated with the mechanisms BGs need to generate in order to manage and internally integrate knowledge from their external markets. For this reason, before developing new knowledge search and integrative mechanisms, firms must stimulate the use of processes that allow original knowledge from different sources to be managed efficiently [22, 48].

BGs are recently created companies and therefore they assume limited resource availability [5, 6, 8, 14, 17, 67]. In these circumstances, networks facilitate the development of absorptive capability in BGs [68]. Nahapiet and Ghoshal [69] indicate that to access the different sources of knowledge from their external markets, firms need to generate communication processes in order to guarantee the capture and integration of real and potential capabilities and resources associated to the relationships an individual unit builds through its network.

Similarly, Cohen and Levinthal [49] suggest that absorptive capability is built on communication structures that cross firm boundaries.

Belonging to a market-oriented network will therefore give BGs some relevant advantages, first by improving their capacity to develop an agreed perception of their markets based on multiple agents and sources of knowledge; and second, by incorporating coordination processes to interpret and understand that knowledge and integrate it into the internal firm's knowledge base [22, 37, 40]. In sum, a market-oriented network facilitates the development of BGs' absorptive capability. We therefore posit that:

H1: Participation of BGs in market-oriented networks stimulates their absorptive capability.

2.3. Absorptive capability and competitive advantages in BGs

To specify these competitive advantages, we are guided by the work of Porter [70], who considers that the different meanings used to refer to competitive advantages can be condensed into two general ones which cover all the rest [13, 71–73]: product differentiation-based and cost-based competitive advantages. The former refers to factors such as quality, design and other attributes that distinguish firms' offers of value from those of their rivals [70–72], as well as advantages linked to services such as delivery speed, reliability and managing additional services [40, 72, 73]. In turn, cost-based advantages lie in the domain of manufacturing, administration and commercialisation costs. They give the producer value in the form of lower costs and offer the consumer the lowest price [40, 70, 72, 73].

Regarding the influence that absorptive capability has on these advantages, Cohen and Levinthal [49] argue that establishing practices which encourage the assimilation of external knowledge creates a positive incentive to invest in R&D and thus improve the firm's possibilities of achieving superior competitive advantages. According to Ref. [74], improving the differential nature of a new company requires (1) the internal application of certain valuable knowledge-based resources and capabilities; (2) the skill to associate them with other external ones; (3) the capacity to integrate the knowledge derived from this association internally and (4) the capability to apply this knowledge to potentially successful business aims. As Laursen and Salter ([75], p.146) manifest 'the lack of openness of firms to their external environment may reflect an organizational myopia, indicating that managers may overemphasize internal sources and under emphasize external sources'. An excessively internal vision may therefore negatively influence the competitiveness of the firm [49]. To encourage firm competitiveness, ideally there should be a balance between the concentration of internal capabilities and openness to the exterior [76]. In this regard, Vinding [77] extols the role of absorptive capability, as it enables the firm's internal capability and its external collaboration to complement each other. On the basis of this capability firms manage to capture, absorb and use external knowledge, thereby facilitating the achievement of competitive advantages [22, 78–80].

BGs tend to gradually define the specifications of their products or services by taking into account the particularities of their customers and the conditions that characterise their competitive environment [22]. BGs thus need to avoid internal short-sightedness when specifying market trends in differential and low cost products or services [3, 22, 81]. Therefore, BGs use the information and knowledge generated on the basis of their absorptive capability to introduce the valuable specifications and features required in their products or services to guarantee the feasibility of their business project. These arguments lead us to propose that:

H2: Greater absorptive capability in BGs leads to greater development of differentiation-based competitive advantages.

H3: Greater absorptive capability in BGs leads to greater development of cost-based competitive advantages.

2.4. Competitive advantages and international performance in BGs

A review of the conceptualisations of the competitive advantage concept shows that, by definition, a firm has a competitive advantage over another firm when it obtains a superior performance [82]. Therefore, the competitive advantage can be seen as a direct antecedent of a BG's international performance because the superiority arising from its attempt to provide value determines the purchasing performance of its target market [55], and consequently its performance [40, 72, 83]. When a firm achieves competitive advantages (differentiation-based and/or cost-based), it has a higher capacity to generate value for its clients and, in turn, greater levels of client satisfaction, business volume and market share and lower customer service costs [30, 84, 85]. As Snoj et al. [83] point out, sustaining competitive advantages is the basis for achieving superior business performance, survival and development. Therefore, the following hypotheses are proposed:

H4: BGs' achievement of differentiation-based competitive advantages contributes to higher levels of international performance.

H5. BGs' achievement of cost-based competitive advantages contributes to higher levels of international performance.

Figure 1 summarises the model of effects for the study.

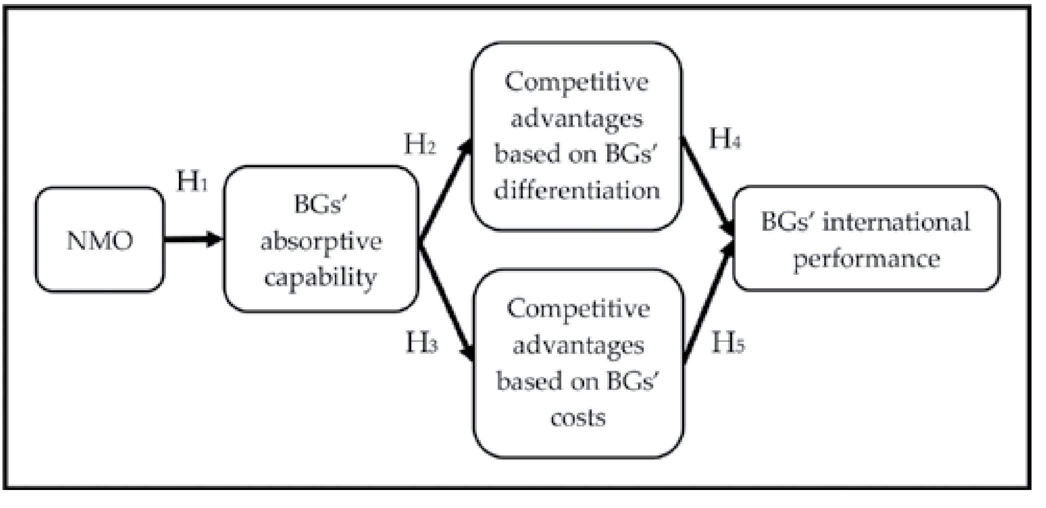

Figure 1. Model of effects.

3. Methodology

3.1. Sample selection and data collection

We started with 2012 Spanish firms, all under 7 years old and operating internationally, taken from the Dun and Bradstreet and SABI databases. To refine the sample and ensure that the firms selected were BGs, a total of six selection criteria were applied on two different occasions: prior to and during the field study. Thus, based on the filters available in the databases, the following criteria were applied: (1) the firms should be no more than 7 years old, thus guaranteeing that they are new firms; (2) they should make their own strategic decisions, thus excluding subsidiary or affiliated firms; (3) they should have a minimum of three employees and a maximum of 250, ruling out micro-firms, self-employed individuals and big firms. This process of refinement resulted in a population of 1023 firms.

The questionnaire was drawn up, based on an in-depth bibliographical review, including the three remaining selection criteria (not available without direct consultation with the firm): (4) their international activity should have started in the first three years following their creation, thus showing their immediate incorporation into foreign markets; (5) they should generate a minimum of 25% of their annual sales abroad, thus providing evidence of a consolidated international presence and (6) they should form a part of a network of firms with a minimum of three members. Regarding this last criterion, in order to ensure that interviewees focused their responses on their main business network, as an introduction the following definition was included, in which business networks are understood as '*the set of relationships that the firm maintains with other agents such as customers, suppliers, competitors, consultants, government agencies, universities, research centres, market research firms, advertising agencies and sales or distribution agents with the aim of obtaining knowledge, information, technology, resources or skills*' ([86], p.24).

The questionnaire was then pre-tested with a pilot sample of 25 firms to ensure it would be correctly understood. An electronic version was then prepared for the field work, of which 303 valid responses were returned (29.62% of the total).

An analysis of the primary data revealed the principal characteristics of the sample (**Table 1**). The firms are SMEs, mostly from the industrial sector (61.2% of the total), notably the agri-food, metal and textile sectors. Commerce is represented by 31.6%, including firms that export and import products related to the aforementioned industrial sectors. Finally, less than 7.2% of firms come from the services sector, including mostly financial, tourism and communication agencies. The firms have on average 28.55 employees, 41.50% of their commercialisation work is abroad, and their average age is 3.90 years.

Regarding the networks to which the firms belong (**Table 2**), almost all of them became part of the network on their creation (96.4% after their first year of life), they are usually networks with marketing aims (in 92.5% of cases) and are composed on average of 5.81 firms, located near the firm (62.19% of the networks have a regional scope).

Years of international experience		Total number of employees		International activities in the value chain*		Activity sector	
Years elapsed	%	Employees	%	Activity	Average%	Sector	%
0	76.6	3–5	26.4	Manufacturing process	11.58	Industrial	61.2
1	19.8	6–11	25.4	Research and development	7.40		
2	2.1	12–25	23.8	Commercialisation	41.50	Commercial	31.6
3	1.6	Over 25	24.4	Advertising and promotion	11.18		
Average years elapsed = 0.28		**Average employees = 28.55**		After-sales service	16.51	Services	7.2
				Average international activity = 17.63			

Note: *Figures expressed as a percentage of total responses.

Table 1. General characteristics of the firms.

Years since creation to entrance in the network		Network size		Geographical scope of the network[1]		Type of network	
Years elapsed	%	Firms	%	Scope	%	Type	%
0	82.4	3	55.6	Self-governing region	62.19	Social network	2.5
1	13.5	4–5	19.4			Technological network	14.9
2	1.4	6–10	11.1	National	15.42	Institutional network	2.0
3	2.7	>10	13.9			Infrastructure network	5.5
Average years elapsed = 0.12		**Average firms = 5.81**		International	22.39	Marketing network	92.5
						Market network	15.4

[1]According to the location of most network members.

Table 2. General characteristics of the main networks of the studied firms.

3.2. Measurement instruments

To measure the market orientation of the network we adapted the scale proposed by Helfert et al. [37]. These authors move away from the idea defended in previous studies of measuring the network's market orientation by simply adapting the dimensions used in the seminal scales of MO. Specifically, this scale includes a total of 12 items on the four dimensions that reflect the relational processes management of NMO: coupling (2 items), coordination (3 items), conflict resolution (3 items) and exchange (4 items).

To measure absorptive capability, we use the three-item scale of Ref. [87] that evaluates the degree to which the firm's management systems encourage the ability to acquire, assimilate, transform and exploit knowledge.

Competitive advantages are measured with the scale developed by Ling-Yee and Ogunmokun [71] and the proposals made by Morgan et al. [72] and Ha-Brookshire and Dyer [73]. This scale reflects the firm's position in relation to competition in terms of differentiation and costs when adapting its offer to international market needs.

Finally, we use an adaptation of the scale proposed by Jantunen et al. [81] to measure international performance. Specifically, we asked BG managers about their degree of satisfaction with their activity in terms of turnover, profitability, market share and global satisfaction.

3.3. Validity and scale reliability

To refine the scales, a confirmatory factor analysis was performed using structural equations models. The analyses guarantee a measurement model consistent with the theoretical proposals, supported by scales that are reliable, valid and present a certain degree of unidimensionality.

Based on the recommendations of Jöreskog and Söbom [88], we first examined the estimation parameters. We removed those indicators with standardised coefficients (λ) under 0.7, significance of the Student t statistic under 2.58 (P=0.01) and R^2 under 0.49, thus ensuring that the strong and weak convergence conditions were met [89]. This process led to the removal of the indicators EXCH.3 from the NMO scale, ABS.1 from the absorption capability scale, and CACOS.3, CADIF.3 and CADIF.4 from the competitive advantages based on costs and differentiation, respectively. Several tests were then performed to verify whether or not the process of refinement of the scales had altered their level of reliability. We used Cronbach's alpha [90] to analyse internal consistency. Other complementary tests of reliability were carried out: the composite reliability of the construct and the analysis of the average variance extracted (see **Table 3**).

Finally, the convergent and discriminant validity were analysed. With reference to the former, it was sufficient to observe that the estimated value of the correlations between the dimensions configuring the scales was high and significant. The confidence interval test was performed to examine discriminant validity, verifying that '1' was not found in the intervals estimated for the correlations between each pair of dimensions (**Table 4**). The measurement model proposed is therefore reliable and valid for use in the testing of hypotheses.

Further tests were also carried out. First, we checked for signs of multicollinearity by testing the variance inflation factor (VIF) among latent variables in our proposed overall model. Values were below 10 [91], suggesting multicollinearity was not an issue in our study. Second, a t-test of independent means was performed on the dimensions of the variables in the proposed model. This test was conducted using the first 45 and last 45 respondents. No significant differences were found between these respondents at the 0.05 level, indicating an absence of non-response bias [92]. Third, various ANOVA were run to confirm that sample characteristics do not affect the model constructs. The following control variables were used, based on the data gathered in the questionnaire: sector of activity, international consolidation, age, international seniority, size, seniority in the network (all firm-related variables) and size of the network. Results revealed no significant differences in any of the analyses. Finally, the possibility of common method variance bias was tested with Harman's test, concluding that the bias caused by the method used was not a problem for the validity of the results obtained in the subsequent testing of the hypotheses [93, 94].

Scale	1st order								2nd order
	PERF	**ABS**	**CACOS**	**CADIF**	**COUP**	**COOR**	**CONF**	**EXCH**	**NMO**
λ	0.74–0.87	0.72–0.84	0.85–0.86	0.71–0.82	0.81–0.91	0.73–0.90	0.77–0.91	0.72–0.87	0.76–0.95
α	0.887	0.749	0.841	0.732	0.845	0.871	0.887	0.847	NP
CR	0.887	0.753	0.842	0.738	0.850	0.876	0.891	0.857	0.915
AVE	0.612	0.606	0.727	0.586	0.741	0.704	0.732	0.667	0.731
Significant loads			All $t > 2.58$			R^2	All $R^2 > 0.49$		

χ^2/df	RMSEA	SRMR	GFI	AGFI	NFI	NNFI	IFI	CFI
1.726	0.049	0.050	0.894	0.864	0.901	0.947	0.956	0.955

Table 3. Summary of the results after the definitive factor analysis.

Pair of variables	CACOS-ABS	CACOS-CADIF	CACOS-NMO	ABS-CADIF	ABS-NMO
I.C.	[0.143; 0.415]	[0.145; 0.421]	[0.124; 0.376]	[0.148; 0.436]	[0.198; 0.454]
Pair of variables	**CADIF-NMO**	**CACOS-PERF**	**ABS-PERF**	**CADIF-PERF**	**NMO-PERF**
I.C.	[0.036; 0.312]	[0.117; 0.369]	[0.049; 0.321]	[0.154; 0.418]	[0.279; 0.503]

Table 4. Discriminant validity analysis using the confidence interval (CI) test.

4. Results

Research in business-related sciences has gradually been enriched by the introduction of more sophisticated methodologies. This greater degree of development has enabled researchers to design and test increasingly complex models addressed to explaining the business reality.

Structural equations models have emerged from the evolution of multi-equation modelling developed chiefly in econometrics and combined with the principles of measurement from psychology and sociology, aimed at overcoming the limitation shared by other multivariate techniques such as multiple regression, factor analysis, multivariate analysis of variance or discriminant analysis, all of which can examine just one relation at a time [91]. Unlike the above-mentioned techniques, a structural equations model (SEM)-based analysis is able to explore a series of dependent relations simultaneously [91]. Therefore, this technique is particularly useful when a dependent variable becomes an independent variable in subsequent dependency relations.

For this reason, as with the scale validation, SEM was used to test the hypotheses, since they have proved to be highly useful in a non-experimental situation when the study aims to uncover the causal influence from one factor to another [88].

The hypotheses that constitute the model of effects were tested using EQS 6.1 software. **Table 5** shows that none of the proposed hypotheses were refuted. First, as expected, NMO presented a positive and significant effect on BGs' absorptive capability (H1: λ = 0.355; t = 4.931). Moreover, BGs' absorptive capability turned out to be a key variable in determining their achievement of competitive advantages, including differentiation-based competitive advantages (H2: λ = 0.222; t = 2.620) and cost-based competitive advantages (H3: λ = 0.330; t = 4.355). Finally each one of these variants of competitive advantage (differentiation-based and cost-based) showed a positive and significant influence on BGs' international results (H4: λ = 0.208; t = 3.050 and H5: λ = 0.128; t = 2.093, respectively).

5. Conclusions

This research was motivated by the large number of studies pointing to the important contribution BGs make to the progress of global economies. This circumstance has identified the study of the particularities that define BGs and that characterise their internationalisation process as a topic of major interest for academics and researchers [5, 6, 14, 17, 22]. Recent work in the international entrepreneurship field has urged researchers to contribute to the current understanding of firms' rapid internationalisation processes through richer empirical and theoretical studies [7, 8, 17, 25]. In this line, the Journal of International Business Studies will dedicate a special issue in 2017 to the determination of the factors that facilitate the creation and capture of entrepreneurial opportunities across national borders.

In general, our work adds to the growing support in the recent literature to the consideration of market knowledge as a key factor that determines the speed with which new companies adopt a proactive approach in crossing their national borders to seize new opportunities in

Relationship	Weight	t	Hyp.	Result
NMO → BGs' absorptive capability	0.355	4.931***	H_1	Not refused
BGs' absorptive capability → Competitive advantages based on BGs' differentiation	0.222	2.620**	H_2	Not refused
BGs' absorptive capability →Competitive advantages based on BGs' costs	0.330	4.355***	H_3	Not refused
Competitive advantages based on BGs' differentiation → BGs' international performance	0.208	3.050**	H_4	Not refused
Competitive advantages based on BGs' differentiation → BGs' international costs	0.128	2.093*	H_5	Not refused

Measurements of quality of fit

χ^2 (gl)	RMSEA	SRMR	GFI	AGFI	NFI	NNFI	IFI	CFI
0.569 (231)	0.043	0.062	0.919	0.895	0.926	0.967	0.972	0.972

* = p<0.05.
** = p < 0.01.
*** = p < 0.001.

Table 5. Results of the estimation of standardised parameters for the model of effects.

other foreign markets [19, 56, 95–98]. As Javalgi et al. [99: p.15] point out, in current dynamic contexts BGs 'must listen to and correctly interpret the voice of the market. [...] Firms that lose touch with the market, that either ignore or misinterpret its signals, will fail in hyper-competitive environments'.

Specifically, our findings contribute to the specialised literature with various relevant theoretical and empirical implications. First, gradualist models emphasise experience as an essential factor in the firm's internationalisation process by centring on determining the most relevant sources of external market knowledge [1]. However, the experience derived from physical presence in foreign markets is minimal in the case of BGs due to their recent creation. Experience cannot therefore be considered as the main source of knowledge BGs use in their entry into foreign markets. For this reason, a growing number of scholars highlight the role of vicarious knowledge from relations in networks as key source of external information and knowledge in BGs [56, 57]. As Lin and Chen [65: p.160] note, 'relationships between firms in a network context constitute an inter-organisational scenario for the exchange, compilation, integration and development of resources and valuable complementary knowledge that originally come from individual agents'. The links a BG builds into its network from its creation give it access to external information, knowledge, experiences and resources that it can apply internally [22]. In line with these arguments, the construct of NMO can be seen as a reference for determining how BGs generate and manage vicarious knowledge.

Second, based on ref. [37], our research enables theoretical identification and empirical testing of the behaviours and basic mechanisms that characterise the development of a coordinated market orientation among firms in BG networks. Our study responds to previous calls emphasising the need to complete the assumptions of individual market orientation with a relational view [43, 100, 101]. These findings show that the market orientation construct must be applied at individual and also network level [101], thereby supplementing the existing literature on the importance of individual market orientation in BGs [102, 103].

Furthermore, our results show that the knowledge these firms derive from their market-oriented networks helps them to develop an absorptive dynamic capability in order to act sustainably in their international markets. Therefore, BGs' development of absorptive capability should not be understood as a completely internal process, but as a relational process. This finding contributes to the discussion around the lack of attention paid to identifying the main variables beyond BG competitiveness [13, 71–73]. Indeed, our study responds to some authors' remarks that, despite the growing interest shown in recent years as a result of the intense process of globalisation in the markets, the theoretical and empirical knowledge about the internal and external antecedents of the international performance of new companies remains insufficient [13, 72, 73, 104, 105]. Our study complements previous literature in which analysis of these variables has tended to adopt an individual approach, highlighting the relevance for BGs of developing a market orientation [102, 103], an entrepreneurial orientation [3, 106, 107] or specific capabilities such as marketing and managerial capabilities [7, 22, 108, 109].

In sum, it is empirically demonstrated that adopting an orientation grounded in market knowledge and social networks (NMO) promotes the development by BGs of a dynamic absorptive capability that contributes to the systematic and effective adaptation to the dynamic and changing markets in which they operate, and the exploitation of the valuable knowledge generated. Our study integrates theoretical approaches from international business and entrepreneurship, providing a new framework that improves our understanding of the central role of knowledge in the way BGs capture and create opportunities across national borders.

6. Limitations and future research

The interpretation of the conclusions derived from this study should take into account some limitations, which lead us to propose certain future lines of research.

Regarding the theoretical limitations, our study proposes one particular model of effects to which other new relationships may be added, taking into account additional variables to complete the explanation of the achievement of competitive advantages and international performance by BGs.

Additionally, considering that our study complements the results from previous works that demonstrate from an individual perspective the influence of BGs' market orientation on their competitiveness, future research could explore the relationship between an NMO and a particular market orientation.

Moreover, taking into account that BGs' main internationalisation decisions are related to the speed and the mode they enter new foreign markets, future studies could analyse the influence of an NMO on different levels of speed and modes of entry.

Methodological limitations include the use of a single nation sample, since our findings may not be generalised to other national contexts. Future research could replicate and contrast the hypotheses presented in our work in other countries. We also used a multi-sector sample. Considering that networks may differ in their behaviour, structure and performance, future research could explore sectors, facilitating a larger homogeneity of firms and networks.

Another methodological limitation concerns the use of a single interviewee response per network and firm. This raises two questions: (1) Can the manager of an individual firm respond to questions on how a network of companies works as a whole? and (2) Similarly, can a single interviewee represent an entire company in his or her responses?

Further doubts may arise on the question of who actually responded to the questionnaire, bearing in mind that it was distributed online.

Finally, to make causal inferences using cross-sectional data can limit the value of the results. New research could usefully analyse the proposed model of effects with longitudinal data.

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Chapter 4

Knowledge Management Hybrid Strategy with People, Technology and Process Pillars

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Additional information is available at the end of the chapter

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Abstract

The importance of knowledge management (KM) contributes organizational competitiveness, which is widely addressed and became a central topic of management agenda in the last decade. This chapter examines three major KM pillars, including people, process, and technology, for effective KM deployment. Based on a questionnaire-based survey, the study investigates the perceived importance of three KM pillars that influence organizational inclinations of KM strategies and ultimately affect organizational performance. Quantitative findings are sought from 44 key informants in organizations. The results show a hybrid strategy that balances the importance of people, process, and technology pillars brings desirable impact on organizational performance, comparing with the KM strategy inclined to a particular KM pillar. Recommendations of KM endeavors on three KM pillars are provided to suggest the joint efforts from both management and employees.

Keywords: knowledge management, process, people, technology, hybrid strategy

1. Introduction

Knowledge management (KM) has been recognized as an imperative element for leveraging organizational effectiveness and performance. Organizations practicing effective KM methods achieve positive results in their organizational competitiveness, particularly innovation and creativity [1–3]. Despite the positive effects of KM, research on the KM pillars remains diverse. This study examines the interplay of the three major KM pillars acting as the platform for effective KM instigation.

On the basis of interviews with KM-intensive organizations, their good practices were categorized through a thematic analysis. Thereafter, an exploratory quantitative study from a sample

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of 44 respondents in different organizations was conducted to examine the relationship of the three major KM pillars. The survey results were further examined to evaluate the effects on organizational performance. Organizations harnessing a hybrid strategy to balance deployment of people, process, and technology gain positive results in their performance. The findings can provide direction for future studies to facilitate management in the deployment and integration of the KM pillars for attaining desirable organizational outcomes.

2. Knowledge management pillars

To understand effective KM practices, interviews were conducted with the senior management from two locally renowned KM-intensive organizations; the interviewees serve as key informants who steer and propagate KM. The qualitative data from these organizations were analyzed and thematized into three essential KM pillars, namely, people, process, and technology, which constitute organizational performance (**Figure 1**) [4–7].

2.1. Pillar of people

KM is embedded in working processes and practiced by each individual at different organizational levels, spanning from the senior-most to junior-most personnel. Typically, top managers champion the instigation of KM programs, provide vision to align the organizational strategy with the KM programs, and oversee the diffusion of KM initiatives throughout their organizations [8]. Members at different organizational levels act as knowledge workers who harness and utilize the knowledge assets residing in their cognitive repositories [9]. Through collective inquiry, sharing, and assimilation of knowledge, innovations and desirable organizational outcomes are boosted [1, 10]. Therefore, people are considered the heart of leveraging and creating knowledge for organizational competitiveness. Their cognitive minds influence their

Figure 1. Three knowledge management pillars.

approach to the processes of accommodating, validating, and creating different ideas solicited from different sources.

2.2. Pillar of technology

Using communication and collaboration technologies to support knowledge management is ubiquitous. Its effect is universally discussed as an indispensable means to facilitate the acquiring, codifying, indexing, updating, and disseminating of knowledge among employees [10–12]. Organizations invest in KM technology, such as document management systems and yellow pages, which enables the presentation of captured knowledge in readily available forms for different users.

Equipped with collaborative-oriented KM technology, employees can connect to one another within (e.g., through organization-specific intranets) and outside organizations (e.g., through the Internet) for rapid knowledge flows with enhanced time value. Employees using KM system (KMS) with learning and creation intention aim to capitalize knowledge assets through social networking and collective inquiries [12, 13]. With trust and reciprocity of exchange, employees share resembling identity over communities of practices to explore or exploit more new ideas and collaboration. User-oriented KM systems (KMS) supports, such as training workshops and forums, may further assist the adoption of KM processes in daily operations.

2.3. Pillar of process

Knowledge is mostly characterized by its tacit and intricate nature, and it resides in the mind of individuals [14–17]. Through individual inquiry and exploration, knowledge is activated from one's repository and externalized in different formats. By engaging through group dialogue, interaction, and exchange, knowledge can be pooled from different sources and created into different explicit stances. KM processes can generally be defined as an array of designated practices facilitating the flow and added value of knowledge. These processes not only help organizations identify and acquire knowledge from multiple sources but also allow their employees to explicate and disseminate knowledge in comprehensible formats. Valuable knowledge, skills, and competencies are documented and stored in knowledge repositories assuming various forms (e.g., minds of employees). Structured and planned documentations enable employees to share and retrieve relevant knowledge for implementing associated tasks. Employees can also assimilate new knowledge input to reconfigure existing knowledge and create new ideas for enhancing organizational goals [18, 19].

3. Organizational performance

A central tenet of harmonizing the three KM pillars is their association with organizational performance. Prior research indicates that effective human resources deployment, such as organizing employees to work as a team to leverage collective expertise, can be conducive to innovative activities [13, 20]. Management should also integrate KM processes allowing employees to harness, access, share, use, and create knowledge at different stances [21].

Equipped with KM technology, employees can leverage personal knowledge and improve skills through sharing and collaborative learning [9].

In this study, management who can utilize knowledge can leverage their capabilities to improve business profitability, streamline working processes, and influence coordination of efforts as well as responsiveness to market-changing innovation [16, 18, 22], thus contributing to desirable organizational performance.

4. Perceived importance, practice, and performance

Prior study explained that although most companies find KM promising, they can only capitalize on a few processes [19]. They further asserted that action is vital to turn knowledge into practice, which, in turn, allows knowledge workers to learn from mistakes and move on to the next stage. As an exploratory examination, the current study focuses on the practice of the three KM pillars in organizations. The relative importance and hierarchical position of the three KM pillars are then examined. The perceived importance of KM pillar is construed to influence the way management steers the KM program. Accordingly, the congruence between perception and the KM orientation is investigated. Given the different KM strategies and mix of the KM pillars, organizational performance is expected to vary. The notions are illustrated in **Figure 2**.

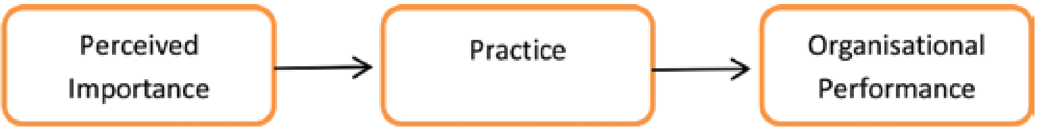

Figure 2. Framework of perceived importance, practice, and performance.

5. Methodology and data collection

This exploratory study employed questionnaire-based survey for data collection. Pilot tests with one professor and one business practitioner were conducted in order to solicit feedback on the structure, readability, and completeness of the questionnaire. In 2013, the revised questionnaires were distributed to 93 study informants, with a cover letter to depict the major objective of the study. To improve the understanding of information from respondents with conception and experience of KM, study informants who engage, steer, or participate in organizational KM were primarily solicited to participate in the survey. The data collection period lasted about 5 months, with 44 valid questionnaires were returned for analysis.

In order to minimize the social desirability bias, anonymity was stated explicitly to all study informants in the cover letter. The study mainly examined the constructs of perceived importance of the KM pillars, practice of KM pillars, and organizational performance. To assess the interplay of the three pillars and their effects on organizational performance, the study also conducted tests of the correlations of the three pillars with the organizational performance. Each pillar was measured with multiple questions. Except for questions regarding the demographic background of respondents and the company information, all questions adopted a five-point Likert scale (**Table 1**).

Characteristics	Number of respondents	Percentage of respondents
Gender		
Male	29	65.91
Female	15	34.09
Age group		
Under 25	2	4.54
25–34	10	22.73
35–44	30	68.19
45–54	2	4.54
Business sector		
Banking and insurance	6	13.63
Engineering	10	22.73
IT and telecommunication	10	22.73
Manufacturing	5	11.36
Wholesale, retail, export, and import	13	29.55

Table 1. Profile of respondents.

6. Results

To assess the interrelationships among the three KM pillars, descriptive statistics and correlation coefficients were derived with the aid of Statistical Package for the Social Sciences (SPSS). The perceptions of respondents were also examined to evaluate whether the three pillars influence how they harness knowledge assets.

6.1. Perceived importance

All 44 respondents expressed a unanimous agreement toward the importance of the three KM pillars, namely, people, technology, and process, to organizational growth. The awareness and recognition toward the three pillars are presumed to influence the KM agenda and endeavors in their organizations.

Upon their consensus, the respondents were asked to rank the order of the three pillars in their organizations according to importance. Two diverse views were identified from the respondents: (1) the three pillars are conceived as equally important and (2) a specific KM pillar is more crucial than the other two KM pillars. In **Figure 3**, nearly half of the respondents (45.4%, 20) explicated that people, process, and technology are inseparable and valued equally significant in their organizations. The rest of the respondents (54.6%, 24) perceived their organizations to have dissimilar emphasis over the three KM pillars. This dissimilarity accounted for the diversity in their organizational profile, history, competitive edges, and environment.

The 24 respondents were further asked to reflect their views toward the most important and rudimentary pillar in their organization and rank the three pillars accordingly (from the most to the least important pillar). The result is illustrated in **Figure 4**; 11 respondents (25.0%) perceived "people" as the most important pillar, followed by eight respondents (18.2%) for "technology," and finally five respondents (11.4%) for "process."

Apart from the ranking order of KM pillars, the 24 respondents were asked to reveal their perception toward the degree of importance of the KM pillars. The study employed a 5-point Likert scale (ranging from 5 = most important to 1 = least important) and computed the mean scores accordingly. The higher the mean, the higher the perceived importance of the particular pillar toward the organizational performance. Among the three KM pillars, "people" was rated with a mean score of 4.19, which was higher than "technology" and "process" pillars with respective scores of 3.88 and 3.71.

6.2. Practice

Emanating from theory of action advocated by Argyris and Donald [23], individuals are encompassed with a disparity between their "espoused" theory and theory in use. For example, participants in community of practice clearly know the benefits of knowledge sharing. However, in practice, employees may not explicate or externalize their knowledge continually because of different private agendas held or reciprocity toward community members.

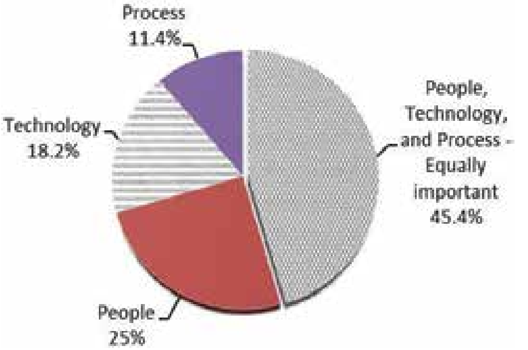

Figure 3. Perception of the most important knowledge management pillar.

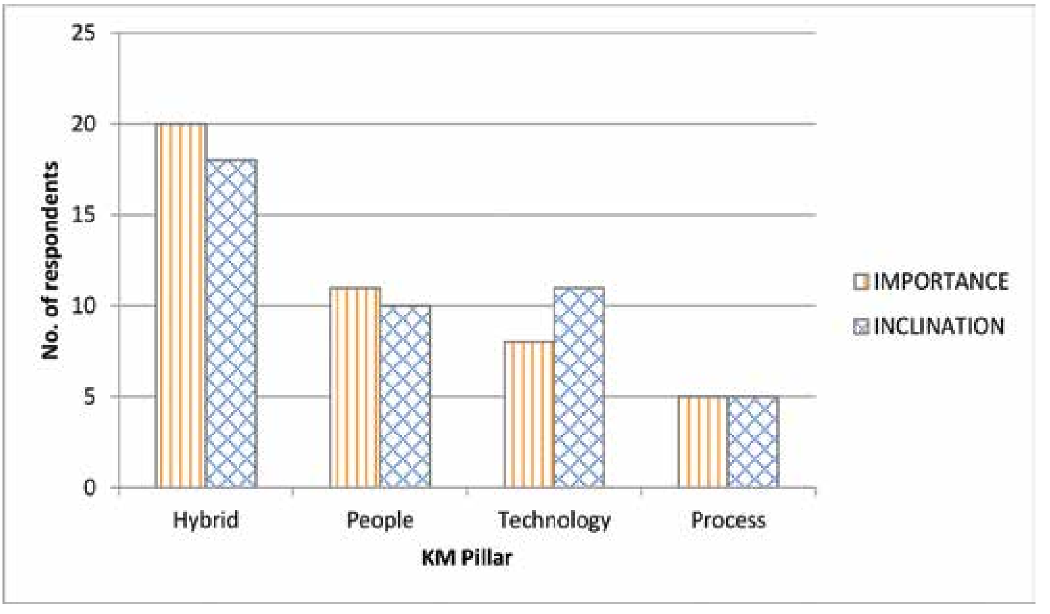

Figure 4. Perceived importance and inclination of knowledge management pillars.

A similar assertion is found in the current study. Despite the slight disparity, the perceived importance of KM pillars communicated to others is realized to be only partially congruent to the respective KM pillar deployment. To illustrate this point, all 44 respondents were further asked to evaluate the inclination of their KM strategy. The findings (**Figure 4**) presented four major KM strategies adopted in the organizations, namely, hybrid, people-oriented, technology-oriented, and process-oriented [24, 25].

In connection with the previous finding, 18 of the 20 respondents revealing the equal importance of the three KM pillars asserted that a "hybrid" strategy of KM practice is deployed in their organizations. Their KM plans incorporated and assimilated the three KM pillars to leverage people to engage in various KM processes, with the aid of KM-related technology to drive innovation and organizational improvement. They emphasized the interdependence and indispensability of people, process, and technology enabling organizational members to explore and exploit different types of knowledge.

Likewise, 10 of 11 respondents discerning "people" as the most important KM pillar, asserted that people-oriented KM strategy is carried out in their organizations. They emphasized that sources of innovation and new ideas are primarily instigated from people, given that most of the knowledge are tacit in nature and deeply residing in the mind of individuals. The organizations deploy diverse groups of KM people to articulate, interpret, and share knowledge among one another.

Concerning the supremacy of the ubiquitous technology in organizations, 11 respondents asserted that the technology-oriented strategy is adopted in their organizations, whereas only 8 respondents conceived "technology" as the most important pillar in the previous session.

The 11 respondents explained that technology is extensively used in their workplace to connect, communicate, and collaborate with parties in and outside the organization. Technology facilitates the integrative (e.g., new and old knowledge combination) and interactive flow (e.g., different knowledge workers exchange knowledge) of knowledge assets.

The five respondents valuing "process" pillar mostly concurred that KM strategies are primarily process oriented. The process-oriented strategy is characterized as a deliberated series of KM activities, including acquiring, storing, retrieving, reusing, applying, and creating knowledge, sequentially integrating with other organizational operations through the knowledge workers or technology-enhanced platforms.

Other than the congruence of the KM perception and KM strategy, understanding the effectiveness of their KM practices is important to evaluate organizational performance. The general results of organizational performance presented in **Table 2** showed that organizations adopting a "hybrid" strategy attained better scores than those organizations adopting KM strategies driven by a particular KM pillar. The 18 organizations demonstrated and experienced the highest organizational performance (mean = 4.32); the three KM pillars were well-adjusted and developed, resulting in moderately high scores of 4.28, 4.08, and 4.11 for people, technology, and process, respectively.

Organizations with KM inclinations showed interesting findings with regard to KM effectiveness. The results from people-oriented organizations revealed that the pillar of people performed the best with the mean score of 3.87, followed by process and technology with mean scores of 2.97 and 2.90, respectively. Technology-oriented organizations deployed efforts and realized highest effectiveness in the pillar of technology when compared with the results of other two pillars (technology = 4.36, process = 3.12, people = 2.33). The KM effectiveness of process- and people-oriented organizations demonstrated a similar pattern. In process-oriented organizations, the most effective KM pillar is process (mean = 4.0), followed by people and technology, which shared the same mean value of 3.40.

Recognizing the organizational performance of other non-hybrid organizations with less favorable results is necessary (**Figures 5–7**): people-oriented, process-oriented, and technology-oriented organizations obtained a mean of 3.47, 3.4, and 3.06, respectively. Although the inclination toward a particular KM pillar enables organizations to exploit their KM resources, the inattentive practice or under-utilization of other KM pillars may hinder their long-term

		Strategy			
		Hybrid	**People**	**Technology**	**Process**
Pillar	People	4.28	3.87	2.33	3.40
	Technology	4.08	2.90	4.36	3.40
	Process	4.11	2.97	3.12	4.00
	Organizational performance	4.32	3.47	3.06	3.40

Table 2. Correlation between knowledge management pillars and knowledge management strategy.

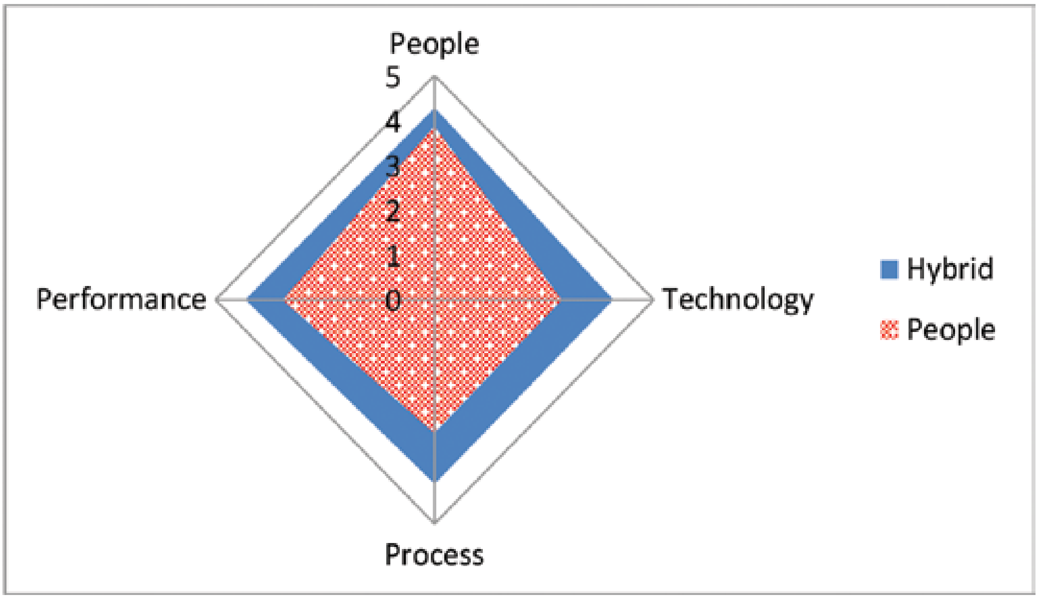

Figure 5. Organizational performance by hybrid strategy and people-oriented strategy.

growth in today's dynamic environment. Given the intricate nature of knowledge process, high mobility of the knowledge workers and swift change in advanced technology as well as support and championship from management are paramount for encouraging organizational members to explore the current knowledge sources in organizations or to acquire the pillars externally (e.g., recruitment of quality staff).

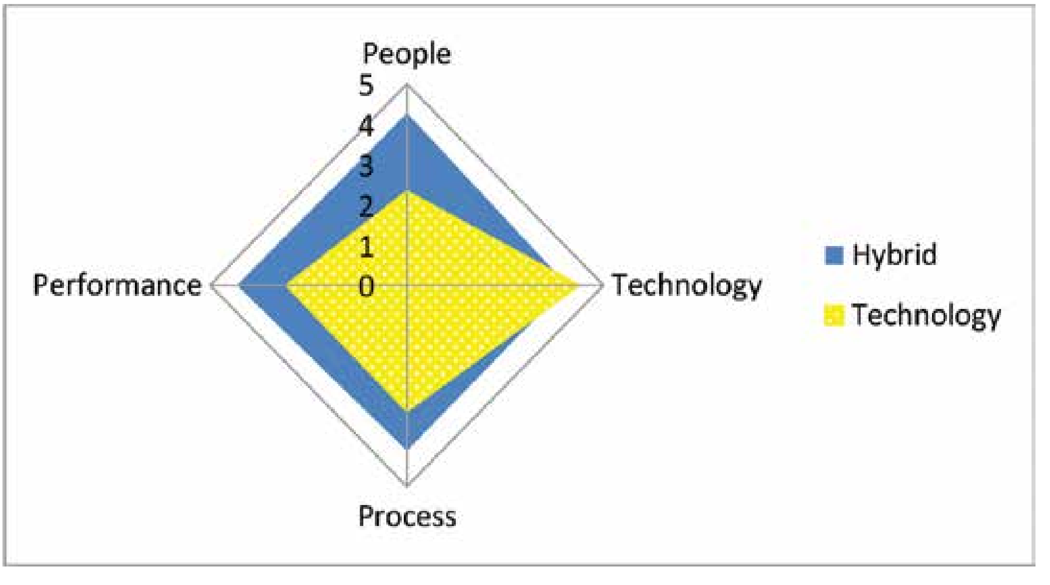

Figure 6. Organizational performance by hybrid strategy and technology-oriented strategy.

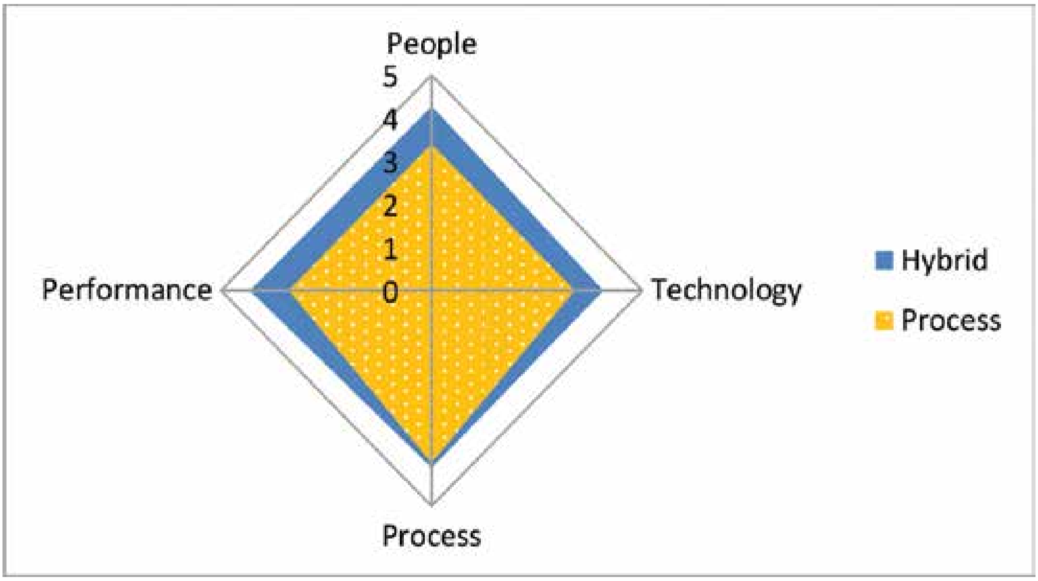

Figure 7. Organizational performance by hybrid strategy and process-oriented strategy.

The descriptive statistical results indicated that the gap between espoused theory (regarding their perceived importance) and theory in use (regarding the inclination practice) was further evaluated. **Figure 8** illustrates the correlation coefficients of the three major pillars. The perceived importance of KM pillars showed a relatively strong relationship with the KM practice (0.80). Most of the organizations are consistent with what they believe and communicate to others in regard to their KM strategies. No obvious disparity exists between their degree of championing KM and the degree they engage in KM. Similarly, the results demonstrated a strong relationship between the KM practice and organizational performance, with a correlation coefficient of 0.87. The KM strategy steered by management is important in promoting the synergistic coordination of different organizational resources to achieve desirable organizational results.

Figure 8. Correlation of perceived importance, practice, and organizational performance.

7. Discussion and KM in the future

The preliminary findings reveal that management and employees have variable perceptions toward the relative importance of the three KM pillars. Their inclined perceptions influence the degree of KM pillar being practiced and exploited in KM programs. The current study also shows that organizations propagating hybrid KM strategy result in relatively higher effectiveness in organizational performance than those non-hybrid organizations do. The skewed emphasis on a particular KM pillar, such as technology orientation, seems like a one-legged chair that is rigidly stacked at a particular point.

Given the dynamic change of business environment, organizations not only have to maximize the effectiveness of organizational routines but also harness changes and develop new competitive strengths. The findings from current study encourage joint efforts from management and employees to configure a hybrid KM strategy, that is beyond the two-dimensional classification of KM strategies, either personalization or codification [26, 27]. The following section provides recommendation to management for courses of action to explore more on KM pillars that may be least attended or emphasized in current stage, ultimately to attain a desirable organizational performance.

7.1. Pillar of people

The attitude of the top management toward KM serves as an explicit gauge for an organization-wide KM activity. Steered by the top management, a KM task force can be created to symbolize their dedication and enthusiasm toward their employees [8]. The key values and affirmative perception toward KM, such as knowledge is a fluid and growing asset; knowledge is not confined as personal power; and knowledge is best valued if it is shared, can be cultivated, and institutionalized to all employees. The vision to embody the significance of KM can attract additional dedication from employees when KM initiative is in its infant stage.

Centered as the frontrunner in KM community, the top management can stretch KM boundary and embody the KM significance to different departments. They can identify early adopters with enthusiasm for KM processes and involve them in propagating the KM vision through connections and interactions. Thereafter, the community can be further extended to diverse work groups/departments and encourage members to bring in a constructive disruption toward the status quo and stimulate other new ideas. The bond among people can be strengthened through the participation of knowledge workers characterized by different roles (e.g., novice, regulars, and experts) in the community. Regular meetings to exchange ideas or articulate competent skills to members are beneficial to peer learning.

Within the community, KM activists, including the top management and employees, can advance the KM perception as a spiritual KM culture. Fostering a knowledge-friendly culture with unwritten norms and beliefs is crucial because turning KM visible to all organizational members requires time. Organizations can encourage people to experiment with different ideas to develop a new working process that is in parallel with their autonomy in task. Such working atmosphere can facilitate open communication channels and knowledge-sharing sessions at both formal and informal setups, such as conducting a bimonthly good work practice sharing allowing employees at all levels to explicate or solicit feedback of their work practices.

7.2. Pillar of process

KM processes involve both formal and informal dynamics, ranging from casual conversations in the hallway to socialization regarding work processes over departmental meals to pre-arranged, focused discussion sessions held in meeting rooms. Organizations can devote extra efforts to engage major processes, including acquisition and capture, conversion and organization, storage and dissemination as well as creation and usage [27]. Further actions are required to interweave the KM processes holistically because such knowledge assets can be an added value to facilitate informed decision making and strategy.

Knowledge is intricate with its multiple facets [1, 2, 28]. Management must identify its paucity and presence at individual, group, and organization contexts. Therefore, employees are encouraged to tap in diverse sources, acquire the critical knowledge, such as core competencies and know-how residing in a particular employee's mind, or capture the knowledge embedded within a particular organization process, or deduce good practices adopted from outside organizations.

Efficiently and effectively conversing and organizing knowledge into the appropriate format for easy access and retrieval are crucial in the organizational KM agenda. Explicit knowledge, such as text-based reports and procedural manuals, is relatively communicable to others. Thus, experts can explicate their knowledge and codify them in a structured form. By contrast, tacit knowledge, such as capability to understand and to read the cues from customers' propensity to purchase, cannot be verbalized and articulated entirely to others. Organizations may have to devote extra resources to convert them into demonstrative video or narrative good practices that can be learned by knowledge seekers through a different mode.

Sharing is one of the most challenging processes if knowledge is confined as a personal asset rather than a social capital in the organization. Equipped with a sound incentive system (covering both monetary and non-monetary recognition), the infant KM stage may progress with a mandatory sharing from experts or experienced staff. During the growth stage of the KM program, sharing exercise can be regularly conducted with the active participation from the top management. Further sharing can be boosted on a voluntary basis, with many employees sharing and exchanging their good practices reciprocally through an informal setup, such as social conversation, or through a formal route, such as documented publications [28].

Knowledge creation is occasionally a spontaneous process, where innovative ideas are not confined to the domain expertise or experienced colleagues. It can also be an emergence of a novel idea or one that adds value to reconfigure a current idea or enhance working practices, which, in turn, can be applied in new contexts. Management can encourage employees to explore their ideas playfully through trial-and-errors for invention. Furthermore, management can provide extra "time" resources to support creation, such as releasing employees from work to cross-fertilize ideas with colleagues from different disciplines.

7.3. Pillar of technology

In some organizations, knowledge management is closely associated with sophisticated systems, enormous database, and advanced infrastructure. Management must realize that the presence of KMS offers no guarantee that the users will automatically come nor hoard knowledge

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and skills from the repositories. KMS is capitalized as an effective and useful conduit when users interact, learn, and collaborate with others and harness reusable knowledge for their own work situations and processes [18, 29].

The perceptions held by the KMS users affect the extent of system usage, such as perceived ease of use and usefulness. Therefore, management can designate the IT staff for involving end users to participate in the KMS design and development process. The genuine needs in knowledge representation, expectation of feature-rich interface, and potential problems in the evolving knowledge repositories can be directly solicited. The involvement from end users reinforces the commitment and satisfaction when the system is launched because KMS is developed "for" them.

Undoubtedly, KMS enables organizations to be more agile and fluid because skills, competencies, and ideas can be stored, accessed, retrieved, and disseminated to the right people, at the right time, and at the right place [11, 12]. It presumably connects employees on a potentially fruitful platform that enables them to access, integrate, and generate knowledge. Therefore, management must be cautious to avoid putting excessive efforts in preserving and storing knowledge assets as stock in the repositories. Employees are encouraged to keep knowledge "alive" through a continuous review, updating, disposal, and sharing. Regular evaluations of system effectiveness, such as portal design and relevance of knowledge content for decision making are required.

8. Limitation and research directions

This study is an exploratory attempt to examine the KM pillars and impacts on organizational performance. Further studies should be conducted to overcome the limitations of the present study. First, the findings were drawn from individual study informants who engage in their organizational KM programs. Using the samples from multiple respondents of a work unit may shed new insights in KM, such as the degree of unanimity on KM pillars moderated by culture, private agenda, or work commitment. Second, the future research can collect more samples to generate additional statistical power and allow added robustness to the model testing. Third, in-depth examination of the hybrid strategy could be conducted to enable organizations to obtain a clear picture of their KM status. For example, future activity can be extended to the behavioral traits of knowledge workers, impact of different KM processes on sustaining competitive advantages, and complementary and substitutability roles of IT in KM process.

9. Conclusions

Knowledge management has become one of the most important activities across different organizations. Management is struggling with the efforts to embark on KM initiatives and the minimal return in competitiveness. This exploratory study identified three KM pillars acting as fundamental constituents driving KM programs to attain a desirable organizational performance. The findings showed that organizations perceived the KM pillars differently, which influence their practices to implement KM strategy. The orientation toward different KM pillars resulted in varying effectiveness of organizational performance. Adapting a hybrid strategy is concluded to yield better results. Accordingly, actions are recommended to enable organizations to re-examine their current status and adopt changes for balanced KM programs.

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Chapter 5

Knowledge Management for Informally Structured Domains: Challenges and Proposals

Karla Olmos-Sánchez and Jorge Rodas-Osollo

Additional information is available at the end of the chapter

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Abstract

Eliciting requirements of products or solutions in informally structured domains is a highly creative and complex activity due to the inherent characteristics of these domains, such as the great quantities of tacit knowledge used by domain specialists, the dynamic interaction between domain specialists and their environment in order to solve problems, the necessity of these solutions of products to be developed by teams of specialists and the asymmetry of knowledge between domain specialists and requirements engineers. The knowledge management discipline promotes an integrated approach in order to face these challenges; therefore, a strategy for addressing requirements elicitation that incorporates techniques and methods of this discipline has been proposed as a serious approach to deal with those challenges. The valuable results of the application of the strategy in real cases prove empirical insights about its utility.

Keywords: knowledge management, informally structured domains, requirements elicitation, tacit knowledge, knowledge creation spiral

1. Introduction

Requirements elicitation (RE) is a valuable process for the identification of *solution* requirements according to the need of clients of users [1]. In this chapter, the concept of *solutions* includes products, such as software systems or intangible solutions, such as data analysis. According to several authors, application domain knowledge is essential to obtain the correct and appropriate requirements. The application domain is an area where a solution is or will be used. Consequently, requirements engineers must understand, as soon as possible, the structure, the processes and the restrictions of a domain in which they are generally

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neophytes. This knowledge belongs to domain specialists, any person possessing application domain knowledge and/or having a role in the domain. Therefore, requirements engineers must elicit the application domain knowledge from domain specialists in order to include it into a set of solution requirements. It is a complex and highly creative activity that involves intensive cognitive activities, especially when the application domain has a high degree of informality where knowledge is informally stated, partially complete, implicitly assumed, tacit and unstructured [2].

This phenomenon is presented in many disciplines such as *intelligent tailored solutions for ill-structured domains, software for complex domains, intelligent tutoring systems, knowledge based systems, industrial design, among others*. In general, every necessity that requires a complex, highly creative solution, in which the requirements engineers are not a part of the application domain and need eliciting sufficient high-quality knowledge to understand the clients' need and expectations, faces this challenge [2]. Therefore, instead of focusing on the challenges of developing a requirements elicitation proposal for each of these complex areas, we have expanded the vision and generalized these domains as *informally structured domains* (ISD) [3], which is widely explained in Section 2.

In addition, solutions in ISD usually respond to clients and users' specific needs. As a result, they are diverse, consensus and unverifiable, and there are not fully defined processes to develop them. Therefore, these solutions or products must be developed according to the experience of domain specialists. These characteristics hamper the requirements elicitation process because the implications of knowledge transfer and transformation, the appropriate management of tacit knowledge and the issues of knowledge exchange must be considered.

In this context, we assume that a perspective of requirements elicitation that emphasizes the importance of knowledge management (KM) is a useful approach for addressing ISD inherent problems. KM is a discipline with the aim of enhancing an organization by sharing and managing knowledge flow among the people, taking advantage of information technologies [4]. Regarding KM in requirements elicitation is not new, but only few efforts offer a full knowledge management perspective [5].

The knowledge management strategy for requirements engineering (KMoS-RE©) [6] is a high-level plan oriented to the transfer or transformation of knowledge. The strategy has the aim of eliciting, structuring and creating knowledge that can be incorporated into a specification closest to the needs and expectations of clients. It is especially design from a full KM perspective in order to be applied in the context of ISD. The goal of this chapter is to describe the challenges of ISD and make a critical analysis of the KMoS-RE© strategy as a serious requirements elicitation proposal to face them. The analysis is based on the experience of applying the strategy in several ISD real cases. According the valuable results, the KMoS-RE© strategy promises to be a useful tool in the requirements elicitation of solution or products, especially in disciplines that share ISD characteristics [8].

The remainder of this chapter is organized as follows: Section 2 presents a characterization of ISD in order to explain the challenges of eliciting requirements in these domains. This section also includes a wide explanation of tacit knowledge. Section 3 describes fundamental concepts of KM in requirements elicitation. Section 4 discusses the utilization of KMoS-RE© as a serial proposal to face the challenges in ISD. Finally, in Section 5, the conclusions and future works are presented.

2. Informally structured domains

2.1. Tacit knowledge

As discussed above, a key element in a successful requirements elicitation process in ISD is *knowledge*. But, *what is knowledge?* Despite the widely recognised importance of knowledge as the main asset in today's society, defining it is an unresolved issue. In order to establish a baseline, this work supports the idea that knowledge has a subjective and personal quality. This view is based on the traditional definition of knowledge as *justified true belief*. However, as in Ref. [9], the focus is on the *justified* rather than the *true* aspect of belief. The *justified* view of knowledge makes it as dynamic, context-specific, humanistic, deeply rooted in individuals' value system and created in social interactions among individuals as opposed to the *true* view in which knowledge is absolute, static and non-human.

According to Ryle, knowledge can be classified in *knowing-that* and *knowing-how. Knowing-that* means storing and recalling facts. *Knowing-how* is a practical knowledge. This distinction carries through Polanyi's theory of personal knowledge, which classifies knowledge in *explicit* and *tacit* [10]. *Explicit knowledge* is transmitted through any language or formal representation: from text written in natural language to complex formalism as ontologies. On the other hand, *tacit knowledge* is personal and context-specific, generated by experience and therefore difficult to communicate and formalize.

Polanyi was interested in '… to show that complete objectivity, as usually attributed to the exact science, is a delusion and is in fact a false idea'. Thus, he examined how individuals gain and share knowledge. He concluded that knowledge is highly personal and questioned the commonly held view of the dispassionate objective scientist. He also emphasized that people can often know how to do things without either consciously knowing, or being able to articulate to others why what they do works.

According to Polanyi, *tacitness* is something personal, usually abilities or skills that people use to solve a problem or to do something valuable. *Tacitness* depends on people's experiences and learning. Polanyi suggested that all knowledge has a tacit component and discussed the process of how the tacit cooperates with the explicit. He also argued that language is a vital tool that people use to share knowledge, and that with the appropriate use of it, much, but not all, of this knowledge can be transmitted among individuals who share a mutually agreed language. When *tacitness* predominates, this articulation is not possible. However, it does not prevent knowledge from being transmitted by other means, such as observation or task repetition. This is what people do when learning to ride a bicycle or when an art master transfers knowledge to his or her apprentices. We should keep in mind that Polanyi's theory was generated in the field of psychology and his work was addressed towards perception. Thus, from Polanyi's perspective, any attempt to convert tacit knowledge to explicit will be unfruitful because it cannot be articulated at all.

Grant [11] provides a graphical representation of knowledge degradation as it is expressed by Polanyi's work (**Figure 1**). The bar represents how the knowledge is flowing in a continuum between tacit and explicit. The continuum ranges from knowledge inherently tacit to knowledge that can be easily expressed by words. The knowledge that can be expressed by words ranges from explicit to experts to explicit to most people. The knowledge explicit to experts requires specialized language. Most of this knowledge is also implicit, i.e. knowledge that can be expressed by words, but that for some reason it has not made explicit. The tacit knowledge ranges from ineffable to highly personal. Much of this knowledge is related to the use of instruments, such as playing piano or using a specialized machine.

To Gourlay [12], Polanyi's work has been misunderstood. He argued that some tacit knowledge does become amenable to analysis and decomposition, allowing recording it in an explicit form. Likewise, tacit knowledge in requirements elicitation has been misused. For example, Janik [12] has identified that the concept of tacit knowledge is used in two ways:

1. Concerning to knowledge that can be expressed, but for some reasons, it remains hidden. Janik identified three reasons why knowledge tends to remain tacit: (1) concern for secrecy and power, (2) because no one has bothered to recognize it or tried to explain it and (3) because it concerns presuppositions, we all generally hold. These situations can be aware, as the first one, or unaware, as the second and third ones. However, there are non-insuperable barriers to make this knowledge explicit.

2. Concerning to knowledge gained through familiarity and practice, which is inexpressible in words, or knowledge gained by perception as sight, smell or know-how. A wine taster or identifying an instrument when listening to a sound, are some examples of this knowledge.

What is really important in requirements elicitation is making the most possible quantity of knowledge explicit. Whether it is tacit, implicit or that for some reason remains hidden, even because nobody asks.

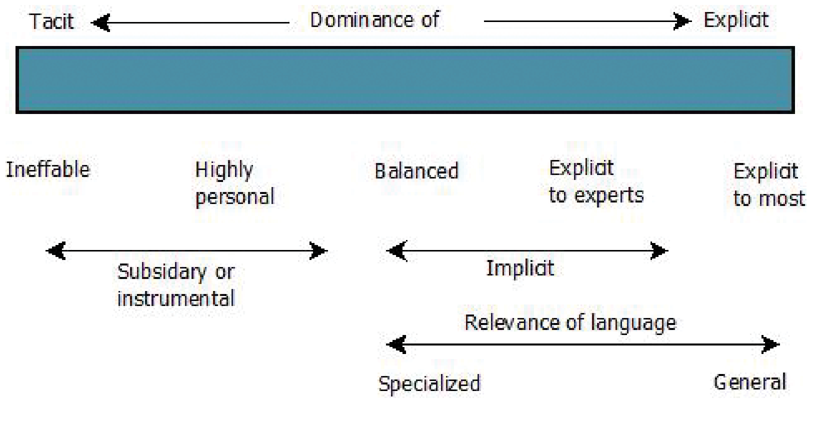

Figure 1. Granularity of knowledge.

The problem of tacit knowledge in requirements elicitation is not new. Goguen [13] did an extensive analysis of the term from a social perspective. He analysed several methods to elicit requirements such as introspection, questionnaires, interviews, focus group and even protocol analysis. He argued that these methods have limitations to manage tacit knowledge. To Goguen, it is indispensable considering a social perspective to attend this problem; thus, he suggests using combinations of these methods besides including discourse, conversations and interactions analysis.

Later, Nuseibeh [14] emphasized the importance of tacit knowledge and how it may affect the requirements of elicitation process. For him, the responses of the domain specialists to direct questions about their domain of expertise do not reflect, neither their current behaviour nor the reality, for the large amounts of tacit knowledge that is handled by them. Thus, product developers or solution solvers should consider theoretical and practical techniques of *cognitive psychology, anthropology, sociology* and *linguistics* to have better results.

The importance of sharing tacit knowledge to improve the problem-solving processes or as a strategy to gain competitive advantage in organizations is undeniable. For example, Wyatt [15] argues that much of the medical progress in modern times has been attributed to an evolution from tacit to explicit knowledge. Despite that, nowadays, tacit knowledge remains as an ambiguous and inconsistent concept. We are aware that not all knowledge of specialists is susceptible to becoming explicit; however, it is essential trying this transformation with a well-founded strategy for the requirements as close as possible to the reality of the application domain.

2.2. Formality and informality

Intuitively, a domain is a well-defined area of human activity with formal and informal issues in which a *universe of discourse* occurs. According to Webster's Dictionary, 'formal' means definite, orderly and methodical. In computer science, to be formal does not necessarily require the use of formal logic, or even mathematics, but the use of a formal notation to represent system models. Everything that computers do is formal because the syntactic structures in a program are manipulated according to well-defined rules [13]. In domains with a significant social context, much of the information is embedded in the social world of domain specialists; it is informal (not susceptible to be formalized or not yet formalized) and depends on the context for its interpretation [16]. These kinds of domains share characteristics such as informally defined concepts and lack of absolute verification of the processes; therefore, the domains specialists should use a great quantity of tacit knowledge to solve everyday situations.

Every domain is susceptible to be formalized to a certain level, but there will always be issues that remain informal. If a domain is mainly formal, the domain specialists can build, in a relative easy way, formal structures to solve problems. On the other hand, if a domain is mainly informal, it does not mean that domain specialists cannot build a structure; definitely they do. In some way, it is possible to solve diagnostic or design problems; however, these structures are informal, i.e. they depend on the context and the domain specialists' experience and knowledge. When informal characteristics prevail, the process and effort to solve problems can be extremely costly and time consuming.

Nguyen and Shanks [17] describe requirements elicitation as an ill-structured problem due to its openness, its context poorly understood and the existence of multiple domains. For Nguyen, solving problems in requirements elicitation requires a complex and dynamic social interaction between domain specialists and developers. The knowledge of both actors evolves as the project advances: the domain specialists get involved with software-solution and the developers with the organizational structure and business processes, i.e. the application domain. According to Nguyen, to solve ill-structured problems, understanding the problem and the structure of the solution are interleaved. The problem solvers, i.e. the requirements engineers, must explore different areas of the problem to find a solution. To accomplish this task, they communicate with the diverse actors who have domain knowledge or another perspective of the possible solution. By performing this task, their domain knowledge increases and they can return to previous stages of the problem, but with additional knowledge that allows them to explore new possibilities of solution. Therefore, the knowledge of the problem and its solution gradually evolves as the requirements engineers gain more knowledge of the domain, mainly due to social interactions and involvement of business processes.

We go further and assume that the grade of informality of the domain application influences the complexity of the process, as **Figure 2** depicts. Our focus is on the requirements elicitation process for domains with a high degree of informality, where knowledge is informally stated, partially complete, implicitly assumed, tacit and unstructured.

2.3. Characteristics of ISD

In order to effectively deal with ISD, we assume that they are located in the intersection of knowledge engineering and requirements engineering, and have the following characteristics [2]:

- Presence of multiple *domain specialists* who have different backgrounds, perspectives, interests and expectations, and whose knowledge, either tacit or explicit, of the application domain varies depending on their experience and their role in the domain. Usually, domain specialists are not aware of the details of the product or solution and only have a vague idea of its general functionality.

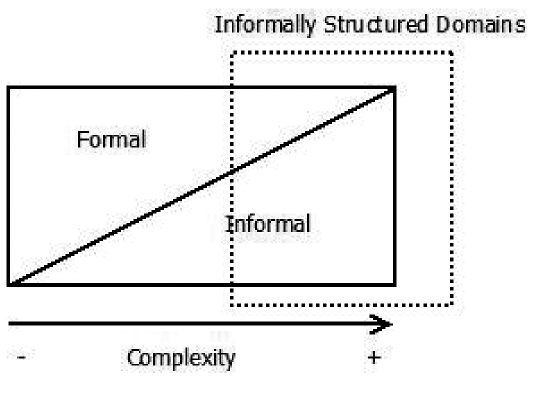

Figure 2. Complexity of domains.

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- Presence of a group of *requirements engineers*, responsible for eliciting the requirements, who generally are not involved in the application domain. They have general technical knowledge about the development of the product or solution; however, they must elicit the application domain knowledge in order to understand the details of it and derive the correct and appropriate solution requirements.
- The solution solves or addresses a particular and unrepeatable situation. Thus, it must have its own design. However, there could be an infinite number of alternative solutions. In addition, the solution could be a tangible or intangible product and must be developed according to a requirements specification.
- A *requirements specification* is a document that contains the set of solution requirements. A requirement is a natural language statement to be enforced by the solution, possibly in cooperation with other system components, and formulated in terms of the application domain. The development of the requirements specification requires eliciting, synthesizing, validating, sharing and creating great quantities of application domain knowledge and solution knowledge in order to reach an acceptable solution. In addition, in order to develop the requirements specification, a dialectical thinking is necessary among all involved in the project.

Figure 3 depicts the characteristics described above; the figure represents *explicit knowledge* by puzzle pieces and *tacit knowledge* by clouds. The *requirements specification* is formed by pieces of knowledge of the domain specialists and requirements engineers. The requirements engineers must make the greatest possible amount of tacit knowledge explicit, synthesize the

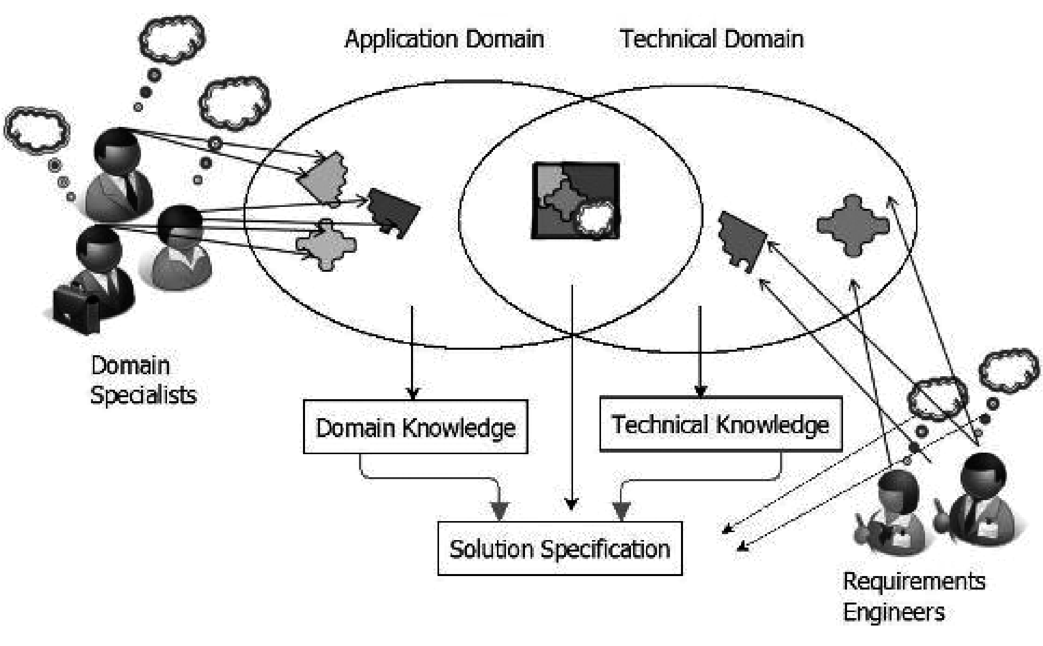

Figure 3. Informally structured domains.

disperse knowledge and reconcile the diverse beliefs and necessities of the domain specialists. In addition, they need to incorporate their own technical knowledge in order to generate the set of requirements of the solution. In the figure, this process is represented by the solved puzzle. The cloud in the solved puzzle means that there will always be knowledge that is not susceptible to be formalized.

2.4. Challenges in ISD

Some challenges of ISD are described as follows:

2.4.1. Tacit knowledge

Tacit knowledge can cause critical knowledge, goals, expectations or assumptions to remain hidden. In consequence, the emergent requirements will appear incomplete and inappropriate, which can cause poor systems or costly effects [18].

2.4.2. Situatedness

Situated actions involve a dynamic interaction with the actor and its environment; they only acquire meaning through interpretation in a specific context [19]. Situated actions involve conscious reference to the context and choice of action. An action is not situated if it takes the form of a prescribed response or if it is an unconscious automatic response. In ISD, situated actions occur frequently; in consequence, requirements are mostly situated and depend on a process of negotiation. In this situation, domain knowledge is fundamental in order to understand the rationality behind requirements, facilitate the negotiation process and propose technological aspects of the solution according to the real necessities of the domain specialists.

2.4.3. Disperse knowledge

Products or solutions in ISD are so complex that the human knowledge required to develop them generally is vastly larger than the maximum individual human capacities [20]. Therefore, organized teams formed of specialists must develop them. In order to cooperate in the solution, domain specialists must share some knowledge about the domain. However, they always have different backgrounds, perspectives, interests and expectations, and their knowledge and experience vary depending on their own practice and role in the domain. Sometimes even inconsistent and incompatible beliefs can exist. Product developers or solution-solvers should reconcile and prioritize the diverse beliefs and knowledge about the application domain in order to incorporate it to the solution.

2.4.4. Asymmetry of knowledge

Domain knowledge is the knowledge of the area to which a set of theoretical concepts is applied. In ISD, the concept of domain knowledge has two meanings. Firstly, solution domain knowledge corresponds to methods, techniques and tools that form the basis for the development of the product or solution. Secondly, those products or solutions are developed to necessities of real-word problems that exist in an application domain. Thus, both solution domain knowledge and application domain knowledge are necessary to develop the product or solution [20].

Asymmetry of knowledge, or symmetry of the ignorance, refers to the knowledge gap that exists between domain specialists, owners of the application domain knowledge, and requirements engineers, owners of the solution domain knowledge [5]. In ISDs, this phenomenon is increased because of the large amount of tacit knowledge involved. When the gap is big, there is not cognitive empathy and the communication process is not effective. Therefore, requirements engineers could produce models that do not represent the reality.

3. Knowledge management

Knowledge management (KM) is a discipline with the aim of enhancing an organization by sharing and managing the knowledge flow among the people [5]. KM is much more than just the use of information technology to manage knowledge. Due to the complexity of deal with knowledge, this discipline has developed theoretical concepts in order to explain and face the underlying problem of elicitation, creation, exchange and validation of knowledge. According to Pilat and Kaindl [5], there are three fundamental concepts in KM closely related to requirements elicitation such as the knowledge transfer and transformation process, the distinction between explicit and tacit knowledge and the issues of knowledge exchange. In addition, we consider that a creation knowledge process, where the knowledge of all involved in the project evolves, is also present in ISD.

3.1. Knowledge transfer and transformation process

The knowledge transfer process is carried out when the knowledge of a person is transformed into natural language, and in non-verbal channels of human communication in order to be transferred to another person, who then decodes this knowledge according to their own interpretation. Any transfer of knowledge is inherently bound to acknowledge transformation, so there will always be some degree of ambiguity. Ambiguity affects the elicitation of correct requirements because people involved in the project could build different and possibly incompatible interpretations of the concepts, relations and processes of the domain. Linguists point to several sources of ambiguity such as lexical, syntactic, semantic and pragmatic. ISD produce an additional kind of ambiguity named nocuous when two people mutually ignore that they have their own different interpretation. In this situation, they end up talking about different concepts while they think that they are talking about the same topic. According to Gacitua et al. [18], any person involved in the process can be aware of this phenomenon, because they do not have access to the tacit knowledge of each other.

3.2. Conversion of tacit knowledge to explicit

Nonaka and Takeuchi [7] propose a model of conversion of knowledge in organizations based on Polany's theory of tacit knowledge. For them, knowledge creation in an organization is the result of social interaction where tacit and explicit knowledge is transferred. The model postulates four iterative conversion modes such as socialization, externalization, combination and internalization (SECI) which are described as follows:

- **Socialization** is the process of transferring tacit knowledge among individuals by sharing mental models and technical skills.
- **Externalization** is the process of converting tacit knowledge to explicit through the development of models, protocols and guidelines.
- **Combination** is the process of recombining or reconfiguring existing bodies of explicit knowledge to create new explicit knowledge.
- **Internalization** is the process of learning by repetition of tasks that apply explicit knowledge. Individuals will absorb the knowledge as tacit knowledge again.

According to Nonaka, if this cycle is done consciously, looping through this knowledge spiral may evolve the overall knowledge held collectively. The spiral of knowledge can be applied to requirements elicitation in order to face the inherent knowledge management challenges of the process. Despite that, we found just a few researches that explore this possibility. Wan et al. [21] proposed a model of knowledge conversion to the requirements elicitation process with the aim to minimize the symmetry of ignorance between developers and domain specialists. The authors base their model on the SECI model and consider the knowledge flowing between domain specialists and developers. They introduced a new agent in the process: the *requirements specialist*. This person would act as an intermediary between the domain specialists and the developers, so he or she must earn the trust of those involved in the process. The authors use their model to analyse a requirements elicitation process of a real software development project. In conclusion, the authors argue that the proposed model can reduce the symmetry of ignorance and facilitate the elicitation of tacit requirements. Nevertheless, to be successful in the process they suggest that the requirement specialists must have enough domain knowledge. We consider that it is difficult, if not impossible, that a person knows about every domain, so the incorporation of this new agent could hinder the, complex by itself, elicitation process. On other hand, Vásquez-Bravo et al. [22] proposed a classification of elicitation techniques to facilitate their selection in an RE process based on the phases of Nonaka's model. However, they do not propose how to use these techniques and how to elicit tacit knowledge.

3.3. Knowledge sharing

In order to implement the knowledge spiral property, it is crucial to facilitate the exchange of knowledge among all involved in the project [16]. It implies focusing on the knowledge holders, especially in ISD where knowledge is mostly tacit. This task may become difficult to handle because requirements engineers can be confronted with several persons whom they do not know. KM offers the concept of knowledge map [5], an artefact that points to knowledge but does not contain it. The artefact could be a table or a matrix indicating which person has what knowledge. The knowledge map should be created and initialized at the beginning of the process and continually be updated as the spiral of knowledge evolves. A knowledge map is also useful to discover for which knowledge a knowledge holder might be missing. In

ISD, we assume that a knowledge map would also be useful for indicating the tacitness level of the knowledge holders. Thus, we propose the piece of knowledge (PoK) matrix, an artefact to fulfil the functions mentioned above and to be used in the KMoS-RE© strategy.

The PoK matrix is a data structure that stores the relation of every individual (solution solver or domain specialist) involved in the project with every piece of knowledge about the domain. A piece of knowledge can be a concept, a relationship or behaviour. The PoK matrix is used as a reference to figure out which concepts, relationships or behaviours had been made explicit and which of them remain tacit. The aim of the KMoS-RE© strategy is to look for the transformation, from 0 to 1, of the most possible values in the PoK matrix. This is in order to make explicit the most possible quantity of tacit knowledge. It would be ideal if the requirements engineers could make explicit all pieces of knowledge. However, there will always be knowledge that it cannot be converted to explicit; therefore, the requirements engineers must propose the most suitable solution with the explicit knowledge obtained at a particular moment.

3.4. Knowledge evolution spiral

As was mentioned above, in ISD, understanding the problem and the structure of the solution are intertwined. The problem solvers, that is, the requirements engineers, must explore different areas of the problem to find a solution. In order to accomplish this task, they should dialogue with the domain specialists, who have their own domain knowledge and perspective of the possible solution. By performing this task, the knowledge of the problem solvers about the application domain evolves. If were necessary, they can return to previous states of the project, but their knowledge is not the same, they will have additional knowledge that allows them to explore new possibilities of solution. In summary, the knowledge of the problem and its solution gradually evolves as requirements engineers gain more knowledge of the application domain due to social interaction and their involvement with the business processes. In order to model that behaviour, the knowledge evolution model for requirements elicitation (KEM-RE) was developed based on the SECI model. The KEM-RE is an iterative cycle (**Figure 4**) that consists of four stages that include the four kinds of knowledge processes in the innovation of complex problem solving:

- **Knowledge elicitation (KE) stage**. The requirements engineers elicit knowledge from domain specialists and vice versa. The socialization mode predominates.
- **Knowledge integration and application (KI & A) stage**. The requirements engineers integrate the acquired knowledge and their own experience into models. This is a complex activity in which combination and externalization modes are presented. In addition, as the requirement engineers develop models they internalize the domain knowledge.
- **Knowledge sharing and exchange (KS & E) stage**. The models developed by requirements engineers will be shared with the domain specialists. This phase takes place through socialization.
- **Knowledge validation (KV) stage**. The domain specialists validate the models. In order to develop this activity, they must internalize the knowledge behind the models through a cognitive dialogue. This process leads to the elicitation of new knowledge. Then the cycle starts again.

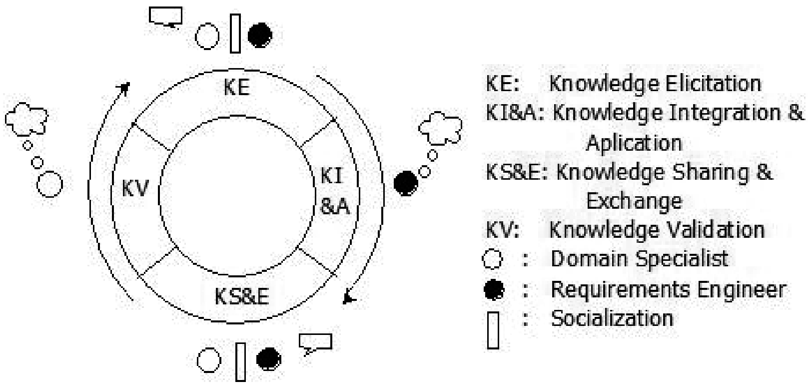

Figure 4. Knowledge evolution model for requirements elicitation.

4. KMoS-RE©: an approach from knowledge management discipline

The KMoS-RE© strategy [6] is a high-level plan to achieve a set of requirements of a solution or product through the eliciting, structuring and creating of knowledge. Following the work of [24], the strategy consists of three phases: *domain modelling (DM), system modelling (SM)* and *specification developing (SD)* and structures its flow of activities according the KEM-RE. Furthermore, it includes transversal activities to identify and make explicit the most possible quantity of tacit knowledge. Those activities are conducted by the identification of presuppositions [18] and classification of verbs according the Blooms' taxonomy [23]. The strategy also includes artefacts to facilitate the sharing knowledge: a record of wrong beliefs and the PoK matrix (Section 4.3). A brief explanation of each phase is provided as follows:

- **Domain modelling phase (DM)**. In this phase, the terms, i.e. the concepts, attributes and relationships, and the basic integrity restrictions are formalized through a consensus, in order to understand the application domain without worry about the solution. The terms are recorded in the Knowledge of Domain on an Extended Lexicon (KDEL); a lexical that classifies them into objects, subjects and verbs. The KDEL is used to facilitate the building of a graphical conceptual model. The externalization of this knowledge will enable achievement a consensus among the stakeholders; hence to minimize the symmetry of ignorance. The concepts and relationships identified in this phase will generate the first version of the piece of knowledge (PoK) matrix. In addition, a graphical conceptual model is required in order to facilitate the cognitive dialogue with the domain specialists. Requirements engineers will decide what kind of conceptual model use, from entity-relationship model to ontologies, depending on the characteristics of the domain.
- **System modelling phase (SM)**. In this phase, the current and future system processes are formalized. The current system corresponds to the system, as it exists at present. The future system represents the system after the deployment of a solution or product. The Use Cases technique was selected to model the system, both current and future, because its usefulness

has been demonstrated through the time. The system model is obtained from the KDEL and the conceptual model. The behaviours identified in this phase will also change the values of the PoK matrix.

- **Specification development phase (SD)**. In this phase, the requirements are derived from the Uses Cases' scenarios of the future system and incorporated into the solution requirements specification (SlRS).

Figure 5 depicts a general view of the KMoS-RE© strategy in a unified modelling language (UML) activity diagram. Every activity of the strategy corresponds to one stage of the KEM-RE: model validations (MV) is related to knowledge validation (KV), knowledge elicitation (KE) is related with the stage of the same name, model discussion (MD) corresponds to knowledge sharing and exchange (KS & E) and domain modelling (DM), system modelling (SM) and specification development (SD) correspond to knowledge integration and application (KI & A). The swim lanes in the figure represent the activities developed by each type of actor.

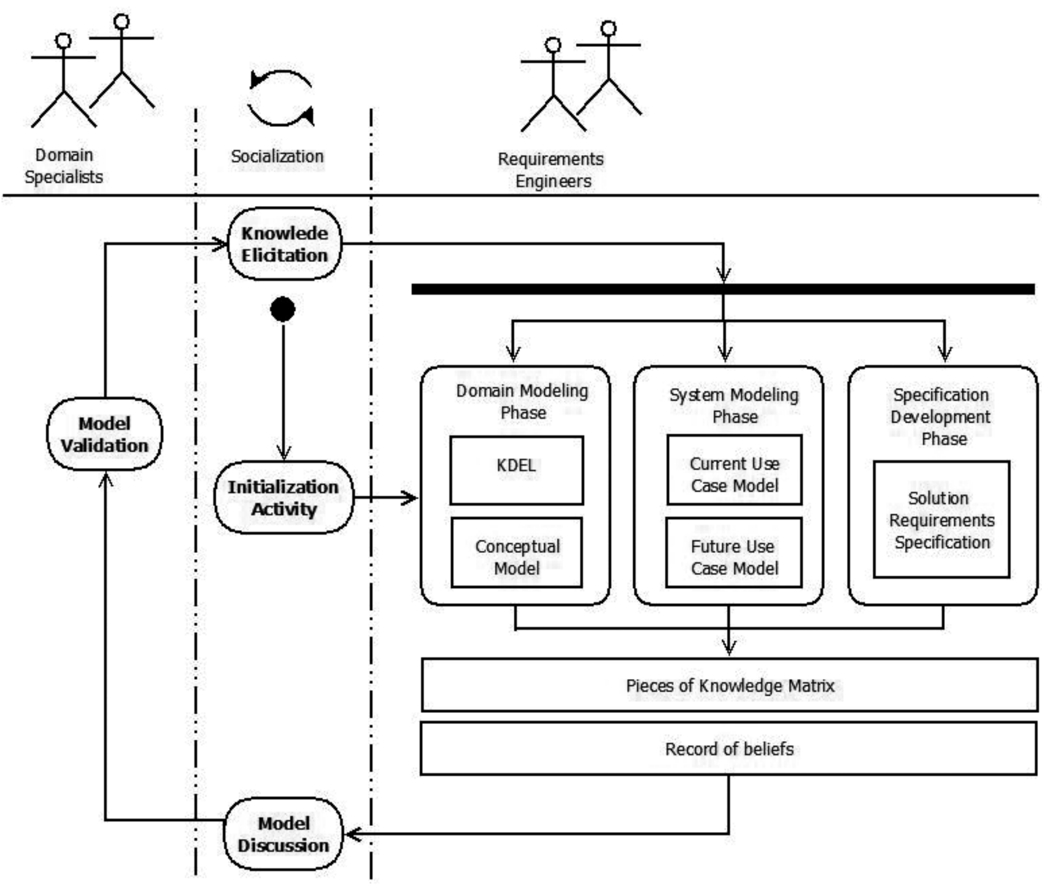

Figure 5. Knowledge management on a strategy for RE.

4.1. KMoS-RE© analysis

According to Maalej and Thurimella [24], managing requirements knowledge is about efficiently identifying, accessing, externalizing and sharing domain and technical knowledge by and to all involved in the project, including analysts, developers, and domain specialists, which is closely related to a full perspective of KM. The rationality of the KMoS-RE© strategy is based on the fundamental issues described as follows:

- The flow of activities in the KMoS-RE© strategy is based on the knowledge evolution model KEM-RE, which is based on the knowledge evolution spiral proposed by Nonaka. The evolution spiral knowledge has the aim of facilitating the conversion of tacit knowledge to explicit. In addition, the incorporation of techniques such as the identification of presuppositions and the classification of verbs according the Bloom's taxonomy make easier-identifying knowledge that could be tacit, and hence hidden.
- Representing requirements knowledge targets an efficient information access and artefact reuse within and between projects. The KMoS-RE© strategy proposes several artefacts in order to represent different views of the system. They can be accessed and shared by all involved in the project. Although several requirements elicitation proposals use lexical, conceptual models, use cases models and scenarios, few of them combine those techniques in a strategy. Besides, the KMoS-RE© strategy proposes two innovative artefacts: the record of belief and the PoK matrix.
- Sharing requirements knowledge improves the collaboration among all involved in the project and ensures that their experiences do not get lost. The knowledge spiral in which the activities of the KMoS-RE© strategy are based compels to sharing the knowledge among solution-solvers and domain specialists through socialization.
- Reasoning about requirements and their interdependencies aims at detecting inconsistencies and deriving new knowledge. Externalizing the knowledge through the development of the different artefacts let the solution-solver reason and internalized the domain knowledge.

4.2. KMoS-RE© applied to real ISD cases

The KMoS-RE© strategy has been applied in the development of solution of several real ISD cases:

- **Software development for complex domains**. This is a complex and creative activity in which software developers should understand, as soon as possible, the knowledge of a domain in which generally are neophytes. Then, combine this knowledge with their own technical knowledge in order to reach a solution that meets clients' expectations. The KMoS-RE© strategy has been used to develop a cognitive rehabilitation system for sclerosis multiple patients [6].
- **Soft computing**. This artificial intelligence (AI) subarea includes several techniques that are suitable for solutions in ISD, since it is tolerant of imprecision, uncertainty, partial truth and approximation. A complex problem in soft computing is how to elicit the knowledge of specialists in order to incorporate it in an appropriate representation and to reach correct solutions. A case-based reasoning system to support heating ventilation and air conditioning (HVAC) design decisions was developed using the KMoS-RE© strategy [8].

- **Intelligent tutoring systems**. Over the past decade, intelligent tutoring systems have become increasingly accepted as viable learning tools in academia and industry. However, most of these solutions had been developed for well-defined domains. Informally structured domains, such as computer programming, laws and ethics, present a number of unique challenges for researchers in intelligent tutoring, especially to represent and evaluate the knowledge. We are currently exploring the adaptation of the KMoS-RE© strategy with the aim of getting a method to develop Bayesian Networks for evaluation in intelligent tutoring systems in the context of ISD.

- **Industrial design**. The KMoS-RE© strategy had been used as a HVAC requirements process in a real company [8]. The HVAC design is a difficult task because the information necessary for solving the problem is incomplete and vague. This knowledge belongs to the domain specialists, generally a set of specialists from different fields, such as mechanical engineers, control engineers, electrical engineers and architects. In addition, there could be multiple and controversial solutions and the criteria that determine the best design solution is complex and imprecise.

4.3. Discussion

Nowadays, the negative effects of inappropriate, incorrect and ambiguous requirements have been widely studied and are well known. Despite the vast quantity of proposals, methods, techniques and tools, requirements elicitation is still an open problem, as shown by many projects that do not fulfil clients' expectations or that exceed the development time due to bad elicited requirements. Thus, there are still clear opportunities to improve.

The application of the KMoS-RE© strategy in real ISD cases has showed that its characteristics are clear contributions to the requirements elicitation area, as it is described as follows:

- **Emphasis on application domain knowledge**. The importance of the application domain knowledge in order to improve the requirements elicitation process is widely accepted. However, currently the most of the methods and tools of requirements elicitation are designed for general problem domains, where problem-specific domain knowledge is not completely necessary [25]. The KMoS-RE© strategy emphasizes the importance of the application domain knowledge, either tacit or explicit, besides of proposing techniques and methods to facilitate its discovery, representation, sharing and appropriation among all involved in the project. Thus, the strategy can be applied in knowledge-intensive projects.

- **Generality and adaptability**. The theoretical concepts of knowledge management, in which the KMoS-RE© strategy is supported, allow it to be applied to domains with different levels of informality. It also has the advantage of being considered as a high-level plan; therefore, the requirements engineers have the authority to decide which phases are necessary. In some cases, they can even choose between different techniques and methods.

- **Evolutive**. The strategy is not limited to the proposed so far. The model allows the incorporation of new proposals from methods and techniques to knowledge management models or perspectives of elicitation of requirements. For example, we are currently analysing the adaptation that is based on goals elicitation approach [26], the knowledge audit model [25] and the social network analysis [27].

- **Algorithmic**. Despite its generality and adaptability, the KMoS-RE© strategy is algorithmic in the sense that the process of its implementation is well defined and limited, so the requirements engineers do not need a deep knowledge about the theoretical concepts of knowledge management. Most of the cases showed in the previous section were led by undergraduate engineering students [8]. Although a process of awareness of the issues of informal structured domains is always recommended.

Finally, we would like to emphasize that the most important contribution of the KMoS-RE© strategy is that it does not try to work against human nature; it recognizes its capabilities and limitations and builds the best proposal based on that. Thus, according to the below and the valuable results of the application of the KMoS-RE© strategy in several and different contexts, it can already be considered as a serious approach for requirements elicitation knowledge.

5. Conclusions and future works

The KMoS-RE© strategy is a novel approach from KM in order to face the challenges of eliciting knowledge and creatively transform it into a set of requirements of a product or solution in order to satisfy the needs and fulfil whole expectations of clients and users. The strategy is focused on dealing with ISD. Due to the characteristics of these domains, the strategy has a full KM perspective, i.e. it incorporates knowledge engineering techniques in order to properly manage tacit knowledge. The *domain modelling phase* handles the problem of formalizing the concepts and relationships; at least a consensus about it is reached. The *system modelling phase* deals with the problem of structuring the processes in the domain. Thus, the problem of handling tacit knowledge has addressed properly by KMoS-RE© strategy.

The strategy was applied to several ISD real cases in different and diverse areas. The solutions achieved provide evidence about the usefulness, the value and the generalization of it. Therefore, the application of the KMoS-RE© strategy in several real cases shows that it is a useful approach in order to elicit the requirement of solutions or products especially in ISD.

Finally, the challenge of managing the tacit knowledge requires to analyze more cases in order to improve all the KM approaches including the KMoS-RE© strategy.

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Chapter 6

Performance Management by Causal Mapping: An Application Field of Knowledge Management

Sarah Kölbel, Wolfgang Ossadnik and
Stefan Gergeleit

Additional information is available at the end of the chapter

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Abstract

As implied by the performance management (PM) concept, modern corporate management has to focus on cause-and-effect relationships underlying a firm´s financial performance generation. To determine the causes of financially desirable effects, subject-bound experiences and knowledge of employees, called tacit knowledge, should be realised. For this, knowledge management (KM) offers various elicitation techniques to reveal corporate-specific success factors (SFs) of financial performance generation from the corporate experts´ implicit knowledge. The identified factors have to be organised within a network of cause-and-effect relationships. In this framework, PM can apply the instrument of mapping to structure the individually revealed knowledge, to aggregate and visualise it for the entire company. For a valid representation of the causal relationships, the subjective bias arising within the mentioned process has to be minimised. In the literature, a variety of mapping methods can be found that differ in their approaches and their level of significance. As such a method, causal mapping will be presented in this paper. For providing intersubjectivity, the decision-making trail and evaluation laboratory (DEMATEL) as a multi-criteria approach will be debated in the context of mapping as a research field.

Keywords: causal mapping, knowledge management, performance management, implicit knowledge, explicit knowledge, success factors, DEMATEL, subjectivity, intersubjectivity

1. Introduction

In today's information age, companies face high competition and pressure while trying to perform successfully in the long term. To meet the dynamic competitive environment and the globalisation of markets accessible, companies are forced to hunt for competitiveness resulting

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from the efficient use of general and specific knowledge. Accordingly, knowledge is becoming a competitive factor and provides an essential cause for company success. Therefore, it is important not only to consider obviously accessible knowledge but also to directly accomplish a performance-related use of the specific, implicit knowledge of a company. These individual experiences and knowledge such as fundamental components of human capital inhere a huge chance to improve the steering and control processes of performance generation and hence to master competition successfully. In the context of such a performance management (PM), expert knowledge is indispensably focused on relations between causes and effects to generate financial performance. By considering cause-and-effect relationships underlying the financial performance generation process the traditional perspective of measuring value realisation is extended to causally ambitioned value generation management. As a consequence, such a causal knowledge reveals options for actions influencing the financially as well as non-financially dimensioned causes, which are linked to future financial performance. Thus, PM provides relevant starting points to control the financial performance generation process.

In reality, companies comprise many departments with multiple environmental factors and, as a consequence, there exist many latent or manifest interdependently structured characteristics relevant for performance generation. Without knowledge of such relations, the management cannot efficiently control desirable effects by their causes. A map of causal relationships could care for more transparency in this respect. However, expert knowledge on success factors (SFs) and their causal relations is usually not available in the explicit form of a graphical representation. Instead, subjectively based knowledge, stemming from individuals´ observations and experiences, which are called implicit or tacit knowledge, might be identifiable and pending to be elicited.

Knowledge management (KM) recognised as a subdiscipline of PM can be applied to convert this implicit knowledge into explicit subjective knowledge on causal relationships, which can be identified and depicted by construction of a tailor-made causal map. Through the construction of the causal linkages during the mapping process, a subjective judgment bias can arise. With regard to this problem of subjectivity, specific methods of the multi-criteria research field, in particular the decision-making trail and evaluation laboratory (DEMATEL), can be used in the mapping context. DEMATEL provides a reduction of a potential personal bias when applying one of the common mapping methods. For this, a fictional case study will be presented adopting the target of achieving intersubjectivity.

2. Performance management and performance measurement

PM and performance measurement can generally be associated with a strategic management and control to focus on long-term financial success. To realise this objective, to implement strategies promisingly and for the alignment of the entire organisation to a consistent development of success potentials, the strategic factors relevant for financial success need to be identified. Through the control of the critical SFs via measureable key performance indicators (KPIs), the company´s financial performance can be influenced beneficially [1, 2]. This requires the identification of upstream causes of the financial success, which can be dimensioned financially or non-financially. With the subsequent consideration of non-financially dimensioned SFs, which often are deeply rooted in the intuitive knowledge of managers and employees, PM offers a concept of steering and control extending the restrictions of traditional control procedures entirely based on logical decompositionally constructed financial ratios [3–6].

According to Neely et al. [7], performance measurement can be described as the 'process of quantifying the efficiency and effectiveness of action'. An evaluation of the efficiency and effectiveness of action always requires the reflection of the corporate strategic objectives [3]. Thus, performance measurement enables a holistic assessment of the company's performance. For analysing the whole performance generation process, it necessitates the additional identification of cause-and-effect relationships. The specific SFs of a company are integrated into a cause-and-effect network. Each factor can directly or indirectly be linked with the company's financial performance [8–10]. A cause-and-effect relationship will only be defined as causal, if a strong correlation between cause(s) and effect(s) exists and the cause of action temporally precedes the effect. Additionally, the relationship has to be plausibly explicable [11]. With an accurate specification of the causal relationships among the factors, a comprehensive understanding of the performance generation is provided. Moreover, in decision-making situations, the consequences of chosen actions on the company's success can be estimated [5, 9].

Within this context, the 'performance' is determined as a multi-criteria and therefore multi-dimensional construct, which—in a causal sense—cannot only be measured ex post, but also ex ante. Performance measurement thereby is classified in a superordinate control context of PM as an integral part of it. At this point PM describes the process of planning, implementing and executing the corporate strategy by a coherent system of actions. In linkage with a strategy, it determines values of measurable KPIs respectively operating numbers. If, due to the permanent monitoring of the operating numbers, a significant variance is identified, the PM can initiate appropriate (feedback- or feedforward-directed) strategic action [1, 6]. In conclusion, for a comprehensive analysis and control of the performance generation, SFs and their company-specific causal relationships need to carefully be identified and examined in depth. Therefore, PM captures KM as a complementary discipline.

3. Knowledge management: explicit and implicit knowledge

KM implies the acquisition, development, transfer, storage and use of knowledge in a company [12–15]. A condition for knowledge generation is generic information like scientific theories and models. The information is based on data defined as simple facts or events etc., which are not systematised for a specific context. Thereby, the information forms a structured, meaningful summary of explicit data points in order to take a conclusion or prediction. In particular, knowledge represents the generic skill to connect and use recent information with previously collected information in several new application fields. As a consequence, the knowledge carriers evolve a new understanding or subjective perception of the actual situation, which generates a new knowledge basis [13, 16]. Here, knowledge can generally differ in explicit and implicit one [17].

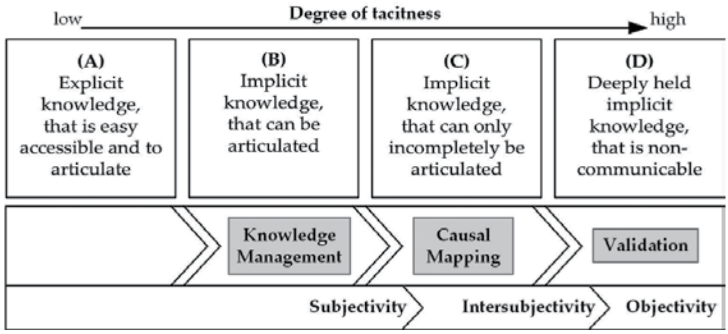

Figure 1. Degree of tacitness and the steps to objectivisation.

Explicit knowledge is communicable and thus not exclusively available to the person who possesses and uses it. It declares the relevant know-what [18, 19]. Knowledge concerning company-specific cause-and-effect dependencies can furthermore be drawn on the subject-bound, intuitive experience-based knowledge of competent employees and managers. This as 'tacit' specified implicit knowledge is difficult or impossible to verbalise as well as to formalise in contrast to explicit knowledge [18]. It is understood as individual specific know-how.

According to Ambrosini and Bowman [20], knowledge can be graded in relation to the degree of tacitness as shown in **Figure 1**.

Between the explicit knowledge (A) and deep-rooted tacit knowledge (D), which cannot generally be revealed, the communicable knowledge (B and C) have to be specified. One specification comprises the implicit knowledge (B), which can be appropriately articulated and revealed. But, this knowledge becomes less obvious over time, because the knowledge carriers have not been mentally concerned with it and no third party has demanded for it. Additionally, there exists tacit knowledge (C), which can be articulated only incompletely. Although it is possible to get access to this knowledge, it is not describable by general language use [20]. The implicit knowledge of type B and C is of special importance for a company in order to discover the performance-relevant SFs and develop their hypothetical causal relationships in a map.

The experts´ tacit knowledge has to be externalised by applying adequate elicitation techniques in the context of KM [15, 21, 22]. For this purpose, three groups are basically distinguished in the literature under the term 'knowledge elicitation techniques': observations and interviews, process tracing and conceptual techniques [23]. It generally cannot be defined that one method is more appropriate than another. The choice of a technique for extracting performance-relevant knowledge should be taken case specifically. However, for the development of causal hypotheses, there exists the experience that interview techniques as most commonly applied methods generate more information on company-specific connections than other approaches [22–24].

Subsequently, the externalised implicit knowledge of the performance-related SFs is causally systematised into a more generic and easily comprehensible form by formulating a causal map [25, 26]. Depending on the chosen mapping method, the causal relationships base on purely subjective judgments. This subjective knowledge stands for the relationship of an individual to its environment. Thus, it is not objective. Subjectivity can be seen as an error source in the current subject, although it offers an epistemic value [27]. Increasing comparability and transparency of individual subjective evaluations about causal relationships generate a degree of intersubjectivity [28]. Thus, intersubjectivity is achievable, if only more than one individual can clearly comprehend the formulation and structuring process of causal relations among SFs.

However, strategic forecasts about the future performance developments are only possible to a certain extent or cannot even be performed by application of subjectively and intersubjectively based maps. (Intersections of subjective maps would deliver intersubjectively based ones.) But, only a statistical validation of the causal map generates an objective understanding of the causal relationships, which thus are directly empirically verifiable [5, 29]. As a consequence, valid predication of the performance generation can be given. Initially, the subjective mapping methods are considered more closely in the following section.

4. Subjective mapping

Mapping methods are used to depict company-specific explicit and implicit knowledge, such as control-relevant factors and their causal relationships [20]. There are several definitions and names of mapping methods in the literature [10, 30–32], which can be distinguished according to their type and to their concept of construction.

4.1. Types of maps

Two types of maps with relevance for the current subject are the 'cognitive mapping' and the 'causal mapping'.

Cognitive maps can be seen as a summary of different concepts of mapping that rely on the beliefs of an individual about a specific topic [26]. In its core, a cognitive map refers to how an individual person can explain its environment and to what extent it is able to understand it. It visualises the individual perception of the reality and thus represents person-specific knowledge [28, 33]. This knowledge is needed for a comprehensive assessment of corporate performance because it captures experiences and know-how about corporate-specific internal and external factors in a detailed way [31].

Causal maps generally illustrate the individual understanding about linkage of events occurring at a certain time [26]. In the context of PM, the instrument of causal mapping is suitable for displaying company-specific explicit as well as implicit information describing the influences of performance relevant causes on the top objective of financial performance [20]. Causal maps consist, on the one hand, of nodes, which can represent control-relevant SFs and, on the other hand, of arrows, which are used to represent the cause-and-effect relationships between these nodes [34]. The node, from where the path of an arrow begins, is interpreted as the cause of the consequently influenced effect. The effect is depicted through the node where the arrow finally ends. The direction of an arrow implies the assumed causality. Thus, a causal map can be interpreted as a cognitive map, which describes the process of performances in a company [8]. But, a cognitive map is always constructed from a single individual, whereas a causal map can also represent the cause-and-effect relationships as an aggregated result of several individuals [35]. **Figure 2** gives an example of a causal map [22]. The contained factors might be measured directly and would be manifest in that case. Otherwise, they are latent and can be operationalised by one or more selected measure(s). Measurable data are transferable into an indicator system of strategic success generation.

4.2. Development and participation in causal mapping approaches

A causal map based on local tacit knowledge can be formed by a group of experts itself [36] or by aggregating the individual maps of the group members [37, 38]. After the development of individual causal maps, it might be a scientific objective to measure the differences between these maps [24, 39]. But, in the related literature, approaches are most favoured that aim for a specific form of an aggregation of individual maps. The aggregation can follow specific 'counting rules' of factors and relations depicted as arrows [8, 34]. Moreover, the finalisation of an aggregated group map is widely spread via group discussions and workshops [31, 38]. Such a group aggregation process can also be computer-supported [40–42]. In order to realise the advantages of causal mapping, it is absolutely necessary to involve a sufficient number of experts in the mapping process [43].

To construct a causal map, one of the elicitation techniques mentioned in section three has to be applied. Afterwards, the mapping process can be conducted by an interviewed expert itself, by the support of qualitative software, solely by an external researcher, a consultant or a team —so-called ethnographical protocol interpretation—or by the interaction of external persons and company experts [8, 20, 44]. The most relevant and applied mapping techniques that can be distinguished from each other and contain essential attributes are the ethnographical protocol interpretation and the interactive mapping.

Figure 2. Example of a causal map.

In addition, there is another approach developing a causal map by group discussion without applying any elicitation technique advance. According to Akkermans and van Helden [45], experts are asked to collectively form one causal map. Herein, the objective basically is to construct a unified view of a group of experts through their discussion. By group discussion, the different individual perceptions are summarised and structured to finally achieve a common understanding of the problem.

When reviewing the mapping procedures in the related literature, it is obvious that the epistemological perspective is far from a comprehensive as well as general approach. The individually conducted steps differ from case to case. A mixture of several techniques is always conceivable and a clear distinction between the documented techniques is difficult to specify. The question 'how to map?' generally depends on the preferences and objectives of internal and external experts that are involved in the process of causal mapping. Notwithstanding the construction process of a causal map, there are advantages and disadvantages provided by causal mapping.

4.3. Advantages and disadvantages of causal mapping

The advantages of causal mapping are apparently associated with a corporate's financial success and the implementation of a strategy: causal mapping enforces (a) the elicitation, (b) the visualisation and (c) the communicability of performance-relevant knowledge.

Already in the starting phase of elicitation, involved individuals develop a more extensive understanding of the corporate performance and its causes. They are invited to reflect all processes in their company and, therefore, will be able to distinguish between performance-relevant factors and those which have less importance. Furthermore, concerned individuals start to reflect their daily operation in a critical manner and may generate an alignment of their work to the principles of PM and performance measurement. Involving a sufficient number of experts from all departments of a company as participants in the mapping process amplifies the acceptance of the respective system. During the implementation of this system, employees do not only provide their causal knowledge but are also motivated to scrutinise it. They develop as well as apply the respective indicator system in a reflective manner and adjust their decisions and chosen actions to this system [46]. Due to this reflexion, learning effects emerge. Besides, the visualisation by causal mapping provokes a focus on those factors that have the largest influence onto the financial performance objective. It induces different people within a company to reflect about it. Moreover, the visualisation creates an extensive comprehension about the effects of certain actions as causes. The existing cause-and-effect chains to achieve a better (or even a worse) performance become obvious [10]. At least, the management of a company is equipped with a mapping tool that enhances the communication of a vision, of strategies as well as objectives and measures based on a common understanding of the performance generation. By causal mapping, the employees communicate on causal relations and become more aware of them. This contributes to an efficient management of the company [10].

Since the cause-and-effect relationships are primarily derived from the experience and knowledge of employees, they are categorised as subjective. The experts from different functional areas may have an unequal perception of processes. During the amalgamation of explicated assessments of cause-and-effect relationships from different subjective perspectives, inconsistent results can occur. Therefore, it will be necessary to aggregate or to synthesise these partial perspectives in a sufficiently complex overall model of causal relationships [47].

Nevertheless, every aggregation of subjective statements can generate biases because involved managers and employees are specialised on their area of responsibility and herein collect their experiences. The subjectivity of the statements might be driven by factors like organisational blindness, vanity, satisfaction as well as dissatisfaction or the degree of motivation. Further, in group discussion, participants might answer strategically in the way to not annoy others [10, 40, 41]. As a consequence, it is not sure that the most important causal relationships among factors will be detected. Instead, it might be the case that less relevant SFs and relationships will be determined. All these challenges have to be overcome and a corrective against the biases resulting from subjective statements has to be offered.

Therefore, the multi-criteria DEMATEL method can be introduced as a technique that is able to decrease the amount of subjectivity in constructing a causal map. Thus, it enables to achieve an intersubjective validity by providing a transparent and replicable process of mapping among all participants. The technique is more appropriate to get an equilibrated and balanced causal map for the purpose of all employees. Group discussions and aggregation approaches cannot meet the requirements of unifying the variety of different individual opinions. DEMATEL, as presented in Section 5, collects the individual opinions in a more unbiased way.

5. Intersubjective mapping

Between 1972 and 1976, Fontela and Gabus have developed the DEMATEL approach for structuring and solving multi-criteria problems in a multi-personal context [48, 49]. DEMATEL can represent an algebraic method of analysis, which aggregates the collected individual implicit knowledge to identify and quantify the causal interdependencies between the detected SFs [50]. Furthermore, it strictly structures the given SFs according to their relevance in performance generation [51]. Finally, the determined causal relationships of the performance-related SFs are illustrated in an appropriate causal map, described as impact relation map (IRM) [50].

5.1. DEMATEL

In this section, some essentials of the DEMATEL approach are briefly described (**Figure 3**) [52].

In the first step, an $n \times n$ individual evaluation matrix X^k of each expert k (k = 1, …, H) is determined as follows [52, 53]:

$$X^k = \begin{pmatrix} x_{11}^k & \cdots & x_{1j}^k & \cdots & x_{1n}^k \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1}^k & \cdots & x_{ij}^k & \cdots & x_{in}^k \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{n1}^k & \cdots & x_{nj}^k & \cdots & x_{nn}^k \end{pmatrix} = \left[x_{ij}^k\right]_{n \times n} \tag{1}$$

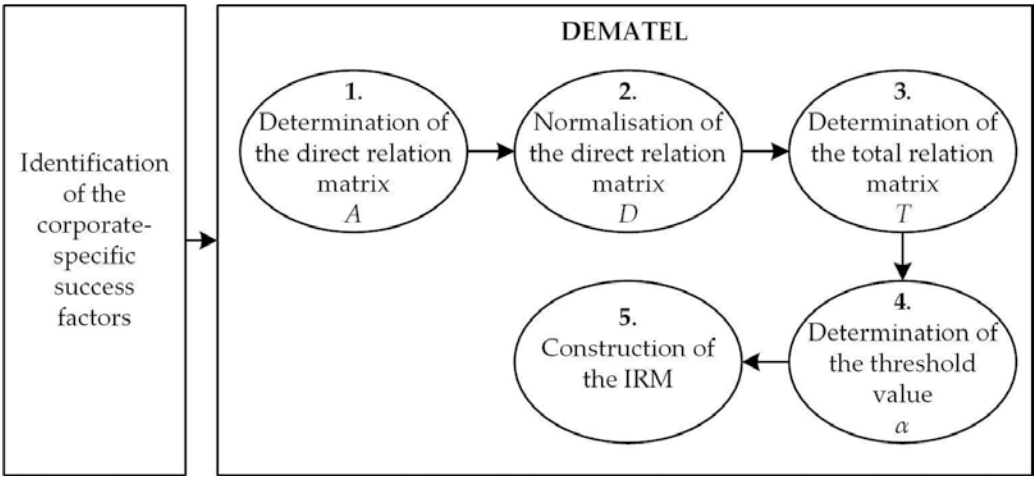

Figure 3. Procedure steps of DEMATEL.

For this purpose, H skilled employees pairwise compare the given factors $i(i = 1, \ldots, n)$ and $j(j = 1, \ldots, n)$ on a Likert scale from 0 to 4 (with 0 = no effect, 1 = very small effect, 2 = small effect, 3 = strong effect, 4 = very strong effect) to identify how strong the factor i directly influences the factor j. The results are described by the matrix elements x_{ij}^k. In addition, for all cases $i = j$, each x_{ij}^k takes the value 0, since the factors are compared to themselves [52]. Hence, it can be formulated the assumption that a cause cannot be its effect at the same time.

According to Eq. (2), the direct relation matrix A is calculated by the aggregation of all individual evaluation matrices. The numerical value a_{ij} illustrates the group perception about the direct causal relationship between the factors i and j. If the condition $a_{ij} \leq 1$ is fulfilled, no cause-and-effect relationship exists [52].

$$A = \left[a_{ij}\right]_{n \times n} = \frac{1}{H}\sum\nolimits_{k=1}^{H} \left[x_{ij}^k\right]_{n \times n} \tag{2}$$

In the second step, the direct relation matrix A is normalised to the matrix D as follows [52, 54]:

$$D = \frac{A}{s} = \left[d_{ij}\right]_{n \times n} \tag{3}$$

$$s = \max\left\{\max_{1 \leq i \leq n} \sum\nolimits_{j=1}^{n} a_{ij}, \max_{1 \leq j \leq n} \sum\nolimits_{i=1}^{n} a_{ij}\right\} \tag{4}$$

Here, the normalisation value s can be specified as the maximum value of the set of maximal column and row sum of the matrix A. Besides, the column sum $\sum_{i=1}^{n} a_{ij}$ of the matrix A represents the total direct effect, which all factors i exert on the factor j. Compared with this, the total direct impact of factor i on all other factors j is described by the row sum $\sum_{j=1}^{n} a_{ij}$ of the matrix A [53, 55].

To determine the direct and indirect interdependent relationships of the SFs, the total relation matrix T has to be calculated in the subsequent step [52]. For generating indirect convergent effects, the potentiation of matrix D needs to convert to infinite as follows [50]:

$$T = \lim_{m \to \infty} (D + D^2 + \cdots + D^m) \tag{5}$$

According to Eq. (6), the total relation matrix T is calculated under consideration of the normalised matrix D as well as the $n \times n$ identity matrix I [52]:

$$T = D(I - D)^{-1} = [t_{ij}]_{n \times n} \tag{6}$$

Before transferring the identified causal relationships of the SFs in an IRM, a threshold α as average influence intensity has to be specified in the fourth step. The threshold α is determined as the quotient from the sum of all values t_{ij} divided by the number of elements N of matrix T and follows the formula [56, 57]:

$$\alpha = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} [t_{ij}]}{N} \tag{7}$$

For a further reduction of complexity and to develop a clearly structured and manageable map, only the elements t_{ij} of the matrix T, which exceed the stated threshold α, are transferred in the map. The cause-and-effect relationship values t_{ij}, that satisfy the condition $t_{ij} > \alpha$, are classified as sufficiently significant and thus as performance-relevant influences [53].

In the last step of the DEMATEL approach, the identified SFs and their performance-relevant relationships are depicted in a causal IRM. Furthermore, the factors can be classified into causes and receivers [14]. For this purpose, the row sum $r_i = \sum_{j=1}^{n} t_{ij}$, as well as the column sum $c_j = \sum_{i=1}^{n} t_{ij}$, of the total relation matrix T have to be calculated [52]. The column sum c_j describes the total direct and indirect effect that all factors i exert on the factor j (called as degree of receiving). Assumed a high degree of receiving, minor changes of the factors i already lead to strong alteration of the factor j. However, the row sum r_i represents in which extent the factor i has an effect on all other factors j (called as degree of causing). A high degree of causing means that a small change of factor i causes great alterations of the other factors j. Moreover, in the case of $i = j$, the total of the row and column sum ($r_i + c_j$) illustrates the accumulated outgoing and received effects of a factor. The higher the determined influence intensity, the higher the relevance of this factor for the corporate management will be [53, 54].

By forming the difference of the row and column sum ($r_i - c_j$) for the case $i = j$, the factors will be specified as causes or receivers according to its resulting net effect. If $c_j < r_i$, then the factor will be defined as a cause, because its impact on the other factors is higher than the other factors' influence on it. But assumed $c_j < r_i$, the factor is mostly influenced by other factors and thus will be assigned to the group of receivers [53, 54].

Finally, all identified SFs and only their performance-relevant causal relationships will be visualised in an IRM. This causal map is framed as kind of coordinate system, of which the abscissa represents the values of the full effects ($r_i + c_j$) and the ordinate axis is scaled to the net effect values ($r_i - c_j$) [53, 54]. In the following section, the approach of DEMATEL will be illustrated in a fictional case study example.

5.2. Case study as an application example

The example of a causal map is demonstrated for a typical company and its PM. For this propose, the financially and non-financially dimensioned SFs are identified and their causal relationships are analysed as well as visualised in a causal map. To construct the map in a manner to achieve intersubjectivity, the DEMATEL method is applied. By conduction of semi-structured interviews with 15 experts from the company and in the following group discussion between an external research team and expert group, a pool of eight strategically relevant factors can be developed. These identified SFs are mentioned as follows: financial success (FC), competitive environment (CE), structural circumstances (SC), product range (PR), product quality (PQ), pricing (PRI), image (IM) as well as ability to supply (AS).

5.2.1. Identification of causes and receivers

First of all, the 15 experts pairwise evaluate the causal relationship structure among SFs on a Likert scale from 0 (no effect) to 4 (very strong effect). The individual evaluation matrices X^k (with k = 1, ith) are described by Eq. (1) and are aggregated to the direct relation matrix A by Eq. (2). After that, the matrix A is normalised to matrix D according to Eqs. (3) and (4). With the help of Eqs. (5) and (6), the final total relation matrix D can be calculated. **Table 1** shows the results which describe the direct influence intensity that SF i exerts on a SF j:

For more clarity in the causal structure, only these influence relationships between the SFs are considered in the IRM, of which the influence intensity is greater than the calculated threshold of α = 0.1426 {Eq. (7)}. In **Table 1**, the sufficiently significant results are marked in bold. Consequently, nearly half of the amount of causal relationships among the factors is specified as above-average causal interdependent and thus can be determined as very performance-relevant relation.

Factors	FS	CE	SC	PR	PQ	PRI	IM	AS
FS	0.1157	**0.1825**	0.0345	0.1235	0.1014	**0.1548**	**0.1535**	0.0785
CE	**0.2940**	0.1303	0.1015	**0.2041**	0.1380	**0.2142**	**0.1944**	0.1132
SC	**0.2905**	**0.1508**	0.0260	**0.1467**	0.0891	**0.1786**	0.1166	0.0464
PR	**0.2808**	**0.2318**	0.0404	0.0769	0.1031	**0.1755**	**0.2556**	**0.1438**
PQ	**0.2995**	**0.2257**	0.0414	0.0880	0.0700	**0.2018**	**0.2881**	0.1083
PRI	**0.2507**	**0.2019**	0.0796	0.0705	0.1106	0.0911	**0.2215**	0.0636
IM	**0.2658**	**0.2067**	0.0294	0.1257	0.1187	**0.1688**	0.1074	0.0940
AS	**0.2019**	**0.1630**	0.0232	0.0727	0.0674	**0.1433**	**0.2019**	0.0390

Table 1. Total relation matrix.

Factors	r_i	c_i	$r_i + c_i$	$r_i - c_i$	Characteristic
Financial success	0.9445	1.9988	2.9433	−1.0544	Receiver
Competitive environment	1.3897	1.4927	2.8824	−0.1030	Receiver
Structural circumstances	1.0446	0.3761	1.4207	0.6685	Cause
Product range	1.3080	0.9082	2.2163	0.3998	Cause
Product quality	1.3229	0.7980	2.1209	0.5248	Cause
Pricing	1.0896	1.3280	2.4176	−0.2385	Receiver
Image	1.1164	1.5391	2.6555	−0.4227	Receiver
Ability to supply	0.9121	0.6868	1.5989	0.2253	Cause

Table 2. Classification of the SFs as causes and receivers.

To organise the SFs in the groups 'causes' and 'receivers', the row sum r_i and column sum c_i as well as their difference have to be calculated in the subsequent step as follows:

According to **Table 2**, the SFs 'structural circumstances', 'product range', 'product quality' and 'ability to supply' are identified as causes, under the condition that $r_i > c_j$ and thus the results of their difference are positive. However, the SFs 'financial success', 'competitive environment', 'pricing' as well as 'image' fulfil the condition $c_j > r_i$. As a result, the calculated difference between the row and column sum is negative and thus the factors are specified as receivers. Moreover, within the groups 'causes' and 'receivers' the SFs can be clearly ranked by their total influence intensity ($r_i + c_i$) in respect of their significance for the performance generation. It can be realised for the group 'causes' that the SF 'product range' is the most influencing factor, which largely determines all other SFs. In contrast the SF 'structural circumstances' has the lowest impact on the whole system. Considering the group 'receivers', the SF 'financial success' is mostly influenced by the other SFs compared to the SF 'pricing', which is less determined by the other ones.

5.2.2. Tailor-made impact-relation map

In this section the identified SFs and only their above-average calculated influence intensity from **Table 1** as well as the group specification of receivers and causes from **Table 2** is finally visualised in an appropriate IRM (**Figure 4**).

According to the coordinate system in **Figure 4**, the ordinate represents the difference between received and outgoing effects of a factor. Factors that can be characterised as causes, for example 'ability to supply', are always pictured in the positive range. Whereas, receivers like the factor 'pricing' are depicted in the negative value range. Furthermore, the abscissa displays the overall intensity of the influence relationship of an individual factor. The further away a factor is located from the coordinate origin, the greater its total influence intensity in the whole system is. Following **Figure 4**, the factor 'financial success' is the most performance-relevant factor in relation to the others.

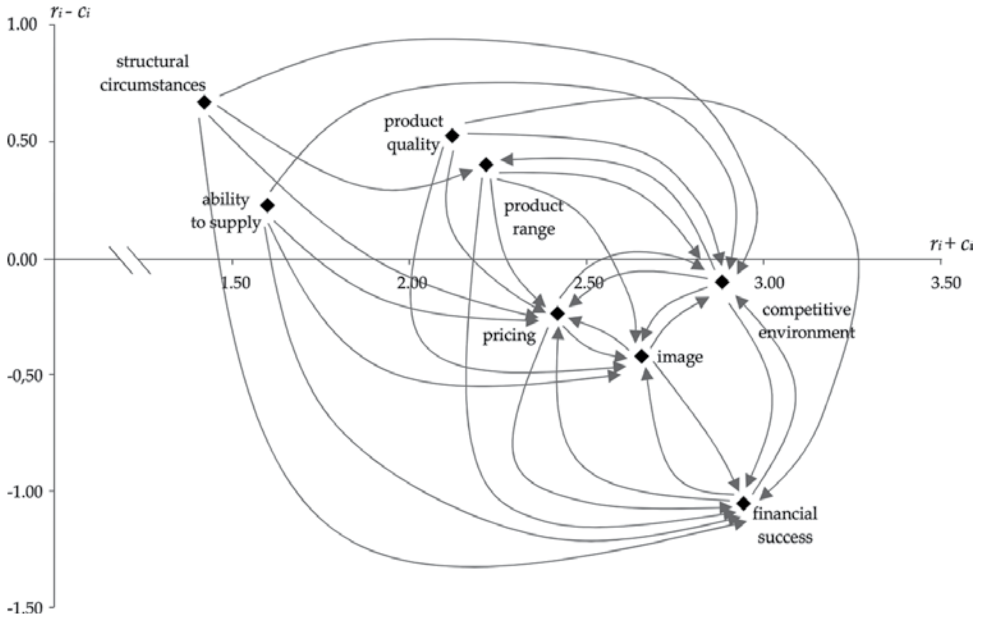

Figure 4. Impact-relation map.

Generally, through the construction of an IRM, a better comprehension of the relevant direct and indirect causal relationships can be developed. Besides, the IRM underlines which SFs are most important for the corporate management and the focus should lay on them. Compared to a qualitative causal mapping process DEMATEL strictly distinguishes the SFs between causes and receivers and quantifies their cause-and-effect relationships [53, 54]. However, because the individual evaluations are ordinal a cardinal interpretation of the SFs´ causal relations cannot be provided. Only a systematisation by building a hierarchy among SFs is possible.

6. Conclusion

Causal knowledge on SFs underlying financial performance generation is an important prerequisite for an effective PM. For this purpose, important parts of the PM have to be drawn on the subjective experiences and knowledge of the employees. It is the current task for KM to extract the subject-bound tacit knowledge and make it explicitly available for the management of an organisation. Subsequently, by application of a convenient mapping method revealed tacit knowledge has to be aggregated, structured as well as systematised in a more general and for the employees' applicable manner. In addition, the complex financial performance generation process will be represented and analysed as for performance relevance of the SFs and their causal relations. In this way, a general and clarified understanding of the performance generation is achievable among the employees.

The concept of causal mapping and the multi-criteria DEMATEL method illustrate approaches how to construct a causal map from the base of externalised tacit knowledge. Both methods differ in procedures and in results. Causal mapping offers a low quality of the identified causal structures of SFs because of the lack of quantitative assessment and the highly subjective aggregation of the implicit knowledge. However, applying DEMATEL in the mapping context, the subjective bias can be minimised by a systematic and transparent pairwise evaluation of the SFs. Because of its replicability it achieves intersubjectivity. But since the discovered causal relationships among the factors are only interpretable on an ordinal scale, strategic forecasts of future performance developments are only possible to a limited extent.

To achieve an objective validity, the existence of adequate data and the use of suitably selected statistical procedures are necessary. If for all variables of the causal map manifest time series data are available, the validation of causal relationships can be done by using a multivariate time series model. When the variables of the causal map are not directly observable, but can be operationalised as latent variables with appropriate factors, structural equation modelling can be used to validate the cause-and-effect relationships among the SFs [29]. The statistical validation of the causal relationship network objectifies the previous ordinal data in metric forms to achieve relative comparability and clear predictability. So, the significance of the map is optimised compared to the one constructed by DEMATEL. Finally, in the context of PM, the performance realisation and generation can be represented and analysed qualitatively as well as quantitatively by the validated map in a comprehensible way.

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Chapter 7

Intelligent Knowledge Retrieval from Industrial Repositories

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Additional information is available at the end of the chapter

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Abstract

Actually, a large amount of information is stored in the industrial repositories. Accessing this information is complicated, and the techniques currently used in metadata and the material chosen by the user do not scale efficiently in large collections. The semantic Web provides a frame of reference that allows sharing and reusing knowledge efficiently. In our work, we present a focus for discovering information in digital repositories based on the application of expert system technologies, and we show a conceptual architecture for a semantic search engine. We used case-based reasoning methodology to create a prototype that supports efficient retrieval knowledge from digital repositories. OntoEnter is a collaborative effort that proposes a new form of interaction between users and digital enterprise repositories, where the latter are adapted to users and their surroundings.

Keywords: artificial intelligence, ontology, semantic web, experts systems, CBR, interoperability

1. Introduction

Nowadays, industrial information provides effective knowledge of existing resources through databases and repositories, which provide details on the hosted equipment, including information on their capacity, performance, start/stop dates, turbine and generators models, etc. All of these properties and information are stored in digital repositories, digital files, and business websites. To collect, contribute, and share the knowledge about the resources installed in the industrial area, online databases named digital industry repository (DIR) is used. Therefore, the way in which information and knowledge stored in digital repositories is retrieved is of vital importance. DIRs provide centralized hosting and access to content, establish permissions, and

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controls for access to content, the ability to share digital objects or files, to protect the intellectual, and integrity property rights of content owners and creators, etc.

So far, traditional search engines treat the information as an ordinary database that manages the content inefficiently. Current search engines retrieve the information by comparing the contents of the database with searched patterns. The generated result is a list of data that contain this patter. Although search engines are becoming more effectively, information overload hinders search and accurate knowledge retrieval. Consequently, it is necessary to develop new semantic and intelligent models that contribute new possibilities. The presented work offers a new approach to the information retrieval based on semantics and intelligent models. For this, the case-based reasoning (CBR) technique is applied contributing to the goal of improving knowledge recovery in the industrial field.

A significant number of researchers have already investigated the application of intelligence and semantic techniques, but just a few from the point of view of full integrated of both technologies an industrial environment. There are researchers and related field works that include ontology retrieval methods such as [1] present a system that uses an ontology query model to analyze the usefulness of ontologies in effectively performing document searches and proposes an algorithm to refine ontologies for information retrieval tasks with preliminary positive results. In this paper [2], real-time image capture was achieved by using digital camera technology and image processing technology. By extracting the glue line curve from image, thinning glue curve by morphological method, and extracting the frame information, the closure and quality of the glue curve can be detected. Results of test show that the effect is satisfactory and the method is effective. The major contribution of [3] is a novel semantic query expansion technique that combines association rules with ontologies and Natural Language Processing techniques, which utilizes the explicit semantics as well as other linguistic properties of unstructured text corpus. It makes use of contextual properties of important terms discovered by association rules, and ontology entries are added to the query by disambiguating word senses.

Semantic Web utilizes concepts, taxonomic relations, and nontaxonomic relations in a given domain ontology to capture knowledge efficiently. For example, [4] describes one component of a knowledge management platform with a multiagent search module (MASH), which employs domain ontology to search for Web pages that contain relevant information to each concept in the domain of interest. The search is then constrained to a specific domain to avoid as much as possible the analysis of irrelevant information. Ref. [5] expounds the function of each layer and analyses the implementation of this system from the knowledge organization and expression and knowledge retrieval and proposes a framework of knowledge management system based on ontology. This management system establishes a sharable ontology that can be understood both by human and computer, which people can found more relations of different concepts through a better circumstance of knowledge retrieval interface. The work of [6] proposes an ontology-based user model, called user ontology, for providing personalized information service in the Semantic Web which utilizes concepts, taxonomic relations, and nontaxonomic relations in a given domain ontology to capture the users' interests. The research of [7] presents a semantics-based digital project which provides faceted search and represents a novel approach to Digital Libraries, integrating social Web and multimedia elements in a semantically annotated repository. In other investigation, Ref. [8] describes the architecture of the dynamic retrieval analysis and semantic metadata management system (DREAM) designed to automatically and intelligently index huge repositories of special effects video clips, based on their semantic content, using a network of scalable ontologies to enable intelligent retrieval. Ref. [9] presents an information search and retrieval framework based on the semantically annotated multifacet product family ontology. The major contribution of [10] is an innovative comprehensive semantic search model, which extends the classic information retrieval (IR) model, addresses the challenges of the massive and heterogeneous Web environment.

There are a lot of researchers on applying these new technologies into current information retrieval systems, but no research addresses artificial intelligence (AI) and semantic issues from the whole life cycle and architecture point of view [11]. This article analyses the search methods efficiency in a distributed data space such as industrial information repositories. The paper presents an intelligent proposal to optimize search engines in a specific industrial domain and to focus our discussion on the indexing and retrieval strategies of cases and provides the application technical aspects. This paper describes the current problems of semantic interoperability and proposes an intelligent method to address them. To do these, technologies based on metadata and intelligent techniques are used. The main proposal goal is the intelligent search management in decentralized industrial repositories, where no global information scheme exists. The most important novel introduced by this proposal is that contextual user profiles are built based on ontologies and metadata facilitating the ontological search using expert systems technologies. The objective has focused on creating technologically complex environments industrial domain and incorporates Semantic Web and AI technologies to enable precise location of industrial resources [12]. For this reason, we are improving representation by incorporating more metadata from within the information.

We propose a new paradigm to achieve efficient knowledge retrieval from digital repositories. This paper presents an intelligent search engine for industrial process, especially for resources repositories, and proposes an intelligent agent–based personalized model. One major research area is intelligent systems, with the general intention to replace human operators with intelligent agents. We have used CBR methodology to develop a prototype for supporting efficient retrieval knowledge from DIR.

In the following sections, we review the CBR framework and its features for implementing the reasoning process over ontologies. Section 2 presents a general overview about the industrial domain and technology infrastructure, analyzing its failures and discovering the needs that push us toward new intelligent paradigms. Section 3 analyses ontology requirements and proposes the design criteria to guide the development of ontologies for knowledge-sharing purposes. Then, we show the methodology followed to conduct this research, and we describe the semantic-based management system in DIRs environment. Next section concerns the design of a prototype system for semantic search framework, in order to verify that our proposed approach is an applicable solution. Moreover, the functional requirements of the engine and the knowledge base are described in detail. Finally, we present the results of our work on the adaptation of the framework, and we outline the future works.

2. Importance of applying ontology in industrial sector

Our objective here is thus to contribute to a better knowledge retrieval in the industry repositories field. Ontologies are being developed to facilitate knowledge sharing and reuse. In this section, we explain more formally what ontologies are and what problems can arise from knowledge sharing in industrial area. We have proposed a method to efficiently search the target information on a digital repository network with multiple independent information sources [13]. The use of AI and ontologies as a knowledge representation formalism offers many advantages in information retrieval [14]. In this chapter we analyzed the relationship between both factors ontologies and expert systems.

Currently, the electronic search is based mainly on matching keywords introduced by the users with sought data Web pages containing those keywords. The ambiguity of word blends and phrases and the poor linguistic features of Web content indexing mechanisms greatly affect the results obtained from Web resource searches. The efficiency of the results search obtained can vary depending on the quality of the search query from a limited set of results to a too large number of irrelevant results. For certain cases specifying a couple of keywords can be enough, if they are really specific and no ambiguity is possible. In another way, many Web users search for information that cannot be described easily by a set of keywords, and this is due to the wideness of expected results, which cannot be retrieved from existing search engines just with one search query [15].

Industrial repositories contain a large volume of digital information, generally focusing on making their knowledge resources to improve associate decision-support systems. Within a pool of heterogeneous and distributed information resources, users take site-by-site searching. Thus, considerable effort is required in creating meaningful metadata, organizing and annotating digital documents, and making them accessible. The presentation of semantic-enabled resources introduces some benefits of the Semantic Web technology as a possibility to perform a semantic search, integration of heterogeneous data, and use of semantically annotated search results by software. This work concerns applications of the Semantic Web technology for improving existing information search systems by adding semantically enabled extensions that enhance information retrieval from information systems.

A recent comprehensive document covering the main aspects of ontologies in AI research is the technical roadmap of the ontology field in Europe and worldwide produced by the OntoWeb project [16]. In this chapter, we want to emphasize that the first step toward real portability between systems is ontologies. Ontologies can be effectively used to address the problem of global and general models construction between similar domains. Furthermore, it is possible to instantiate and adapt ontology with a specific configuration to automatically build and validate new models [17]. With respect to the research involved in this study, ontologies can provide:

- Share and common understanding of the knowledge domain that can be communicated among agents and application systems.

- Explicit conceptualization that describes the semantics of the data.

The proposal is based on the principle that information items are abstracted to a characterization by introducing metadata, which is used and processed by search engines. This principle is based on a vocabulary/ontology that is shared in order to access the relevant sources of information. This creates new challenges for the research community and motivates scientists to look a recovery approach based on ontologies and intelligent information that automatically search and filter information based on a higher level of understanding required. In this sense, in the present work, we make an effort of investigating techniques that use ontologies to improve the effectiveness in knowledge retrieval. Thus, ontologies are key elements for the definition of the semantic Web [18].

To achieve these objectives, we must consider the interoperability of information. In other words, the ability of different information systems, platforms, and services to share, communicate, and exchange data, information and knowledge effectively and accurately, as well as integrate with other systems, applications, and services in order to deliver new electronic services and products.

Initiatives in this sense such as interoperability between different industrial domains require the establishment of collaborative semantic repositories between private and public sector organizations. Especially, semantic interoperability is necessary, which has a special relevance within the program to support the implementation of distributed services.

3. Challenging the interoperability between systems

Industry and companies are seeking to gain maximum business value from their investments in information and communications technologies. The industry has recognized the ever-increasing importance of systems and software interoperability to enable business process/government service development and the integration of systems and business processes. In the business case, it expands to include the ability of two or more business processes, or services, to easily or automatically work together [19]. In order to reduce costs of industrial integration and inefficiencies, increase business agility, and allow the adoption of new and emerging technologies, the ability to interoperate between systems is key issue. For two systems to be interoperable, they must be able to exchange data and subsequently present that data such that a user can understand it. Interoperability describes the extent to which systems and devices can exchange data and interpret that shared data. Connectivity and interoperation among computers and entities and among software components can increase the flexibility and agility of industrial systems, thus reducing administrative and software costs for industry.

In June 2002, European heads of state adopted the Europe Action Plan 2005 at the Seville summit. It calls on the European Commission to issue an agreed interoperability framework to support the delivery of European digital services to enterprises [20].

This document recommends policies and technical specifications for linking public administration information systems across the EU. This research is based on open standards and the use of open source software. These are the pillars to support the European provision of digital services in the recently adopted European Framework of Interoperability (EIF) [21] and its Spanish equivalent [22]. This document is the reference for the interoperability of the new Interoperable Program of Digital PanEuropean Services Provision to Public Administrations, Companies, and Citizens (IDAbc). European institutions and bodies should use the EIF for their operations with each other and with the citizens, businesses, and administrations of the respective EU Member States (IEF, 2014). Member States' administrations should use the guidance provided by the EIF to complement its national interoperability frameworks with a pan-European dimension and thus enable pan-European interoperability.

In this context, interoperability is the ability of information and communication technology systems and the business processes they support to exchange data and enable the exchange of information and knowledge. The ISO/IEC 2382 Information Technology Vocabulary defines interoperability as the ability to communicate, execute programs, or transfer data between several functional units in a way that requires the user to have little or no knowledge of the unique characteristics of those units. Interoperability can be considered on very different abstraction levels, and the distinctions to be made in this respect cut across all the other matrix dimensions. An interoperability framework can be described as a set of standards and guidelines, which describe the way in which organizations have agreed, or should agree, to interact with each other.

At the level of technical infrastructure, the industry is approaching interoperability through standards and in many cases conceptualizes those standards through stacks of technology. Technology stacks are conceptual layers of software and software functionality that interoperate between layers within stacks and between stacks in the same conceptual layer [23]. Within a continuum rank from a very concrete to a very abstract perspective, it is possible to distinguish three layers as shown in next **Figure 1**.

The main semantic interoperability objective is to improve communication on industrial knowledge related both between machines and between humans. To achieve this, a twofold approach is necessary to achieve a unified ontology and tackle specific and clearly delineated issues. Inside semantic interoperability, various dimensions, such as medial/administrative or human/machines levels, can be distinguished. Organizational interoperability is defined as the state in which the organizational components of the industrial system are able to function perfectly together. The goal is an integrated industrial system, which provides efficient, effective, and holistic. The functional objective is to allow data to be exchanged between different platform in various corporations using different software, hardware, equipment, etc. from multiple manufacturers. Technical interoperability allows communication and iteration between systems from different manufacturers. Technical dimension of interoperability include uniform movement of industrial data, uniform presentation of data, uniform user controls, uniform safeguarding data security and integrity, uniform protection of industrial confidentiality, and uniform assurance of a common degree of service quality.

Numerous efforts are being leveraged by many standard efforts to address semantic and organizational interoperability and are proving to be a model for addressing semantic and organizational interoperability such as ebXML, RosettaNet, the new CEFACT/UN work to align their global work process standards with Web services, etc.

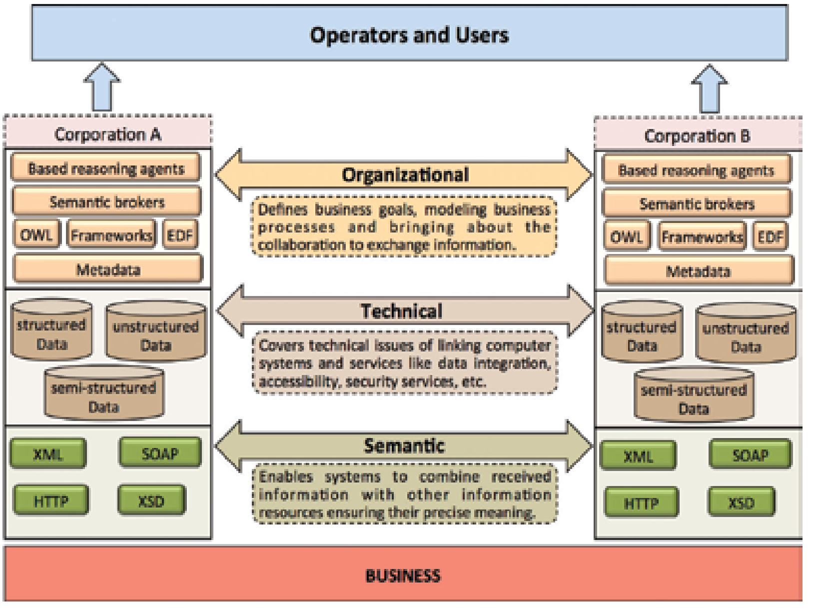

Figure 1. Conceptual interoperability layers.

The achievement of semantic and organizational interoperability requires strictly agreeing on the meaning of information and aligning business processes between companies/governments. At one level, general interprofessional frameworks and software infrastructure approaches can and are being developed for semantics and business processes. For example, the general semantics of major business transactions, such as purchase orders and invoices, is described through standards such as Universal Business Language (UBL), CEFACT Core Components, and Open Applications Group Integration Standard.

4. Intelligent and semantic architecture

The goal is achieved from a search perspective, with possible intelligent infrastructures to construct decentralized industrial repositories, where no global schema exists. This goal implies the application of CBR technique [24]. The prototype is the main tool to verify that the proposed architecture is an applicable solution, and this work attempts to achieve such verification by documenting in the proposal solution. In order to support the semantic of retrieval knowledge in industrial repositories, we develop a prototype named OntoEnter based on ontologies and expert system technologies. Obviously, our system is a prototype; nevertheless, it gives a good picture of the on-going activities in this new and important field. The architecture of our system is shown in **Figure 2**, which mainly includes three parts: the search engine, ontology knowledge base, and intelligent user interface.

The proposed architecture relies on the approach to efficiently retrieve information through metadata characterization and the inclusion of domain ontology. It involves using ontology as a vocabulary to define complex and multi-relational case structures to support CBR processes. Our system works by comparing objects that can be retrieved through heterogeneous repositories and capturing a semantic view of the independent world of data representation.

4.1. The case-based reasoning engine

Keeping in mind that our final goal is to reformulate queries in the ontology to queries in another with least loss of semantics, we come to a process for addressing complex relations between ontologies. CBR is widely discussed in the literature as a technology for building information systems to support knowledge management, where metadata descriptions are used to characterize knowledge elements. CBR is a paradigm of problem solving that solves a new problem, in our case a new search, remembering a similar previous situation and reusing information and knowledge of that situation. Recovering one solves a new problem or more previously experienced cases, reusing the case, reviewing, and retaining. This approach when a description of the current problem is input to the system, the reasoning cycle may be described by the following processes **Figure 3**.

The system retrieves the closest matching cases stored in a case base. Reuse a complete design where case-based and slot-based adaptation can be hooked, provided. If appropriate, the validated solution is added to the case for use in solving future problems. Review the proposed solution, if necessary. Given that the proposed result may be inadequate, this process can correct the first proposed solution. Keep the new solution as part of a new case. This process allows CBR to learn and create a new solution. The solution is validated by comments from the user or the environment.

In our CBR application, problems are described by metadata concerning desired characteristics of an industry resource, and the solution to the problem is a pointer to a resource described

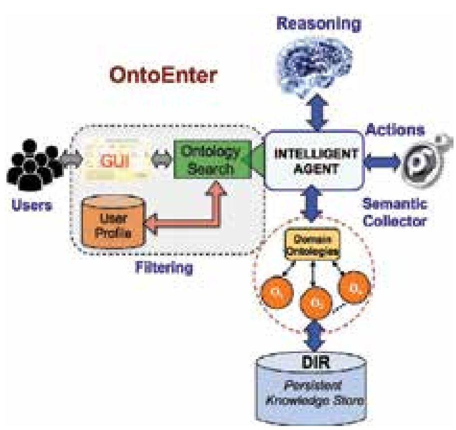

Figure 2. System architecture of OntoEnter.

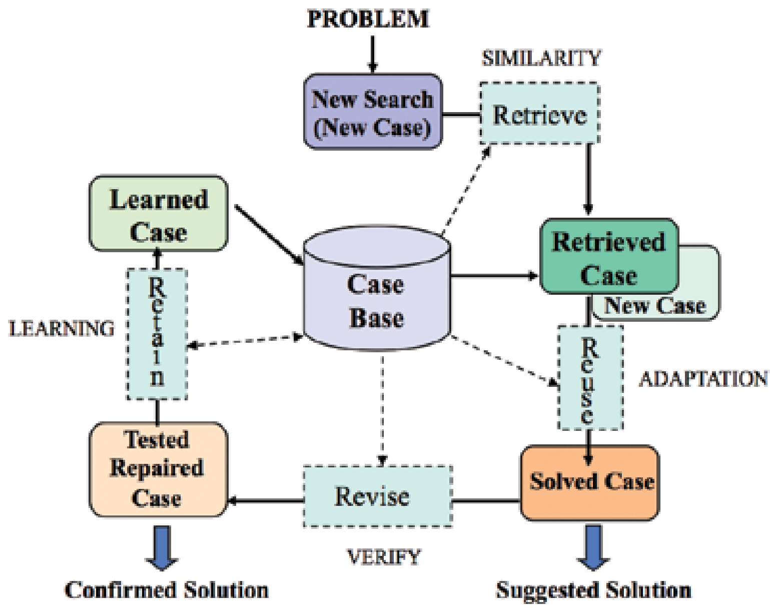

Figure 3. Case-based reasoning cycle in OntoEnter.

by metadata [25]. The development of a quite simple CBR application already involves a number of sttif, such as collecting case and background knowledge, modeling a suitable case representation, defining an accurate similarity measure, implementing retrieval functionality, and implementing user interfaces. CBR case data could be considered as a portion of the knowledge (metadata) about an OntoEnter object [26]. Every case contains both description problem and the associated solution.

Compared to other AI approaches, CBR reduces the effort required to acquire knowledge and representation significantly, which is undoubtedly one of the main reasons for the commercial success of CBR applications. However, implementing a CBR application from scratch remains a time-consuming software engineering process and requires a lot of specific experience beyond pure programming skills [27]. In this work, we have chosen framework jColibri to develop the intelligent search.

JColibri is a java-based configuration that supports the development of knowledge intensive CBR applications and helps in the integration of ontology in them [28]. The metadata descriptions of the resources and objects (cases) are abstracted from the details of their physical representation and are stored in the case base. This way the same methods can operate over different types of information repositories. The mapping between the two layers is done by connectors that read the values of the columns and the ontology of the database and return them to the application. That is to say, assign these values to different attributes of the case. Based on the same idea, the case base implements a common interface for similarity methods to evaluate cases. This includes the generation of case representations, the definition of similarity measures, the testing of retrieval and use of explanation functionality, and finally, the implementation of stand-alone applications. The main focus of methods in this category is to find similarity between cases.

The use of structured representations of cases requires approaches for the evaluation of similarities that allow to compare two objects structured in different ways, in particular, objects belonging to different classes of objects. An important advantage of the similarity box recovery is that if there is no case that exactly matches the user's requirements, this may show cases that are more similar to your query. The use of structured representations of cases requires approaches for similarity assessment that allow to compares two differently structured objects, in particular, objects belonging to different object classes. The retrieval strategy used in our system is correlation technique. Correlation is a bivariate analysis that measures the strengths of association between two variables. A line that runs through all the data points and has a positive slope represents a perfect correlation between the two objects. In statistics, the value of the correlation coefficient varies between +1 and −1. When the value of the correlation coefficient is about ±1, then it is said to be a perfect degree of association between the two variables [29]. As the value of the correlation coefficient goes toward 0, the relationship between the two variables will be weaker, **Figure 4**.

We measure correlations with the Pearson correlation method. The Pearson coefficient is a more complex and sophisticated approach to finding similarity. This best fit line is generated by the Pearson coefficient, which is the similarity score. The following formula is used to calculate the Pearson *r* correlation:

$$\rho_{x,y} = \frac{\mathrm{cov}(X, Y)}{\sigma_x \sigma_y} = \frac{E\left[(X - \mu_x)(Y - \mu_y)\right]}{\sigma_x \sigma_y}$$

Where:

r = Pearson r correlation coefficient.

N = number of value in each data set.

$\sum xy$ = sum of products of paired scores.

$\sum x$ = sum of x scores.

$\sum y$ = sum of y scores.

$\sum x^2$ = sum of squared x scores.

$\sum y^2$ = sum of squared y scores.

Pearson r correlation is widely used in statistics to measure the degree of the relationship between linear related variables. For example, in the industrial stocks and storage, if we want to measure how two commodities are related to each other, Pearson r correlation is used to measure the degree of relationship between the two commodities. The coefficient is found by dividing the covariance by the product of the standard deviations of the

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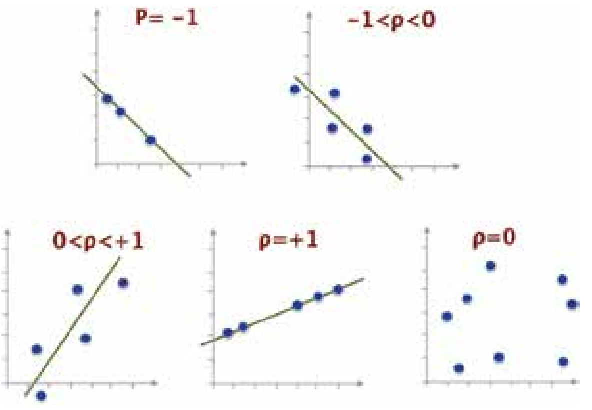

Figure 4. The method generates a best-fit line between attributes in two data objects.

attributes of two data objects. The advantage of the Pearson Coefficient over other techniques is that it is more robust against data that is not standardized. For example, if one person gives the rank for movies "a", "b", and "c" with scores of 1, 2, and 3, respectively, has a perfect correlation to someone who ranked the same movies with 4, 5, and 6. The following python code implements the Pearson coefficient for the same data described previously.

```
#Return the Pearson Coefficient for person1 and person2
def similarity_pearson(preferences, person1, person2):

  #Get the list of mutually rated items
  shared_items={}
  for item in preferences[person1]:
    if item in preferences[person2]: shared_items[item]=1

  #Find the number of elements
  num_shared = len(shared_items)

  #If there are no ratings in common, return 0
  if num_shared == 0: return 0

  #Add up all the preferences
  sum1 = sum([preferences[person1][item] for item in shared_items])
  sum2 = sum([preferences[person2][item] for item in shared_items])

  #Sum up the squares
  sum1_squares = sum([pow(preferences[person1][item],2) for item in shared_items])
  sum2_squares = sum([pow(preferences[person2][item],2) for item in shared_items])

  #Sum up the products
  prod_sum = sum([preferences[person1][item]*preferences[person2][item] for item in shared_items])

  #Calculate the Pearson score
  num = prod_sum - (sum1*sum2/num_shared)
  den = sqrt((sum1_squares-pow(sum1,2)/num_shared)*(sum2_squares - pow(sum2,2)/num_shared))
  if den == 0: return 0
  r = num/den

  return r
```

The open source jColibri system provides a framework for building CBR systems based on state-of-the-art software engineering techniques. The reason for choosing the jColibri framework is based on a comparative analysis between it and other frameworks, designed to facilitate the development of CBR applications. jColibri enriches the other shells CBR: CATCBR, CBR * Tools, IUCBRF, Orenge, in several aspects:

- Availability: open source framework.
- Implementation: Java implementation is one of our main requirements with respect to easy integration into the OntoEnter system, which is implemented in the J2EE environment.

Another decision criterion for our choice is related to the fact that jColibri offers the opportunity to incorporate the ontology in the CBR application to use it for the representation of cases and methods of reasoning based on content to evaluate the similarity between them. Providing easy-to-use model generation, data import, similarity modeling, explanation, and test functionality along with convenient graphical user interfaces, the tool allows even CBR beginners to quickly create their first CBR applications. However, at the same time, it ensures sufficient flexibility to enable expert users to implement advanced CBR applications.

4.2. Ontology knowledge base

Semantic modeling can help define the data and relationships between these entities. An information model provides the ability to abstract different types of data and provides an understanding of how data elements are related. A semantic model is a type of information model that supports the modeling of entities and their relationships. The total set of entities in our semantic model comprises the class taxonomy that we use in our model to represent the real world. Together, these ideas are represented by an ontology—the semantic model vocabulary that provides the basis upon which user-defined model queries are formed. The model supports the representation of entities and their relationships and can withstand the constraints on those relationships and entities. This provides the semantic composition of the information model [30].

Semantic models allow users to ask questions about what is happening in a modeled system in a more natural way. As an example, an oil production company could consist of five geographic regions, each region containing three to five drilling rigs and each drilling rig controlled by various control systems, each with a different purpose. One of these control systems could control the temperature of the extracted oil, while another could control the vibration in a pump. A semantic model will allow the user to ask a question like "What is the temperature of the oil extracted in Platform 3?" Without having to understand details such as, what specific control system supervises that information or what physical sensor is reporting temperature of oil on that platform.

The understanding provided through semantic models is fundamental to be able to correctly drive the correct ideas of supervised instrumentation that can ultimately lead to optimize business processes or, in this case, city services. As a result, semantic models can greatly improve the usefulness of the information obtained through operations integration solutions.

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Ontology models can be used to relate the physical world, to the real world, in the line-of-business and decision makers. In the physical world, a control point such a valve or temperature sensor is known by its identifier in a particular control system, possibly through a tag name like 14-WW13. This could be one of several thousand identifiers within any given control system, and there could be many similar control systems across an enterprise. To further complicate the problem of information referencing and aggregation, other data points of interest could be managed through databases, files, applications, or component services with each having its own interface method and naming conventions for data accessing. A key value of the semantic model then is to provide access of information in the context of the real world in a consistent way. Within a semantic model implementation, this information is identified using "triples" of the "subject-predicate-object" form; for example:

Tank1 <has temperature> Sensor 7
Tank 1 <is part of> Platform 4
Platform 4 <is part of> Plant1

These triples, taken together, constitute the Plant1 ontology and can be stored on a model server, as is described in more detail later in this article. This information, then, can be easily traversed using the model query language to answer questions such as "What is the temperature of tank 1 on Platform 4," more easily than the case without a semantic model.

We concentrate on the critical issue of metadata/ontology-based search and expert system technology. The main objective of the system is to improve the modeling of a semantic coherence to allow the interoperability of different modules of environments dedicated to the industrial area. We have proposed to use ontology together with CBR in acquiring expert knowledge in the specific domain. The primary information managed in the OntoEnter domain is metadata about industrial resources, such as guides, digital services, alarms, information, etc. We need a vocabulary of concepts, resources, and services for our information system described in the scenario that requires definitions about the relationships between objects of discourse and their attributes [31]. OntoEnter project contains a collection of codes, visualization tools, computing resources, and data sets distributed across the grids, for which we have developed a well-defined ontology using RDF language. Our ontology can be regarded as quaternion OntoEnter:={caller, resources, properties, relation), where profiles represent the user kinds, collection contains all the services and resources of the institutional repository, the matter cover the different information sources: electronic services, web pages, BB.DD., guides, etc., and a set of relationships intended primarily for standardization across ontologies.

We integrate three essential sources for the system: electronic resources, the catalog of documents, and the personal database. The W3C defines standards that can be used to design an ontology [32]. We write the description of these classes and properties in RDF semantic markup language. We chose Protégé as our ontology editor, which supports the acquisition of knowledge and the development of knowledge bases. Protégé provides an environment for the creation and development of semantic knowledge structures-ontologies and semantically annotated Web services. Protégé organizes these elements as a dynamic workflow [33]. For the construction of the ontology of our system, we follow the sttif detailed below.

- Determine the domain and scope of the ontology. This should provide the location of different online resources. These are included from different sources: Catalog of Publications, Websites, Electronic Resources, etc.
- Enumerate important terms in the ontology. It is useful to write down a list of all terms we would like either to make statements about or to explain to a user.
- Define the classes and the class hierarchy. When designing the ontology, we need first group together related resources of the institutional repositories. There are three major groups of resources: users, services, and resources. IA detailed picture of our effort in designing this ontology is available in **Figure 5**. This shows the high level classification of classes to group together OntoEnter resources as well as things that are related with these resources.
- Generating the ontology instances with SW languages. To provide a conversational CBR system to retrieve the requested metadata satisfying a user query, we need to add enough initial instances and item instances to the knowledge base.

After designing the ontology, we write the description of these classes and properties in RDF semantic markup language. Then the domain expert, in this case, the administrative staff fills the blank units of the instance according to the knowledge of the domain. A total

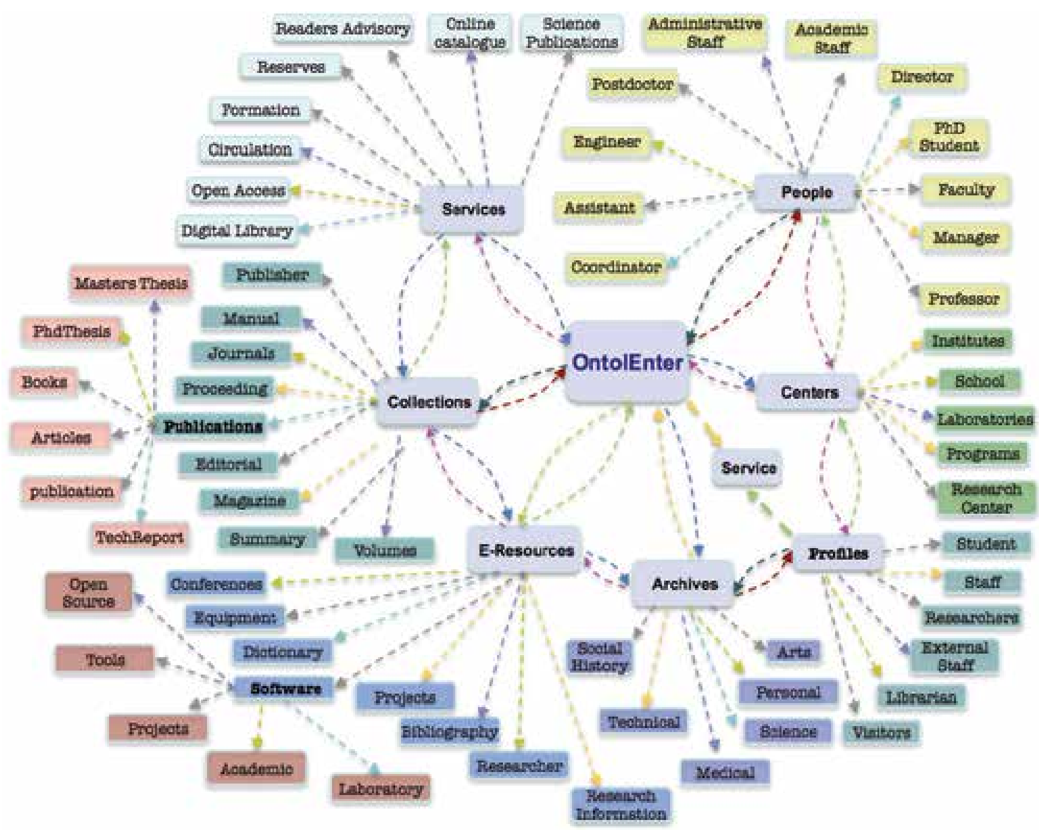

Figure 5. Class hierarchy for the OntoEnter ontology.

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of 13,000 cases were collected for user profiles and their different resources and services. Each case contains a set of attributes related to both metadata and knowledge. As a plus, domain specific rules defined by domain experts can infer more complex high-level semantic descriptions, for example, by combining low-level features in local repositories. Considering that our final objective is to reformulate queries in the ontology to queries in another with less loss of semantics, we arrive at a process to approach complex relations between two ontologies. As mentioned in previous sections, the relationships between ontologies can be compounded as a form of declarative rules, which can be handled in inference engines.

In addition, our system combines ontologies with rules into the ontology-based search due to the description limitations in current ontology languages. As mentioned in previous sections, relations among ontologies can be composed as a form of declarative rules, which can be further handled by inference engines.

4.3. Intelligent user Interface

OntoEnter is software, which is an intermediate link between users and search engine. By using OntoEnter user can tune the query in accordance with his needs. Advanced conversational user interface interacts with users to solve a query, defined as the set of questions selected and answered by the user during a conversation. The real way to get an individualized interaction between a user and a website is to present the user with a variety of options and allow the user to choose what is of interest at that specific time. In our system, the user interacts with the system to fill the gaps to retrieve the correct cases.

The algorithms used allow to give intelligent advice on improving the search query to obtain more relevant results to a narrow number of documents obtained or, conversely, to extend it. But the main task of OntoEnter is to specify in which exact word, the word is used and to formulate the "question" to the search engine, excluding answers from an inappropriate domain and adding semantically similar results [34].

For the distributed retrieval of learning resources, we use profile users, which are used for personalized searches according to user specifications. The methodology was based on incremental user profiling, which assumes mapping of a user's keywords to the concepts of the domain ontology according to the presented transformation rules. Transformation algorithm was implemented in the research prototype as the combined capability of the query transformation agent and the ontology agent of the intelligent multi-agent information retrieval mediator. The user interface helps user to build a particular profile that contains his interest search areas in the industry repositories domain. In an intelligence profile setting, people are surrounded by intelligent interfaces merged, thus creating a computing-capable environment with intelligent communication and processing available to the user by means of a simple, natural, and effortless human-system interaction. The objective of profile intelligence has focused on creating of user profiles: Plan Managers, Assistants, Operators, and Engineers. If the information space is well designed, then this option is easy, and the user achieves optimal information through the use of natural intelligence, that is, the options are easy to understand so users know what they will see if they click in a link, and what they negate by not following other links, **Figure 6**.

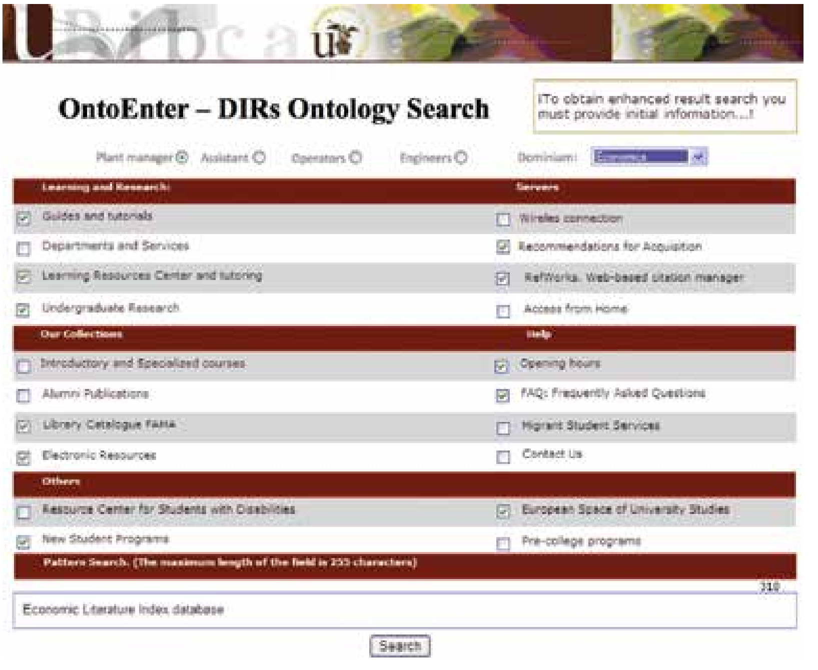

Figure 6. User profiles, graphical user interface.

The profile agent is an environment, in which software agents can be executed to retrieve E-learning resources and which is wrapped by a Web service. This configuration contains the user requirements that typically described the relative needs, tasks, and goals of the user for an individual search. Profile agents help students with the search, according to the specifications they made. Search parameters in a profile, the initiation of a search, or access to the list of retrieved learning objects can be controlled by invoking appropriate search operations that extract learning resource metadata. Ideally, profile agents learn from their experiments, communicate and cooperate with other agents, around in DL. A profile agent uses a registry to locate learning searches. The agent compares the metadata and the search keywords for possible matches and presents the search results to the user. For this, a statistical analysis has been done to determine the importance values and establishing specified user requirements.

5. Experimental evaluation

In order to validate the approach, we have developed intelligent control platform in an electrical power system. This system integrates management knowledge into network resource specifications. We study an example of alarm detection and intelligent resolution of incidents related to a private network. We have used a telecommunications network belonging to a company in the electricity sector Sevillana-Endesa (SE), a Spanish electricity company. OntoEnter is used to optimize the operation of hundreds of connected sensors currently installed. Many of these sensors are wireless because they can be installed more quickly and at less cost than their wired equivalents, often with no required downtime. These low-cost wireless sensors and accompanying analytics can dramatically improve plant performance, increase safety, and pay for themselves within months. The Spanish electricity grid has a wireless network in the regional high voltage grid. Part of the long distance traffic in this network is controlled by a wireless intelligent system distributed through this private network. The use of knowledge integration in agents can help the system administrator to use the maximum capabilities of the intelligent network management platform without having to use another specification language to customize the application [35].

The intelligent development of the system must meet the following requirements: it must be robust, and the management activity should not interfere with the normal operations of the network and should only intervene when necessary. We will use the SCADA system due to management limitations of the network communication equipment. SCADA consists of the following subsystems **Figure 7**.

- Remote terminal units (RTUs) are connected to sensors in the process, the conversion of sensor signals to digital data and the sending of digital data to the monitoring system.
- Communication infrastructure that connects the monitoring system to RTUs.
- A monitoring system (computer), collecting (acquiring) data about the process and sending commands (control) to the process, which is our IA.

SCADA systems are configured around standard basic functions such as data acquisition, monitoring and event processing, archiving and data storage analysis, etc. The RTU encodes sensor inputs in protocol format and sends them to the SCADA master. The fundamental role of an RTU is the acquisition of various types of power process data, accumulation, packaging,

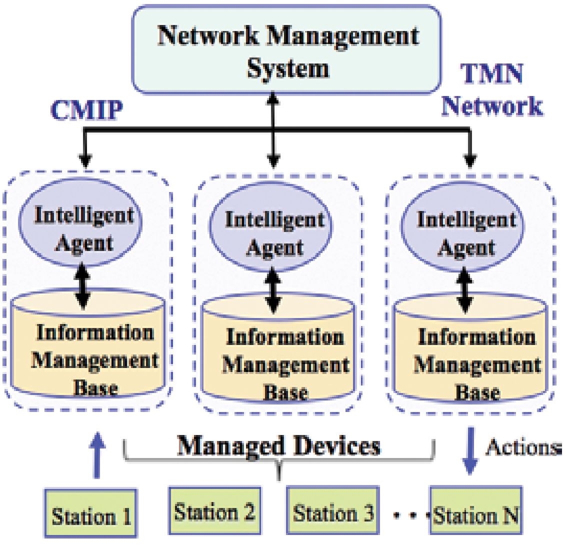

Figure 7. Elements of the prototype.

and data conversion in a form that can be communicated back to the master, interpretation and output of the commands received from the master, local filtering performance, calculation, and processes to allow specific functions to be performed locally. The supervision below and RTU includes all network devices and substation and feeder levels like circuit breakers, reclosers, autosectionalizers, the local automation distributed at these devices, and the communications infrastructure [36].

OntoEnter can monitor, in real time, the network's main parameters, making use of the information supplied by the SCADA, placed on the main company building, and the RTUs are installed at different stations. From the information provided, the operator can take action to solve any errors that may arise or send a technician to repair the station equipment. OntoEnter allows the operator to search for information, alarms, or digital and analog parameters of measurement, registered in each IA or RTU. The system has the ability to select the IA that is best suited to satisfy the client's requirements, without the client being aware of the details about the agent. In addition, the AI is able to communicate and negotiate with the other IAs. Collaborative IAs are useful, especially when a task involves several systems in the network.

6. Evaluation and proofs

When we perform a search on a search engine, we are looking to find the most relevant material, while minimizing the junk that is retrieved. This is the basic objective of any search engine. Get important information while avoiding junk is difficult, if not impossible to accomplish. The experiments carried out, in order to evaluate the effectiveness of the assignment of run-time ontology. The main objective has been to verify if the agent-assisted query formulation mechanism provides a suitable tool to increase the number of significant documents extracted from the DIRs to be stored in the CBR. For our experiments, we included about 50 users with different profiles. It set a context for users, they were asked to at least start their essay before issuing any query to the system. They were also asked to look through all results returned by OntoEnter before clicking on any result [37].

We compared the top 10 search results for each keyword phrase per search engine. Our application recorded the results they clicked on, which we used as a form of implicit user relevance in our analysis. We must consider that the relevance of recovered documents is subjective. That's different people can assign different relevance values to the same document. In our study, we have agreed different values to measure the quality of recovered documents, excellent, good, acceptable and poor, as can be seen in **Table 1**. After the data were collected, we had a record of queries with an average of 5 queries per user. From these queries, some of

	Excellent	Good	Acceptable	Poor
OntoEnter	7.5%	42.3%	35.1%	14.4%
Traditional SE	1.4%	25.7%	31.5%	21.3%

Table 1. Analysis of retrieved document relevance for select queries.

them had to be deleted, either because multiple results were clicked, no results were clicked or no information was available for that particular query.

In each experiment, we report the average rank of the user-clicked result for our baseline system, another search engine, and for our search engine OntoEnter. Thus basically, we can define two set-based measures: precision and recall.

$$precision = \frac{|\{relevan\ t_{document}\} \cap \{retrieve\ d_{documents}\}|}{|\{retrieve\ d_{documents}\}|}$$

$$recall = \frac{|\{relevan\ t_{documents}\} \cap \{retrieve\ d_{documents}\}|}{|\{relevan\ t_{documents}\}|}$$

It is possible to measure how well a search performed with respect to these two parameters. For each such set, precision and recall values can be plotted to give a precision-recall curve. We need these measures, if we are to evaluate the ranked retrieval results for search engines. These measures are computed using unordered sets of documents. The remaining queries were analyzed and evaluated **Table 2**.

It is easy to compare several classifiers in the precision graph. Curves near the perfect precision-recall curve have a better performance level than those closest to the baseline. In other words, a curve above the other curve has a better performance level (**Figure 8**).

Precision and retrieve are inversely related, i.e., as precision increases recall falls and vice-versa. When a relevant document is not retrieved at all, the precision value in the above equation is taken to be 0. A balance between these two needs to be achieved by the search engine that to achieve this and to compare performance, the precision-recall curves come in the practice.

Recall	OntoEnter Precision	Traditional SE Precision
0.10	0.90	0.60
0.20	0.85	0.56
0.30	0.79	0.43
0.40	0.68	0.35
0.50	0.61	0.25
0.60	0.52	0.05
0.70	0.39	—
0.80	0.20	—
0.90	0.05	—
1.00	—	—

Table 2. Precision and recall values.

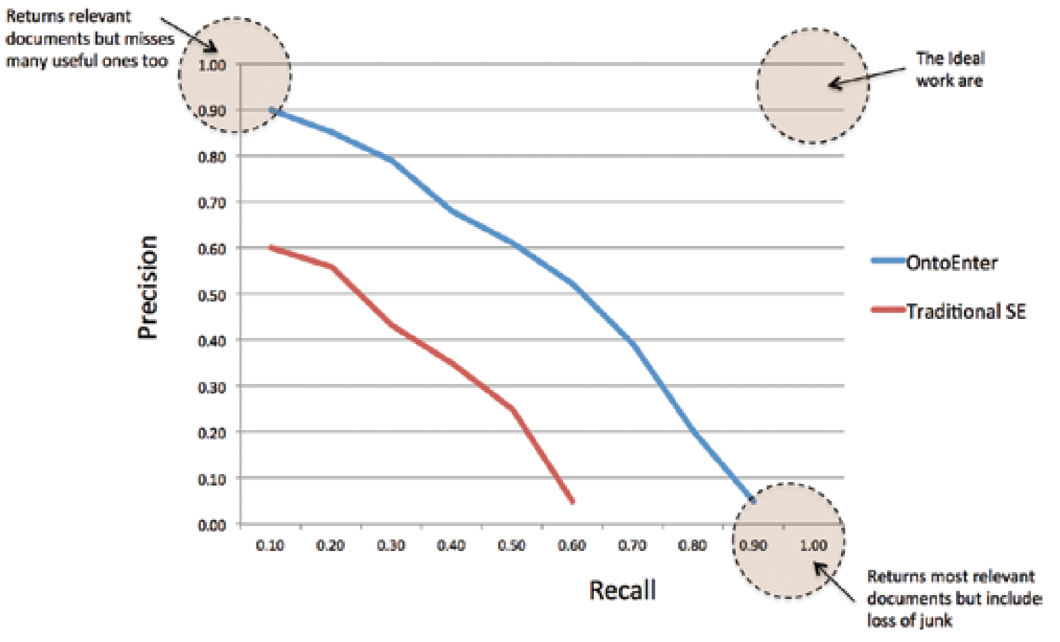

Figure 8. Performance OntoEnter & Traditional Search Engine (TSE).

This trade-off between precision and recall can be observed using the precision-recall curve and an appropriate balance between the two obtained. The precision-recall curves for two algorithms are shown. Depending on the requirement of high precision at the cost of the recall, or high recall with lower precision, an appropriate algorithm can be chosen. In our case, we choose the appropriate system depending on the high precision and data with false positives allowed. Two precision-recall curves represent the performance levels of the two search engines. The search engine OntoEnter clearly outperforms TSE in this domain example. Our system performs satisfactorily with about a 95.2% rate of success in real cases.

Another important aspect of the design and implementation of OntoEnter is the determination of the degree of speed in the answer that the system provides. During experimentation, heuristics and measures that are commonly adopted in information retrieval have been used. A statistical analysis was performed to determine the importance values in the results. While users were performing these searches, an application continued to run in the background on the server and captured the content of the written queries and search results. We can establish that OntoEnter speed in our domain improves the answer time and the average of the traditional search engine. **Figure 9** shows a graphic of these parameters that was collected as a part of the experiment.

We can establish that the speed in the system improves the procedure time and the average of the traditional search engine. Results for OntoEnter are 15.1% better than procedure time and 19.5% better than running time/sec searches on traditional search engines.

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Figure 9. OntoEnter search analysis report.

7. Conclusion and future works

In this chapter, we investigated how the semantic technologies can be used to provide additional semantics from existing resources in industrial repositories. For this purpose, we presented a system based on ontology and AI architecture for knowledge management in industrial repositories. We describe an effort to design and develop a prototype to manage resources in a repository such as the OntoEnter project and exploit them to help users as they select resources. Our study addresses the main aspects of a Semantic Web Information Retrieval System architecture attempting to respond to the requirements of the next generation of Semantic Web users. This scheme is based on the following principle: knowledge elements are abstracted from a characterization by a metadata description that is used for further processing.

In this chapter, we offer different possibilities, which the semantic Web opens for the industry. An important goal is to study appropriate industrial cases, compile arguments, launch industrial projects, and develop prototypes for industrial companies that not only create with us but also benefit from the semantic Web.

As described here, semantic models play a key role in the evolving solution architectures that support the business goal of obtaining the complete view of "what is happening" within operations and then deriving business insights from that view. Semantic models based on industry standards take that one step further, especially as application vendors adopt those standards (which, as always, will happen more rapidly through pressure from the user community). This study addresses the main aspects of a semantic and intelligent information retrieval system architecture trying to answer the requirements of the next-generation semantic search engine. We have investigated how the semantic technologies can be used to provide additional semantics from existing resources in institutional repositories.

This scheme is based on the principle of knowledge elements that are abstracted from a metadata description characterization that is used for further processing. We have proposed to use ontology together with CBR in acquiring expert knowledge in the industry specific domain. We have developed the domain ontology, and we have studied how the content-based similarity between the concepts typed attributes could be assessed in CBR system. The study analyses the implementation results and evaluates the viability of our approaches in enabling search in intelligent-based digital repositories. It introduced a prototype Web-based CBR retrieval system, which operates on an RDF file store. With this, characteristic of the model ability of an individual will be increased to learn through collective searches experience. Furthermore, an IA was illustrated for assisting the user by suggesting improved ways to query the system on the ground of the resources in industry repositories according to his own preferences, which come to represent his interests. We have used all the profile agents effectively to generate relevant and recommended personalized profile for the different users.

OntoEnter can be part of a bigger framework of interacting global information networks including other DIRs, scientific repositories, commercial providers, and relies as much as possible on standards and existing building blocks as well as be based on Web standards. The combination of effective information retrieval techniques and IAs continues to show promising results in improving the performance of the information that is being extracted from the online repositories for users. Our findings suggest that IA is the central manager in the knowledge transfer process. Their mediation is essential to help adapt the knowledge produced by academics and makes it easier to adopt and use by the educational community. We conclude pointing out an important aspect of the obtained integration: improving representation by incorporating more metadata from within the information and intelligent techniques into the retrieval process, the effectiveness of the knowledge retrieval is enhanced. The model has good characteristics in providing preference to the users with a novel approach of finding nearby meaning of query and user can also recommend result pages by their opinion.

Future work will address the exploitation of information from other institutional repositories and digital services and refine the suggested queries, expand the system to provide other support, and refine and evaluate the system through user testing.

Future work will focus on the design of distributed and self-managed services based on the Web and services, which are:

- Able to examine and filter information based on semantic similarity and closeness
- Able to handle heterogeneous data/knowledge /intelligence sources.
- Able to discover, compose, and integrate heterogeneous components automatically.
- Able to create, deploy, and exploit linked data.
- Able to perform automated and user-driven application/service orchestration and choreography, etc.

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Affective Technology Acceptance Model: Extending Technology Acceptance Model with Positive and Negative Affect

Angela Lee Siew Hoong, Lip Sam Thi and
Mei-Hua Lin

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.70351

Abstract

Research works on TAM, TAM2, TAM3 and UTAUT has always focused on cognitive aspect of technology acceptance in the past two decades. Acceptance of technologies such as eCommerce, Mobile and ERP that considered emotion and affect are still less. This creates a gap in the technology acceptance research, which consider the role of affect into technology acceptance model. This study considers the role of affect of a knowledge worker that work in Multimedia Super Corridor (MSC)-status organizations in Malaysia on their behavioural intention to use knowledge sharing tools (KS tools) in their day-to-day tasks. Hence, Affective Technology Acceptance (A.T.A) model has been proposed. The behavioural intention on the acceptance of KS tools will be hypothesize in the Affective Technology Acceptance (A.T.A) model. Positive (PA) and Negative (NA) affect as the role of affect construct were introduce in this model to investigate its influence on KS tools usefulness and ease of use among employees in Multimedia Super Corridor organizations. The findings of this study highlighted that NA has no impact on perceive usefulness. The findings also showed that PA has very significant positive influence on PU, PEOU and BI with impact on PEOU being the greatest.

Keywords: positive affect, negative affect, TAM, knowledge sharing tools, knowledge workers, affective technology acceptance model

1. Introduction

In the past few decades, works on technology acceptance research have always focused on cognitive instead of emotional factors to predict acceptance of technologies. The role of affect influence, state of mind, and feelings are not comprehended as comprehension

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and wordings utilized as a part of this range has dependably been utilized conversely by specialists. Numerous conflicting reports and clashing discoveries from past investigations that consider influence have brought about modest number of research endeavors here. Nonetheless, inquiry about them has demonstrated that reflexes, social judgment, discernment, and conduct [1, 2] are impacted by influence, mind-set, and feeling that constitute the major parts of individuals.

In the information systems' (IS) area, client assessment or client acknowledgment of information technology (IT) is considered as a volitional conduct [3] and has been examined basically with an intellectual introduction [4–6]. Research in this area has dependably been vigorously affected by the insight state of mind conduct models, from Theory of Reasoned Action and the Theory of Planned Behavior [7]. Even though some works on affect, affectivity, playfulness, enjoyment, and emotion have been studied, the affective aspects are less central in most of these studies, with some exceptions, such as studies on aesthetics [8], computer playfulness [9], flow [10], and users' experiences in technology acceptance [11]. Therefore, if the roles of affect indeed play a role in technology acceptance, what aspect of study should be examined and in what relationships of role of affect toward other constructs in the technology acceptance model.

2. Research gaps

Due to conflicting findings and inconsistent terminologies used in the research that considers affect, moods, emotions, and feelings, and the role of affect has been very much ignored by researchers in general. However, recent research has found that the inclusion of affective constructs is able to explain attitude and behavior more extensively in their models. Nevertheless, research that examines role of affect from the perception of the knowledge workers on the KS tools' characteristics in terms of features and functions to induce positive or negative affective (PA and NA) states is lacking. This study extends technology acceptance model (TAM) with PA and NA on perceived ease of use (PEOU), perceived usefulness (PU), and BI to predict the behavioral intention to use KS tools by knowledge workers in MSC-status organizations.

3. Literature review

3.1. Related works on technology acceptance

Davis [4] develops technology acceptance model (**Figure 1**) to determine factors that influence the acceptance of technology. Two most important individual beliefs about using information technology are perceived usefulness (PU) and perceived ease of use (PEOU) that are able to explain individual's intention to use the technology. Davis [4] concluded that

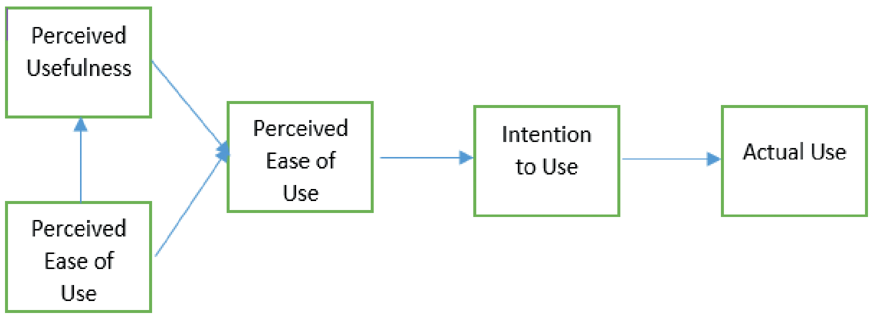

Figure 1. Technology acceptance model [4].

perceived usefulness was the strongest predictor to one's intention to use an information technology.

In TAM, the goal is to utilize the primary determinant of use to accept or not to accept a new tool. The intention to utilize is controlled by the individual's personality toward utilizing a specific tool. Perceived usefulness (PU) and perceived ease of use (PEOU) impact a person's state of mind toward utilizing a specific tool. Perceived usefulness (PU) is characterized as how much individuals trust that utilizing a specific tool would improve his or her task execution [4]. Perceived usefulness is the key determinant that emphatically influences users' convictions and expectation to utilize the innovation. Perceived ease of use (PEOU) is characterized as how much the user utilizes a specific tool, and it is free of effort [4]. Past research has demonstrated that perceived ease of use (PEOU) impacts aim in two ways: direct and indirect impact through usefulness of the tool [4]. As indicated by Davis [4], PEOU has no critical impact on behavioral expectation to utilize in light of the fact that PU intervened its impact. PEOU does not affect straightforwardly on user's behavioral goal since it affects behavioral expectation through PU.

Venkatesh and Davis [12] extended TAM by calling it TAM2 with social influence and cognitive processes on the Perceived Usefulness and intention usage (**Figure 2**). In TAM2, subjective norm [7] is hypothesized to have a direct effect on the intention of an individual to choose to perform a certain behavior even if he/she is not favorable toward that behavior, but due to other referents think he/she should; hence, the individual complies with these referents. In mandatory system usage settings, subjective norms were found to have direct effect on intention over PU and PEOU. The model posits voluntariness as a moderating variable to distinguish between mandatory versus voluntary. Nevertheless, subjective norms can influence intention indirectly through perceived usefulness that is called internalization. Therefore, according to TAM2, the direct compliance-based effect of subjective norm on intention over PU and PEOU will occur in mandatory but not voluntary system usage settings [12]. Job relevancy, output quality, and result demonstrability are determinants for cognitive instruments on PU.

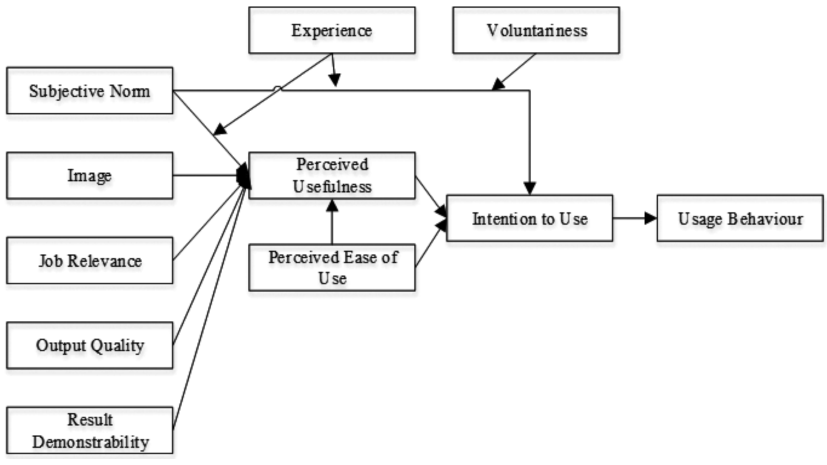

Figure 2. Extended technology acceptance model (TAM 2) [12].

TAM2 proposes that individuals rely on the fit between their job and the performance outcomes of using the system. This will determine their perceived usefulness of the system based on the job relevancy. It was defined as an individual's perception regarding the degree to which the target system is applicable to his or her job. Output quality is the quality of the end result produced by the system to the individual. An individual will take into account on how well the system performs those tasks. If the system does not produce any desirable output to enhance individual performance, it is deemed to believe that the user acceptance rate will drop. Therefore, TAM2 theorizes that result demonstrability defined by Moore and Benbasat [13] as "tangibility of the results of using the innovation" will directly influence perceived usefulness. TAM3 [12] is an extension of TAM where anchors and adjustments are hypothesized to influence PEOU in the model. Anchors are the degree to have general beliefs about computers and its usage, whereas adjustments are the degree of belief that is shaped based on direct experience with the target technology. The results indicate that there are strong correlations for these variables to PEOU. The antecedents for perceived ease of use include computer self-efficacy, perceptions of external control, computer anxiety, computer playfulness, perceived enjoyment, and objective usability. Unified theory of acceptance and use of technology (UTAUT) was introduced by Venkatesh in 2003. UTAUT was developed through the consolidation of various construct of eight models applied to IS usage behavior. These eight models are TAM, TRA, TPB, motivational model, integration of TAM and TPB, PC utilization model, innovation diffusion theory, and social cognitive theory. Behavioral intention and usage behavior were the two dependent variables. On the other hand, eight independent variables include performance expectancy, effort expectancy, social influence, facilitating condition, gender, age, experience, and voluntariness of use. Three main constructs are the determinants of the intention to use and behavior usage (**Figure 3**): performance expectancy, effort expectancy, and social influence. Performance expectancy was the strongest predictor among the eight factors. UTAUT theorizes that social influence holds significance only in mandatory technology use of situations.

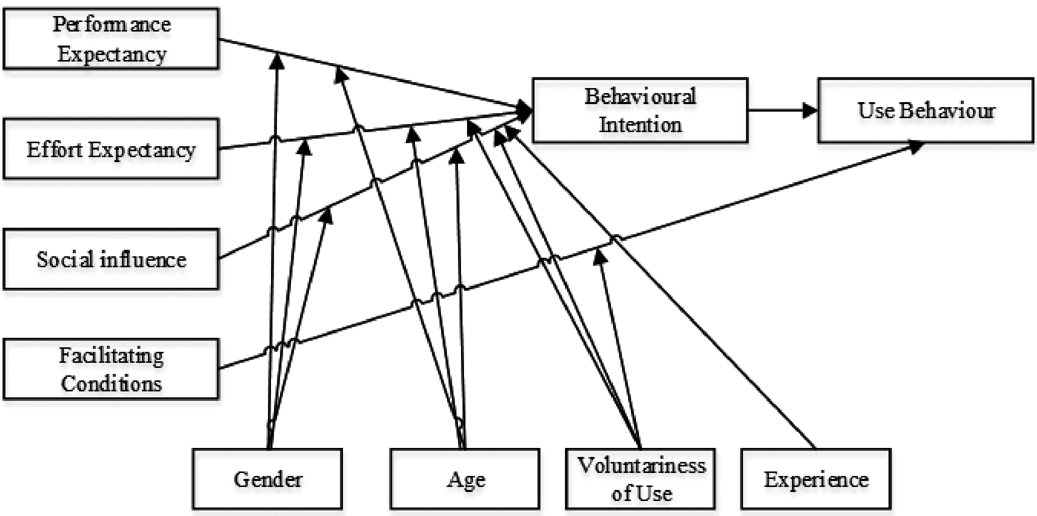

Figure 3. The unified theory of Acceptance and Use of Technology [6].

3.2. Affect, mood, emotion, sentiment, and feeling

Every single sociology shares an interest to attempt, to clarify, and to foresee individual's behaviors, where these behaviors are impacted by subjective procedures. Most theories derived from behavioral often ignore role of affect factors. Role of affect refers to one's feeling or how an individual feels when performing tasks [14, 15]. Affect also refers to one's emotions, moods, and feelings, and they are used interchangeably [2, 16–18].

Dispositional affect is defined as a person's affective predisposition toward perceiving the world around him or herself either positively or negatively [17, 19]. It has strong influences on individual behavior [20, 21]. Many related information systems research uses different terms to represent the role of affect such as "anxiety" when using computers, "computer playfulness," "affect" toward computers, the influence of emotions toward users' attitudes, and use of specific IT [9, 22–24]. Mood is an intra-individual change, generally nonintentional which is not associated with explicit intentions to act [25, 26]. Lazarus [17] defined mood as an affective state that comes and goes depending on particular conditions. Mood is low intensity, diffuse feeling states that usually do not have a clear antecedent [27]. Mood can be characterized as relatively unstable short term intra-individual changes [28]. Mood can be evoked by both dispositional affect and emotions. Unlike emotions, people may not realize that they are experiencing a "mood" and may also not realize that mood is influencing their behavior [27]. Emotions differ from both dispositional affect and mood. Emotions have a clear cause or object, usually are shorter in duration and more focused and intense [29]. Emotions are more likely to change beliefs than mood [30, 31]. Emotions are more likely to disrupt activity [17]. It is also said as an intense feeling; a complex and usually strong subjective response that typically accompanied by physiological and behavioral changes in body [32]. Emotions can occur during the impact period (i.e., when the new information technology (IT) had been deployed and was being used). In this period, emotions are generated based on individuals' perceptions on the features of the new technology and on their usage of the new technology resources. Individuals will assess whether the technology constitutes a threat or an opportunity and how it can adapt into their daily tasks by changing their working behaviors [33]. Some specific emotion terms such as pleasure, arousal, and enjoyment are used to relate users' attitude toward actual use of a technology [6]. Feelings are sensations perceived by the sense of touch; an affective state of consciousness that resulted from emotions, sentiments, or desires. On the other hand, cognition arises on the human beings' perception toward using technologies [16, 34]. Behavioral aspect would be from the individual's reactions toward using the information technologies [11]. Emotional Intelligence is a variable with a multifactor individual difference [35] that meets the traditional standards of intelligence. Being emotionally intelligent involves being actively able to identify, understand, process, and influence one's own emotions and those of other to guide feeling, thinking, and action. Sentiments are valence appraisals of an object that involves evaluation of whether something is liked or disliked. These evaluations were evoked by phenomena. It can come from previous experience with the object or situation or through social learning [29]. Satisfaction has been the most widely studied sentiment. Most of the work conducted has focused on satisfaction at the individual level either because of workplace events or as a predictor of workplace outcomes [19].

Zhang and Li [36] examined the affects of emotional assessments of IT on IT utilized choices. Refer to Zhang and Li [36], two protest based full of feeling assessment builds: recognition on IT's ability to incite positive affect and impression of the IT's capacity to prompt negative affect able to influence. Their investigation demonstrated that positive affect and negative affect are particular ideas that affect perceived usefulness (PU), perceived ease of use (PEOU), and attitude toward utilizing IT tools. These impacts remain constant amid individuals in using and utilizing IT tools (ATT). Positive affect impacts PU, PEOU, and ATT, yet it turns out to be less critical to PU after some time, and positive affect just impacts PEOU; however, it turns out to be more vital to PEOU over the long run. Therefore, Zhang and Li [37] presumed that affect influence a key part in individuals' connections in using IT tools.

Loiacono and Djamasbi [15] also found that positive mood played a significant role in the adoption of a new technology. Their study looked at the effects of positive mood, and to understand how individual's characteristics affect an individual's cognition and behavior on the acceptance of a Decision Support System. The objective of their research is to investigate how affect can be a vital component for technology acceptance to make rational decision making. Based on Isen et al. [38], qualities of task characteristics impact one's certain state of mind particularly on tolerating another innovation, for example, Decision Support Systems (DSS) which requires subjective capacities to deal with troublesome/complex task. Association can control one's state of mind by encouraging positive temperament inside the association, and it can enhance association's results [16]. From their findings, Loiacono and Djamasbi [15] reported that positive mood could bring improvements in new technology acceptance.

4. The proposed affective technology acceptance (ATA) model

Based on the literature findings, affective technology acceptance model involves PA and NA that were used to induce positive and negative affect states on the individuals who uses the technology were proposed. Zhang and Li [36] adapted these constructs and defined them as the perception of IT's capability to induce these feelings. It was said that the technology functions and features are capable of inducing these feelings in the individuals. Therefore, this research proposed an extension on the technology acceptance model by including this two affect states on the use of KS tools by the knowledge workers in the MSC-status organizations in Malaysia. Indication of the respondent's feelings was recorded at eight different points in times on the instrument to gather the different affective states of the knowledge workers on using the knowledge sharing tools. The measurement scale was adapted from Perlusz [39]. Two groups of undergraduate students were used to validate the scale, and it was found that the technology affect scale were consistent and valid in Perlusz studies.

In this research, PA and NA are defined as the perception on KS tools' characteristics in terms of features and functions to induce positive or negative affective states [36, 37, 40]. PA and NA were adapted from Zhang and Li [36], where they defined PA and NA as the perception of an IT's capability to induce positive or negative affect. It is an individual's perception or evaluation that an IT has the features and functions to induce positive or negative affect in him or her. In this study, the external stimulus is KS tools used by the knowledge workers in the MSC-status organizations in Malaysia. The respondents were asked to indicate the extent of how he/she feels on the usefulness, ease of use, and intention to use the KS tools in eight different points in times in the instrument. The different affective states of the knowledge workers were self-reported on the survey form. The measurement scale for PA and NA is adopted from Technology Affect Scale [39] where Perlusz [39] adapted the 10-item scale from Watson and Tellegen [41]. The scale was validated using two groups of undergraduate students who were exposed to several types of affects before interacting with mobile technologies. The Technology Affect Scale is found to be consistent and valid in his experiments.

4.1. PU, PEOU, ATT, and BI in technology acceptance model

The relationships among PU, PEOU, ATT, and BI are consistent with the literature. TAM originally included attitude as a mediator between the personal beliefs constructs, and behavioral intention [4]. Individual's actual usage of the technology is dictated by behavioral goal, which is determined by perceived usefulness and perceived ease of use. The value of perceived usefulness is the degree to which an individual trusts that utilizing the innovation will upgrade his or her employment performance, and perceived ease of use is the degree to which individual trusts that utilizing the technology will be free of effort [4].

H7: There is a significant relationship between PEOU and PU.

H8: There is a significant relationship between PU and ATT.

H9: There is a significant relationship between PEOU and ATT.

H10: There is a significant relationship between ATT and BI.

4.2. PA and NA on the perceived usefulness, perceived ease of use, and behavioral intention to accept KS tools

This research considers PA and NA based on evidences obtained by Zhang and Li [36]. They found that PA strongly influences PEOU, PU, and ATT, while NA only influences PEOU at the initial stage of usage. In their work, BI is mediated by ATT, but the direct influence of PA and NA on BI was not being investigated (**Figure 4**). Isen [42] presented his findings by stating that positive affect state such as joy and elation will lead a person to be creative, playful, and explore innovative ideas and think broadly. Another piece of work conducted by Isen et al. [38] using four experiments on positive and negative affects induced by a series of activities such as watching comedy films for few minutes, receiving a small bag of candy, or showing film of unpleasant feelings. They found that positive affect induced by a comedy film or a small gift of candy facilitates creativity on tasks given. At the same time, activities that designed to induce negative affect using primitive arousal devoid of any affective tone (exercise) had no effect on these measures. In their findings, negative affect neither facilitates nor impairs creativity. However, they pointed out that one of their experiments showed that negative affect was only induced by showing subjects film that induces unpleasant feelings. The proposed work in this research hypothesized the extent of how a person feels in his perception on the KS tools' features and functions (or characteristics) in their day-to-day tasks that induce positive or negative affect. This research fills the gap by examining the relationship of PA and NA and the behavioral intention to accept KS tools in the organizations. The affect induced by the perception toward how knowledge workers evaluate KS tools' affective quality is believed to be able to influence an individual's behavior and intention to accept a

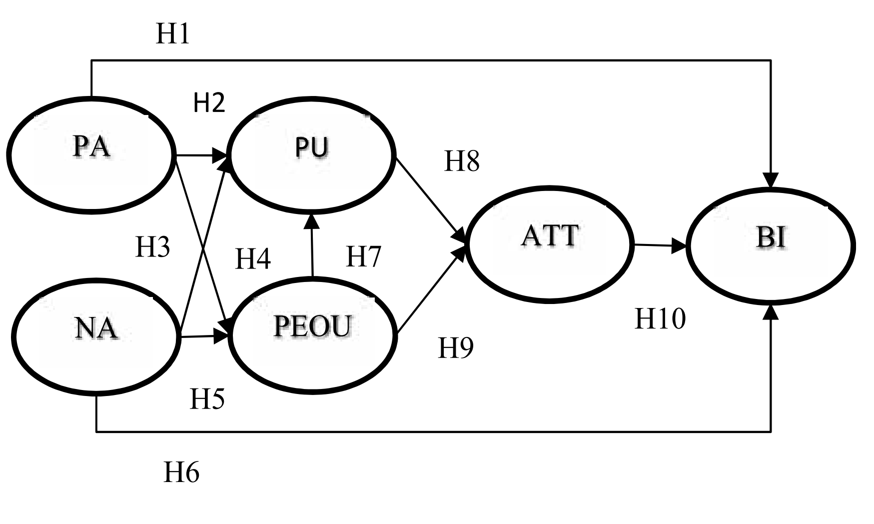

Figure 4. ATA model.

tool. Affect construct included in the proposed Affective Technology Acceptance Model, the hypothesis is as follow:

H1: There is a significant relationship between PA and BI.

H2: There is a significant relationship between PA and PU.

H3: There is a significant relationship between PA and PEOU.

H4: There is a significant relationship between NA and PU.

H5: There is a significant relationship between NA and PEOU.

H6: There is a significant relationship between NA and BI.

5. Methods

5.1. Study contexts and samples

The population where sample will be drawn in this research consists of knowledge workers who work in MSC-status organizations in Malaysia. The samples are individuals who deal with information, require developing, or using knowledge to solve problems in their jobs. About 2500 MSC-status organizations from the MSC directory (http://www.mscmalaysia.my/company_directory) have been invited to participate in this research. Two thousands and five invitations were sent out to these organizations and 300 forms were received. Two hundred ninety-five forms were usable. A response rate of 11.87% was gathered from the self-administered questionnaire. **Figure 5** illustrates KS tools that are highly utilized by the respondents, and **Figure 6** presents those that are not used at all in the activities that are carried out by the respondents.

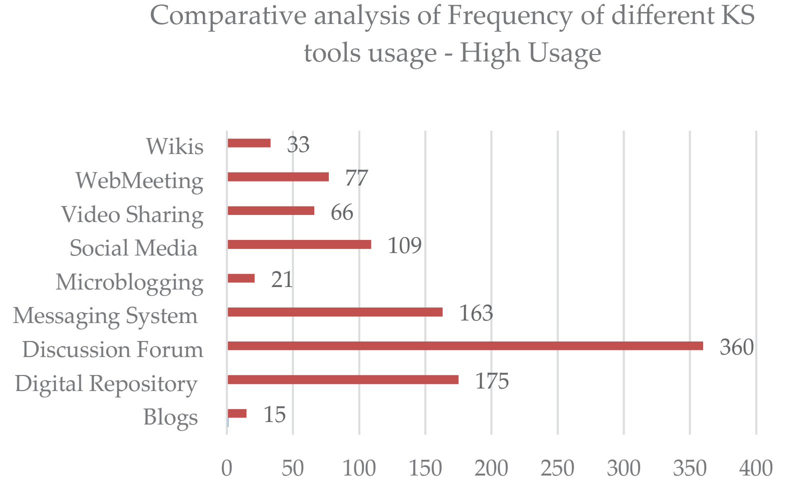

Figure 5. KS tools with high usage frequency.

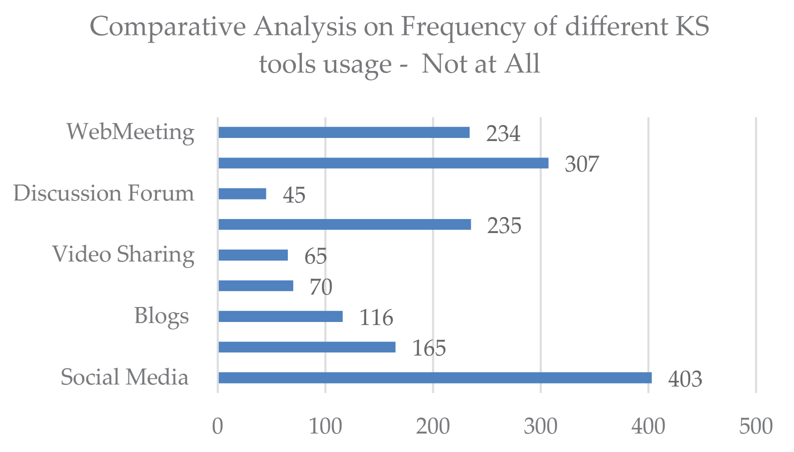

Figure 6. KS tools not used at all among knowledge workers in MSC organizations.

Most of these organizations are in their initial stages of tool implementation or tools have been implemented but with very minimum tools usage among knowledge workers in these organizations. This rationalized the importance to carry out a research on their intention to use KS tools in their day-to-day jobs.

5.2. Instrument and measures

All the constructs in the research model were measured with items adapted from prior research. All the items in the questionnaire used a five-point Likert-type scale ranging from "Strongly Agree" to "Strongly Disagree" (**Table 1**).

Sections	No. of items
General information	9
KS tools behavioral intention	30
Role of affect	24

Table 1. Instrument.

Respondents were asked to indicate to what extend one feels when one evaluates the KS tools when interacting and using the tools. The respondents were asked to record their feelings that were induced by the tools when they interacted with them. The positive and negative affect (PA and NA) are hypothesized to have an impact on PEOU, PU, and BI in the research model. Items for positive and negative affect (PANAS) were adapted from Perlusz [39], Tellegen [28], Watson [43], and Watson et al. [44]. Pre-test and pilot test were carried out before actual survey took place. A total of 30 respondents participated in these tests.

5.3. Data analysis

The proposed model and hypothesis testing was carried out using SmartPLS 3.0 software. The measurement and structural model analysis follows methodology described in Hair et al. [45]. In this research, a sample size of 295 is sufficient using G*Power software to examine the predictive accuracy of constructs and path coefficients of relations in the proposed model. The analysis on the years of experience of the knowledge workers in these MSC-status organizations highlighted that most of them have been in their industry more than 10 years. The preliminary analysis highlights that long service in the industry gives knowledge workers more domain knowledge where majority of them possess an undergraduate degree.

6. Results

6.1. Measurement model analysis

This section discusses the measurement model, which consists of several analyses. **Table 2** illustrated the composite reliability on the results. Based on the analysis, it was shown that PU, PEOU, ATT, and BI all achieved the value of composite reliability higher than 0.90, which satisfy the threshold of composite reliability.

Convergent validity looks at the extent to which a measure correlates positively with alternative measures of the same construct. In **Table 2**, it was found that all the constructs' AVE are significant with at least 0.50 and above.

Discriminant validity is the extent to which a construct is truly distinct from other constructs by empirical standards. This means a construct has captured the phenomena not represented by other constructs in a model. Cross loading and Fornell-Larcker criterion discriminant validities are used in this analysis. The analysis indicates that AVE of all constructs has high correlation. Formative measurement analysis conducts a separate set of validity and consistency test. The formative constructs in the proposed model consist of positive and negative affect for PU (NA_PU and PA_PU), positive and negative affect for PEOU (NA_PEOU and PA_PEOU), and positive and negative affect for BI (NA_BI and PA_BI). Convergence validity is the extent to which a measure correlates positively with other measures or indicators of the same construct. A redundancy analysis is used to perform the convergence validity test by

Constructs	Composite reliability (CR)	Cronbach's alpha	AVE (Convergent validity)	Discriminant validity	
				Cross loading	Fornell-Larcker criterion
Perceived usefulness (PU_I)	0.945	0.932	0.710	Y	Y
Perceived ease of use (PEOU_H)	0.928	0.913	0.591	Y	Y
Attribute toward use of KS tools (ATT_G)	0.925	0.906	0.639	Y	Y
Behavioral intention to use KS tools (BI_J)	0.937	0.922	0.682	Y	Y

Table 2. Composite reliability for reflective constructs.

evaluating formative measurement models; one must test whether the formatively measured construct is highly correlated with a reflective measure of the same construct. A global indicator is designed for this test. To conduct the convergent validity, a separate model is created with the global indicator for each formative construct. From the outcomes of the redundancy analysis, negative affect on perceive usefulness, negative affect on perceive ease of use, negative affect on behavioral intention, positive affect on perceive ease of use and positive affect on behavioral intention are 0.8 or above. Their formative indicators are significant enough to capture content that these constructs want to capture.

For collinearity assessment, when collinearity has high correlations between two formative indicators in a formative construct, it is a problematic indicator and it is unwanted for a formative construct. VIF is used to assess collinearity. Once the collinearity of formative indicators has been treated, outer weights in formative measurement models can then be interpreted. All formative indicators satisfy the requirement of VIF values uniformly with values below the threshold value of 5. There are five items used to test PA → PU, PA→PEOU, and PA → BI. Similarly, five items were designed for NA → PU, NA → PEOU, and NA → BI. The items that are labeled as AA1A..E, BB1A..E, and CC1A..E are positive affect items whereas AA1F..I, BB1F..I and CC1F..I are negative affect items. There is no collinearity problem found in the model except for the items AA1G and AA1H from negative affect on perceived usefulness, BB1G and BB1H from negative affect on perceived ease of use and CC1F and CC1J from negative affect on behavioral intention. Based on items AA1G, AA1H, BB1G, BB1H, BB1J, CC1F, and CC1J being important questions to measure negative affect on perceived usefulness, perceived ease of use, and behavioral intention in the instrument, therefore, these items will be retained. A formative indicator of its relevance is analyzed based on the values of its outer weight as it is compared with others to determine its relative contribution to the construct.

To determine whether an indicator is significant or not, each indicator's *t*-value must fulfill the critical value of l.65 for two-tailed tests at a significant level = 10%. The indicator significance level analysis for positive affect and negative affect on perceived usefulness is significant. Positive and negative affect on perceived ease of use has ten formative items that measure the construct. Five items were chosen to measure positive and negative affect, respectively. One negative affect item is not significant. Its *t*-value is less than 1.65, and outer weight and outer loading do not fulfill the criteria. However, BB1J was not considered to be deleted from this construct because this item has been validated and tested in the previous instrument. Positive and negative affect on behavioral intention has ten formative items that measure the construct. Five items were chosen to measure positive and negative affect, respectively. Negative affect has one item that is not significant. The outer loading value of 0.482 for CC1J is rounded up to be 0.5. Hence, all items are significant. In short, based on the theoretical model and measurement scale used for the proposed research model, the existing items for each construct will be kept.

6.2. Structural model analysis

Collinearity assessment on a structural model involves examination of each set of predictor constructs for each part of the structural model. Collinearity is assessed based on those constructs that have tolerance levels below 2.0 or VIF above 0.50. If such collinearity exists, one should consider eliminating the constructs, merging predictors into a single construct, or creating higher-order constructs to treat collinearity problem. **Table 3** shows that there is no collinearity problem encountered in the research model.

Structural model is used to calculate the estimates of the structural model relationships (path coefficient) that are represented as the hypothesized relationships among the constructs. For this research, we choose to take a significant level of 10% with a critical value of 1.65. Besides examining *t*-values, *p*-values are considered in this analysis. To obtain the *t*-values, a bootstrapping procedure with 5000 resamples was applied. Based on the analysis results, the hypothesis testing results are summarized as follows in **Table 4**.

Another important measure is the total effect of each path. Direct effect for each path may not be very significant in some cases; hence, Total Effect is to assess the significant of paths in the model. The coefficient of determination is a measure of the model's predictive accuracy using R^2 where it represents the exogenous latent variables' combined effects on the endogenous latent variables. R^2 also represents the amount of variance in the endogenous constructs explained by all the exogenous constructs linked to it. In scholarly research that focuses on marketing issues R^2 values of 0.75, 0.50, and 0.25 for endogenous latent variables can be described as substantial, moderate, and weak, respectively.

Attitude toward using KS tools can predict with an accuracy that is close to value 1. Followed by behavioral intention to use KS tools with a R^2 value of 0.625 and Task Category-KS tools Fit of a R^2 value of 0.593. As for perceived usefulness, it has a R^2 value of 0.45 and perceived ease of use has the smallest R^2 value of 0.360. By examining *t*-values based on the critical values 1.65 for two-tailed tests at a significant level = 10%, all the *t*-values in the table are significant. Hence, all the predictive accuracy values are significant (**Table 5**). Hence, ATT_G and BI_I are substantial and PU_I and PEOU_H are moderate endogenous latent variables in the proposed model.

Constructs	ATT_G	BI_J	PU_I	PEOU_H
ATT_G		2.326		
NA_BI		1.075		
PA_PU			1.307	
NA_PU			1.062	
PEOU_H	1.421		1.492	
PU_I	1.421			
PA_BI		1.371		
PA_PEOU				1.211
NA_PEOU				1.051

Table 3. Summary of VIF for collinearity analysis.

No	Hypothesis	Results
1.	There is a significant relationship between PA and BI.	Supported
2.	There is a significant relationship between PA and PU.	Supported
3.	There is a significant relationship between PA and PEOU.	Supported
4.	There is a significant relationship between NA and PU.	Not supported
5.	There is a significant relationship between NA and PEOU.	Supported
6.	There is a significant relationship between NA and BI.	Supported
7.	There is a significant relationship between PEOU and PU.	Supported
8.	There is a significant relationship between PU and ATT.	Supported
9.	There is a significant relationship between PEOU and ATT.	Supported
10.	There is a significant relationship between ATT and BI.	Supported

Table 4. Summary of the hypothesis testing results.

Endogenous latent variable	R^2	*t*-values
ATT_G	0.628542	14.3111
BI_J	0.625851	16.30823
PU_I	0.450406	6.329501
PEOU_H	0.360258	6.716182

Table 5. R^2.

7. Discussion and conclusion

Role of affect has been measured in this study to investigate on its relationship between positive and negative affect with knowledge workers' behavioral intention to use knowledge-sharing tools. The results show that these two constructs have significant relationship on behavioral intention to use and this was also supported by Zhang and Li's findings in 2007. Zhang and Li [36] pointed out that negative affect is easier to measure and investigate compared to positive affect. It was believed that negative affect creates impacts on knowledge worker's performance and their intention to use a technology. However, this study outcome produces a new finding where the results show that negative affect has no impact on individuals' perceived usefulness on the knowledge-sharing tools, whereas the results for attitude toward knowledge-sharing tools usage aligned with past literature works [4, 6]. Negative affect has a strong impact on behavioral intention usage of KS tools in the ATA model. From the findings, we know that knowledge workers use knowledge-sharing tools to perform their daily task in work, and the results gather their affect states after interacting with the tools. From the study, we conclude that if individuals have a strong negative influence on their behavioral intention, they will show less interest in the use of knowledge-sharing tools. Therefore, negative affect has the strongest influence on perceived ease of use and perceived usefulness of the tools. On the other hand, positive affect shows significant impact on perceived ease of use, perceived usefulness and behavioral intention. This implies that positive affect plays a great role in behavioral intention to use a technology; therefore, constant improvement on the tools is needed to induce positive affect on the individuals in using the tools.

Positive and negative affects are a major determining factor in technology acceptance. Past review works in information systems show that the outcomes were inconclusive and inconstant. Operationalization of affect and its related terms has been ambiguous. Many terms have been used interchangeably in a number of research; however, this is a growing field and interest among many researchers [12, 28, 37, 39, 40, 41, 46–56]. From the past related works, it has shown empirical evidence on the role of affect and it was used to explain better in a behavioral study. The proposed ATA model has hypothesized positive affect and negative affect in influencing PEOU, PU, and BI to use knowledge-sharing tools. Past research works has shown that affect has no significant impact on the usefulness of the tools. However, in this study, we found that positive affect has significant influence on the usefulness and ease of use on knowledge-sharing tools and subsequently influence individuals' behavioral intention to use. These findings are a new contribution to the theoretical aspect of affect relating technology acceptance area of study.

Practitioners and business operators can then maximize these findings by knowing what to do to their tools in order to encourage more usage of the tools. Software designers can consider affect element as they design new tools for knowledge workers. Unpleasant and uncomfortable feelings at the first glance on the tools may induce negative affect on the individuals, hence, impact of affect must be considered while designing user interface of a technology. Technology that induces positive affect will increase the tools acceptance. This study brings new implications to the top management on the factors that impact the knowledge workers' intention to use KS tools in their works. This study suggests that organizations should focus on knowledge workers' affective aspects besides other factors before implementing any KS tools in their organizations. The affective aspects of knowledge workers induced by the tools are found to be significant in this research. Therefore, top management should pay attention while formulating their knowledge-sharing tools implementation strategies in their organizations.

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Section 2

Knowledge Management Applications

Chapter 9

The Impact of the Internet of Things to Value Added in Knowledge-Intensive Organizations

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Additional information is available at the end of the chapter

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Abstract

This chapter has focused on the importance and influence of Industry 4.0 and consequently the Internet connected technologies' creation of the value added for knowledge-intensive organizations and society. The chapter considers the development of knowledge management through different periods; it has focused on its importance during the use of social media and the rise of the Internet of Things. The goal of this chapter is to achieve a better understanding of the impact of knowledge management processes to the value of knowledge that is established by the extent of knowledge sharing within the organization and with suppliers and customers (knowledge sharing outside the organization).

Keywords: knowledge organization, Internet of Things, innovative economy, value added chain, knowledge management, organizational changes

1. Introduction

In the last 25 years, as a rapidly developing discipline, knowledge management (KM) has become the utmost important source for organizations that aim to raise efficiency, innovation, and hence the competitive abilities [1, 2]. During this period, the theory of knowledge management has also been developing [3] due to the recognition of knowledge as a fundament for competitiveness and the key to business success [4].

Handzic [5] defined the fundamental purpose of knowledge management as collecting, organizing, and processing knowledge into a form that is useful to all employees. An important role of knowledge management is shown in applications that exist in the organizations, such as intranet, enterprise resource planning systems (ERP), and customer relationship management systems (CRM). Such applications store transactions and customer data for business

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decision-making processes [6]. With launching the Web 2.0 and social media, these processes are running outside the organization [7]. According to the fast adoption of the social media platforms and mobile applications in the last 10 years, organizations have faster (in real time) and easier access to the knowledge that is created in human living environment [2]. The Internet transformation of the digital industry is still in progress; the artificial intelligence, big data, and connectivity indicate the certainty of a new round of digital revolution [8].

The concept of Industry 4.0 has launched the fourth technological revolution, which is based on the concepts and technologies that include cyber-physical systems, the Internet of Things (IoT) and the Internet of Services (IoS). Industry 4.0 is based on perpetual communication via Internet that allows a continuous interaction and exchange of information, not only between humans and machines, but also between the machines themselves [9]. This communication interaction influences the establishment knowledge management 4.0. The trend of the social customer relationship management (social CRM) for an emergent concept that integrates classical customer relationship management (CRM) and social media is leading toward the establishment of a communication channel for the continuous exchange of information about the needs and individual situations in real time to e-retailers, healthcare, manufacture, housekeeping, coworkers, customers themselves, energy suppliers, etc. [10].

This chapter has focused on better understanding of the impact of the Internet of Things on organizational changes in knowledge-intensive organizations. The contribution of the article is mainly conceptual.

2. Transformation from knowledge economy to innovative economy

The transformation of "traditional heavy industry" into the technological development-oriented economy proceeded in the middle of 1980s in twentieth century [11]. The economic period of knowledge economy has influenced organizational changes in strategies, structures, and management styles [12].

The emergence of the Internet in the early 1990s of the twentieth century (period of the Internet or digital economy) has influenced the rise of the third wave of capitalism. The Internet launched the new institutional revolution in the globe. Consequences have been seen in increasing the importance of networks and crowds in relation to market institutions. Internet revolution is based on a population size (N), the resources feeding supply sub-system (F) encompassing both the natural resources and food system, and accumulated technological and scientific knowledge sub-system (K). The key factors N-F-K have an important influence on human development and economic growth [13].

The technological development forces organizations that are based on the Taylors paradigm hierarchy into the changes of the business processes that consequently lead to the changes of the organizational structures. Organizations must have in mind that their role in a new "smart technological capitalistic" era will be not only to provide the development of a high-tech information and communication technologies, but also to support the social innovative projects and thus have an impact on social and economic development of the society [14].

During the time of economic crisis (2008–2009), the first signs of changes in business models occurred. Innovation companies gave an answer how to increase the economic growth in last few years. Entrepreneurs have begun to open up a start-up technology companies related to the development of online platforms and digital technologies [15]. The launching of a new business models based on the Internet and digital technologies affected in last few years due to the changes in the consumer behavior. The fast Internet connections and mobile technologies enable the development of the trading and sharing platforms (e.g., Airbnb, Backfeed, Fairmondo, Uber, Tapaz, etc.). Digital platforms enable individuals and business operating in real time via the Internet, which increases the range of potential customers and due to the nature of the business reduces the cost of marketing and business resulting in lower prices for goods and services [16].

Managers and leaders should be aware also of the knowledge negative aspects, because it can cause economic crisis. Control of the knowledge resources and prevent sharing of knowledge and information have a negative impact on the development of innovative society. Cause is the large gap between developed and emerging countries [17]. Pagano and Rossi [18] claim that the cause of the crisis lies at the monopoly of developed countries over intellectual rights. International agreements on trade-related aspects of intellectual property have caused a rise in the cost of investments in countries that had neither abundant inexpensive labor nor high amounts of intellectual property. The authors believe the solution to the crisis, besides changes in monetary policy, financial regulation, and standards of Keynesian economic policy, also needs a measure that will reduce the intellectual monopolization of the economy.

The innovative economy that succeeded knowledge economy introduces new approaches for the development of business models in the process of organizational evolution. The innovative smart Internet connected technologies become a system for creating and distributing the knowledge and as such they have characterized firms and many other social systems [19]. The main factor for the development of the entrepreneur idea is not any more the financial capital but a social capital, because products or services are a result of knowledge that is based on innovative ideas by either individuals or teams [20]. Knowledge and information have become a key factor for success in the knowledge economy as an innovative economy [21].

It is necessary for the development of an innovative environment to facilitate access to venture capital (e.g., crowdsourcing, kickstar, venture capital funds, etc.) and move on to the new forms of cooperation that are based on short term relations for which the duration depends on the project timeframe, provide tax relief for R&D, enhancement of intellectual property rights (patents and licenses), and facilitation of the networking organization that facilitates cooperation among businesses (e.g., clustering).

2.1. Industry 4.0 and rise of Internet of Things

A new concept of German economic policy was formed in Germany in 2011, based on high-tech strategies named as Industry 4.0 [22]. That concept raised the fourth technological revolution, which is based on the concepts and technologies that include cyber-physical systems, the Internet of Things (IoT), and the Internet of Services (IoS) [23, 24], based on perpetual communication via Internet that allows a continuous interaction and exchange of information, not only between humans (C2C) and human and machine (C2M), but also between the machines themselves (M2M) [25].

The rise and expansion of Industry 4.0 with its current fundamental concepts (**Table 1**) is based on the assumption of increasing global urbanization [26]. Demographic changes are becoming a challenge for urban renewal and development, which will have to enable the infrastructure of residents for ensuring their quality of life and sustainable orientation [7, 24]. What actually presents the phenomenon of Industry 4.0, and in which parts of the economy and the human environment it is expanding, is probably most evident from the expressions with which it is associated. These fundamental concepts of Industry 4.0 and the explanation of their contents are shown in **Table 1**.

As shown in **Table 1**, in order to create a smart project, smart technologies and devices have been used. A critical component for the success of urbanization and societal development will be a smart technology. It is predicted that the purpose of the technology will be aimed at collecting and analyzing data from the human environment in order to design a circular economy, increase revenues, lower capital spending, improve services, and mobility [9, 27].

An organization needs a developed business-support infrastructure as a result of initiating partnerships, which allows it access to information, advice, and education. In this model, information is changing and in such a rapidly changing environment, information is not so much important [4].

Expression/fundamental concept	**Explanation**
Smart factory, smart manufacturing, intelligent factory, factory of the future	The smart factory will be more intelligent, flexible, and dynamic. Manufacturing will be equipped with sensors, actors, and autonomous systems. Machines and equipment will have the ability to improve processes through self-optimization and autonomous decision-making
New systems in the development of products and services	Product and service development will be individualized. In this context, approaches of open innovation and product intelligence as well as product memory are of outstanding importance
Self-organization	In manufacturing, processes change in the entire supply and manufacturing chains. These changes will have an impact on changing processes from suppliers to logistics and to the life cycle management of a product. Along with all these changes manufacturing processes will be closely connected across corporate boundaries These changes in supply and manufacturing chains require greater decentralization from existing manufacturing systems. This fits with a decomposition of the classic production hierarchy and a change toward decentralized self-organization
Smart product	Products inserted with sensors and microchips that allow communication via the Internet of Things, with each other and with human beings. Cars, t-shirts, watches, washing powder, etc., are set to become "smart," as their makers attach sensors to their packaging that can detect when the product is being used, and that can communicate with smartphones when scanned. Smart products are eliciting the question of invasion of privacy and consequently personal safety

Expression/fundamental concept	Explanation
New systems in distribution and procurement	Distribution and procurement will increasingly be individualized
Adaptation to human needs	New manufacturing and retailers' systems should be designed to follow human needs instead of the reverse. It is suggested that these systems may well be a combination of robotic-like tools such as personal intelligent agents such as Siri, Viv, Cortana, Google Now, and others, which will be combined with the Internet of Things. That can become the dominant model of the interaction between buyers and sellers
Cyber-physical systems	Systems will integrate the computation, networking, and physical processes. Embedded computers and networks will monitor and control the physical processes, with feedback loops where physical processes affect computations and vice versa. An example is the control of vital human functions that allow urgent health care through mobile applications, sensors in clothing, sensors, and surveillance cameras in flats
Smart city	Smart city is defined as a city that comprises six factors in its development policy: smart economy, smart mobility, smart environment, smart people, smart living, and smart governance. It is the product of accelerated development of the new generation information technology and knowledge-based economy, based on the network combination of the Internet, telecommunications network, broadcast network, wireless broadband network, and other sensors networks where IoT as its core
Digital sustainability	Sustainability and resource-efficiency are increasingly in the focus of the design of smart cities and smart factories. It is necessary to respect ethical rules when using private information. These factors are fundamental framework conditions for successful products
Source: Ref. [2].	

Table 1. Fundamental concept of the Industry 4.0 and implementations of IoT.

If management wishes that the new digital business models have an impact on increasing the added value of organizational knowledge, it is necessary to focus on:

- Definition of adoption of human communication methods in the external environment (terms of quality, distinctiveness, and ownership of data, information, and knowledge).
- How people account for the risk of sharing their content with strangers. Are people receptive to the issues of ownership and transfer of data between strangers (the problem of transmission of information from researchers and developers with external experts to help create the so-called open innovation)?
- How it affects the takeover or merger of the development organization that owns the new technologies developed by its members to communicate with experts in acquiring.

It must be realized that today the company due to globalization changes is exposed to more rapid changes in society and nature, which as such have the greatest impact on product development, operations, and ultimately to the success of the company [28]. This change caused the growth of importance of reaction in interaction with the environment in which the entity operates (headquarters, production), as well as the markets in which it sells. This means that the massive classical information passes into custom-made information known user or target groups of users with high added value [27]. Such information is transformed into specialist advice and continuous monitoring of users, while education is increasingly necessary in the fields of encouraging companies for corporations, informing about the types of cooperation and management of partnership development networks.

3. Changes in knowledge management and in the knowledge-intensive organizations

3.1. Knowledge-intensive organizations

In the case of the contents described in this chapter, the objective is to contribute to the understanding of the structures and contexts of utilization of knowledge-based resources; the question is how complex implementation of the Internet of Things as a technological instrument effects on organizational changes and adaptation of knowledge processes; and to the understanding of the relationship between innovations of IoT technologies and organizational performance. According to Porter [29], a value chain represents a key source of competitive advantage. In this case, cost advantages and successful differentiations are tracked more effectively by considering the chain of activities that organization performs with the goal to deliver value to its customers. The most products of the knowledge-intensive organizations are hidden assets. These invisible assets have presented knowledge about what the organization produces, how an organization is organized, and for what reasons [30].

Organization is an open system that is affected by the external environment with emphasis on the global nature and constantly changing requirements of customers, suppliers, and market conditions (nature conditions, the legislation, customs, taxes, and religion). The value of external system is featured as the ability to solve problems and needs of our customers. According to the information about customer behavior, organization can establish a policy for the customer relationship management (CRM) and suppliers develop a marketing strategy that provides market positioning and design of brand loyalty [3]. Web platforms become an important source of knowledge about the customers and with help from information getting from web platforms and Internet connected products, organizations have created the content value chain. This is achieved by linking complementary organizations and respective organizations with their distributors and customers [31].

The external effects on the organization are evident in organizational effectiveness and relevance of the activities in the field of R&D of individuals and groups within the organization and the organization's contribution to society [7]. The purpose of networking between organizations is the tendency to develop and implement technology solutions and processes that will enhance the organizational added value and bring added value to the customer in the form of utility value. Linked organizations that constitute the value chain have to reach decisions on strategies to increase the added value (e.g., acquisition, accumulation, and divestment) with a consensus with partners. In order for successful participation to occur in the value chain, organizations have to identify common goals, be complementary, and trust each other [32].

Internet saturation is influenced on changing the Internet architecture (architecture principles named Kondratieff cycle that began in 1970). The sixth Kondratieff cycle is started with new Internet technologies and it is predicted that IoT and big data will change the KM in next few years [33].

Drucker et al. [34] used the term "knowledge work" such as the fact that knowledge is a key resource in most organizations, not capital land or labor. Knowledge combined with experience helps in decision-making and innovation. The economy, which is variable and uncertain knowledge, appears as nonstatic phenomenon.

Drucker [35] had, at the end of the 1980s, pointed to the emergence of a new organization based on knowledge, consisting of experts, subject to share their experiences (and thus gain quick response) with their colleagues, customers, and the leadership of the organization. He named it as the information-oriented organization.

Zack [36] defines knowledge-intensive organizations by their process, place, purpose, and perspective, which will be discussed briefly and including the case of smart health services.

- *Process*: This includes application of existing knowledge and creation of knowledge. Knowledge sharing within organization provides benefit based on past knowledge, increase of teamwork, creation of new knowledge, and emergence of opportunities for experimentation and learning.
- *Place*: The knowledge-intensive organization, people, and supporting resources are creating and applying knowledge by continued interaction. The organization is seeking for knowledge wherever and connects with anyone who can help it to learn.
- *Purpose*: The organization should establish a corporate culture that will enable sharing, exploitation, and use of internal organizational knowledge in everyday working processes. Organization uses information and information technologies in order to ensure performance of these processes. The knowledge-intensive organization focuses on who needs to work with whom instead for whom.
- *Perspective*: The organization is holding its knowledge-oriented image regardless of the service or a product that is provided by it. Knowledge and learning are the primary criteria for evaluating organizational working processes, location, and relationships with customers. It is what, and how it learns from the customers. The cost of learning is investment in future innovations, not a cost.

Mahesh and Suresh [8] and Gummesson [9] identified three types of knowledge-intensive organizations, based on knowledge perspective:

- Manufacturing organizations: knowledge-intensive work is limited to the research and development departments. A narrow group of employees is tied to creating knowledge-intensive decisions and creation of a value-added chain within this context. Cognitive and social distances are lower among the employees in departments and higher at the entire level of organization.
- Consulting firms, legal firms, and pure play technology organizations: knowledge constitutes a major part of the output. The value chain depends on the ability of processing specialist knowledge of employees in the firm. Social and cognitive distance is smaller in all parts of the organization.
- Information, communication, and consumer-oriented technology organizations: these organizations have a diverse business network, producing and marketing a wide range of customized business and technology products and services. Investment in high technology and innovations represent key factors for their existence. This causes a perspective distance between the middle and the bottom level of hierarchy of the organizations. The consequences are visible in slower responses to market conditions. The measures cannot be thought cross the organizational hierarchy quickly. This has led to problems in achieving set goals of management at the business process level and the transfer of responses of organizational changes from the lower to a higher management level.

An example of a knowledge-intensive organization and its features in the period of the fourth industry revolution is presented in case of the digital-health companies and processes of a smart home health care.

In the case of a smart home, health care is going for the system where embedded computers and networks are monitoring and controlling the physical processes with feedback loops where physical processes affect computations and vice versa. All information is stored in clouds and digital-health companies enable the exchange of health data [37].

The concept of the smart home health care enables ill people to stay home as much as possible and continue living a quality life. Such digital healthcare platform is not only influenced by organizational changes of a health-service but also by decreasing costs of this service. McKinsey research showed that implementation of patient self-services with using digital channels instead of the direct physician visit, or patient self-management solutions can produce net economic benefits of 7–11% of total healthcare spending [38].

Control of vital human functions can be presented as a case study; this allows urgent health care through mobile applications, sensors in clothing, sensors, and surveillance cameras in flats (e.g., integrated in the house or smart phone application) monitoring the patient and sending information to physicians [10, 3].

In the case of a process of a smart home health care, the integration and sharing information are the key concept. It is going for the process of knowledge management 4.0 whose characteristics are defined by the following [39]:

- Big data are acquired directly from the things and users. Information is analyzed and saved in clouds;
- Information is shared in real time. Content is available online. There are no limitations for sharing information between people or things. The development of Internet technologies resulted in creation of knowledge and its easier sharing in external organizational environment.
- In the case of personal data, it is necessary to allow access only to authorized personnel. High level of privacy and strong data protection should be provided.
- Information sharing and collaboration is going on via wireless communications between people, between people and things, and between things.

3.2. Creation and the importance of knowledge management

Marshall et al. [33] defined KM as a process in which we are trying to figure out what kind of human capital lies in the minds of individuals and the shift in organizational capital, to which he is able to access a large group of individuals, each of which depends on the development of the organization.

Nonaka [26] claims that the production of knowledge at the individual level, which is available to others, is the pivotal activity of the organization, based on knowledge-creating company. The author emphasizes that it is a permanent process that takes place at all the levels within the organization, which may, in certain moments, occur in unexpected forms. He claims that the quantitative data acquisition of new knowledge—increase efficiency, reduction of costs and improvement of return on investment—is not sufficient for knowledge management. It recalls the importance of rapid response to customer needs, creating new markets, and innovative products.

Rowley [40] identified KM as a definition, acquisition, use, maintenance, and disposal of the assets of knowledge, for the purpose of increasing the value and benefits of all stakeholders.

Epistemology is claimed on what knowledge is valid in research, how that knowledge is presented, and what kind of knowledge is found in knowledge-intensive organizations, society, environment, and specially with using and analyzing the information obtained from social media and Internet of Things in the virtual world (e.g., big data clouds storage) [15].

The creation of new knowledge is not just a matter of processing objective information. The point is that the creation of new knowledge depends on the exploitation of tacit knowledge and often highly subjective knowledge of each employee within the organization [20]. In addition to the tacit knowledge, it is necessary to be vigilant even in explicit knowledge (knowledge of official records, such as patents) and the importance of their mutual interaction in the development of new products or services [7].

Kogut and Zander [23] share knowledge in the organization on information and "know-how." They believe that knowledge is based on the competencies of individuals and the principles of the organization, through which relations between individuals, groups, and members of the business connections are arranged and coordinated. The authors present the conclusion that organizations exist only because they are better able to transmit and share knowledge as a market. This conclusion follows from the premise that organizations are able to process and store large amount of information than individuals [41].

The development of knowledge management can be divided into three phases (**Table 2**). First phase appeared in the mid-1990s, and it can be classified as a classical knowledge processes development phase. The main feature of this period is that knowledge is sought outside the organization. The task of the organization is to capture, decode, and share the knowledge in organization and its environment. The procedures of knowledge management begin after the creation of knowledge, and the next processes are knowledge development and its transformation into practice. Organizations were highlighted in this first phase of the integration of knowledge in business processes [42].

In the first period of development of knowledge management, it was lead to the conclusion that knowledge has to be produced in a social environment. It has been established that the knowledge is generated through the processes of individuals. The creators of knowledge are obliged to care for its accuracy. In the process of cooperation between individuals both within the organization and in the external environment, it comes to sharing knowledge [42, 43].

The second phase started around 2003 with the launch of the Internet 2.0-based knowledge processes.

The second phase of knowledge management is characterized by the awareness of the importance of external information and knowledge to the organization. Providing access to external information and knowledge, including their involvement in the value chain creation is of utmost importance. Important characteristics of knowledge organizations are in their advantageous utilization of superior information technology and highly skilled employees (knowledge workers) that is able to implement its innovative activities into realization [44, 45].

Classical knowledge processes	Internet 2.0-based knowledge processes	IoT knowledge processes
Knowledge based on the data acquired from the intranet, CRM. Data is saved in local servers	Information is accessed and stored via clouds and platforms like Google and Facebook	Big data acquired directly from the things and customers. Analyzed and saved in clouds
Local time and personal limited access	Business or private content is available on any device, any place, and any time	Real time. Content is available online. No limitations for sharing information between people or things
Organization limited networking; information sharing and discussion via email or intranet	Internet 2.0 provides online relations between the customer and supplier. The discussion is limited to the matter of content and physical data entry	Information sharing and collaboration via wireless communications between people, between people and things, and between things
Source: Ref. [39].		

Table 2. Differences between classical knowledge processes and the IoT knowledge processes.

The emergence of the Web 2.0 has had a significant impact on the development of the third stage of KM. During the period after 2005, with the development of social media, web portals were integrated [7]. Knowledge thus became available outside the organization and management, which is one of the critical factors of business success [46]. Von Krogh [45] proposed the theory that the Web 2.0 applications are not necessarily included in the context of KM, but simply a means of enabling access to knowledge. By integrating information and communication technology (ICT) into products, the von Krogh theory is a basis for the understanding of next third phase of knowledge management development. The IoT has influenced the development of new knowledge management generation (**Figure 1**) that is arising from the phase of integration between people and people with documents and passes to the phase of connection between devices. KM processes are also located between the consumer and the manufacturer or service provider.

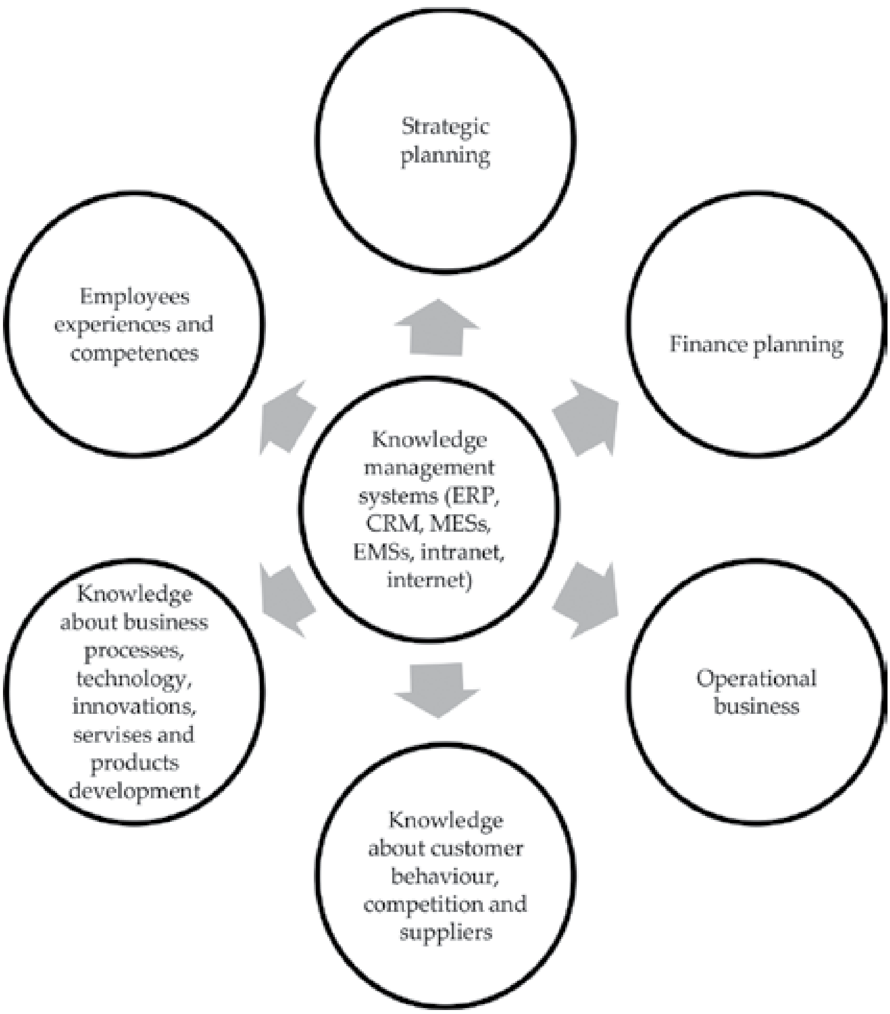

Figure 1. Implementation of the knowledge management system in small and medium company. Source: Authors.

Industry 4.0 is based on mobile computing, cloud computing, and big data. The importance of cloud computing and mobile computing for Industry 4.0 lies in the provision of services, which can be accessed globally via the Internet. Services can easily be integrated and used [2].

For the establishment of the IoT and the course of the processes of knowledge management, companies set up a circuit between product and service: (i) radio frequency identification (RFID); (ii) wireless sensor networks (WSN); (iii) middleware, (iv) cloud computing, and (v) IoT application software [37]. This system can operate both with the help of people and artificial intelligence. The data collected with the help of these systems is saved in clouds. Products integrated with cloud computing in the field can provide data that enable a predictive maintenance, and to provide information about optimization possibilities in production. The use of integrated networking and integration of products into Internet data will allow for far reaching possibilities to collect data [47]. Instead of single data points or short intervals, a continuous stream of data is now available. The huge amounts of data available can now be used to continuously analyze and optimize production. This enables fostering of predictive analytics [48]. Such system is based on big data analytics, which enables, for example, the informing of vehicles that are driven in a column, the distances between them, events on the road in front of them, weather conditions, etc. The drivers of vehicles—thus not only based on geostationary information—know the route, but with the help of sensors and connectivity between vehicles, receive notice of current dangers on the road [37, 15].

3.2.1. Processes of knowledge management in organizations

Organization must develop an organizational culture to the level of employee awareness that knowledge sharing is presenting a fundamental concept for the firm, which enables further growth of the organization. The process includes the identification of the knowledge, sharing knowledge, knowledge acquisition, collection, and storage of knowledge and refresher [49].

Grower and Davenport [50] consider that the processes of KM are located between the information and the source of income of the firm (services rendered or products sold). The process is based on three sub processes: acquisition of knowledge, a definition (record) of knowledge, and the transfer of knowledge and realization. The general concept model of the process stems from the fact that by coordinating, coordinated and introduced operational processes occur. Together, these processes form the system of KM as important operational processes so representing [26]:

- Need for skills: determine which skills the organization needs. This process also includes the sharing of the existing knowledge, because the purpose is to figure out which is the already known knowledge that could be helpful for the organization;
- Acquisition and knowledge creation: new knowledge is often generated also by combining existing knowledge of the transfer;
- Documenting and storing knowledge: the results of the newly acquired knowledge that is documented and retained.

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3.2.2. Organizational knowledge sources and their value

Knowledge has become a force, a power, which is providing to the organization a competitive advantage. In doing so, the organization shall establish all levers (for example, the establishment of corporate culture) that enable it to exploit and use internal organizational knowledge in daily operations [51, 30]. Knowledge, which is used in business processes, is called organizational knowledge [30]. Organizational knowledge can be found in databases, business papers, archive organization, and minds of individuals. Knowledge is in newly emerging companies typically fragmented, and it can be found in chunks throughout the organization. When an organization moves the initial period of operation and begins to grow, to make all these fragmented pieces integrated into the system KM the purpose of which is to collect, organize, and process the knowledge into a usable form, applicable to all employees (for example, in this end, the organization set up an intranet, ERP systems, CRM systems, etc.) [14].

An advantage of using the KM system is that it allows the conversion of intangible assets into useful business resources. In practice, for example, it shows in the event that the organization develops a commercial solution (technology, processes, designs presentations, etc.). In addition, hereinafter referred to license to offer in the form of advisory services (in the case of a consulting company) or in the form of licenses and franchises. An organization that purchases a license can use the existing knowledge to solve similar problems and create sources of revenue for the license vendor.

Organizations often include a KM system into the marketing strategy, especially when they want to reach out to their customer, and they are entrusted with the execution of a specific project (for example, the establishment of CRM and other software solutions to customer needs) by an external service provider. Through the system of KM as subscriber's they see what employees know about the project, which will be implemented, and what solutions have already been developed in the past.

In fact, KM as system has to ensure a more accurate communication between employees and thereby accelerate the settlement procedures and search, and providing solutions, which gives employees the ability to make better decisions [42]. It is necessary to understand that all of the obsolete knowledge that can be found inside or inside the organization is in various forms, which have to be physically moved into the KM system.

Organizational knowledge is being created on the basis of resources [9, 52]:

1. Explicit knowledge: official documents, procedural instructions, and patent;
2. Tacit knowledge: unstructured knowledge, usually personal knowledge, based on the experience of an individual;
3. Strategic knowledge: the knowledge to which access is restricted (marketing strategy, financial analysis, business contracts, software code, etc.).

The system KM is formed on the basis of the organizational structure and the company's own needs. All databases connected into a whole have represented the KM as system (**Figure 1**).

4. Conclusions

The chapter represents an important theoretical contribution to the understanding of the influence of the IoT to value added in knowledge-intensive organizations. Managers should be aware that innovative information and communication technologies are influencing the business performance in the twenty-first century.

The trend of KM 4.0 is leading toward the establishment of a communication channel for the continuous exchange of information, in most cases between machines themselves. The purpose of such automation is the individual customer-oriented adaptation of products and services that will increase value added for organizations and customers [14, 53]. Therefore, the IoT technology enables the creation of completely new products, services, and business models, which promise gains in virtually all industries [54, 55].

The findings are based on the literature review. A particular limitation of the text is that no research was made. Further researches should be focused on the effect of this direction of technology on the ecosystem. Deeper investigation of this topic could include case study with elements of implementation, testing business benefits, and social and environmental benefits with real data.

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Chapter 10

Knowledge Management Trends in Biotechnology in Brazil

Maria de Fátima Ebole Santana

Additional information is available at the end of the chapter

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Abstract

This chapter presents a study on knowledge management and innovation in biotechnology area through analysis of scientific and technological advances of biotechnology trends in Brazil, providing an overview of the science profile as well as regional development and its relation to issues on topics based on the analysis of scientific publications for the last 20 years. Given these promising prospects, the monitoring and searching of scientific advances and trends in this area of knowledge have become essential for searching opportunities in research and development and also for potential innovations and business opportunities, both in the developed countries as well as in countries of emerging economies such as Brazil. The research was realized using database Web of Science with 60 terms selected in Biotechnology area and 73,125 documents have been organized. Scientific indicators were produced using data/text mining tools. A greater number of scientific publications were found in areas such as biochemistry and molecular biology; genetics and heredity showing a greater frequency in these terms: vaccine, PCR, and genome. Results pointed out the US as the main foreign partner-country of scientific publications followed by the UK, France, and Germany. It was possible to verify cooperation network with others Latin American countries.

Keywords: knowledge management, innovation, scientific trends, biotechnology, Brazil

1. Introduction

Technological advancement has been the dominant driving force in modern society leading to a widespread diffusion of products from the rational activity as well as of scientific, technological, and administrative sources, which in turn requires new types of management [1].

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This technological progress has induced a new paradigm based on the development of a set of intensive knowledge on scientific technologies, which represent many applications of scientific discoveries, whose core is to develop an increasing competence to manage information and knowledge. In this contemporary setting, the intangibles assets such as knowledge (know how), patents, and intellectual capital become increasing value strategic elements to be the center of contemporary forms of capital accumulation [2].

Biotechnology as a highly scientific sector is one of the most knowledge-intensive activities in the contemporary economy, having a direct and indirect impact on regional and national economies. The phenomenon of growth in the production of biotechnological products is relatively new, and in the long term, the growth potential is probably associated with the greater diffusion and use of your products and processes due to its convergence with nanotechnologies, information technologies, and other applied sciences [3].

In this context, biotechnology is considered as one of the most important technological tools nowadays. It is considered a key "future-bearing technology" and its applications have contributed to the structuring of new economic and social systems [4]. In this sense, biotechnology appears to have the characteristics of a core technology, with the potential to underpin a new technoeconomic paradigm.

Biotechnology represents a set of technologies "that use biological systems, living organisms, or their derivatives to produce or modify products and processes for a specific use" [5]. Biotechnology features a multidimensional nature, involving different knowledges, scientific and technological. Indeed, biotechnology can be considered as the result of a scientific revolution that involves many disciplines. In other words, it is a "constellation of scientific revolutions" [6], which is based on different areas of knowledge such as molecular biology, biochemistry, computer science, biophysics, engineering, and others.

The large set of biotechnological methods along with its different forms of application results in different interpretations about the dimensions that compose the biotechnology [7]. It has helped to generate new high-impact services in various segments such as health area with impressive revolution in the treatment of diseases as well as the use of new drugs for humans. It is also possible to verify its impact on agriculture with the development of functional foods and the reproduction of plant species; in the chemical and petrochemical industries with treatments of wastes and wastewaters; and the sustainable use of biodiversity, among other areas [2].

When assessing the potential application of modern biotechnology for the next 20 years, some authors assert that areas such as genomics, proteomics (spatial identification of protein structures), biomaterials, bioengineering, pharmacogenomics, genetic engineering, genetically modified foods, and synthetic biology will have a great impact on the future [2, 8].

In view of these future prospects, the monitoring and research of scientific advances and trends in this area of knowledge have become essential for searching opportunities in research and development (R&D), as well as for potential innovations and business opportunities, in the developed countries and mainly in countries of emerging economies such as Brazil [2]. Countries with rich biodiversity, mainly South American countries such as Brazil and Colombia, have tried to develop national capacities in science and technology (through

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improving their infrastructure, greater participation in network experts, training of human resources, the increase publications) that allows a better optimization of scientific resources and economics and the generation of technological products based on nationally developed biotechnology [2, 9].

In this situational scenario, in order to propose worldwide profile of knowledge management of trends in biotechnology in Brazil, this chapter presents science trends in this area, mapped out through a set of variables such as the identification of the actors involved as well as the institutional partnerships, the major journals, among others, using the analysis of all Brazilian scientific publications of international dissemination for the period of 1995–2014.

2. Biotechnology in the global market and Brazilian government programs

2.1. Biotechnology in the global market

For centuries, humans have used biotechnology in their daily lives. Biotechnology presents as the growth area and development products and technologies observed in different areas of economy, which use live microorganisms or parts of them [10], showing up as a promising area among the diverse emerging technological developments. Being a multidisciplinary area presents the possibility of new products and processes. The bioindustry has contributed to the economic and social growth by bringing new solutions to problems concerning to human and animal health, to agribusiness, the environment, and the creation of new materials. In these aspects, biotechnology is a technological innovation that also provides products or processes with social or commercial use [11].

As technological progress advances based on life sciences, the possibilities of obtaining products with higher added value or lower production costs increase. The most prospected areas of biotechnology are health (pharmaceutical) and agriculture (food) [2]. On the economic bias, biotechnology is a major focus of activities on research, development, and innovation in the developed countries and it is becoming increasingly central in developing countries due to the potential of exploiting great biodiversity [12].

For a long time, it has been emphasized about the biotechnology potential and the future full of innovations that it provides. However, today, we can observe that the largest potential innovators are in the United States and Europe (the United Kingdom, Germany, and France). Due to their investments in the chemical and pharmaceutical corporations they become owner of biotechnology companies, enlarge their capabilities of innovation, or maximized new products generation [13].

The biotechnology industry has been grown rapidly in recent years, more than doubled its worldwide revenue in the last decade, going from US$ 8 billion in 1993 to US$ 20 billion in 1999 [14]. According to the study presented in Ref. [15], the worldwide market for biotechnology resources moves expressive values of about $ 410 billion per year. The worldwide market for biotechnology between 2002 and 2006 grew at a compound annual growth rate (CAGR) of 13.4% [16]. Figures in this market are not very consistent. According to the study presented in Ref. [17], the United States alone moved the biotechnology industry resources of US$ 3.7 billion in 2009, being the market that moves much capital in this biotechnology market.

Regarding innovative effort, we can affirm that the United States is the country that spent more on R&D in biotechnology. In 2009, it spent only in entrepreneurial sector, US$ 22 billion on R&D, followed by France, Germany, and Canada, with the total expense on R&D about US$ 2.5, 1.3, and 1 billion, respectively [18].

In Asia and Pacific, among the countries that are more prominent, Japan is the most advanced in the biotechnology area, due mainly to the cooperation work developed by Japanese government, universities and private sector, directed especially to build an adequate infrastructure for innovative business *start-ups* [18]. After that the focus turns on Singapore, Taiwan, China, India, and Australia. The Chinese government, for example, invested about US$ 40 billion in the biotechnology industry in 2012 and, the Singapore government hopes to increase 20% biotechnology investments in the next 5 years, that is, it is intended to spend about US$ 12.5 billion in R&D in this sector [18].

2.2. Biotechnology in Brazilian government programs

The biotechnology segment holds a special place among the priorities at government policies, as much for the developed country and as for developing countries. The wide set of opportunities created by biotechnology, especially in health and agriculture areas, show the essentiality of its development as competitive strategy and expansion input in international market, mainly in developing countries such as Brazil. Brazil is a country with great potential for the development of agricultural biotechnology because it has a wide biological diversity and is rich in plants, animals, and microorganisms [19]. Since the 1970s, the biotechnology applied in agriculture has been productive and economic relevance in the country.

This chapter focuses on the characteristics and development of biotechnology in Brazil and refers to the public investment, with the main aspects of the most noteworthy programs and financing structure. There is a governmental structure in the country directed for the development of the area. This structure is composed of the following ministries: the Ministry of Science, Technology and Innovation (MST&I); Environment and Agriculture; Production and Trade; and Health and Social Development. At the same time, the government also acts through its government agencies, the private sector, and academia [2].

The government policies to support the development and financing on biotechnology in Brazil have started since 1980 with the promotion of several programs dedicated to the area, the Integrated Genetic Program, which aimed at introducing some specific actions on genetic engineering. In 1981, the government officially unveiled the National Program for Biotechnology (Pronab) which was to consolidate public investments for maintenance of the research groups in areas related to the program.

In 1984, the Ministry of Science and Technology (MST) had created a wide program in order to support, finance, and develop strategic areas in the country. This program was the development support to Scientific and Technological Program (PADCT), cofinanced by International Bank for Reconstruction and Development (BIRD). Since its beginning, biotechnology has been seen as a strategic area for the scientific development in the country and, thus, established a specific subprogram to support it, the Biotechnology Subprogram (SBIO). PADCT started in 1985 and its actions were continued until the 2000s. At first, PADCT prioritized the development of some activities such as molecular biology, genetic engineering, and biosafety, without forgetting areas such as biochemistry, microbiology, and agronomy.

From the wide vision, PADCT aimed to build physical structures for research centers and development projects in cooperation in order to attract private investment, promote dissemination, and technology transfer from academic centers to the production sector. During this period, the first biotech products emerged that were human insulin, biodegradable plastics, biofilm, genetically modified plants, among others.

Early in the 1990s, both the government and the private sector have reduced the resources applied to biotechnology due to low commercial return of biotech products developed so far.

In 1999, the government changed the pathway of financing in Brazil through the creation of sources of fiscal financing from various economic sectors, called sectoral funds. In 2001, the biotechnology sector fund was created and its main objective was to ensure the continuity of biotechnology research, especially those considered as strategic for the country. Somehow, the creation of Biotech fund strengthens the National Program of Biotechnology and Genetic, established in 2000 and under MST&I responsibility. The program emphasized actions to "conservation genetic resources and development of biotechnological products and processes with applications in industries, agriculture, and human health". Several of these opportunities have been adopted as strategy of the project management in networking way in order to increase the flow of innovation and the results to society.

Among the many action plans applied from 2002, it is worth mentioning the following: Brazilian Genome Project, Structural Biology Network, Brazilian Proteomics Network, the development of biopharmaceuticals and immunobiology, and the development of new technological routes.

In 2004, the government using the Brazil's Industrial, Technological and Foreign Trade Policy (PITCE) pointed out biotechnology as the "future-bearing technology." On that political occasion, the Biotechnology Competitiveness Forum had created in order to put together all actors involved in the production chain in favor of strengthening industrial competitiveness.

Biotechnology research is funded by federal, private, and international agencies. The Organic Law of Science, Technology and Innovation (Decree No. 10.973 of 2/12/2004) defines some coordination organizations on the national level, and the Ministry for Science, Technology and Innovation (MST&I) represents the leading national organization [2].

From Biotechnology Competitiveness Forum, in 2007, begun the Biotechnology Development Policy (PDB), which established the National Biotechnology Committee (CNB). On the whole policy, structuring actions were defined in order to promote transfer of technology, investments, training of human resources, strengthen networks, regulatory framework, and to improve infrastructure for research centers and R&D. Examples of priority areas supported were: plant and animal breeding, food technology, bioinformatics and immunology, diagnosis and prospecting on biotechnology, and detection of genetically modified organisms.

3. Methodology and recovery documents

3.1. Database

The research was based on the selection of scientific publications collected in ISI/Web of Knowledge^{SM} database. It is international bibliographic data and is used as reference for the generation of indicators of S&T and Innovation [2].

3.2. Strategies for recovery documents

The strategy for the recovery of publications on a particular scientific topic must be carried out carefully to avoid damaging in the analysis of scientific literature. For the analysis of results in an accurate overview of the subject, ideally, the "search expression" must promote the recovery of all relevant publications on the subject present in the database, and at the same time, exclude nonrelevant publications. However, such situation is difficult to achieve since the multidisciplinary issues receive contributions from several areas of knowledge.

The solution for recovery of significant and coherent set of publications that allows an analysis of the scientific production in the biotechnology area was the elaboration of a complex search expression, consisting a large of set selected and tested keywords.

At first, we tried to develop search strategies in the mode "ISI-general search," using keywords from the available literature and descriptors present on the *Platform-Lattes*/National Council for Scientific and Technological Development (CNPq) - Brazil and *Portal Innovation*/MSCT-Brazil related to research groups and ongoing research in the biotechnology area. These search expressions were just an exploratory character, that is, serve as a basis for elaborate more refined expressions and evaluate how the area is organized into database [20]. A selection from bibliographic references was also used.

In order to achieve the purpose of mining scientific production on biotechnology in Brazil over a period of 21 years (1995–2015), 60 distinct descriptors (**Table 1**) were used, selected by experts in biotechnology area, interviewed and research groups in the biotechnology area sought in the base *Plataforma Lattes CNPq/Brazil* and *Portal Innovation*/MSCT-Brazil.

From our previous experiences, we found that the best way to do this recovery would be a combination of different expressions. For this, we used the advanced search mode of ISI/Web of Science and the advanced search. Once defined the strategy, we used all these keywords, and various search expression and their combinations in the database ISI/Web of Science only looking for indexed publication using document types "article." The fields "Title, Summary, and Keyword" were used to analyze the themes of scientific publications with international dissemination [21].

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Antisense	Biomaterial	Proteins engineering	GMO
Recombinant antigen	Biopolymer	Genetic engineering	Protein
Biodiversity	Bioprocess	Metabolic engineering	Recombinant protein
Biocatalyst	Bioprospection	Molecular engineering	Proteome
Biofuel	Bioreactor	Gene expression	Proteomic
Bioeconomy	Bioremediation	Pharmacogenomics	PCR
Bioengineering	Biosensor	Phytoremediation	RNA
Bioethics	Biosorption	Gene	Microarray DNA
Biofiltration	Biosurfactant	Genetic	Microarray RNA
Bioindustry	Biosulfurization	Genome	Transcriptome
Bioinformatics	Biotechnology	Genomic	Transgenic
Biolixiviation	Stem cells	Microbiota	Cellular therapy
Computational biology	Cloning	Biology modeling	Gene therapy
Biome	T cells	Nanobiotechnology	Molecular therapy
Biomass	DNA	Peptide	Vaccine

Table 1. Biotechnology-related terms used to search articles in database ISI/Web of Science.

The software VantagePoint® was used to perform the processing of information from articles retrieved in order to expand and enrich the results. VantagePoint® allows management of big data and information in order to present correlations of distinct variables of interest. It also allows us to identify Who, What, When, and Where, help us clarify relationships and find critical patterns, among other possibilities [2].

For visualization of the data, we used the software VOSviewer®. It is a latest free software for the representation and analysis of information, which appears as an alternative to the traditional techniques of multidimensional representation and network display. VOSviewer combines the visualization and clustering techniques, favoring analysis while bypassing unnecessary technical complications. It make possible to view the maps of collaboration between institutions, countries, and keywords [22].

After this step, macroindicators were generated for providing a global overview of the scientific production on biotechnology in Brazil and raising the main issues as follows: (1) the total number of articles published per year (1995/2015) and the trend of publication of the most frequently used terms; (2) major journals that institutions often publish their articles in this specific area; (3) key areas of knowledge and the number of articles published on the used terms; and (4) the number of papers published by institutions and maps of network (institutions and countries) for the purpose of identifying partnership [2].

The trends for biotechnology were mapped out through a set of variables such as the identification of the actors involved as well as the institutional partnerships and networking.

4. Overview of the global scientific development in biotechnology in Brazil

4.1. Analysis of results and cowords networks

Government policies to incentive and promote R&D activities in biotechnology in Brazil have started since the 1980s. However, from the late 1990s and the early 2000s, especially in 2001, with the creation of the national fund for biotechnology, the area aimed at real conditions of productivity and competitiveness in R&D. Biotechnology has its amended financing path taking up considerable resources of 97% between 2002 and 2003, with the resources allocation from the National Fund for Scientific and Technological/FNDCT, managed by the MSCT, CNPq, and Studies and Projects Financing Institution (FINEP) [23].

From the data collected in the ISI database, bibliometric indicators have been produced that will help us to understand the scientific activity in the biotechnology area.

With regard to the scientific literature on biotechnology for the period between 1995 and 2015, it was retrieved 102,326 documents containing terms selected by experts in the fields of title, abstract, and keywords, and 69,977 documents where Brazil as the home country (1st author). **Figure 1** shows the evolution of publication number in biotechnology area since 1995.

By analysis, the number of articles published throughout this period was possible to observe that there is an increase in publication trends, which indicates an intensive scientific activity over the past 15 years, mainly in the last 8 years. An exponential growth with increased production greater than 6500% was observed, as shown in **Figure 1**. However, this scenario

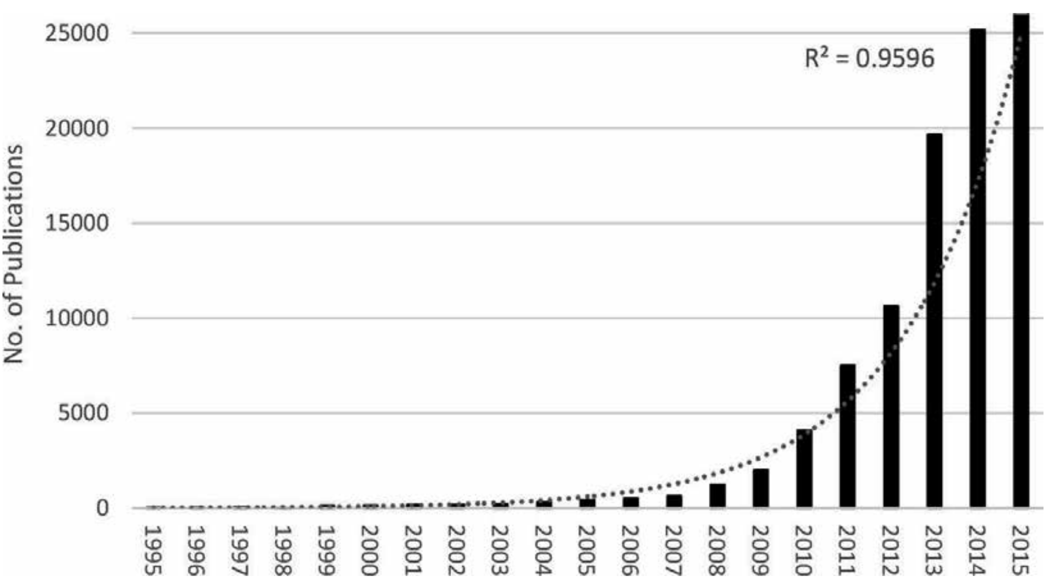

Figure 1. Historical evolution of biotechnology scientific publishing indexed in Brazil since 1995.

of accelerated growth should be modified in the coming years because of the reduction of R&D investments by government agencies in recent two years (2014–2016); due to the severe economic crisis that Brazil has been facing since 2013, which will reflect in a slowdown of the scientific production in the country for the next years.

A probable cause of this growth seems to be the key role that the activities of biotechnology have gained notoriety on a worldwide scale in recent decades. In Brazil, this increase observed reflects the research government incentives, established the financial investments in the area and the implementation of government policies, as aforementioned.

With respect to the most frequently used terms to screen the biotechnology area in Brazil, it was possible to find a large dispersion in relation to them [2], which means that there are more than 7000 distinct descriptors (keywords) described by the authors in the scientific publications as examples: Vaccine, PCR, DNA, Genome, Leishmania, *Trypanosoma cruzi*, HIV, among others. Some of them were not used as initial descriptors when searching the database.

In the specific evaluation of these terms, we noted that terms such as DNA and PCR are often used since the beginning of the period analyzed, which means that since 1998, these are being associated with modern biotechnology techniques [2]. Other terms such as "genomic," (72 articles) "proteomics," (32 articles), and "stem cell" (37 articles) are further frequent, however, they are related to more advanced future-bearing technologies of modern biotechnology, being mentioned in Brazil by the National Biotechnology Committee as the frontier areas of biotechnology. This observed result is associated with the Brazil collaboration in the genome projects, as example the mapping of the *Xylella fastidiosa* genome in 1997, and later, working in international project such as Human Genome Project (HGP) in 1999. *X. fastidiosa* is a bacterium that attacks citrus agriculture producing "little yellow" and decreasing agricultural productivity, so this project was essential for the control of this pest in Brazilian farming. This project was much important because it was the first phytopathogen sequenced in the world.

According to Santana et al. [2] and Pisano [6], some areas of biotechnology will have a significant impact in the near future on the development of new technologies and its applications, which are the genomics, pharmacogenomics, transcriptomics, biomaterials, bioengineering, and synthetic biology. Some themes related to these terms were detected in this dataset. **Table 2** presents the terms mentioned by the authors (keywords' author) with more than 50 citations related to the field of biotechnology.

From the total of scientific publications found, it can be observed the terms like *Leishmania*, *T. cruzi*, *Schistosoma mansoni*, and Chagas disease, which refer to a potential application. It should be emphasized that the data collected point out that scientific research on biotechnology in Brazil is directly related to the study of some relevant social problems of a country mainly related to tropical diseases.

Neglected tropical disease (NTD) has become an extremely important issue in public health in Brazil, as they profoundly affect the quality of life and generate negative socioeconomic impacts for the population of the poorest countries. Although not unique to developing countries, they arouse little financial appeal from the large pharmaceutical industry, since they do not reach the large consumer market that is the developed countries. In Brazil, the

Articles	Top terms (keywords)	Articles	Top terms (keywords)	Articles	Top terms (keywords)
380	Vaccines	99	Cell	71	Molecular marker
324	PCR	83	Diagnosis	69	gene
232	DNA	82	Expressed gene	65	HIV
183	Genetic	85	Genotype	64	Microsatellite
134	Brazil	79	*Trypanosoma cruzi*	66	Chromosome
120	Genome	78	Oxidative stress	61	Apoptosis
115	Polymorphic	75	Cytokine	63	Bovine diseases
131	Leishmania	72	Genomics	57	Cancer
56	*Schistosoma mansoni*	56	Inflammation	54	Fish
54	Chagas disease	53	Epidemiology	50	Drugs

Table 2. Terms with more than 50 citations used by authors in the fields title, abstract and keywords in the articles published by Brazil.

Ministries of Health, Science and Technology and the Health Surveillance Secretariat defined seven neglected tropical diseases based on epidemiological criteria, disease impact, and demographic data. They are dengue, Chagas disease, leishmaniasis, malaria, schistosomiasis, leprosy, and tuberculosis [24].

Figure 2 presents a network map where the main lines of research stand out. This map representation was obtained using VOSviewer®, taking as the matrix of cooccurrence of the 7000 keywords' and authors standardized by the measure of strength of association [21].

Although the keywords, which represent the domain of cells and genome, show a highly interrelated distribution, the structure can be clearly seen. Analysis of the relations among the most frequent descriptors reveals four well-defined groups, but with a variable degree of dispersion. In the upper part (1), around the nodes infection and vaccine, we find the most compact group of the network. It includes descriptors that represent documents in the areas of immunology, infectious diseases, and tropical medicine, related fundamentally with the application and clinical research into tropical diseases.

This scenario is compounded by the lack of innovation in drug R&D programs in the area of NTD; thus, the situation requires a concentrated global for the creation and maintenance of R&D programs focused on the discovery of new alternative therapies for the control and treatment of these diseases [25, 26]. Modern biotechnological tools (e.g., genomics, functional genomics, proteomics, metabolomics, and cytometry) have provided valuable insights for the discovery and development of new drugs that are extremely useful in coping with these NTDs. Extremely important initiatives are being successfully implemented to include Brazil in an increasingly significant science and technology scenario. According to Guido et al. [25, 26], three examples are presented to illustrate the breadth and diversity of networks and partnerships that have provided great opportunities and challenges in the area of NTD.

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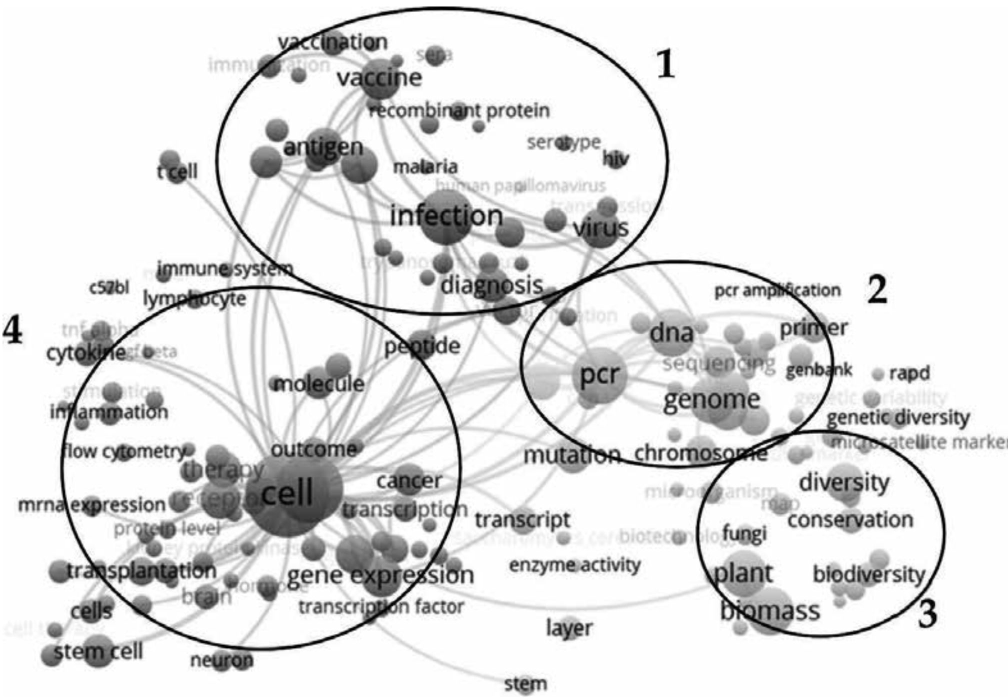

Figure 2. Map of keywords based on a co-occurrence network on biotechnology in Brazil. *Source*: Map presentation software VOSviewer®.

To the right, cluster 2, the keywords genome, PCR, and DNA connect with a well-defined cluster of descriptors related to genetics, and molecular biology research related fundamentally with the application and clinical research into the genome of *X. fastidiosa* begun in the 1990s.

Genomics is also closely related to agriculture not only in genetic improvement of species such as transgenic crops (with resistance to pests and tolerance to pesticides), but also in the product quality changes (plants that produce hormone, eucalyptus with higher production cellulose). More recently, Brazil has been developing research on feasibility of plants, animals, and microorganisms as biofactories of molecules of agricultural, pharmaceutical and industrial interest; identification and applications of genes and biological functions that promote tolerance to abiotic and biotic stresses and elimination of contaminants in food; identification and characterization (structural and functional) of new molecules to increase the production capacity of biologically based products with low environmental impact; and identification and applications of genes and biological functions that promote tolerance to abiotic and biotic stresses and elimination of contaminants in food [27].

Meanwhile, the terms of biomass, diversity, and conversation compose the third cluster 3, far right, including areas of biotechnology and biodiversity. To the left, cluster 4, we have the keywords (cell, gene expression, and stem cell) associated with molecular biology and cell biology areas related to the processes of modern biotechnology associated with a medicine, oncology, and neuroscience therapies.

The information obtained through keywords analysis is much more comprehensive and precise. For this reason, even though the two largely coincide or overlap, subject categories (see **Figure 3**) are more general or superficial than the information based on keywords (**Figure 2**). The latter shows, with a greater level of desegregation, the distribution of the descriptors that specifically configure each thematic profile, plus the less productive or incipient research that would otherwise remain hidden [28].

4.2. Profile of the scientific sector: biotechnology

By its intrinsic multidisciplinary characteristics, biotechnology permeates many areas of knowledge. Therefore, when analyzing the frequency of publication of scientific areas, there is a predominance of biochemistry and molecular Biology (12.4%), followed by genetics and heredity (10.94%), immunology (8.66%), microbiology (7.57%), and veterinary science (6.22%) together representing 45.79% of total articles published. However, this study highlights the wide dispersion of scientific publications by all thematic areas. **Figure 3** demonstrates the percentage distribution for all the 20 areas with the number of articles greater than 200 indexed in ISI/Web of Science.

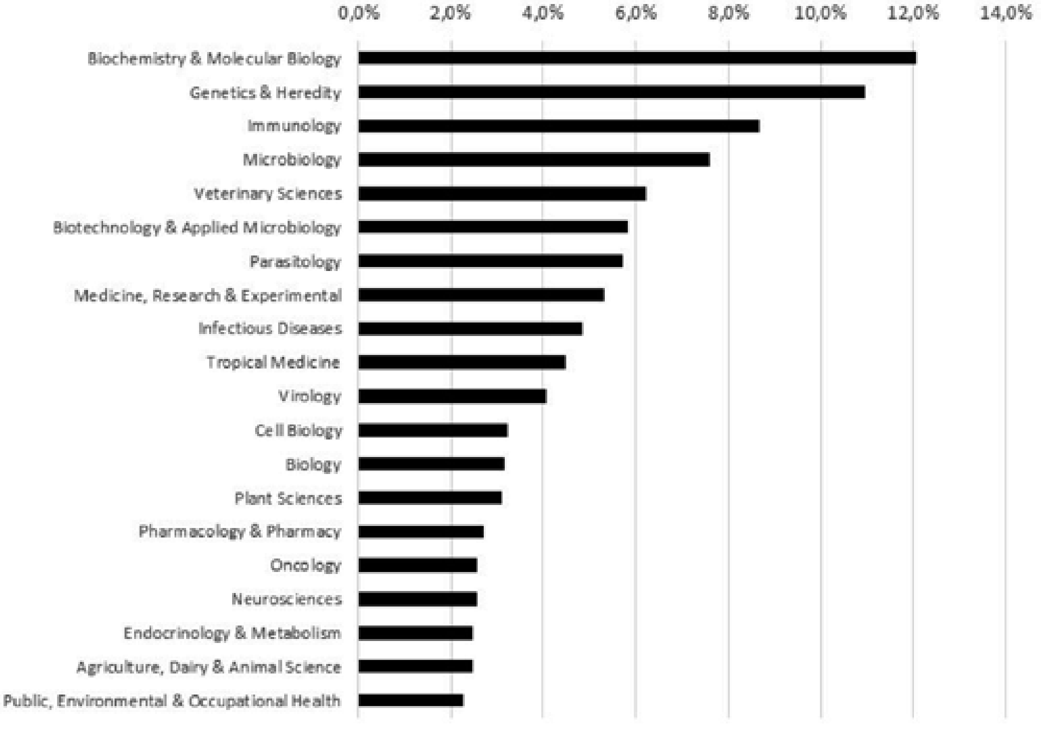

Figure 3. Percentage distribution of scientific publications on biotechnology by areas of knowledge indexed on database. Period 1995–2015.

It can be observed that most of the articles found are in the areas like life sciences and health, highlighting specific areas such as molecular biology, genetics, immunology, and microbiology. The predominance of these areas was already expected due to the characteristics of biotechnology, but it is interesting to note that areas such as molecular biology and genetics have a significant interest toward other traditional areas such as chemical and pharmaceutical industries.

Note, also, that a considerable number of articles are classified as multidisciplinary, confirming that research in biotechnology, as mentioned previously, brings together researchers from different areas of knowledge. This, probably, highlights the increasingly important role of biotechnological techniques for the development of new products.

Of the 73,125 articles published in internationally indexed journals it was possible to realize a trend of publication in two main areas: health and life science. It is worth mentioning that both thematic areas coincide with the prevailing keywords previously identified. Besides this fact, an interesting aspect observes the concerns of the regional coverage of the top 20 journals, which means that the majority of Brazilians scientific articles are submitted in Brazilian journals (60%), or particularly in indexed American journals (30%). This indicator illustrates the little dynamics of international cooperation of Brazilian research groups. Among the indexed journals, the Vaccine journal has the highest number of articles (12.65%), followed by other journals such as Memórias Instituto Oswaldo Cruz (10.98%), and genetics and molecular biology (10.58%).

Figure 4 presents the top 20 journals with a number of scientific publications greater than 40 articles. The list of journals is in accordance with classification presented in **Figure 3**.

An interesting fact observed is the leadership position of Vaccine Journal, which justly gives priority, an analysis of information and knowledge about human vaccines (infectious diseases and noninfectious diseases) and veterinary vaccines, molecular biology, immunology, production and manufacturing, regulatory, and legislation aspects. It is followed by others publications in areas such as microbiology, biology, genetics, life sciences, and others.

Considering the authors′ affiliation, it is observed that there are 441 institutions, showing a high dispersion among the authors′ institutions in Brazil. It is important to highlight the significant number of articles produced by institutions such as the University of São Paulo (USP) representing 32.71%, followed by the Oswaldo Cruz Foundation (FIOCRUZ) with 8.92%, and the Federal University of Rio Grande do Sul (UFRGS) with 7.58% articles, respectively. Another significant topic to be observed is the prevalence of public governmental institutions such as research centers or universities, evidencing a concentration of activities in biotechnology by public institutions or nonprofits corporations at research levels. It is also worth mentioning a few numbers of scientific publications indexed by the Brazilian biotechnology companies in the research period, less than 1%, which indicates a small number of companies working in that area or that they are still consolidating their capacities, according Santana et al. [2]. It is should be highlighted the public institution Brazilian Agricultural Research Corporation (EMBRAPA) Genetic Resources with the 8th institution in the ranking, which is the public company with

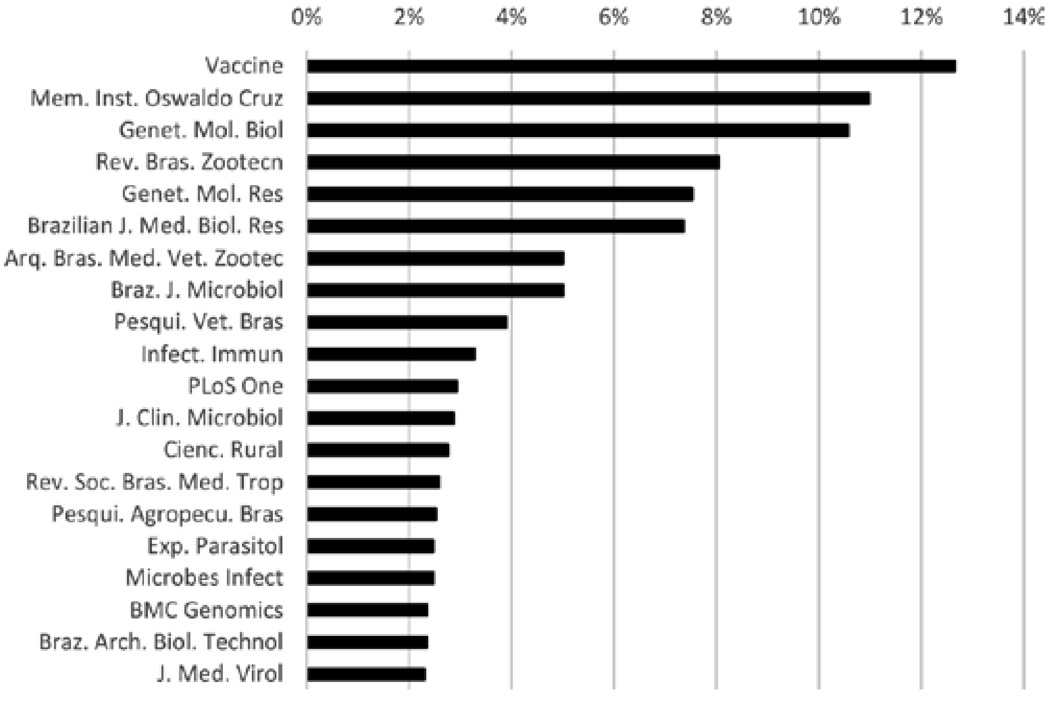

Figure 4. Main internationally indexed journals with biotechnology-related articles.

leadership in transgenic research in the agricultural area in the country. **Figure 5** shows the top 20 institutions that have published more than 100 articles in the observed period.

The research results present that the most of institutions are located in South/Southeast regions, which are more developed regions of the country. There is little representation of institutions in the Center-West/ Northwest regions, presented only for 4 universities: University of Brasília, Federal University of Pernambuco, University of Goiás and Federal University of Ceará.

In addition, there is the significant presence of the public universities of São Paulo (USP, UNESP, and UNICAMP), which together account for a significant share of national scientific output in the biotechnology area, that is, 46.31% of published articles in journals are from USP. This observed result was expected because since the beginning of projects development in the biotechnology area (*X. fastidiosa* genome and HGP/Brazil), there was an intensive participation of research groups of these universities. Furthermore, we can mention the continuous financial support from FAPESP foundation for the development of projects in the areas such biotechnology and bioprospection.

4.3. Maps of knowledge and network collaboration

According to Santana et al. [2], regarding the analysis of relationships between composing agents of the National Organizational System of S,T&I, many authors refer to the central idea

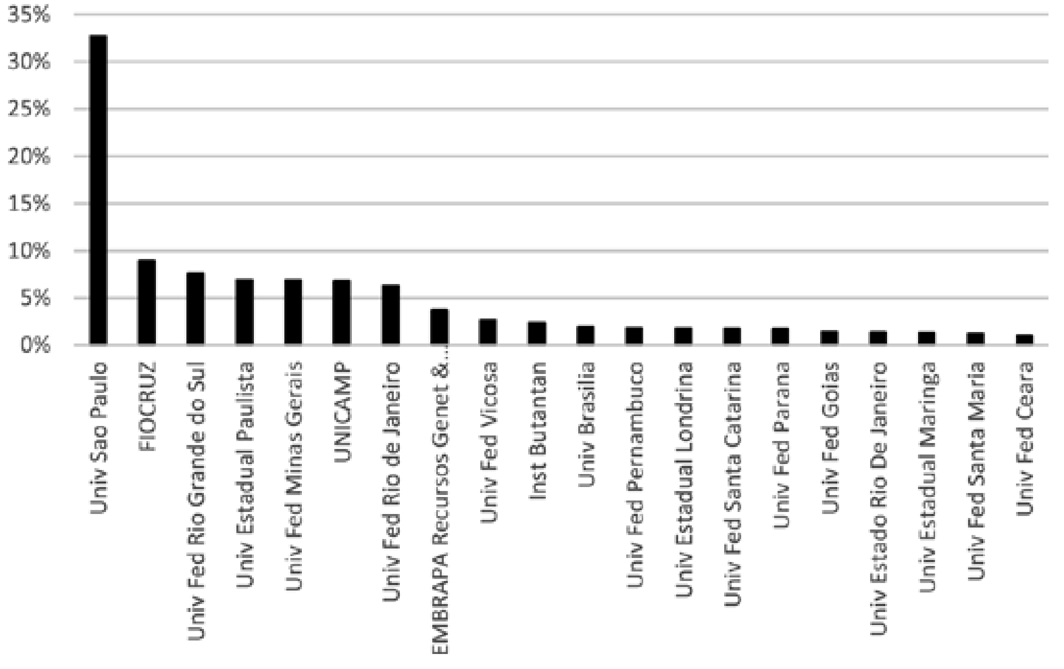

Figure 5. Leading Brazilian institutions with major publications in biotechnology for the period 1995–2015.

of networking and the valuable interactions between system components and its main actors in order to promote the dissemination and use of new scientific knowledge [29].

In accordance with these premises, we sought to analyze the links established between the organizations by observing how these actors relate to each other using the number of publications of scientific cooperation between institutions and countries; on a macro level, the international relationships developed by these institutions for R&D. The best representation of these collaborations is the visualization of maps of knowledge, where the existence or not of correlations and the degree of its intensity are clear, which provide to decision-makers some strategic subsidies in future planning of national activities of ST&I [2].

Considering the network map of articles′ authorship in Brazil, for the biotechnology area, it is possible to verify an intensive cooperation between diverse institutions, especially among Brazilian institutions, showing that 66.9% of articles are written with internal collaboration, which subsidize the relevance to develop endogenous capacity of Brazilian groups and publish papers with little support from international cooperation [2].

It is possible to note groups with strong collaboration such as the University of São Paulo (USP), Federal University of Rio de Janeiro (UFRJ), the University of Campinas (UNICAMP), and Oswaldo Cruz Foundation (FIOCRUZ). These collaborations between Brazilian institutions demonstrate that relationship is based more heavily on the model of interaction between universities, research centers, and nongovernmental research centers and of little interaction with companies. It should be emphasized that this scenario will modify since the implementation of the Organic Law of Science, Technology and Innovation in January 2016, where the private sector was encouraged to invest more in partnerships with public institutions and/or in internal activities of ST&I, aiming to promote alliances between the private sector with scientific research center and universities [2, 29]. **Figure 6** shows the collaboration network among institutions with more than 60 articles published.

From a macro perspective, there is a large international collaboration, particularly with five countries: the United States (12.81%), the United Kingdom (2.27%), France (2.22%), Germany (1.43%), and Spain (1.30%). As seen previously, when focusing on Latin America, the block represents only 1.89% of all countries' collaboration, it is possible to identify that Brazil has networks of scientific collaboration and research with almost all countries. Inside this block, Argentina is a major coauthored number of articles (41.94%), followed by Colombia (19.47%), Chile (12.17%), Uruguay (9.92%), and Venezuela (8.80%). **Figure 7** shows the map collaboration network among 40 major countries and Brazil in the biotechnology area.

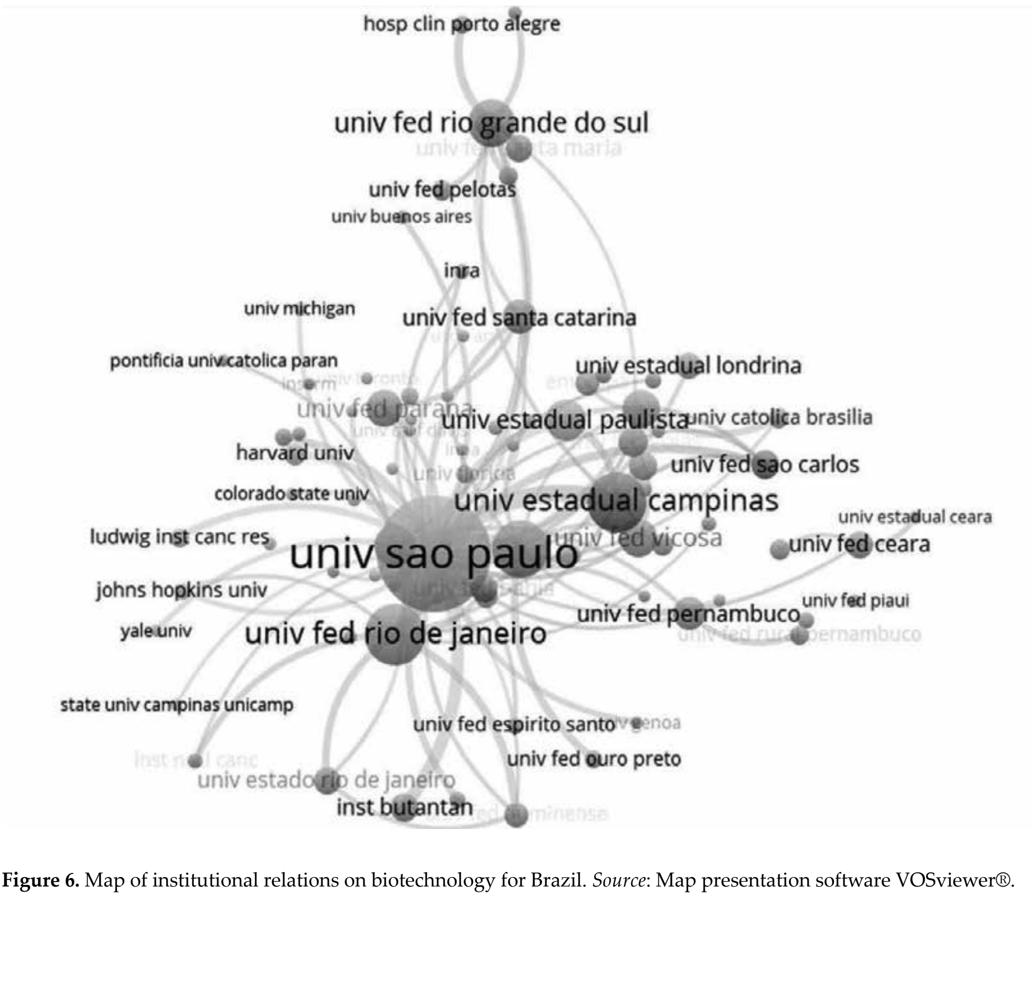

Figure 6. Map of institutional relations on biotechnology for Brazil. *Source*: Map presentation software VOSviewer®.

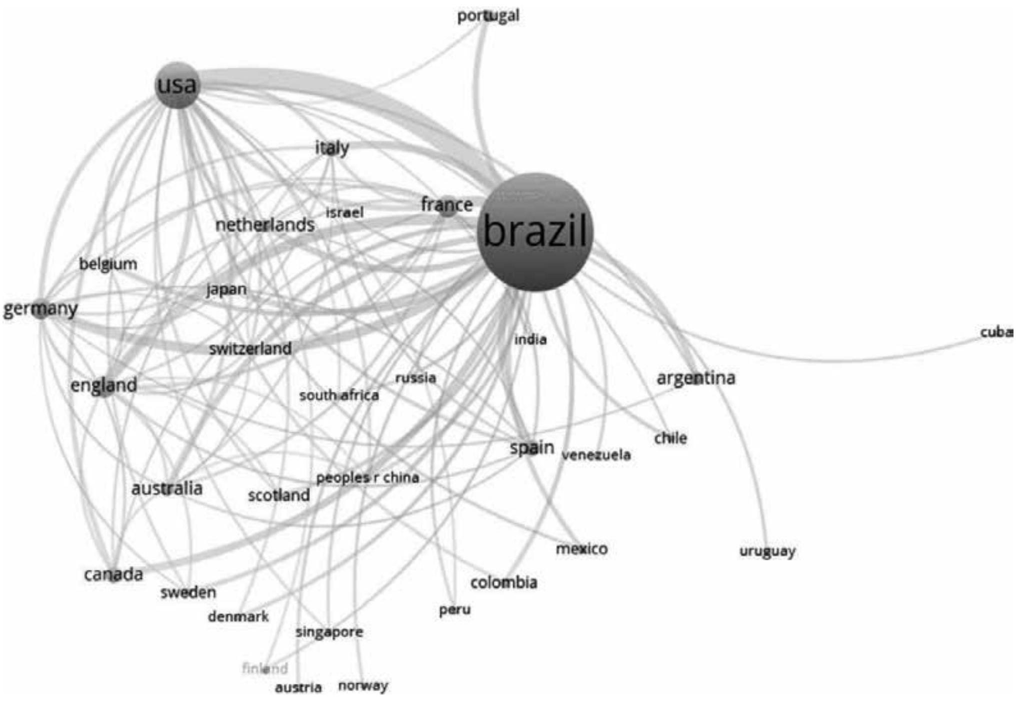

Figure 7. Map of network based on a co-authorship between Brazil and the 40 major countries on the biotechnology area. *Source*: Map presentation software VOSviewer®.

5. Conclusions

Traditionally, biotechnology is a technology that is strongly dependent on the studies of the basic research area. Its great success in any country is strongly related to government policies regarding the incentive of science and its technological diffusion. This chapter presents the growing of scientific research on biotechnology in Brazil, over the number of scientific articles published in the area, showing a higher growth of 1.930%, in the last 20 years, more specifically in the last 5 years. With respect to searched terms, "Vaccine," "PCR," and "DNA" are among the terms most frequently applied, being cited, since 1995, by the authors as keywords in scientific journals as well as in relevant journals such as Vaccine and Mem Inst Oswaldo Cruz. Terms such as proteomics and stem cells, related to the frontier area of knowledge, have also appeared in this scientific research. This fact indicates that the research in this area in Brazil is consistent with worldwide trends. Another significant topic is that the biotechnology research in Brazil is very important for studying the country's social problems, especially related to tropical diseases, which presents itself as an important starting point for formulating policies on ST&I, since decision-makers should encourage links between scientific institutions and companies. It is important to point out that Brazilian agricultural biotechnology research has taken significant steps toward the development and use of innovations for sustainable production systems that provide safer food (biofortified foods with vitamins, minerals, and better quality proteins).

A wide dispersion in relation to the thematic areas of biotechnology is observed, however, concentrated mainly in areas such as biochemistry and molecular biology and genetics and heredity. Three institutions are highlighted here: São Paulo University (USP), Oswaldo Cruz Foundation (FIOCRUZ), and Federal University of Rio Grande do Sul (UFRGS). It is worth mentioning that institutions that carry out scientific research in this area are primarily governmental. Regarding the analysis of relationships between agents that compose the National System of Science, Technology and Innovation in Brazil, it was found that for biotechnology, there is a large network of cooperation among international and national institutions, as well as networking among many countries that present a positive factor in the biotechnological development of a country [2]. In conclusion, it was possible to identify the United States as a major coauthor of scientific publications relating the subject, but there are also partnerships with other Latin American countries such as Colombia and Argentina.

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Chapter 11

Exploring the Impact of Online Clinical Guidelines on Individual Knowledge Management Behaviors and Individual Net Benefits

Shofang Chang, Tain-Junn Cheng and
Chung-Hsien Chan

Additional information is available at the end of the chapter

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Abstract

Health care is an industry of high knowledge intensity; the knowledge and skills of the medical staff are the key advantages for hospital competitiveness. This research aims to explore how the use of online clinical guidelines influences individual KM behaviors and the net benefits. It investigates the users, including 120 physicians and 80 physician assistants (PAs) who used the online clinical guidelines in a medical center of southern Taiwan. A total of 195 of the 200 questionnaires surveyed including 111 physicians and 70 PA are effective, leading to 97.5% effective response rate.This research uses a structural equation model, partial least squares (PLSs) to verify the research model and hypotheses. The R^2 of the overall model is 0.68, which implies good reliability and validity of this model. The results reveal that the use of online clinical guidelines and user satisfactions has positive effects on individual KM behaviors and individual net benefits. Individual KM behaviors have partial effects on the individual net benefits. In addition, there are mediating effects of the individual KM behaviors and user satisfactions on the use of online clinical guidelines and the individual net benefits.

Keywords: online clinical guidelines, individual knowledge management (KM) behavior, partial least squares (PLSs)

1. Introduction

In the era of knowledge economy, knowledge has gradually become one of the most important assets for most enterprises. In the health-care industry, clinical knowledge, especially physicians' knowledge, has been recognized as an important asset and a core competence

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area for hospitals. Information technology's rapid transformation and the rise of the Internet have resulted in rapid changes in data and knowledge. The establishment of knowledge portals in a health-care management system could lower health-care costs and foster diagnostic accuracy, thus improving the quality of patient care. Hence, within the knowledge-intensive health-care industry, the management of clinical knowledge is evidently the hospital's most important challenge.

In 1990, the Institute of Medicine proposed the clinical practice guideline as a systematic operational guide to help clinical researchers or patients select suitable treatment strategies when experiencing specific clinical conditions [1]. These clinical guidelines serve to improve the quality of treatment, decrease health-care costs, and reduce medical heterogeneity [2–5].

In this information and cloud-computing age, online clinical guideline may improve the accessibility, reliability, validity, and velocity for searching best practice, thus enhancing the efficiency and effectiveness of medical practice. The implementation of an online clinical guideline system is an important way to promote medical knowledge management, develop knowledge management ability, and improve individual net benefit. Future users of the online clinical guideline system will be able to break through traditional space and time restrictions to enhance medical expertise and technology, change knowledge management behaviors, and improve health-care quality and capability to maintain their core competences.

2. Research objectives

The research objectives were as follows: (1) to explore the interactions among the satisfaction level of medical professionals who use the online clinical guideline system, individual knowledge management behavior, and net benefit; (2) to compare disparities between all aspects of various modes of interactions across different medical professionals; and (3) to provide relevant suggestions regarding the online clinical guideline system's infrastructure and implementation.

3. Literature review

3.1. Online clinical guideline

Isern and Moreno [6] pointed out that an online clinical guideline system benefits clinical physicians and patients but remains an area of ongoing research with insufficient implementation and has yet to be integrated into existing management systems of health-care protocols and used in routine medical infrastructures. Isabelle et al. [7] noted that the integration of clinical guidelines into the online network will solve problems faced by physicians in patient care and will increase the likelihood that these guidelines will be used by physicians.

Isern and Moreno [6] also proposed that the compilation of the clinical guidelines database should include a web-based version. Moreover, collaborative features are very helpful in improving and creating various systems of clinical guidelines for different medical professionals. Studies have stated that, when computerized, a clinical decision support systems combine decisive strategies and clinical protocols and can provide concrete support for patients, improving clinical practice guideline compliance and treatment results for patients [8].

3.2. Individual knowledge management behavior

Nonaka and Takeuchi [9] argued that only individuals can create knowledge, and, through interactions with one another, individuals can develop organizational knowledge. Knowledge internalization and socialization should be the major knowledge management behavior of individuals. Rogers [10] categorized employees' knowledge behavioral conducts into three types regarding measurement of various aspects of cooperative knowledge behavior between employees, including knowledge acquisition, knowledge creating, knowledge sharing, knowledge hoarding, knowledge shirking, and knowledge appropriation. This study used knowledge socialization and internalization as the measuring variables of individual knowledge management behaviors.

3.3. Information system success model

Many studies use academics Delone and Mclean's [11] Information System (IS) success model for information system importing and effectiveness evaluation. This study focused on evaluating the effectiveness of an online clinical guideline system. The variables include system use, user satisfaction, user intention, and net benefits. Thus, we chose Delone and Mclean IS success model to evaluate the system, since they [11] have divided the actual system use and use intention. This study used two variables to measure the construct of system use.

4. Research methodology

4.1. Research hypothesis

This study's main focus was to investigate the satisfaction and usage levels associated with the online clinical diagnosis and treatment guideline system and the relationship between medical professional employees' knowledge management behavior and net benefit and to further explore relationships between various dimensions.

This study presented the following hypotheses:

H1: An online clinical guideline system use has a significant positive impact on its user satisfaction.

H2: An online clinical guideline system use has a significant positive impact on individual knowledge management behavior.

H3: An online clinical guideline system use has a significant positive impact on individual net benefit.

H4: An online clinical guideline system's user satisfaction has a significant positive impact on individual knowledge management behavior.

H5: An online clinical guideline system's user satisfaction has a significant positive impact on individual net benefit.

H6: Individual knowledge management behavior has a significant positive impact on individual net benefit.

4.2. Research design

This study investigated a medical center in Tainan, primarily focusing on some of the center's resident physicians, part-time physicians, practicing physicians, medical interns, and specialist assistants, and conducted questionnaire-based surveys and investigation. It investigates the users, including 120 physicians and 80 physician assistants (PAs) who used the online clinical guidelines in a medical center of southern Taiwan. A total of 195 of the 200 questionnaires surveyed including 111 physicians and 70 PA are effective, leading to 97.5% effective response rate.

5. Research results

5.1. Model reliability and validity test

In every dimension of the physicians and specialist assistant category, advertising value equivalency (AVE) values were all greater than the standard value of 0.5; CR values in all cases were greater than the standard value of 0.7. The overall model regression analysis R^2-value was 0.68, and Cronbach's α falls above 0.84, exceeding Fornell and Larcker's [12] recommended high reliability index value (>0.7). This suggests that this study's structural model has good reliability and validity (**Table 1**).

	AVE	CR	R^2	Cronbach's α
User intention	0.81	0.92		0.88
Actual system use	0.68	0.89		0.84
User satisfaction	0.80	0.96		0.95
Knowledge socialization	0.64	0.91		0.89
Knowledge internalization	0.69	0.91		0.88
Individual net benefit	0.76	0.96	0.68	0.96

Table 1. Reliability and validity.

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5.2. Path analysis

This study utilized partial least squares (PLSs) to evaluate the study. Using covariance structure as a basis, structural equation modeling (SEM) recommended that sample size must be at least 200 or above or 10 times the parameter [13]. Second, using covariance structure as a basis, SEM's predicted value must comply with the norm; otherwise, a disassociation with reality effect will ensue [14, 15]. In addition, a covariance-based SEM can only process reflective indicators and is unable to process formative indicators. As this study was conducted with a sample size of 195, which did not meet the standard 10 times of the parameter, PLS was selected as the method for analysis (**Figure 1**, **Table 2**).

This study found that online clinical guideline system usage had a significant positive impact on the system's user satisfaction ($\beta = 0.228$, $p < 0.05$). Additionally, regarding the relationship between individual knowledge management behavior and individual net benefit, only a small portion had a significant positive impact. Knowledge internalization has a significant impact on individual net benefit ($\beta = 0.183$, $p < 0.05$), while knowledge socialization reveals no impact on individual net benefit ($\beta = 0.05$, $p > 0.1$). The online clinical guideline system's user satisfaction had a significant positive impact on both individual knowledge management behavior (user satisfaction→knowledge socialization, $\beta = 0.191$, $p < 0.1$; user satisfaction→knowledge internalization, $\beta = 0.306$, $p < 0.05$) and individual net benefit ($\beta = 0.549$, $p < 0.05$), and individual knowledge management behavior had a partial significant positive impact on individual net benefit (knowledge socialization→individual net benefit, $\beta = 0.05$, $p > 0.1$; knowledge internalization→individual net benefit, $\beta = 0.183$, $p < 0.05$).

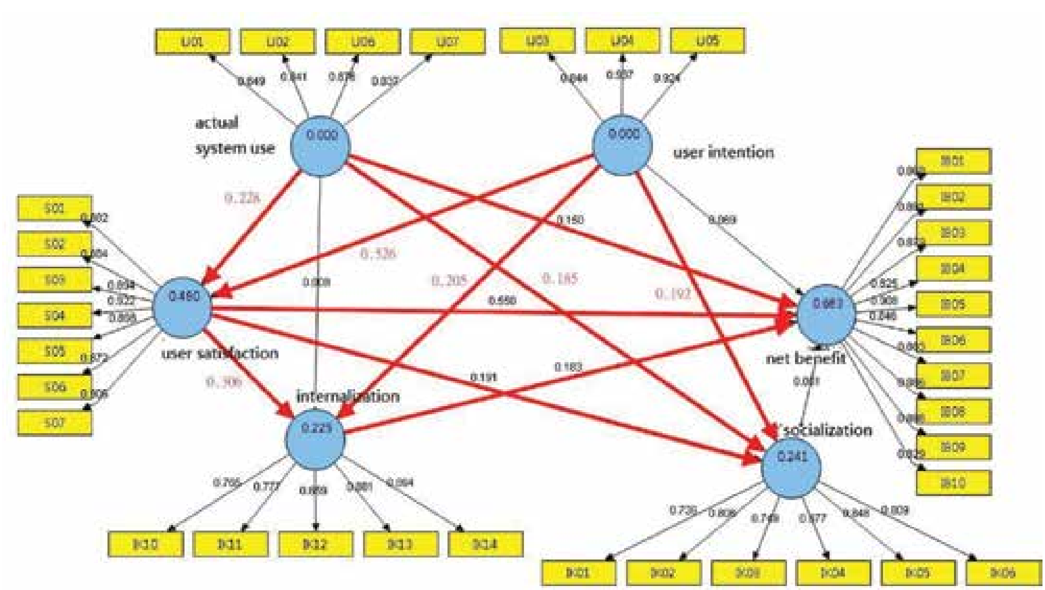

Figure 1. PLS model.

	Path coefficient	*t*-Value
User intention→ user satisfaction	0.526	7.45**
Actual system use →user satisfaction	0.228	3.06**
User intention→knowledge socialization	0.192	2.21*
Actual system use →knowledge socialization	0.185	2.29*
User intention→knowledge internalization	0.205	2.35*
Actual system use→knowledge internalization	0.008	0.11
User intention→individual net benefit	0.068	1.2
Actual system use→individual net benefit	0.149	2.90**
User satisfaction→knowledge socialization	0.191	1.80*
User satisfaction→knowledge internalization	0.306	3.48**
User satisfaction→individual net benefit	0.549	8.27**
Knowledge socialization→individual net benefit	0.050	0.83
Knowledge internalization→individual net benefit	0.183	2.83**

Remarks: path coefficient's statistical significance testing utilized BT method to redraw.
Sample size: 500 $^{*}p < 0.05$; $^{**}p < 0.01$.

Table 2. Structural method's path coefficient testing result.

Thus, hypotheses H1, H4, and H5 are supported. However, system use did not significantly influence knowledge internalization, user intention did not significantly influence individual net benefits, and individual knowledge socialization did not have a significant impact on individual net benefit. As a result, hypotheses H2, H3, and H6 are partially supported.

6. Conclusions and discussions

The results of this study showed that medical professionals had a certain tendency toward supportive systems that help their own fields and concurred that this type of system will always increase usage frequency but will also create dependence on the system to assist their medical strategies. It is evident, then, that medical professionals view usage of the online clinical guideline system as important to provide support and guidance for health-care work, which corresponds the viewpoints of Isern and Moreno [6] and Dongwen et al. [8]. On the other hand, with regard to medical decisions, they will still depend on their own professional knowledge.

This study also found that medical professionals have a certain degree of satisfaction with the online clinical guideline system. Online clinical guidance system's user satisfaction with the user's conscious satisfaction has successfully increased the functionality and practicality of using the system and indirectly assisted professional health-care employees to improve individual work performance. Simultaneously, users' satisfaction with the system is also an important factor determining continual usage of the system.

Regarding individual knowledge management behavior, this study developed two dimensions, "Knowledge Socialization" and "Knowledge Internalization," measuring personal knowledge management behaviors. Analysis of the results indicated that medical professionals expressed a higher degree of individual knowledge internalization related to socialization. When agreeing with individual knowledge internalization through "browsing of related professional websites," "obtaining expert knowledge," "educational training," "working," "observation," and related methods, individual knowledge can be increased. In individual knowledge socialization, through methods such as "internal and external department meetings," "sharing of ideas with colleagues," "team exchange of ideas," "discussion," and "seminars," a knowledge socialization effect can be achieved.

For individual net benefit, this study showed that medical professionals view the online clinical guideline system's usage to have a considerable impact on individuals' work and decision-making performance; notably, they expressed, "Using online clinical guideline system allowed for the quality of health-care strategies to improve," and "An online clinical guideline system can increase my work efficiency." From this, it is evident that the usage of the online clinical guideline system has a positive effect on medical professionals' work performance.

Based on this study's results, the usage of the online clinical guideline system has a positive impact on individual knowledge management behavior and individual net benefit; moreover, individual knowledge management behavior has a positive impact on individual net benefit. In addition, the online clinical guideline system's satisfaction level has an impact on individual net benefit that is greater than that of the online guidance clinical system or individual knowledge management behavior.

This study uses PLS and constructs a full model of online clinical guideline behaviors. Besides, the integration of the clinical guidance system into the Internet allowed us to know medical professionals' level of acceptance of the system by measuring their degree of satisfaction with using the system. This subsequently proved that medical professionals' acceptance level of the online clinical guideline system was recognized. Additionally, medical professionals, through the system's practical operation and usage, discovered that employees strongly value the practicality and reliability of data systems.

This study utilized a survey method focusing on only one medical center to investigate online clinical behavior and individual net benefit. Future research would be suggested to conduct the survey in multiple hospitals so as to improve the generalization of the research.

In addition, due to the time restriction, this study fails to further explore the impact of online clinical guideline on patient satisfaction and health-care quality. Future research is suggested to extend the effect on patient level so as to build a more comprehensive model toward the effectiveness of online clinical guidelines.

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Chapter 12

Knowledge-Based Assignment Model for Allocation of Employees in Engineering-to-Order Production

Matjaz Roblek, Maja Zajec and Benjamin Urh

Additional information is available at the end of the chapter

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Abstract

In today's rapidly changing business environment, it is necessary to react promptly in response to the product changes that happen constantly in an Engineering-to-Order production environment. Very often, there is not sufficient time to educate employees regarding new and necessary knowledge. If we insist on the standardization of a process execution, the process always requires appropriate knowledge from among available employees. In this chapter, an option for adjusting processes to available knowledge is studied. Following calculations, it was concluded that a partial corruption of a perfect process leads to a better knowledge alignment of employees. At first, with the corruption of a perfect process, its efficiency is decreased, but with better knowledge alignment, process efficiency is consequently increased to a level better than the original one. The optimization model presented in this chapter is based on a modified classic assignment problem and it includes a numerical example based on the data of ETO company. We proved our findings from the aspects of balance, employee capacity load and process efficiency.

Keywords: knowledge allocation, optimization model, activity-cutting principle, ETO

1. Introduction

Global competitiveness requires constant innovations of products and processes, which inherently require changes on the part of production companies. Management of these changes is especially important for those companies for which the production of new products is a regular business, that is, for which every customer requirement is so unique that it requires for the integration of research and development (R&D) department employees to a certain level. Linking of sales, R&D and production in such way is called an 'Engineering-to-Order

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production strategy' (ETO). Products in ETO production have a complex structure and a customer-specified production that is treated as a project. These projects are generally unique and were never previously executed. Therefore, it is impossible that they be handled with existing standard project activities. Problems with the allocation of employees appear in the first activities of the ETO production project, in which activities require a high level of innovation, and the project requires a proper knowledge allocation prior to capacity allocation. Of course, the management needs both allocation views, but the knowledge aspect is more important when dealing with new product or technology changes. The typical question before executing each ETO project is: Do we have appropriate knowledge to do that?

Knowledge is an element of the employees and also an element of the activities of business processes [1]. In Make-to-Stock (MTS), production activities are highly specialized and require a small set of required knowledge. In ETO production, employees execute many activities with a large set of required knowledge. Due to salary requirements, the human-resource-required knowledge is linked to the work position definitions [2]. The management goal is to optimize the required knowledge of work positions and the current knowledge of employees. With every product or process change, the knowledge structure of the work position is changed. If changes are permanent, there will be a continuous searching for new appropriate employees. However, what if the process of change was adjusted so that it took into consideration currently available knowledge? These employees are the only source that is available at the time a new product requires new knowledge in the process. What if the capacity load of each employee's knowledge and not just the employee's capacity in general were taken into consideration?

2. Literature review

In literature, this kind of optimization problem is classified as the worker assignment problem [3]. Applications of this problem are matching employees on work positions, where the required knowledge of work positions is compared to the actual knowledge of known employees [4]. The optimal solution (objective function) depends on the global minimum of the current knowledge deficit or the global maximum of the current knowledge surplus.

In a real environment, production processes are complicated and diverse. Almost every product and its production technology require modification of its objective function or modification of the entire optimization problem. Even if there is production of the same product in different locations, there will be modification needs, despite work standardization efforts. During process execution (over several years), the optimization problem also changes because of expected and unexpected events, such as production errors, economic opportunities and new arrangements. These events are sometimes very important for optimization. In the case of the presence of a more important and/or urgent business event, their importance for optimization disappears, and their priorities for optimization are changed. Therefore, there are many specific solutions for the worker assignment problem in the literature. Some solutions are case specific while other are made in an attempt to be universally applicable. Depending on the complexity of the worker assignment problem, researchers implement different optimization methods: mathematic programming models (linear, non-linear, integer), genetic algorithms and heuristics.

The following research has been used as a background for the worker assignment problem in this chapter. From the perspective of tasks, Azizi and Liang [5] developed an integrated approach to the worker assignment problem. Their dominant assignment problem includes workforce flexibility acquisition and task rotation. They used a constructive-search heuristic method and set the objective to minimizing the total cost including the incremental cost of new training cost, flexibility cost and productivity loss cost. The learning effect in the worker assignment model was also the subject of research in a project task scheduling problem [6]. They used a mixed non-linear integer program, solved by a proposed genetic algorithm. The objective function was to minimize outsourcing costs. From the task perspective, there is optimization model of task allocation and knowledge worker scheduling [7]. The purpose of this model is to assign knowledge workers to every task and arrange them (the tasks) in order to minimize the total time required to finish all projects. Their optimization is based on the Ant Colony algorithm as an optimization technique [8]. Nembhard [9] uses a heuristic approach for assigning workers to tasks that is based on individual learning rates.

There are also worker assignment models originating in production layout and shifts. McDonald et al. [10] developed a worker assignment model to evaluate a lean manufacturing cell, using a binary integer programming model that is solved using a branch-and-bound approach. The objective of this model is to minimize net present costs (initial training costs, incremental training costs, inventory costs and cost of poor quality). Previously, a model of worker assignment considering technical and human skills in cellular manufacturing was developed [11]. It is classified as mixed-integer programming problem. The objective of the model is to maximize profit, where profit has three components: productivity, quality costs and training costs. Ingolfsson et al. [12] combined integer programming and the randomization method to schedule employees by using an integer programming heuristic to generate schedules; they used the randomization method to compute service levels. They described a method to find low cost shift schedules with a time-varying service level that is always above a specified minimum.

There are worker-assigning models that deal with the satisfaction of workers. Brusco and Johns [13] defined a model of staffing a multi-skilled workforce with varying levels of productivity. They applied integer linear programming model with the objective of minimizing workforce staffing costs subject to the satisfaction of minimum labour requirements across the planning horizon of a single work shift. Mohan [14] created a model of scheduling part-time personnel with availability restrictions and preferences to maximize employee satisfaction. He proposed an integer programming model to maximize employee satisfaction (while considering their seniority and availability) and to meet the demand requirements for each shift. A branch-and-bound algorithm was used for this.

From the perspective of competencies [15], there is a competence-driven staff assignment approach that is based on a stochastic working status model. This model seeks to minimize employee wages and maximize strategic gains of the company from the increment of desirable competencies. The authors used a genetic algorithm as the optimization method. Competencies are also used in a model that seeks to maximize a weighted average of economic gains from projects and strategic gains from the increment of desirable competencies. As a sub-problem, the scheduling and staff assignment for a candidate set of selected projects is also optimized [16]. The authors used non-linear mixed-integer program formulation for the overall problem and then proposed heuristic solution techniques composed of a greedy heuristic for the scheduling and staff assignment, and alternative 'meta' heuristics for the project selection.

Recent studies are showing that the worker assignment problem is still important subject of research. Grosse et al. [17] designed a framework for integrating human factors into planning models. Crawford et al. [18] showed application of worker assignment problem in project scheduling and they innovated optimization approach using hyper-cube framework. A similar problem that discuses assignment of health care staff to tasks using fuzzy evaluation method was presented by Mutingi et al. [19]. Olivella et al. [20] gave emphasis on the cross-training goals, while Senjuti et al. [21] optimized the assignment of tasks to workers by proposing efficient adaptive algorithms. Current efforts are dealing with additional variables in creating the perfect optimization framework (knowledge, cross-training, etc.), or in finding the best optimization algorithms for solving worker assignment problem. They still assume that tasks are allocated to workers as 'they are'. Our effort was to study the effect of task redefinition in the meaning of splitting tasks on smaller parts with the goal of better knowledge alignment. From the organizational view, especially when the creative job must be done (like in ETO companies), the list of required tasks is created according to the available knowledge of workers, and the new definition of tasks is a subject of optimization output. This was our main theoretical issue that is described as real business example as follows:

- At first, there is an optimal worker assignment on the work position requirements of ETO company.
- Then, one or many workers leave the company at their own initiative. Because of the high level of customer demand, there is no time to re-educate the existing employees, and management will not approve recruiting new employees.
- The quality of process output (product) must remain at the same quality level. It is assumed that the quality can be reached only with proper knowledge.
- The quantity of process output may be reduced.

This is a typical example of a company that needs to increase the use of its internal sources. Many cases have been found in practice in ETO companies in which the management solved the problem of outgoing knowledge with reorganization of internal employees rather than with the simple extension of employees' existing capacities, for example, overtime work [22]. We also set two assumptions that were not subjects of this research: first, we accepted that in ETO production, business processes are constantly changing and, therefore, knowledge requirements are also changing. Second, because these are simulations, the relation between knowledge and the process efficiency was accepted: if employees have proper knowledge for

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the execution of activities, then these activities are performed faster. This has an impact on better efficiency of the whole process if that activity is simultaneously a process bottleneck [23].

3. Method

The key solution of adjusting processes to the current knowledge lies in the theory of business process management [24], in which the main problem of achieving a short process throughput time lies in the waiting times among different work positions that are the consequence of unbalanced work. This problem is insignificant if the entire process is executed by only one employee who occupies one work position, because there are no work position breaks [25]. This works only in small companies. Large business systems are complicated: they have many business processes with diverse knowledge requirements (e.g. ETO production) and require many employees with different types and levels of knowledge. Work is divided into activities between different work positions. Each work position has its own knowledge requirements. In this case, management needs control over the specific knowledge and over the number of the work position changes, and must keep them at the 'desired' minimum level so that the optimal process efficiency and the work balance are reached. The problem is also in the required and actual capacity of the specific knowledge. The process output quantity reflects the frequency of activity executions [26]. From a previous description of the principle of minimization work position breaks, when the capacity of one employee is exceeded, an additional employee who can perform all activities in the process is required. Such a broadly educated employee is too expensive, and this solution is thus irrational. Therefore, the process is divided into activities (tasks) among many work positions with the least expensive employees. Management creates work positions with a simple and complex knowledge structure. However, dividing work in too many work positions slows down the process: the throughput time is extended because of the additional waiting time each time the work position is switched.

Regarding the theory of work position breaks, work position knowledge structure and employee knowledge capacity, we modified our previously published model [22]. **Figure 1** shows the steps of upgraded conceptual model. In the new model, we are measuring the effect of the partial corruption of a perfect process regarding better current knowledge alignment from the perspective of employee capacity load and from that of process efficiency; with corruption of the process, we are decreasing its efficiency due to new additional work position breaks, but with better knowledge alignment we are again increasing the process efficiency.

3.1. Measuring optimal knowledge alignment

We can observe in practice that if the current knowledge deficit is below the required knowledge, the result is less efficient work. Surprisingly, even an excess of actual knowledge over

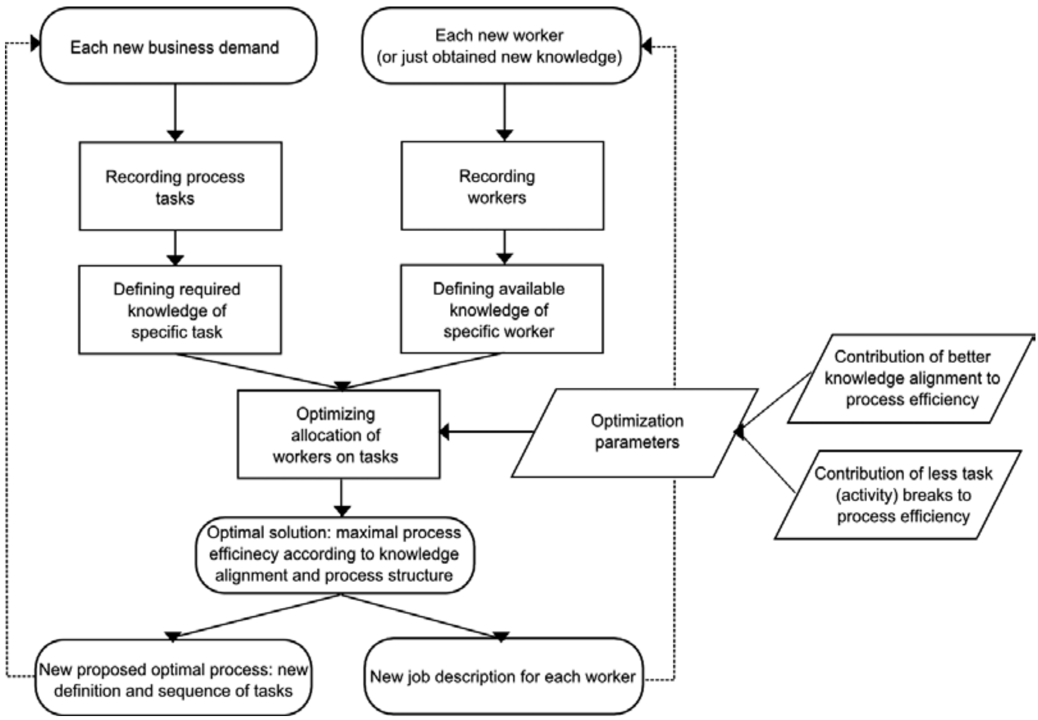


Figure 1. Knowledge-based assignment conceptual model.

the required level of knowledge has the same result of over-educated and intelligent employees becoming bored when they are executing routine activities [22]. Therefore, we modified a classic assignment linear integer problem of Kolman and Beck [3]. In the original optimization model (Eq. (1)), the value c_{ij} represents the added value if employee *i* is allocated to work position *j* and the optimization function maximizes a profit.

$$max\ z = \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij} \cdot x_{ij} \quad (1)$$

We replaced the added value with the minimal knowledge deficit/surplus (absolute) gap of *n* key required knowledge K_k. That means if we allocate an employee with his/her actual knowledge that is nearest to required knowledge on the work position (neither below nor above) then we have attained optimal knowledge alignment. The idea is to minimize the overall absolute key knowledge gap in the processes of the specific company (Eq. (2)).

$$min\ z = \sum_{i=1}^{n}\sum_{j=1}^{n}\left\{\left(\sum_{k=1}^{n}\frac{|K_k|}{n}\right)_{ij} \cdot x_{ij}\right\} \quad (2)$$

where $i\ldots\ n$ = number of compared employees; $j\ldots\ n$ = number of different work positions; $k\ldots\ n$ = number of compared key knowledge; and $|K_k|$ = absolute difference between required and actual knowledge K.

In case of a new required ETO production change, this model can be used in the following situations:

- If there is an 'open' set of available employees, all potential candidates in the optimization function can be matched. If the candidate knowledge gap is excessive (the appropriate level was not a subject of this research) the candidate is inappropriate for the work position because the performed work will be less efficient. This action has certain inherent costs (hiring, firing).
- If there is time to provide additional education to employees, then the knowledge deficit can be decreased with additional knowledge. This action has additional education and training costs.
- Existing employees can also be re-assigned on existing work positions so that the company knowledge alignment is optimal.

Are these all the possible management actions?

3.2. Measuring the corruption of a perfect process

As an innovation, the effect of a partial corruption of a perfect process was tested, including its impact on a better knowledge alignment with the limitation that the set of employees must remain untouched. The hypothesis was that with a corruption of the process, a better knowledge alignment can be achieved and, consequently, the process efficiency can be increased, despite a simultaneous decrease of its efficiency due to new additional work position breaks. Moreover, there must be a point in the process corruption procedure after which the inefficiency of the process exceeds the benefits of better knowledge alignment.

The effect of work position breaks in the process is measured by structural index K_{wpb} (Eq. (3)) [27]. This is a common key performance indicator in the theory of analysing business processes.

$$K_{wpb} = \frac{C_{wp}}{P_a} \cdot 100 \tag{3}$$

C_{wp} counts all work position breaks in a specific process. P_a counts all activities in that process. In this theory, the process slightly stops each time the next process activity is performed by different employee (on a different work position). This is one of practical causes for additional waiting time in the structure of throughput time of the process. There can be up to $n - 1$ work position breaks in a process of n sequential activities. According to the total number of all process activities, a small number of work position breaks means that the process is more efficient.

In practice, poor work quality can be found in the process due to inappropriate knowledge alignment. This generates additional feedback loops, activities are repeated and the result is additional work position breaks. Determining the causes of additional activity breaks is not a subject of this research.

3.3. Linking knowledge optimization and work position breaks

From the perspective of real business in ETO production, especially in this time of global economic crisis, accessibility to newly required knowledge is greatly limited due to extra educational costs. Downsizing also means that processes must be executed with fewer employees but at the same time the level of product quality must remain equal to previous process executions. Management typically reacts with reorganization of employees on activities. Furthermore, because we cannot split 'the human body', his or her structure of knowledge and the time capacity of that knowledge cannot be optimal for current (ideal) process. In the theory, the problem can be easily solved if we have all current employees with all required knowledge of the process.

In ETO production, there are many specialists (e.g. electrical engineers, mechanical engineers, software engineers) with one or two dominant fields of knowledge of very high quality or strength, and few employees with wide spectra of high quality knowledge (senior engineers, mechatronics), because the latter are too expensive. However, they are also key employees for the ETO production; they have the big picture over each new product, and they can control the efficiency and quality of the overall production process. They are never 'bottlenecks' in the process with regard to knowledge, but they can be problematic with regard to the available time capacity of his/her specific required knowledge, because they are involved in many processes (ETO projects).

This phenomenon is also a result of the accumulation of many small organizational changes in processes over time. When the company was established (or after process re-engineering project), processes and work positions were optimally designed for execution, employees were carefully selected and their knowledge was appropriate for knowledge requirements of work positions (**Figure 2**).

Over time, new activities were slowly added to work positions, thus generating newly required knowledge. These changes were so small at the beginning that the management did not recognize them as knowledge problems or capacity problems. They had no effect on the employees except that the work position received one or two new key pieces of knowledge that employees had to obtain. After a few years of small changes, the work position and their key knowledge structure had expanded in such a way that the management and the employee did not know which pieces of knowledge of the work position were key for business success (e.g. a designer in ETO production is working 30% of his capacity on designing, 40% of the time he is occupied with routine paper work and another 30% he is attending meetings; if we require 100% design work, then this person's design knowledge is a capacity bottleneck).

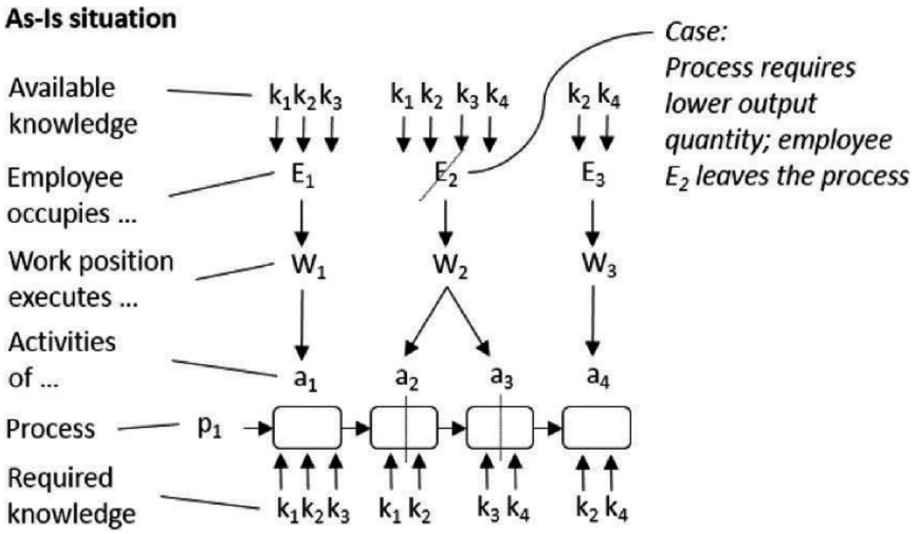


Figure 2. Explanation of cutting activities when employee leaves the process.

For such cases, we created a process and knowledge algorithm that is connected with a Key performance indicators (KPI) that measures process corruption as follows:

1. We must have input data of current processes (As-Is), their activities and times, current work positions, required knowledge, current employees and their actual knowledge.
2. Then, we test the impact of employee reduction on the knowledge structure of process. We can start with required knowledge that is recognized as a process bottleneck or with knowledge that is missing at the new activity executor.
3. In first case, we reduce the process activity until only work with knowledge that was bottlenecked remains (i.e. knowledge that is available by only one employee). The removed parts of activity with removed knowledge are distributed among other employees in the process until the optimal knowledge alignment is reached (Eq. (2)). If some knowledge is insufficient with one employee, the part of activity requiring this knowledge is given to an employee who can cover it successfully. Then, we repeat this procedure until optimal process knowledge alignment is reached.
4. At the same time, we measure the impact of the activity-cutting principle on the process (Eq. (3)). Because the better knowledge alignment improves the process efficiency, and the activity-cutting principle reduces the process efficiency, the algorithm serves as a 'trading' point when we are balancing and allocating employee knowledge on activities within his/her available time capacity (**Figure 3**)
5. The final result (output) is a new process (To-Be) that is feasible.

Such a reorganized process is reengineered on the basis of knowledge.

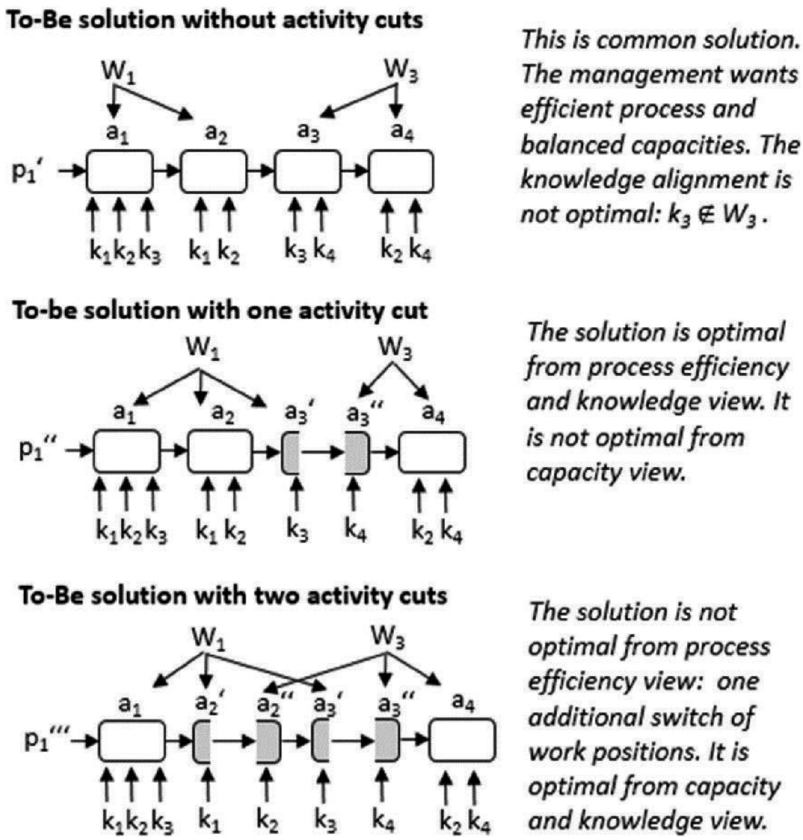


Figure 3. Possible outputs of algorithm for optimal knowledge alignment in ETO production.

4. Input data

4.1. Processes, process activities, work positions and required knowledge

In ETO production, at first sight, almost every product has its own and unique production process (routing). The fact is that activities (operations) among different processes are almost the same with regard to required knowledge. They differ mostly in the time required for execution. Because each product has its unique structure (bill of material), the process is named in practice as a project and its operations are named as activities. However, from the top-down approach, each project in ETO production has almost the same set and the same sequence of project phases (with many sub-activities), for example, (1) preparation, (2) design, (3) construction, and (4) testing. Therefore, it can be assumed that we have a standard form of the process (with activities) for almost all new products.

The same process activity could appear in a structure of many different processes and it is usually performed by the same work position (e.g. the same quality control activity with the same control parameters and tools for the whole product group). Moreover, one work position executes many activities. Until the system is well organized, a work position aggregates activities with approximately the same required set of knowledge. We defined that the required knowledge of a specific work position is represented as a set of knowledge from all executed activities. The sets of required knowledge of specific activity and their strength (Likert scale from 1 to 5; 5 meaning very important) are defined by the company's internal and external experts. If a specific piece of knowledge is required for the execution of many activities, the model uses its maximal value as a required strength.

Complex work positions have a wide range of required knowledge, many of unimportant strength. Reducing the amount of various required knowledge can simplify the calculations. Simplification was achieved with the definition of key knowledge K_k for each work position. If the strength of specific knowledge is above a specific level, it is treated as key knowledge of that work position.

In practice, the above-described idea of capturing process activities and their required knowledge can be used for documenting As-Is processes and, more importantly, for predicting future products, To-Be processes and their expected required knowledge. This is of great importance for planning required knowledge of future ETO production. We can analyse the following:

- Which activity among all activities of specific process is the most important from the key knowledge aspect, for example, to find the activity that is the 'knowledge bottleneck' in a process. Then we can combine this information with activity throughput rate and find an activity that is the real-time capacity bottleneck in the process.
- Which process (from among all of them) is the most important from the aspect of key knowledge, for example, for ranking all processes on the basis of the knowledge required (i.e. which process is currently the most important/crucial for the company from the knowledge view; this is important information for any ETO company in addition to the information regarding which process is crucial from capacity aspect).
- In ETO production, each work position typically executes many different activities in many different processes. Therefore, we are interested which work position has the highest required strength of all key knowledge, for example, we can use this information as a basis for creating salary grades.
- Which work positions in the company are exceptional from the knowledge aspect; a work position that has only one key type of knowledge but with a high required strength (e.g. CNC programmer) and which work positions are universal, that is, have many key types of required knowledge (e.g. ETO project manager).
- Which type of knowledge is dominant (repeats at every executed activity) for the specific process (short-term view) and for the whole company (long-term view).

If we have proper data on all the above mentioned entities (processes, activities, work positions, knowledge requirements with required strength) for the present time, and if we have good knowledge requirements (definitions) of new products (especially required technology and activities), we can then simulate all future knowledge requirements in advance. Therefore, we can determine differences, for example, which work position must be knowledge-reconstructed in the future; consequently, we can define projected mandatory changes in a structure of actual knowledge (employees).

4.2. Employees, actual knowledge and knowledge gap

Employees represent the basis for gathering current knowledge. There are many approaches to prove that an employee possesses specific knowledge and what the quality of it is (strength, level). In our approach, the 360° feedback method [28] was used. We used a list of all key required knowledge and assessed all employees (Likert scale from 0 to 5; 0 means knowledge not available). We gave employees the opportunity to extend this explicit knowledge with their tacit knowledge. In the context of our model, the term 'tacit' means the knowledge of an employee that is currently unknown to the company. Knowing about tacit knowledge is essential information when new processes have requirements for new types of knowledge. In practice, for optimization, it is also recommended that we have the knowledge data about potential candidates for employees.

The last step of input data preparation is a calculation of the key knowledge gap: each employee is compared to all work positions. We used the criterion c_{ij}, explained in Eq. (2). Any deviation of actual knowledge over and below the required knowledge is considered to be inappropriate and will lower process efficiency (**Table 1**).

Table 1 shows a numerical example of matching the actual knowledge from *k*1 to *k*10 of employee *E*1 on activities from *a*1 to *a*7 of work position *W*1 (e.g. Product Manager of ETO project). The example is based on the real data of ETO company, Iskratel. Negative values (grey cells) represent deficits of employee knowledge strength compared to the required knowledge of a work position. The top rows represent activities of the work position with a

	Activities	a_1	a_2	a_3	a_4	a_5	a_6	a_7
Knowledge		-2.48	-2.98	-6.64	-1.2	-0.11	-0.14	-0.27
k_1	-0.40	0.60	-0.40	2.27	0.00	1.77	1.03	2.04
k_2	0.0	1.19	1.18	1.57	0.60	2.40	2.26	2.73
k_3	-0.62	-0.24	-0.38	0.23	0.60	1.62	0.26	1.51
k_4	-4.54	-0.79	-1.00	-1.50	-1.00	-0.11	-0.14	1.44
k_5	-1.20	1.77	-1.20	1.70	2.20	1.37	0.20	0.31
k_6	-0.97	0.41	0.98	-0.97	0.40	0.59	0.06	0.64
k_7	-1.54	0.76	0.40	-1.27	1.40	1.23	0.69	-0.27
k_8	-2.45	-1.45	1.00	-1.00	0.60	1.00	1.57	1.33
k_9	-1.07	0.20	0.47	-0.87	-0.20	1.08	2.80	2.58
k_{10}	-1.03	1.15	0.13	-1.03	0.40	1.41	2.80	2.36

Table 1. Matching required and actual knowledge.

sum of negative values. We can identify activities that the employee is not suitable to execute (e.g. *a*1, *a*2, *a*3). The left column represents the required knowledge with the sum of negative values. We can identify the lack of employee knowledge (e.g. *k*4, *k*8).

In practice, we could integrate in our model the effect of learning and forgetting knowledge over time (decreasing knowledge strength if employee is not using that type of knowledge in processes for a long time). Because of model simplicity, this was not a subject of this research.

5. Results

We demonstrated the capabilities of our model on a small section of the real process that was described in **Figure 3**. This numerical example is based on the data of company Iskratel. We performed simulations of this example with the same tools as the calculations of real cases (**Tables 2** and **3**). Definitions of processes were recorded in the repository of Aris Toolset software [29]. Definitions of actual and required knowledge were recorded with MS Share Point and MS SQL. All data were then exported to the MS Excel analytical tool and solved with the WhatsBest [30] add-on. MS Excel was also used as reporting tool.

5.1. Input data of simulation scenarios

We prepared four simulation scenarios as follows:

- Scenario 0: As-Is situation. In the current state, there are three employees assigned to their own work positions, and the processing of four activities with four different types of knowledge.
- Scenario 1: employee on work position w_2 left the company. His/her activity a_2 is assigned to w_1 and a_3 to w_3. This is typical management decision that does not generate an additional work position switch in the sequence of activities.
- Scenario 2: use of our algorithm: achieving better knowledge alignment. Employee on w_3 has no knowledge K_3 that is required for execution of activity a_3; therefore, we split activity on a'_3 and a''_3.
- Scenario 3: is same as scenario 2, with one additional activity cut: we are searching for better balance of capacities between w_1 and w_3. We split activity a_2 and we add knowledge K_2 to work position w_3.

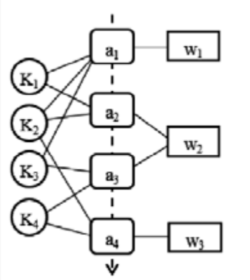
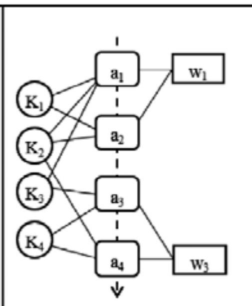
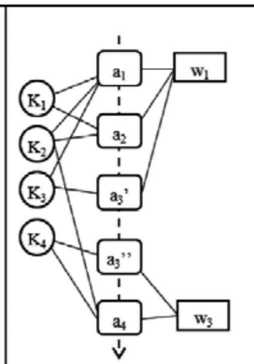
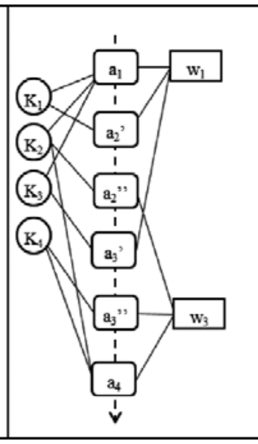
We can observe the things as follows:

(i) In scenario 1, the result of management action on knowledge distribution among work positions: Knowledge K_1 and K_2 are moved from w_2 to w_1. Knowledge K_3 and K_4 are moved from w_2 to w_3. In case this is the same knowledge, we used the maximal strength as the required strength.

(ii) In scenario 2, the result of optimization algorithm: according to As-Is situation, we moved from w_2 to w_1 knowledge K_1 and K_3. This caused the rise of the strength of both

Simulation scenarios			
Scenario 0	Scenario 1	Scenario 2	Scenario 3

I. Input data: processes (ARIS EPC) and activities (a_n), work positions (w_n) and required knowledge (K_n)

Scenario 0	Scenario 1	Scenario 2	Scenario 3
			

II. Input data: actual knowledge strength of employees (Likert scale 0 to 5)

	S0 E_1	S0 E_2	S0 E_3	S1 E_1	S1 E_3	S2 E_1	S2 E_3	S3 E_1	S3 E_3
K_1	3	5	0	3	0	3	0	3	0
K_2	2	3	5	2	5	2	5	2	5
K_3	1	2	0	1	0	1	0	1	0
K_4	0	1	2	0	2	0	2	0	2

III. Input data: required knowledge strength of work positions (Likert scale 0 to 5)

	S0 w_1	S0 w_2	S0 w_3	S1 w_1	S1 w_3	S2 w_1	S2 w_3	S3 w_1	S3 w_3
K_1	4	5	0	**5(i)**	0	**5(ii)**	0	**5(iii)**	0
K_2	2	2	5	2	5	2	5	2	**5(iii)**
K_3	1	3	0	1	**3(i)**	**3(ii)**	0	**3(iii)**	0
K_4	0	1	2	0	2	0	**2(ii)**	0	**2(iii)**

Table 2. Input data of simulation scenarios.

types of knowledge for w_1. We moved from w_2 to w_3 only knowledge K_4, because the newly required strength is below the current required strength so it remains as it was for w_3.

(iii) In scenario 3, the new activity cut did not cause any change in knowledge requirements (and strength) of w_1 and w_3 according to scenario 2.

5.2. Simulation results

We can see in Scenario 2 (implementing activity-cutting principle) that we decreased the knowledge gap in Scenario 1. Now, we must 'merge' the results of optimal knowledge alignment to determine the impact of using the activity-cutting principle on classic production optimization parameters (Scenario 3). Otherwise, we will break some lean manufacturing principles, for example, work balancing or eliminating waiting times. We added additional input data of As-Is process in **Table 4**.

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Scenario 0	Scenario 1	Scenario 2	Scenario 3
I. Comparison of actual and required knowledge (absolute knowledge gap ; $c_{i,j}$)			

Scenario 0:

	E_1	E_2	E_3
W_1			
K_1	-1	1	-4
K_2	0	1	3
K_3	0	1	-1
K_4	/	/	/
$C_{i,j}$	**0.3**	**1.0**	**2.7**
W_2			
K_1	-2	0	-5
K_2	0	1	3
K_3	-2	-1	-3
K_4	-1	0	1
$C_{i,j}$	**1.3**	**0.5**	**3.0**
W_3			
K_1	/	/	/
K_2	-3	-2	0
K_3	/	/	/
K_4	-2	-1	0
$C_{i,j}$	**2.5**	**1.5**	**0.0**

Scenario 1:

	E_1	E_3
W_1		
K_1	-2	-5
K_2	0	3
K_3	0	-1
K_4	/	/
$C_{i,j}$	**0.7**	**3.0**
W_3		
K_1	/	/
K_2	-3	0
K_3	-2	-3
K_4	-2	0
$C_{i,j}$	**2.3**	**1.0**

Scenario 2:

	E_1	E_3
W_1		
K_1	-2	-5
K_2	0	3
K_3	-2	-3
K_4	/	/
$C_{i,j}$	**1.3**	**3.7**
W_3		
K_1	/	/
K_2	-3	0
K_3	/	/
K_4	-2	0
$C_{i,j}$	**2.5**	**0.0**

Scenario 3:

	E_1	E_3
W_1		
K_1	-2	-5
K_2	0	3
K_3	-2	-3
K_4	/	/
$C_{i,j}$	**1.3**	**3.7**
W_3		
K_1	/	/
K_2	-3	0
K_3	/	/
K_4	-2	0
$C_{i,j}$	**2.5**	**0.0**

Scenario 0	Scenario 1	Scenario 2	Scenario 3
II. Employees allocation optimization (problem specification)			
Variables: x_1= E_1 occupies W_1 x_2= E_2 occupies W_1 x_3= E_3 occupies W_1 x_4= E_1 occupies W_2 x_5= E_2 occupies W_2 x_6= E_3 occupies W_2 x_7= E_1 occupies W_3 x_8= E_2 occupies W_3 x_9= E_3 occupies W_3 Optimization function: Z_{min}= $0,3x_1+1x_2+2,7x_3+1,3x_4+$ $0,5x_5+3x_6+2,5x_7+1,5x_8+0x_9$ Boundaries functions: E_1 can occupy: $x_1+x_4+x_7=1$ E_2 can occupy: $x_2+x_5+x_8=1$ E_3 can occupy: $x_3+x_6+x_9=1$ W_1 must be occupied: $x_1+x_2+x_3=1$ W_2 must be occupied: $x_4+x_5+x_6=1$ W_3 must be occupied: $x_7+x_8+x_9=1$	Variables: x_1= E_1 occupies W_1 x_2= E_3 occupies W_1 x_3= E_1 occupies W_3 x_4= E_3 occupies W_3 Optimization Function: Z_{min}= $0,7x_1+3x_2+2,3x_3+1x_4$ Boundaries Functions: E_1 can occupy: $x_1+x_3=1$ E_3 can occupy: $x_2+x_4=1$ W_1 must be occupied: $x_1+x_2=1$ W_3 must be occupied: $x_3+x_4=1$	Variables: x_1= E_1 occupies W_1 x_2= E_3 occupies W_1 x_3= E_1 occupies W_3 x_4= E_3 occupies W_3 Optimization Function: Z_{min}= $1,3x_1+3,7x_2+2,5x_3+0x_4$ Boundaries Functions: E_1 can occupy: $x_1+x_3=1$ E_3 can occupy: $x_2+x_4=1$ W_1 must be occupied: $x_1+x_2=1$ W_3 must be occupied: $x_3+x_4=1$	Variables: x_1= E_1 occupies W_1 x_2= E_3 occupies W_1 x_3= E_1 occupies W_3 x_4= E_3 occupies W_3 Optimization Function: Z_{min}= $1,3x_1+3,7x_2+2,5x_3+0x_4$ Boundaries Functions: E_1 can occupy: $x_1+x_3=1$ E_3 can occupy: $x_2+x_4=1$ W_1 must be occupied: $x_1+x_2=1$ W_3 must be occupied: $x_3+x_4=1$
III. Optimization results (minimal absolute knowledge gap and employees allocation)			
Z_{min} = **0.8** if x_1=1. x_5=1 and x_9=1	Z_{min} = **1.7** if x_1=1 and x_4=1	Z_{min} = **1.3** if x_1=1 and x_4=1	Z_{min} = **1.3** if x_1=1 and x_4=1

Table 3. Simulation results.

- The first assumption (i) in our evaluation is the amount of time that is added to process throughput time each time we change the work position (sending work from me to you etc.). In a real case, this could be measured exactly but in our demonstration we assumed a fixed value of 3 min.
- The second assumption (ii) in our evaluation is the amount of time that is added to process throughput time because of non-optimal knowledge alignment. In the As-Is process, we

Scenario 0: As-Is Process

Process Times (in minutes)

Knowledge sequence ↓	Activity sequence → a_1	a_2	a_3	a_4
K_1	12			
K_2	15			
K_3	3			
K_1		5		
K_2		10		
K_3			7	
K_4			8	
K_2				10
K_4				20
Total activity time	30	15	15	30
Work position	w_1	w_2		w_3
(i)Moving time		3		3
(i)Planned throughput time	30+3+15+15+3+30 = **96 min**			
(ii)Expected throughput time	(0.8/0.1)×1% = 8% => 96 min × 1.08= **103.68 min**			
Process Throughput rate per shift (450 min)	$\min\begin{cases} w_1; \frac{450}{30} = 15 \\ w_2; \frac{450}{3+15+15} \cong \mathbf{13} \\ w_3; \frac{450}{3+30} \cong \mathbf{13} \end{cases}$			
Capacity Load per shift (%)	**86.7**	**95.3**		**95.3**
Expected Efficiency	(90min/103.68min)×100 = **86.8%**			
KPI_{wpc}	(2 wpc / 4 activ.)×100 = **50%**			

Table 4. Production parameters of As-Is process.

know that we have 0.8 by the Likert non-optimal knowledge alignment. If the times in this table were measured without being aware of this knowledge gap then the real throughput time is longer. In a real case, we could measure this by comparing the knowledge gap and the difference between planned and real production times (we have to exclude other causes for time extension first). In our demonstration, we assumed that every 0.1 of knowledge gap adds 1% to planned process throughput time.

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6. Discussion

The main specialty of our model is that we permit changes of the process because the actual knowledge is not appropriate for it. However, we do not allow changes in the sequence of activities; we allow only changes in the sequence of using employees. The results are new partial activities in the process; consequently, the process workflow is jumping forwards and backwards between employees.

In our model, we removed all unnecessary knowledge from the work positions that were process 'bottlenecks' and replaced it with the new process structure; this was done by taking into consideration the availability of the actual knowledge of employees. The entire individual employee time capacity is now focused only on the utilization of knowledge that is bottlenecked. Other required knowledge in the process that is also present in other employees is removed from that work position. Employee capacity is now free of all non-bottleneck knowledge, and this raises its capacity availability.

In our simulations, we used process time indicators to verify our assumption, even if we know, on the basis of real projects [31, 32], that the best improvements in the ETO production are achieved on the process quality indicators. Time indicators are improved indirectly as a result of better product quality: fewer aftermarket repairs means less additional invested time in the total production time of the specific product. The starting point of all scenarios is the departure of one employee from the original process (Scenario 0). In Scenario 1, we reacted by implementing the lean manufacturing principle of capacity balancing: the work of the lost employee is divided among remaining employees on the basis of capacity levelling without additional work position breaks. This is a common management decision, and it is expressed as a load capacity per shift (%) indicator in **Table 4**. This decision produced the knowledge gap of 1.7 (**Table 3**).

In Scenario 2, we used our model with the activity-cutting principle, and we reduced the knowledge gap by 0.4 or 23.5% (**Table 3**). Most time indicators were also improved (**Table 5**), except for the unbalanced load capacity per shift (%) indicator, and a lower process throughput rate (from 9 to 8 products per shift). Both indicators would have negative impact in mass or serial production, but according to the requirements of the ETO production it is more important that we achieved the desired quality of knowledge for production process because there are no repetitions (rather only unique, one-time process executions). Management can balance these indicators and make the decision that is adopted for a specific process 'case'.

In Scenario 3, we tested the total ignorance of the Lean Manufacturing principles, and we performed additional activity cuts for searching for even better knowledge alignment. We did not achieve a lower knowledge gap (**Table 3**); we also worsened all time indicators according to Scenario 2 (**Table 5**). This indicated that there is a point in the repetition of activity-cutting procedure after which the process becomes so inefficient that is better to hire a new employee if the knowledge gap is still too high for achieving the appropriate quality of ETO products. Where that point is, what the gap should be and whether its value is of universal use or case sensitive are all subjects of future research.

Scenarios without employee on work position w2

	Scenario 1				**Scenario 2**					**Scenario 3**					
	Activity sequence →				Activity sequence →					Activity sequence →					
Knowledge sequence ↓	a_1	a_2	a_3	a_4	a_1	a_2	a_3'	a_3''	a_4	a_1	a_2'	a_2''	a_3'	a_3''	a_4
K_1	12				12					12					
K_2	15				15					15					
K_3	3				3					3					
K_1		5				5					5				
K_2		10				10						10			
K_3			7				7						7		
K_4			8					8						8	
K_2				10					10						10
K_4				20					20						20
Total activity time	30	15	15	30	30	15	7	8	30	30	5	10	7	8	30
Work position	w_1		w_3		w_1			w_3		w_1		w_3	w_1	w_3	
Moving time			3					3				3	3	3	
Planned throughput time	**93 min**				**93min**					**99 min**					
Expected throughput time	**108.8 min**				**105.1 min**					**111.9 min**					
Process Throughput rate per shift (450 min)	$\min\begin{cases} w_1; \frac{450}{45} = 10 \\ w_3; \frac{450}{48} \cong \mathbf{9} \end{cases}$				$\min\begin{cases} w_1; \frac{450}{52} \cong \mathbf{8} \\ w_3; \frac{450}{38} = 11 \end{cases}$					$\min\begin{cases} w_1; \frac{450}{45} = 10 \\ w_3; \frac{450}{54} \cong \mathbf{8} \end{cases}$					
Capacity Load per shift (%)	**90.0%**		**96.0%**		**92.4%**			**72.9%**		**80.0%**				**96.0%**	
Expected Efficiency	**82.7%**				**85.6%**					**80.5%**					
KPI_{wpc}	**25%**				**20%**					**50%**					

Table 5. The impact of activity-cutting principle on production parameters in scenarios from 1 to 3.

7. Conclusions

In Make-to-Stock, Assemble-to-Order and Make-to-Order production, assignment models for the allocation of employees assume that tasks of production processes (or routings) are of a fixed structure. Managers believe they found the most 'efficient' process of producing products and, therefore, all current optimization models are searching for appropriate employees for that process. Small deviations between the required and the actual knowledge are resolved with alternative routing; its structure is also known and fixed in advance. All of this is possible because extra time is invested for testing and preparing optimal processes for many repetitions. Extra time is also invested for finding employees with proper knowledge for that processes. This is the case of known theoretical and practical solutions of worker assignment problem.

However, in ETO production, and consequently in all knowledge-intensive processes or case-like processes, we determined that processes are structured around the available knowledge of employees. Otherwise, the cost of searching for missing knowledge in the form of a new employee could exceed all the added value to the business. Process 'cases' are never the same and each process 'repetition' requires a process structure that is adapted to the actual knowledge and its capacity in the company; the bottleneck is not the capacity of the employee but the capacity of his/her specific actual knowledge. With the activity-cutting principle in our

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assignment model, we proved that we can release the 'hidden' time capacity of employee who is the bottleneck so that we could remove all activities and consequently the knowledge that is also available with other employees from the work position. We recommend that this principle can be an option of all assignment models for the allocation of employees for ETO production and all other knowledge-intense companies. This is our main contribution to the theory of modelling worker assignment problem.

Of course, this research raises additional questions for our future work, especially in the field of practical application: is knowledge the right category in our assignment model or is it better to use all measureable work habits and personal skills [33]? There are also assumptions in **Table 4** that will need additional research and explanation. Nevertheless, our concept of redefining tasks with the goal of reaching optimal worker knowledge alignment could be used as a 'smart' reorganization principle for dynamic and real-time redefinition of processes in companies, where the standardization of tasks is not the main factor of reaching efficiency.

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An Examination of the Knowledge Management Process in the Emerging Chinese Hotel Industry

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Additional information is available at the end of the chapter

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Abstract

Since the Open-Door Reforms of the Chinese market to foreign investment in the late 1970s, numerous Western firms have sought to enter and establish their presence as a market leader in their particular industry. Establishing a presence and generating growth in the emergent Chinese market has proven challenging for Western firms; operating effectively and efficiently in this 'new' market environment (characterised by significant psychographic, cultural, legal and political differences) has highlighted a number of significant research opportunities. One such opportunity has manifest in a call to develop a finer-grained understanding of the knowledge management processes required by Western hotel chains attempting to enter and establish their operations in China. This chapter presents an exploratory analysis of the knowledge management issues and processes experienced by the Marriott Group during its entry and growth in the Chinese hospitality industry. This analysis is based on a series of semi-structured interviews with senior managers present during Marriott's entry into China. The chapter concludes with a discussion of the managerial and theoretical implications emanating therefrom.

Keywords: hospitality industry, knowledge management, China

1. Introduction

The strategic management of organisational knowledge requires a comprehensive understanding of the process by which the various forms of tacit and explicit knowledge are generated, coded, stocked and leveraged for competitive gain (see Refs. [1, 2]). The process of extracting value from the careful management of knowledge-based assets has been investigated in multiple disciplines, industries and markets (see Ref. [3]); however, according to

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Refs. [2, 4], investigation into what constitutes appropriate knowledge management processes within emerging/developing markets remains limited. Many Western-based organisations seeking to enter emerging economies (such as those in South East Asia) have achieved mixed success, which in part has been attributed to the inherent limitations of transferring extant Western-based knowledge management processes to new international contexts (see Refs. [5–7]). Such attempts can be seen in the highly competitive Chinese hotel sector, which has become an important investment platform for leading multinational hotel groups including, but not limited to Marriott International, Accor, Inter-continental and Shangri-La (see Ref. [8]). Despite the heavy investment of these Western hotel groups, their ability to compete effectively in China remains an issue of ongoing concern (see Refs. [8–10]). As a result, Refs. [11–14] have called for a finer-grained understanding of what constitutes 'effective knowledge management' by Western firms in the highly competitive Chinese hotel sector. Focussing on one major Western hotel chain operating in China (i.e. Marriott International), this chapter presents an empirical exploration into the issues inherent to knowledge management processes in the Chinese hospitality industry. In addition, the potential implications identified during this exploration have been used to prepare and present an agenda for future research into knowledge management practices within the Chinese hospitality industry.

2. Knowledge management processes and the Chinese hotel industry

The knowledge management concept has been extolled across multiple disciplines as a control process whereby organisational knowledge is generated, retained and leveraged to enhance competitiveness and organisational growth (see Refs. [11, 15]). Organisational efforts to strategically manage their store of knowledge continue to intensify as the business environment becomes progressively competitive, and new, dynamic markets continue to emerge (see Refs. [14, 16]). The rapid expansion speed of new markets has allowed little time for Western organisations investing in markets such as China to reflect on the applicability of their existing managerial strategies to this emerging-market context (see Ref. [4]). Indeed, current theories related to knowledge management have predominantly been developed in Western markets where business dealings are traditionally transactional based; to date, little consideration has been given to the generalisability of these theories to Western organisations operating in emerging Asian economies where relational based business dealings are the norm (see Refs. [2, 4, 17, 18]). In order to improve our understanding of what constitutes effective knowledge management for Western organisations seeking to enter and compete in the Chinese hotel sector, we felt it appropriate to adopt a knowledge management process model to guide our data gathering and analysis.

For this study, the Knowledge Management Cycle (KMC) model has been chosen; the KMC consists of seven phases: identify and/or create; store; share; use; learn; improve; and create 'organisational knowledge' (see Ref. [1]). If a request for new knowledge is triggered within an organisation, the first stage is to identify if existing codified and encapsulated knowledge assets and subjectively held tacit knowledge exist, or if new knowledge assets need to be created. The KMC model, therefore, suggests that managing the knowledge process is

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primarily reliant on (a) an organisation's executives' definition of what constitutes relevant 'knowledge' and 'knowledge gaps' in their organisation and (b) their ability to implement efficient and systematic methods to gather and/or communicate new knowledge to employees (see Refs. [18, 19]). Organisational specific rules, cultures and evaluative criteria are able to be used as a lens for interpreting, analysing and applying existing or newly created knowledge to decision making (see Ref. [20]). If deemed valuable, any new knowledge generated is codified and systematically stored in organisational memory from which it can be drawn, shared and protected (see Ref. [1]). Fulfilment of these tasks can embed a learning culture within the organisation (see Ref. [21]); learning cultures enable employees to generate their own internal store of knowledge and leverage their own understanding to make innovative decisions and contribute to their organisation's dynamic capabilities (see Refs. [19, 22]).

Research has determined that the existence of flexible and dynamic organisational networks, or communities of practice, provide the most effective means for encouraging and facilitating the dissemination of explicit and tacit organisational knowledge (see Refs. [14, 18, 20]). Once shared, the value from knowledge assets can be extracted and applied (see Ref. [20]). However, this stage can prove difficult as the ability of employees to extract value from the complex interplay of codified, encapsulated and tacit knowledge may also be influenced by additional factors, such as national culture and the institutional context (see Refs. [2, 14, 23]). The ability to simultaneously engage in continual organisational learning and develop a fluid store of country-specific knowledge (that supports distinctive culture-specific business practices) would seem, therefore, to be critical to Western organisational success in the Chinese market context. The success of knowledge management processes is therefore predicated on an organisation's Human Resource Management (HRM) practices and its ability to recruit, develop and motivate employees (see Refs. [2, 17]). This in itself can prove problematic as studies into the HRM practices of Western firms in China have identified the inability to find talented employees (see Ref. [23]), and the lack of employee initiative and acceptance of responsibility (see Ref. [17]) to be major inhibitors for organisational performance. An additional complication is employee leakage from the industry due to open competition for skilled/Western-trained labour between economic sectors in emerging economic settings (see Ref. [20]). Given these complicating factors, this chapter seeks to contribute to the knowledge management literature by exploring one Western organisation's (i.e. Marriott International's) successful entry into the Chinese hotel industry and provide a discussion of the managerial and theoretical implications emanating from the organisation's experience in assessing and developing its knowledge management practices in this context.

3. Sample and methodology

In order to explore the knowledge management process in the Chinese hotel industry context, the case study method was adopted. This method allowed the researchers to explore an existing theoretical concept (knowledge management) in a new context (a Western organisation operating in the Chinese hospitality industry) and to refine and elucidate previously unidentified issues. To achieve this, the authors conducted a series of semi-structured interviews with senior managers in the Marriott Group's Chinese operation. The choice of Marriott was driven by three factors; the first being that it presents a revelatory case, whereby senior management can deliberate those aspects of knowledge management critical to the strategic management of its business. Secondly, Marriott represents a renowned global organisation seeking to leverage its brand into the expanding Chinese market. Finally, the researchers were able to secure access to the organisation's senior management team through a key informant, who is recognised in the industry as one of the longest serving General Managers in China. In total, twelve Marriott senior managers were recruited to provide primary data relating to the organisation's knowledge management processes in the Chinese hospitality industry. Of the twelve senior managers: three were General Managers, three were Marketing Directors (that had been working with Marriott since its entry into China in the mid-1990s), three were Human Resource Directors and three were Sales Directors.

A longitudinal approach to primary data collection was adopted whereby each respondent was interviewed four times, over a period of 4 years (i.e. 2009–2012). Given the complexity of the phenomenon, this approach was adopted for two reasons: firstly, it gave respondents the time needed to reflect on knowledge management issues idiosyncratic to the Chinese hospitality industry. Secondly, it gave the authors' time to probe evidence gathered from other sources and focus interviews on factors identified as specific to knowledge management processes in the Chinese context. The semi-structured interview questions were formulated to cover the necessary knowledge management issues, yet framed in an open-ended manner. This design provided respondents with ample scope for introspection, and the freedom to pursue and openly report on matters they considered important. In total, 46 semi-structured interviews were conducted over the 4 years, each with a duration of 60–120 min. Secondary data were sourced from historical publications pertaining to China's economic and hospitality industry development, annual reports of the Marriott group, local and international newspaper archives, and Chinese government agency publications. This collection of data from various sources provided triangulation and subsequently assisted in the aggregation, analysis, and validation of information.

A rigorous content analysis process using the five-stage protocol forwarded by Refs. [24–26] was applied to each interview transcript and all secondary data. The content analysis and the verification of the conclusions drawn were facilitated by the use of the NVIVO software package. During Stage One of the content analysis, the aims and objectives of the research were identified. During Stage Two, the interview transcripts and secondary data were converted into MS Word® format and entered into a codified NVIVO database. Stage Three comprised an interrogation of the coded data to detect any significant themes emerging with regard to knowledge management issues in Marriott's strategic management of operations in China. These emergent trends and themes provided the basis for the second round of data coding categories. Stage Four of the content analysis involved a refinement of the second-round coding results, while Stage Five involved finalisation of the research findings. These findings are discussed in the following sections, along with implications for future research in the cross-cultural knowledge management field.

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4. Marriott's knowledge management process in China's hotel industry

The second stage coding of the annual report data indicated that Marriott's knowledge management (as developed for the Chinese hotel industry) followed a five-stage process: (1) assessing the organisation's cross-cultural knowledge-base, (2) accessing domestic labour-market knowledge, (3) developing domestic labour-market/domestic employee knowledge, (4) developing domestic supply-chain knowledge, and (5) managing domestic employee satisfaction and commitment. Each of these five stages will be discussed in the following sections.

4.1. Stage 1: assessing the organisation's cross-cultural knowledge-base

During its entry stage into the Chinese hotel industry (i.e. the early 1990s), Marriott's senior management identified that a cross-cultural knowledge deficiency gap existed with regards to its Chinese operations. To address this deficiency and to simultaneously improve its image in the Chinese labour market, Marriott's senior management implemented strategies to (1) increase its capacity to understand the Chinese culture through its labour market and (2) establish its reputation as an 'employer of choice' in the Chinese hotel industry. Initially, Marriott implemented a two-tier brand reputation building and recruitment strategy; at the first-tier level, Marriott used their pool of existing domestic managers to work closely with (and gather data from) domestic hotel owners, recruitment agents and government officials regarding operational matters. At the second-tier level, Marriott used experienced expatriate managers to focus on working with the higher level national and local governments on its brand and reputation:

> *We always have a pool of well-trained and experienced managers ready to be posted anywhere in the world. The combination of this pool of foreign managers supported by our selected domestic managers is one of Marriott's strengths (Human Resources Director 3, Personal interview, 2010).*

> *… its two-tier brand [reputation] building strategy, Marriott able to depend on management capability to effectively negotiate between domestic hotel owners, governments and Marriott's head office in the United States (General Manager 1, Personal Interview, 2011).*

As part of this two-tier recruitment strategy, Marriott sourced skilled and qualified domestic workers to fill essential positions across its hotels and overcome its deficiency in terms of local cultural knowledge. The central part of this strategy was leveraging the personal networks of experienced domestic managers and using them to identify and recruit qualified and appropriately skilled workers. These personal networks comprised past work colleagues, family members and relatives, friends and government officials. Marriott's senior management also drew upon the negotiation expertise and comprehensive understanding of the domestic employment context possessed by their experienced domestic managers. These insights provided key inputs into public relations activities that were designed to promote Marriott's reputation and assist in the negotiation of employment contracts:

We have a better understanding of domestic employment regulations and what governments are trying to achieve in the labour market…in a much better position to negotiate with relevant authorities regarding employment terms and conditions (Human Director 1, Personal Interview, 2010).

Marriott realised that if it were to continually improve its reputation as an employer of choice in the Chinese labour market (and, therefore, be able to attract skilled and qualified domestic workers), it would need to continue to improve its understanding of the Chinese market and establish a competitive advantage distinct from its international competitors. To achieve this aim, the Marriott website was used as a channel to promote the company to the domestic Chinese labour market and increase its brand reputation in the domestic market:

In the last three years [2002–2005], developed seventeen international sites…to learn about different cultures, and how to tailor sites for specific markets. We're interested in understanding Chinese consumer habits and upcoming market trends (Director of User Experience, in Ref. [27]).

4.2. Stage 2: accessing domestic labour-market knowledge

During the early 1990s, the Chinese hotel industry was considered an attractive industry to work in by the domestic workforce. However, with the influx of international hotels and consistent double-digit gross domestic product growth, China developed into a highly competitive labour market for hospitality workers. As the skilled and educated workers sought more secure and lucrative careers with government departments and multinational organisations in other industries, the hotel industry was faced with ongoing skill-shortages. Marriott recognised that in order to recruit enough skilled workers, they needed to improve their domestic management expertise and knowledge (to compete with other industries for domestic talent). In order to achieve this outcome, Marriott implemented a modified version of one of their successful recruitment strategies employed in the United States during the 1960s; Marriott actively recruited veteran Chinese hotel operators from surrounding countries, such as Hong Kong and Singapore, to improve their domestic management expertise and knowledge. According to Marriott's senior management, the modified recruitment strategy enabled Marriott to effectively source many of its skilled and qualified workers from across various provinces and cities:

[Domestic] managers are all Marriott people and the first job they do is to find domestic talent, as they know the domestic market (General Manager 1, Personal Interview, 2012).

…skilled employees with good language skills are one of the most important success factors in the Chinese hotel industry today…our extensive domestic networks assist us in finding our potential associates to fill positions across different functions and in different cities (General Manager 3, Personal Interview, 2012).

In order to build on its reputation as an employer of choice, Marriott's senior management also implemented a series of strategies to promote and retain its existing experienced domestic Chinese managers. One such strategy was to provide experienced domestic managers with a distinctive career succession plan and promoting them to the position of general manager in newly opened hotels in second and third-tier cities. This succession strategy was designed to leverage their experienced domestic managers' expertise, knowledge and networks to serve the emerging domestic segments in the second and third-tier cities and provide a retention incentive:

Our US managers not very effective in communicating with our Chinese key stakeholders [suppliers, hotel owners, and domestic government officials], needed domestic managers who speak Chinese and understand local culture to work closely with stakeholders to achieve desired outcomes for all parties (Human Resources Director 1, Personal Interview, 2009).

Marriott uses the second-tier cities as part of their domestic executive promotion strategy…it gives Marriott the domestic representation it needs in these cities, it also acts as an incentive to retain managers and to increase staff loyalty (Key Informant 1, Personal Interview, 2012).

4.3. Stage 3: developing domestic labour-market/domestic employee knowledge

During the early stages of its operation in China, Marriott's senior management found that the level of trust and productivity between the domestic employees and management was substantially lower in China than in the US. From their experience, Marriott recognised that if they were to successfully build trust and productive relationships with their domestic employees, they needed to gain their loyalty through organisational culture-based training and development initiatives. Marriott leveraged their experienced managers to work closely with employees (whom they term 'associates') to achieve required organisational standards and at the same time, to instil its organisational culture of the 'Marriott's Way':

…in the early 1990s, hotel employees had no clue and no ideas of how to handle their own grooming and personal hygiene, not to mention providing quality service to guests… started with very basic training to get them up to our minimal standards, then slowly introduced standard operating procedures (General Manager 1, Personal Interview, 2009).

…our domestic associates needed to be shown how to perform tasks and to be reminded how to work within the boundaries of procedures and processes (Human Resources Director 2, Personal Interview, 2010).

According to Marriott, the 'Marriott's Way' enabled the company to build strong relationships with its employees that encouraged them to share tacit knowledge across the company's structure:

Our competitive advantage is that we care about our people, our associates…the "Marriott's Way" is the core capability to our success for over eighty years, based on the philosophy of if you treat your associates well, in turn they will treat your customers well (General Manager 2, Personal Interview, 2011).

Overall, good experienced managers are still looked upon as the person who set the brand standards in a country where human capital is still at a development stage and the "Marriott's Way" is still very effective in associates' training and development. Hopefully, we can keep them for as long as possible before our competitors poach them away (General Manager 1, Personal Interview, 2012).

Marriott attempted to reinforce a strong bond with its domestic Chinese employees by conducting a series of ongoing targeted training and development programs throughout their careers. For example, an average 78 h of on-the-job training (plus another 34 h of professional development) is provided to each associate every year; for more senior employees, Marriott provided a specialised career and training paths to ensure they were prepared for future management positions:

…in the 1990s and even in the early 2000s investing in your employees and treating them well were not common management practices in China…Marriott is perceived as a very good employer in the Chinese market (Human Resources Director 1, Personal Interview, 2012).

Marriott is very good with in-house training programs….we spending around US$800.00 per manager per year in training expense back in the early 2000s…we value our skilled associates and in China where hospitality skills are very hard to find, we use our in-house training programs to increase our available pool of skilled human resources (General Manager 1, Personal Interview, 2011).

4.4. Stage 4: developing domestic supply-chain knowledge

To continually and systematically promote Marriott as an employer of choice within the labour market, its senior management actively sought to engage with supply-chain members of the hospitality industry. For example, Marriott entered into arrangements with domestic hospitality training schools across China (as well as selectively inviting suitable candidates to participate in their internship program). Marriott's senior management state that their talent building campaigns focused on both the internal and external labour markets have provided them with a skilled labour force providing consistent delivery of its brand promises:

We [Marriott] work closely with domestic hospitality training schools in China…we get good students from some of these schools…our in-house training programs help students to get up to our standards pretty quickly once they have started with us (Human Resources Director 3, Personal Interview, 2011).

Marriott also promoted the 'Marriott's Way' organisational culture (on their "Destination Marriott" career website) to local supply companies to reinforce the quality standards required by the company. The 'Destination Marriott' career website was designed to assist potential employees to apply for the various careers available at Marriott worldwide and to highlight the various benefits and rewards enjoyed by Marriott's associates. For the more senior positions within Marriott, senior management continued to leverage their domestic managers' networks to seek out and appoint experienced managers from other industry sectors, as well as from direct competitors.

A fluent Mandarin speaking expatriate manager is still a rare resource in today's market, but we commonly transfer them across our hotels internally….one of our immediate issues is finding enough English speaking associates…English language skills are still considered to be low in China and that causes us concern with regard to our service quality level (Human Resources Director 1, Personal Interview, 2011).

The country [China] and its cities can build the world's most outstanding or tallest buildings…but the skills level is still very much behind most of the developed markets (General Manager 5, Personal Interview, 2011).

As part of Marriott's strategy in China, its senior management continued to actively seek high growth opportunities in second and third-tier cities outside the major urban areas. These cities are located outside key gateway cities such as Shanghai and Beijing in different provinces across China. The local governments, supply chain members and customers were the three major market segments identified in these second and third-tier cities. Marriott's senior management recognised that if they were to compete effectively in these emerging market segments, they needed to communicate key messages to these segments which focussed on how the company could better serve and satisfy their needs. To achieve this, Marriott implemented a modified recruitment strategy that they had employed when first expanding into China (i.e. by appointing experienced senior domestic managers to work closely with these three major emerging market segments in second and third-tier cities):

Our growth has been fast in emerging markets like China, but we have to do things differently to succeed. Manpower is an issue. Finding experienced associates is difficult….Awareness is an issue, so public relations and local marketing efforts are important to establish the brand (Senior Vice President of International Marketing, in Ref. [28]).

…we get relocated to second-tier cities to manage our major clients [domestic governments and key stakeholders] and to train our management team to ensure our domestic customers get the services they want (General Manager 4, Personal Interview, 2009).

4.5. Stage 5: managing domestic employee satisfaction and commitment

As skill shortages continued to be one of the major challenges faced by the hotel industry in China, Marriott implemented a number of strategies designed to build staff loyalty with both its internal and external labour markets. Marriott's senior management implemented internal employment strategies which were designed to promote and retain experienced domestic managers. Further, as part of their internal staff loyalty building campaigns in China, a variety of in-house multi-disciplinary training and development programs were implemented which were designed to up skill all associates. For example, Marriott continued to develop and promote their experienced domestic female managers to senior management positions as part of its Global Diversity and Inclusion policy and Women's Leadership Development Initiative:

Human capital capabilities are becoming more important than having a western manager…western management strategy no longer requires a certain number of foreigners working as staff to operate in China….Foreign managers no longer have the monopoly of first pick of all the good positions (Human Resources Director 3, Personal Interview, 2012).

…with good support and training from Marriott's international office, we able to achieve good results from some of the newly implemented processes and systems in areas such as hotel operation standards, overall food and beverage offerings and management and general customer service…but up-skilling our associates took longer…a continuous process (General Manager 1, Personal Interview, 2010).

As previously discussed, according to Marriott's senior management, the use of action and policies designed to communicate and instil the ethos of "Marriott's Way" enabled the company to build productive relationships with its associates as well as to motivate them to improve their performance:

…if you see some strangers talking to your top managers, you can be certain that your top managers are being poached by your competitors (General Manager 4, Personal Interview, 2011).

It is becoming more difficult to employ and retain younger, quality staff because there are so many opportunities now open to young people in China (Director of User Experience, in Ref. [28]).

To maintain its market leadership position in China, Marriott continued to strategically build and market their brand as the employer of choice in the domestic market. Being the employer of choice enabled Marriott to select and recruit a skilled workforce to maintain and deliver its quality service level and to combat protected domestic competitors:

…the one child policy has contributed to the current skill-shortage situation in China. However, hotels are also competing with the domestic government departments for skilled employees, as the domestic governments are now providing benefits such as welfare, less hours and higher salaries to attract talents (Human Resources Director 3, Personal Interview, 2009).

Marriott was awarded the top employer in China by the Corporate Research Foundation Institute in 2012 (Human Resources Director 1, Personal Interview, 2012).

Marriott builds on its success by using initial strategy coupled with domestic experience and learning…Marriott's new processes and services in China are blended with domestic culture to create a unique quality standard (General Manager 1, Personal interview, 2012).

5. Concluding remarks

Given the results of this qualitative analysis, we propose the following five-stage knowledge management process model (see **Table 1**) for the emerging Chinese hotel industry. This process model illustrates Marriott's experience in assessing its knowledge management deficiencies in its Chinese operations, and the human resource/strategic management practices used to address them.

Stage One	Assessing the organisation's cross-cultural knowledge-base
Stage Two	Accessing domestic labour-market knowledge
Stage Three	Developing domestic labour-market/domestic employee knowledge
Stage Four	Developing domestic supply-chain knowledge
Stage Five	Managing domestic employee satisfaction and commitment

Table 1. A knowledge management process model for the Chinese hotel industry.

In terms of assessing the organisation's cross-cultural knowledge base, Marriott utilised its human resource inventory systems not only to audit the store of human resources it controlled in its Chinese hotel operations but also to gauge the extent to which the organisation had the capacity to access the tacit knowledge it possessed. Strategically, therefore, the initial stage of the knowledge management process required not only an understanding of what information/knowledge deficiencies the organisation possessed, but also what data-gathering deficiencies it had in this regard. In terms of accessing domestic labour-market knowledge, Marriott recognised the importance of its recruitment and selection processes; in particular, it recognised that it had to adapt its recruitment and selection processes (that had been effective in the Western context) to account for the idiosyncrasies of the Chinese labour market. Strategically, Marriott recognised the need to establish itself as an "employer of choice" within the Chinese

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hotel industry to attract, motivate and retain the highest quality employees. In terms of developing its domestic labour-market/domestic employee knowledge, Marriott sought to develop strong employee-employer relationships with its domestic Chinese employees via its training and development programs. In addition to the organisation's standard programs (which focused on improving operational performance), the company also sought to improve the levels of trust in the organisation through training and development programs focused on indoctrination into the organisation's culture. In terms of developing domestic supply-chain knowledge, Marriott ensured that it maintained dynamic and mutually beneficial relationships with domestic suppliers, educational institutions and government departments. Lastly, Marriott found that one of the most effective ways of protecting the store of knowledge they had generated in the Chinese hotel industry was to take measures to ensure that their domestic employees were satisfied with their employment relationship and reported high levels of organisational commitment. Indeed, in the face of intense competition from within China's expanding hotel industry (and from employers in other industry sectors), the raising of the 'exit barriers' for their domestic employees represented a strategic priority.

Given these findings and the potential implications for Western organisations' knowledge management practices within the Chinese hospitality industry, we suggest the following avenues for future cross-cultural knowledge management research within the Chinese context (and emerging Asian economies generally): firstly, we believe that there needs to be further in-depth analysis of the link between knowledge management practices and 'employer-of-choice' and 'industry-of-choice' concepts within the Chinese hospitality/emerging market context. A finer-grained understanding of knowledge management practices within China may enable Western organisations to become employers-of-choice and foster a strong organisational culture. For example, at an organisational level such investigation could inform the design of superior human resource and employer-marketing strategies that communicate the expected international standards of skill and behaviour to both existing and potential domestic employees. At an industry level, this research suggests the need for industry-wide marketing efforts formulated to promote hospitality as an industry of choice providing valuable long-term career options. The absence of such industry-based marketing efforts may result in the hospitality industry being seen as nothing more than a training ground for any alternate industry better able to market their career opportunities. It is anticipated that outputs from this research agenda would not only benefit both domestic operators looking to improve their competitive stance within this highly dynamic market and international hospitality operators engaged in (or considering) investment in the Chinese market, but importantly, it would contribute valuable insights and extend the current store of knowledge management theory.

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Chapter 14

Widening the Understanding of Risk Approaches by Comparing Definitions from Different Disciplines

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Abstract

The aim of this chapter is to critically reflect definitions of hazard, risk, and risk perception and their assessments used in different scientific disciplines and give examples of the potential implications for scientific discussions, knowledge management, and risk communication. Scientists with backgrounds in public health, psychology, environmental health, occupational health, engineering, sociology, and medicine were asked for a definition of hazard, risk, risk assessment, and risk perception seen from their specific scientific disciplines. Hazard is generally seen as an adverse event or condition. For most risk definitions, probability and severity are important aspects. Often a quantification of risk is desired, whereas risk perception is seen as a subjective appraisal and a cognitive construct. As risk perceptions are based on a combination of knowledge and individual values and affects, it may not provide a reliable guidance for risk management decisions on a societal level. Discipline differences are mainly connected to terminology and interpretation of key concepts, but the differences are based on different tasks and perspectives. For dealing with controversies in science across disciplines, an acceptance and appreciation of terminology and perspectives from different scientific disciplines are needed to ensure a transparent risk assessment process.

Keywords: risk, hazard, risk perception, risk assessment, multidisciplinary

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1. Introduction

The aim of this chapter is to critically reflect on definitions used in different disciplines during the procedure of risk management. Knowledge management is an important part of risk management and can be defined as a collaborative and integrated approach to the creation, capture, organization, access, and use of an intellectual asset [1]. This definition underlines the importance of knowledge management in risk management when different disciplines work together to identify the hazard, assess the risk, and finally predict mitigation mechanism [2]. To facilitate communication between different disciplines, we compared how risk management was approached in different disciplines. We recognized that harmonization of these approaches or definitions would be contraproductive as it would undermine the variety of knowledge and the tasks and perspectives of the different disciplines during the process of risk management. We, therefore, suggest to widen the understanding through appreciation of these differences between disciplines and not to harmonize definitions.

2. Method

The following disciplines were involved: public health, psychology, environmental health, occupational health, engineering, sociology, and medicine. The selection was made to get a wide variety of disciplines working in different areas but all with a link to risk and risk management. All selected participants have coauthored this chapter. They were recognized experts of risk-related disciplines. They expressed their opinions and synthetized conclusion in a reiterative process. Each scientist was asked to present his/her own views on the given topics. The following questions were developed to get comparable responses from the participants: What is hazard and risk? How is hazard/risk assessed and which practice of hazard identification and risk assessment is used? and How is risk perception defined? The results were summarized, commented, and discussed by all authors. This method is appropriate as it allows and discusses different opinions. The aim was not to agree on one set of definitions, but critically reflect on the discipline-related definitions of hazard, risk, and risk perception, and their assessments.

3. Introduction in risk research

Risk is human being's attempt to understand and deal with life's dangers [3]. Thus, the main reason for talking about hazard and risk is to have a sufficiently accurate perception of the situation to make decisions and manage situations in a manner minimizing the probability of adverse effects. In some instances, these decisions are strictly personal and have implications for the individual only, but in other cases, the decision may have implications for larger groups of people, even for the whole population, or for the environment. Disciplines predominantly dealing with numbers and quantifications define risks based on a calculable phenomenon; biological, natural, and technological scientists define risks as objective reality (mostly also in quantitative ways); sociologists view it as a social and cultural construct, whereas psychology looks at it as a cognitive and behavioral phenomenon. Each discipline

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commonly utilizes their own terms about risks, while keeping different perspectives on what it is [4]. Also, risk communication is hampered by this semantic ambiguity not only in the communication between stakeholders and lay people, but also between different scientific disciplines working together to manage risk [4, 5].

Knowledge management plays an important role in risk issues, for example risk analysis and risk regulations, and knowledge transfer and knowledge sharing are important parts in risk communication. Explicit knowledge is easier to communicate which clarifies the particular problem with newly emerging risks, where explicit or generalized knowledge is unfortunately not available [6].

4. Knowledge about hazard and risk

In the historical perspective, no notion of risk is to be found in traditional cultures: preindustrial hazards or dangers like famines, plagues, or natural disasters were experienced as pregiven. They came from "others"—gods, nature, or demons [7]. However, when carefully reinterpreting the historical perspective, it appears that the notion of risk was already there, albeit implicitly, because one does not have to know the origin of a hazard in order to apply mitigation measures to avoid harm and suffering. One could even argue that sacrificing a virgin to please the god to avoid plagues or nature catastrophes involved an understanding and/or management of a hazard. It may well be that preventive actions taken today will in the future be regarded as similarly useless and surprisingly little evidence-based as sacrificing virgins to prevent plagues is regarded today.

In the historical perspective, first with the beginning of societal attempts to control risk, and particularly with the idea of steering toward a future of predictable security, the consequences of risk became political issues. Thus, it is a societal intervention—in the form of decision-making attempts to transform incalculable hazards into calculable risks.

Nowadays, it is necessary to separate the notions of risk and hazard. Knowledge about the hazard should be present before labeling any event as "risky." Hazard can be defined as an event [8] but it can also be considered as a condition or factor with a potential for causing an event, thus, as a synonym to danger. In this way, hazard is a qualitative term that tells whether exposure to a chemical or drug or certain behavior such as physical inactivity has the potential to cause an undesirable outcome on human health or other things we value, e.g., the environment. The evaluation of an event as a hazard is a mix of objective and subjective data, with the latter depending on individual or at least cultural preferences. The scientific component of the evaluation of the hazard aims to be objective and with a dichotomous (qualitative) outcome, namely being hazardous or not. Scientific uncertainty adds to complexity, if for instance studies on the carcinogenicity of a chemical are controversial, which may add some subjective elements (different researchers interpreting the same studies in different ways) and a categorical scale replacing the dichotomous one to express the level of scientific uncertainty. Nevertheless, researchers then continue to collect further evidence until ultimately the hazard can be established or rejected. Objectively, hazards can be fatal or life-threatening, leading to disability or only to temporary discomfort; hence, classified according to dimensions of impact on life and of reversibility. The assessment of severity is a quantitative part of hazard evaluation, and the subjective acceptance is the qualitative part. It is subjective because it is the individual's own judgment reflecting their values and preferences.

On the basis of these facts, a dichotomous hazard will be transformed into a quantitative risk term [9]. In all disciplines, there are two most known concepts of risk definition: the probability of occurrence and severity of the undesirable outcome. Under this approach, risk is the probability function that reflects in quantitative terms the likelihood that a hazard manifests itself while as we have alluded to earlier, the undesirable outcome is the hazard.

5. Dealing with knowledge during risk assessment

Normally, scientific risk assessment should be performed before labeling any event as "risky." Identification of a hazard is the first step in the risk assessment process. Before identifying the hazard, potential disease or outcome clusters need to be found. For example, before 1989 only one disease outbreak per year was identified in a population of over 60 million people in the Philippines. A surveillance system was set up in 1989 and in 1995 more than 80 disease outbreaks were identified [10]. This means that risks cannot be described as such unless there are procedures to identify or measure outcome clusters or hazards (perceived or real) and our vulnerability to them. Another point worth mentioning is that if you do not know the hazard, you cannot perceive the related risk. The second stage of the risk assessment process entails an estimate of the associated level and extent of potential harm which together with the expected probability of an unwanted event are important, because the evaluation of the acceptability of the options for mitigating the identified risk will usually depend on how much harm the hazard we identify can be estimated to make. For the assessment procedure, two forms of assessment are discussed in detail: the technical procedure and the observational approach.

In the technical procedure like *engineering*, material properties, technical performances, or technical measurements are based on tests or experiments. The results are countable from numerous versions of repeated experiments. The experimental approach allows estimating a small confidence interval considering probabilistic calculations. One example is the overall construction procedure in the design of the roof for a building. First, the total design load on the roof must be computed. The different loads could typically be: self-weight, wind load, and snow load. A design load can then be computed as the sum of these loads. However, as the loads are stochastic in nature, each load is multiplied by a coefficient that accounts for the lower probability that all loads are maximal at the same time. Strengthening the construction is intended to reduce the risk of failure, but will never eliminate it, and the design of a construction is, therefore, a balance between strength and acceptable risk for failure.

In the observational approaches of *epidemiological and public health* studies, the outcomes of interest are often death or diseases like cancer, myocardial infarction, or infectious diseases. There may be several causes for having that outcome and several hazards may need to be considered for the risk assessment. One cause hardly ever leads to only one single outcome. Stress at work, for example, is a risk factor for myocardial infarction. But other risk factors like hypertension, overweight, unhealthy blood lipid profile, or lack of physical activity are also risk factors for myocardial infarction and all of them may be related to stress at work. On the other hand, overweight has more than one adverse consequence, including a higher risk of some cancers or diabetes. The complexity is topped by the inherent and much higher heterogeneity in susceptibility to an adverse outcome in a population of humans than among construction parts in engineering. Risk assessment is still possible; and for the quantitative estimation of absolute or relative risk, epidemiological measures are used by calculating disease rate and comparing rates of exposed and unexposed groups [11].

Risk assessment in *occupational health* is traditionally based on a four-stage process: hazard identification, exposure assessment, dose-response assessment, and risk characterization. However, risk assessment is typically put into the broader context of managing occupational risks and often includes ongoing monitoring and evaluation of the effectiveness of any initiative to decrease risk to an acceptable level. An acceptable risk level is defined not solely by health arguments but, especially in the case of carcinogenic agents that have stochastic health effects, such as hexavalent chromium exposure in electroplating causing lung cancer, also includes considerations on financial and technical feasibility. Since the main reason of risk assessment is to determine what, if any, measures should be taken by the employer to prevent adverse health effects in workers, it is common to integrate risk assessment and risk management in occupational health practice [12, 13]. Occupational health and safety is, therefore, one of the most regulated areas in terms of legal requirements for risk assessment [14].

Medical and environmental risk assessments to guide risk management become increasingly challenging, when certain exposures have both risks and benefits, or when the hazard is intended or inherent in a specific scenario. Medical application is a common example of balancing benefit and harm. The use of computed tomography (CT) with its high resolution can clearly lead to better diagnosis and planning of treatment and then becomes lifesaving, but given its exposure to ionizing radiation, a well-known carcinogen, endorses recommendations that unnecessary examinations need to be avoided and optimal dose adjustment, for example for children, is to be applied [15]. However, there may clearly be a huge risk related to avoiding the hazard of undergoing a CT examination, for instance, due to a delayed detection of cancer. Also, in environmental health not all hazards are entirely avoidable, but risk assessment can guide policy decisions insofar as where to set priorities for an acceptable level of risk and of how much risks can be reduced.

6. Dealing with knowledge in risk perception

Identifying hazard and severity of a damage has direct consequences for risk perception: "Perception is a process by which individuals select, organize and interpret stimuli to generate a coherent and meaningful picture" [16]. In contrast to risk assessment, which can have a scientific basis with a structure and procedures, risk perception is subjective, involves affects and there are many factors that can influence the way a risk is perceived.

Literally, risk cannot be perceived. Therefore, *psychological research* focusing on risk perception explores how judgments about the riskiness of an event, substance, agent, or technology are made in which cognitive, affective, and moral processes are involved. Although the first risk perception studies were conducted more than 50 years ago, the concept of "perceived risk" only began to gain popularity in the mid-1970s [17]. Slovic's approach known as the psychometric paradigm aims at the "quantitative description of the cognitive and evaluative mental structure of risk and its determinants" [18]. His research focuses on "what people mean when they say that something is (or is not) 'risky', and to determine what factors underlie those perceptions" [19]. It focuses on the beliefs laypersons hold with regard to how chemicals cause health risks. For instance, laypersons are less sensitive to dose-response relationships compared to toxicologists suggesting that laypersons do not differentiate between the qualitative hazard and the quantitative risk, and therefore do not see risk as something that can be increased or reduced due to interventions or changes in exposure levels. This misconception is a continuing challenge in medical risk communication because most interventions, especially health promoting interventions, reduce but do not eliminate risks. Risk of an adverse event can generally only be reduced, but specific risks related to a certain hazard might be eliminated if the hazard is eliminated, though it may take some time. If you quit smoking, after 20 smokeless years, you will have vascular disease mortality comparable with never smokers [20], but like the rest of the population you still may die of vascular disease because of other hazards leading to the same adverse event.

From the rational point of view, to evaluate a risk, you need to know something about the hazard, assess probabilities as well as consequences of the negative outcome. In fact, however, intuitive risk judgment has a strong affective component, and it is associated with moral concerns and may neglect any probability consideration in risk appraisal. Doing something about your personal risk depends on how you understand the risk. This is a subjective exercise including the compilation of the more objective information on hazard and risk in combination with individual assessments on severity of risk and potential side effects, and last but not least on personal values and preferences.

From the *sociological point* of view, probabilistic risk assessment alone is unsociological. Sociological understanding of risk needs additional social, cultural, and historical contexts. Sociology explains how risks are handled in a society and might thereby clarify potential public misperceptions of risk. When technically defined risks are not contextually generated, public risks understanding will be defined as wrong, if it differs from the factual experts' opinion. From the sociological point of view, it is an error not considering contextual factors like traditions, culture, norms, etc. even though that does not mean that the factual knowledge is wrong. The role of sociology, when it comes to risk, is to explain why errors in dealing with risk in a society occur but not the truth behind them. Implication of this perspective deals with risk communication. The factual knowledge about specific risks needs to be understood and communicated. Sociology emphasizes that when dealing with communication it is important to consider different segments of the public understanding of risks to avoid misperception. Sociological amplification of risk explains how risks and events or accidents interact with psychological, social, institutional, and cultural processes, and often increase or decrease risk perception, public concern, and thereby risk behavior. The objective risk assessment provides information about the risk, but for a sociologist the task is to analyze how this information is understood and reflected in practical social actions in the public. Risks and hazards are sociocultural events and they are not only neutral facts that generate specific signals. It should be considered that also an assessment of a risk can be seen as a construction of a risk and hazard. This implies for sociology to see and explain risk as an overall product of social and cultural processes [21].

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7. Knowledge management considering different disciplines

All risk concepts of the different disciplines have one element in common; the distinction between reality and uncertainty. **Figure 1** illustrates the tasks of the different disciplines in the process of risk management. Engineering and occupational health focuses on hazard and risk identification (explicit knowledge). Sociology looks at the risk on humans and society (social knowledge). Psychology works with risk perception and manages risk on a personal level (individual knowledge). The latter two disciplines rely on the first to identify and describe risk as objective as possible, and the former depend on the psychology and sociology to translate their observations and calculations into something usable for individuals and society. Therefore, it is essential that these disciplines keep their definition and taxonomy of risk knowledge. However, interaction and knowledge sharing is important for the overall risk management process.

The engineer tells the occupational hygienist technical details for the risk assessment; the occupational hygienist communicate risk assessment results to medicine to allow the best treatment for the exposed individual; the doctor needs to explain the information to the patient. Finally, the patient should perceive the risk in that manner to do the right action. Already for a straightforward treatment, a long chain of knowledge transfer needs to work. However, risk

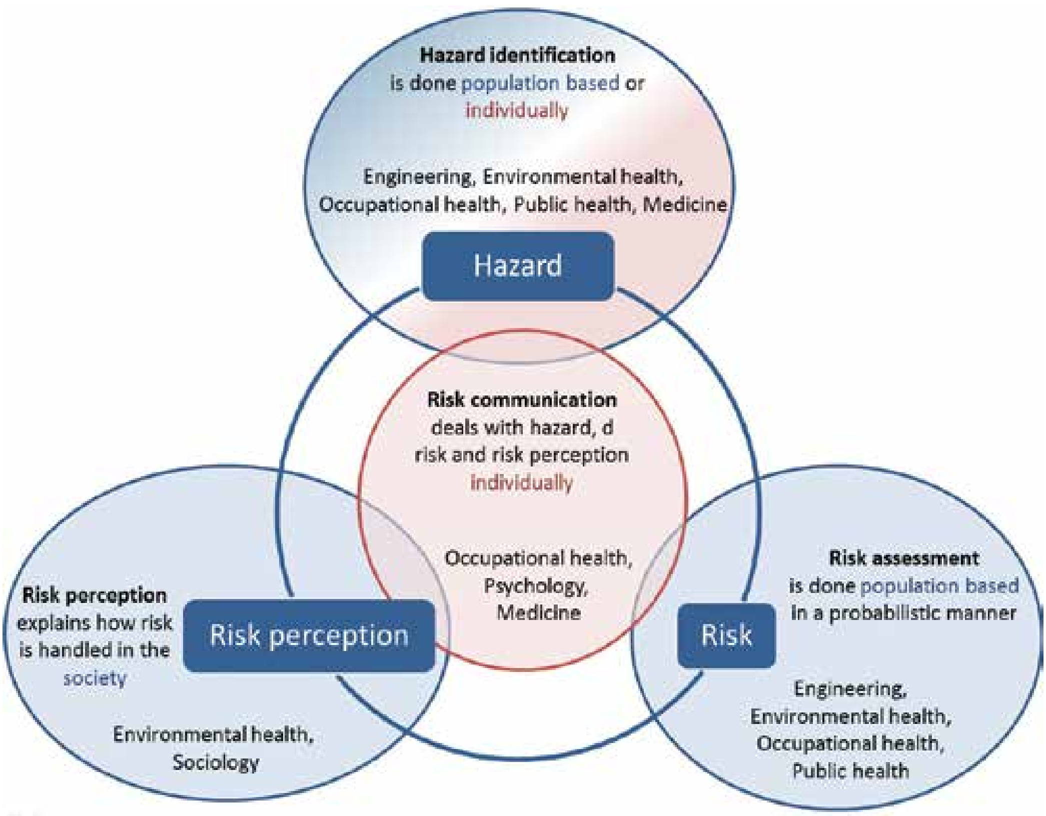

Figure 1. Concepts of considered disciplines while defining risk.

assessment and management to reduce the risks is rarely straightforward, especially when scientific uncertainty and, at the same time, competing benefits and risks come into play. A recent example is management of potential risks related to the use of electronic cigarettes [22, 23], for which on the one hand, long-term adverse health effects are expected, but on the other hand, electronic cigarettes are also expected to be safer than conventional cigarettes to facilitate to quit smoking. Public health researchers mainly request strict regulation to minimize potential future health effects and avoiding electronic cigarettes to become a new socially acceptable way of smoking, especially among youngsters, and thereby torpedoing the efforts for achieving a smoke-free environment.

Therefore, it is very important to understand underlying terminology from different disciplines. But even more important is to understand their tasks and their views on the topic. For example, the role of sociology "to explain why errors occur but not the truth behind them" clarifies that communication is more important for the sociological perspective than the risk assessment procedure itself, even though both parts are necessary for the overall risk management. If these different views are not taken into account, conflicts and misunderstandings can happen.

In knowledge management, knowledge creation tools were often criticized. One critique is that most tools hide or eliminate important contextual information [24]. Furthermore, it could be shown that individual communication skills have more importance for perceived quality of risk knowledge sharing than the used technical systems [6]. Additionally, lack of time or awareness for the importance of sharing knowledge, missing communication skills, as well as differences in education and culture are seen as the most important barriers for interdisciplinary work [25]. In our opinion, collaborating researchers need to understand their used terms but also have to understand why there are differences. It is very important to know the terminology, tasks, and perspectives from different disciplines. Different terminology can be dealt with in a wiki development, a website that provides collaborative work on terminologies. However, further research is necessary on how to deal with different discipline-related aims or perspectives in the process of risk management.

Most differences between the disciplines are dealing with risk assessment. All disciplines have the theoretical wish to estimate the real quantitative risk and all disciplines agree that this is difficult to achieve or sometimes not even possible. Disciplines typically using probabilistic approaches, such as engineering or occupational health, define risks mathematically and more objectively. Consequently, these disciplines emphasize the importance of external validity and standardized procedures. Observational research is often connected with a black box phenomenon and is sometimes evaluated as giving less support to evidence than experiments. The presentation of results is more complex and difficult to understand and to trust. Consequently, in these disciplines, problems in objectivity and communication are more obvious. The cognitive approach seen in psychology and social sciences focuses more on the perception of risk. They evaluate the understanding of different risk presentations and look into emotions and cognitive processes while collecting risk assessment information. Due to the fact that risk assessment is seen as less objective, risks are seen as expectations or predictions. However, all disciplines agree that risk assessment should be as objective as possible. To allow for this, evidence-based information must be used to identify hazards and to assess dose-response relationships, while exposure assessment should be based on documented, preferably quantitative, measurable, and representative data.

8. Conclusion

There is a broad common denominator between the disciplines; hazard is a negative event or condition; for most risk definitions, probability and severity of the risks are important; and finally risk perception is seen as subjective and a mental construct. Risk assessment should be evidence-based, preferably quantitative, measurable, and based on representative data. Assessment of concerns and perceptions is important as well but should be done separately.

Differences can be seen with regard to risk assessment between disciplines with cognitive and probabilistic approaches. However, differences are connected to the interpretation and terminology but not to procedures. Coping with scientific controversies is an important factor in risk management. Different scientific institutions often come to different conclusions and it is easy to select a specific opinion that supports only one view of risk. A transparent risk assessment framework considering different scientific perspectives is important to deal with controversies in risk science.

Knowledge management in risk management needs to account for different use of terminologies by different disciplines. It is important to consider the diversity of tasks and perspectives of various fields when defining terminologies and distributing work. A transparent risk assessment process can only be ensured with an acceptance and appreciation of terminologies and perspectives from different disciplines.

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Knowledge management (KM) has become an important business strategy in an era of accelerated globalization, digitalization, and servitization of products and services. Maximizing the use of organizational resources becomes fundamental for continuous growth and prosperity. Organizations of various kinds such as resource-based organizations, product-based organizations, as well as knowledge-intensive service-oriented organizations require specific policies and support services to improve the knowledge management in their respective organizations. Knowledge Management Strategies and Applications focuses on the way organizations can create knowledge, share existing or new knowledge, and disseminate them among the stakeholders, most importantly among the employees, managers, customers, and suppliers. The selected topics are drawn from several fields of studies and give a multidisciplinary outlook. The book will be interesting not only for the researchers and students but also for the managers who want to improve knowledge sharing and innovation capabilities in their organizations.

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