Improving Board Knowledge with Information and Communication Technologies

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Abstract: There is increased pressure for a more active role in corporate directors' oversight and several surveys are reporting that directors still do not have the necessary information and knowledge to help them fulfill their emerging roles and responsibilities. These factors have created an urgent need for organizations to examine their board's knowledge deficiencies and find adequate solutions. Although information and communication technologies (ICT) have the potential to dramatically improve the ability of boards to identify, acquire, analyze and act on the most relevant knowledge, they remain under studied and underused. The objective of this paper is to develop some propositions on the way boards of directors can potentially improve their decision making process through various knowledge strategies supported by information and communication technology. To do so, we perform a "knowledge audit" of boards based on a review of the literature on corporate board information and decision making limitations. Then we relate these problems to the literature on ICT for potential solutions, following a design science research methodology. We also describe the current commercial board portal tools that have emerged to support the work of corporate directors. Our results can provide guidance to companies and their boards wishing to implement a knowledge strategy that addresses board widespread problems such as information asymmetry, information overload, and groupthink.

Keywords: Board of directors, Knowledge strategy, Information and communication technology, Board information, Board portals.

1. Introduction

In the last 20 years, securities regulators around the world have established governance requirements that entail significant changes regarding the composition and the responsibilities of corporate boards. Indeed, while corporate directors typically focussed on monitoring management, they are now expected to assume an advisory role by participating in strategy formulation and implementation (Adams and Ferreira, 2007; Brown, 2015; Pugliese et al., 2009). Boards are also encouraged to have a majority of independent directors (Spencer Stuart, 2016). Since independent directors do not necessarily possess the same industry-specific or organization-specific knowledge as non-independent directors and executive managers do, they can be at a disadvantage to really understand the reality of their organization and industry (Hemphill and Laurence, 2014). Studies grounded in the agency theory perspective typically refer to this imbalance as "information asymmetry".

Hence, in these contemporary board conditions, members' knowledge deficiencies can have a negative impact on their ability to provide sound advice and to monitor the organization's activities. Furthermore, they can be exposed to liability for their inability to exercise due diligence, i.e. "making the appropriate inquiries, reviewing the documentation provided to them, ensuring that appropriate controls or procedures are in place, consulting experts when necessary and giving thoughtful consideration to issues" (Osler et al, 2014). Arbitrarily increasing the information provided to board members is not a solution as it can cause greater problems such as information overload. Undoubtedly, the efficiency of boards and the effectiveness of their decisions are highly dependent on the nature and quality of information they receive or have access to, through management or outside sources (Brennan et al., 2016; Zhang et al., 2015). While information and communication technology (ICT) has facilitated the flow of information, the extent, nature and quality of the information provided to corporate directors are still judged as insufficient and unsatisfactory (Bhagat, 2015; Thomas et al., 2009).

Several studies have demonstrated that efforts aimed at reducing information asymmetry (such as increasing the number and length of board meetings) do have a positive impact on board performance (Zhang, 2010; Zhu et al. 2016). Although the sensitive nature of board information has raised important accessibility barriers for researchers, some studies have focused on the actual information boards have at their disposal (Johanson,

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2008; Roy, 2011; Rutherford and Buchholtz, 2007; Zhu, 2016). While these studies have certainly provided valuable insights into information-related issues and board effectiveness, there remains a strong need for a comprehensive approach that will both help identify specific board knowledge-related problems and determine how they can be addressed. Also, ICT can dramatically improve the ability to identify, acquire, analyze and act on the most relevant knowledge, but such benefits remain under examined and under used in the context of boards of directors (Thomas et al., 2009). The objective of this paper is to present an overview of board knowledge related problems and to propose knowledge strategies supported by ICT that can be put forth to improve the board decision-making processes. Specifically, the paper attempts to provide guidance to directors and managers seeking to increase the board's knowledge capital and to improve its effectiveness.

In section 2, we present the knowledge management (KM) concepts we will build upon to examine boards' decision making process and due diligence role. In sections 3 and 4, we respectively describe our methodology and recount a "knowledge audit" (KA) of board knowledge-related problems mostly found in the governance and group decision making literature. For each of these problem categories, we highlight how knowledge strategies and ICT solutions proposed in the information management, knowledge management, and decision-making literature can be adapted to the context of corporate boards. In section 5,we review existing commercial board portal solutions that have emerged in an attempt to improve board efficiency.

2. Knowledge Management Perspective of Boards

Lindblom and Tikkanen (2010) consider KM as ''a conscious strategy of getting the right knowledge to the right people at the right time and helping people share and put information into action in ways that will improve organizational competitiveness''. The goal is to ensure that people can make the very best decisions as business problems arise (Guptill, 2005; Perrott, 2007). Although past studies have mostly looked at the "information" provided to board members, it is clear that a "knowledge" perspective is necessary to fully address their capacity to understand the complexities of the decision environment. García-Álvarez (2015) suggested that the examination of the following four processes are essential to identify and potentially solve knowledge related problems: socialization, externalization, internalization and combination.

Socialization: Through this process, tacit knowledge is passed on to form part of other tacit knowledge. In other words, it is based on the understanding and assimilation of tacit knowledge, derived from the interaction among people, mainly through social exchange. In the context of corporate boards, it is the process through which board members acquire new knowledge about the company through direct exchange with experts, employees or other board members.

Externalization: This process relates to the transformation from tacit to explicit knowledge. Therefore, the objective is to make tacit knowledge explicit by means of any type of medium that would allow other people to acquire it, such as language or other formal representations. For corporate boards, this could entail encoding specific company knowledge in order to be frequently and easily accessed by board members when they need it.

Internalization: This refers to a process where explicit knowledge becomes tacit. In this case, new knowledge from external sources is integrated to become one's own knowledge. In other words, the process permits acquiring new knowledge and learning from available information. For example, when board members consult company information that is presented in a way that is easy to understand, it will enrich their perspective and subsequently improve the quality of their decisions.

Combination: This last process refers to moving from one type of explicit knowledge to another. It is based on the exchange, association and structuring of explicit knowledge from different sources, facilitating the creation of new knowledge. For example, when explicit knowledge of a company is combined and processed to extract information, its value to board members is enhanced.

These four processes form the basis for knowledge management strategies that can impact board knowledge and its ability to efficiently assume its role. It also identifies avenues that should be explored to provide relevant knowledge and ICT solutions. The identification of KM strategies to optimize board knowledge requires a good understanding of their specific needs which can be done through a knowledge audit.

3. Methodology

Our analysis is consistent with a design science research (DSR) methodology that aims to create better solutions in the form of more efficient and effective products, processes, services, technologies, or ideas. This type of research contends with a known application context for which useful solution artifacts either do not exist or are clearly suboptimal and draw from a deep understanding of the problem environment to build innovative artifacts as solutions to important problems (Gregor & Hevner, 2013). As suggested by Peffers et al. (2007), DSR aims to search for: "the existence of an artifact that has not yet been formally thought through as a solution for the explicit problem domain in which it will be used. Such an artifact might come from another research domain, it might have already been used to solve a different problem, or it might have appeared as an analogical idea".

A DSR approaches require a clear definition of the problem and the identification of specific objectives. A knowledge audit is considered as a valuable methodology to analyze situational requirements (Burnett et al., 2004; Levy et al., 2010; Roy et al. 2016) and to identify and address gaps and inefficiencies in KM (Friedman, 2002; Malerba, 2006; Radnor and Noke, 2006; Wang and Xiao, 2009). Many different techniques have been proposed (Burnett et al, 2004, Liebowitz et al, 2000, Perez-Soltero et al., 2007, Roy at al., 2014). Most of these techniques have common goals, i.e. they aim to both identify and link knowledge uses, gaps, flows, carriers, sources to core processes and objectives. Accordingly, KA often starts with the identification of objectives and core processes, followed by the identification of knowledge needs. After performing the KA analysis, and as prescribed by the DSR approach, it is possible to generate a set of problem solutions and knowledge strategies. We used a literature review to examine the existence of knowledge strategies and ICT solutions that could potentially be borrowed to address the problems identified in the previous steps.

Our literature review was guided by our main research questions: What are board's main knowledge needs and problems, and how can knowledge strategies and supporting ICT improve boards of directors' decision-making process? Because these questions are broad and cover different literatures, such as governance, knowledge management, information technology, decision-making, our literature review process was twofold: First, we focused our review on the analysis of the board's contextual requirements and knowledge gaps. A great deal of thought must be given to the actual keywords used for the database search. For this first part of the review, we used the following search terms: board of directors and (knowledge management or information management or group decision-making or board efficiency or board behavior). We considered both conceptual and empirical articles in scholarly journals using ProQuest ABI / INFORM Global and EBSCO (business source complete) databases. The literature review allowed us to identify board problems and group them into six distinct categories. Then, using the same databases, specific literature reviews were executed focussing on knowledge and ICT solutions for each of the six categories of problems we identified.

4. Board KA and Potential Solutions

Although there have been some changes in the definition of the role of boards of directors over time, most agree that they have a fiduciary duty to represent the owners' interests in protecting and creating shareholder value. As such, boards of directors have been characterized as "large, elite, and episodic decision-making groups that face complex tasks pertaining to strategic-issue processing" (Forbes and Milliken, 1999). From a general standpoint, group decision-making has been considerably examined in the literature (Tropman, 2013). The expectations that groups can be more effective decision makers than individuals has often been challenged as several studies have highlighted that social factors and limited group processing capabilities can have adverse consequences on the quality of decisions (Bainbrige, 2002).

Group decision making is a collaborative effort towards problem solving that principally entails interactions, communication, and deliberation (Turban et al., 2011). However, it is important to note that in the case of corporate boards, this decision-making process can also include preparation activities that can be done individually. Furthermore, the quality of this process is highly dependent on appropriate information management activities (Citroen, 2011; Johanson, 2008; Rutherford and Buchholtz, 2007; Zhu et al., 2016). Hence, much attention must be given to functions such as collecting, processing, storing, and distributing information. However, information in and of itself can't guaranty success; rather, "actionable information in context" is required, taking into account the role of human actors in processing and sense-making (Alavi and Leidner, 1999).

The starting point of our knowledge audit is a good understanding of boards' objectives and activities. Monitoring and advising have been identified as the two most critical board objectives (Brown, 2015, Pugliese et al, 2007): While Monitoring refers to controlling and guarding against opportunistic behaviour, advising refers to involvement in strategic decisions. To accomplish these objectives, corporate directors must carry out several activities that will require appropriate information and knowledge. A recent survey from the National Association of Corporate Directors (NACD, 2015) revealed that directors spend on average 248 hours a year on board-related activities. The time that is said to be spent on these specific activities are: attending meetings (29,5%, preparing for meetings (24,6%, informal meetings 12%, and educational activities (7,7%). The results suggest that board meetings are a core activity for directors and that much consideration must be given to potential ways to make them more productive. Also, although boards receive management information and updates about company operations on a regular basis, the majority of this information is related to topics discussed during board and committee meetings. These statistics also highlight the importance of distinguishing between knowledge problems observed in the "preparation phase" from those in the actual meetings.

Our literature review has identified a series of knowledge related problems that could impair the quality of board decisions as they assume their role to monitor and advise the company. One of these problems concerns **information asymmetry.** The difference between the information available to management and what is presented to the board, combined with independent directors' dependency on managers for information/knowledge, can limit independent directors' ability to exercise their role effectively (Brennan et al., 2016). Brennan et al. (2016) further suggest that agency theory's approach to information asymmetry typically focusses on explicit information. However, managers' knowledge is mainly undocumented, transmitted largely by word of mouth or from "intuitive (non-explicit) processes" and results in implicit/tacit knowledge which remains unknown to boards unless the manager makes a concentrated effort to disseminate it. Hence, a more nuanced characterization of this information imbalance between managers and non-executive directors is essential as it can focus attention towards more comprehensive solutions. The transition from personal/implicit to collective/explicit information/knowledge is one of the main challenges to reduce information asymmetry (externalization). Nonaka (2008) states that in this knowledge conversion process, some degree of "socialization" is still necessary to facilitate tacit to tacit knowledge exchange and sharing.

With the recent development of social web tools and communities as well as the availability of new high bandwidth connections which support more real-time interactions, it has been argued that most shortcomings of tacit knowledge sharing are likely to disappear (Lopez-Nicolas and Soto-Acosta, 2010). Indeed, social media applications build an environment in which social interactions and tacit knowledge sharing are better facilitated. Social web tools vary in form and have different abilities to facilitate tacit knowledge sharing. As shown in Table 1, these tools include blogs, Wikis, Podcasts/Vodcasts, social networking sites, social bookmarking, multimedia sharing tools, RSS, etc. (Panahi et al., 2013). Although few boards have these socialization support systems at their disposal, they would certainly benefit from their use, particularly to exchange with managers.

In order to address director background heterogeneity, some organizations have implemented extranets for their boards as online storage tools. Indeed, given their different backgrounds, some directors could be satisfied with summaries and short reports, while others may require or desire additional and more detailed information that can be made available via such extranets. Through these, directors could also access short video tutorials that could facilitate information comprehension in the case of material that is not well suited to non-technical board audiences. As seen in Table 1, providing access to expert interpretations and expert comments through tools such as expert yellow pages, annotations and blogs could also address background diversity and reduce information asymmetry. These solutions contribute to an externalisation process as it helps directors capture manager knowledge and expertise on specific topics.

Table 1: Examples of knowledge solutions and supporting tools

Problems	Knowledge solution	ICT support
Information asymmetry	Increase tacit knowledge sharing Expert interpretation Expert comments	Social media applications Board extranets Web conferencing Vodcasts-Podcasts Expert yellow pages Annotations Multimedia sharing tools RSS Blogs
Information overload	Summaries Expert comments Indicators Priority setting Parceling and distribution over time Information visualization	Search tools Blogs Dashboards News and updates Note-taking and book-marking Alerts
Relevant information	Strategic information Forward looking information Industry information	Subscription to industry Web sites / ICT trends Web sites Communication channels with expert Internet-based tools that facilitate the choice of information Visual displays Text and data mining
Reliability	Better access to information External sources of information	External links External expertise Document management systems Remote access Mobile applications
Timeliness	Punctual updates	Newsfeeds Board extranets
Behavioral aspects Groupthink Social loafing Shared information bias	Improve flow of information Ensure effective debate and discussion Ability to articulate relevant information Mindfulness	Survey tools and templates for board self-assessments Group support systems for developing consensus Voting systems Communication channels with other members and outside experts.

Information overload is also a well-documented board problem. Indeed, providing directors with too much information may overburden them with excessive data that they might not be able to assimilate due to cognitive limitations and time constraints *(*Cohan, 2002; Roy, 2011). However, too little information poses the risk that directors will be unable to understand the issues and provide effective oversight (Zhu et al., 2016). Hence, it is important to ensure that the information provided to directors meets criteria about presentation and practicality such as conciseness and clarity, in order to facilitate "internalization". As seen in Table 1, knowledge solutions to information overload and associated tools emphasize proper visualization, compression and aggregation of information (Meyer, 1998). Information visualization tools may help reduce the cognitive load of information which in turn drives a better interpretation, shared understanding, integration and coordination, problem formulation and solving, as well as decision and sense making (Laud and Schepers, 2009). For example, visualization and dashboard technologies could improve the board's ability to rapidly evaluate business performance indicators. Simpson and Prusak 1995) maintain that the essential mechanisms to fight information overload are to assure that the information provided is of high value, and that it is delivered in the most convenient way and format. Management and other parties preparing board information can facilitate this by including an explanatory narrative as well as summaries that highlight the key points the board should be considering. To make the most of limited meeting time, board members need to "get up to speed" quickly on the material they receive.

Given the risks associated with information overload, and in order to counter information asymmetry problems, much consideration must be given to ensuring that **relevant** information is provided to directors (Finkelstein and Mooney, 2003; Zhang, 2010). Surveys are reporting that the more involved directors are not only provided with basic financial information, but also with forward-looking information that provides insight into the company's future competitive position (Bhagat et al., 2014). Many researchers have long criticized the limitations of financial accounting information as a management tool, because it focuses on historical data.

Traditional financial measures are typically viewed as lagging indicators, i.e. they measure current and past performance, but do not adequately predict future performance (Johanson, 2008). Because one of a board's key roles is to set strategic direction for the organization, board members require information that is forward looking and will help them develop policies that have long-term viability. By being aware of emerging trends, boards are better able to assess what might be the effect of the trends on the organization, and to determine the appropriateness of current approaches and policies. Many online information sources are now available on industry specific trends and challenges. Board members would benefit from having direct access to these Web sites. Also, similar to the overload problem, relevance can be optimized with access to expert opinions and user friendly tools to rapidly identify and understand critical information. Therefor "combination" KM strategies that provide more relevant and forward looking explicit knowledge may improve board knowledge.

We also found in the governance literature several articles tackling **reliability** issues (Rutherford and Buchholtz, 2007; Zhang et al., 2015). They are of particular interest since directors receive most of their information from management. Hence, to develop an independent opinion on major decisions and to increase the reliability of their information, directors need to supplement the internal information they receive from management with external sources. Board members should not passively wait for management to supply information to them but work proactively to obtain the information they need to fulfill their responsibilities (Office of the auditor general of British Colombia, 2016). They may not be able to develop a full understanding of an issue if relevant information from external sources such as subject matter experts and external auditors is not made available to them. Also, internal reports may have been amended or changed to downplay bad news, withhold project information, or provide information that is biased toward specific recommendations. Providing tools that can facilitate access to experts, outside information or organizational information in a flexible way (with mobile applications or document management systems) is critical for boards to reach out for knowledge beyond what they receive in their information packet. Of course, establishing a network of external experts on areas that are relevant to the board is an essential part of this process (see Table 1). Therefore, the internalization of outside knowledge sources appear to be critical for board knowledge and effectiveness.

Timeliness has also been identified as an important factor driving board efficiency (Erismann-Peyer et al., 2008; Osler et al., 2014). Board members require information as promptly as possible when faced with discussing matters related to the organization's strategic direction and decision making. They also require information that is up-to-date. If information is delayed or not current, board members could form an inaccurate picture of the current state of the organization, especially in a volatile environment. As mentioned, some organizations now design extranets for their boards to disseminate information to their directors for more efficient communication (see Table 1). These tools can certainly provide an efficient means for scheduling, organizing, and distributing information about meetings in a timely manner. They also allow members to review materials in advance of meetings, and to access or request additional data about key elements. Further, these board extranets allow storage of historic data and the updating of information. They can provide on-line references, contact information, and all policies and procedures affecting board operations. Board members can easily and quickly access the latest corporate information, current and historic company records, and key contact information. They can also use their extranet to share opinions and discuss major corporate events with other board members and managers before meetings. If chosen, new technologies can ensure that some of these virtual discussions remain anonymous. Therefor board extranets or portals appear to be important internalization support tools for the "timeliness" knowledge needs.

Issues such as information overload, timeliness, or reliability mostly deal with problems during the "preparation phase" and focus on the information that must be collected, stored and distributed to board members. However, there are numerous **behavioural** problems during actual board meetings that are documented in the literature that could also be addressed through KM strategies and ICT. Our literature review allowed us to identify three main behavioural problems. The first one is **groupthink** (Elms *et al*., 2015; Forbes and Milliken, 1999; Maharaj, 2008). Janis 1972) defined groupthink as: "A mode of thinking that people engage in when deeply involved in a cohesive in-group, when the members' strivings for unanimity override their motivation to realistically appraise alternative courses of action." The key causes include group cohesion, directive leadership and ideological homogeneity. The common symptomatic behaviors resulting from these causes include overestimation of the capabilities of the group, closed mindedness and pressures for uniformity. The consequent decision-making flaws included inadequate contingency planning, insufficient information search and biased assessments of risk, cost benefits and moral implications. Therefore, companies

should be cautious that values and groupthink are not so strong that they override the essential knowledge base of directors.

Broadly speaking, two main types of solutions to the problem of groupthink have been suggested. The first are process solutions, solutions that seek to include particular processes in decision-making meetings with the aim of ensuring effective debate and discussion. The second type of solutions deals with behavioral, cultural, and information changes such as improving the flow of information to leaders and increasing group members' ability to articulate relevant information (Ben-Hur et al., 2012).

Fortunately, information technology that combine communication, computer, and decision technologies may transform inefficient and ineffective group meeting processes associated with groupthink into more productive processes (Miranda & Saunders, 1995). For the knowledge and motivation of directors to be functional, there must be clear and fluent transmission channels for socialization. When transmission channels are available, board members are able to communicate among themselves, management and outside consultants, and are thus less likely to involve personal agendas or political status (Maharaj, 2008). ICT tools have been developed to support group decision processes, for instance, voting systems, presentation tools, annotation, parallel discussions forums, agenda control or automatic minutes (see electronic meeting system, Wikipedia, brainstorming and categorization (see Table 1). These types of tools also address a second obstacle to effective group decision making, that is **shared information bias** (Baer et al., 2013; Bainbridge, 2001; Zhang, 2010). Baer et al. (2013) suggested that teams with heterogeneous backgrounds tend to discuss only the information that is "commonly held at the expense of unique and uncommon information". Hence, instead of leveraging the knowledge from a rich pool of diverse expertise to improve the quality of decisions, the group focuses on limited options leading to inferior decisions. Group support systems for developing consensus, voting technology, and survey tools for board assessments could also address a third often reported problem like **social loafing** where some directors may choose to not fully engage in board discussions and other activities because it can be unnoticed in a large group (Hemphill and Laurence, 2014).

To summarize, research indicates that board members face several challenges in acquiring, processing and sharing information. In turn, these challenges can impede their ability to fulfill their mandate adequately. Even though KM solutions do exist, they seem to have not received proper attention in previous research and, needless to say, are not well understood by practitioners. In the next section, we review the "state of the art" of available board support tools.

5. Board Portals

In the last section, we highlighted how companies and their boards can implement specific ICT solutions to address particular board problems. In an attempt to address information issues and to support the work of corporate boards, a new type of software, "board portals", has emerged. Such portals include products such as Diligent Boards, BoardEffect, Boardvantage, Idside – Web Governance and Leading Boards (Aprio, 2016; Diligent, 2016; Gartner, 2014; idealware, 2015; StreamLink Software, 2014). Such tools come with their own technology characteristics (for example, whether the software is installed on premise or is cloud-based, or whether it can be used on tablets, PCs and mobile phones) and pricing structure. But beyond these, board portals also come with features designed to support individual directors and sometimes the whole board, in addition to features aimed specifically for the corporate secretary's office.

The basic functions of these portal products mainly focus on information access. At a minimum, they add a structured interface to a shared hard drive and help organise documents either for the full board or for committees, and they often include a common calendar (which may be linked with directors' own calendaring software such as Outlook) and contact information. Beyond the usual meeting documents, they can also include policies, by-laws, and corporation background information. Key characteristics of board portals are typically the ease of the user interface, access to past documents, printing options, navigation through sections of the board book, and search tools.

Board portals can help address information asymmetry as adding information is more convenient than with traditional paper-based board binders. However, they can also lead to information overload if the structure of the board application is not intuitive or if the search engine is not efficient. In addition, it is generally assumed that board portals may improve the timeliness of the information, provided that the information is available

long enough in advance. If members receive the information too late, or if the information is updated several times up to the last minute, timeliness becomes an issue even with electronic tools.

More elaborate functions can allow corporate directors to interact with documents. For example, they can highlight important information or add personal notes or bookmarks. Therefore, these tools can have a direct impact on the ability of a director to appreciate the information provided and to be effective in a board meeting.

Finally, some board portals allow directors to interact with each other, and with management and/or experts. This could mean the ability to send each other emails or to send out a survey to schedule a new meeting for example. Some more elaborate portals go beyond and propose voting systems (for unofficial or official votes, anonymous or not) or shared document editing. Others will support online conferencing to hold remote live meetings and presentations, sometimes with chatting functions. To date, however, most board portal users have minimal functions and more sophisticated collaborative tools have yet to invade the board portal universe.

6. Conclusion

Recent regulatory changes and pressures from the public have led to significant changes in the way corporate boards carry out their responsibilities. Demands for increased oversight have forced institutions to address whether directors have the necessary knowledge to participate fully in this process, while surveys of corporate directions indicate that information limitations are important.

In order to understand board's needs and solutions with a knowledge management perspective, we developed an approach based on both design science research and knowledge audit prescriptions. Our approach started with a generic KA of board knowledge and information problems through the existent relevant literature. The findings reveal a complex network of interrelated knowledge types that must underlie their high-level decision making requirements. These needs include: Increased tacit knowledge sharing, better combination processes to provide a more complete and richer knowledge base about the organization and its' environment, internalization facilitation through easier access to knowledge and the externalization to capture tacit company knowledge. Through this analysis, it becomes clear that, although people and operational processes are needed to address these knowledge requirements, ICT support is also an important and underexploited component, as we observe from our overview of available board tools.

These findings are emergent, developed from the small amount of past research on board knowledge needs and problems. They can be used as the basis for more efficient and effective development of tools and knowledge strategies for boards. Moreover, they represent a first step in developing a comprehensive KM framework for boards and future research can build on these findings to enhance our understanding of the KM-board landscape and providing these decision makers with a modern ICT environment designed for their specific needs. Additional research may even push further the KM domain as board members may display different KM behaviors than managers. Consequently, this study's findings contribute to the KM literature by proposing a framework that draws on various complementary fields. Another important contribution of this study is its detailed characterization of board informational and knowledge needs drawing from the knowledge management literature. As such, it constitute a significant contribution to the governance literature.

This study has a number of managerial implications and should provide guidance to organizations currently examining board functioning. We hope to encourage boards to contrast their own situation with our framework and to evaluate whether they could revise their existing board knowledge strategy. Ultimately, possible solutions to a board's knowledge challenges should be identified and integrated into a knowledge strategy that signals the company's overall commitment and direction as it relates to the quality of knowledge it wishes to provide to its board. The strategy should be tied to clear objectives and performance indicators about efficiency and satisfaction; constant monitoring of the strategy is critical to improve its quality.

We briefly overviewed the board portal tools that have been developed and are gradually being introduced to board settings. These usually contain basic functionalities, but could provide a good starting point to add on the different tools mentioned in table 1, depending on the knowledge strategy and specific needs. Board application vendors could improve their products to interface with in-house systems, for instance higher-level

ERP systems modules such as top-level business intelligence and strategic reporting (Niu and Ozdemir, 2014, and integrate more sophisticated features supporting social media, information visualisation, expert yellow pages and direct links to relevant outside Web sources.

Finally, implementing novel board knowledge strategies through ICT can represent a major challenge for most organizations since they will usually constitute a significant departure from existing practices. More research is needed to study the adoption of ICT in board processes, barriers to its use and the overall benefits of appropriate ICT on board decision performance.

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