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Playing with fire: Knowledge management in the Quebec fire service

Présentée par
Claude Beauchamp

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“ To the Bravest ”

Acknowledgment

In 2000, I answered an ad in the local journal: the fire department was hiring. I already had a job as a teacher, but I was looking for a way to get involved in my community. Part-time firefighting seemed a great idea: challenge myself, meet new people, learn something new, and contribute to the social good. Little did I know, answering this ad would change my life.

I discovered a group of individuals dedicated to each other and to public service. It quickly had an impact on me as I was learning new things riding the mythical red trucks. Volunteering in the fire service was changing who I was, how others saw me: from a teacher I became a firefighter familiar with the cultural codes and norms of the fire service, some obvious to the public as well as the tacit ones institutionalized in the organizational culture. Still, as a teacher, I was amazed at all that needed to be learnt to be a firefighter. One thing struck me: I never saw a colleague shy away from sharing what he knew about firefighting.

From 2000 to 2009, I worked part-time in the fire service in the Province of Quebec (Canada), as a firefighter, then as a lieutenant, and finally as a training officer. Having found a passion in the fire service, I quit my job as a teacher to work for the Quebec National Fire Academy, from 2003 to 2013. I joined the Academy as an academic advisor and subsequently move to the position of director of operations. As director, I had the chance to lead a team of subject-matter experts creating training programs required by the provincial legislation. I also served on several committees related to fire service training and certification and collaborated to training manuals.

Since 2013, my career has offered me many new challenges in public administration. Still, the fire service has always been close to my heart: “You can take the guy out of the firehouse, but you can’t take the firefighter out of the guy”, as they say. My research interest is knowledge management in public sectors, with a focus on the fire service. Like other public sectors, the fire service is facing leadership and managerial challenges related to public expectations and knowledge management. Academic research on the fire service is

flourishing but there have been no attempts to better understand mechanisms of knowledge management in this public service. This doctoral research may be my way of giving back to the fire service, to salute these men and women who make a difference in our daily lives.

I could not have pursued this doctoral journey without some people by my side to whom I am forever grateful. Professor Lilly Lemay guided me through all these years and shared her wisdom and experience. In moments of success and difficulties, she found a way to keep me going. She also took me in generously a few times with Jean-Luc for dinner in Quebec City which created great memories. I am also in debt to Dr. Robert England who found a way to share his thoughts and wisdom from his home state of Oklahoma. Special thanks also to my Okie fire service brother, Jeff Fortney, who provided insights for my first paper. To Michel, Christian, Maxime, and Patrick, thank you for the critical advices, though-provoking comments, and support.

If I can cross the finish line, it is most of all because my family stood beside me. Encouraged by the kids and Winston the cat, those were long hours where I was away at my desk reading and writing.

And there will always be a beacon to guide me: my one and true love, Stéphanie.

Résumé

Cette thèse traite de la gestion des connaissances dans le secteur public et répond aux appels précédents concernant le manque de recherche sur la gestion des connaissances dans les services d'urgence tels que les pompiers. Trois questions de recherche sont posées : *Comment les connaissances sont-elles gérées dans les services de pompiers volontaires ? Comment la culture organisationnelle des services de pompiers influence-t-elle la gestion des connaissances dans les services de pompiers volontaires ?* et *Comment l'aDsorption des connaissances affecte-t-elle la conversion des connaissances dans un secteur d'activité public ?* Le cadre conceptuel intégré de la thèse est basé sur l'intersection de quatre volets théoriques. Tout d'abord, il s'inspire du modèle SECI de conversion des connaissances de Nonaka et du concept de Ba pour décrire comment fonctionne le mouvement en spirale de la création de connaissances dans un secteur d'activité public. Deuxièmement, le cadre utilise la théorie de la gestion des connaissances pour évaluer les processus de création, de stockage et de partage des connaissances dans les services de pompiers volontaires. Troisièmement, il s'appuie sur la théorie des loisirs sérieux pour s'attarder sur les aspects de la culture organisationnelle des services de pompiers volontaires afin d'expliquer si cette culture agit comme un levier ou un obstacle aux processus de gestion des connaissances. Enfin, il s'appuie sur les recherches concernant la capacité d'absorption pour évaluer la manière dont les connaissances précieuses sont absorbées et gérées dans un secteur d'activité public. Le design de recherche est une étude de cas multiple sur le secteur des services d'incendie dans la province de Québec (Canada). La collecte de données est basée sur un sondage auprès du personnel des services d'incendie (*N=301*), des entretiens semi-structurés avec le personnel des services d'incendie (*N=10*), une analyse du contenu de sites web municipaux (*N=20*) et une analyse du contenu des sources de documentation officielle (*N=9*). Cette thèse présente trois articles scientifiques. Le premier article est une revue de littérature systématique de la recherche sur les services d'incendie. Le deuxième article est une étude empirique de la gestion des connaissances dans les services de pompiers volontaires et il répond aux premières et secondes questions de recherche. Le troisième article est une étude empirique et théorique de la capacité d'absorption dans un

secteur d'activité public et il introduit le concept d'aDsorption des connaissances. Les résultats montrent, tout d'abord, que la recherche sur les services de pompiers en est à ses débuts. Trois méta-catégories structurent la recherche publiée sur les services d'incendie : la santé et la sécurité, la gestion et la culture organisationnelle. Deuxièmement, les résultats montrent que le partage des connaissances entre les pompiers est le principal processus gestion des connaissances au sein des services d'incendie. Le concept d'apprentissage par les pairs (*buddy-learning*) explique comment les pompiers puisent dans les connaissances de leurs collègues pour apprendre. Trois facteurs sont associés de manière positive à la gestion des connaissances : l'apprentissage en binôme, le développement personnel et la créativité. Deux facteurs sont associés négativement : le transfert et le stockage des connaissances. Enfin, les résultats montrent que le mouvement de spirale de la création de connaissances n'est pas linéaire entre les modes de conversion des connaissances du SECI, mais plutôt consubstantiel dans le secteur public. Un nouveau modèle montre l'importance de la systématisation du Ba dans le secteur public. Les résultats fournissent, par ailleurs, une formule complète pour étudier la capacité d'absorption dans des contextes organisationnels/sectoriels par le biais d'un nouveau triptyque composé de la capacité d'absorption, de l'adsorption et de la désorption des connaissances. La discussion ouvre la voie à une meilleure compréhension de la gestion des connaissances dans le secteur public et offre plusieurs suggestions pour de futures recherches.

Management des connaissances, secteur public, services d’incendie, pompiers, étude de cas.

Abstract

This dissertation deals with knowledge management in the public sector and answers previous calls about the lack of research on knowledge management in emergency services such as the fire service. Three research questions are posed: *How is knowledge managed in volunteer fire departments?; How does the fire service organizational culture influences knowledge management in volunteer fire departments?; and How does knowledge aDsorption affects knowledge conversion in a public sector of activity?* The dissertation's integrated conceptual framework is based on the intersection of four theoretical strands. First, it draws from Nonaka's SECI model of knowledge conversion and concept of *Ba* to describe how the spiralling movement of knowledge creation works in a public service sector. Secondly, the framework uses knowledge management theory to assess processes of knowledge creation, storage, and sharing in volunteer fire departments. Thirdly, it builds on serious leisure theory to dwell into organizational culture aspects of volunteer fire departments to explain if this culture acts as leverage or barrier to knowledge management processes. Finally, it draws from research on absorptive capacity to assess how valuable knowledge is absorbed and managed in a public sector of activity. The research design is a multiple case study on the fire service sector in the Province of Quebec (Canada). Data collection is based on a survey of fire service personnel (*N=301*), semi-structured interviews of fire service personnel (*N=10*), content analysis of municipal websites (*N=20*), and content analysis of official documentation sources (*N=9*). This dissertation presents three scientific papers. The first paper is a systematic literature review of research on the fire service. The second paper is an empirical study of knowledge management in volunteer fire departments and it answers the first and second research questions. The third paper is an empirical and theoretical study of absorptive capacity in a public sector of activity and it introduces the concept of knowledge aDsorption. Results show, first, that research on the fire service is in its infancy. Three meta-categories structure published research on the fire service: health and safety, management, and organizational culture. Secondly, results show that knowledge sharing among firefighters is the main knowledge management in the fire service. The concept of *buddy-learning* explains how firefighters

tap into their colleagues' knowledge to learn. Three factors are positively associated with knowledge management: buddy-learning, personal development, and creativity. Two factors are negatively associated: knowledge transfer and knowledge storage. Finally, results illustrate that the spiralling movement of knowledge creation is not linear between the SECI modes of knowledge conversion but rather consubstantial in the public sector. A new model arrangement is showing the importance of the systemizing *Ba* in the public sector. Results provide a complete formula to study absorptive capacity in organizational/sectoral settings through a new tryptic composed of absorptive capacity, knowledge adsorption and knowledge desorption. The discussion opens the way for a better understanding of knowledge management in the public sector and offers several suggestions for future research.

Knowledge management, public sector, fire services, firefighters, case study.

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LIST OF ACRONYMS

CRM: county regional municipality
EFA: exploratory factor analysis
ENAP : École nationale d'administration publique

Fire service :

ACSIQ: Association des chefs en sécurité incendie du Québec
IFP: Institute of fire protection
LLOD: Line of duty death
MPS: Ministry of Public Security
NFA: national fire academy
VFD: volunteer fire department

Knowledge management:

AAR: academic and applied research
AC: absorptive capacity
CUST: customers/citizens
EK: explicit knowledge
IT: information technologies
KC: knowledge creation
KM: knowledge management
KSH: knowledge sharing
KST: knowledge storage
PART: partners
TM: top management
TK: tacit knowledge
SECI: socialization, externalization, combination, internalization
SUP: suppliers

Serious leisure theory:

DEWO: devotee work
QUAL: qualities
RWD: rewards
SL: serious leisure
TPF: thrills/psychological flow

INTRODUCTION

This dissertation deals with knowledge management in the public sector. Its focus is the fire safety sector in the Province of Quebec (Canada). It considers three scales of analysis: firefighters, fire departments, and the sector composed of different organizations with complementary missions for this public service. This research in management theory of public organizations was realized in an evolutionary and constructive approach. It is structured in three scientific papers for obtaining the degree of Philosophiae Doctor (Ph. D.). The dissertation is presented according to the required guidelines of the École nationale d'administration publique du Québec (ENAP), in effect in 2017.

The research subject and research questions

The first article is a literature review of research on the fire service, an understudied sector of activity. This first stage of the research revealed three key elements on published research on the fire service: (1) the majority of articles focus on firefighters' health and safety; (2) research highlights the importance of serious leisure characteristics (Stebbins, 2007) associated with the profession, which have an impact on KM at the individual and organizational levels; and (3) studies on the management of these organizations has declined over the last twenty years.

The second paper addressed KM in Quebec volunteer fire departments (VFDs), which represent 76.6% of the fire service. Two questions guided this research based on a survey (*N=301*) and interviews (*N=10*):

(Q1) How is knowledge managed in VFDs?

(Q2) How does the fire service organizational culture influences knowledge management in VFDs?

This stage of the research provided three main results: (1) in addition to basic skills training, volunteer firefighters learn primarily from each other, what has been termed *buddy-learning* which is closely associated with serious leisure's characteristics; (2) despite the importance placed by volunteer firefighters on personal development and knowledge acquisition (other characteristics of serious leisure), little or no external knowledge (e.g.

research, experience in other fire departments) is absorbed by fire departments; (3) respondents considered that KM is not well developed in their fire departments - only qualifying training receives more attention. In addition, written material (explicit knowledge) is rated lower compared to practical learning (exchange of tacit knowledge) hindering the development of organizational memory.

The third paper, which was theoretical and empirical in nature, focused on the knowledge-absorbing capacity of organizations. A question guided this part of the research: (Q3) How does knowledge aDsorption affects knowledge conversion in a public sector of activity? The study was carried out at the fire service sectoral level because the organizations that compose the sector have complementary missions to render public services. The study indicated that a phenomenon not of closure but of impermeability occurs and prevents the aBsorption of new knowledge in the sector. The concept of aDsorption, the opposite of aBsorption, was used for the first time in this article. The concept of desorption (Denford & Ferriss, 2018), linked to the ability to provide value-added knowledge for the sector, joined the other two to form a complete formula for analyzing KM in a public sector. In addition, the analysis technique made it possible to build a framework for analysis and reflection on knowledge-based strategic governance.

The problematic

Knowledge is said to be a critical asset in organizational life (Easterby-Smith & Lyles, 2011; Lam, 2000; Tsoukas & Mylonopoulous, 2004) and is defined as a "fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information" (Davenport & Prusak, 2000, p.5). Moreover, it is said that "improved knowledge management is essential to governmental agencies at the national, regional, or local levels, because governmental organizations are basically knowledge-based organizations" (Yuen, 2007). On one hand, managing knowledge in public administration entails "a systematic and organised attempt to use knowledge within the organisation to provide services to the public and to improve performance" (Syed-Ikhsan & Rowland, 2004b). On the other hand,

KM also involve creating higher learning through collaborative governance regimes (Emerson & Gerlak, 2014).

There is a need to "understand and to measure the activity of KM so that organizations, and systems of organizations, can do what they do better" (Pollitt, 2003). Scholars underlined that efficient and strategic KM could: (1) further service efficiency; (2) support the development of new systems supporting performance and knowledge access; (3) improve accountability, risk management and decision-making processes promoting rapid problem-solving strategies; and (4) contribute to better public services in terms of costs, quality levels and better use of public funds (Riege & Lindsay, 2006; Seba & Rowley, 2010).

Research on KM in the public sector is still an emerging field (Jain & Jeppesen, 2003; Potts & Kastelle, 2010; Riege & Lindsay, 2006; Seba & Rowley, 2010; Syed-Ikhsan & Rowland, 2004a, 2004b). Scholars argue that, "relatively little attention has been paid to the means by which public service organizations create, share and apply knowledge" (Rashman, Withers, & Hartley, 2009, p.466). In particular, research on KM in the context of public organizations should be deepened to have a better understanding of its mechanisms (Rashman, Withers & Hartley, 2009; Vigoda-Gadot, Shoham, Schwabsky, & Ruvio, 2005). Moreover, according to Massaro, Dumay, and Garlatti (2015), there is an important research gap to be filled about KM in emergency services such as police, ambulance, and the fire service.

Firefighting in North America

Firefighting in North America has its roots in the 18th Century as a communal activity when men volunteered in groups to protect their community (Perkins & Benoit, 1997; Thompson & Bono, 1993; Thompson, 1993; Carp, 2001). The club-like spirit of the fire service provided the basis for the development of a community of firefighters characterized by rules, social norms, codes and moral values, and a distinctive knowledge stock (Perkins & Mets, 1988; Stebbins, 1996; Perkins & Benoit, 1997). Many fraternal groups that served as the baseline for the first fire companies were made up of military veterans and the organizations adopted their conservative culture and rank structure (Goodson & Murnane,

2008). With the urbanization of social life, the communal activity of firefighting became a profession in the 20th century through institutionalization in the municipal bureaucracy (Ashenfelter, 1971; Smith & Lyons, 1980), standardization of practices, and the development of an agreed-upon body of knowledge.

In North America, firefighters are usually identified as career or volunteer (Goodson & Murnane, 2008). Most fire service organizations in North America are composed of volunteer firefighters (65% in the United States, 83% in Canada)[1]. The situation in the Province of Quebec is similar with volunteer and part-time firefighters representing 76,7% of the fire service[2]. For career firefighters, firefighting is the primary occupation and full-time employment of the job incumbent, usually in urban settings. Their work conditions are the object of a collective agreement, and they are usually grouped in squads that rotate on a predetermined schedule. Career fire departments exhibit an elaborated structure that can include divisions responsible for maintenance, operations, training, fire prevention and code enforcement to name a few. The rank structure is elaborate, from firefighter to officer and chief. Usually, career firefighters must complete standardized pre-employment training program prior to hiring. Once on the job, they maintain their skills through elaborate training programs, usually having access to dedicated training facilities.

Volunteers are mostly found in the suburbs and rural areas. Individuals have a primary occupation and invest their time and energy in the local fire department, often with minimal or even without monetary compensation (Perkins & Metz, 1988; Perkins, 1989; Perkins, 1990). Volunteer fire departments exhibit a similar organizational structure as their career counterparts but without the same level of human and organizational resources. Pre-employment training is usually not mandatory. Training will be conducted in-house, sometimes through structured training programs, allowing individuals to develop in qualified firefighters (Thompson & Bono, 1993).

[1] https://www.nfpa.org/News-and-Research/Data-research-and-tools/Emergency-Responders/US-fire-department-profile and https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/oscanadafirefighters.ashx [accessed 2019-09-28]

[2] https://www.securitepublique.gouv.qc.ca/securite-incendie/quebec.html [accessed 2019-09-28]

The need for knowledge management strategies

Firefighting is complex and requires the individual to master an extensive knowledge stock. For example, firefighters need to learn how to use many tools and equipment in various situations, understand elements of building construction, and learn how to translate fire growth physics and heat flow path into sound strategies and tactics to extinguish building fires. Therefore, extensive hands-on training is key to preparedness. However, firefighting has changed in many dimensions in the last 40 years and these changes have a direct effect on what firefighters need to know.

In the sixties and seventies, dwellings were built mostly with solid wood around a floorplan composed of small compartmented rooms. This type of construction allowed firefighters to access the roof for ventilation operations, having enough time to operate before the risk of building collapse. Legacy furniture was the norm, made of wood and natural fabrics. Today, engineered elements made of laminated wood, glue and other substances are used in construction allowing for larger open spaces. Open floorplans are the staple of today's houses, but they make for faster fire propagation and create a higher risk of rapid collapse which has changed firefighting strategies. Modern furniture is often made of synthetic fibres, plastic, and other products that also contribute to rapid fire growth. When burning, these newer products expose firefighters to dangerous chemicals that have been linked by research to different types of occupational cancers.

Over the years, fire prevention activities have supported public education strategies towards awareness of dangers associated with fire. Sprinklers are the norm in public dwellings, households are equipped with smoke detectors, and the general public has become more prudent about fire. These changes in social mentalities and habits have influenced the number of fire that firefighters respond to. Data from the National Fire Protection Association[3] indicate that the number of fires in the United States has steadily declined over the last 40 years. Available data from the Quebec ministry of public security[4]

[3] https://www.nfpa.org/News-and-Research/Publications-and-media/NFPA-Journal/2018/September-October-2018/Features/2017-US-Fire-Loss-Report [accessed on 2019-09-28]
[4] https://www.securitepublique.gouv.qc.ca/securite-incendie/publications-et-statistiques/incendies-declares/2015.html [accessed on 2019-09-28]

show a similar tendency. Therefore, firefighters now respond to less fires which has prompted many fire service organizations to diversify their services to the public. For example, many fire departments have trained their firefighters to respond as medical first responders. Others have diversified their expertise by developing competencies in technical rescue such as water rescue, rope rescue, or urban search and rescue. All this has added to an already complex knowledge stock.

September 11, 2001, changed the World has we knew it. On that day, 343 firefighters from the New York City fire department died in rescue operations in the World Trade Center. On the one hand, this tragedy became an acute illustration of firefighters' heroism and dedication to public safety. On the other hand, it brought terrorism at the forefront of emergency preparedness with the necessity to train fire service organizations. Training firefighters to be proficient at mitigating hazardous material incidents was not enough anymore. Knowledge needed to be expanded to include response to incidents involving weapons of mass destruction and terrorism acts.

Over the last 20 years, the World has seen many disasters in the form of tsunamis, hurricanes, floods, or industrial accidents. These events have prompted a new awareness about civil security and the necessity to develop systems of organizations able to respond in case of disasters. The Province of Quebec experienced such events, for example: a historic ice storm, in the middle of winter 1998, that left a large portion of the Province without electricity for many weeks; in 2013, a railroad derailment of tank cars filled with flammable liquid caused a major fire that burned the downtown core of the city of Lac Mégantic, killing 47 people; or historical flooding, in 2018 and 2019, to name a few. Fire service organizations must also train and prepare their firefighters to respond to these kinds of situations.

Year after year, firefighters are recognized in popular surveys as a cherished group from citizens. They are trusted by their fellow neighbours and recognized for their dedication to the betterment of society. However, citizens expect firefighters to respond to any situation, anywhere, anytime, with the appropriate knowledge and skills (Yarnal & Dowler, 2002). Therefore, one could argue that fire service organizations should be proficient at creating,

sharing, and translating knowledge. Obviously, volunteer fire service departments may not be as well organized as career departments. Their organizational structure may not include a training division or specialized units and they may not have the necessary resources to develop extensive training on a diversity of subjects, considering that their members volunteer the time they can to the department. Therefore, in this general context requiring fire service organizations at large to maintain an agile knowledge stock, it is pertinent to ask: how is knowledge managed in the fire service sector? However, there has been no research on this subject to this day.

Research approach

To fulfill the research goal and answer the three research questions, a multi case-study is proposed of twenty Quebec volunteer fire departments. The research's conceptual framework is based on four theoretical strands: Nonaka's theory of knowledge creation (Nonaka, 1994), the knowledge management literature, the serious leisure theory, and the absorptive capacity literature. This dissertation presents three scientific papers in the following order:

- The fire paper (Paper 1) is a systematic literature review of global research on the fire service, published either in English or French. Intitled Discovering Underlying Themes in Fire-Related Research: An Analysis of 238 Peer-Reviewed Studies, the paper was submitted and published, in 2017, in the sole peer-reviewed journal dedicated to research on the fire service, the *International Fire Service Journal of Leadership and Management*.
- The second paper (Paper 2) is a research paper presenting an empirical study of KM in VFDs and it answers the first two questions (Q1-Q2). It is based on triangulation of data from an exploratory factor analysis of a firefighter's survey results (*N = 301*), semi-structured interviews of firefighters (*N = 10*), and content analysis of VFDs' municipal websites (*N = 20*). Intitled When Passion Fuels the Fire: Knowledge Sharing Among Volunteer Firefighters in Canada, the paper was submitted and published in 2018 in the *International Fire Service Journal of Leadership and Management*. The second paper was published in the same journal

as the first one because it constituted a logical sequence for the targeted audience of firefighters.

- The third paper (Paper 3) is a research paper, part theoretical and part empirical and it answers question three (Q3). It defines and illustrates the phenomenon of knowledge aDsorption in a public sector of activity, namely the Quebec fire service sector, through an application of Nonaka's model of knowledge conversion (Nonaka, 1994, 1998). This paper is based on triangulation of data from survey results ($N = 301$ firefighters), semi-structure interviews of firefighters ($N = 10$), and content analysis of nine sources: (1) **legislative texts** on the fire service sector; (2) **minutes** from (a) the Quebec National Assembly, from 1992 to 2000, pertaining to the fire service and from (b) a fire service sector forum held 2012; (3) **annual reports** from the National Fire Academy (NFA), from 2001 to 2018; (4) the sole **research report** from the NFA; (5) a NFA's **memorandum** submitted at the 2012 forum; (6) a **research report** published in 2015 by the association of fire chiefs (ACSIQ); (7) a **white paper** on the state of the Quebec fire service published in 2018 by ACSIQ; (8) **reports** on the fire service from the Coroner, the occupational health and safety agency, and the Ombudsman; and (9) **websites** of the NFA, ACSIQ, the fire instructors' association, and the fire prevention officers' association. Results were submitted to three subject-matter experts for critique and rival explanations. Intitled Knowledge aDsorption in the public sector: Heavy smoke showing in the fire service sector, the paper was submitted, in February 2020, to the *Journal of Information and Knowledge Management*.

The dissertation author, Claude Beauchamp, is the first and only author of Paper 1 and Paper 2. Paper 3 was written in collaboration with Professor Lilly Lemay, Ph.D. (research director) as second author. This research has received an ethical certification from ENAP's ethical committee.

Dissertation structure

This study constitutes a dissertation by scientific articles in accordance with ENAP's guidelines. Chapter 1 is intitled *Literature review and conceptual framework*. It presents a literature review of the four theoretical strands of research serving as the base for this research. It develops a general conceptual framework serving as an anchor point for this study. It also provides a chronological description of the Quebec fire service, from 1990 to 2019. Chapter 2, *Methodology*, presents the research strategy and associated methods, data treatments, data tables, criteria, and limits. *Results* are presented in the following three chapters: chapter 3 corresponds to Paper 1, chapter 4 to Paper 2, and chapter 5 to Paper 3. Chapter 6 presents a *Discussion* synthesizing the three papers in order to underline principal observations, main contributions, and future research suggestions. A *Conclusion* offers a general synthesis of this dissertation.

CHAPTER 1: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

This chapter presents the theoretical foundations and conceptual framework on which this research is based to answer three research questions:

(1) How is knowledge managed in VFDs?
(2) How does the fire service organizational culture influences knowledge management in VFDs?
(3) How does knowledge aDsorption affect knowledge conversion in a public sector of activity?

This chapter's objectives are to define the principal terms used in this research, review the scientific literature strands serving as theoretical grounds, and to develop the study's conceptual framework. The chapter also provides a description of the Quebec fire service sector which serves as the context for the case study on volunteer fire departments.

1.1 Definitions

Knowledge is considered a strategic organizational asset (Easterby-Smith & Lyles, 2011; Lam, 2000; Tsoukas & Mylonopoulous, 2004) and is defined as "a fluid mix of experience, values, contextual information, and expert insights that provide a framework for evaluating and incorporating new experiences and information" (Davenport & Prusak, 2000, p.5). Knowledge has tacit and explicit dimensions (Nonaka, 1994; Polanyi, 1966) and is "heavily social in character" (Brown & Duguid, 1998, p.91). Knowledge is said to be context-specific and dependent on time and space (Nonaka, Toyama, & Konno, 2000). Moreover, organizational knowledge entails to make "*judgments* within a *collective domain of action*, based on an appreciation of *context* and/or set of *generalizations*" (emphasis in text, Tsoukas & Vladimirou, 2001, in Tsoukas & Mylonopoulos, 2004, p.8). As new knowledge is institutionalized in the organization, it alters beliefs and assumptions even challenging the organizational worldview (Sun & Scott, 2005).

Knowledge management (KM) refers to "ways of measuring, disseminating, storing, and leveraging knowledge in order to enhance organizational performance" (Easterby-Smith & Lyles, 2011, p.3). Knowledge is socially embedded (Lam, 2000) and is said to be difficult

to manage per se, due to its complex, personal, and somewhat intangible nature (Senge, 2006; von Krogh, Ichijo, & Nonaka, 2000). This explains why KM involves soft issues such as trust and mutual understanding (Guzman & Wilson, 2005), and processes embedded in the social organizational culture such as sharing, interpreting, combining information and storing the information (Argote, Ingram, Levine, & Moreland, 2000).

Organizational knowledge transfer is defined as "the process through which organizational actors – teams, units, or organizations – exchange, receive and are influenced by the experience and knowledge of others" (Van Wijk, Jansen, & Lyles, 2008, p.832). Knowledge can or cannot be easily accessible. Sometimes, knowledge may be difficult to transfer, for example due to complexity, tacitness, or cultural differences. In fact, "the more tacit, specific, and complex the underlying knowledge, the less easily it can be transferred" (Van Wijk, Jansen, & Lyles, 2008, p. 838).

Cohen and Levinthal (1990) introduced the concept of absorptive capacity (AC), defined as the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (p.128). In this sense, high levels of AC can sustain strategic knowledge management to transfer valuable knowledge from external sources. Zahra and George (2002) refined AC's definition as a "set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability" (p.186). They suggested that AC exists as two subsets of potential and realized AC in a dynamic cycle where social integration mechanisms, such as formal or informal knowledge sharing among members, contribute to knowledge assimilation and exploitation.

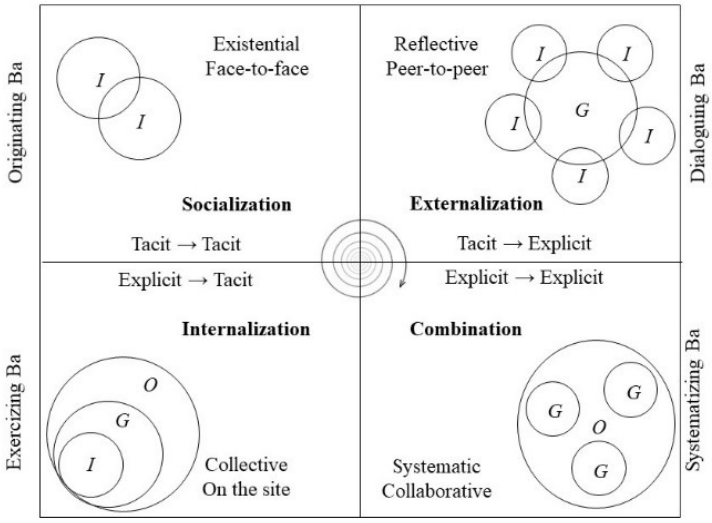
Organizational culture is defined as "a pattern of shared basic assumptions learned by a group as it solves its problems of external adaptation and internal integration, which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems" (Schein, 2010, p. 18). Organizational culture is a product of social learning (Schein, 2010) and therefore influences organizational knowledge as it is constituted of the stories, routines, experiences and information stock from which the organization can draw to further capabilities in KM

(Cook & Yanow, 1993; Lucas & Kline, 2008). Each organizational culture has dominant characteristics (Parolini & Parolini, 2012) that have an impact on KM. Organizational culture can impose barriers to organizational learning (Schilling & Kluge, 2009), for example perpetuating problems when transferring knowledge from old timers to newcomers (Koskinen & Pihlanto, 2006). Organizational culture can also have a variety of influences on the institutionalization of knowledge as coalitions may form around shared cultural understandings and either impede or sustain change (Miller, 1996; Crossan, Lane, & White, 1999; Wang & Ahmed, 2003). Therefore, it has a tangible impact on an organization's absorptive capacity.

1.2 Knowledge creation

Nonaka's theory of dynamic knowledge creation (Nonaka, 1991, 1994; Nonaka & Takeuchi 1995) has been recognized as a major advancement in KM theory (e.g.: Andreeva & Ikhilchik, 2011; Easterby-Smith & Lyles, 2011; Handzic, 2011; von Krogh, Ichijo, & Nonaka, 2000). This theory introduced the SECI model (Figure 1.2) which describes how knowledge moves continuously in a spiralling way from tacit to explicit to tacit, at different levels in the organization. Knowledge is said to transit between individuals (I), groups (G), and the organization (O) through four modes of knowledge conversion – socialization, externalization, combination, and internalization (Nonaka, 1991, 1994; Nonaka & Takeuchi 1995; Nonaka, Toyama, & Konno, 2000). The assumption is that, while moving through these modes, knowledge is bonified and new knowledge is created thus improving knowledge value (Rice & Rice, 2005).

Figure 1.2: Nonaka's SECI model



Legend: I – individual; G – group; O – organization

Source: adapted from Nonaka & Toyama (2003)

Knowledge conversion happens in different places or *Ba*, a Japanese philosophical construct referring in some way to 'context'. For knowledge creation to happen, 'knowledge activists' (von Krogh, Ichijo, & Nonaka, 2000) are required in the different *Bas*. These leaders must surface and become catalysts of knowledge creation. Acting as coordinators of knowledge-creation initiatives, activists also contribute by becoming merchants of foresight selling the vision and fighting organizational myopia.

In the *originating Ba*, individuals interact (*socialization*) and share personal knowledge, emotions, and perceptions. Trust and care play a key role in this sharing of knowledge. It is in the *dialoguing Ba* that tacit knowledge is transferred to explicit (*externalization*) through dialogue and metaphors. The *systemizing Ba* is collaborative in nature and refers to a virtual place where, for instance, technology is used to recombine existing knowledge in new knowledge (*combination*). Finally, the *exercising Ba* seeks to convert into tacit knowledge the acquired knowledge from the *systematizing Ba*.

Nonaka and Konno (1998) point out that *Ba* "exists at many levels and these levels may be connected to form a greater *Ba* (known as a *Basho*)" (p.41). Therefore, the team represents

the *Ba* of individuals, the organization represents the *Ba* of teams, and the market/sector environment encompasses the *Ba* of the organizations.

In theory, the concept of *Ba* allows to identify places where knowledge can be found and the SECI process illustrates how knowledge is created in these *Bas*. However, Nonaka's work has also drawn diverse criticism. Some argue that the model suffers from flaws in the conception of knowledge (Essers & Schreinemakers, 1997) or that its empirical foundations (Nonaka, 1992; Nonaka, Byosiere, Borucki, & Konno, 1994) lack credibility thus affecting its 'engine' (Gourlay, 2006). Others claim that the model's embeddedness in the Japanese culture makes it difficult to apply in other cultural environments where values, communications, and work arrangements are different (e.g.: Andreeva & Ikhilchik, 2011; Glisby & Holden, 2003). Therefore, some organizations may be able to implement the SECI process and have it run easily while others may face various problems.

However, Nonaka has responded to these criticism (e.g. Nonaka, von Krogh, & Voelpel, 2006) and his work remains a dominating influence when discussing organizational knowledge (Easterby-Smith & Lyles, 2011). The SECI model implies to find and connect all relevant *Ba* (Travaille & Hendriks, 2010) and to identify key processes of KM enabling knowledge creation.

1.3 Knowledge management

Four factors are generally considered in KM analysis: internal context, content, process, and external environment (Oliveira, Pedron, Romão, & Becker 2011; Syed-Ikhsan & Rowland, 2004a, 2004b; Oliva, 2014; Hsieh, Lin, & Lin, 2009; Martin, Hatzakis, Lycett, & Macredie 2005; Kruger & Johnson, 2011; Soltani, Joneghani, & Bozorgzad, 2011). Constructs associated with each factor are integrated in this study.

First, internal context refers to top management support (TM) and how technological systems (IT) contribute to maintaining an up-to-date internal knowledge base (Oliveira, Pedron, Romão, & Becker 2011; Rašula, Vukšić, & Štemberger, 2008; Hsieh, Lin, & Lin, 2009). KM involves some degree of change, and support from top management is therefore crucial. Top management support (TM) is defined as "the degree to which top management

understands the importance of knowledge management and the extent to which top management is involved in knowledge management practices" (Lin, 2011 in Oliveira, Pedron, Romão, & Becker 2011). As organizational strategies seek to develop the organization as a learning entity aimed towards strategic placement in a complex environment (Argyris, 1976; Argyris, 1982; Brown & Duguid, 1998; Easterby-Smith, Crossan & Nicolini, 2000; Lemay, Bernier, Rinfret, & Houlfort, 2012), top management support thus becomes the foundation on which rest KM processes. Among these processes, management will seek to stock knowledge in technological systems (IT) allowing for future use and profitability (Teece, 1998; Vera, Crossnan, & Apaydin, 2011).

Secondly, content is the factor related to management of tacit and explicit knowledge. Knowledge is tacitly (TK) held by the individual (Nonaka & Konno, 1998; Nonaka, 1998; Nonaka & Von Krogh, 2009) and organizational strategies are deployed to render this knowledge explicit (EK) in order to transfer it to other individuals (Wang & Ahmed, 2003; Koskinen & Pihlanto, 2006). Knowledge transfer (Szulanski, 1996) from one individual or unit to another allows for experience sharing (Argote & Ingram, 2000; Argote, Ingram, Levine & Moreland, 2000) as well as perpetuation and codification of organizational culture (Rouiller & Goldstein, 1993; Paulus & Yang, 2000; Cohen & Levinthal, 1990).

Thirdly, process refers to the processes of knowledge creation, storage and sharing (Hsieh, Lin, & Lin, 2009; Türetken & Demirörs, 2004; Oliveira, Pedron, Romão, & Becker, 2011; Oliveira, Pedron, Nodari, & Ribeiro 2014; Lin, Wu, & Yen, 2012; Khatibian, gholoi pour, & Jafari, 2010). Knowledge discovery or knowledge creation (KC) may be defined as "the development of new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge" (Hsieh, Lin, & Lin, 2009, p. 4089). Knowledge creation is among the processes that sustain innovation and the development of new services (Oliveira, Pedron, Nodari, & Ribeiro 2014). Knowledge storage (KST) refers to "appropriation, revision and organization of knowledge in a way that allows it to be accessed and updated" (Oliveira, Pedron, Nodari, & Ribeiro 2014, p. 758).

Problems related to this process have been identified as barriers to knowledge maturity (Oliva, 2014) because knowledge storage is often associated with efficiency in sharing explicit and tacit knowledge (Hsieh, Lin, & Lin, 2009). Knowledge sharing (KSH) is the action by which individuals or units share their acquired knowledge with others (Oliveira, Pedron, Nodari, & Ribeiro 2014; Hsieh, Lin, & Lin, 2009). In some instances, knowledge sharing can be slowed or impaired by knowledge stickiness (Szulanski, 1996) which connotes the difficulty to transfer knowledge, for example, when there is a lack of absorptive capacity (Cohen & Levinthal, 1990) in the recipient unit or difficulties in replication of organizational practices. Groups can also tend to focus on information they have in common rather than on sharing their unique expertise, thus creating barriers to knowledge transfer (Paulus & Yang, 2000). Knowledge transfer is also influenced by commitment as the motivation of individuals to share knowledge may be shape by their organizational commitment (Hislop, 2003). Furthermore, learning what is new or transforming routines may have a significant cost which will impact the willingness to change and perpetuate path-dependent tendencies despite novelty (Carlile, 2004).

Finally, the external environment refers to the knowledge sources that can be accessed by an organization outside its boundaries. These sources include suppliers (SUP), partners (PART), and customers (CUST). Trying to gain knowledge from the external environment is seen as an important strategy such as hiring an expert from the competition or entering a new network (Hartley & Allison, 2002; Powell & Grodal, 2005). Other strategies related to knowledge transfer include training, communication, observations, technology transfer, scientific publications or presentations (Argote, Ingram, Levine, & Moreland, 2000). In this study, suppliers (SUP) are understood as private sector firms that provide firefighting equipment to the fire department. In the context of municipal service of the fire department, partners (PART) are either other municipal departments or mutual aid fire departments which interact with the fire department. Customer (CUST) are understood as the citizens the fire department provides service to. Finally, since there is a body of research in the external environment of the fire service that is challenging assumptions, academic and applied research will be utilized as a construct (AAR).

1.4 VFDs organizational culture as serious leisure

Stebbins seminal work on serious leisure theory supports a framework enabling the analysis of different variations of volunteer work in various domains (Stebbins, 1996), Volunteer firefighting has been characterized as a serious leisure (Stebbins, 2008; Elkington & Stebbins, 2014). A serious leisure is defined as: "the systematic pursuit of an amateur, hobbyist, or volunteer activity sufficiently substantial, interesting and fulfilling for the participant to find a (leisure) career there acquiring and expressing a combination of its special skills, knowledge and experience" (Elkington & Stebbins, 2014).

The serious leisure theory is based on a three-part typology: (1) the amateur in a domain where professionals do exist (sports, astronomy, magician, etc.), (2) the hobbyist where no professionals exist (running, collectors, numismatic, etc.), and (3) the volunteer who engages for a period of time in work aimed at helping others without being forced to do so and without expecting any gratification, pay or rewards for the work done (Habitat for Humanity, firefighter, community work, elder's support, etc.) (Yarnal & Dowler, 2002). The amateur, the hobbyist and the volunteer are all anchored in their own world-view characterized by groups, events, routines, practices, organizational structures, and the necessity to acquire new skills and competencies (Stebbins, 1996). Thus, volunteering in the local fire service requires the individual to develop a good understanding of the organizational culture, and entails mastering a unique knowledge stock.

A serious leisure is characterized by four components that are used as constructs in this research (Elkington & Stebbins, 2014): (1) qualities (QUAL) provided by the serious leisure that individual can develop through time; (2) rewards (RWD) linked to motivation as the individual engages with others in the core activity of leisure; (3) thrills and psychological flow (TPF) or the sensation that comes with the actual enacting of the core activity; and (4) devotee work (DEWO) which allow an individual to express creativity and innovation in a valued and profound core activity that requires substantial skills, knowledge or experience or a combination thereof (see Table 1.4).

Table 1.4: Serious leisure characteristics (adapted from Elkington & Stebbins, 2014)

Qualities	Rewards/motivation	Thrills/flow	Devotee work
Perseverance; Search imagination for new approaches; Opportunity to follow a leisure career; Significant personal effort (using specially acquired knowledge, training, skills, or all three); Durable benefits; Unique ethos; Distinctive identity.	Personal rewards: Personal enrichment; Self-actualization; Self-expression; Self-image; Self-gratification; Re-creation; Financial return. Social rewards: Social attraction; Group accomplishment; Contribution to group.	Sense of competence in executing the activity; Requirement of concentration; Clarity of goals of the activity; Immediate feedback from the activity; Sense of deep, focused involvement in the activity; Sense of control in completing the activity; Loss of self-consciousness during the activity; Sense of time is truncated during the activity.	Valued core activity; Core offers significant variety; Core offers significant opportunity for creative innovation (showing imagination and application of routine skill or knowledge); Reasonable control over the amount of time to put into the core activity; Aptitude and taste for the required work; Physical and social milieu encourages the pursuit of the core activity.

Characteristics presented in Table 1.4 underline the importance of knowledge in a serious leisure. The individual engages in a significant personal effort to acquire and develop the necessary knowledge and skills. By being able to use this knowledge, the individual experiences a quality of the serious leisure. Moreover, by becoming knowledgeable in the leisure, the individual gains the rewards of personal enrichment, self-gratification, and the capacity to contribute to a group. In turn, by mastering the necessary knowledge and skills, the individual develops a sense of competence in executing the activity even more so when the activity allows to use knowledge in creative ways.

Still, these serious leisure characteristics are in tension with the conservative nature of the fire service. The fire service culture is characterized by a dominant logic (Bettis, Wong, & Blettner, 2011) embedded in routines (Miller, 1996) and expressed by the importance of hierarchy, tradition, conservatism, and reluctance to change (Thompson, 1995). Such values, many of them implicit, are reinforced by role models, status rituals, procedures, and vocabularies (Miller, 1996). This logic contributes to maintaining clear roles in the hierarchy. Key organizing principles are specialization, standardization and control which depend heavily on encoded knowledge. Research on organizational learning and KM suggests that centralized and hierarchical structures where routinization, formalization and

procedures are key elements tend to reinforce institutionalized behaviours and slow learning processes (Nicolini & Meznar, 1995; Parolini & Parolini, 2012). In fact:

> "Hierarchical divisions of labor often distinguish thinkers from doers, mental from manual labor, strategy (the knowledge required at the top of a hierarchy) from tactics (the knowledge used at the bottom). Above all, a mental-manual division predisposes organizations to ignore a central asset, the value of the know-how created throughout all its parts" (Brown & Duguid, 1998, p.99).

This type of logic makes the organization continuously strive for stability through codification of knowledge by the managerial hierarchy, even to the point of organizational rigidity (Lucas & Kline, 2008).

The fire service is highly dependent on institutionalized knowledge which is disseminated through direct or subtle indoctrination (Miller, 1996) as consensus and a strong organizational ideology discourage any intervention that would question tradition (Lucas & Kline, 2008). Moreover, this institutionalized consensus expressed through a shared vision and a common knowledge stock can undermine organizational learning and knowledge transfer as suppression of variance reduces organizational knowledge capabilities even to the point of knowledge fossilisation (Bettis, Wong, & Blettner, 2011). In the fire service, this reduction of variance is seen through the *groupthink* phenomenon:

> "Highly consensual networks can actually impede learning where they fail to challenge shared views and common assumptions, potentially leading to actions with negative consequences. Janis and Mann (1977) identified this problem in groups, labelling it 'groupthink': when groups that work well together and share similar perspectives fail to challenge shared views" (Rashman, Withers, & Hartley, 2009, p.480).

Research has shown that fire departments are breading grounds for groupthink as (1) there is no tolerance for non-conformity; (2) 'probies' and young firefighters will censure themselves in order to be accepted by the group; and (3) the group maintains an illusion of invulnerability (Laughlin, 2008). Knowledge becomes highly fragmented and only

integrated at the top of the hierarchy through procedures and guidelines causing the organization to operate "on a partial, incomplete and impoverished knowledge base" (Lam, 2000, p.478).

In sum, the fire service organizational culture is showing signs of conservatism that may impair innovative thinking and transfer of knowledge from external sources. Knowledge appears fossilized in agreed-upon practices centralized in the hierarchy as culture seems to hinder individual initiative in creative innovation. In turn, the lack of KM strategies sustaining knowledge maturation towards innovative ways of thinking can lead to discrepancies between the actual level of service and citizens' expectations.

1.5 Absorptive capacity

Since Cohen and Levinthal's paper (1990), the concept of absorptive capacity has been studied extensively, mostly in the firm's context, to refine its definition and understand its implications in KM (e.g. Escribano, Fosfuri, & Tribo, 2008; Lenox & King, 2004; Vasconcelos, Matins, Ellis, & Fontainha, 2018). Examples include understanding AC in cross-sector social partnerships (e.g. Pittz & Intindola, 2015), relationship between leadership styles and AC (e.g. Méndez, Valle, & Alegre, 2018), and effects of AC on interorganizational learning (e.g. Lane & Lubatkin, 1998; Schildt, Keil, & Maula, 2012).

Van den Bosch, Volberda, and de Boer (1999) suggested that two organizational determinants impact the level of AC in a firm. First, they contend that organizational forms (functional, divisional, or matrix) present various levels of potential for AC. At the bottom, the functional form presents low potential for AC due to strong hierarchy and focus on efficiency and stability. Divisional forms offer more potential for AC since loose coupling among divisions supports knowledge adsorption. Matrix forms offer flexibility, agility, and present few hierarchical levels thus offering high levels of flexibility and potential for AC. Second, they suggested that three types of combinative capabilities sustain AC: systems, coordination, and socialization capabilities. Suggesting similarities between systems capabilities and the combination phase of knowledge creation (Nonaka, 1994), the authors underscored that policies, procedures, and manuals contribute to absorb explicit knowledge. Coordination capabilities underline how relations between members of a group

enhance AC. Finally, socialization capabilities refer to the impacts on AC of shared ideology and values, collective interpretations, and organizational culture.

In a landmark article, Zahra and George (2002) proposed a reconceptualization of AC by suggesting that AC exists as two subsets of potential and realized AC. Proposing a new definition of AC as a "set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability" (186), they sketched AC as a dynamic cycle between these four dimensions. In their model that emphasises potential versus realized AC, social integration mechanisms such as formal or informal knowledge sharing among members contribute to knowledge assimilation and exploitation.

The Zahra and George (2002) model became the focus of numerous studies. For example, Jansen, Van den Bosch, and Volberda (2005) contended that research on AC had largely ignored organizational antecedents. Focusing on the unit level, they illustrated how organizational mechanisms associated with coordination enhance potential AC while socialization capabilities strengthened realized AC. Another study came from Todorovan and Durisin (2007) who were critical of the model. They suggested that an AC model needed to consider dynamics like feedback loops, a feature absent in Zahra and George's (2002) proposition.

In their AC literature review, Lane, Koka, and Pathak (2006) challenged the AC scholarship by stating that AC had become reified. It was now necessary, according to Lane, Koka, and Pathak (2006), to move away from a structural perspective of AC and see AC as a dynamic capability defined as:

> "a firm's ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning, (2) assimilating valuable new knowledge through transformative learning, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning" (p.856).

Therefore, studying AC in different organizational contexts required, first, to focus attention on knowledge management processes such as transfer, sharing, and creation and, second, to investigate individual cognition and shared mental models.

Even though research had stressed the importance of organizational design and the individual level for the study of AC, other scholars have concluded that these areas of research remained relatively neglected (Volberda, Foss, & Lyles, 2010). In fact, it seemed that studies had not documented sufficiently the impacts of internal mechanisms influencing AC such as communication processes and the distribution of knowledge and expertise in the firm. Among the many research gaps on AC identified in this review, studies on intraorganizational antecedents (e.g. organizational structure, managerial styles, organizational culture, and network ties) was needed.

Building on this body of research, Lewin, Massini, and Peeters (2011) found that AC's specific organizational routines and processes were still unclear. In part, capabilities related to internal knowledge (combination, recombination, transformation, exploitation, and assimilation) needed to be explicated. Therefore, they proposed a framework to identify the micro foundations of AC "in the form of a metaroutine taxonomy underlying absorptive capacity and their expression in organizations in the form of practiced routines" (p.83). Their framework showed the relations between AC internal metaroutines, which include contextual organization-specific routines such as knowledge sharing and combination, and external metaroutines such as identifying external knowledge sources and learning from external organizations. In this framework, both sets of metaroutines are moderated by sociocultural shared values and norms that build connectedness between the organization's members. According to these authors, there needs to be complementarities between internal and external routines. If the organization is incapable of transferring knowledge and integrating it in knowledge creation processes, external AC routines will be useless. Like previous research (Van den Bosch, Volberda, & de Boer, 1999), these scholars underlined the relation between AC's effectiveness and organizational forms. Again, highly hierarchical structures appeared detrimental to AC.

Finally, a recent meta-analysis of AC research (Song, Gnyawali, Srivastava, & Asgari, 2018) found that the literature is still characterized by fragmented theoretical propositions based on a diversity of measures. Moreover, reification of the concept (Lane et al., 2006; Lewin, Massini, & Peeters, 2011) has somewhat stalled research and resulted in the use of AC as a general construct.

Still, a recent strand of research on AC, mostly anchored in the supply management literature (e.g. Bravo, Ruiz-Moreno, & Montes, 2018; Meinlschmidt, Foerstl, & Kirchoff, 2016) and based on work on open innovation (Lichtenthaler, 2009; Lichtenthaler & Lichtenthaler, 2009), has proposed to consider AC as a continuum between knowledge absorption and what has been termed knowledge 'desorption' (Denford & Ferriss, 2018). Knowledge desorption is composed of two steps: "proper identification of the knowledge transfer opportunity and the transfer process itself, which supports application of the knowledge at the recipient" (Bravo, Ruiz-Moreno, & Montes, 2018, p.534). Thus, desorptive capacity is the inverse of absorptive capacity and is defined as "the mechanism for identifying what knowledge resources have economic value for the firm and the ability to transfer the knowledge to realize value for the firm" (Denford & Ferriss, 2018, p.1427). However, much research remains to be done to refine the concept's definition and its application.

What becomes apparent from existing literature is that scholars seem to agree that AC should be understood as dynamic in nature involving synergy between different modes of knowledge conversion. Nonetheless, it becomes difficult to associate a clear sequence of modes of knowledge conversion to AC. There is no agreement on what these modes should be because studies reference general modes of knowledge conversion without grounding them in specific theory. For example, Zahra and George (2002) refer to acquisition, assimilation, transformation, and exploitation, while Lewin, Massini, and Peeters (2011) refer to combination, recombination, transformation, exploitation, and assimilation. On the other hand, there is agreement that AC is moderated by aspects of organizational culture such as: (1) shared mental models, norms, and values, (2) communication processes, and (3) individual behavior towards knowledge. Moreover, research points to the importance of prior related knowledge, such as basic skills and shared language, since AC also depends

on knowledge transfer across and within sub-units. Finally, scholars consider that AC is directly linked to networking capabilities being moderated by organizational forms and hierarchical structures.

In sum, this literature review underlined that scholars have concentrated their work on aBsorption of knowledge while leaving aside problems associated with knowledge aDsorption, a new concept introduced here. By analogy with chemistry[5], knowledge aDsorption in organizations - particularly in the public sector - implies a phenomenon of organizational boundaries' closure: opportunities for learning or acquisition of external knowledge arise, but they remain at the state of potential in the sectoral environment. Such problems of knowledge aDsorption may prove detrimental, in the public sector, to efficient networking activities necessary to resolve wicked problems (Provan & Kenis, 2008; Weber & Khademian, 2008).

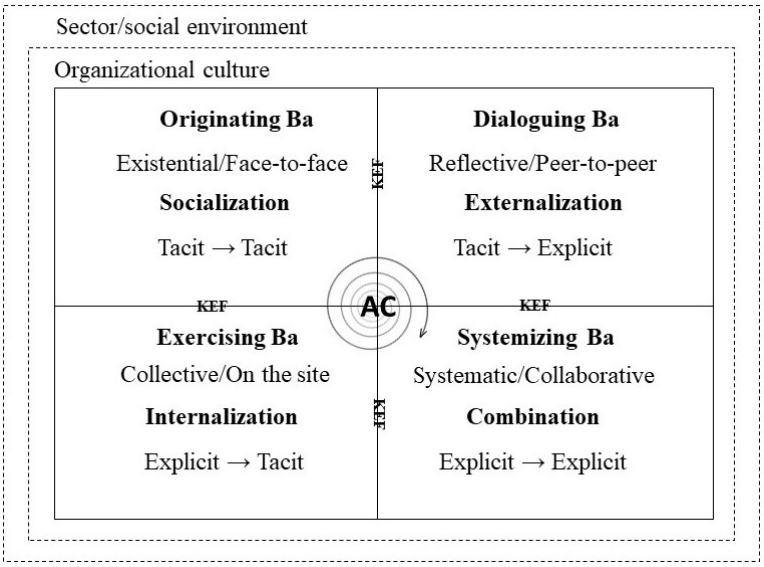
Organizational porosity to knowledge depends on energetic and kinetic factors. On the energy front, organizational AC goes through people, their modes of exchange and management as well as KM and learning. However, it is not enough to rely on the goodwill of a few. Structural (kinetic) movements become necessary, ranging from change-incentive events to structural or strategic changes to bring about behavioral changes. Still, when there is dissymmetry between kinetic and energetic factors, the organization can suffer from the phenomenon of knowledge aDsorption. However, there is still a potential to open boundaries and absorb new knowledge. As in chemistry, this shift from aDsorption to aBsorption can come from changes in the porosity properties of organizational boundaries to capture and integrate new knowledge.

[5] Adsorption, not to be confused with absorption, is a surface phenomenon by which molecules of gases or liquids attach to the solid surfaces of the adsorbents. If the energetic or kinetic conditions allow the molecule to penetrate within the adsorbent phase, there is absorption. (Translated from French from: https://www.futura-sciences.com/sciences/definitions/chimie-adsorption-3468/, page consulted on August 2nd 2019).

1.6 Integrated conceptual framework

To answer the three research questions, this study's integrated conceptual framework is based on the intersection of the four preceding theoretical strands. First, it draws from Nonaka's SECI model of knowledge conversion and concept of *Ba* to describe how the spiralling movement of knowledge creation works in the Quebec fire service sector. Secondly, the framework uses KM theory to assess processes of knowledge creation, storage, and sharing in VFDs. Thirdly, it builds on serious leisure theory to dwell into organizational culture aspects of VFDs to explain if this culture acts as leverage or barrier to KM processes. Finally, it draws from research on AC to assess how valuable knowledge is absorbed and managed in the Quebec fire service sector. Figure 1.6 illustrates the conceptual framework.

Figure 1.6: Conceptual framework



In Figure 1.6, the spiralling movement of knowledge conversion supports the sector's absorptive capacity (AC). Knowledge transit from one *Ba* to another under the impulse of kinetic and energetic factors (KEF). In this framework, knowledge creation is valued by top management (TM/IT) and is supported by the spiralling movement of socialization, externalization, combination, and internalization of knowledge. Tacit and explicit

knowledge (TK-EK) continuously flow in the sector to create a dynamic knowledge stock. KM processes of knowledge creation (KC), storage (KST), and sharing (KSH) contribute to the sector's AC. In turn, dynamic processes of KM and proactive leadership sustain knowledge desorption practices to the betterment of the sector of activities or external entities.

Knowledge management strategies related to knowledge conversion are also tributary of the dominant organizational culture. In the present case, this culture is associated with the qualities (QUAL), rewards (RWD), thrills and psychological flow (TPF), and devotee work (DEWO) characteristics of a serious leisure. Doted lines represent that this organizational culture is somewhat porous to external knowledge sources located in the sector of activity or the external environment at large. These sources are customers/citizens (CUST), partners (PART), suppliers (SUP), and academic/applied research (AAR).

1.7 Quebec fire service

From the early 1980s to 2000, KM was at the forefront of an on-going debate about the future of the Quebec fire service among fire service leaders and government representatives, as reported in the National Assembly's minutes. The fire service was experiencing staggering losses to fire, rising costs associated with injuries, and poor access to knowledge, in particular for volunteer firefighters. Most fire departments were plagued by an outdated knowledge stock. Individuals were learning mostly from traditions passed along by other firefighters, themselves trained by others before them. Fire chiefs pleaded for the necessity to reform the fire service through legislation and protested the lack of support from government by organizing a public manifestation, on November 26, 1992, at the National Assembly in Quebec City.

During this period, incidents involving volunteer firefighters drew attention to enduring problems related to poor KM. On June 27, 1993, a barn fire caused the explosion of a propane cylinder killing all four volunteer firefighters of the first arriving crew and injuring seven others. On June 19, 1998, a fire in an industrial complex caused a natural gas explosion that killed two volunteer firefighters and injured six others. The provincial occupational health and safety agency's reports on these events indicated that lack of

appropriate knowledge and necessary skills were among the primary causes of death and injuries (CSST, 1995, 1999). Those two tragedies found an echo in the Quebec National Assembly, sadly providing a reality check for the necessity of a new fire safety legislation based on performance enhancement and renewed KM.

Passed in 2000, the Quebec Fire Safety Act became one of the most comprehensive pieces of legislation on fire safety in Canada. Among many topics addressed, the Act included mandatory training for all firefighters through the accompanying *Regulation respecting the conditions governing the exercise of functions within a municipal fire safety service*. The Act also included the creation of a National Fire Academy (NFA) acting as a sector-wide knowledge governance entity and a knowledge activist for the provincial fire service sector. The NFA's mission is to ensure that firefighters and other municipal fire safety personnel in Quebec receive pertinent, high-quality and coherent qualifying professional training, which includes basic and advanced training. Moreover, the NFA is required to foster, facilitate and plan exchanges of expertise with persons or bodies outside Quebec and encourage participation by Quebec specialists in international exchange missions on fire safety training.

In 2012, the Ministry of Public Security hosted a provincial Forum to reflect on the first decade of the Fire Safety Act enforcement. Even though data revealed an increase in the level of competency of firefighters (Quebec, 2013), issues related to KM in volunteer fire departments were and still are of concern, as illustrated by the following examples.

- In 2006, a citizen became stranded off-route for a significant period after sustaining serious injuries from an all-terrain vehicle accident. Rescue operations were difficult, and the citizen filed a complaint to the Quebec Ombudsman. This event led to a report from the Ombudsman on rescue operations in remote areas and one of the conclusions identified KM and skills in rescue operations as problematic in some fire departments (Protecteur du Citoyen, 2013).
- In 2008, the inquiries into two line of duty deaths in volunteer fire departments, the first on March 4 and the second on March 9, underlined again that KM, lack of

training and appropriate skills were among the causes of death (CSST, 2009a, 2009b).

- During the night of January 23, 2014, a major fire in a retirement home caused the death of 32 elders. After a public inquiry, the investigator[6] linked operational deficiencies on the part of the VFD to lack of knowledge, inefficient KM, inadequate training, deficiencies in the incident command system, and faulty situational awareness.

Surely, KM in the Quebec fire service has progressed since the 2000 Act. Today, most firefighters are trained at least in basic firefighting skills and continuous training programs are implemented in many fire service organizations. However, network governance of knowledge has still to be realized. To this end, fire chiefs are critic of the government's leadership in the fire service sector, in particular about the paucity of strategic KM actions from the NFA. Somewhat isolated by the fact that Quebec is a French-speaking territory in the English-speaking North America, the Quebec fire service is still not gaining access to many external knowledge sources which reflects in difficulties to implement strategic knowledge governance at the sector level.

[6] The final report is available at: http://www.coroner.gouv.qc.ca.

CHAPTER 2: METHODOLOGY

2.1 Epistemological position

The epistemological position guiding this research is one that recognizes reality as a social construction (Berger & Luckmann, 1966). Therefore, a legitimate and meaningful way to generate data to study a process which operates situationally (Mason, 2002) is to give voice to individuals. To achieve this goal, the following sources of evidence are of interest: people, organizations and institutions, texts, settings, and artefacts (Mason, 2002, Yin, 2014). Stemming from contextual information suggesting that KM is a pressing issue in the fire service, this research is based on an intellectual "mechanical puzzle" (Mason, 2002, p.18) seeking to understand (1) how knowledge is managed in VFDs, (2) how the fire service organizational culture influences KM, and (3) how does knowledge aDsorption affect knowledge conversion in a public sector of activity.

2.2 Case study

This case study was based on a flexible design (Robson, 2002) and an iterative strategy to examine "a contemporary phenomenon in its real-life context" (Yin, 1981, p.59), namely KM in the fire service sector. Case studies are suited for exploratory research (Gagnon, 2012) and entail "an intensive study of a single unit for the purpose of understanding a larger class of (similar) units" (Gerring, 2004, p. 342). Moreover, case studies are said to be relevant when the focus of study is to answer 'how' questions (Baxter & Jack, 2008; Yin, 2014) and research seeks to "illustrate causal relationships more directly" (Siggelkow, 2007, p. 22). Furthermore, case study is relevant when one wants to "understand a real-world case and [assumes] that such an understanding is likely to involve important contextual conditions pertinent to [the] case" (Yin, 2014, p. 16).

2.3 Study design components

A case study design is said to have five components (Yin 1992; Yin, 2014; Zucker, 2009): the research question(s), its propositions, its unit(s) of analysis, multiple sources of evidence with data converging in a triangulation fashion, and criteria to interpret the findings.

2.3.1 Research questions, propositions, and unit of analysis

This research is based on three main questions. The first and second questions: (1) How is knowledge managed in volunteer fire departments? and (2) How is the organizational culture influencing KM? are focused on the profession of firefighting. These questions are supported by the following propositions:

P1: Knowledge sharing among firefighters is their main source of learning.

P2: Serious leisure components are levers to knowledge management in volunteer fire organizations.

P3: Turned inward, the fire service organizational culture impairs knowledge transfer for external sources such as other fire departments, partners, customers, suppliers, and academic and applied research.

The third question (How does knowledge aDsorption affect knowledge conversion in a public sector of activity?) is focused on the fire service sector of activity.

For this case study, the unit of analysis referred to volunteer fire departments in the Province of Quebec, Canada.

2.3.2 Sources of evidence and criteria for analysis

About case study research, Eisenhardt (1989) stated that "triangulation made possible by multiple data collection methods provides stronger substantiation of constructs and hypotheses" (p.538). Using a mixed methodology is pertinent in case study research (Yin, 1981, 2014) and is a recognized strategy for triangulation allowing to "collect a richer and stronger array of evidence" (Yin, 2014, p.66). This research was based on triangulation from the following data sources.

First, an online survey of volunteer firefighters was realized to gather data on KM in volunteer fire departments throughout the Province of Quebec. Second, municipal websites of the fire departments participating in this study where analyzed to document e-government practices on KM. Third, semi-structured interviews of firefighters and fire

officers allowed to refine the understanding of survey results and dwell more in-depth in understanding the impacts of the organizational culture of the fire service on KM strategies and processes. Finally, a corpus of governmental and non-governmental documents related to the fire service was studied to enhance the contextualization of findings. The following sections provide explanations about the criteria for analysis.

2.4 Online Survey

The questionnaire was written in French to be administered in the Province of Quebec and subsequently translated to English for publication purposes (see ANNEX A). The survey was first submitted to three subject matter experts with extensive knowledge of the Quebec fire service (one retired fire chief, one deputy chief, and one battalion chief) who provided comments and suggestions for improvement thus contributing to robustness and validity of the survey instrument (Field, 2009; Robson, 2002). The survey was made accessible using an online survey engine (http://www.surveymonkey.com) through a dedicated web page acquired for this research (http://www.sondagepompier.ca). Individuals could access the survey at their convenience, during a designated period, using a computer, an electronic tablet, or an intelligent portable phone.

2.4.1 Survey sampling

The survey was administered in volunteer fire departments in the Province of Quebec, Canada. Volunteer firefighters, or part-time firefighters as they are called in this Province, are in the majority (78%; $N = 13,860$) (Québec, 2013). Using a five-point Likert scale ranging from one (strongly disagree) to five (strongly agree), the on-line survey questionnaire was designed to measure firefighters' perceptions about their preferred knowledge sources and KM processes in their fire department (Robson, 2002). The survey included questions related to the four dimensions of KM and four components of the serious leisure of fire fighting.

The Province of Quebec is divided into county regional municipalities (CRMs). This geographical division served as a base for a two-step sampling strategy. First, a purposive sample (Sample A) (Robson, 2002; Teddlie & Yu, 2007) was composed of the 17 volunteer

fire departments located in one CRM. Purposive sampling is based on the researcher's judgment as to typicality (Robson, 2002; Teddlie & Yu, 2007). This CRM was chosen because its 17 departments are diverse in their composition: some provide services in small rural municipalities and have less resources, others present a more elaborated organizational structure and are located near a rapidly expanding suburb. While some departments may have full-time positions (such as fire chief), volunteer firefighters staff all departments. The researcher personally contacted each fire chief to explain the research project and to gain their collaboration. Chiefs were informed of the research's ethical certification, granted by the university's ethics committee where the researcher is affiliated. As an incentive, chiefs were promised a summary of findings for their own departments. Of the seventeen chiefs contacted, thirteen agreed that their firefighters (*N = 351*) could be solicited for the survey. Out of the 351 firefighters, 47% (*N = 165*) participated in the survey.

The second sample (Sample B) was gathered through cluster sampling (Robson, 2002). Seven CRMs were randomly selected, based on their geographical location, to cover the entire Province. Next, random sampling was applied to select one volunteer fire department from each CRM. These seven departments represent a sample of 356 firefighters. Fire Chiefs were contacted in the same manner as for Sample A. About 38% (*N = 136*) of the firefighters participated in this survey. In summary, out of a total of 707 solicited volunteer firefighters, 317 firefighters (44.9%) participated in both surveys. Sixteen respondents were deleted from the dataset because they did not answer a single question in the survey, thus leaving a final sample of 301 firefighters (42.5%). With a population of 13 860, and a sample of 301 firefighters, the survey's margin of error at 95% confidence level is 6%.

The majority of the firefighters who completed the surveys were male, young, and spoke and read French and had studied either a trade in high school or a technical profession in college. A large majority of the firefighters had served in their departments for less than ten years. Finally, all firefighters were qualified or were in the process of obtaining their qualifications, as required by provincial legislation (see Table 2.4.1).

Table 2.4.1: Demographic data

Firefighter	Sample A	Sample B
Gender = Male	96%	91%
Age: Between 18 and 40 Between 41 and 50 Between 51 and 60 Over 60	 49.8% 27.8% 9.1% 13.3%	 56.8% 20.0% 16.8% 6.4%
Language	French as first language. Individuals indicate basic capacities in English.	French as first language. Individuals indicate basic capacities in English.
Academic background (between third year of high school to either a trade certification or second year of College)[a]	90.7% (e.g.: carpenter, plumber, contractor, technician, etc.)	87.7% (e.g.: carpenter, plumber, contractor, technician, etc.)
Years of service in the fire department	0 – 10 years = 70%	0 – 10 years = 68%
Firefighter qualifications[b]	All qualified, some in the process of obtaining their qualification.	All qualified, some in the process of obtaining their qualification.
a: In Quebec, there is a collegiate level between high school and university. b: In Quebec, legislation mandates firefighter qualifications regardless of status (volunteer or career firefighter).		

2.4.2 Exploratory factor analysis of survey data

Note to the reader: in order to facilitate the reading of the following sections, only the principal data tables have been included in the text. All other relevant tables have been grouped in ANNEX B. These tables are referenced as Table Bn.

Exploratory factor analysis (EFA) is effective for "unearthing the basic empirical concepts in a field of investigation" (Rummel, 1967, p.451) and it is particularly suited to research where little is known allowing to build progressive knowledge on a topic to sustain future research (Henson & Roberts, 2006; Swisher, Beckstead, & Bebeau, 2004; Yong & Pearce, 2013). EFA produces a simpler structure of results which illustrates underlying relations between variables therefore adding to validity of research (Brown, 2009a; Field, 2009; Kline, 1994; Rummel, 1967; Tabachnick & Fidell, 2013, Université de Sherbrooke, 2018).

Number of participants in this study (*N=301*) was satisfactory for EFA (Tabachnick & Fidell, 2013; Williams, Onsman, & Brown, 2010). Two EFA were conducted on aggregated data from both samples, using the Statistical Package for Social Science (SPSS,

version 22). The first EFA was conducted on KM constructs and the second on serious leisure constructs.

2.4.3 Survey data cleaning

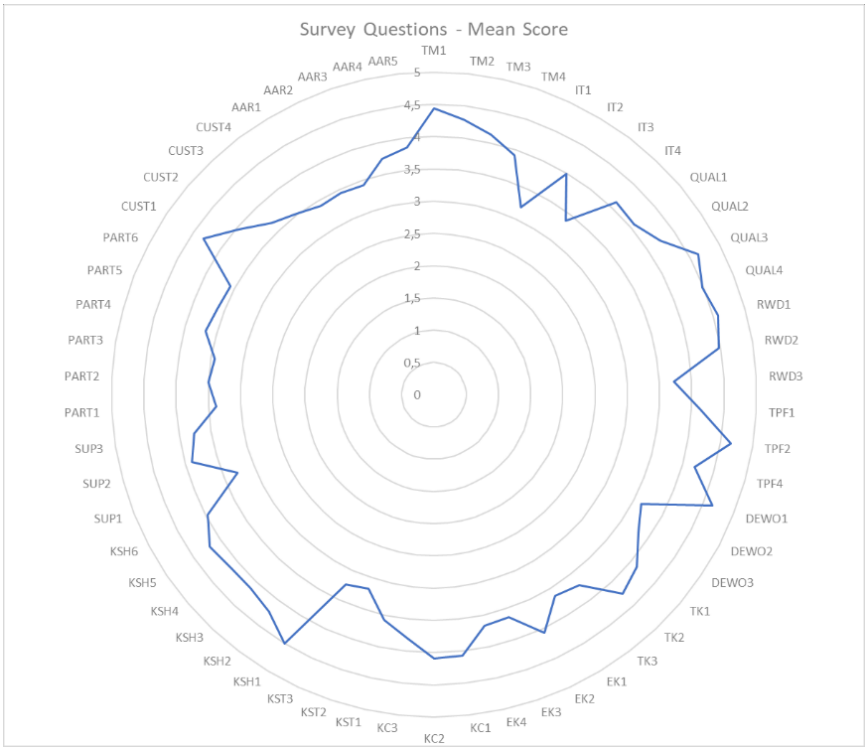
Survey data cleaning (Chan, 2003; Kandel et al., 2011) was performed through exploratory data analysis (Aguinis, Gottfredson, & Joo, 2013; Pryjmachuk & Richards, 2007). At this point, sixteen respondents were deleted from the data bank because they did not answer a single question thus leaving a final set of 301 participants (*N=301*). Outliers were identified (Bourque & El Adlouni, 2016; Field, 2009; Kandel et al., 2011; Meier & Brudney, 2002; Pryjmachuk & Richards, 2007; Tabachnik & Fidell, 2013), which were corrected using the series' mean (Bourque & El Adlouni, 2016; Tabachnik & Fidell, 2013). These corrections allowed to produce a final set of descriptive statistics for each survey scale (Table 2.4.3).

Table 2.4.3: Survey Scales Descriptive Statistics

Descriptive Statistics									
						Skewness		Kurtosis	
	N	Minimum	Maximum	Mean	Standard Deviation	Statistics	Standard Deviation	Statistics	Standard Deviation
TM	301	2.13	5.00	4.1912	.67084	-.791	.140	.206	.280
IT	301	1.70	5.00	3.6704	.74020	-.277	.140	-.394	.280
QUAL	301	2.75	5.00	4.3601	.45642	-.438	.140	-.066	.280
RWD	301	2.17	5.00	4.2587	.52710	-.352	.140	-.141	.280
TPF	301	3.00	5.00	4.3327	.46788	-.377	.140	-.337	.280
DEWO	301	2.17	5.00	4.0338	.67768	-.303	.140	-.580	.280
TK	301	2.17	5.00	4.0335	.57117	-.422	.140	.464	.280
EK	301	1.75	5.00	3.7553	.80617	-.605	.140	-.202	.280
KC	301	2.17	5.00	3.9922	.73133	-.501	.140	-.319	.280
KST	301	1.17	5.00	3.3349	.96144	-.171	.140	-.620	.280
KSH	301	2.73	4.83	4.1938	.44590	-.460	.140	.080	.280
SUP	301	2.17	4.77	3.6481	.55048	-.126	.140	.110	.280
PART	301	1.50	5.00	3.5307	.79929	-.411	.140	-.087	.280
CUST	301	2.33	4.78	3.8655	.54657	-.376	.140	.082	.280
AAR	301	1.50	5.00	3.5768	.74598	-.296	.140	.282	.280
N valid (list)	301								

These descriptive statistics were than reproduced in a visual format (Figure 2.4.3), a recommended practice at the exploration phase of data analysis (Field, 2009).

Figure 2.4.3: Survey Questions – Mean Score – Radar format



At this point, the radar graphic rendition of survey data indicated that scores obtained for the IT, KST, SUP, PART, CUST, and AAR scales were lower than scores for the other scales. Before continuing data analysis, the scales' validity was verified.

2.4.4 Survey scales validity

2.4.4.1 Cronbach's alpha

As a measure of validity, Cronbach's alpha was calculated for each survey scale (University of Virginia Library, 2018). Table 2.4.4 shows the alpha for the final scales which is recommended to be at least .7 (Field, 2009). While most scales obtained a score close to or well above .7, the tacit knowledge's scale (TK) obtained the lowest score (.565). In the end, this lower score did not affect the quality of the exploratory factor analysis.

Table 2.4.4: Cronbach's alpha

SCALE	TM	IT	QUAL	RWD	TPF	DEWO	TK	EK	KC	KST	KSH	SUP	PART	CUST	AAR
α	.832	.697	.680	.839	.682	.816	.565	.866	.892	.851	.853	.751	.915	.844	.942

2.4.4.2 Levene's test (variance)

In general, survey results indicated similar tendencies in both samples. Table B1 shows Levene's test for equality of variance on each scale. It was not significant for eleven of the fifteen scales (p>.05) (Field, 2009). Therefore, it can be assumed that the variance was close to equal between the two groups (Field, 2009).

However, the test was significant (p<.05) for the information technologies (IT), explicit knowledge (EK), knowledge storage (KST), and customer (CUST) scales. Yet, the r values indicated a very small to small effect size, except for IT which was close to a medium effect size of .3 (Field, 2009). Therefore, the low r values suggested that these variances did not imply important differences between the two samples.

2.4.4.3 EFA Validity

Bartlett's tests of sphericity indicated that correlations between items were sufficiently large for factor analysis: KM (741) = 8790,890, p < .001 and serious leisure (55) = 1283,162, p < .001. No general factor was apparent in the unrotated factor structure. The Kaiser-Meyer-Olkin measures verified the sampling adequacy for the analysis and were well above the value of .6 required for factor analysis (Tabachnick & Fidell, 2013, p.620): KM KMO = .937 ('superb' per Field, 2009) and serious leisure KMO = .796 ('great' per Field, 2009).

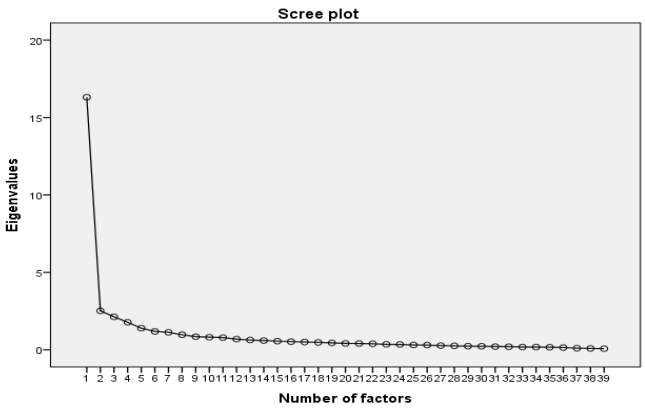
2.4.5 EFA – Knowledge Management

The reader can refer to ANNEX B for the total variance explained (Table B2), correlation matrix (Table B3), the communality's matrix (Table B4), and the structure matrix (Table B5). First, communalities were verified, and five items were removed because of score below .03 (IT2 = .171; IT4 = .299; TK1 = .231; TK2 = .226; KSH6 = .291) (Field, 2009; Osborne & Costello, 2009). Then, an initial analysis was run to obtain eigenvalues for each

component in the data. Seven components had eigenvalues over Kaiser's criterion of 1 but items loaded poorly on each.

The scree plot is often used as reference to choose the number of factors to retain, even though subjectivity can influence the reference breaking point choice (Hayton, Allen, & Scarpello, 2004). In the present case, the scree plot breaking point (Figure 2.4.5) was somewhat ambiguous between a three or four-factor solution.

Figure 2.4.5: KM – EFA Scree Plot



After oblique rotation, the three-factor solution (Table B6) provided the cleanest factor structure as items loaded with more precision on each factor explaining 50,19% of variance, with few cross loadings (Brown, 2009a; Brown, 2009b; Brown, 2009c; Kline, 1994; Osborne & Costello, 2009; Rummel, 1967).

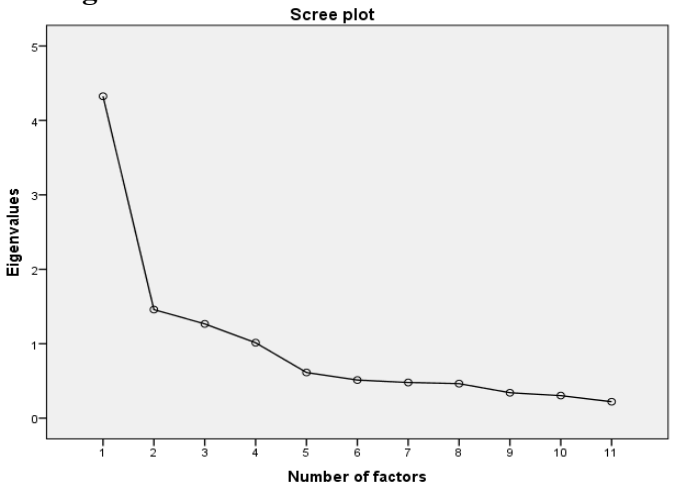
Finally, the component correlation matrix (Table B7) indicated that factor 1 had no or little relationship with the other factors, but factors 2 and 3 were interrelated to some extent. This is not estranged from the fact that factor 1 designated the main process that firefighters used to manage knowledge while the other factors were related to KM processes that seemed to be problematic.

2.4.6 EA - Serious Leisure

The reader can refer to ANNEX B for the correlation matrix (Table B8), the communality's matrix (Table B9), total variance explained (Table B10), and the structure matrix (Table B11).

For the serious leisure EFA, two items were removed because of low communality (TF2 = .211; DW1 = .139). The initial analysis rendered four components with eigenvalues over 1. Again, the breaking point of the scree plot was not clear on how many factors should be considered for analysis (Figure 2.4.6). The three-factor solution (Table B12) provided, after oblique rotation, the cleanest structure, explaining about 64% of variance with very low cross-loadings.

Figure 2.4.6: Serious Leisure – EFA Scree Plot



This time, the component correlation matrix (Table B13) indicated some relation between the three factors. This is consistent with findings indicating that the three factors were closely related. For firefighters, personal development is linked to creativity and commitment.

2.5 Semi-structured interviews

Qualitative methods are said to be useful when the object of study is a form or social process that needs to be understood in a rounded way (Lofland, Snow, Anderson, & Hofland, 2006; Mason, 2002). Interviews were conducted privately and face-to-face by the researcher.

2.5.1 Gaining individuals' free-willing participation

Before the beginning of the interview, the researcher explained the research's context and goals. Forms were handed out to participant, detailing the ethical certification of the research as well as the confidentiality guaranty. The researcher read the forms out loud and asked for interviewees to sign the consent form. Participants were made aware that they were under no obligation to answer questions that they preferred not to, or of their capacity to leave at any point during the interview. All participants agreed to be interviewed and answered all the questions.

2.5.2 Interviews' participants

To ensure that a wide range of perspectives were represented, firefighters of different ranks (firefighter, acting lieutenant, lieutenant, deputy-chief and chief) and years of experience were interviewed (*N=10*) (see ANNEX C for interview scripts and consent forms).

The first interview was realized with a deputy-chief. Next, two firefighters were interviewed together. Then, a firefighter, an acting-lieutenant, and a lieutenant were interviewed together. Once these interviews were completed, the researcher conducted a phone interview with a fire chief due to time and distance constraints. Finally, an interview was realized face-to-face with a group composed of two firefighters and a lieutenant.

2.5.3 Interviews' pattern

Interviews were digitally recorded and supplemented by field notes. The average length of the interviews was one hour and twenty minutes (Table 2.5.3). Participants were first asked to provide demographic information, rank, and years of experience in the fire service. Then, the interview followed the question list. Once the question list was completed, the researcher asked an open question, offering the participants an opportunity to address any other topic they would see relevant about knowledge management or to revisit their answers to previous questions.

Table 2.5.3: General information on interviews

Participant (years of service)	Medium	Duration	Recording method	Word pages
One deputy-chief (24)	Semi-structured interview, face to face	1h15	Digital recording and field notes	20
Two firefighters (5 and 15)	Semi-structured interview, face to face	1h34	Digital recording and field notes	25
One firefighter (11), one acting-lieutenant (7), and one lieutenant (15)	Semi-structured interview, face to face	1h24	Digital recording and field notes	29
One fire chief (22)	Semi-structured interview, phone interview	1h00	Field notes	3
Two firefighters (7 and 7) and one lieutenant (9)	Semi-structured interview, face to face	1h29	Digital recording and field notes	20

2.5.4 Method of analysis for evidence from interviews

A general inductive approach was used to structure the analysis of evidence from the interviews (Blais & Martineau, 2006; Thomas, 2006) and treatment of data followed Thomas (2006) recommended process. First, recorded raw data were transcribed and cleaned using a word processor. Then, close reading of text allowed to create main categories and lower-level categories (Table 15) (Robson, 2002; Thomas, 2006).

2.6 Municipal websites analysis

A content analysis (Robson, 2002) was performed on the municipal website of each fire department (*N = 20*) participating in this study. Websites were all accessed the same day allowing for contemporary comparison of published information about the following topics: composition of service/staffing, history, mission/vision/values statement, training, services provided, social implication, statistics on calls/runs, information on the departmental regional safety cover plan, and questions by citizens (link present on the website allowing citizens to exchange information with the fire department).

2.7 Contextuality

According to Potter (1996), in order to "add to the library of discourse on human life, […] contextualization is essential" (p.184). Essentially, contextualization links a phenomenon to selected elements of its global environment. It is a process by which significant information can emerge to add to the comprehension of the phenomenon (Paillé & Mucchielli, 2016). Therefore, a corpus was constituted consisting of three series of documents from the Quebec fire service sector contributing to set this case study in its real-world context (Yin, 2014).

First, close-reading of the National Assembly's minutes, for the period of 1990 to 2001 (Table 2.7), allowed to document the political antecedents of the fire service sector's reform of 2001. Then, governmental documents published by the ministry of Public Security were studied: the Fire Safety Act, the Regulation respecting the conditions governing the exercise of functions within a municipal fire safety service, and the Orientations.

Table 2.7: List of minutes consulted[a]

Entity	Date
Permanent Commission on Institutions - Debate	Thursday, April 29th, 1993 Monday, April 18th, 1994 Friday, December 8 th, 1995 Monday, April 22 th, 1996 Tuesday, April 23 th, 1996 Thursday, April 24 th, 1997 Wednesday, April 30 th, 1997 Tuesday, June 17th, 1997 Tuesday, September 8th, 1998 Tuesday April 20th, 1999 Wednesday, February 2nd, 2000 Thursday, February 2nd, 2000 Tuesday, February 8th, 2000 Thursday, February 10 th, 2000 Thursday, June 8th, 2000
National Assembly - Debate	Thursday, November 26th, 1992 Thursday, April 18th, 1996 Friday, June 6 th, 1997 Thursday, June 19th, 1997 Tuesday, June 6 th, 2000 Wednesday, June 14 th, 2000
Permanent Commission on Public Administration - Debate	Thursday, November 11 th, 1999
a Minutes retrieved from http://www.assnat.qc.ca/archives	

Second, the corpus included official reports on the fire service sector from the occupational health and safety agency, the provincial ombudsman, and the fire commissioner. These documents provided reliable information on different events which had an impact on the fire service sector such as inquiries into firefighters' line of duty death, description of operational challenges for fire departments, or consequences of major fires.

Thirdly, the corpus included annual reports from the National Fire Academy, from 2001 to 2018, as well as the Academy's sole research report and memorandum submitted for the 2012 provincial forum on the fire service. Websites of the Quebec Association of Fire Chiefs, the fire instructors' association, and the fire prevention officers' association were also consulted.

Finally, documents from the provincial forum on the fire service sector, held in 2012, were consulted. These documents included the governmental records published after the forums and memos submitted by participating entities. A white paper published in 2018 by the Quebec Association of Fire Chiefs was also included in the corpus. Taking stock of the

development of the provincial fire service sector since the 2012 forum, the paper detailed the sector's challenges from the view of the fire chiefs. A research report, from the Chiefs' association, on the situation of fire chiefs in the Province was also included in the corpus.

2.8 Pressing for high quality analysis

Yin (2014) points out that "at least four principles underlie all good social science research" (p.168). First, it is recommended seeking to "use as much evidence as was available" (Yin, 2014, p.168). According to Eisenhardt (1989), "the combination of data types can be highly synergistic" (p.538) in conducting case study. Exploratory in nature, the present research benefited from triangulation of different sources of evidence which were presented above.

Second, the study should address all plausible rival interpretations in the event that "someone else has an alternative interpretation for one or more of your findings" (Yin, 2014, p.168). Knowledge management had never been studied before in the fire service and, consequently, there were no rival explanation of this phenomenon. However, submitting findings to subject-matter experts allowed to gather valuable insights and refined the analysis.

Third, the research should keep a clear focus and address the most significant aspect of the case study. The case study focus was clear from the onset: knowledge management in the fire service. The steps taken to insure data treatment through recommended processes, namely exploratory factor analysis (Field, 2009; Rummel, 1967), semi-structured interviews (Mason, 2002; Lofland, Snow, Anderson, & Lofland, 2006; Robson, 2002), and content analysis (Robson, 2002), also provided the foundation for a chain of evidence (Yin, 1981). A chain of evidence is said to be necessary in case study and a principle that must be followed to increase reliability of the information: "the principle is to allow an external observer – in this situation the reader of the case study – to follow the derivation of any evidence from initial research questions to ultimate case study conclusions" (Yin, 2014, p. 127).

Finally, the study should benefit from the researcher's own prior expert knowledge in order to "demonstrate awareness of current thinking and discourse about the case study topic" (Yin, 2014, p.168). The researcher served as a firefighter and a lieutenant in a volunteer fire department between 2000 and 2009. Between 2002 and 2013, He also worked for the Quebec National Fire Academy as an academic advisor and subsequently as director of operations. In this position, the researcher was involved in board duties and representation in international fire service organizations dedicated to training and certification of fire service personnel.

2.9 Validity and limits

Four criteria were used to assess the rigor of this case-study research, based on Yin (2014): internal validity, external validity, construct validity, and reliability.

Internal validity ensures that a different researcher would reach similar conclusions about the case using the same data set (Gagnon, 2012). Internal validity of case studies is generally considered strong (Gagnon, 2012; Yin, 2014). For this case-study, the following techniques were used:

- Data triangulation from three different sources (survey data, semi-structured interviews, and documents);
- Validation of survey and documents data by the semi-structured interviews;
- Protection of raw data for future use;
- Critic of data analysis by the thesis director;
- Clear exposure of data collection and methodology through this dissertation ensuring enough space for explanations, data presentation and treatment, and a chain of evidence;
- Researcher's reflexivity based on a pragmatic approach to the semi-structured interviews;
- Continuous attention to possible rival explanations by ensuring a variety of perspectives during the semi-structured interviews (firefighters of different fire departments and of different ranks) to favor representation of the population.

External validity refers to the generalization of findings from a study. Therefore, a different researcher, applying the same research design in a different setting should reach similar conclusions. External validity is not a strong characteristic of case-study research due to their idiosyncratic nature (Gagnon, 2012, p.26). Nonetheless, this research followed Yin (2014, p.45) recommended tactics to address problems of external validity:

- The research was based on seminal work from four theoretical strands of research well documented;
- The case-study included many cases of volunteer fire departments;
- Survey sampling strategies provided data from a population of firefighters scattered throughout the Province of Quebec which could then be contextualized through semi-structured interviews;
- Document analysis was based on official publications from government, public organizations, and official websites.
- Analytical tools offered by Paper 3 can be utilized to document absorptive capacity in different public sectors.

Construct validity is defined as "the accuracy with which a case study's measures reflect the concepts being studied" (Yin, 2014, p. 238). Construct validity is said to represent a challenge for case-study research (Yin, 2014). The following measures were taken to ensure construct validity:

- All concepts were defined based on four theoretical strands: knowledge creation, knowledge management, organizational culture/serious leisure, and absorptive capacity;
- The research was based on multiple sources of evidence;
- A clear chain of evidence was established.

Reliability refers to the consistency and replicability of the research (Yin, 2014). In the present case, this dissertation documents the case-study protocol and all the methodological procedures used to collect, analyze, and explain the data.

Even though this research followed recommended best practices in data collection and case-study analysis, it presents limits. The first limit is imposed by the Province of Quebec's sociopolitical context. Quebec is the only French-speaking territory in North America. Therefore, its culture and communications are different from other jurisdictions. If the occupation of firefighter remains similar to the rest of North America, laws and regulations differ. Thus, results from this research may be tinted by this sociocultural reality. Different rules and regulations in another jurisdiction could influence a similar research. Another limit is related to the sampling strategy for the survey. Even though the strategy allowed to constitute a final sample of 301 firefighters and tests of validity confirmed the robustness of quantitative data, a larger sample could have expose nuances that may be absent in the analysis.

Nonetheless, these limits are mitigated by the research's strengths. This research followed a rigorous research design, and analysis of data was based on a sound conceptual framework based on four research strands. Participants in the interviews provided valuable insights into the world of firefighting that shed light on the characteristics of the fire service organizational culture, on how firefighters learn, and on nuances that needed to be considered in data analysis. Also, the longitudinal view (1990-2018) provided by the document analysis sustained a rich analysis of data in the context of the Quebec fire service reform. As the first study of knowledge management in the fire service, this research provided the first set of empirical data on knowledge management in the fire service, and it documented a replicable methodology.

CHAPTER 3: SYSTEMATIC LITERATURE REVIEW (PAPER 1)

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Discovering Underlying Themes in Fire-Related Research: An Analysis of 238 Peer-Reviewed Studies

Keywords: Fire, fire service, fire department, firefighter, service d'incendie, incendie, pompier.

3.1 Abstract

Even though the fire service has been the subject of a growing body of academic studies since the early 1970s, no attempt has been made to discover underlying themes or the contributions and limitations of this research. As such, this article presents a systematic literature review of a representative sample of 238 fire-related academic studies drawn from peer-reviewed journals published between 1970 and 2016. Findings suggest three themes or meta-categories define fire-related academic research during the 46 years time span. In order of importance (based on the number of studies in a meta-category) the themes or meta-categories of research are health and safety, management, and organizational culture. Results presented here suggest that research bridging the intersections of the meta-categories will enhance the development of a more in-depth understanding of the links among health and safety issues, managerial work, and organizational culture in the fire service.

3.2 Introduction

In the wintery night of January 23, 2014, a major fire in a retirement home caused the death of 32 elders in the municipality of L'Isle-Verte, located in the Province of Quebec, Canada. A government inquiry into the matter correlated deficiencies in fire ground operations in part to flaws in knowledge management processes. Similarly, a recent literature review on knowledge management in the public sector concluded that: "surprisingly, there were few articles [on knowledge management] investigating key public services such as police, fire, ambulance, and the armed forces" (Massaro, Dumay, & Garlatti, 2015, p.545). This conclusion raises the question as to the state of research on the fire service. In fact, even though the fire service has been the object of a growing body of academic studies since 1970, to date, no attempt has been made to discover underlying themes or the contributions and limitations of this research. As such, this article presents a systematic literature review analysis of 238 fire-related academic studies drawn from peer-reviewed journals published between 1970 and 2016. The article is organized into three sections. The first section presents the methodology used to select the sample of academic studies upon which the literature review analysis is based. Based on the analysis of 238 academic studies, section two first identifies three themes or mega-categories underlying the academic fire-related literature published between 1970 and 2016 and second discusses the contributions and limits of this body of literature. Finally, in section three findings emerging from the literature review are used to offer suggestions for the future direction and development of fire-related academic research.

3.3 Methodology

The focus of this systematic literature review analysis is on 238 academic, peer-reviewed articles published in English and French found in refereed journals, although a few books, chapters in academic books and reports are also included to support the author's analysis of the articles and provide references to theories discussed in the research. The review is based on an iterative process and flexible design (Robson, 2002) characterized by a methodology that allows for replicability and transparency through an audit trail of the analyst's decisions, technique, and conclusions (Tranfield, Denyer, & Smart, 2003).

The data (e.g., academic studies) review started by searching databases (e.g.: ProQUEST, JSTOR, EBSCO, Cairn, Erudit, Taylor & Francis, Persée, Google Scholar, and Directory of Open Access Journal) using Boolean operators and the following keywords in study titles and/or abstracts: *fire*, *fire service*, *fire department*, and *firefighter* (in French*: service d'incendie, incendie*, and *pompier*). This initial search found 169 fire-related research studies. An analysis of the 169 article abstracts and/or keywords sections provided evidence of three themes or meta-categories in which to group the research papers. In order of importance, based on the number of studies, the three meta categories were: health and safety, management, and organizational culture. Reading and analysis of the 169 studies allowed the creation of subcategories of topics in each meta-category (e.g., studies of fire fighter stress in the health and safety meta-category or research on leadership in the management meta-category). Sub-categories for each meta-category are presented, in alphabetical order, in Table 3.3.

Table 3.3: Meta-categories and topics

Categories	**Health and Safety**	**Management**	**Organizational Culture**
Topics	Alcohol consumption Cancer Cardiovascular problems Contamination/exposure Effects of equipment Fitness Line of duty death Managing health and safety Obesity Stress Tobacco use	Court rulings Emergency response Gender/minority issues Finance HR management Leadership Optimization Performance Provision of services Training Work organization Work relations	Commitment Culture Emotions Family (internal & external) Knowledge Motivation Role Serious leisure Trust

Another step in the search process involved scanning the "reference lists" of the 169 originally identified studies and "mining" other new academic research articles. A total of 64 new studies were found. This second-phase of the search and analysis process identified no new underlying themes (e.g., mega-categories) or sub-categories were investigated by the authors of the 64 new studies. As such, each of these 64 articles were assigned to one of the three mega-categories.

Finally, a third and final database search was carried out using as keywords the 32 sub-categories of fire-related research studies associated with the three mega-categories (see Table 3.3). In total, five new relevant fire-related research studies were found. In sum, as noted previously, the analysis that follows is based on a final set of 238 peer-reviewed articles.

3.4 Findings

3.4.1 General observations about 238 literature review studies

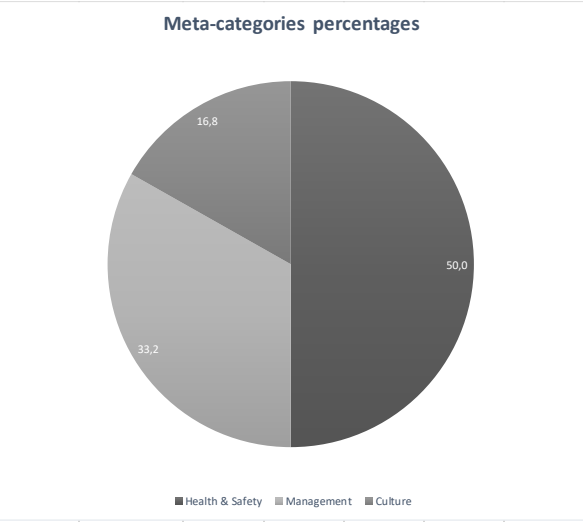
As a general observation, scholarly work in both the health and safety and the management meta-categories is largely based on quantitative methods (surveys, samples, calculations, etc.), while research in the organizational culture meta-category is in large part based on qualitative methods (interviews, observations, discourse, etc.). Both quantitative and qualitative methods are found in English research, while most French research stems from the social science perspective and is based on qualitative methods.

Regardless of whether they are called career (e.g., USA) or professionals (e.g., France), studies generally separate firefighters into two categories -- those who hold a permanent full-time position in a fire department, or volunteer, citizens who have a different primary occupation and volunteer in a fire department. Research work in the health and safety meta-category has shown an interest in both career and volunteer firefighters, while the focus has been more on career firefighters in the management meta-category and on volunteer firefighters in the organizational culture meta-category.

There is a global interest in research on the fire service. Table 3.4 shows the distribution (percentage) of the 238 articles included in the analysis across the three meta-categories (health and safety, management, and organizational culture) by nation.

Table 3.4: Articles distribution

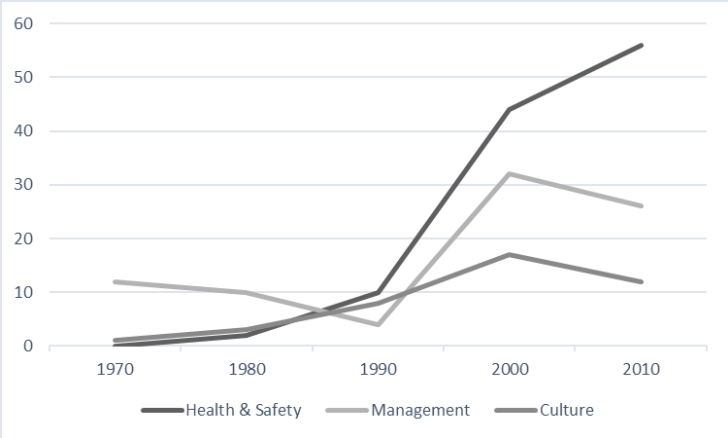
Country	Health & Safety	%	Management	%	Culture	%	Total	%
United States	75	63,0	41	52	19	48	135	56,7
United Kingdom	9	7,6	13	16	0	0	22	9,2
Canada - English	5	4,2	10	13	1	3	16	6,7
Australia	6	5,0	2	3	6	15	14	5,9
Canada - French	0	0,0	1	1	3	8	4	1,7
France	2	1,7	2	3	9	23	13	5,5
Comparative	3	2,5	4	5	0	0	7	2,9
Poland	3	2,5	1	1	0	0	4	1,7
Iran	4	3,4	0	0	0	0	4	1,7
Spain	0	0,0	1	1	0	0	1	0,4
Nigeria	1	0,8	0	0	0	0	1	0,4
Nordic	1	0,8	0	0	0	0	1	0,4
Ukraine	1	0,8	0	0	0	0	1	0,4
Germany	0	0,0	1	1	0	0	1	0,4
Lithuania	1	0,8	0	0	0	0	1	0,4
Philippines	0	0,0	0	0	1	3	1	0,4
Croatia	1	0,8	0	0	0	0	1	0,4
Portugal	1	0,8	0	0	0	0	1	0,4
Turkey	1	0,8	0	0	0	0	1	0,4
Taiwan	0	0,0	2	3	0	0	2	0,8
Saudi Arabia	2	1,7	0	0	0	0	2	0,8
Malaysia	1	0,8	0	0	0	0	1	0,4
Japan	1	0,8	0	0	0	0	1	0,4
Sweden	1	0,8	1	1	1	3	3	1,3
Total	119	50	79	33	40	17	238	100,0



In Table 3.4, data indicate that almost 57 percent (56.7%) of the 238 fire-related studies originated in the United States. Moreover, studies from the United States, United Kingdom, Canada-English and Australia represent 78.6 percent of all published material. As indicated in Table 3.4, only 7 studies (3.7%) offer a comparative analysis between or among nations. Clearly, to date, an attempt to understand the differences or commonalities among fire services across nations has not been a priority of fire service scholars.

Table 3.4 also shows that the mega-category of health and safety studies represents one-half (*N = 119*, 50%) of the literature on the fire service, with management studies equaling 33 percent (*N = 79*), and organizational culture constituting 17 percent (*N = 17*). Finally, spanning almost five decades, Figure 3.4 shows the exponential growing interest of research on the fire service.

Figure 3.4: Longitudinal view of research on the fire service



The following three sections detail findings for each of the three meta-categories based on the relative order of importance of each topic (as measured by the percentage of studies included in a category).

3.4.2 Health and Safety Meta-category

The health and safety meta-category refers to research on the impacts of firefighting and of lifestyle on the general health and safety of firefighters, both inside and outside of the fire house. Figure 3.4 shows the overall interest of research on this topic since 1970. As the Figure shows, research in this genre began to grow exponentially beginning in the early 1990s and continues this pattern of growth today.

Studies in this meta-category focuses mostly on male subjects; research on female firefighters is sorely lacking (Jahnke, et al., 2012). Firefighters routinely work in environments that are immediately dangerous to life and health (IDLH) (Austin, Dussault, & Ecobichon, 2001; Graham et al., 2008; Kales et al., 2001; Lees, 1995; Luz, 2003; Moschella, 2009; Wyant, 2010) and this provides a rich context for research. On one hand, the prevalence of stress, cancer, cardiovascular events, and line-of-duty deaths (LODD) are incentives for research work (e.g.: Bryant & Harvey, 1996; Poston et al, 2014; Golden, Markowitz, & Landrigan, 1995; Guittodi & Clough, 1992; Hansen, 1990; Lemon & Hermiston, 1977, Regher & Glancy, 2000). On the other hand, the importance of this meta-

category is not estranged from the impacts of traumatic events such as the terrorist attacks on September 11, 2001, which put at the forefront the dangers associated with firefighting and rescue work.

Firefighting: a Stressful Job: For the public, firefighting is synonymous to courage and heroism (Jeantet & Gernet, 2011; St-Denis, 2013). Although this may be true, researchers from around the globe (e.g., USA, Canada, Iran, Ireland, and France) have correlated firefighters' involvement in traumatic events to stress (Brown, Mulhern, & Joseph, 2002; Mauro, 2009; Sepidarkish, Hosseini, Pakzad, & Safiri, 2014; Yazdi & Shafiran, 2001), as many of these first responders develop symptoms of post-traumatic stress disorder (Beaton, et al., 2001; Beaton, et al, 1997; Carter, 2007; Corneil et al., 1999; Fullerton et al., 1992; Gasaway, 2007; Jeannette & Scoboria, 2008; O'Neill & Wagner, 2012; Palmer & Spaid, 1996; Pillai & Williams, 2004; Wagner & Waters, 2014).

Stress has been correlated with sleep-related problems and anxiety experienced by Canadian, US, and Iranian firefighters during normal shift work and at home (Beaton & Murphy, 1993; Beaton et al., 1998; Beaton et al., 1999; Mehrdad, Haghighi, & Naseri Esfahani, 2013). In addition, research on Canadian firefighters has shown that, for some individuals, regular exposure to emergency situations can lead to hostility, which is a predictor of obsessive-compulsive behavior, depression, and anxiety (Wagner, Pasca, & Crosina, 2016). In fact, research on US firefighters shows firefighters tend to present a higher percentage of clinical symptoms of depression (16%) than the general population of men (7%) (Pyle, et al., 2009). As a result, research findings draw attention to the consequences of this stressful environment on the individual, such as the concerning problem of alcohol consumption by both male and female firefighters (Bacharach, Bamberger, & Doveh, 2008; Boxer & Wild, 1993; Haddock et al., 2015; Jahnke et al., 2012; Murphy et al., 1999; Piazza-Gardner et al., 2014) and the risk of cardiovascular incidents.

***At the Heart of the Matter*:** A significant number of firefighters' death are attributable to cardiac arrest, caused by factors such as strenuous work, stress, fatigue, and sedentary lifestyle (Aronson, Tomlinson, & Smith, 1994; Davis & Dotson, 1978; Guittodi, 1993;

Kales et al, 2007; Kunadharaju et al, 2011; Patterson, et al, 2013; Roy, Kirschbaum, & Steptoe, 1998; Staley, 2009; Vastag, 2007; Wolkow et al, 2014). Heat stress is of concern for firefighters (Olafiranye et al, 2015; McLellan & Selkirk, 2006; Stevenson, 1985). Tests conducted on US firefighters in training conditions shows that after an intense effort in a hot environment, blood composition is altered that, in turn, places firefighters at risk of cardiovascular incidents (Smith, 2002; Smith & Petruzello, 1998; Smith, Dyer, & Petruzello, 2004; Smith, Manning, & Petruzello, 2001; Smith et al, 2005; Smith et al, 2001; Smith et al, 1995; Smith et al, 1997; Smith et al, 1996).

During these tests, many firefighters have also shown clinical signs of hypoglycemia that were mitigated only after 90 minutes of rest and intense rehydration (Smith et al., 2001), which is rarely available on the fire ground. In addition, research work has shown that fire smoke exposure can cause elevated blood carboxyhemoglobin (Al-Malki, 2009). Minimum carboxyhemoglobin thresholds previously considered safe have recently been associated with triggering angina or myocardial ischemia in persons with cardiac preconditions (Dickinson et al., 2008).

Although this line of research points to the importance of preventive measures such as physical fitness and quality of lifestyle based on healthy habits, authors from the US have documented a series of indicators of firefighters' sedentary lifestyle such as poor physical condition, poor cardiovascular conditions, as well as aerobic capacity inferior to occupational standards (Saupe, Sothmann, & Jasenof, 1991). Similar research was carried out in the Ukraine. Stetsenko and Arhipenko (2015) suggested optimizing control over professional physical education to sustain physical self-improvement motivation. On the same topic, researchers from countries such as the US and Croatia also documented the negative impact of obesity (Brown et al., 2014; Brown et al., 2015) and of firefighters' high body mass index on cardiovascular capacity and working ability (Lalić, Bukmir, & Ferhatović, 2007).

For fire service leaders, addressing the impacts of firefighters' life habits such as smoking, malnutrition, lack of exercise, and/ or obesity on cardiovascular health (Jahnke et al, 2013; Jitnarin et al, 2013; Onieal, 2010) then becomes a priority to reduce the risk of

cardiovascular incidents. While researchers from Poland and the US point to the necessity of supporting fire leaders in their attempts to promote the wellness of firefighters, they also note that these leaders must do so using the relative accuracy of devices and of calculation formulae to measure physical demands on firefighters, which at times can lead to poor or inexact evaluations (Clapa et al., 2015; Klaren et al., 2014; Lindberg et al., 2015; Mehta et al., 2015; Mier & Gibson, 2004).

Firefighters and Cancer: A Public Policy Issue. Exposure to toxic substances on the fire ground or in training (Alkali, Bandele, & Ballah, 2013; June-Soo et al, 2015; Kirk & Logan, 2015; Rotander et al, 2015) is an aggravating factor that places firefighters at a greater risk of developing different types of cancers (e.g., brain, lung, and prostate) and leukemia (Demers, Heyer, & Rosenstock, 1992; Edelman et al., 2003; Ide, 2014).

The correlation between cancer and firefighting has been established and research is still ongoing globally (e.g., Canada, US, Nordic Countries, and Scotland) to determine with greater certainty those aggravating factors that contribute to the development of different types of cancer (Daniels et al., 2014; Daniels et al., 2015; Fritschi & Glass, 2014; LeMasters et al., 2006; Pukkala et al., 2014). Research reviewed in this article provides public administrators at all levels of government the information they need to confidently recognize cancer as an occupational disease among firefighters. As such, preventive cancer measures are now an important challenge for fire service leaders. Even though firefighters wear personal protective equipment and breathing apparatus, they are still at risk of cross-contamination from carcinogens. In essence, this may mean rethinking tradition-based procedures and implementing innovative decontamination measures and other preventive actions.

Line of Duty Deaths (LODD). Since 1977 in the United States, an average of 100 firefighters have died each year in the line of duty (LODD) (Malo & Delorio, 2008). This statistic is six times higher than other industrialized nations (Pessemier & England, 2012) pointing to a serious organizational problem for US fire leaders (Ruan & Groves, 2010; Smith & DeJoy, 2014).

In a recent study, researchers identified a cluster of three factors that represent 97.5 percent of LODD: poor health and physical condition, personal protective equipment, and human error (Moore-Merrell et al., 2008). Slightly more than a majority of deaths occurred in volunteer departments (52%), whereas 39 percent occurred in full-time departments and 9 percent in combination departments (Moore-Merrell et al., 2008). Subsequent work by Moore-Merrell and her colleagues showed that a cluster of three factors was significant in explaining LODD, thus supporting some of their previous conclusions: lack of situational awareness (37.35%), poor health and physical condition (28.57%), and human error (10.65%) (Moore-Merrel et al., 2009). Again, firefighters' poor health and physical condition stand out in the complex equation between the actual risks of firefighting and preventive measures. In the context of volunteer fire departments, these findings pose a real challenge to fire service leaders who must contend with the difficulties associated with recruitment of volunteer personnel while at the same time meeting the health and fitness requirements set forth by occupational standards.

***Equipment and Tools*.** This systematic review of 238 fire-related studies found a global interest on equipment and tools used by firefighters. Researchers are interested in a wide range of subjects ranging from the properties and maintenance of protective clothing (Atalay, Bahadir, & Kalaoglu, 2015; Grineviciute et al, 2014) to the risks of hearing loss on the fire ground due to the use of fire service equipment (Negar Assadin, Esmaily, & Mostaan, 2013; Root et al., 2013).

Other studies have illustrated the importance of injuries sustained during road accidents and the risks associated with the operation of tanker trucks oftentimes by inexperienced drivers (Weider & Roche, 2008). The review also found a series of papers investigating the effects of protective equipment on the postural balance and gait of firefighters. Results suggest that heavy boots, suboptimal air bottle design, and the lack of flexibility of turnout gear are correlated with problems associated with posture, fatigue, and injuries (Hur et al., 2015; Park et al., 2015; Rosengren, Hsiao-Wecksler, & Horn, 2014; Sobeih et al., 2006).

The review found two studies on the etiology of injury in the fire service, one from the US (Poplin et al., 2012) and one from Poland (Pawlak, Gotlib, & Galazkowski, 2016). This research shows that in-station activities such as physical and sporting exercise, training exercises, and maneuvers are important sources of injury.

Health and Safety as a Leadership Challenge: Summary of Research in Meta-category. Research in this meta-category brings attention to a plethora of risks that firefighters face every day from stress to cancer to injuries. Proactive health and safety management in the fire service is of concern both to scholars and fire service leaders, especially given the high number and relatively stable yearly line of duty deaths (Karter & Stein, 2013; NFPA, 2015) and an organizational culture that leans towards low levels of fitness and sedentary life habits (Jahnke, Haddock, & Poston, 2014).

A lack of focus on the health and physical fitness knowledge of firefighters is putting them at risk (Grace, 2013). Scholars have documented the fact that some organizations may not assign sufficient importance to creating a safety climate (Smith & DeJoy, 2014), maybe because of a limited understanding of what constitute a proactive organizational safety culture (Pessemier & England, 2012).

As discussed above, research on cancer in the fire service has grown significantly in the last decade. Incorporating strategies to influence behavioral changes in the way firefighters think about their own protection would assist fire leaders with implementing ongoing prevention measures. To this end, research results suggest that implementing a comprehensive health and safety program tends to have beneficial outcomes on the general health of firefighters (Easterling & Prince, 2007; Elliot et al., 2004; Pessemier, 2008; Poplin et al., 2015; Strawson, 2008; Welbourne & Booth-Butterfield, 2005), on suicide prevention (Finney et al., 2015), and even on the health of firefighters' spouses (Zimmerman et al., 1988). However, many of the papers reviewed failed to give a full or clear definition of what a comprehensive program should encompass to bring about longlasting changes in firefighters' health and safety behavior.

As research shows, addressing health and safety issues involves upending institutionalized and entrenched behaviors and norms. For fire service leaders, this requires an adaptive leadership approach (Heifetz & Linsky, 2002) that commands a change in thinking towards higher standards of prevention and protection and mandates a revision of the "structuring activities managers undertake in order to deliberately shape the behavior of organization members" (Andrews, 2010, p.89).

3.4.3 Management Meta-category

For this meta-category, management is understood as "organizational process and practices that focus on weighing up and balancing opportunities and constraints from the environment with the internal capabilities, with the aim of enhancing public value and to achieve higher levels or organizational performance" (Walker, 2010, p.227). Figure 3.4 illustrates the fact that research on the fire service began with an interest on management topics in the early 1970s. The figure also shows a surge of research on management during the first decade of 2000s, after a decline in research during the 1990s. Departing from the theoretical models characterizing this meta-category in the 1970s and 1980s, studies now focus on a variety of managerial challenges.

Optimization of Service Delivery. The management meta-category focuses mainly on career fire departments and finds its roots in the RAND corporation studies about the New York Fire Service in the early 1970s (Green & Kolesar, 2004). Researchers were mostly interested in optimization of service from an operations research perspective (e.g. Carter, Chaiken, & Ignall, 1972; Carter & Rolph, 1973; Wallace, 1977. See also Hogg, 1968 for a first attempt at a mathematical model.).

For example, studies focused on location modeling and assignation problems through complex calculations of squad deployment and firehouse siting optimization (Green & Kolesar, 2004; Ignal et al., 1975; Kolesar & Blum, 1973; Kolesar & Walker, 1974). Scholars also discussed problems related to efficiency of first-due unit dispatch (Chaiken, 1978; Ignall, Carter, & Rider, 1982; Swersey, 1982), and staffing policies (Halpern, Sarisamlis, & Wand, 1982). Even though the calculations provided data to optimize squad

deployment, findings were criticized for not considering the socioeconomic environment in which the fire stations were located (Seley, 1979; Wallace, 1978; Wallace, 1993).

This genre of research is still carried out globally providing new models to optimize the number of responding firefighters in Canada (Sadeghi-Naini & Asgary, 2013); reconfigure fire and rescue services in the UK (Murphy, Greenhalgh, & Parkin, 2012); identify the influence of organizational features in perceived emergency management performance in Australia and New Zealand (Bhandari, Owen, & Brooks, 2014); take into account environmental conditions on technical efficiency in Spain (Garcia Sanchez, 2006); and establish new collaborations in daily response in Sweden (Weinholt & Granberg, 2015).

Other research correlated the efficiency of service delivery to the wealth of neighborhoods showing that property value can be an indicator of fire protection (Coulter, 1979) or that a correlation exists between high level of social capital and fire service outcomes (Andrews & Brewer, 2010). Some authors showed an interest in rating systems for fire departments (Coe, 1983) and in calculations to improve fire protection through the installation of detection devices in dwellings rather than adding fire stations (Halpern, 1979).
In the evidence reviewed, researchers tested different operational and economic models to measure the cost of fire protection (Seward, Plane, & Hendrick, 1978) and to determine the optimum level of performance in employee staffing with regards to the type of department (career, volunteer, or combination) (Brudney & Duncombe, 1992; Brunet, Deboer, & McNamara, 2001; McDavid, 1986). While these studies were instructive, the results and the generalization of findings were often limited by the use of case studies (Band et al., 2010; Craig, Verbeek, & Schwartz, 2010; Deng et al., 2001; McDavid, 1986; Woska, 1988).

Leadership: Between Authority and Sensemaking. A number of studies in this literature review focused on the topic of leadership in the fire service (Carter, 2007; Kupietz, 2010). Leadership is often depicted as the cornerstone of career development for fire officers (Jones & Feller, 2009) and as a channel to give orders.

Early research on leadership in the fire service showed that willingness to expose oneself to danger was associated with effective leadership as seen in military combat (Frost, Fielder, & Anderson, 1983). Departing from this view of leadership, authors suggested that the ability to mobilize emotional communication skills is a crucial asset of leadership (Riggio et al., 2003) and that transformational leadership in routine situations may support subordinates in learning opportunities (Pillai & Williams, 2004). Researchers also suggested that fire service managers should attempt to create a better understanding of fire service operations as business management and dispel the myth that surrounds incident commanders as inflexible, autocratic, and paramilitary (Williams, 2010). Research also underscored the concept that firefighters under the command of a charismatic officer who expresses positivity are happier than those under the command of a non-charismatic superior (Erez et al., 2008).

Systems applied to manage emergencies vary between countries and scholars have shown an interest in understanding decision-making processes of fire service leaders in the stressful environment of the fire ground (Young, St Clair Wilson, & Wetherell, 2013). Research from Australia, for example, shows that different decisionmaking patterns have been associated with the officer's rank as the available information can be different for the first arriving officer or the officer assuming command in a multi-alarm emergency (Lauder & Perry, 2014). Scholars have demonstrated that, in some instances, firefighters rarely base their decision on the first information at hand, instead taking some time to analyze the situation (Bayouth et al., 2013).

For some researchers, intuition is key for situational awareness as fire ground incidents are too fast-paced to facilitate time-consuming rational decision-making processes (Gasaway, 2007) As such, sensemaking, the process by which "people make retrospective sense of the situation in which they find themselves" (Weick, 1995, p.15), then becomes an important asset amidst a confusing environment (Moschella, 2009).

Research from Canada shows that decision-making processes underline ethical responsibilities as the individual must assume the responsibilities of his/her decision (St-Denis, 2016) and research from the UK found that personal biases affect the selection of information used in decision making (Catherwood et al., 2012).

Complex Managerial Issues. Research on management in the fire service is based on multiple paradigms (Hassard, 1991) and focuses on a number of complex managerial issues. For example, researchers have analyzed labor relations and confirmed the effects of impasse procedures (Kochan & Baderschneider, 1978) and of arbitration measures (Ashenfelter, 1971; Devinatz, 2015; Dinan et al., 2006; Wasylenko, 1977; Wheeler, 1977; Wheeler & Kochan, 1977) on the constant increase of firefighters' wages (Smith & Lyons, 1980). There is also research interested in understanding legal grounds for mandatory retirement due to age (Klassen & Gillin, 1999).

Delivery of contemporary fire-related services (including suppression, emergency medical services, education, and training) occurs in a stressful environment (Brunsden, Woodward, & Wilson, 2007) characterized by financial austerity and "cutback management" worldwide (Murphy, Greenhalgh, & Parkin, 2012; Perrot & Blenkarn, 2015; Weinholt & Granberg, 2015). This fiscal stress has made it difficult for fire leaders to maintain adequate levels of service to citizens and in some citieshad led to station closures or brown-outs (England & Brown, 2014), personnel reductions (Fry, Magazine, & Rao, 2006), and can impact the training required by fire departments to successfully execute confined space emergency response (Wilson, Madison, & Healy, 2012; see also Halbesleben & Clark, 2010).

Studies analyzed in this literature review also assessed the impact of fire service initiatives on public services. For instance, research by Moschella & Chou (2013) suggest that few fire departments in their study fully maximized the use of electronic government (e-government) in rendering efficient public services. On the other hand, there are examples of successful initiatives. A study from the UK showed that a new education-based program based on the desire to listen to and learn from individuals who have actually experienced a fire can result in improved fire services (Wales & Thompson, 2013). In Sweden, a study

on new collaborative patterns between security officers who could respond to emergencies and the fire service has documented possible cost benefits (Weinholt & Granberg, 2015). In Canada, a study of the impact of door-to-door fire prevention by on-duty firefighters confirmed a reduced frequency and severity of fires (Clare et al, 2012).

Finally, issues related to difficulties in the recruitment of volunteer firefighters have drawn global attention. Simpson (1996) documented the impact of modernization in rural New York State as the new middle class is less inclined at volunteering in the fire service. In Taiwan, austerity measures have impacted recruitment processes where there is now a need to refine core competency indicators for employee selection (Lin, 2016). In France, where 80 percent of firefighters are volunteers, managing volunteerism now entails new organizational structures between localities and regions (Chevreuil, 2010; Derboulles, 2001).

In a rare comparative study between male and female motivations to join the fire service in Canada, Perrot and Blenkarn (2015) have shown that female volunteers showed a distinct pattern of motivations that could prove beneficial for the fire service. Still, this study underlined that the highly masculinist culture of the fire service places female workers in an environment where they must cope with hostility, "problems with equipment and protective apparel, challenges in childcare, and the perception that they are not up to the task" (Perrot & Blenkarn, 2015, p.244). This portrait is in line with the findings of many scholars who studied diversity issues in the fire service as women and minorities still represent a small percentage of firefighters trying to find a place as outsiders (Maleta, 2009; Yoder & Aniakudo; 1997) within a mostly white male oriented profession (Clarke & Kaleem, 2010; Hashem & Lilly, 2007; O'Brien, 2003; Pfefferkorn, 2006; Pudal, 2011b; Scaife & Lilly, 2007).

Management as a Leadership Challenge: Summary of Research in Meta-Category. In summary, research on management in the fire service has covered a variety of interesting and relevant topics, but there remains a critical need to address these issues in the contemporary context of both career and volunteer fire departments. For instance, applying models of firefighters and apparatus deployment in the volunteer context would shed light

on topics largely unexplored in the peer-reviews literature. As difficult choices challenge fire service leaders, updating economic models and providing comparative results between fire departments would provide necessary data on which to base strategic decisions. Moreover, these data would enrich the discussion on management in difficult financial times, on quality of service delivered to citizens, and on e-government capacities. For example, few research studies address fire service management in the context of networks of other actors sharing an environment of constraints (Meier & O'Toole, 2010). Furthermore, the fire service would gain from research on diversity (Pitts, 2010) documenting, for instance, the influence of women in leadership positions on both managerial and cultural aspects of the fire service. These studies could address questions such as: how does gender influence managerial strategies, human resources management and recruitment? This line of research would surely further our understanding of the relationship between public service motivation and organizational performance (Brewer, 2010).

3.4.4 Organizational Culture Meta-category

Organizational culture consists of collective basics assumptions that people share: values such as priorities and philosophies and visual artifacts that act as representations of culture (Hofstede et al., 1990; Schein, 1984). Research on the culture meta-category has been in constant evolution since the 1970s, and it has centered mostly on understanding the act of volunteering. There is a strong emphasis on the life, work, and play of volunteer firefighters while research on career firefighters is not as documented on these topics.

***Firefighting as Serious Leisure*.** The fire service has its roots in rural communities and is characterized by a social club-like structure based on a localized vision centered on protecting the community and its common goods and values (Carp, 2001; Thompson, 1995). Stebbins seminal work on serious leisure theory (Elkington & Stebbins, 2014; Stebbins, 1996; Stebbins, 2008) has been used extensively to explain the folklore associated with the firehouse, which revolves simultaneously around work and leisure (Perkins, 1989; Perkins & Benoit, 1997) and differentiates the fire service from other municipal services (McCarl, 1984; Perkins, 1989; Perkins, 1990; Perkins & Benoit, 1997;

Perkins & Metz, 1988; Thompson, 1993; Thompson & Bono, 1993). A serious leisure is defined as:

> "the systematic pursuit of an amateur, hobbyist, or volunteer activity sufficiently substantial, interesting and fulfilling for the participant to find a (leisure) career there acquiring and expressing a combination of its special skills, knowledge and experience" (Elkington & Stebbins, 2014, p.4).

Volunteer firefighters represent a strong illustration of the intersection between volunteering and serious leisure (Stebbins, 1996; Stebbins, 2008), as individuals enter a specific world-view characterized by groups, events, routines, practices, organizational structures, and a unique knowledge stock (Stebbins, 1996).

***Commitment: Firefighters and the Sense of Belonging*.** Personal as well as functional reasons explain what it means to be a volunteer firefighter (Liao-Troth, 2005). In many countries, a volunteering family history, often with the same fire department (Retière, 1994); being part of a social network linked to a fire department, and/or a sheer sense of commitment to the community (Chevrier & Dartiguenave, 2011; McLennan & Birch, 2009) are vectors of volunteering in the fire service. The sense of belonging to a closely-knit group where confidence in each other acts as an organizational cement (Auger & Reynaud, 2007) is also a strong incentive which promotes self-esteem (Pudal, 2011b). For instance, in Canada, France, and the United States, the fire station is often seen as the higher locus of men's sociability as they become actors of the community social life (Chevrier & Dartiguenave, 2011; St-Denis, 2015; Tracy & Scott, 2006), which in turn allows firefighters to engage in a privileged relationship with citizens who often idealize the occupation (Jeantet & Gernet, 2011; Tracy & Scott, 2006). In fact, in many communities, it is through the volunteer fire department that men express strong values of democracy, patriotism, and autonomy (Lozier, 1976; Perkins, 1989; Perkins, 1989; Pudal, 2012; Scott & Kroman Myers, 2005).

Firefighters usually commit themselves for the long term when they join the fire service, where they find old and new friends and a sense of community (Thompson, 1993; Thompson, 1995; Thompson & Bono, 1993). US firefighters who are members of church organizations have even indicated that being a firefighter is as much important, if not even

more so, than their affiliation with their religious community (Perkins & Metz, 1988). Moreover, many volunteer firefighters experience a higher degree of satisfaction doing their work in the fire service than in their primary occupation. They are happier and tend to work harder in the fire service. The volunteers show a greater interest in what they do, feel more useful, and sense that their efforts are better recognized. In turn, they feel a greater sense of belonging as they gain new responsibilities (Thompson & Bono, 1993).

Data support the strong commitment of volunteer firefighters with a significant correlation between age and years of service (Perkins, 1989; Perkins, 1990). For example, research on Phillipino firefighters showed that they tend to score high on scales measuring predisposition to help (Magno, 2010) and Lee & Olshfski (2002) have shown that US firefighters are committed to their job which they view as honorable and dedicated to community service. Very few firefighters wish to leave their role as they justify their desire to join the fire service as a way to serve their community. Equally important, being a firefighter also allows one to engage in devotee work (Perkins & Metz, 1988), be part of an action-oriented primary group, and provide meaningful service to the local community (Perkins, 1989). These activities help fight alienation by taking part in work characterized by commitment and self-realization (Thompson & Bono, 1993).

Knowledge as a Gateway into the Fire Service. As part of the group, firefighters learn a valued knowledge stock (Retière, 1994) about firefighting through experiential learning and on-the-job training (Bromé, Lyman, & Told, 2014; Hagemann, Kluge, & Greve, 2012; Moran & Starling, 2005; Sommer & Njå, 2011; Taber, 2008). Through legitimate peripheral participation in the community of firefighters (Brown & Duguid, 1991; Fuller, 2007; Lave & Wenger, 1991), the newcomer slowly becomes an insider (Lloyd, 2007; Huysman, 2004). Knowledge transfer from experienced firefighters to newcomers is often the way by which some of the best practices are taught and shared. In this context, discipline (Dietrich, Riberot, & Weppe, 2016), storytelling (Dietrich, Riberot, & Weppe, 2016), and critical reflection (Childs, 2005; Douesnard & Saint-Arnaud, 2011) play important parts in the dissemination of knowledge as the novice firefighter “engages with institutionally sanctioned information” (Lloyd & Somerville, 2006, p.190).

Learning from the old timers is also an occasion to develop a singular understanding of rules of sociability in the fire service as well as the institutionalized culture (Myers, 2005; Perkins, 1989; Yarnal & Dowler, 2002): "when discussing initial firefighter training, it is not simply technical skill training, but an introduction into the 'culture of firefighting'" (Taber, Plumb, & Jolemore, 2008, p.274). Exercises and drills then become occasions for firefighters to learn in groups and engage in learning by doing (Bourgeois & Chapelle, 2011; Roloff, Wooley, & Edmondson, 2011).

Becoming a Firefighter: A Total Role. Firefighters usually enjoy widespread gratitude, status, and prestige in their community and are recognized through symbols (jackets, clothing, patches, blue lights, etc.) (Thompson & Bono, 1993). In turn, this social recognition can also trigger tensions since the role of firefighter is understood as a "total" role since being a firefighter has an impact on many other important roles around which an individual organizes his or her self-concept (Perkins, 1989; Pudal, 2011b; Smith et al, 2001). Research has shown a strong presence of rituals, traditions, and codes that regulate the entire life of a firefighter in a culture that well exceeds the workplace (Perkins, 1989; Pudal, 2011a). Thus, firefighters are caught managing emotions between social recognition and personal coherence (St-Denis, 2013). As a consequence, investing oneself in the fire service can lead to tensions, conflicts in family relations, or with other social obligations, in particular when there is a need to be available 24 hours a day.

Being a firefighter has a substantial impact on personal identification, accomplishment, fun, and camaraderie all the while imposing constant negotiation and compromise between personal obligations, serving the community and the enjoyment of being part of the fire service (Yarnal & Dowler, 2002). In theory, a leisure participant can quit whenever he/she wants to pursue another interest. On the contrary, volunteer firefighters feel that social pressure precludes them from leaving their role: the pressure to stay is at the same time influenced by the norms and cultural pressure of the group and by the sense of duty towards the community. In the end, the sense of commitment and obligation becomes more important than anticipated when joining the ranks in part because volunteer firefighters think that citizens are overly absorbed with the heroic image of fire ground operations (Lavillunière & Bialès, 2012). In turn, the citizens do not envision the interrupted work

time, conflicting family schedules, sick children, or missed family events (Yarnal & Dowler, 2002).

Evidence from research underlines the fact that volunteer firefighters voice concern over community expectations because citizens most often do not make any distinction between volunteer and career firefighters, as types of firefighters face the challenge of professional evaluation when discussing quality and provision of services (Yarnal & Dowler, 2002). To this end, a relatively small number of articles address the issue associated with balancing firefighting with family life. Data point to the negative effect of shift work on family life, transfer of stress from traumatic events to family siblings (Pfefferbaum et al, 2002), and the pressure of the social atmosphere of the firefighters' group on families (Cowlishaw, Evans, & McLennan, 2008; Regher, et al., 2005).

Cultural traits of volunteer firefighters identified by research are somewhat notable in their career counterparts. Results from research on assimilation in a US career fire department suggest that in high reliability organizations, newcomers quickly adopt organizationally prescribed roles and integrate into their new environments as socialization efforts seek member reliability and mutual trust (Myers, 2005). Newcomers in dangerous or emergency rescue organizations must quickly learn to communicate and behave in ways that instill trust (Colquitt et al., 2011) and confidence with their coworkers (Myers, 2005). Research results have also shown that fire stations can become environments showing signs of the *groupthink* phenomena (Laughlin, 2008) where variance is not tolerated and shared similar perspectives fail to challenge shared views (Rashman, Withers, & Hartley, 2009). Groupthink creates pressure on newcomers to adopt behaviors that are in accordance with institutionalized practices in the group of firefighters.

Leveraging Organizational Culture to Support Leadership: Summary of Research In Meta-Category Research findings in the organizational culture meta-category helps one understand what it means to be a firefighter and the almost sacred aspects of the fire service culture. Being a firefighter appears to be more than a profession: it is an encompassing role that defines the individual in all aspects of social and private life.

Based on the studies reviewed in this article, additional research on serious leisure in the fire service, in the contemporary social, familial, and cultural context, would allow a better understanding of the tensions associated with a firefighter's many, and at times conflicting, roles. Since firefighting activities are mostly carried out in immediately dangerous conditions to life and health, this serious leisure has the potential to cause important tensions in the lives of volunteers as it creates ambiguity between pride, heroism, courage, self-abnegation, idealism, and social pressure.

Additional research is also needed to understand the ambiguity of citizens' expectations of firefighters. For example, research discussed previously shows that the populace view firefighters as courageous and heroes. Does this perspective mean firefighters should be risk averse in order to save lives that may already be lost in a fire or to save property? Understanding how the public's expectations fare with the realities of firefighting could shed life on firefighter's agency, recruitment, and provisions of services (USFA, 2007).

Analysis of studies reviewed here also found that firefighters feel pressured by the citizens of their communities to perform to high standards regardless of whether they are volunteer or career personnel. As such, these men and women dedicate themselves to mastering a complex knowledge stock. In turn, this knowledge stock is being challenged both by the necessity to develop new competencies to respond to evermore complex emergencies and by scientific and applied research that force firefighters to reconsider agreed-upon practices (e.g., Holmgren, 2014; Madrzykowski, 2013).

Finally, most of the work on culture, role, and commitment has focused on volunteer firefighters. Research on culture in the context of career fire departments could prove helpful to sustain a holistic research agenda providing data to support studies in the health and safety and management meta-categories.

3.5 Discussion

In general, the body of research on the fire service does not show the *superstar effect*, where a very small group of scholars published the overwhelming majority of articles (Massaro, Dumay, & Garlatti, 2015). In fact, authors generally contributed one or only a few articles

to the body of knowledge about firefighting and firefighters. This plurality of research perspectives added richness and diversity to the study of firefighting across the world. The paucity of peer-reviewed, fire-related articles produced over the past 46 years suggests that the field of research on the fire service is still in its infancy; much work remains to be done.

This review tells a story about firefighters. In many communities, the firehouse becomes a focal point for the individual's engagement in public service. Joining the fire service allows these men and women to gain a special status that defines the boundaries of a respected role in the community. In fact, through their commitment in this public service, firefighters gain a sense of belonging and, as underlined by the studies reviewed here, this special status comes with serious trade-offs. Firefighting is a stressful profession that requires fitness and self-discipline to be able to function in a working environment characterized by significant danger, loud noises, and multiple aggressors that have important and long-lasting health consequences such as hearing impairment, lung-diseases, and cancer – and unfortunately all to often death.

Assuming a leadership position within the fire service comes with numerous challenges. First, citizens recognize firefighters as a pillar of community life through their involvement in protecting others as well as the symbolic representation of courage. Juggling with these expectations and optimization of service in an austere financial environment becomes a complex public administration challenge. Second, fire service leaders must also face the challenge posed by the risk of line of duty deaths and promote a cultural change in basic assumptions related to health and safety. On one hand, the organizational culture is a strong asset to leaders with such values as commitment, engagement, and service. On the other hand, as this same culture leans towards low level of fitness and life habits, it becomes a barrier to necessary changes. Finally, as documented in this review, there is an important knowledge stock to be mastered in the fire service. With a growing body of academic research on the fire service, leaders need to engage in strategic knowledge management and leverage available data from research into best practices on the fire ground. In doing so, fire leaders could bring valuable changes in the training programs by raising future firefighters' awareness on issues such as health and safety, lifestyle and factors related to line of duty deaths.

Results presented here suggest that research work bridging the intersections of the meta-categories would sustain the development of an in-depth understanding of the links between managerial work, health and safety issues and organizational culture. Examples include research on diversity and women's leadership in the fire service, the interface between the fire service and other public agencies, mergers of fire departments, and change management in a conservative organizational culture often characterized by groupthink.

Future comprehensive literature reviews of research on the fire service should encompass peer reviewed articles published in different languages. This approach would allow for a more comprehensive, comparative, and global understanding of the fire service.

3.6 Conclusion

The purpose of this article was to present a systematic literature review of 238 fire-related academic studies drawn from peer-reviewed journals published between 1970 and 2016. No claim is made here that these 238 studies represent the *population* of fire-related academic studies published during this 46-year time span. Undoubtedly, some peer-reviewed articles were missed because they were not indexed in major searchable databases such as EBSCO or JSTOR and/or the title or abstract of an article did not contain the keywords -- *fire*, *fire service*, *fire department*, and *firefighter* (in French*: service d'incendie, incendie*, and *pompier*). In order to overcome these search limitations, the *reference lists* of articles found in the initial search were mined and 64 additional articles were added to the literature review. Finally, five new studies were identified using the meta-category sub-categories shown in Table 1. Nevertheless, the studies included in this literature review are offered as a *representative sample* of peer-reviewed articles appearing between 1970 and 2016.

The literature review offered here makes three important contributions to the body of knowledge on the fire service. First, as the first systematic, global, and inclusive literature review of research on the fire service, it provides empirical evidence of three meta-categories that characterize the state of research on the fire service. In order of importance (based on the number of studies in a category) the three meta-categories are (1) health and safety, (2) management, and (3) organizational culture. Second, the review offers the first

longitudinal view (1970-2016) of research work on the fire service written both in in English and French. Third, based on analysis of the 238 studies, the review offers multiple recommendations where additional research could prove beneficial to fire service leaders.

Based on the publication dates of studies, the last decade underscores a clear surge of interest of research on the fire service. An encouraging sign of the growing maturity of this field of research is now the possibility, and one could argue the necessity, for meta-analyses allowing for a better understanding of a multiplicity of studies in the same meta-category – e.g., health and safety.

Firefighters are viewed by their fellow citizens as modern heroes. The peer-reviewed, academic research studied here and summarized into three meta-categories holds the potential to support fire service leaders in their efforts to bringing everyone home safely.

CHAPTER 4: KNOWLEDGE MANAGEMENT IN VOLUNTEER FIRE DEPARTMENTS

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When passion fuels the fire: Knowledge sharing among volunteer firefighters in Canada

Keywords: knowledge management in the fire service, firefighters, volunteer fire departments, Buddy Learning, serious leisure, factor analysis.

4.1 Abstract

Little is known about how knowledge is managed in the fire service. Based on data from (1) a survey of volunteer firefighters in the Province of Quebec, Canada, (2) 20 fire department municipal websites, and (3) semi structured interviews, this article presents, to our knowledge, the first model explaining knowledge management in volunteer fire departments. Findings emerging from the analysis of the data support the three propositions guiding the research effort. First, knowledge sharing among firefighters, called Buddy Learning in this study, is the main source of learning for firefighters. Second, serious leisure components are levers of knowledge management in volunteer fire departments. Third, turned inward, the fire service organizational culture impairs knowledge transfer from external sources such as other fire departments, partners, customers, suppliers, and academic and applied research.

4.2 Introduction

A recent literature review of 238 peer-reviewed studies found that research focusing on the fire service could be grouped into three metacategories: studies on (1) health and safety, (2) management, and (3) organizational culture (Beauchamp, 2017). Research on health and safety showed that new strategies are necessary to reduce the risks associated with cancer, cardiovascular incidents, or stress in a culture prone to poor health habits (Jahnke, Poston, Haddock, & Jitnarin, 2013; Jitnarin, Haddock, Poston, & Jahnke, 2013; Kunadharaju, Smith, & Dejoy, 2011; Onieal, 2010). Studies on management explained why fire-service leaders must now maneuver through complex managerial challenges such as service optimization, diversity, work-agreement negotiations, and rising service expectations in an austere financial environment (e.g., Devinatz, 2015; England & Brown, 2014). Finally, scholars investigated the fire service's organizational culture, mostly in the context of volunteer fire departments (e.g., Perkins, 1989; Perkins & Benoit, 1997). In the serious leisure of volunteer fire fighting (Stebbins, 1996), firefighters find a purpose that helps shape their identities; they are held in high esteem by their fellow citizens (Jeantet & Gernet, 2011; Tracy & Scott, 2006).

Firefighters, regardless of whether they are career or volunteer, are expected to develop and use the appropriate knowledge to protect their fellow citizens (Yarnal & Dowler, 2002). Beauchamp's extensive literature review of 238 peer-reviewed studies confirmed previous findings by Massaro, Dumay, and Garlatti (2015) that one of the current limits of research about the fire service is understanding how knowledge is managed in modern fire departments.

Problems related to knowledge management (KM) have been documented as an important organizational challenge in fire departments in the United States, the United Kingdom, and Canada. For example, numerous reports identified KM flaws as contributing factors in firefighters' injuries or death (e.g.: Commission de la santé et sécurité du travail (CSST), 2009a, 2009b; National Institute of Occupational Safety and Health (NIOSH), 2015, 2017; Watterson, 2015). Key recommendations to address problems caused by the lack of KM include the following: (1) the creation/revision of standard operating procedures; (2) the

transfer of current academic and applied fire-service research to improve fire-fighting practices, health and safety, and organizational culture; (3) the revision/implementation of training programs; and (4) gathering of information through preincident planning.

The purpose of this study is to provide an exploratory analysis of KM processes in volunteer fire departments in Canada. The research is organized into five remaining sections. The first section identifies the research propositions guiding the study. Section two presents the conceptual framework guiding the research effort, and section three discusses the methodology used to test research propositions. Findings emerging from data analyses are outlined in section four. Finally, a conclusion is offered in which limits of the study are identified and future research suggestions are offered.

4.3 Research propositions

This section discusses the three research propositions that guide the present study. The three topics are knowledge sharing and learning among firefighters; volunteer firefighting as a serious leisure (SL) activity; and tradition as a barrier to knowledge management.

4.3.1 Knowledge sharing and learning among firefighters

Fire fighting is a team-based profession. Training allows firefighters to share their knowledge with each other to master the use of equipment and coordinate their actions (Myers, 2005; Perkins, 1990). By sharing their knowledge with each other, firefighters ensure that agreed-upon practices are taught and maintained in the group. In this context, storytelling plays an important part in the dissemination of knowledge as the novice firefighter "engages with institutionally sanctioned information" (Lloyd & Somerville, 2006, p.190) and the newcomer slowly becomes an insider (Huysman, 2004).

In fact, learning from the 'old timers' is an occasion to develop a singular understanding of social rules in the fire service as well as its organizational culture (Myers, 2005; Perkins, 1989; Yarnal & Dowler, 2002). "When discussing initial firefighter training, it is not simply technical skill training, but an introduction into the 'culture of firefighting'" (Taber, Plumb, & Jolemore, 2008, p. 274). Therefore, knowledge sharing among firefighters is an

important mechanism of KM in volunteer fire organizations, which leads to proposition one:

Proposition 1: Knowledge sharing among firefighters is their main source of learning.

4.3.2 Volunteer firefighting as a serious leisure (SL) activity

Volunteer fire fighting has been described as a serious leisure (SL), which is defined as:

> The systematic pursuit of an amateur, hobbyist, or volunteer activity sufficiently substantial, interesting, and fulfilling for the participant to find a (leisure) career there acquiring and expressing a combination of its special skills, knowledge, and experience (Elkington & Stebbins, 2014, p. 4).

In a SL, individuals enter a specific world-view characterized by groups, events, routines, practices, organizational structures, and a unique knowledge stock (Stebbins, 1996, 2008). Volunteer firefighters are citizens who work in different occupations where they have developed their personal skill sets which, in turn, they bring to the fire department. Individuals join the fire service for a variety of reasons — to help their communities, as extra sources of income, to avoid personal isolation, to make friends, etc. (Perkins & Mets, 1988; Thompson, 1993, 1995; Thompson & Bono, 1993).

Regardless of why they choose to join, most individuals engage with passion in the serious leisure of volunteer fire fighting; they find unique qualities in the core activities of fire fighting. The volunteers have access to a unique knowledge stock that contributes both to durable benefits and a distinctive identity in society. As these 'just plain folks' (Brown, Collins, & Duguid, 1989; Lave, 1988) enculturate through apprenticeship in the fire service, they seek to acquire the signature skills (Davenport & Prusak, 2000) of fire fighting. Therefore, to learn is also to become part of a team as the individual develops the capacity to contribute to the group's performance and success. As such, the second proposition upon which the present study is based is as follows:

Proposition 2: Serious leisure components are levers of knowledge management in volunteer fire organizations.

4.3.3 Tradition as a barrier to knowledge development

The fire service's organizational culture is characterized by a dominant logic expressed by the importance of hierarchy, tradition, conservatism, and reluctance to change (Bettis, Wong, & Blettner, 2011; Thompson, 1995). Routines are reinforced by role models, status rituals, procedures, and vocabularies (Miller, 1996) as firefighters show pride in their standings and will ostracize anyone who does not conform (Brauer, 2016).

In fact, strong consensus discourages interventions that would question tradition (Lucas & Kline, 2008). As such, firefighters may eschew external knowledge sources that challenge the status quo such as academic and applied research (Rouse, 2004) or avoid transferring into the organization knowledge from partners, suppliers, or customers towards the implementation of best practices. Tradition as a barrier to knowledge development leads to proposition 3, which states the following:

Proposition 3: Turned inward, the fire service organizational culture impairs knowledge transfers from external sources such as other fire departments, partners, customers, suppliers, and academic and applied research.

4.4 Conceptual framework

This research's conceptual framework is based on the four dimensions of KM: (1) management, (2) content, (3) processes, and (4) external environment. In addition, the framework is built upon the four components of a SL, (1) qualities, (2) rewards/motivation, (3) thrills/psychological flow, and (4) devotee work. It also includes selected elements from each of the four components. A discussion of KM dimensions and SL components is given in the following sections.

4.4.1 Knowledge management dimensions

KM is comprised of three dimensions — management, content, processes, and external knowledge sources. These dimensions are discussed in the following sections.

4.4.1.1 Management

Management refers to how top management (TM) supports KM practices and how it uses information technologies (IT) to maintain an up-to-date internal knowledge base. Management is defined as "the degree to which top management understands the importance of knowledge management and the extent to which [it] is involved in knowledge management practices" (Lin, 2011 in Oliveira, Pedron, Nodari, & Ribeiro, 2014).

4.4.1.2 Content

Content is the dimension related to tacit knowledge (TK) and explicit knowledge (EK). Individuals tacitly own knowledge and organizational strategies are deployed to render this knowledge explicit through codification and transfer to other individuals. Knowledge transfer then allows for experience sharing (Argote & Ingram, 2000; Argote, Ingram, Levine, & Moreland, 2000), perpetuation and codification of organizational culture (Cohen & Levinthal, 1990; Paulus & Yang, 2000; Rouiller & Goldstein, 1993), and creation of new knowledge (Nonaka, 1994; Nonaka & Toyama, 2003).

4.4.1.3 Processes

Knowledge creation (KC) is defined as "the development of new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge" (Hsieh, Lin, & Lin, 2009, p. 4089). Knowledge storage (KST) refers to "appropriation, revision and organization of knowledge in a way that allows it to be accessed and updated" (Oliveira, Pedron, Nodari, & Ribeiro, 2014, p. 758) and is often associated with efficiency in sharing explicit and tacit knowledge (Hsieh et al., 2009). Knowledge sharing (KSH) is the action by which individuals or units share their acquired knowledge with others, therefore enhancing organizational capabilities (Ipe, 2003; Nordin, Pauleen, & Gorman, 2009).

4.4.1.4 External knowledge sources

External knowledge sources can be accessed by an organization outside its boundaries such as trying to gain knowledge from the external environment (Hartley & Allison, 2002; Powell & Grodal, 2005) or accessing training, communication, observations, technology transfer, scientific publications, or presentations (Argote et al., 2000). In this study, external sources include suppliers (SUP), partners (PART), customers (CUST), and academic and applied research (AAR).

Suppliers (SUP) are private-sector firms that provide fire-fighting/rescue equipment to the fire department. Partners (PART) are either other municipal departments or mutual-aid fire departments that interact with the fire department. Customers (CUST) are the citizens to whom the fire department provides services. Finally, academic and applied research (AAR) refers to knowledge generated by studies on the fire service.

4.4.2 Serious leisure components and elements

A serious leisure is characterized by the four components shown in Table 4.4. The first component is *qualities,* which is defined by six distinctive elements such as perseverance and distinctive identity. The second component of serious leisure is rewards and motivation, which is comprised of seven personal (e.g., self-actualization and self-image) and three social (e.g., social attraction and group accomplishment) rewards gained through participation in the serious leisure. The third component shown in Table 1 is thrills and psychological flow that the firefighter may experience. Examples of elements in this component include a sense of deep and focused involvement in the activity and the sense of loss of self-consciousness during the activity. In total, eight different elements help define the thrills/psychological flow component. Finally, devotee work is the fourth quality. This quality is based on six criteria that generate devotion to the core activity of the serious leisure.

Table 4.4: Serious leisure components and elements

Component: Qualities	Component: Rewards/Motivation	Component: Thrills/Psychological Flow	Component: Devotee Work
Elements (1) Perseverance (2) Opportunity to follow a leisure career (3) Significant personal effort (using specially acquired knowledge, training, skills, or all three) (4) Durable benefits (5) Unique ethos (6) Distinctive identity	**Elements** <u>Personal Rewards</u>: (1) Personal enrichment (2) Self-actualization (3) Self-expression (4) Self-image (5) Self-gratification (6) Re-creation (7) Financial return <u>Social Rewards</u>: (8) Social attraction (9) Group accomplishment (10) Contribution to group	**Elements** (1) Sense of competence in executing the activity (2) Requirement of concentration (3) Clarity of goals of the activity (4) Immediate feedback from the activity (5) Sense of deep, focused involvement in the activity (6) Sense of control in completing the activity (7) Loss of self-consciousness during the activity (8) Sense of time is truncated during the activity	**Elements** (1) Valued core activity (2) Core offers significant variety (3) Core offers significant opportunity for creative innovation (showing imagination and application of routine skill or knowledge) (4) Reasonable control over the amount of time to put into the core activity (5) Aptitude and taste for the required work (6) Physical and social milieu encourages the pursuit of the core activity

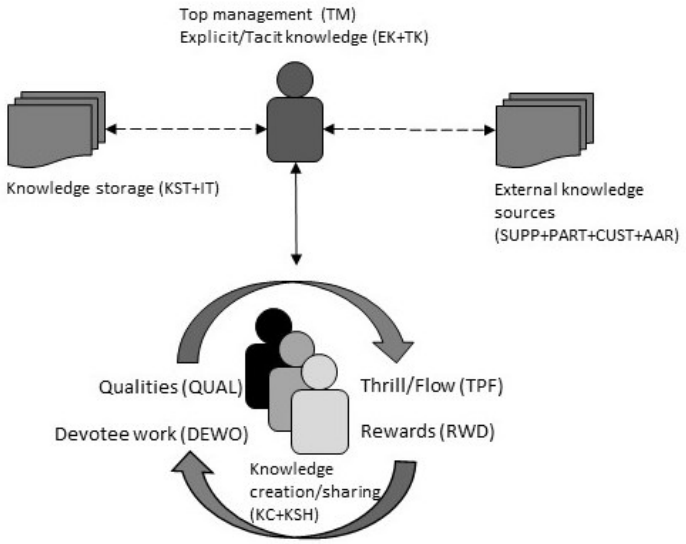
Source: Adapted from Elkington & Stebbins, 2014.

As part of the conceptual framework, selected specific elements from each of the four SL components were chosen to include in the survey administered to study participants. These elements reflect the how and why firefighters engage in volunteer firefighting and how the organizational culture of volunteer firefighters may impact KM processes.

4.4.3 Conceptual framework model

Based on the KM dimensions and SL components discussed in the last section, the conceptual framework guiding this study can be represented by the model show in Figure 4.4. Explanation of the model follows.

Figure 4.4: Conceptual framework



First, volunteer fire departments appear conducive to knowledge creation and sharing (KC + KSH) among firefighters at the team level. This form of KM is tested by **Proposition 1:** Knowledge sharing among firefighters is their main source of learning.

Second, in managing explicit and tacit knowledge (EK + TK), top management (TM) could realize gains in KM by leveraging different components of the organizational culture. **Proposition 2**, which states SL components positively support KM in volunteer fire organizations, tests this aspect of the model.

Finally, volunteer fire departments seem unwilling to input into the organization knowledge generated from external sources (SUPP + PART + CUST + AAR), which results in minimal knowledge storage strategies (KST + IT). This avoidance of transfer of knowledge into volunteer fire departments from external sources is tested by **Proposition 3**, which states, turned inward, the fire service organizational culture impairs knowledge transfer from external sources such as other fire departments, partners, customers, suppliers, and academic and applied research.

4.5 Methodology

This research was conducted in volunteer fire departments in the Province of Quebec, Canada. Volunteer firefighters, or part-time firefighters as they are called in this Province, are in the majority (78%; *N = 13,860*) (Québec, 2013) — as is the case throughout North America (Karter & Stein, 2013; National Fire Protection Association [NFPA], 2015; Perkins & Metz, 1988).

The research strategy was based on data triangulation from three sources. First, an online survey of volunteer firefighters was used to gather data throughout the Province. Second, fire departments' municipal websites were reviewed to document the extent to which e-government practices were used to communication with citizens. Finally, semi structured interviews were conducted to complement and enrich survey results. Each data source is discussed further in the sections that follow.

4.5.1 Online survey

Using a five-point Likert scale ranging from one (strongly disagree) to five (strongly agree), the on-line survey questionnaire was designed to measure firefighters' perceptions about their preferred knowledge sources and KM processes in their fire department (Robson, 2002).

The survey included questions related to the four dimensions of KM and four components of the serious leisure of fire fighting (see Conceptual Framework section). The survey was constructed using an online survey engine and was made accessible through a dedicated web page acquired for this research.

4.5.1.1 Survey sampling

The Province of Quebec is divided into county regional municipalities (CRMs). This geographical division served as a base for a two-step sampling strategy. First, a purposive sample (Sample A) (Robson, 2002; Teddlie & Yu, 2007) was composed of the 17 volunteer fire departments located in one CRM. Of the seventeen chiefs contacted, thirteen agreed

that their firefighters (*N = 351*) could be solicited for the survey. Out of the 351 firefighters, 47% (*N = 165*) participated in the survey.

The second sample (Sample B) was gathered through cluster sampling (Robson, 2002). Seven CRMs were randomly selected, based on their geographical location, to cover the entire Province. Next, random sampling was applied to select one volunteer fire department from each CRM. These seven departments represent a sample of 356 firefighters. About 38% (*N* = 136) of the firefighters participated in this survey. In summary, out of a total of 707 solicited volunteer firefighters, 317 firefighters (44.9%) participated in both surveys. Sixteen respondents were deleted from the dataset because they did not answer a single question in the survey, thus leaving a final sample of 301 firefighters (42.5%).

The majority of the firefighters who completed the surveys were male, young, and spoke and read French and had studied either a trade in high school or a technical profession in college. A large majority of the firefighters had served in their departments for less than ten years. Finally, all firefighters were qualified or were in the process of obtaining their qualifications, as required by provincial legislation (see Table 4.5).

Table 4.5: Demographic data

Firefighter	Sample A	Sample B
Gender = Male	96%	91%
Age: Between 18 and 40 Between 41 and 50 Between 51 and 60 Over 60	 49.8% 27.8% 9.1% 13.3%	 56.8% 20.0% 16.8% 6.4%
Language	French as first language. Individuals indicate basic capacities in English.	French as first language. Individuals indicate basic capacities in English.
Academic background (between third year of high school to either a trade certification or second year of College)[a]	90.7% (e.g.: carpenter, plumber, contractor, technician, etc.)	87.7% (e.g.: carpenter, plumber, contractor, technician, etc.)
Years of service in the fire department	0 – 10 years = 70%	0 – 10 years = 68%
Firefighter qualifications[b]	All qualified, some in the process of obtaining their qualification.	All qualified, some in the process of obtaining their qualification.
a: In Quebec, there is a collegiate level between high school and university. b: In Quebec, legislation mandates firefighter qualifications regardless of status (volunteer or career firefighter).		

4.5.1.2 Exploratory factor analysis of survey data.

Two exploratory factor analyses (EFAs) were conducted on aggregated data from both samples. The first EFA was focused on KM dimensions, and the second EFA focused on SL components. After oblique rotation, a three-factor solution provided the cleanest factor structure for both factor analyses; items loaded with more precision on each factor with few cross loadings (Field, 2009; Kline, 1994; Osborne & Costello, 2009; Tabachnick & Fidell, 2013).

4.5.2 Fire department municipal websites

A content analysis (Robson, 2002) was performed on the municipal website of each fire department (*N = 20*) participating in this study. Websites were all accessed the same day allowing for contemporary comparison of published information about the following topics: composition of service/staffing, history, mission/vision/values statement, training, services provided, social implication, statistics on calls/runs, information on the departmental regional safety cover plan, and questions by citizens if a link was present on the website that allowed for them.

4.5.3 Firefighters interviews

After survey results were analyzed, interviews were conducted. Data were gathered through semi structured interviews, and saturation was reached after 10 respondents (i.e., no new information was provided after 10 interviews) (see Mason, 2002; Teddlie & Yu, 2007). Interviews were based on the following five main questions:

(1) What are the main sources of knowledge in your fire department?

(2) What is the impact of the fire-service organizational culture on knowledge management in your fire department?

(3) What concrete measures are in place to manage knowledge in your fire department?

(4) Is knowledge shared between your fire department and other organizations?

(5) Is knowledge from research transferred in your fire department?

4.6 Findings

Findings emerging from the factor analyses of the KM and SL survey questions are organized into two sections. In the first section, factor analysis as a statistical tool is discussed, and the KM and SL factor analyses are presented and reviewed more from empirical and statistical perspectives. In the second section, the six factors that emerged from the factor analyses of the KM and SL survey responses are discussed from a more theoretical and substantive perspective. This discussion is also enriched with statements provided by study participants during in-depth interviews, demographic information of survey participants, and the findings emerging from the review of the websites of the 20 Quebec volunteer fire departments that participated in the study.

4.6.1 Factor analysis of KM and SL survey questions: empirical and statistical perspectives

In order to identify *patterns* occurring in the 301 study participants' responses to survey questions, two factor analyses were performed — one of KM survey questions and one of SL survey questions. Factor analysis is a well-known, widely-used statistical tool employed to group interdependent variables into descriptive categories, usually called *factors.* As explained by factor-analysis expert R. J. Rummel (1967):

> Factor analysis is a means by which the regularity and order in phenomena can be discerned. As phenomena co-occur in space or in time, they are *patterned* (emphasis added); as these co-occurring phenomena are independent of each other, there are a number of *distinct patterns* (emphasis added). Each pattern will appear as a *factor* (emphasis added) delineating a distinct cluster of interrelated data. (pp. 445, 447)

Table B6 and Table B12, in ANNEX B, show the full-pattern matrices for the KM factor analysis and the SL factor analysis, respectively.

4.6.1.1 The KM factor analysis.

The KM pattern matrix shows that the factor analysis of the 39 variables produced three factors (the labelled columns in Table B6) of interrelated data (i.e., survey questions): (1) Buddy Learning, (2) Knowledge Transfer, and (3) Knowledge Storage. Collectively, the three factors explained about 50% of the variation among all the variables involved in the

patterns (Buddy Learning = 40.6%; Knowledge Transfer = 5.3%; and Knowledge Storage = 4.3%). The factor labelled Buddy Learning is the strongest factor (eigenvalue = 16.3) in the data, accounting for about 40% of the variance.

The alpha values or coefficients of reliability (shown as the symbol α in Table B6) for the three factors show high reliability: 0.910 for Buddy Learning, 0.935 for Knowledge Transfer, and 0.923 for Knowledge Storage. Alpha values range from 0 to 1; the higher the α coefficient, the more the items (variables) in the factor share covariance and measure the same underlying concept (see University of Virginia, 2018).

The values shown in the columns under each factor in Table B6 are called *factor loadings.* They show which variables are involved in which factor pattern and to what degree (Rummel, 1967). They can be interpreted like correlation coefficients and show both the strength (from a +1.0 to a -1.0) and direction (positive or negative) of the relationship of a variable with a factor. Once again, the factor analysis of the KM variables produced three factors. Factor 1 is called Buddy Learning and is defined by the 13 variables shown in bold font in the first column (from KSH3 to TK3). All of the variables in the factor are **positively** related to the factor. For example, for the first variable (knowledge sharing 3 = KSH3), survey respondents were **highly likely** (factor loading = 0.716) to **agree** with the statement that "In my fire department, when a firefighter is competent at a task, colleagues will ask him/her to show them how to do it."

Factor 2 or Knowledge Transfer is comprised of the variables labelled AAR2 through PART6 shown in bold font in Table B6. In contrast to Factor 1 or Buddy Learning, the variables in Factor 2 are **negatively** associated with Factor 2. For example, for the first variable associated with Factor 2 or Knowledge Transfer (academic or applied research 2 = AAR2), survey respondents were **highly likely** (factor loading = -0.934) to **disagree** with the statement that "In my fire department, results from academic or applied research on the fire service are used to modify practices and procedures."

Finally, Factor 3 or Knowledge Storage is defined by the variables KST1 through PART4 shown in bold font in Table B6. Like Factor 2, all of the variables in the Knowledge Storage factor are **negatively** associated with the factor. For example, for the first variable

associated with Factor 3, Knowledge Storage (knowledge storage 1 = KST1), survey respondents were **highly likely** (factor loading = -0.863) to **disagree** with the statement that "In my fire department, processes and tools to store knowledge for future use are well organized."

4.6.1.2 SL factor analysis.

The SL pattern matrix in Table B12 shows that the factor analysis of the 11 variables produced three clusters (the labelled columns in Table B12), or factors, of interrelated data (i.e., survey questions): (1) Personal Development, (2) Creativity, and (3) Commitment. Collectively, the three factors explained about 64 percent of the variation among all the variables involved in the patterns (Personal Development = 39.3; Creativity = 13.3; and Commitment = 11.5). The factor labelled Personal Development is the strongest factor in the data, accounting for about 40% of the variance (eigenvalue = 4.3).

The alpha values or coefficients of reliability (shown as the symbol α in Table B12) for the three factors show high reliability: 0.833 for Personal Development, 0.816 for Creativity, and 0.763 for Commitment. As noted previously, alpha values range from 0 to 1; the higher the α coefficient, the more the items in the factor share covariance and measure the same underlying concept (see University of Virginia, 2018).

The values shown in the columns under each factor in Table B12 are called *factor loadings*. Factor loadings show which variables are involved in which factor pattern and to what degree (Rummel, 1967). They can be interpreted like correlation coefficients and show both the strength (from a 1.0 to a -1.0) and direction (positive or negative) of the relationship of a variable with a factor. Once again, the factor analysis of the SL variables produced the following three factors.

- ***Factor 1 (Personal Development)*** — This factor is defined by the 4 variables shown in bold font in the first column — from RWD1 to QUAL4. All of the variables in the factor are **positively** related to the factor. For example, for the first variable (rewards 1 = RWD1), survey respondents were **highly likely**

(factor loading = 0.800) to **agree** with the statement that "Being a firefighter encourages personal development by developing abilities and knowledge."

- ***Factor 2 (Creativity)*** — Similarly, the variables labelled DEWO3 and DEWO2 in bold font in Table B12) are also **positively** associated with Factor 2. For example, for the first variable associated with Factor 2, Creativity (devotee work 3 = DEWO3), survey respondents were **highly likely** (factor loading = 0.852) to **agree** with the statement that "Fire fighting allows me to demonstrate imagination in the application of abilities and knowledge."

- ***Factor 3 (Commitment)*** — This factor is defined by the 5 variables QUAL1 to TPF1 shown in bold font in Table B12. Like Factor 2, all of the variables in the Commitment factor are **positively** associated with the factor. For example, for the first variable associated with Factor 3, Commitment (qualities 1= QUAL1), survey respondents were **highly likely** (factor loading = 0.761) to **agree** with the statement that "In my fire department, firefighters persevere to become more competent."

Attention now turns to a detailed discussion of the three factors that emerged from the KM factor analysis and the three factors that emerged from the SL factor analysis.

4.7 Factor analysis of KM and SL survey questions: theoretical and substantive perspectives

In order to facilitate this discussion of the individual survey questions (i.e., variables) associated with factors emerging from the KM and SL factor analyses, the full factor-pattern matrices shown in Tables B6 and B12 have been stripped of their data components and the survey questions truncated in some cases. In contrast to the pattern matrices shown in Table B6 and B12, Table 4.7.1 and Table 4.7.2 show only the survey questions defining each factor and their codes (e.g., Factor 1 or Buddy Learning, KSH3 is the code for the question "When a firefighter is competent at a task, a colleague will ask him/her to show

him/her how to do it.") These codes are used to refer to the survey questions in the discussion in the following section.

Also, when discussing theoretically and substantively the factors associated with the KM and SL factor analyses, those **four** factors identified in the previous section that loaded **positively** with KM in the fire service are discussed together. As a reminder, the four factors are (1) Buddy Learning from the KM factor analysis and the three factors associated with the SL factor analysis: (2) Personal Development, (3) Creativity, and (4) Commitment. Then, the theoretical and substantive implications of the **two** factors that were **negatively** associated with knowledge management (i.e., Knowledge Transfer and Knowledge Storage) in the fire service associated with the KM factor analysis are discussed.

Table 4.7.1. Knowledge management factor analysis

(3 factors and 39 variables - questions are slightly truncated in some instances)

1. Buddy-Learning Factor

1. **KSH3**. When a firefighter is competent at a task, a colleague will ask him/her to show him/her how to do it.
2. **KSH4**. When firefighters learn something new, they share it with their colleagues.
3. **KSH2**. Firefighters ask their colleagues to share their skills when they need to learn something new.
4. **KSH1**. Experienced firefighters willingly share their knowledge with new firefighters.
5. **KC1**. Firefighters can propose ideas and new knowledge.
6. **KC3**. Firefighters can propose new ways of doing things.
7. **KSH5**. Firefighters benefit the group with competencies developed in their primary occupations.
8. **TM1**. High-ranking officers believe it is important to encourage firefighters to share their knowledge with colleagues.
9. **TM3**. High-ranking officers are aware of motivations in the fire service, and they inform firefighters about it.
10. **KC2**. Firefighters train regularly on tasks to develop their competencies.
11. **TM4**. High-ranking officers (chiefs) foster motivation and change.
12. **TM2**. High-ranking officers adjust training after problems were encountered in operations to help firefighters improve.
13. **TK3**. Informal conversations and meetings are used to share knowledge.

2. Knowledge Transfer Factor

1. **AAR2**. Results from academic or applied research on the fire service are used to modify current practices and procedures.
2. **AAR3**. Results from academic or applied research on the fire service are incorporated in training.
3. **AAR4**. Results from applied or academic research on the fire service are used to further health and safety in the workplace.

4. **AAR1**. High-ranking officers (chiefs) use results from academic or applied research in their decisions.
5. **CUST4**. Knowledge obtained from citizens is used to innovate (for example: update prevention program).
6. **CUST3**. Knowledge obtained from citizens is incorporated into the department's operations.
7. **SUP3**. Knowledge obtained from service or equipment suppliers is used to innovate.
8. **SUP1**. Knowledge is shared from either side with services and equipment suppliers.
9. **PART2**. Knowledge obtained from partners is incorporated into the department's operations.
10. **CUST2**. Citizens are asked to share their knowledge (for example: information while on emergency scenes).
11. **AAR5**. It is considered important that knowledge from research be known.
12. **PART1**. Knowledge is shared reciprocally with partners (for example: public works, police, and ambulance).
13. **PART3**. Knowledge obtained from partners (for example: police) is used to innovate.
14. **CUST1**. Firefighters share their knowledge with citizens (for example: explanations, prevention tips, etc.)
15. **SUP2**. Knowledge obtained from service or equipment suppliers are incorporated into the department's operations.
16. **PART5.** Knowledge obtained from mutual-aid fire departments is incorporated in the department's operations.
17. **PART6**. Knowledge obtained from a mutual-aid fire department is used to innovate.

3. Knowledge Storage Factor

1. **KST1**. Processes and tools to store knowledge for future use are well organized (for example: data banks).
2. **EK4**. Knowledge is shared by means of documentation such as manuals.
3. **EK1**. Knowledge can be easily accessed through documents or manuals.
4. **EK3**. Results from projects or meetings are documented.
5. **EK2**. There is a standard training program, and its objectives are known by firefighters.
6. **KST2**. Firefighters take part in knowledge storage activities for future use (for example: review procedures).
7. **KST3**. Firefighters know where stored knowledge that can be useful to them can be found.
8. **IT3**. Firefighters regularly use information technologies in their tasks (for example: during inventory, etc.).
9. **PART4**. Knowledge is reciprocally shared with mutual-aid fire departments.

Table 4.7.2. Serious leisure factor analysis (3 factors and 11 variables)

1. Personal development Factor

1. **RWD1**. Being a firefighter encourages personal development by developing abilities and knowledge.
2. **RWD2**. Being a firefighter encourages self-expression by developing abilities and knowledge.
3. **Qual3**. Being a firefighter promotes personal enrichment, self-expression, a sense of accomplishment, social interactions, and a sense of belonging.
4. **Qual4**. Being a firefighter means to develop a distinctive identity in society and to be part of a group that share values, beliefs, and goals.

2. Creativity Factor

1. **DEWO3**. Fire fighting allows firefighters to demonstrate imagination in the application of abilities and knowledge.
2. **DEWO2**. Fire fighting offers a significant opportunity for creative and innovative work, which favors personal expression.

3. Commitment Factor

1. **QUAL1**. Firefighters persevere to become more competent.
2. **QUAL2**. Firefighters make significant efforts to use their knowledge, training, and skills.
3. **TPF4**. Firefighters feel a deep sense of involvement during fire fighting.
4. **RWD3**. Firefighters see as a reward their contributions to maintaining and developing the group.
5. **TPF1**. Firefighters have the feeling of being competent during fire fighting.

4.7.1 Buddy Learning, personal development, creativity, and commitment as factors positively associated with KM in the Canadian volunteer fire service.

The concept of Buddy Learning is inspired by an emergency technique called buddy breathing that is used by firefighters during interior fire fighting to tap into the air supply of a colleague in the event of failure of their own breathing apparatus. This technique is used as a metaphor in this study to explain how firefighters tap into their colleagues' knowledge to learn.

Firefighters do not hoard knowledge for their own benefit. They willingly share their knowledge with their fellow firefighters (KSH4, KC1). Moreover, firefighters believe that they can ask their colleagues questions in order to gain new knowledge and skills (KSH2, KSH3). Firefighters gain access to their colleagues' tacit knowledge (TK3) most often when working with experienced firefighters or sometimes through informal conversations.

As shown in the demographic data shown previously in Table 2, volunteer firefighters in Canada come from different trades and professions where they each developed a personal skill set. Individuals benefit the group by sharing (KSH5) the competencies developed in their primary occupations. They equate this behavior with their continuous contribution to the group: "We always strive to be better, always, always, I think nobody says, 'I know enough', so that's why I think that knowledge sharing is on-going, always, at all levels of the organization," said a firefighter in a personal interview. This attitude stems in part from a desire to project an image of professionalism to citizens: "You want the department to [present] an image of professionalism; [that] firefighters . . . are trained," said an acting lieutenant.

In volunteer fire departments, the firehouse becomes a physical and social space conducive to knowledge sharing (KSH). Data showed that top management (TM1) provides a social milieu where trust is valued, and KSH is encouraged. Training sessions at the firehouse give access to a valued knowledge stock while acting as gateways into the group. Hands-on training allows firefighters to master routine procedures and to avoid improvisation or freelancing in emergency operations. During training, firefighters will exchange ideas, practices, and tricks of the trade, but they will also discuss the latest calls because they cannot attend all calls. Sharing the knowledge that can be drawn from these past experiences maintains group cohesion and a sense of belonging. Furthermore, training is adjusted by top management (TM2) after problems are encountered in operations. In summary, the firehouse offers tangible occasions to transcend the boundary of the actual self to acquire a new identity through learning — to learn to fight fires is to become a firefighter.

This sharing behavior serves two purposes: First, at the individual level, it is a way to foster relationships with others. As one firefighter said, "We have learned to know each other." In fact, firefighters exhibit care towards each other, which gives rise to mutual trust. One firefighter commented: "You need to trust the person with you and you need to trust the pump operator . . . to bring water, to trust the next guy, so you have no advantages in knowing more than the others." When asked if the department promoted knowledge

sharing (KSH), one firefighter gave the following typical answer: ". . . it is a mentality that we have to help each other."

At the group level, KSH is a way to maintain cohesion and to regulate what is known by everyone. "Like I said, if someone would come here thinking, 'Well I will keep my knowledge to myself and I will use it to move on up in the hierarchy and do my own business,' well he will be put in his place by the group," said a firefighter. Thus, this KSH behavior is both an illustration of the democratic nature of knowledge among firefighters and of the cement that holds the team together. An illustrative comment came from an acting lieutenant: "You know, on the contrary, you have more advantages to know as much [as your teammates] and to mutually push together to become better rather than have one who knows everything and the others nothing." Data showed that being part of a group of firefighters promoted personal enrichment, self-expression, and self-actualization. By acquiring knowledge and a special skill set on fire fighting, individuals contribute to the group's accomplishments (RWD1; RWD2; QUAL3; RWD3). Therefore, firefighters are committed to persevere to become more competent (QUAL1). They make significant efforts to use their knowledge, training, and skills (QUAL2) as they feel competent during fire fighting (TPF1).

Buddy Learning is also a resultant of a passion in commitment to fire fighting. Asked why they are firefighters, survey respondents gave these typical answers. "Fire fighting has always been a passion for me. I found a great passion [in the fire service]." "[Firefighting is] a passion and an opportunity to help citizens." As one lieutenant said: "We are united by our goal" to which another firefighter added, "fraternity . . . brotherhood."

During interviews, firefighters identified what they considered to be the main characteristics of the volunteer fire-fighting culture: passion, team work, fraternity, creativity, help, commitment, and personal development. When asked if these characteristics were levers or barriers to knowledge development, they unanimously answered that they constituted levers. "[Development of these characteristics] sure helps, we all want to be a family, we all want to be professionals, so you have every interest in sharing your knowledge," said an acting lieutenant. The volunteer firefighters are proud to

be members of the fire service and they pride themselves at being proficient at what they do. “I see [a report on the fire department’s operations] on the news and I’m proud of my boys even though I wasn’t on that call and it makes me happy,” said an acting lieutenant. Consequently, firefighters invest time and efforts in training where they can share knowledge with each other and develop their skills (KC2).

Their passion is also fueled by emergency work that requires concentration amid all the danger that such work brings. The dangerous situations also offer an opportunity for creative innovation. One firefighter said, “You need an open mind to learn multiple tasks and, you know, fire fighting has become so complex that you need to be able to do everything.” Therefore, firefighters feel they are challenged to find new approaches to resolve a variety of complex issues using their knowledge, imagination, abilities, and creativity (DEWO 3, DEWO2). “That’s the fun of it, when we try to find solutions,” said one firefighter.

The passion to serve others has impacts well outside the physical space of the firehouse. Being a volunteer firefighter is to enter a social space where one is recognized positively by other firefighters and by citizens. Being a firefighter leads to a distinctive identity in society and the chance to contribute to a group that shares similar values, beliefs, and goals (QUAL4). It promotes a sense of accomplishment, social interactions, and a sense of belonging (QUAL3). Still, this dedication to the group and to public service comes with drawbacks. Firefighters acknowledged that their involvement with the fire department puts a lot of stress on their personal lives. “It’s them [wife and children] that make the biggest sacrifice,” said a firefighter. “It’s tough on family life,” said another firefighter.

While Buddy Learning helps explain the strong relationship among firefighters and KM in the fire service, the impact of Buddy Learning across departments is variable. Volunteer fire departments may be very different in various aspects such as the number of personnel, management of training requirements, volume of calls, and capabilities to train firefighters in realistic conditions. As one lieutenant said, “We have simulators, but we do not have a structure such as a marine container in which we could simulate a room-and-content fire.” In contrast, a deputy chief from a department equipped with a complex structure made of

marine containers underlined the fact that this facility had a real impact on training and consequently on the readiness of crews in emergency response. “Firefighters are better prepared, they understand the command structure, and they are better at doing forced entry, stretching water lines, or water supply.”

In summary, results from the KM factor analysis supported Proposition 1 of this study. Knowledge sharing or Buddy Learning (Factor 1 of the KM factor analysis) among firefighters was the principal strategy used by volunteer firefighter survey participants to access and manage knowledge. Findings emerging from the SL factor analysis supported Proposition 2 of research presented here. SL components produced three factors: (1) Personal Development, (2) Creativity, and (3) Commitment. These factors serve as positive levers of KM in volunteer fire organizations.

4.7.2 Knowledge transfer and knowledge storage as factors negatively associated with KM in the Canadian volunteer fire service.

The factor analysis of the 39 KM survey questions resulted in the identification of two factors that loaded **negatively** with KM in the fire service: (1) Knowledge transfer and (2) Knowledge Storage (see Pattern Matrix in Table B6). These negative factor loadings suggest that survey participants do **not** view external knowledge sources such as customers (CUST), suppliers (SUP), partners (PART), and academic or applied research (AAR) as key or important sources of KM in their fire departments. In other words, extra organizational perspectives rarely challenge the organizational culture and knowledge stock of the volunteer fire departments participating in this study.

Firefighters do not consider citizens/customers as preferred sources of information (CUST1; CUST2; CUST3; CUST4). Similarly, the study of municipal websites (see Table 4.7.2) also shows that the 20 fire departments in this study do not share much information online with citizens.

Table 4.7.2: Municipal website content analysis

Public Rendition About:	N = 20	%
Composition/Organization of Department	11	55
History of Department	3	15
Strategic Vision: • Mission • Vision • Values	 8 0 0	 40 0 0
Links to Regional Safety Cover Plan	2	10
Services Provided	10	50
Social Implication	4	20
Training	3	15
Number of Calls/Runs	2	10
Link for Questions from Citizens	16	80

Findings in Table 4.7.2 show that none of the volunteer fire departments published a strategic plan that could inform citizens about organizational priorities such as KM and mid- to long-term vision of this fire services. Three departments out of twenty provided information on KM activities related to training of personnel. Half of the departments provided information on the composition of the service and only two published data on calls/runs. In summary, little information is shared online to citizens by the fire departments in this study.

Even though fire departments routinely work with partners (PART1) such as other fire departments, police departments, ambulance providers, and other city departments, knowledge transfer from these organizations remains scarce (PART2; PART3; PART5; PART6). When asked why fire departments do not share knowledge with other organizations, firefighters offered these explanations. “It’s like a mentality, each department pretends to be able to manage everything on its own and doesn’t need [anything] from other [organizations],” said one lieutenant. “Back in the days, there was a saying that there were little steeple wars between villages and fire departments, well it’s still like that [today],” said another lieutenant. Moreover, firefighters indicated that knowledge was seldom exchanged with service or equipment suppliers (SUP1; SUP2; SUP3); they rarely used this source of knowledge to adjust work policies or procedures or to innovate.

When asked about the use of knowledge from academic or applied research on the fire service (AAR1; AAR2), firefighters did not believe that top-management officers (e.g., fire chiefs) often used research results in their decisions or to modify current practices and procedures. Moreover, research results (AAR3) seemed seldom incorporated into training policies or practices or used as reference knowledge (AAR4) when discussing current issues such as health and safety. Furthermore, even though some firefighters considered that it was important that knowledge from research be known (AAR5), current KM strategies in the fire departments did not favor this knowledge source. “There is no one to check on that and to give us feedback,” said one lieutenant. During an interview, a deputy chief acknowledged that current knowledge from research was not transferred into the department and pointed to a language issue. “It’s all published in English and I have difficulties understanding English,” he said.

All firefighters interviewed indicated that they often searched the Internet to find information about fire fighting. Still, this search was more an individual interest than a structured process to ameliorate practices. Results presented here suggest that external knowledge sources constitute blind spots for the volunteer fire departments in this study. This situation may not be estranged from the fact that knowledge storage processes appear to not be well implemented, even for the internal knowledge stock of these departments. As noted previously, all items of the third factor (Knowledge Storage) in the Pattern Matrix shown in Table B6 have negative loadings. Results showed that storage of explicit knowledge (KST1) either by codification in documents or manuals or of results from projects or meetings (EK1; EK3) was not a favored strategy.

During interviews, firefighters said they received documentation while attending classroom sessions but rarely consulted the information after completing the course. Firefighters occasionally consulted standard operating procedures (SOPs) that reference institutionalized ways of doing things in their departments, but it was not their strategy of choice to access knowledge (EK4). This type of behavior was also reflected in the fact that, even if they invested themselves in the hands-on part of training, firefighters did not show a great interest in the codified aspects of their training program (EK2). As one firefighter said, “It is not that I don’t need to [consult documentation], but with all the hands-on

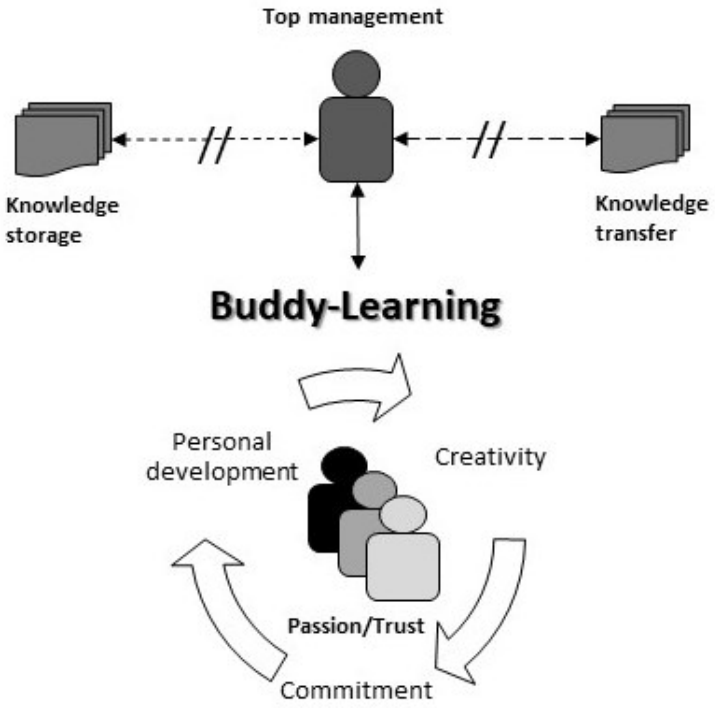
training that we have [I don't feel the need to]." Moreover, results showed that firefighters did not regularly use information technologies (IT3) such as computers at the station to access knowledge or to perform their daily tasks. These results were not estranged from the fact that processes and tools to store knowledge for future use such as library materials, data banks, and manuals were not seen as priorities by firefighters (KST1; KST2; KST3). The use of information technologies is also influenced by the fact that many volunteer firefighters are present at the firehouse only when they respond to an emergency call or when they attend hands-on training sessions; thus, these firefighters do not believe they need such technologies.

In summary, the negative relationship of study participants' responses to survey questions found in Factor 2 (Knowledge Transfer) and Factor 3 (Knowledge Storage) of the KM factor analysis supports **Proposition 3** of this study. This proposition said: Turned inward, the fire-service organizational culture impairs knowledge transfer from external sources such as other fire departments, partners, customers, suppliers, and academic and applied research.

4.8 Discussion

Previous studies assert that research is needed to explain how firefighters relate to various knowledge sources and how KM processes are implemented in the fire service (Beauchamp, 2017; Massaro et al., 2015). The study reported here provides such research findings and has both empirical and theoretical significance. The use of survey research and factor analysis provides the first empirical evidence about KM processes in volunteer fire departments. The study also contributes to the general theoretical literature on KM and serious leisure. Findings of the analysis reported in the Results section are conceptualized in Figure 4.8.

Figure 4.8: Volunteer fire department KM model



First, this study illustrated how knowledge sharing among firefighters is the main process of KM in the fire service. This sharing process was labelled *Buddy Learning*. Empirical evidence indicated that top management supported knowledge sharing by enabling a context conducive to exchanges between and among firefighters (i.e., team members). Previous findings in the KM literature on the public service suggested that, in an organizational context, individuals tend to keep knowledge to themselves as a prized asset (see, for example, Amayah, 2013; Liebowitz & Chen, 2003, found in Syed-Ikhsan & Rowland, 2004), even to the point of creating knowledge monopolies (Davenport & Prusak, 2000). In contrast to previous findings, firefighters in this study *did not* base their actions on individuality and willingly shared their knowledge with each other. It was through Buddy Learning that firefighters showed creativity in sharing their own skill set with group members.

All firefighters interviewed were preoccupied by the safety of their colleagues. Since these firefighters regularly work in an environment immediately dangerous to health and life, they saw value in not only maintaining but also expanding the group's overall knowledge stock by sharing what they know with each other. Knowledge shared by seasoned firefighters and postmortem discussions following emergencies were good examples of mutual interest to learn from the experience of others.

At the same time, to have a positive effect on fireground efficiency, knowledge sharing appeared contingent on the fire department's capabilities. Lack of training in realistic settings, poor equipment quality, and lack of experience appeared to diminish the positive impact of knowledge sharing in actual fire-fighting operations — all factors already identified as contributors to line-of-duty deaths (Moore-Merrell, Zhou, McDonald, Ficher, & Moore, 2008).

Second, this research showed how serious leisure components can be relevant in understanding the influences of the volunteer fire service organizational culture on knowledge-management processes. Namely, personal development, creativity, and commitment (the three factors emerging from the factor analysis of serious leisure-related survey questions shown in Appendix C) influenced how firefighters perceived their involvement with the fire department and how they interacted with their colleagues.

As described in previous studies, passion and trust sustain learning and knowledge sharing in a team work environment (e.g.: Dawes, Cresswell, & Pardo, 2009; Van Maanen & Barley, 1982; Von Krogh, 1998). In personal interviews, firefighters provided vivid descriptions of how passion and trust are central to their commitments to each other as they hoped to contribute to the team's knowledge stock. Fire fighting provides thrills and psychological flow, gratification, and value to the individual. Strong bonds are created among firefighters who trust each other and commit themselves to helping group members. Trust becomes the cornerstone of membership in the team; this trust regulates the individuals' actions by means of explicit and tacit rules.

The team also fosters mutual aid among firefighters who seek continuous improvement to maintain a public image of professionalism. Hence, it is at the intersection of passion and knowledge that serious leisure components help to explain a knowledge-sharing culture in volunteer fire departments. Therefore, not only Buddy Learning is a strong illustration of firefighters' commitment to teamwork, it becomes a personal and a social reward intrinsically part of volunteer fire fighting.

Finally, this study underlined the paucity of strategic KM in volunteer fire departments. These departments showed signs of organizational myopia (Catino, 2013) towards the transfer of knowledge from external sources and knowledge-storage processes. In contrast, previous research suggests that providing quality services and high performance in public services in an ever-changing environment requires knowledge transfer across organizational boundaries (Von Krogh, Ichijo, & Nonaka, 2000) and networking (Meier & O'Toole, 2010). Moreover, comprehensive knowledge transfer strategies are said to add capabilities and approaches (Wiig, 2002) to further public services.

This research found that volunteer fire departments' strategic access to external knowledge sources was not a well-developed process. Transferring knowledge across boundaries was not a priority for top management. In turn, this situation may not be estranged from the fact that organizational capabilities vary greatly from one volunteer fire department to the other.

Analysis of the fire departments' websites corroborated previous findings from Moschella and Chou (2013) that these organizations make limited use of e-government strategies to interact with their external environments. As a result, fire departments face absorptive capacity challenges (Cohen & Levinthal, 1990) as they are turned inward maintaining a knowledge stock influenced by tradition and conservatism. Therefore, a high level of stickiness (Turner & Makhija, 2006; Szulanski, 1996) characterizes this knowledge stock, which is rarely challenged by novelty or by scientific or applied data from research.

As this study also illustrated, the lack of knowledge transfer in volunteer fire organizations also has an impact on knowledge-storage strategies as new knowledge rarely challenges organizational memory (Moorman & Miner, 1998). In a now fast-paced environment

where information and knowledge are rapidly transacted, it may be timely for volunteer fire organizations to rethink knowledge-storage processes to sustain continuous learning.

In summary, research reported here illustrates how KM processes are mobilized in volunteer fire departments. This area of research has received little attention. As such, this paper has contributed towards a better understanding of knowledge sharing among firefighters. In addition, this study provided evidence of a lack of strategies in volunteer fire departments to develop knowledge at the organizational and interorganizational levels.

The research adds to the application of serious leisure theory. Scholars have noted that serious leisure theory needs to deepen its understanding of the relationship and attachment that participants develop with the space associated with the core activity (Elkington, 2014). This attachment is said to be substantially determined by the "capacity of that space to facilitate the expression of skill and knowledge" (Elkington & Stebbins, 2014, p. 206).

This study provided an example of the importance of space in relation to learning and knowledge using the example of the firehouse. In this shared space, situations structure cognition (Brown et al., 1989), for example, through training sessions, informal discussions, or when *old timers* share knowledge with newcomers. In knowledge-creation theory, Nonaka and Konno (1998) have introduced the concept of *ba* to describe a shared space that serves as a foundation for knowledge creation. The firehouse certainly represents a *ba*: an iconic physical and emotional space for volunteer firefighters where they share knowledge. Still, other *ba* could be studied to better understand interactions in enabling knowledge creation (Nonaka, Toyama, & Konno, 2000) at the organizational and interorganizational levels of volunteer fire fighting.

4.9 Conclusion

Future research on KM in the fire service could focus on comparative studies of volunteer fire departments located in different countries. Undoubtedly, there may be jurisdictional characteristics that may differ — such as legislative requirements, codes, and standards — that may have different influences on KM strategies and practices in volunteer fire departments. Research results presented here are based on fire departments in one nation

(Canada) and only one province (Quebec) in that country. As such, while instructive, the study is exploratory in nature, and findings have limited generalizability. The body of knowledge on the fire service would also benefit from KM research in career and mixed (combination volunteer/career) fire departments. Such studies would provide for a comparative KM literature. In short, much research on KM in fire departments remains to be done. This study is a first step in that direction.

CHAPTER 5: ABSORPTIVE CAPACITY IN THE FIRE SERVICE SECTOR

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Knowledge aDsorption in the public sector: Heavy smoke showing in the fire service sector.

Keywords: Knowledge management, absorptive capacity, knowledge adsorption, fire service, public sector.

5.1 Abstract

Research on absorptive capacity in the public sector is lacking where multiple knowledge sources must be mobilized for public value delivery. The concept of knowledge aDsorption is introduced, a condition by which valuable knowledge forms a layer at the organizations' boundaries surface without being absorbed in the internal knowledge stock. Through an empirical application of Nonaka's SECI-Ba model, the purpose of this article is to explain how kinetic and energetic factors may induce knowledge aDsorption thus affecting knowledge conversion and reducing absorptive capacity in the public sector. This case-study used a mixed method design to collect and analyze data from a survey of two fire service personnel samples (*N=301*), interviews of ten fire service personnel, and content analysis of nine documentation sources. Findings support a view that a public sector's capacity to absorb new knowledge involves a paradigm shift from a functionalist, siloed organizational view to an inter-cognitive view of public value creation involving both individuals and organizations, and their interactions within the sector. Findings provide public sector leaders with a framework to recognize and mitigate knowledge aDsorption and a question grid to develop a sector-wide knowledge management strategy.

5.2 Introduction

Knowledge is recognized as a strategic organizational asset (Easterby-Smith & Lyles, 2011; Tsoukas & Mylonopoulous, 2004; Wiig, 2002). Cohen and Levinthal (1990) introduced the concept of absorptive capacity (AC), defined as the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (p.128). In this sense, high levels of AC can sustain strategic knowledge management (KM) to transfer valuable knowledge from external sources. However, knowledge absorption may prove difficult to achieve since organizational culture, norms, and values can act as barriers to knowledge absorption (Beauchamp, 2018; Cook & Yanov, 1993; Lucas & Klein, 2008; Wenger, 1998), so can knowledge stickiness (Szulanski, 1996), lack of translation capacity (Carlile, 2004; Rouse, 2004), and organizational myopia (Catino, 2013). Obstacles to collaboration (Heikkila & Gerlak, 2005) and imbalances between participants (Sousa & McGrory Klyza, 2007) can also hinder an organization's abilities to transfer and absorb new knowledge.

Research is needed to understand AC and KM processes in the public sector where organizations are not linked together by competitive market arrangements but by politico-administrative ties and the common good (Harvey, Skelcher, Spencer, Jas, & Walshe, 2010; Rashman, Whiters, & Hartley, 2009). Developing a strategic knowledge stock in the public sector is not so much associated with competitive strategies like the private sector but rather with creating 'public value' (Moore, 1995). As such, one could argue that knowledge conversion (Nonaka, 1994) should be well developed in order to improve collective performance towards the 'good of society' (Walker, Boyne, & Brewer, 2010, p. 1). In fact, scholars contend that high levels of AC and KM efficiency in the public sector could enhance service efficiency and performance (e.g. Riege & Lindsay, 2006; Seba & Rowley, 2010).

Despite AC's laudable qualities, public organizations are often taxed of guarding their knowledge by working in silos, functioning through rigid bureaucratic structures and organizational boundaries (Lam, 2000; Wilson, 1989) detrimental to collaborative efforts necessary to modernization public actions. As a result, public organizations may be

surrounded by valuable external knowledge, such as knowledge coming from the sector of activity or scientific research but be unable to absorb it due to their boundaries' lack of porosity.

This paper extends the literature on AC and KM by introducing the concept of knowledge aDsorption, a condition in which valuable knowledge forms a layer at the organizations' boundaries surface without being absorb in the internal knowledge stock. The impact of aDsorption is an area of AC's research that has received less attention, and especially so in public sector organizations. Based on a case-study of the fire service sector reform in the province of Quebec (Canada), the purpose of this article is to answer the following question: How does knowledge aDsorption affects knowledge conversion in a public sector of activity?

The article is structured in five remaining sections. Section one presents the study's theoretical framework. Section two presents the research setting and outlines the methodology. Section three reports the results while section four presents a discussion outlining the study's theoretical and practical contributions. Finally, section five concludes the article by presenting the research's limits and offering suggestions for future research.

5.3 Theoretical grounds

5.3.1 Absorptive capacity of knowledge (AC)

5.3.1.1 Structure

Since Cohen and Levinthal's paper (1990), a large body of literature has grown to refine the understanding of AC. Van den Bosch, Volberda, and de Boer (1999) suggested that two organizational determinants impact the level of AC in a firm: organizational forms and combinative capabilities. Functional forms present low potential for AC due to strong hierarchy and focus on efficiency and stability whereas divisional forms offer more potential for AC since loose coupling among divisions supports knowledge absorption. Matrix forms offer flexibility, agility, and present few hierarchical levels thus offering high levels of flexibility and potential for AC. Three types of combinative capabilities sustain AC: systems, coordination, and socialization capabilities. Suggesting similarities between

systems capabilities and the combination phase of knowledge creation (Nonaka, 1994), they found that policies, procedures, and manuals contribute to absorb explicit knowledge. Coordination capabilities underline how relations between members of a group enhance AC. Finally, socialization capabilities refer to the impacts on AC of shared ideology and values, collective interpretations, and organizational culture.

5.3.1.2 Routines

In a landmark article, Zahra and George (2002) proposed another framework, this time more align with organizational routines rather than structure. They suggested that AC exists as two subsets of potential and realized AC. Through a new definition of AC as a "set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability" (p.186), they sketched AC as a dynamic cycle between these four dimensions. In their model, social integration mechanisms, such as formal or informal knowledge sharing among members, contribute to knowledge assimilation and exploitation.

The Zahra and George (2002) model influenced numerous studies. Jansen, Van den Bosch, and Volberda (2005) contended that research on AC had largely ignored organizational antecedents as they focused on the unit level. They illustrated how organizational mechanisms associated with coordination enhance potential AC while socialization capabilities strengthened realized AC. Todorovan and Durisin (2007) were critical of the model, suggesting that any AC model needed to consider dynamics like feedback loops, a feature absent in Zahra and George's (2002) proposition.

In their AC literature review, Lane, Koka, and Pathak (2006) challenged the scholarship by stating that AC had become reified. It was now necessary to move away from a structural perspective of AC to define AC as a dynamic capability of recognizing, assimilating, and using knowledge through 'exploitative learning' (p. 856). Therefore, studying AC required, first, to focus attention on KM processes such as transfer, sharing, and creation and, second, to investigate individual cognition and shared mental models.

Even though research had stressed the importance of organizational design and the individual level for the study of AC, other scholars concluded that these areas of research remained relatively neglected (Volberda, Foss, & Lyles, 2010). It seemed that research had not sufficiently documented the impacts of internal mechanisms influencing AC such as communication processes and the distribution of knowledge and expertise in the firm. Among the many research gaps identified in this review, studies on intraorganizational antecedents (e.g. organizational structure, managerial styles, organizational culture, and network ties) were needed.

5.3.1.3 A process to be specified

Building on this body of research, Lewin, Massini, and Peeters (2011) found that AC's specific organizational routines and processes were still unclear. In part, capabilities related to internal knowledge (combination, recombination, transformation, exploitation, and assimilation) needed to be explicit. Therefore, they proposed a framework to identify the microfoundations of AC "in the form of a metaroutine taxonomy underlying absorptive capacity and their expression in organizations in the form of practiced routines" (p. 83). Their framework showed the relations between AC internal metaroutines, which include contextual organization-specific routines such as knowledge sharing and combination, and external metaroutines such as identifying external knowledge sources and learning from external organizations. In this framework, both sets of metaroutines are moderated by sociocultural shared values and norms that build connectedness between the organization's members. According to these authors, there was a need for complementarities between internal and external KM routines. If the organization is incapable of transferring knowledge and integrating it in knowledge creation processes, external AC routines appear useless. Like previous research (Van den Bosh, Volberda, & de Boer, 1999), these scholars underlined the relation between AC's effectiveness and organizational forms. Again, highly hierarchical structures appeared detrimental to AC.

Finally, a recent meta-analysis of AC research (Song, Gnyawali, Srivastava, & Asgari, 2018) found that the literature is still characterized by fragmented theoretical propositions. Moreover, reification of the concept (Lane, Koka, & Pathak, 2006; Lewin, Massini, &

Peeters, 2011) has somewhat stalled research and resulted in the use of AC as an umbrella construct.

Still, a newer strand of research, mostly anchored in the supply management literature (e.g. Bravo, Ruiz-Moreno, & Montes, 2018; Meinlschmidt, Foerstl, & Kirchoff, 2016) and based on work on open innovation (Lichtenthaler, 2009; Lichtenthaler & Lichtenthaler, 2009), has proposed to consider AC as a continuum between knowledge absorption and what has been termed knowledge 'desorption' (Denford & Ferriss, 2018). Knowledge desorption is composed of two steps: "proper identification of the knowledge transfer opportunity and the transfer process itself, which supports application of the knowledge at the recipient" (Bravo, Ruiz-Moreno, & Montes, 2018, p.534). Thus, desorptive capacity is the inverse of absorptive capacity and is defined as "the mechanism for identifying what knowledge resources have economic value for the firm and the ability to transfer the knowledge to realize value for the firm" (Denford & Ferriss, 2018, p.1427). However, much research remains to be done to refine desorption's definition and its application.

5.3.1.4 AC and the public sector

The study of AC in the public sector context is a recent field of inquiry. Prior research indicated that the high political salience of public organizations' performance and its associated cost of failure should direct attention to AC's relevance in the public sector (Harvey et al., 2010). Scholars also underlined that the intensity and efforts required to create AC in the public sector should not be underestimated (Murray, Roux, Nel, Driver, & Freimund, 2011). Prior research included AC in the context of cross-sector partnerships where mutual trust and goal interdependence appeared as moderating factors (Pittz & Intindola, 2015). Others suggested a contingent relationship between the supply side of regions' labour market and their ability to absorb external knowledge for innovation (Roper and Love, 2006). AC has also been conceived as an integral part of technological projects in municipal environments (Techatassanasoontorn, Tapia, & Powell, 2010). For some, middle managers' practices influence AC by providing contextual information that allow group members to better understand the relevance of external knowledge (Richards & Duxbury, 2014). For others, AC seems to present clear and different moderation effects

under different management contexts (e.g. Cong, Li-Hua, & Stonehouse, 2007; Hodgkinson, Hugues, & Hugues, 2012). Yet, which factors moderate AC in the public sector or how is AC contingent on distinctive features of public service still need to be researched.

5.3.1.5 From organisation to network

So far, the literature on AC emphasizes the importance of organizational design as an enabling or constraining factor and of individuals in the process of identifying, transferring, acquiring and integrating knowledge. However, researchers focused on the individual and organizational scales that highlight the importance of internal processes and the moderating impact of cultural and normative factors. Only few researchers considered that AC is directly linked to networking capabilities being moderated by organizational forms and hierarchical structures. While some authors, such as Denford and Ferris (2018) or Lichtenthaler (2009) and Lichtenthaler and Lichtenthaler (2009) make the link with the outside world from a strategic knowledge watch perspective, there is still a research gap to be filled when considering AC from a sectoral perspective. This need is certainly typical in the public sector since the public services are often provided by the contribution of different (para)-public organizations, community's stakeholders, and even private actors.

5.3.1.6 Moderating factors for knowledge conversion

In addition, based on AC's existing literature, scholars seem to agree that AC should be understood as dynamic in nature involving synergies between modes of knowledge conversion. However, there is no agreement on what these modes should be because studies reference general modes of knowledge conversion without grounding them in specific theory. For example, Zahra and George (2002) refer to acquisition, assimilation, transformation, and exploitation, while Lewin, Massini, and Peeters (2011) refer to combination, recombination, transformation, exploitation, and assimilation. On the other hand, there is agreement that AC is moderated by aspects of organizational culture such as: (1) shared mental models, norms, and values, (2) communication processes, and (3) individual behavior towards knowledge. This raises the question of how to take these moderating factors into account and through which knowledge conversion processes.

5.3.1.7 ADsorption phenomenon

Finally, this literature review underlined that scholars have concentrated their work on aBsorption of knowledge while leaving aside problems associated with knowledge aDsorption. By analogy with chemistry[7], knowledge aDsorption in organizations - particularly in the public sector - implies a phenomenon of organizational boundaries' closure: opportunities for learning or acquisition of external knowledge arise, but they remain at the state of potential in the sectoral environment. Such problems of knowledge aDsorption may prove detrimental, in the public sector, to efficient networking activities necessary to resolve wicked problems (Provan & Kenis, 2008; Weber & Khademian, 2008).

5.3.1.8 Porosity's kinetic and energetic factors

Organizational porosity to knowledge depends on energetic and kinetic factors. On the energy front, organizational AC goes through people, their modes of exchange and management as well as KM and learning. However, it is not enough to rely on the goodwill of a few. Structural (kinetic) movements become necessary, ranging from change-incentive events to structural or strategic changes to bring about behavioral changes. Still, when there is dissymmetry between kinetic and energetic factors, the organization can suffer from the phenomenon of knowledge aDsorption. However, there is still a potential to open boundaries and absorb new knowledge. As in chemistry, this shift from aDsorption to aBsorption can come from changes in the porosity properties of organizational boundaries to capture and integrate new knowledge.

In sum, the literature on knowledge aBsorption capacities considers the structural and routine dimensions in organizations while identifying moderating factors such as culture or mental models. However, the processes of knowledge acquisition and integration need further study to better understand the opposite phenomenon to aBsorption, namely

[7] Adsorption, not to be confused with absorption, is a surface phenomenon by which molecules of gases or liquids attach to the solid surfaces of the adsorbents. If the energetic or kinetic conditions allow the molecule to penetrate within the adsorbent phase, there is absorption. (Translated from French from: https://www.futura-sciences.com/sciences/definitions/chimie-adsorption-3468/, page consulted on August 2nd 2019).

aDsorption, which prevents knowledge from percolating in the organization, and of *desorption* which involves the identification of value-added knowledge. Moreover, better knowledge of the structural-functional (kinetic) and relational (energy) factors that promote or block the transfer or integration of knowledge useful to an organization or sector of activity would also contribute to this literature. Furthermore, research on AC should address the peculiarity of the public sector where a paradigm shift is necessary since public service involves different organizations with complementary missions that would benefit from functioning as a knowledge network rather than exclusively in functional silos. Therefore, the next section details a conceptual framework for analyzing the kinetic and energetic factors conditioning absorption-adsorption-desorption phenomena in a process of knowledge exchange and integration.

5.3.2 A public sector AC's conceptual framework

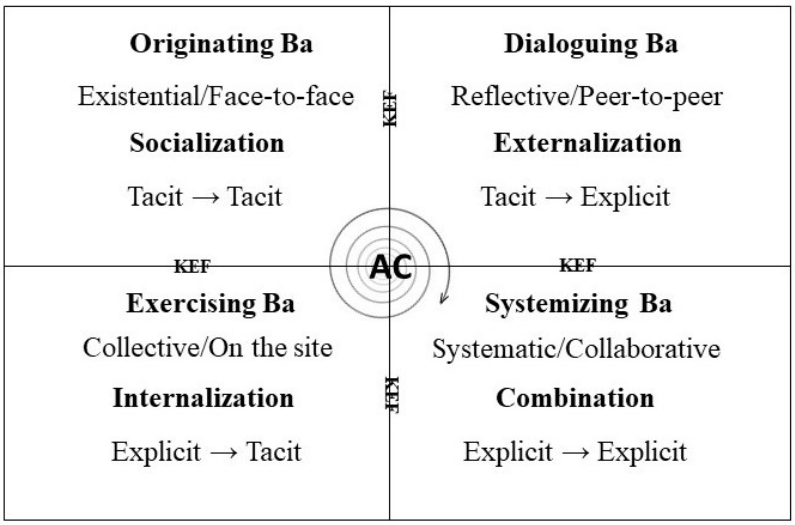
To answer the research question (How does knowledge aDsorption affects knowledge conversion in a public sector of activity?) there is a need for a conceptual framework that considers, as enabling or constraining factors, both the dynamic processes of knowledge conversion at the sectoral level, and the sector's structural, cultural, and historical or institutional dimensions.

To reconcile the actual theoretical confusion in the AC's literature about knowledge conversion's modes, the framework is based on Nonaka's classic SECI model: socialization – externalization – combination – internalization (Nonaka, 1994). This model considers the cultural aspects of organizations including shared mental models, values, and norms (von Krogh, 1998). It also places AC at the center of the knowledge conversion process. The conversion is achieved in a spiralling movement constantly fueling AC to expand the current knowledge stock (Nonaka & von Krogh, 2009), suggesting a synergistic effect for more efficiency (Nonaka & Takeuchi 1995; Nonaka, Toyama, & Konno, 2000).

Knowledge conversion happens in different places or *Ba*, a Japanese philosophical construct defined as a "shared context in motion, in which knowledge is shared, created, and utilized" (Nonaka & Toyama, 2003, p.6). The concept implies the possibility of thinking and acting simultaneously in interrelated contexts and at different levels, which is

relevant to the study of KM in a public sector of activity. Figure 5.3.2 illustrates how each mode of knowledge conversion is associated with a *Ba*. Kinetic and energetic factors (KEF) activate the spiralling movement of knowledge conversion which contributes to AC in a sort of feed-back loop.

Figure 5.3.2: KEF and the SECI-Ba model



KEF: Kinetic/energetic factors

Ba also refers organizational boundaries' porosity. According to Nonaka and Toyama (2003), *Ba* is not limited to the frame of a single organization but can be created across the organizational boundary: "*Ba* can be built as a joint venture with a supplier, an alliance with a competitor, or an interactive relationship with customers, universities, local communities, or the government" (2003, p.8). Therefore, to understand the transition from one *Ba* to another is also to uncover the efficiency of KM strategies to manage KEF, porosity to external knowledge sources, and KM dynamics of a sector of activities. Table 5.3.2 details the investigation joint table used in this study to analyze the effects of AC's KEF on strategic KM in a sector of activity.

Table 5.3.2: absortion-aDsorption/*Ba* KEF analytic frame

Ba (Nonaka, 1994; Nonaka & Konno, 1998**;** Nonaka et al., 2000; Nonaka & Toyama, 2003; Nonaka et al., 2006; Nonaka & von Krogh, 2009; von Krogh et al., 2000)	**Current and potential aBsorption factors**	**aDsorption factors**
Originating *Ba* - socialization Tacit-tacit + existential –face to face The originating *Ba* is the socialization mode of knowledge conversion's locus and is characterized by face-to-face interactions between individuals. It is an existential place, a habitus, where individuals transcend the boundary between self and others by sharing experiences, feelings, emotions, and mental models. Care, love, trust, and commitment form the basis for knowledge conversion among individuals. The originating *Ba* is influenced by modes of socialization, the activity's core values, organizational culture, traditions, norms, and routines.	**Which factors condition the individual's sense of belonging and moderate learning by socialization?** Kinetic/energetic factors	**Which factors restrict or block learning by socialization?** Kinetic/energetic factors
Dialoguing *Ba* - externalization Tacit-explicit + reflective peer to peer The dialoguing *Ba* is the externalization mode of knowledge conversion's locus where knowledge is outsourced through collective and face-to-face interactions between actors. In this *Ba*, mental models and skills are shared, converted into common terms, and articulated as concepts. The articulated knowledge is also brought back to each actor, and further articulation occurs through self-reflection. The dialoguing *Ba* requires mechanisms supporting exchanges between units and networking capacity. This *Ba* is influenced by the actors' modes of communication and capacity to reflect on and define the sector's activities (mental models, competencies).	**What are the sources of reflection on knowledge and channels of communication in the sector?** Kinetic/energetic factors	**Which factors prevent reflection or communication within the sector?** Kinetic/energetic factors
Systemizing *Ba* - combinaison Explicit –explicit + collaboration The systemizing *Ba* is the combination mode of knowledge conversion's locus as explicit knowledge is transmitted to many actors in explicit form. It is characterized by collective and virtual interactions allowing actors to exchange necessary information or answer each other's questions in order to collect and disseminate knowledge and information effectively and efficiently. The systemizing *Ba* supports mechanisms to uniformize the collective knowledge capital and is influenced by the degree through which a sector is structured so that actors interact in a complementary way.	**What are the sources and opportunities for collaboration that moderate learning within the sector?** Kinetic/energetic factors	**Which factors restrict or block learning by collaboration?** Kinetic/energetic factors
Exercising *Ba* - internalization Explicit - tacit + collective The exercising *Ba* is the internalization mode of knowledge conversion's locus as knowledge moves from explicit to tacit. It is characterized by individual and virtual interactions and synthesizes the transcendence and reflection through action to enhance organizational knowledge capital. This *Ba* is conducive to innovation and paradigm changes and represents the space where new knowledge is integrated in the actor's knowledge capital. The exercising *Ba* is influenced by the degree through which a sector of activity promotes learning or not.	**What are the sources or opportunities for innovation in the sector?** Kinetic/energetic factors	**Which factors inhibit innovation?** Kinetic/energetic factors

5.4 Research setting and methodology

This research was based on a case-study of the Province of Quebec (Canada) fire sector. In 2001, the provincial government passed a new Fire Safety Act that signaled an extensive reform of the fire service sector. At the core of this reform, a new KM governance was to be installed to sustain the sector's march towards professionalization.

The research reported in this paper was based on a mixed methods design (Creswell and Creswell, 2018) to provide a comprehensive analysis of the following data sources: (1) an online survey of volunteer firefighters; (2) semi-structured interviews of fire service personnel; and (3) content analysis of textual sources.

5.4.1 Survey sampling

Volunteer fire departments (VFD) from one county regional municipalities were used as purposive sample (Sample A) and a second sample (Sample B) was gathered through cluster sampling (Robson, 2002; Teddlie & Yu, 2007) for a total of twenty VFDs. This strategy is particularly useful when a population is dispersed over a large territory (Robson, 2002) as is the case for the Province of Quebec. Out of 707 firefighters, representing the theoretical total of samples A and B, 317 firefighters participated in the online survey for a response rate of 44.9%. After data cleaning (Bourque & El Adlouni, 2016; Tabachnik & Fidell, 2013), a final sample of 301 firefighters (*N=301*) was used for the study.

5.4.2 Semi-structured interviews

Qualitative methods are useful to study social processes (Lofland, Snow, Anderson, & Lofland, 2006). To ensure that a wide range of perspectives were represented, firefighters of different ranks and years of experience were interviewed (firefighter, acting lieutenant, lieutenant, deputy-chief and chief) privately and face-to-face by the researcher. Data saturation was reached after 10 respondents (Mason, 2002). The average length of the interviews was one hour and twenty minutes. A general inductive approach was used to structure the analysis of evidence from the interviews and data treatment followed Thomas's (2006) method.

5.4.3 Content analysis

Finally, to anchor the study in its historical context, a content analysis (Robson, 2002) was performed on the following textual sources: (1) **legislative texts** on the fire service sector; (2) **minutes** from (a) the Quebec National Assembly, from 1992 to 2000, pertaining to the fire service and from (b) a fire service sector forum held 2012; (3) **annual reports** from the National Fire Academy (NFA), from 2001 to 2018; (4) the sole **research report** from the NFA; (5) a NFA's **memorandum** submitted at the 2012 forum; (6) a **research report** published in 2015 by the association of fire chiefs (ACSIQ); (7) a **white paper** on the state of the Quebec fire service published in 2018 by ACSIQ; (8) **reports** on the fire service from the Coroner, the occupational health and safety agency, and the Ombudsman; and (9) **websites** of the NFA, ACSIQ, the fire instructors' association, and the fire prevention officers' association.

5.4.4 Validity strategy

For validity purposes (Yin, 2014), the research included recommended strategies: triangulation of data sources, rival explanations of results from subject-matter experts, and an audit trail (Creswell & Creswell, 2018; Robson, 2000).

5.5. Case-study description: a fire service sector reform

Historically, the Quebec fire service has relied on volunteer or part-time firefighters. As a volunteer firefighter, individuals have a primary occupation while also investing their time and energy in the local fire department. Recent data indicated that out of 23 240 firefighters, 76.7% (*N=17 833*) were volunteer or part-time firefighters (Quebec, 2013).

On November 26, 1992, fire chiefs from all over the Province of Quebec manifested on the grounds of the Province's National Assembly to protest the lack of support from government. At the time, the fire service sector was plagued by an outdated knowledge stock, rising number of fires and deaths to fire compared to other Provinces, and rising costs associated with insurances' claims. The sector had become stalled by an originating *Ba* entrenched in folkloric traditions and inoperant dialoguing, systemizing and exercising

Bas. Fire chiefs were hoping that a strong governance would be installed to provide, among other things, comprehensive KM to the sector's benefit.

This manifestation became a tipping point that marked a ten-year journey towards an extensive legislative reform to modernize the sector. In 2001, government passed a new Fire Safety Act and a Regulation mandating training for all firefighters. These legislative provisions were accompanied by the minister of public security's Orientations to guide the sector and local authorities in implementing regional safety cover plans. The Act also established a National Fire Academy (NFA) having the mission to ensure that firefighters and other municipal fire safety personnel in Quebec receive pertinent, high-quality and coherent qualifying professional training. At the time, this fire service reform was seen as one of the most progressive in Canada.

Up to 2001, access to knowledge was problematic for firefighters. Only career firefighters were required to complete the vocational studies program delivered by the Institute of fire protection (IFP), a dedicated fire school under the ministry of education's jurisdiction. Most firefighters were volunteer or part-time firefighters and did not have access to this program, even though it was considered the training reference in the sector. Therefore, great expectations were placed on the NFA to provide relevant training to all firefighters.

The reform's first years became synonymous with extensive changes that would have a definitive impact on the sector's systemizing *Ba*. Regional safety cover plans – which would need to be attested by the minister of public security - required municipalities to work together to reorganize their response to emergencies. There were now obligations to declare service delivery standards, for example, how ten firefighters with the required equipment and apparatus would be on scene in a ten-minute delay. Moreover, the NFA worked extensively to provide all the necessary training programs for firefighters to meet the required certifications mandated by the new Regulation on training.

However, even though the NFA had a definitive impact, in its first years, on the standardization of the fire sector's knowledge stock, the organization was also faced with problems that hindered its leadership as the KM governing entity. Its governmental financial subsides were constantly reduced over the years. Having to cut down on staffing

and investments, the NFA had difficulties fulfilling many aspects of its mandate, such as fostering, facilitating, and planning exchanges of expertise with persons or bodies outside Quebec. Therefore, the NFA could not play its role as an innovation agent that would have supported the development of the sector's exercising *Ba*. Moreover, since the Regulation on training mandated the IFP's program for firefighters working in major cities, it had the effect of restricting the NFA's scope and leadership to volunteer firefighters. As a result, its credibility to career firefighters was never established.

In 2012, the ministry of public security (MPS) organized a provincial forum to reflect on the first decade of the reform, an event that became a landmark in the sector's dialoguing *Ba*. Fire chiefs and representatives from the municipal, education, and insurance sectors as well as fire sector associations gathered in Quebec City. While participants agreed that the fire sector had changed for the better, they also noted disparities in safety cover plans, lack of investment from municipal authorities, and pressing problems related to KM governance at the sector level such as training costs, access to training programs and disparities in training offers.

In the stormy and wintery cold night of January 23, 2014, a major fire in a retirement home claimed the lives of 32 elders in a small rural town. A public investigation on the matter held by the Coroner lead to a devastating report on fire operations and public safety. Lack of knowledge, training, situational awareness, and operational capabilities were identified as contributing factors to the many deaths. Moreover, the Coroner also criticized a legislative grand-father clause that exempted from training and certification processes firefighters hired prior to 1998. Furthermore, the report underlined government's laxism in passing regulation mandating automatic fire suppression systems in retirement homes. In a nutshell, the Coroner's report summed up many problems that were still affecting the sector, mostly in the systemizing *Ba*. This report prompted government to implement an extensive financial program to support small municipalities in training their firefighters.

In 2018, the provincial fire chiefs' association (ACSIQ) offered an overview of the sector's reform by publishing a White paper. While the chiefs recognized many valuable changes in the level and quality of service offered to the population, the benefits of comprehensive

fire prevention initiatives, and the advances in firefighter training, they were critical of a reform that faded over time. For them, safety cover plans did not prompt local authorities to invest sufficiently in fire protection therefore creating a false sense of security in the population. Moreover, the ministry of public security's gradual disengagement in the attestation of these plans depreciated their value and relevance to local authorities. Furthermore, the chiefs considered that the NFA's leadership problems were also a sign that KM governance was still to be achieved. Finally, amidst new challenges prompted by disasters and civil security emergencies, chiefs considered it was now time to conceive the sector through a comprehensive all-risks approach. In order to achieve this vision, they underscored - much like a Groundhog Day and as they did in 1992 - the necessity to achieve a strong fire service sector governance.

5.6 Results

In the first stage, data analysis identified structural/functional (kinetic) and relational (energetic) factors that block (aDsorption) or promote (aBsorption) knowledge conversion between organizations in the Quebec fire safety sector. Different knowledge sources are or would be available for knowledge conversion - such as academic and applied research, research and development projects, networking, collaboration, and international exchanges - but many KEFs still induce aDsorption in the sector thus limiting AC and the development of an optimal knowledge stock (see Tables 5.6.1 to 5.6.4). In the second stage of data analysis, two key results emerged: a revised SECI/*Ba* model for the public sector and a KM practice question grid.

Table 5.6.1: Originating Ba

Ba	Current and potential aBsorption factors	aDsorption factors
Originating *Ba* - socialization Tacit-tacit + existential –face to face	**Which factors condition the individual's sense of belonging and moderate learning by socialization?** **EF:** • Characteristics of volunteer firefighting as a serious leisure still present (qualities, rewards, thrill/psychological flow, and devotee work). • Firefighters come from different trades with knowledge and skills that benefit the group's knowledge stock. Firefighting requires basic and advanced qualifications, but also ingenuity that can come from diversity in skills. • Paramilitary culture/nature of firefighting foster a sense of strength, courage and great capacity in the home group. • Since its origins, the organizational culture maintains a sense of 'esprit de corps' and competition between fire services. • Buddy-Learning [how firefighters tap into their colleagues' knowledge to learn, see Author (2018)] as a mode of socialization and belonging to the group: learning from others, sharing knowledge with others. • Relationships characterized by passion, care, trust, teamwork, fraternity, creativity, help, commitment, and personal development. • Firefighters identify strongly with their profession: the lives of others and their own are at stake; they also identify with their fire station and their environment. • Fire station is a sacred place of socialization where the individual must share his/her knowledge in order to be accepted by the group. • Construction of local training sites that promote complex learning and team-building activities. • Firefighters also socialize through their involvement in social life: food drives, parades, etc. • Individuals acquire the identity of firefighters: they are community members who make the choice to volunteer to fight fires while protecting people and property. Being recognized as a group member is also influenced by the social psyche that fixes an image on the individual who acts as a firefighter. Serving as a firefighter has a strong impact on the individual's being that transcends the boundary between self and others: a strong desire to fit the codes expected and defined by the group. Strong identification with the job becomes a motivation to socialize and learn continuously beyond the fire station.	**Which factors restrict or block learning by socialization?** **KF:** • Linguistic factors limit many individuals to what can be learned in French. • Many fire service organizations isolated in remote regions. • Recruitment difficulties (labour market changes, values associated with balance between work and personal time). • Fire service culture remains conservative/diversity and inclusion. • Fire chief position often filled in-house thus maintaining agreed-upon culture. **EF:** • Buddy-Learning strongly internally-oriented: knowledge shared between individuals represents the most value. • Experience-based knowledge is valued at the expense of new paradigms. • Paramilitary culture resistant to novelty. • Citizens' loss of interest in becoming volunteer firefighters. • Volunteer firefighters characterized as hands-on individuals not prone to theoretical studies. • Recruitment challenges like other social club-like organizations.

Table 5.6.2: Systemizing Ba

Ba	Current and potential aBsorption factors	aDsorption factors
Systemizing *Ba* - combinaison Explicit – explicit + collaboration	**What are the sources and opportunities for collaboration that moderate learning within the sector?** **KF:** ▪ Act, art. 8 (safety cover plans): establish a fire safety cover plan determining fire protection objectives, including the development and maintenance of staff knowledge. ▪ Act, art. 21 (safety cover plans): The Minister shall issue a certificate of compliance to the regional authority or propose any amendments the Minister considers necessary to remedy any deficiency within the time indicated by the Minister ▪ Act, art. 52 (NFA): NFA's mission is to ensure that firefighters and other municipal fire safety personnel in Quebec receive pertinent, high-quality and coherent qualifying professional training. ▪ Orientations: "an integrated municipal vision of risk management marks the interdependence of fire safety and other major municipal functions, including the organization and delivery of other public safety services. It is to be hoped that by being more aware of the incidental effects, on the allocation of fire safety resources or on the balance sheet of human and material losses, of many measures taken in other spheres of their administration, municipalities will thus be led to consider fire risk management in all of their strategic planning and operational management processes". ▪ NFA's professional qualification processes accredited by international fire service accrediting agencies (IFSAC and ProBoard). ▪ Standardization of practices through production and translation of training documents and regional courses. ▪ NFA's implementation of regional training managers. ▪ Statutory training obligations for all firefighters. ▪ Regional merging of fire services.	**Which factors restrict or block learning by collaboration?** **KF:** • Lack of coordination between government organizations: loss of energy, costly duplication, under-utilized resources. • Lack of resources in some regions to carry out the safety cover plan exercise (planning and coordination problems). • Act, art. 38 (NFA): *Not in force*. Any training received to meet the conditions set by the government must be validated by the NFA. • Act, art. 55 (NFA): Restriction of the NFA's capacity to offer training programs provided by the ministry of education, thereby reducing the scope of its influence. • Problem of coordination and standardization of practices related to the disparity and multiplicity of the provincial training offer. • Lack of risk management overview associated with poor sectoral knowledge systematization (fragmented structure of education institutions, few training requirements for fire chiefs, few training requirements for risks other than fire). • Training prerequisites beyond the regulation mandatory for some larger cities due to salary equity with other municipal functions. • Difficulty hiring fire chiefs trained in organizational management. **EF:** • MPS's gradual disengagement since 2001. • NFA's incapacity to assume KM sectoral governance leadership. • Resistance to ministerial change/directions: negative attitude of some fire chiefs and elected representatives towards the reform and risks. • Municipal officials' varying degree of acceptance of risk coverage plans' obligations (fear to lose sovereignty, difficult acceptance of a new paradigm of volunteer firefighters' professionalization, and fear of rising costs). • Fire chiefs' problem of adequacy between part-time status and regulatory requirements. • Sector's slow adhesion to the NFA's professional qualification processes: sector's lack of knowledge about professional qualification and accreditation processes. • Sector's fear of rising costs and too high standards associated with professional qualification processes • IFP's sovereignty attitude towards NFA. • NFA's non-recognition by many career firefighters. • Despite pre-employment training requirements, many fire chiefs retrain their recruits once hired.

Table 5.6.3: Dialoguing Ba

Ba	Current and potential aBsorption factors	aDsorption factors
Dialoguing *Ba* - externalization Tacit-explicit + reflective peer to peer	**What are the sources of reflection on knowledge and channels of communication in the sector?** **KF :** ▪ ACSIQ's annual conference, regional meetings, and seminars. ▪ Fire instructors and fire prevention officers' associations joint annual study session. ▪ NFA's courses, seminars, and instructor certification sessions. ▪ Training provided by regional poles. ▪ Regional merging of fire services. ▪ Inter-municipal assistance during fires or disasters. ▪ Training workshops delivered by various firms. **EF:** ▪ Fire chiefs's manifestation of 1992 triggering fire service reform. ▪ ACSIQ's White Paper. ▪ MPS's Forum (2012). ▪ Incident operations post-mortem debriefings. ▪ Local and regional charity events (firefighters' day/parade, fire station open house, etc.). ▪ Increased contacts between fire services and external partners during emergency operations other than fire (natural disasters, hazardous material incidents, etc.). ▪ Social networks and dedicated fire service pages/websites.	**Which factors prevent reflection or communication within the sector?** **KF :** • Organizational structure focused on a localized vision of service delivery. • Multiplication and disparity of training offers. **EF :** • Municipalities' parochialism towards the need for regional collaboration. • Steeple wars between fire chiefs causing resistance to networking and exchange (except during mutual aid for rescue). • Chiefs value knowledge sharing among brigade members but are reluctant to create opportunities for knowledge sharing with other brigades. • Vision of several municipal elected officials reducing the position of Fire Chief to a municipal fire technician whose duties are internally oriented (reflected in several job postings). • Fire chiefs expressed criticism about MPS's lack of integrative leadership to the sector's benefit.

Table 5.6.4: Exercising Ba

Ba	Current and potential aBsorption factors	aDsorption factors
Exercising *Ba* - internalization Explicit - tacit + collective	**What are the sources or opportunities for change in the sector?** **KF :** ▪ Act, art. 55 (NFA): offer advanced training activities and conduct training-oriented fire safety research; ▪ Act, art. 56 (NFA): conclude an agreement with researchers, experts, fire safety services and educational or research institutions; ▪ Act, art. 57 (NFA): conduct or commission research or studies in areas related to the work of municipal fire safety personnel and that may have an impact on their training; the results shall be published and disseminated by the school; ▪ Act, s. 58 (NFA): foster, facilitate and plan exchanges of expertise with persons or bodies outside Quebec and, in particular, encourage participation by Quebec specialists in international exchange missions on fire safety training. ▪ Guidance from the Minister on an integrated municipal vision for risk management. • Investigations' results following specific incidents. • Scientific and applied research on the fire service. • Technological advances in equipment. • Expansion of the profession from fire safety to emergency response (first responders and emergency rescue). **EF:** • Some fire chiefs want to induce a culture of openness/diversity and new technologies. ▪ Rescue operations' increasing complexity necessitates inter-organizational collaboration and collective development of knowledge.	**Which factors inhibit change?** **KF:** • NFA's reduced capacity to assume the sector's KM governance. • NFA's absence of commissioned research or studies related to the fire service and of international missions on fire safety training. • Sector's culture is bureaucratic, mechanistic and resistant to novelty. • Lack of French-language research on fire safety • Lack of mechanisms for translating and disseminating current fire safety research. • Knowledge management is limited to meeting regulatory requirements and maintaining competency through training. • Grand-father clause for firefighters hired before 1998 decried by the Coroner. • Focus on potential costs rather than on the efficiency/effectiveness ratio in continuous improvement or innovation. **EF:** • Weak collaborative sectoral KM governance. • ACSIQ places responsibility for sector's issues with the MPS. • ACSIQ questions NFA's leadership in coordinating multiple offers in the areas of training, learning and research. • Lack of KM at the sector level to ensure continuous improvement and innovation, despite the evolution and greater complexity of public safety. • Lack of sectoral leadership in research, particularly by the NFA. • Low qualification level of many fire chiefs: no professionalization path for fire service executives and few senior officer designations (executive fire officer, chief fire officer, etc.). • Wait-and-see attitude: procedures corrected following tragic or serious events.

5.6.1 A revised SECI/Ba model

Nonaka's model assumes both the validity and relevance of the spiralling movement of knowledge conversion and the absorptive capacity of individuals and organizations. This model is also based on a specific linear sequence between *Bas* (see Figure 1), one that has rarely been challenged (Glisby & Holden, 2003; Gourlay, 2006). However, when considering this model in the study of KM in a public sector of activity, results suggest the necessity of a new *Ba* arrangement.

First, even when plagued with problems, the public sector will still operate which indicate that all four *Bas* are somewhat always active in a movement of knowledge conversion. Second, public organization are dependent on legislation and regulations to systemize their operations. Therefore, the systemizing *Ba* becomes fundamental for the public sector to operate and develop strong dialoguing and exercising *Bas*. After all, fire chiefs pleaded to government to provide the means to systemize the fire sector hoping to develop strong dialoguing and exercising *Bas*.

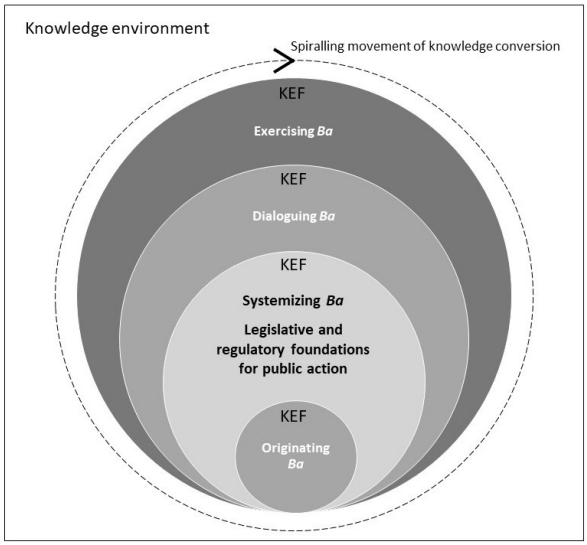
Results also showed that the Originating *Ba* (knowledge conversion through socialization) was characterized by a localistic vision of the fire service, turned inward. Even though energetic factors, such as the individuals' desire to share knowledge among themselves, support learning and AC at the individual and group levels, the same factors induce organizational myopia and reluctance to paradigm changes therefore causing aDsorption.

The reform's objectives were to move pass this Originating *Ba* by systemizing (knowledge conversion through collaboration) the fire service sector through kinetic factors in the form of legislation, regulations, key stakeholders' responsibilities, and the NFA. However, the Fire safety Act included provisions, such as articles 38 and 55, restricting the NFA's scope of action. Meanwhile, many energetic factors related to the sector's cultural and leadership issues induced knowledge aDsorption causing the spiralling movement of knowledge conversion to somewhat stall at the Systemizing *Ba*. Therefore, it is to no surprise that the Dialoguing (knowledge conversion through reflexiveness and communication) and Exercising *Bas* (knowledge conversion through change) exhibit so many KEFs causing knowledge aDsorption. Among the many causes of aDsorption, parochialism, steeple wars,

MPS's fading leadership, lack of collaboration of some municipal authorities, and absent networking impaired this public sector's reform.

Based on results from this study, Figure 5.6.1 depicts a revised SECI/*Ba* model by showing that all four *Bas* have a simultaneous and direct effect on the spiralling movement of knowledge conversion.

Figure 5.6.1: *Bas* sequence for public sector knowledge conversion



It this new *Ba* arrangement, the concept of knowledge aDsorption proves beneficial, requiring to consider KEFs related to AC. It then becomes possible to identify which factors have a negative effect on the sector's AC and identify the most problematic *Ba*.

Results showed that the systemizing *Ba* was to become a lever for the fire service sector in developing a new KM sectoral governance towards value-added knowledge (*desorption*). However, problems related to KEFs in that *Ba* explained why the dialoguing and exercising *Bas* haven't reach their full potential: knowledge activism (Von Krogh, Ichijo, & Nonaka, 2000) and strategic KM were impaired by the lack of networking competencies (Meier & O'Toole, 2010) illustrated in part by leadership issues, steeple wars, and parochialism.

In particular, the NFA's leadership problems presented an illustrative example of distance between regulation and practices (Rouse, 2004). Even though its mandate is stated in legislation, the NFA has still to play a KM leadership role in knowledge *desorption*. For instance, knowledge from research on firefighters' health and safety is still not translated into practice in the provincial fire service sector, an issue otherwise plaguing emergency management at large (Rouse, 2004). Positioned by its mission as a knowledge activist, the NFA could act as the network administrative organization (Provan & Kenis, 2008) or gatekeeper (Cohen & Levinthal, 1990) to help the sector mitigate knowledge aDsorption. However, no real strategies are in place to support the development of KM governance (Scwella, 2014) at the sector level. Thus, the NFA's leadership issues raise questions about horizontal collaboration (Kettl, 2000) and collaborative governance (Emerson & Gerlak, 2014).

5.6.2 A sectoral KM practice question grid

Results also allowed to distill a question grid enabling key stakeholders to assess the practice of KM at the sectoral level, such as fire safety and emergency response by firefighters, towards *desorption* of value-added knowledge into public value (see Table 5.6.2).

Table 5.6.2: Sectoral KM practice question grid

Originating Ba: What are the profession's core characteristics? What are the kinetic and energetic factors in this Ba? Which Ba(s) should be activated to meet the need for knowledge?
KEF ⬇⬆ KEF
Systemizing Ba: Is there a need to revise current legislation? Is there appropriate governance? What are the kinetic and energetic factors in this Ba? Are stakeholders collaborating as they should within the sector?
KEF ⬇⬆ KEF
Dialoguing Ba: Is there a need to activate/animate knowledge governance in the sector? What are the kinetic and energetic factors in this Ba? Which stakeholders should be involved in knowledge governance? What are the appropriate mechanisms to foster dialogue/networking between stakeholders?
KEF ⬇⬆ KEF
Exercising Ba: How can new knowledge be translated in practice? What are the kinetic and energetic factors in this Ba? How can the sector innovate or make continuous improvement for the betterment of public service? Which stakeholders can lead and implement change? How can value-added knowledge be translated into public value?
Feed-back loop to Originating Ba ↻

By answering the question grid and documenting KEFs, one can form the basis of a sectoral KM strategy.

5.7 Discussion

This article makes theoretical and practical contributions. On the theoretical level, the research enriches the AC's literature, in particular by introducing the concept of *aDsorption*, which makes it possible to identify and explain factors blocking transfer and absorption of new knowledge. In turn, it becomes possible to assess if and how a public sector uses *desorption* to transfer value-added knowledge into public value, a new mode of application for this recent concept. In fact, *aDsorption* completes the relation between *aBsorption* and *desorption* of knowledge thus providing a complete formula for analysis. This article also contributes to a better understanding of the fire service sector where research is needed (Beauchamp, 2017).

The SECI-BA model has become a classic in the KM literature but has been scarcely used in applied research, particularly at the inter-organizational level in the public sector. The systemizing *Ba* has a decisive importance in the public sector because of its legislative and regulatory components. Nevertheless, while some have questioned the linearity of the knowledge conversion process in this model, the case studied and the results obtained suggest that there is necessarily simultaneity of the process with the different interacting *Bas* creating an overall Ba. In essence, knowledge conversion is rarely sequential since the *Bas* are intertwined working in a consubstantial way.

Results illustrated how knowledge *aDsorption* and problems of knowledge transfer can be detrimental for fire service organizations in their sector of activity. The case-study showed that the fire service sector still relies on traditional and standardized knowledge acquired through training, even if this 'normal' training is no longer enough to take on the many challenges of present-day emergencies (Okoli, Weller, & Watt, 2014). These organizations' boundaries have low porosity to valuable knowledge from external sources thus indicating low level of AC. This area of research had never been explored before. As such, this paper has contributed towards a better understanding of knowledge *aDsorption*, AC, and KM processes in the fire service and on an area of public activity scale.

In line with previous research about the importance of interactions with the environment to achieve AC in the public sector (Harvey, Skelcher, Spencer, Jas, & Walshe, 2010; Murray, Roux, Nel, Driver, & Freimund, 2011), results reported here indicate that the capacity to absorb and transfer knowledge in a public sector involves a paradigm shift from a functionalist, siloed organizational view to an inter-cognitive view of public value creation involving both individuals, organizations and their interactions within the public sector.

On a practical level, the research provides better knowledge of the fire service and highlights the relevance and importance of KM as a lever for the development and evolution of a public sector of activity. AC is said to facilitate inter-organizational knowledge transfer (Van Wijk, Jansen, & Lyles, 2008) since the porosity of organizational boundaries has a significant impact on knowledge transfer and overall organizational performance (Argote, McEvily, & Regans, 2003). Results underscored that the fire service sector is still characterized by silos with constituent organizations having difficulties opening their boundaries. This is a signal of knowledge *aDsorption*: valuable knowledge accumulates at the boundaries without being absorb in the sector causing a decrease in realized AC (Jansen, Van Den Bosh, & Volberda, 2005).

In sum, this research proposed a two-step approach to analyze a public sector of activity: (1) a diagnostic analysis based on factors promoting or constraining KM through socialization, collaboration, dialogue and practice, and (2) a question grid to develop a sectoral KM strategy. The case-study reported here surely has peculiar dimensions associated with the Quebec fire service socio-political context which may be different from other jurisdictions and may have influenced how the fire service sector has developed. However, findings illustrated the phenomenon of knowledge *aDsorption* in public organizations working in silos, even though there is a need for knowledge transfer to face wicked problems.

While this research provided a new method for analyzing a public sector in its capacity to develop through KM, governance - understood here as a KM steering process - has yet to be studied. For instance, even though the *systemizing Ba* may support functional

governance through legislative means and by establishing the roles and responsibilities of the key players in the sector of activity, legal provisions may not be sufficient to ensure efficient KM governance in sector of activity. To this end, the example of the NFA's hindered capacities reported in the case-study is eloquent.

5.8 Conclusion

Research reported in this paper aimed to answer the question: How does knowledge aDsorption affects knowledge conversion in a public sector of activity? The public sector is often taxed of being composed of multiple organizations complementary in their mission but working in isolation from each other. Results showed that knowledge aDsorption is a consequence of a functionalist, siloed organizational view. In order to mitigate knowledge aDsorption, a paradigm shift appears necessary to implement an inter-cognitive view of public value creation involving both individuals and organizations, and their interactions within the sector.

Research on KM in public sectors still needs attention from scholars. Further research could focus in areas of activity concerned with complex issues such as disaster mitigation, global warming or sustainable development. These challenging issues require multiple organizations to work cohesively and to transfer and absorb knowledge from multiple sources.

CHAPTER 6: DISCUSSION

This discussion presents a synthesis of the three papers' discussions. It is divided in three parts. The first part summarizes the papers' results and content. The second part underlines the research's contributions and offers a general discussion on findings, while the third part suggests future research directions.

6.1 Synthesis

The first paper was a systematic literature review which served as a starting point for the other two papers. It is the first literature review of research on the fire service published either in English or French globally. In total, 238 peer-reviewed papers constituted the review. Results show that the published literature can be grouped in three categories: health and safety, management, and organizational culture. Articles in the health and safety category represented the majority (50%) of published research. The review underscored the necessity of research on KM in the fire service. This paper contributes to research by providing a first contemporary map of academic studies on the fire service over the period of 1970 to 2016. This paper underlined the paucity of peer-reviewed, fire-related articles produced over the past 46 years suggesting that the field of research on the fire service is still in its infancy. Therefore, it contributes to research by identifying many research gaps to be filled.

The second paper was empirical and exploratory in nature. It focused on exposing and explaining VFDs' internal KM processes. This article, the first to report research on KM in VFDs, builds on KM literature and on serious leisure theory to advance a framework explaining how VFDs manage their knowledge stock. The paper illustrated how knowledge sharing among firefighters is the main process of KM in the fire service. It also introduced the concept of *buddy-learning* to explain how firefighters tap into their colleagues' knowledge to learn. The sampling strategy ($N = 310$, response rate of 42,5%) allowed to gather a credible and sufficiently robust pool of data. Exploratory factor analysis provided evidence supporting the first empirically tested model of KM in VFDs. Interviews of firefighters of different ranks ($N = 10$) and content analysis of municipal websites ($N = 20$) added nuances and contextualization for a rounded analysis of survey data. This paper also

contributed to serious leisure theory (SL). First, it provided evidence of SL's pertinence to explain VFDs' organizational culture characteristics. Second, the paper provided strong data through factor analysis indicating that SL's four components (qualities, rewards, thrills and psychological flow, and devotee work) influence how knowledge is managed in VFDs.

The third and final paper was a theoretical and empirical study of absorptive capacity in a public sector of activity, namely the Quebec fire service. This article is the first to report research on KM in the fire service sector. It introduced the concept of knowledge aDsorption, a condition by which valuable knowledge otherwise available in the sector's environment is not transferred or absorbed. It focused on exposing and explaining how kinetic and energetic factors may induce knowledge aDsorption in a public sector of activity.

As a rare application of Nonaka's SECI model in the public sector, the paper showed that a new *Ba* arrangement is necessary in this sector since the systemizing *Ba* appears as the cornerstone to build efficient and dynamic dialoguing and exercising *Bas*. Triangulation of many data sources (survey of firefighters, semi-structured interviews of firefighters, and content analysis of nine different official sources) provided a rich depiction of the Quebec fire service sector's reform, both from a path-dependency perspective to a contemporary view of current KM challenges in this sector. This paper contributed to KM theory in general, to the understanding of absorptive capacity, while providing an empirical application of the SECI model. The paper also provided the first analysis of its kind on the fire service. Table 6.1 summarizes the three papers' structure and interrelations.

Table 6.1 Papers' structure and interrelations

	Paper 1	Paper 2	Paper 3
Title	Discovering Underlying Themes in Fire-Related Research: An Analysis of 238 Peer-Reviewed Studies.	When Passion Fuels the Fire: Knowledge Sharing Among Volunteer Firefighters in Canada.	Knowledge aDsorption as a barrier to strategic knowledge management: a case-study in the fire service.
Keywords	Fire, fire service, fire department, firefighter, service d'incendie, incendie, pompier.	Knowledge management in the fire service, firefighters, volunteer fire departments, Buddy Learning, serious leisure, factor analysis.	Absorptive capacity, knowledge adsorption, knowledge management, fire service, public sector.
Published/submitted	**Published**: Beauchamp, Claude (2017). Discovering Underlying Themes in Fire-Related Research: An Analysis of 238 Peer-Reviewed Studies, *International Fire Service Journal of Leadership and Management*, *11*, 49-68.	**Published**: Beauchamp, Claude (2018). When passion fuels the fire: Knowledge sharing among volunteer firefighters in Canada. *International Fire Service Journal of Leadership and Management*, *12*, 31-50.	**Submitted**: (*Journal of Information and Knowledge Management)*: Beauchamp, C. and Lemay, L. (2020). Knowledge aDsorption in the public sector: Heavy smoke showing in the fire service sector
Type of paper	Literature review	Research paper/empirical	Research paper/theoretical/empirical
Background	No literature review of research on the fire service ever published. There has been a surge in research on the fire service in the last decade.	KM literature identified KM as a research gap in the fire service. Research gap confirmed in Paper 1. Public administration performance linked to KM.	KM literature identified KM as a research gap in the fire service. Research gap confirmed in Paper 1. Public administration performance linked to KM. Paper 2 concluded that research is needed (1) on different *Bas* in the fire service to better understand interactions in enabling knowledge creation at the organizational and interorganizational levels and (2) on absorptive capacity in the fire service.
Aim	State of peer-reviewed research in English or French on the fire service.	Exploratory analysis of KM processes in volunteer fire departments in Quebec.	Explain how public sector organizations working in silos experience difficulties in transferring and absorbing knowledge by introducing the phenomenon of knowledge aDsorption.
Research question	What is the state of research on the fire service? What are the research themes that have been explored so far?	(Q1) How is knowledge managed in VFDs? (Q2) How does the fire service organizational culture influences knowledge management in VFDs? **Proposition 1**: Knowledge sharing among firefighters is their main source of learning **Proposition 2**: Serious leisure components are levers of knowledge management in volunteer fire organizations. **Proposition 3**: Turned inward, the fire service organizational culture impairs knowledge transfers from external sources such as other fire departments, partners, customers, suppliers, and academic and applied research.	(Q3) How does knowledge aDsorption affect knowledge conversion in a public sector of activity?
Conceptual background	Fire service; KM.	Fire service; KM; organizational culture; serious leisure.	Fire service; KM; knowledge conversion; absorptive capacity; knowledge transfer.
Design and method	Systematic literature review.	Multi case-study. Exploratory factor analysis.	Multi case-study. Mixed methodology.

Data	238 peer-reviewed articles, published between 1970 to 2016, and retrieved from 9 databases.	**Online survey** of firefighters (*N*=301), **interviews** of firefighters (*N*=10), municipal **websites** (*N*=20), **documents** (minutes from the National Assembly from 1990-2001; minutes from the 2012 governmental forum on the fire service; 4 reports from the occupational heath and safety agency; 1 report from the Ombudsman; 1 report from the Coroner; 1 white paper from the fire chiefs' association; 17 annual reports, from 2001 to 2018, the National fire school; the Fire Safety Act of 2001; the Regulation respecting the conditions governing the exercise of functions within a municipal fire safety service of 2001; the Orientations of 2001.)	**Online survey** of firefighters (*N*=301), **interviews** of firefighters (*N*=10), municipal **websites** (*N*=20), **documents** : (1) **legislative texts** on the fire service sector; (2) **minutes** from (a) the Quebec National Assembly, from 1992 to 2000, pertaining to the fire service and from (b) a fire service sector forum held 2012; (3) **annual reports** from the National Fire Academy (NFA), from 2001 to 2018; (4) the sole **research report** from the NFA; (5) a NFA's **memorandum** submitted at the 2012 forum; (6) a **research report** published in 2015 by the association of fire chiefs (ACSIQ); (7) a **white paper** on the state of the Quebec fire service published in 2018 by ACSIQ; (8) **reports** on the fire service from the Coroner, the occupational health and safety agency, and the Ombudsman; and (9) **websites** of the NFA, ACSIQ, the fire instructors' association, and the fire prevention officers' association.
Main results	Definition of three meta-categories: health and safety, management, and organizational culture. Scholarly work in both the health and safety and the management meta-categories is largely based on quantitative methods (surveys, samples, calculations, etc.), while research in the organizational culture meta-category is in large part based on qualitative methods (interviews, observations, discourse, etc.). Both quantitative and qualitative methods are found in English research, while most French research stems from the social science perspective and is based on qualitative methods.	Three factors are related to KM in VFDs: buddy-learning, knowledge transfer, and knowledge storage. Three factors pertaining to serious leisure theory are related to VFDs' organizational culture: personal development, creativity, and commitment.	Paper 3 introduced the phenomenon of knowledge aDsorption and is the first study on absorptive capacity in the fire service. Results indicate that kinetic and energetic factors cause knowledge aDsorption in the Quebec fire service sector.
Main findings	Data indicate that almost 57 percent (56.7%) of the 238 fire-related studies originated in the United States. Studies from the United States, United Kingdom, Canada-English and Australia represent 78.6 percent of all published material. Only 7 studies (3.7%) offer a comparative analysis between or among nations. Health and safety studies represent one-half (n = 119, 50%) of the literature on the fire service, with management studies equaling 33 percent (n = 79), and organizational culture constituting 17 percent (n = 17). Knowledge management in the fire service represents a research gap.	Knowledge sharing among firefighters is the main process of KM in the fire service. The concept of *buddy-learning* explains how firefighters tap into their colleagues' knowledge to learn. Three factors are positively associated with KM in VFDs: buddy-learning, personal development, and creativity. Two factors are negatively associated with KM in VFDs: knowledge transfer and knowledge storage.	Known valuable knowledge can accumulate at the organizational boundaries' surface without being absorb by the organization (knowledge aDsorption). Spiralling movement of knowledge creation paralyzed at the onset between VFDs at the sector level because of problems associated with knowledge transfer and cultural resistances.
Main contributions	First, as the first systematic, global, and inclusive literature review of research on the fire service, it provides empirical evidence of three meta-categories that characterize the state of research on the fire service. In order of importance (based on the number of studies in a category) the three meta-categories are (1) health and safety, (2) management, and (3) organizational culture. Second, the review offers the first longitudinal view (1970-2016) of research work on the	First set of empirical data on KM in VFDs. Conceptual framework to better understand KM in VFDs. Identification of main factors influencing KM in VFDs. Introduction of the *buddy-learning* concept.	Conceptual framework to understand knowledge aDsorption in the public sector. Empirical application of Nonaka's SECI model and concept of *Ba* showing that the spiralling movement of knowledge creation is not linear between the SECI modes of knowledge conversion but rather consubstantial. New model arrangement showing the importance of the systemizing *Ba* in the public sector. Concept of knowledge aDsorption

	fire service written both in in English and French. Third, based on analysis of the 238 studies, the review offers multiple recommendations where additional research could prove beneficial to fire service leaders.		allows to explain problems of absorptive capacity in all four *Bas*. Paper 3 responded to calls in the literature for a deeper understanding of KM processes in public emergency services. The paper also advanced conceptual and operational understanding of KM in the fire service. Paper 3 provided a blueprint for fire service and municipal leaders, first, to implement KM strategies to access and transfer valuable knowledge and, second, to recognize and mitigate knowledge aDsorption. Paper 3 details two new research tools that can be applied to research in different sectors. The first is an analytical matrix to identify kinetic and energetic factors sustaining or blocking absorptive capacity. The second is a question grid supporting strategic decision-making about knowledge management in a sector of activity. Paper 3 provide a complete formula to study absorptive capacity in organizational/sectoral settings through a new tryptic composed of: absorptive capacity, knowledge adsorption and knowledge desorption.
Research suggestions	Examples include: stress, cancer, comparative studies, health and safety programs, updates on economic and operational models, leadership styles, diversity, citizens' expectations, organizational culture of career fire departments, and KM at large in the fire service.	Comparative studies of volunteer fire departments located in different countries. KM research in career and mixed (combination volunteer/career) fire departments. Research on different *Ba* to better understand interactions in enabling knowledge creation at the organizational and interorganizational levels of VFDs. VFDs' absorptive capacity challenges.	Advance the understanding of knowledge aDsorption and desorption by studying the interactions of public sector's organizations engaged in complex issues such as disaster mitigation, global warming, or sustainability.

6.2 Main observations and contributions

This research was aligned with previous work suggesting the necessity of research on KM processes, knowledge transfer and AC, and the fire service. Scholars asserted that a difficulty in understanding organizational learning was the lack of research on actual learning processes and knowledge (Easterby-Smith & Lyles, 2011). There were also calls for research to consider processes of inter-organizational knowledge transfer (e.g. Easterby-Smith & Lyles, 2011) and to explain how "non-cognitive factors, such as emotions, self-perceptions, personal background, and organizational politics, shape managerial cognition" (Tsoukas & Mylonopoulos, 2004, p.11). Moreover, previous studies underlined a series of research directions to better understand mechanisms associated with AC, such as the impacts of a changing social context on multi-sector relationships (Pittz & Intindola, 2015), knowledge transfer relationships (Denford & Ferriss, 2018), and leadership styles (Méndez, Valle, & Alegre, 2018). Finally, scholars identified a need for more research on KM in the public sector (Rashman, Withers, & Hartley, 2009; Vigoda-Gadot, Shoham, Schwabsky, & Ruvio, 2005), and precisely about the fire service were research was said to be lacking (Massaro, Dumay, & Garlatti, 2015).

As a case-study, this research supports mid-range theoretical contributions (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Weick, 1974) on KM in the fire service. Therefore, it should be viewed as contributing to extend current knowledge about KM theory and about KM in public sector organizations, in particular in the fire service. This research provides answers to understand how knowledge is managed in the fire service sector. It documents the first set of empirical data explaining how knowledge is acquired and subsequently disseminated in VFDs through 'situated practice' as the "individual understands and acts in the world through drawing on a set of socially defined values, beliefs and cognitive categories within particular material and social circumstances" (Tsoukas & Mylonopoulos, 2004, p.7). In the present case, values, beliefs, and cognitive categories of the fire service have a significant impact on what the individual learns, which knowledge is shared, and how organizational behavior impairs knowledge transfer from various sources. The research also extends the scientific interest of both KM in the public sector and the empirical applicability of Nonaka's SECI model.

This research built on four theoretical strands presented in Chapter 1 and integrated to various degree in the three scientific papers. The first strand is Nonaka's theory of knowledge conversion and its associated SECI model and concept of *Ba* (Nonaka, 1991, 1994; Nonaka & Takeuchi 1995; von Krogh, Ichijo, & Nonaka, 2000). Our results showed that this model, applied empirically, allows to explain KM practices in organizations and in between organizations and their relations with AC and knowledge transfer.

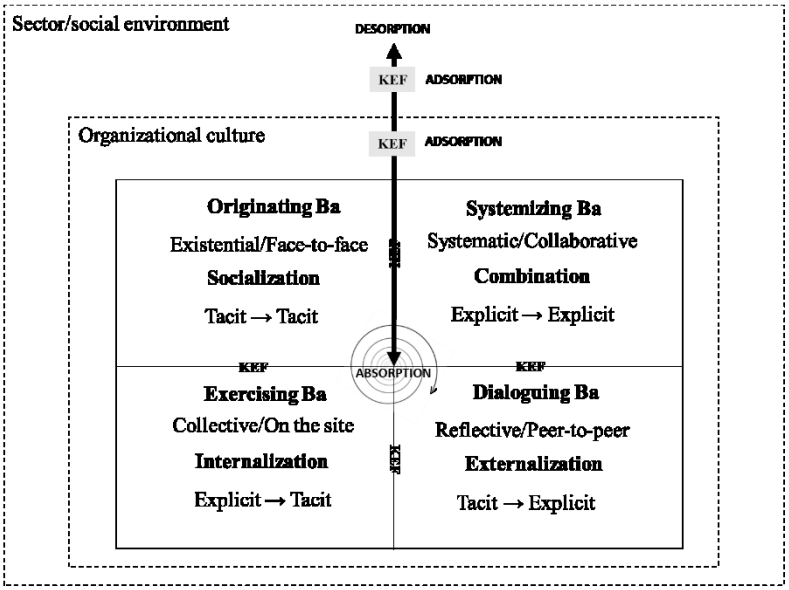
Secondly, we used the general KM theory (e.g. Brown & Duguid, 1998; Easterby-Smith, Crossan & Nicolini, 2000; Oliveira, Pedron, Romão, & Becker 2011; Syed-Ikhsan & Rowland, 2004a, 2004b; Oliva, 2014; Hsieh, Lin, & Lin, 2009; Martin, Hatzakis, Lycett, & Macredie, 2005; Kruger & Johnson, 2011; Soltani, Joneghani, & Bozorgzad, 2011) to assess VFDs' processes of knowledge creation, storage, and sharing. Our results are in line with this body of research in confirming that four factors (internal context, content, process, and external environment) significantly mediate KM processes in organizations.

Thirdly, we mobilized serious leisure theory (Stebbins, 1996; Stebbins, 2008; Elkington & Stebbins, 2014) to relate significant aspects of VFDs' organizational culture to KM processes. Our results confirmed that the serious leisure's four main characteristics (qualities, rewards, thrill and psychological flow, and devotee work) have a definite impact on KM processes in VFDs. Our results also advanced the understanding of space in relation to serious leisure theory through the description of the firehouse as *Ba*.

Finally, the research built on AC theory (Cohen & Levinthal, 1990; Lane, Koka, & Pathak, 2006; Lewin, Massini, & Peeters, 2006; Song, Gnyawali, Srivastava, & Asgari, 2018; Van den Bosch, Volberda, & de Boer, 1999; Zahra & George, 2002). Our results suggested that the fire service sector face AC challenges which cause difficulties transferring knowledge from (absorption) and to (desorption) the external environment. The research also extended the understanding of AC by introducing the phenomenon called knowledge aDsorption, a condition in which valuable knowledge forms a layer at the organizations' boundaries surface without being absorb in the internal knowledge stock.

One of the main contributions of this dissertation is the integration of these four theoretical strands of research. This integration is centered around Nonaka's theory of knowledge creation (Nonaka, 1991, 1994; Nonaka & Takeuchi 1995; von Krogh, Ichijo, & Nonaka, 2000). This theoretical integration, illustrated by Figure 6.2, allows to advance previous research on at least three aspects: the necessity to reconfigure the Ba sequence in Nonaka's theory when studying the public sector, the empirical applicability of Nonaka's theory, and the importance of knowledge aDsorption in the study of absorptive capacity.

Figure 6.2: The dynamics of knowledge absorption/adsorption in public activity sectors



The public sector is distinct from the private sector in which its functions are based on laws and regulations that systemize its scope of action. Therefore, as illustrated in Figure 6.2, the *Ba* sequence in Nonaka's model needed to be adjusted to reflect this particularity. In fact, this research showed the nonlinearity of the SECI modes of knowledge conversion but rather their consubstantiality. As was shown by Paper 3, the systemizing *Ba* serves as the foundation for active dialoguing and exercising *Bas*. A strong systemizing *Ba* also provides structure to cultural habitus. Paper 2 illustrated how serious leisure theory concepts still describe with accuracy the fire service organizational culture. It is mainly

through sharing what they know with others that individuals learn (*buddy-learning*). Anchored in traditions, conservatism, and norms passed as legacy between individuals, the fire service culture is still reluctant to change. Therefore, the systemizing *Ba* should provide structure to the fire service sector to mature in its KM strategies.

This is where the concept of knowledge aDsorption proved beneficial. Through its kinetic and energetic factors (KEF), this concept allows to describe how knowledge is absorbed or blocked therefore fuelling/slowing the knowledge conversion process in Nonaka's model. Paper 3 illustrated how the study of kinetic and energetic factors provide empirical evidence to explain the spiralling movement of knowledge creation. Figure 6.2 shows that researching KEF is to direct one's attention at strategic boundary points of KM strategies in a public sector.

In sum, Figure 6.2 offers a framework for future research on KM in a public sector. At its core is a rearranged version of Nonaka's model. On the vertical axis, the attention is focused on the continuum between knowledge absorption and knowledge desorption. In theory, this continuum should allow a public sector to integrate new knowledge, innovate, and transfer this knowledge to the sector or social environment as a benefit to public value. However, knowledge aDsorption poses a series of challenges as KEF may support or hinder the movement of knowledge along this continuum.

This dissertation contributes on many levels to the advancement of research. The fire service is a fairly new object of study, as was documented by Paper 1. In fact, research on this public service is still based on single initiatives and there is a lack of integrative studies to structure this research field. Therefore, Paper 1 now provides researcher with the first systematic literature review on the fire service allowing to have a structured understanding of current research. Paper 1 also identified many research gaps that, once addressed, could prove beneficial for fire service leaders.

Research on KM in the fire service at large is deficient. For one thing, empirical data on KM in this public service is lacking. Moreover, the subject had never been studied in the Quebec context. Therefore, one contribution of this dissertation is to provide the first set of empirical data on KM in the fire service and a replicable research.

This dissertation also contributes on the conceptual level. First, it introduces the concept of *Buddy-Learning* (Paper 2) which stems from an application of serious leisure theory to KM theory. Second, it introduces the concept of knowledge *aDsorption* (Paper 3) which completes a formula composed of three key concepts to understand KM strategies: absorption, adsorption, and desorption.

Finally, this dissertation advances previous research by documenting a rare application of Nonaka's theory in the public sector context (Paper 3). Based on empirical data about knowledge conversion processes, this dissertation provides a first replicable application of the SECI model to understand KM strategies in a public sector.

6.3 Future research

This dissertation offers many future research suggestions. Research is certainly needed on occupational health of firefighters, various forms of cancer, and cardiovascular risks associated with firefighting. In an organizational culture prone to habits contrary to rigorous health initiatives, research could provide guidance on best practices and risk identification. For instance, research on the health of female firefighters is sorely lacking. On management in the fire service, there is a need to better understand operational metrics to optimize service delivery in the context of volunteer fire departments. Diversity, leadership styles, and communication skills could also benefit from further research. There is also a need to better understand how the traditional and conservative fire service organizational culture fares with new perspectives on social life. Nowadays, volunteering in the fire service may be at odds with current social values or with a fast-pace life that favours conciliation between work and family activities. In that regard, there is a need to further explore how serious leisure theory can be applied to support a contemporary description of the fire service culture. For instance, this theory has never been applied in the context of career fire departments. Surely, career firefighters are not volunteers as described in the theory. Still, the fire service culture being so homogenous, studying how characteristics of qualities, rewards, thrills and psychological flow, and devotee work apply to career firefighters would definitely shed light on cultural habitus in the fire service. Moreover, there is still much to be known about how this culture supports or hinders new

managerial styles in context of networking, managing with data or lean management. Finally, there have been very few comparative studies or meta-analysis which may be a sign that the fire service is still a developing object of study.

Research on KM in the fire service also needs further exploration. First, there is a need to better understand KM processes in career fire departments. These departments often respond to incidents in complex environments such as high-rise buildings, subway and transit systems, and densely populated areas. How this organizational reality impact KM processes needs to be better described. Second, scholars could study KM mechanisms and strategies from a comparative angle in career, combination, and volunteer fire departments. How these organizational arrangements affect differently or not KM processes is unknown. For instance, understanding if the concept of buddy-learning also applies to combination and career departments would help understand the relationship that these firefighters have with learning and which knowledge sources are deemed of importance for them. Thirdly, research on KM in the fire service could explain if and how career firefighters that also act as volunteer firefighters have an impact on the knowledge stock of volunteer fire departments. Fourthly, there has been no research on KM maturity in the fire service. How KM processes and strategies sustain or hinder gains in KM maturity is unknown. Finally, this research showed that strategic KM governance in the fire sector is not easily achieved. Further research on this topic could help determine with more accuracy which mechanisms should be favoured, depending on context, to achieve strategic governance of knowledge towards public value.

Finally, this dissertation invites scholars to pursue research on KM in the public sector. First, future research could explore if dedicated metrics should be used to analyze KM in the public sector context. Currently, these metrics almost always stem from the private sector context and are applied with few adjustments to the public sector context. For instance, understanding how to measure the effect of knowledge desorption from public organizations on public value could nourish research on the impacts of strategic planning in the public sector. Secondly, there is a need to further explore the application of the knowledge aDsorption concept. This concept proved beneficial in explaining how different factors hinder innovation and knowledge desorption from public organizations. It also

helped explain why organizations working in silos have difficulties sharing and transferring knowledge. Still, the applicability of this new concept would benefit from tests in various organizational environments.

CONCLUSION

This dissertation's goal was to understand how knowledge is managed in the fire service. It focused on KM in the fire service, considering three scales of analysis: firefighters, fire departments, and the sector composed of different organizations with complementary missions for this public service. This case-study research was carried out in the Quebec fire service sector context and was based on three main questions:

(Q1) How is knowledge managed in VFDs?
(Q2) How does the fire service organizational culture influences knowledge management in VFDs?
(Q3) How does knowledge aDsorption affects knowledge conversion in a public sector of activity?

A mix-methodology research design structured the collection of quantitative and qualitative data. Triangulation of data from a survey (*N=301*), semi-structured interviews of ten fire service personnel (*N=10*), municipal websites (*N=20*), and various documentation sources supported an in-depth description of KM in the Quebec fire service context as well as ensuring robust findings. For validity purposes, findings were submitted to three subject-matter experts that provided independent opinions thus contributing to the overall pertinence of this research.

The first paper provided the first systematic literature review of research on the fire service. It confirmed that research on KM in the fire service was needed. The second paper focused on KM processes in VFDs. It offered a vivid description of how firefighters learn through buddy-learning. Findings presented in Paper 2 also explained how the traditional and conservative fire service organizational culture is conducive to organizational myopia towards external sources of knowledge. Finally, paper 3 illustrated how strategic KM is difficult to achieve in a public sector. Empirically applying Nonaka's SECI-*Ba* model in the public sector revealed the necessity for a new *Ba* arrangement more align with the public sector reality. Moreover, this paper introduced the concept of knowledge aDsorption which proved beneficial to describe why KM strategies are difficult to implement in the fire service sector. By adding aDsorption to absorptive capacity and knowledge desorption,

this paper offered a complete formula for future research on KM strategies in the public sector context.

Entitled Playing with fire: Knowledge management in the Quebec fire service, this dissertation points to the current duality of KM strategies in the fire service sector. On the one hand, the leisure aspects of volunteering are still very much present in this public service. The *playing* aspects of volunteering as a firefighter still contribute to defining these public servants. If they are still in to seriously play with the fire trucks and equipment, these individuals strongly engage themselves in learning how to fight fires and how to become a real firefighter. They find a reward in knowing what to do which in turn provide them thrills and psychological flow. On the other hand, this dissertation highlights the fact that KM is still precarious in the fire service sector. By being somewhat blind to external knowledge sources, knowledge transfer opportunities or knowledge exchange through networking, fire service organizations are placed at risk. Amidst the fast-paced environment of modern-day life, the recurrence of disasters and complex incidents, not implementing robust KM strategies in the fire service sector literally equals to *play with fire*.

All in all, this dissertation's goal was to answer calls from previous research about the necessity to study KM in the public sector context, in particular the emergency services. By offering a first empirical analysis of KM in the fire service sector, this research signals the necessity of a structured research agenda that could find relevance in the study of KM between fire service, police, and first medical responders' organizations. At the intersection of strategic KM governance, collaborative governance regimes, and public service performance, this research path could support public service leaders in creating public value.

ANNEX A: SURVEY QUESTIONS' LIST

Survey questions (French and English versions)

French version

1. Quel est votre service d'incendie?
2. TM1 Dans mon service d'incendie, les officiers de l'État-major (directeur(s) et chef(s)) croient qu'il est important d'encourager les pompiers à partager leurs connaissances avec leurs collègues.
3. TM2 Dans mon service d'incendie, les officiers de l'État-major (directeur(s) et chef(s)) ajustent la formation et l'entraînement à la suite de problèmes rencontrés en intervention pour aider les pompiers à s'améliorer.
4. TM3 Dans mon service d'incendie, les officiers supérieurs (directeur(s) et chef(s)) connaissent les nouveautés dans le domaine de la sécurité incendie et ils en informent les pompiers.
5. TM4 Dans mon service d'incendie, les officiers supérieurs (directeur(s) et chef(s)) encouragent l'innovation et le changement.
6. IT1 Dans mon service d'incendie, les pompiers utilisent des banques de données électroniques (par exemple des ordinateurs en caserne) pour avoir accès à des connaissances.
7. IT2 Dans mon service d'incendie, les pompiers utilisent des réseaux de connaissances (par exemple une communauté virtuelle ou un site de partage virtuel, Facebook, Twitter, etc.) afin de communiquer entre eux.
8. IT3 Dans mon service d'incendie, les pompiers utilisent régulièrement les technologies de l'information dans leurs tâches (par exemple prise d'inventaire, rédaction de rapport, etc.).
9. IT4 Dans mon service d'incendie, les technologies de l'information sont utilisées lors des réunions, de la formation ou de l'entraînement (logiciels de présentation, logiciels de simulation, vidéo, etc.).
10. QUAL1 Dans mon service d'incendie, les pompiers font preuve de persévérance pour devenir plus compétents.
11. QUAL2 Dans mon service d'incendie, les pompiers font des efforts importants pour utiliser leurs connaissances, leur entraînement et leurs habiletés.
12. QUAL3 Être pompier favorise l'enrichissement personnel, l'expression de soi, un sentiment d'accomplissement, des interactions sociales et un sentiment d'appartenance.
13. QUAL4 Être pompier signifie développer une identité distinctive en société et faire partie d'un groupe qui partage des valeurs, des croyances et des buts.
14. RWD1 Être pompier encourage le développement de soi par le développement d'habiletés et de connaissances.
15. RWD2 Être pompier encourage l'expression de soi par le développement d'habiletés et de connaissances.
16. RWD3 Dans mon service d'incendie, les pompiers voient une récompense dans leur contribution au maintien et au développement du groupe.
17. TPF1 Dans mon service d'incendie, les pompiers ont le sentiment d'être compétents lors du combat d'incendie.
18. TPF2 La lutte contre les incendies exige de la concentration.
19. TPF3 Dans mon service d'incendie, les pompiers ressentent un sentiment de contrôle lors du combat d'incendie.
20. TPF4 Dans mon service d'incendie, les pompiers ressentent un sentiment profond d'implication lors du combat d'incendie.
21. DEWO1 La lutte contre les incendies exige des habiletés, des connaissances et une expérience substantielle ou une combinaison des trois.
22. DEWO2 La lutte contre les incendies offre une opportunité significative pour du travail créatif et innovant qui favorise l'expression personnelle.
23. DEWO3 La lutte contre les incendies permet de faire preuve d'imagination dans l'application des habiletés et des connaissances.
24. TK1 Dans mon service d'incendie, les connaissances nécessaires aux pompiers peuvent être facilement obtenues auprès de collègues.

25. TK2 Dans mon service d'incendie, une des façons d'apprendre c'est de travailler avec des pompiers d'expérience.
26. TK3 Dans mon service d'incendie, des conversations et des rencontres informelles sont utilisées pour partager des connaissances.
27. TK4 Dans mon service d'incendie, des connaissances sont obtenues par l'entremise des relations entre collègues.
28. EK1 Dans mon service d'incendie, les connaissances (comment faire, ou les processus pour résoudre des problèmes) peuvent être facilement obtenues à partir de différents documents ou manuels.
29. EK2 Dans mon service d'incendie, il y a un programme de formation structuré et ses objectifs sont connus des pompiers.
30. EK3 Dans mon service d'incendie, les résultats des projets ou des rencontres sont documentés.
31. EK4 Dans mon service d'incendie, les connaissances sont partagées au moyen de documents tels que des manuels.
32. KC1 Dans mon service d'incendie, les pompiers peuvent proposer des idées et contribuer à amener de nouvelles connaissances.
33. KC2 Dans mon service d'incendie, les pompiers s'entraînent régulièrement à la tâche pour développer leurs compétences.
34. KC3 Dans mon service d'incendie, les pompiers peuvent proposer de nouvelles façons de faire.
35. KST1 Dans mon service d'incendie, les processus ou les outils pour conserver des connaissances pour un usage futur sont bien organisés (par exemple: banques de données, cahiers de procédures, fiches d'information, bibliothèque, etc.).
36. KST2 Dans mon service d'incendie, les pompiers participent à des activités permettant de conserver les connaissances pour un usage futur (par exemple: classer des documents, réviser des procédures, produire des documents explicatifs, etc.).
37. KST3 Dans mon service d'incendie, les pompiers savent où sont conservées les informations qui peuvent leur être utiles.
38. KSH1 Dans mon service d'incendie, les pompiers d'expérience partagent volontiers leurs connaissances avec les nouveaux pompiers.
39. KSH2 Dans mon service d'incendie, les pompiers demandent à leurs collègues de partager leurs habiletés lorsqu'ils doivent apprendre quelque chose de nouveau.
40. KSH3 Dans mon service d'incendie, lorsqu'un pompier est bon dans une tâche, ses collègues lui demandent de leur montrer comment faire.
41. KSH4 Dans mon service d'incendie, lorsque les pompiers apprennent quelque chose de nouveau, ils le partagent avec leurs collègues.
42. KSH5 Dans mon service d'incendie, les pompiers font profiter le groupe de leurs compétences qu'ils ont développées dans leur emploi principal (par exemple: mécanicien, menuisier, plombier, etc.).
43. KSH6 Dans mon service d'incendie, les pompiers échangent régulièrement les uns et les autres à propos de leurs tâches en cours.
44. SUPP1 Dans mon service d'incendie, les connaissances sont partagées de part et d'autre avec nos fournisseurs de services ou d'équipements.
45. SUPP2 Dans mon service d'incendie, les connaissances obtenues des fournisseurs de services ou d'équipements sont incorporées dans les opérations du service d'incendie (par exemple: ajustement des façons de faire, règle de l'art, utilisation sécuritaire, etc.).
46. SUPP3 Dans mon service d'incendie, les connaissances obtenues des fournisseurs de services ou d'équipements sont utilisées pour innover (par exemple: nouvelles façons d'utiliser un équipement, nouvelle méthode de travail, etc.).
47. PART1 Dans mon service d'incendie, les connaissances sont partagées de part et d'autre avec des partenaires (par exemple: travaux publics, police, ambulance).
48. PART2 Dans mon service d'incendie, les connaissances obtenues des partenaires (par exemple: travaux publics, police, ambulance) sont incorporées dans les opérations du service d'incendie (par exemple: ajustements à des façons de faire, meilleure compréhension du travail des partenaires, etc.).
49. PART3 Dans mon service d'incendie, les connaissances obtenues des partenaires (par exemple: travaux publics, police, ambulance) sont utilisées pour innover (par exemple: nouvelle méthode de travail, nouvelle procédure, etc.).
50. PART4 Dans mon service d'incendie, les connaissances sont partagées de part et d'autre avec les services d'incendie de l'entraide municipale.

51. PART5 Dans mon service d'incendie, les connaissances obtenues des services d'incendie de l'entraide municipale sont incorporées dans les opérations du service d'incendie (par exemple: ajustement des façons de faire, uniformisation des méthodes de travail, etc.).
52. PART6 Dans mon service d'incendie, les connaissances obtenues des services d'incendie de l'entraide municipale sont utilisées pour innover (par exemple: nouvelle méthode de travail, nouvelle procédure, etc.).
53. CUST1 Dans mon service d'incendie, les pompiers partagent leurs connaissances avec les citoyens (par exemple: explications, prévention, conseil, etc.)
54. CUST2 Dans mon service d'incendie, on demande aux citoyens de partager leurs connaissances (par exemple: informations sur les lieux de l'intervention).
55. CUST3 Dans mon service d'incendie, les connaissances obtenues des citoyens sont incorporées dans les opérations du service d'incendie (par exemple: ajustement des façons de faire, prise en compte de la relation client, etc.).
56. CUST4 Dans mon service d'incendie, les connaissances obtenues des citoyens sont utilisées pour innover (par exemple: nouveau programme de prévention, nouvelle campagne de sensibilisation, etc.).
57. AAR1 Dans mon service d'incendie, l'état-major (directeur(s) et chef(s)) utilise les résultats de la recherche universitaire ou appliquée sur les services d'incendie dans ses décisions.
58. AAR2 Dans mon service d'incendie, les résultats de la recherche universitaire ou appliquée sur les services d'incendie sont utilisés pour modifier les pratiques ou les procédures actuelles.
59. AAR3 Dans mon service d'incendie, les résultats de la recherche universitaire ou appliquée sur les services d'incendie sont inclus dans l'entraînement.
60. AAR4 Dans mon service d'incendie, les résultats de la recherche universitaire ou appliquée sur les services d'incendie sont utilisés pour l'avancement de la santé et sécurité au travail.
61. AAR5 Dans mon service d'incendie, on considère qu'il est important que les nouvelles connaissances provenant de la recherche soient connues.
62. Vous êtes :
- Un homme
- Une femme
63. Votre âge :
- 18-25
- 26-30
- 31-35
- 36-40
- 41-45
- 46-50
- 51-55
- 56-6
- + 60
64. Quel est votre emploi principal?
65. Langue(s) parlée(s) :
- Français
- Anglais
66. Langue(s) lue(s) :
- Français
- Anglais
67. Qualification scolaire (la plus récente) :
- Primaire
- Secondaire 3
- Secondaire 4
- Secondaire 5
- DEP
- DEC
- Certificat universitaire
- Baccalauréat
- Maîtrise
- Doctorat

68. Poste actuel au service d'incendie (si vous êtes affecté en intérim sur un poste, indiquez votre poste de base) :
- Pompier
- Lieutenant
- Capitaine
- Chef aux opérations
- Chef de division
- Directeur adjoint
- Directeur

69. Années d'ancienneté dans le poste actuel au service d'incendie :
- 0-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-30
- 31-35
- + 35

70. Années d'ancienneté dans le domaine de la sécurité incendie :
- 0-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-30
- 31-35
- + 35

71. Qualification actuelle de pompier :
- Actuellement en formation
- Clause remorque (clause grand-père) avant 1998
- Profil équivalent à Pompier I
- Pompier I
- Pompier II
- DEP
- DEC

72. Qualification actuelle s'officier :
- Aucune
- Profil II
- Officier I
- Officier II
- Gestionnaire en sécurité incendie

73. Qualification actuelle d'instructeur en sécurité incendie :
- Aucune
- Profil III
- Instructeur I
- Instructeur II

English version (for publication)

Questions 62 to 73 of the French version were not translated to English.

2. TM1 In my fire department, high-ranking officers (chiefs) believe it is important to encourage firefighters to share their knowledge with colleagues.
3. TM2 In my fire department, high-ranking officers (chiefs) adjust training after problems were encountered in operations to help firefighters improve.
4. TM3 In my fire department, high-ranking officers (chiefs) are aware of innovations in the fire service an they inform firefighters about it.
5. TM4 In my fire department, high-ranking officers (chiefs) foster innovation and change.
6. IT1 In my fire department, firefighters use electronic data banks (for example computers at the station) to have access to knowledge.
7. IT2 In my fire department, firefighters use knowledge networks (for example a virtual community or a virtual information sharing site, Facebook, Twitter, etc.) to communicate among them.
8. IT3 In my fire department, firefighters regularly use information technologies in their tasks (for example during inventory, report writing, etc.).
9. IT4 In my fire department, information technologies are used during meetings, learning activities, or training (presentation software, simulation software, video, etc.).
10. QUAL1 In my fire department, firefighters persevere to become more competent.
11. QUAL2 In my fire department, firefighters make significant efforts to use their knowledge, training, and skills.
12. QUAL3 Being a firefighter promotes personal enrichment, self-expression, a sense of accomplishment, social interactions, and a sense of belonging.
13. QUAL4 Being a firefighter means to develop a distinctive identity in society and be part of a group that share values, beliefs, and goals.
14. RWD1 Being a firefighter encourages personal development by developing abilities and knowledge.
15. RWD2 Being a firefighter encourages self-expression by developing abilities and knowledge.
16. RWD3 In my fire department, firefighters see as a reward their contribution to maintaining and developing the group.
17. TPF1 In my fire department, firefighters have the feel competent during fire fighting.
18. TPF2 Fire fighting requires concentration.
19. TPF3 In my fire department, firefighters feel a sense of control during fire fighting.
20. TPF4 In my fire department, firefighters feel a deep sense of involvement during fire fighting.
21. DEWO1 Fire fighting requires abilities, knowledge, and experience or a combination of the three.
22. DEWO2 Fire fighting offers a significant opportunity for creative and innovative work which favors personal expression.
23. DEWO3 Fire fighting allows to demonstrate imagination in the application of abilities and knowledge.
24. TK1 In my fire department, the necessary knowledge for firefighters can be obtained through colleagues.
25. TK2 In my fire department, one way to learn is to work with experienced firefighters.
26. TK3 In my fire department, informal conversations and meetings are used to share knowledge.
27. TK4 In my fire department, knowledge is obtained through relations between colleagues.
28. EK1 In my fire department, knowledge (how to or processes to resolve a problem) can be easily accessed through documents or manuals.
29. EK2 In my fire department, there is a structure training program and its objectives are known by firefighters.
30. EK3 In my fire department, results from projects or meetings are documented.
31. EK4 In my fire department, knowledge is shared by means of documentation such as manuals.
32. KC1 In my fire department, firefighters can propose ideas and new knowledge.
33. KC2 In my fire department, firefighters train regularly on tasks to develop their competencies.
34. KC3 In my fire department, firefighters can propose new ways of doing things.
35. KST1 In my fire department, processes and tools to store knowledge for future use are well organized (for example : data banks, procedure manuals, information cards, library, etc.).

36. KST2 In my fire department, firefighters take part in knowledge storage activities for future use (for example: document classification, review procedures, produce explanatory documents, etc.).
37. KST3 In my fire department, firefighters know where is stored knowledge that can be useful to them.
38. KSH1 In my fire department, experienced firefighters willingly share their knowledge with new firefighters.
39. KSH2 In my fire department, firefighters ask their colleagues to share their skills when they need to learn something new.
40. KSH3 In my fire department, when a firefighter is competent at a task, colleagues will ask him/her to show them how to do it.
41. KSH4 In my fire department, when firefighters learn something new, they share it with their colleagues.
42. KSH5 In my fire department, firefighters benefit the group with competencies developed in their primary occupation (for example: mechanic, carpenter, plumber, etc.).
43. KSH6 In my fire department, firefighters exchange regularly about their ongoing tasks.
44. SUP1 In my fire department, knowledge is shared from either side with services and equipment suppliers.
45. SUP2 In my fire department, knowledge obtained from services or equipment suppliers are incorporated in the department's operations (for example: adjusting ways of doing something, art rules, safety tips, etc.).
46. SUP3 In my fire department, knowledge obtained from service or equipment suppliers is used to innovate (for example: new ways of using a piece of equipment, new work method, etc.).
47. PART1 In my fire department, knowledge is shared reciprocally with partners (for example: public works, police, ambulance).
48. PART2 In my fire department, knowledge obtained from partners (for example: public works, police, ambulance) is incorporated in the department's operations (for example: adjustments to work method, better understanding of the partners' work, etc.).
49. PART3 In my fire department, knowledge obtained from partners (for example: public works, police, ambulance) is used to innovate (for example: new work method, new procedure, etc.).
50. PART4 In my fire department, knowledge is reciprocally shared with mutual aid fire departments.
51. PART5 In my fire department, knowledge obtained from mutual aid fire departments is incorporated in the department's operations (for example: adjusting a work procedure, uniformization of work procedures, etc.).
52. PART6 In my fire department, knowledge obtained from the mutual aid fire departments is used to innovate (for example: new work method, new procedure, etc.).
53. CUST1 In my fire department, firefighters share their knowledge with citizens (for example: explanations, prevention tips, etc.).
54. CUST2 In my fire department, citizens are asked to share their knowledge (for example: information while on emergency scenes.).
55. CUST3 In my fire department, knowledge obtained from citizen is incorporated in the department's operations (for example: adjustments to practices, taking into account client service, etc.).
56. CUST4 In my fire department, knowledge obtain from citizen is used to innovate (for example: updated prevention program, new awareness campaign, etc.).
57. AAR1 In my fire department, high-ranking officers (chiefs) use results from academic or applied research in their decisions.
58. AAR2 In my fire department, results from academic or applied research on the fire service are used to modify current practices and procedures.
59. AAR3 In my fire department, results from academic or applied research on the fire service are incorporated in training.
60. AAR4 In my fire department, results from applied or academic research on the fire service are used to further health and safety in the workplace.
61. AAR5 In my fire department, it is considered important that knowledge from research be known.

ANNEX B: DATA TABLES

Table B1: Levene's test of variance (*t*-test)

Survey scales: *t*-test							
Scale	**Sample**	**Mean**	**SD**	**SE**	***t***	**sig.**	***r***
TM	A	4.100	0.715	0.056	-2.617	$p > .05$	0.150
	B	4.302	0.598	0.051			
IT	A	3.010	1.100	0.086	-5.361	$p < .05$	0.292
	B	3.635	0.922	0.079			
QUAL	A	4.359	0.477	0.037	-0.063	$p > .05$	0.004
	B	4.362	0.432	0.037			
RWD	A	4.519	0.518	0.040	-0.227	$p > .05$	0.013
	B	4.532	0.475	0.041			
TPF	A	4.135	0.615	0.048	-0.957	$p > .05$	0.055
	B	4.201	0.567	0.049			
DEWO	A	3.672	0.968	0.075	-1.207	$p > .05$	0.070
	B	3.802	0.884	0.076			
TK	A	3.985	0.583	0.045	-1.626	$p > .05$	0.094
	B	4.092	0.553	0.047			
EK	A	3.628	0.895	0.070	-3.058	$p < .05$	0.174
	B	3.910	0.654	0.056			
KC	A	3.923	0.876	0.068	-0.415	$p > .05$	0.024
	B	3.964	0.855	0.073			
KST	A	3.263	1.023	0.080	-1.452	$p < .05$	0.082
	B	3.422	0.874	0.075			
KSH	A	4.251	0.533	0.041	0.144	$p > .05$	0.008
	B	4.242	0.575	0.049			
SUP	A	3.488	0.771	0.060	-0.940	$p > .05$	0.054
	B	3.567	0.673	0.058			
PART	A	3.435	0.839	0.065	-2.299	$p > .05$	0.132
	B	3.647	0.734	0.063			
CUST	A	3.556	0.850	0.066	-0.791	$p < .05$	0.046
	B	3.634	0.854	0.073			
AAR	A	3.364	0.859	0.067	-1.549	$p > .05$	0.089
	B	3.506	0.702	0.060			

Table B2: EFA/KM – Total variance explained

EFA/KM - Total Variance Explained							
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
Component	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total
1	16.308	40.571	41.814	16.308	40.571	40.571	11.150
2	2.512	5.339	48.255	2.512	5.339	45.910	12.529
3	2.129	4.283	53.714	2.129	4.283	50.194	11.056
4	1.773	4.547	58.261				
5	1.395	3.576	61.836				
6	1.186	3.042	64.878				
7	1.124	2.883	67.761				
8	.968	2.482	70.243				
9	.843	2.162	72.405				
10	.808	2.072	74.477				
11	.783	2.008	76.485				
12	.686	1.759	78.243				
13	.630	1.615	79.859				
14	.593	1.520	81.379				
15	.554	1.412	82.799				
16	.521	1.336	84.135				
17	.500	1.281	85.416				
18	.472	1.211	86.628				
19	.441	1.130	87.757				
20	.410	1.052	88.809				
21	.402	1.031	89.840				
22	.384	.985	90.826				
23	.347	.,890	91.715				
24	.341	.875	92.590				
25	.306	.785	93.375				
26	.302	.774	94.150				
27	.266	.683	94.833				
28	.250	.641	95.474				
29	.232	.594	96.068				
30	.227	.582	96.650				
31	.203	.521	97.171				
32	.197	.504	97.675				
33	.177	.454	98.129				
34	.172	.440	98.570				
35	.162	.416	98.986				
36	.141	.361	99.347				
37	.099	.254	99.602				
38	.087	.223	99.824				
39	.069	.176	100.000				
Extraction Method: Principal Component Analysis							

Table B3 : KM – Correlation matrix

KM - Correlation Matrix[a]																																						
		Q2	Q3	Q4	Q5	Q8	Q26	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q44	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57	Q58	Q59	Q60	Q61
Correlation	Q2	1,000	.552	.582	.579	.338	.489	.434	.457	.374	.381	.497	.385	.532	.378	.393	.322	.395	.400	.366	.432	.303	.373	.411	.352	.348	.385	.369	.263	.316	.340	.266	.229	.283	.330	.336	.344	.329	.324	.484
	Q3	.552	1.000	.590	.518	.285	.443	.389	.422	.423	.325	.493	.392	.460	.396	.373	.365	.301	.317	.322	.329	.304	.282	.290	.339	.350	.398	.365	.326	.351	.375	.294	.227	.292	.324	.321	.335	.317	.326	.474
	Q4	.582	.590	1.000	.585	.357	.483	.527	.494	.438	.434	.462	.463	.524	.377	.409	.408	.381	.430	.434	.477	.307	.330	.295	.417	.339	.373	.393	.390	.389	.443	.368	.188	.324	.389	.405	.406	.380	.340	.462
	Q5	.579	.518	.585	1.000	.320	.446	.348	.413	.404	.366	.539	.408	.566	.355	.348	.382	.323	.354	.319	.428	.264	.387	.365	.399	.391	.398	.395	.345	.353	.438	.346	.290	.362	.374	.412	.419	.377	.371	.472
	Q8	.338	.285	.357	.320	1.000	.466	.370	.342	.372	.359	.301	.304	.378	.421	.467	.410	.292	.275	.262	.349	.268	.367	.361	.348	.332	.334	.325	.395	.392	.394	.348	.284	.297	.423	.312	.291	.297	.293	.353
	Q26	.489	.443	.483	.446	.466	1,000	.380	.436	.477	.404	.435	.439	.453	.347	.469	.383	.344	.376	.351	.435	.292	.422	.297	.373	.391	.427	.409	.366	.411	.443	.356	.262	.345	.402	.378	.365	.338	.346	.472
	Q28	.434	.389	.527	.348	.370	.380	1.000	.574	.567	.640	.421	.369	.465	.632	.541	.574	.280	.442	.398	.443	.322	.406	.287	.364	.396	.391	.419	.462	.465	.477	.259	.143	.239	.355	.330	.364	.330	.318	.379
	Q29	.457	.422	.494	.413	.342	.436	.574	1.000	.675	.625	.406	.359	.465	.603	.502	.480	.285	.332	.335	.314	.263	.358	.267	.295	.335	.362	.414	.399	.353	.390	.314	.214	.327	.357	.369	.398	.373	.330	.457
	Q30	.374	.423	.438	.404	.372	.477	.567	.675	1.000	.642	.428	.390	.484	.631	.575	.602	.281	.333	.311	.396	.297	.426	.336	.370	.332	.426	.440	.443	.458	.453	.357	.245	.375	.418	.419	.438	.420	.374	.451
	Q31	.381	.325	.434	.366	.359	.404	.640	.625	.642	1.000	.354	.343	.434	.640	.562	.494	.242	.305	.289	.364	.275	.397	.323	.372	.389	.404	.417	.433	.450	.472	.277	.151	.242	.312	.436	.436	.416	.341	.386
	Q32	.497	.493	.462	.539	.301	.435	.421	.406	.428	.354	1.000	.406	.817	.319	.337	.366	.445	.423	.422	.487	.423	.382	.319	.368	.344	.417	.390	.293	.336	.413	.381	.275	.289	.378	.380	.380	.341	.350	.437
	Q33	.385	.392	.463	.408	.304	.439	.369	.359	.390	.343	.406	1.000	.484	.328	.386	.310	.331	.412	.402	.448	.280	.421	.250	.428	.342	.362	.389	.270	.274	.324	.345	.225	.308	.360	.327	.294	.346	.238	.391
	Q34	.532	.460	.524	.566	.378	.453	.465	.465	.484	.434	.817	.484	1.000	.353	.411	.428	.442	.460	.451	.530	.434	.469	.365	.461	.388	.438	.411	.349	.423	.489	.372	.256	.336	.438	.460	.427	.370	.378	.508
	Q35	.378	.396	.377	.355	.421	.347	.632	.603	.631	.640	.319	.328	.353	1.000	.662	.671	.248	.261	.244	.299	.253	.400	.319	.303	.404	.442	.441	.384	.398	.370	.238	.208	.307	.333	.374	.360	.362	.325	.352
	Q36	.393	.373	.409	.348	.467	.469	.541	.502	.575	.562	.337	.386	.411	.662	1.000	.649	.289	.300	.302	.383	.293	.455	.335	.368	.408	.464	.476	.376	.395	.418	.309	.218	.324	.412	.350	.381	.370	.375	.469
	Q37	.322	.365	.408	.382	.410	.383	.574	.480	.602	.494	.366	.310	.428	.687	.649	1.000	.269	.359	.401	.419	.357	.425	.330	.250	.367	.404	.402	.389	.403	.437	.319	.280	.332	.428	.375	.379	.327	.349	.357
	Q38	.395	.301	.381	.323	.292	.344	.280	.285	.281	.242	.445	.331	.442	.248	.289	.269	1.000	.558	.522	.592	.417	.281	.304	.354	.340	.397	.411	.329	.288	.318	.364	.283	.292	.305	.298	.284	.307	.323	.332
	Q39	.400	.317	.430	.354	.275	.376	.442	.332	.333	.305	.423	.412	.460	.261	.300	.359	.558	1.000	.630	.598	.410	.373	.332	.406	.450	.506	.499	.388	.401	.414	.402	.353	.397	.450	.364	.355	.298	.251	.329
	Q40	.366	.322	.434	.319	.262	.351	.398	.335	.311	.289	.422	.402	.451	.244	.302	.401	.522	.630	1.000	.647	.455	.292	.323	.340	.377	.402	.420	.372	.321	.353	.403	.277	.316	.338	.309	.304	.266	.284	.324
	Q41	.432	.329	.477	.428	.349	.435	.443	.314	.396	.364	.487	.448	.530	.299	.383	.419	.592	.598	.647	1.000	.498	.390	.351	.417	.389	.468	.454	.427	.397	.403	.444	.316	.360	.410	.390	.387	.337	.364	.429
	Q42	.303	.304	.307	.264	.268	.292	.322	.263	.297	.275	.423	.280	.434	.253	.293	.357	.417	.410	.455	.498	1.000	.338	.259	.309	.329	.310	.285	.337	.286	.296	.241	.204	.274	.318	.206	.169	.186	.222	.343
	Q44	.373	.282	.330	.387	.367	.422	.406	.358	.426	.397	.382	.421	.469	.400	.455	.425	.281	.373	.292	.390	.338	1.000	.593	.603	.567	.517	.499	.487	.493	.503	.377	.337	.456	.448	.535	.496	.536	.500	.478
	Q45	.411	.290	.295	.365	.361	.297	.287	.267	.336	.323	.319	.250	.365	.319	.335	.330	.304	.332	.323	.351	.529	.593	1.000	.647	.365	.377	.376	.394	.401	.391	.360	.400	.373	.358	.367	.393	.403	.429	.388
	Q46	.352	.339	.417	.399	.348	.373	.364	.295	.370	.372	.368	.428	.461	.303	.368	.250	.354	.406	.340	.417	.309	.603	.647	1.000	.430	.430	.447	.408	.478	.473	.436	.310	.416	.492	.491	.521	.533	.511	.517
	Q47	.348	.350	.339	.391	.332	.391	.396	.335	.332	.389	.344	.342	.388	.404	,408	.367	.340	.450	.377	.389	.329	.567	.365	.430	1.000	.797	.761	.537	.527	.516	.378	.307	.413	.460	.477	.480	.455	.444	.387
	Q48	.385	.398	.373	.398	.334	.427	.391	.362	.426	.404	.417	.362	.438	.442	.464	.404	.397	.506	.402	.468	.310	.517	.377	.430	.797	1.000	.873	.523	.550	.532	.438	.353	.484	.537	.502	.528	.507	.483	.464
	Q49	.369	.365	.393	.395	.325	.409	.419	.414	.440	.417	.390	.389	.411	.441	.476	.402	.411	.499	.420	.454	.285	.499	.376	.447	.761	.873	1.000	.543	.531	.548	.417	.386	.485	.544	.468	.502	.459	.457	.399
	Q50	.263	.326	.390	.345	.395	.366	.462	.399	.443	.433	.293	.270	.349	.384	.376	.389	.329	.388	.372	.427	.337	.487	.394	.408	.537	.523	.543	1.000	.785	.758	.354	.275	.326	.368	.343	.381	.371	.417	.373
	Q51	.316	.351	.389	.353	.392	.411	.465	.353	.458	.450	.336	.274	.423	.398	.395	.403	.288	.401	.321	.397	.286	.493	.401	.478	.521	.550	.531	.785	1.000	.870	.363	.265	.297	.440	.413	.431	.435	.417	.413
	Q52	.340	.375	.443	.438	.394	.443	.477	.390	.453	.472	.413	.324	.489	.370	.418	.437	.318	.414	.353	.403	.296	.503	.391	.478	.516	.532	.548	.758	.870	1.000	.374	.253	.341	.460	.438	.432	.413	.424	.446
	Q53	.266	.294	.368	.346	.348	.356	.259	.314	.357	.277	.381	.345	.372	.238	.309	.319	.364	.402	.403	.444	.241	.377	.360	.436	.378	.438	.417	.354	.363	.374	1.000	.411	.457	.505	.463	.475	.454	.414	.418
	Q54	.229	.227	.188	.290	.284	.262	.143	.214	.245	.151	.275	.225	.256	.208	.218	.280	.283	.353	.277	.316	.204	.337	.400	.310	.307	.353	.386	.275	.265	.253	.411	1.000	.655	.552	.328	.385	.337	.388	.327
	Q55	.283	.292	.324	.362	.297	.345	.239	.327	.375	.242	.289	.308	.336	.307	.324	.332	.292	.397	.316	.360	.274	.456	.373	.416	.413	.484	.485	.326	.297	.341	.457	.655	1.000	.732	.438	.448	.389	.422	.398
	Q56	.330	.324	.389	.374	.423	.402	.355	.357	.418	.312	.378	.360	.438	.333	.412	.428	,305	.450	.338	.410	.318	.448	.358	.492	.460	.537	.544	.368	.440	.460	.505	.552	.732	1.000	.545	.569	.495	.512	.504
	Q57	.336	.321	.405	.412	.312	.378	.330	.369	.419	.436	.380	.327	.460	.374	.350	.375	.298	.364	.309	.390	.206	.535	.367	.491	.477	.502	.468	.343	.413	.438	.463	.328	.438	.545	1.000	.889	.789	,699	.619
	Q58	.344	.335	.406	.419	.291	.365	.364	.398	.438	.436	.380	.294	.427	.360	.381	.379	.284	.355	.304	.387	.169	.496	.393	.521	.480	.528	.502	.381	.431	.432	.475	.385	.448	.569	.889	1.000	.858	.765	.592
	Q59	.329	.317	.380	.377	.297	.338	.330	.373	.420	.416	.341	.346	.370	.362	.370	.327	.307	.298	.266	.337	.186	.536	.403	.533	.455	.507	.459	.371	.435	.413	.454	.337	.389	.495	.789	.858	1.000	.757	.586
	Q60	.324	.326	.340	.371	.293	.346	.318	.330	.374	.341	.350	.238	.378	.325	.375	.349	.323	.251	.284	.364	.222	.500	.429	.511	.444	.483	.457	.417	.417	.424	.414	.388	.422	.512	.699	.765	.757	1.000	.643
	Q61	.484	.474	.462	.472	.353	.472	.379	.457	.451	.386	.437	.391	.508	.352	.469	.357	.332	.329	.324	.429	.343	.478	.388	.517	.387	.464	.399	.373	.413	.446	.418	.327	.398	.504	.619	.592	.586	.643	1.000

Sig. (1-tailed)	Q2		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q3	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q4	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000	.000	.000
	Q5	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q8	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q26	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q28	,000	,000	,000	,000	,000	,000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q29	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q30	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q31	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.004	.000	.000	.000	.000	.000	.000	.000
	Q32	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q33	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q34	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q35	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q36	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q37	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q38	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q39	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q40	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	,000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q41	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q42	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.002	.001	.000	.000	.000	.000
	Q44	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q45	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q46	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q47	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q48	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q49	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q50	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	,000	,000	,000	,000	,000	,000	,000	,000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q51	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	,000	,000	,000	,000	,000	,000	,000	,000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q52	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000		,000	,000	,000	,000	,000	,000	,000	,000	,000
	Q53	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q54	.000	.000	.001	.000	.000	.000	.007	.000	.000	.004	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000	.000
	Q55	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000	.000
	Q56	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000
	Q57	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000
	Q58	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.002	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000
	Q59	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000	.000
	Q60	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000		.000	.000
	Q61	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	

a. Determinant = 4,56E-014

Table B4 : KM – Communalities matrix

KM - Communialities Matrix		
	Initial	Extraction
TM1. In my fire department, high-ranking officers (chiefs) believe it is important to encourage firefighters to share their knowledge with colleagues.	.587	.431
TM2. In my fire department, high-ranking officers (chiefs) adjust training after problems were encountered in operations to help firefighters improve.	.525	.375
TM3. In my fire department, high-ranking officers (chiefs) are aware of innovations in the fire service and they inform firefighters about it.	.614	.489
TM4. In my fire department, high-ranking officers (chiefs) foster innovation and change.	.556	.415
IT3. In my fire department, firefighters regularly use information technologies in their tasks (for example during inventory, report writing, etc.).	.420	.303
TK3. In my fire department, informal conversations and meetings are used to share knowledge.	.495	.414
EK1. In my fire department, knowledge (how to or processes to resolve a problem) can be easily accessed through documents or manuals.	.652	.600
EK2. In my fire department, there is a structure training program and its objectives are known by firefighters.	.634	.548
EK3. In my fire department, results from projects or meetings are documented.	.658	.616
EK4. In my fire department, knowledge is shared by means of documentation such as manuals.	.631	.610
KC1. In my fire department, firefighters can propose ideas and new knowledge.	.729	.493
KC2. In my fire department, firefighters train regularly on tasks to develop their competencies.	.464	.353
KC3. In my fire department, firefighters can propose new ways of doing things.	.769	.570
KST1. In my fire department, processes and tools to store knowledge for future use are well organized (for example : data banks, procedure manuals, information cards, library, etc.).	.720	.670
KST2. In my fire department, firefighters take part in knowledge storage activities for future use (for example : document classification, review procedures, produce explanatory documents, etc.).	.633	.554
KST3. In my fire department, firefighters know where is stored knowledge that can be useful to them.	.669	.513
KSH1. In my fire department, experienced firefighters willingly share their knowledge with new firefighters.	.509	.447
KSH2. In my fire department, firefighters ask their colleagues to share their skills when they need to learn something new.	.606	.537
KSH3. In my fire department, when a firefighter is competent at a task , colleagues will ask him/her to show them how to do it.	.580	.504
KSH4. In my fire department, when firefighters learn something new, they share it with their colleagues.	.637	.593
KSH5. In my fire department, firefighters benefit the group with competencies developed in their primary occupation (for example : mechanic, carpenter, plumber, etc.).	.417	.331
SUP1. In my fire department, knowledge is shared from either side with services and equipment suppliers.	.655	.500
SUP2. In my fire department, knowledge obtained from services or equipment suppliers are incorporated in the department's operations (for example: adjusting ways of doing something, art rules, safety tips, etc.).	.592	.344
SUP3. In my fire department, knowledge obtained from service or equipment suppliers is used to innovate (for example: new ways of using a piece of equipment, new work method, etc.).	.661	.479
PART1. In my fire department, knowledge is shared reciprocally with partners (for example: public works, police, ambulance).	.718	.471
PART2. In my fire department, knowledge obtained from partners (for example: public works, police, ambulance) is incorporated in the department's operations (for example: adjustments to work method, better understanding of the partners' work, etc.).	.841	.556
PART3. In my fire department, knowledge obtained from partners (for example: public works, police, ambulance) is used to innovate (for example: new work method, new procedure, etc.).	.815	.533
PART4. In my fire department, knowledge is reciprocally shared with mutual aid fire departments.	.726	.415
PART5. In my fire department, knowledge obtained from mutual aid fire departments is incorporated in the department's operations (for example: adjusting a work procedure, uniformization of work procedures, etc.).	.829	.459
PART6. In my fire department, knowledge obtained from the mutual aid fire departments is used to innovate (for example: new work method, new procedure, etc.).	.818	.489
CUST1. In my fire department, firefighters share their knowledge with citizens (for example: explanations, prevention tips, etc.).	.437	.389
CUST2. In my fire department, citizens are asked to share their knowledge (for example: information while on emergency scenes.).	.545	.319
CUST3. In my fire department, knowledge obtained from citizen is incorporated in the department's operations (for example: adjustments to practices, taking into account client service, etc.).	.687	.422
CUST4. In my fire department, knowledge obtain from citizen is used to innovate (for example: updated prevention program, new awareness campaign, etc.).	.704	.535
AAR1. In my fire department, high-ranking officers (chiefs) use results from academic or applied research in their decisions.	.845	.679
AAR2. In my fire department, results from academic or applied research on the fire service are used to modify current practices and procedures.	.889	.764
AAR3. In my fire department, results from academic or applied research on the fire service are incorporated in training.	.802	.702
AAR4. In my fire department, results from applied or academic research on the fire service are used to further health and safety in the workplace.	.711	.644
AAR5. In my fire department, it is considered important that knowledge from research be known.	.646	.502
Extraction Method: Principal Component		

Table B5 : KM – Structure matrix

KM - Structure Matrix			
	Factors		
	1	2	3
KSH4. In my fire department, when firefighters learn something new, they share it with their colleagues.	,767	-,496	-,432
KSH2. In my fire department, firefighters ask their colleagues to share their skills when they need to learn something new.	,727	-,479	-,373
KC3. In my fire department, firefighters can propose new ways of doing things.	,724	-,512	-,559
KSH3. In my fire department, when a firefighter is competent at a task , colleagues will ask him/her to show them how to do it.	,710	-,405	-,361
KC1. In my fire department, firefighters can propose ideas and new knowledge.	,688	-,450	-,482
KSH1. In my fire department, experienced firefighters willingly share their knowledge with new firefighters.	,664	-,408	-,306
TM3. In my fire department, high-ranking officers (chiefs) are aware of innovations in the fire service and they inform firefighters about it.	,635	-,457	-,584
TM1. In my fire department, high-ranking officers (chiefs) believe it is important to encourage firefighters to share their knowledge with colleagues.	,613	-,419	-,522
TM4. In my fire department, high-ranking officers (chiefs) foster innovation and change.	,591	-,494	-,505
KSH5. In my fire department, firefighters benefit the group with competencies developed in their primary occupation (for example : mechanic, carpenter, plumber, etc.).	,571	-,315	-,348
TK3. In my fire department, informal conversations and meetings are used to share knowledge.	,565	-,479	-,546
KC2. In my fire department, firefighters train regularly on tasks to develop their competencies.	,565	-,413	-,447
TM2. In my fire department, high-ranking officers (chiefs) adjust training after problems were encountered in operations to help firefighters improve.	,546	-,409	-,522
AR2. In my fire department, results from academic or applied research on the fire service are used to modify current practices and procedures.	,375	-,861	-,472
AR3. In my fire department, results from academic or applied research on the fire service are incorporated in training.	,344	-,821	-,456
AR1. In my fire department, high-ranking officers (chiefs) use results from academic or applied research in their decisions.	,395	-,818	-,463
AR4. In my fire department, results from applied or academic research on the fire service are used to further health and safety in the workplace.	,365	-,795	-,420
CU4. In my fire department, knowledge obtain from citizen is used to innovate (for example: updated prevention program, new awareness campaign, etc.).	,532	-,716	-,425
PA2. In my fire department, knowledge obtained from partners (for example: public works, police, ambulance) is incorporated in the department's operations (for example: adjustments to work method, better understanding of the partners' work, etc.).	,579	-,708	-,518
PA3. In my fire department, knowledge obtained from partners (for example: public works, police, ambulance) is used to innovate (for example: new work method, new procedure, etc.).	,576	-,683	-,527
SU1. In my fire department, knowledge is shared from either side with services and equipment suppliers.	,488	-,681	-,516
AR5. In my fire department, it is considered important that knowledge from research be known.	,515	-,677	-,520
SU3. In my fire department, knowledge obtained from service or equipment suppliers is used to innovate (for example: new ways of using a piece of equipment, new work method, etc.).	,525	-,669	-,423
PA1. In my fire department, knowledge is shared reciprocally with partners (for example: public works, police, ambulance).	,522	-,653	-,484
CU3. In my fire department, knowledge obtained from citizen is incorporated in the department's operations (for example: adjustments to practices, taking into account client service, etc.).	,480	-,629	-,326
PA6. In my fire department, knowledge obtained from the mutual aid fire departments is used to innovate (for example: new work method, new procedure, etc.).	,532	-,608	-,597
PA5. In my fire department, knowledge obtained from mutual aid fire departments is incorporated in the department's operations (for example: adjusting a work procedure, uniformization of work procedures, etc.).	,484	-,602	-,577
CU1. In my fire department, firefighters share their knowledge with citizens (for example: explanations, prevention tips, etc.).	,514	-,590	-,338
SU2. In my fire department, knowledge obtained from services or equipment suppliers are incorporated in the department's operations (for example: adjusting ways of doing something, art rules, safety tips, etc.).	,454	-,560	-,388
PA4. In my fire department, knowledge is reciprocally shared with mutual aid fire departments.	,488	-,559	-,553
CU2. In my fire department, citizens are asked to share their knowledge (for example: information while on emergency scenes.).	,408	-,531	
KST1. In my fire department, processes and tools to store knowledge for future use are well organized (for example : data banks, procedure manuals, information cards, library, etc.).	,350	-,423	-,813
EK3. In my fire department, results from projects or meetings are documented.	,457	-,496	-,780
EK4. In my fire department, knowledge is shared by means of documentation such as manuals.	,388	-,455	-,778
EK1. In my fire department, knowledge (how to or processes to resolve a problem) can be easily accessed through documents or manuals.	,504	-,406	-,763
KST2. In my fire department, firefighters take part in knowledge storage activities for future use (for example : document classification, review procedures, produce explanatory documents, etc.).	,437	-,475	-,739
EK2. In my fire department, there is a structure training program and its objectives are known by firefighters.	,450	-,427	-,737
KST3. In my fire department, firefighters know where is stored knowledge that can be useful to them.	,461	-,444	-,708
IT3. In my fire department, firefighters regularly use information technologies in their tasks (for example during inventory, report writing, etc.).	,433	-,428	-,499
Extraction Method : Principal Component Analysis. Rotation Method : Oblimin with Kaiser normalization.			

Table B6: KM Pattern matrix

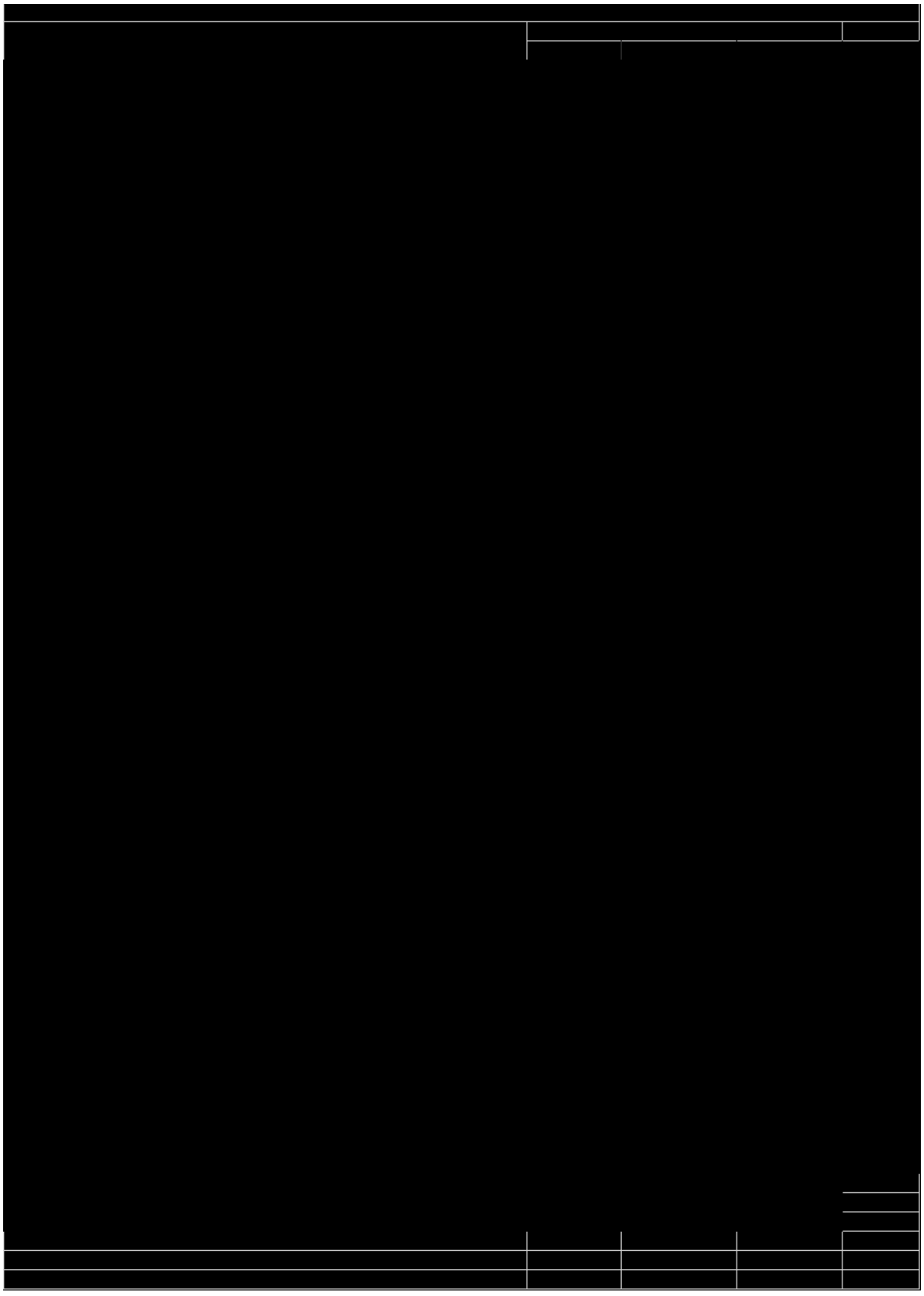


Table B7: KM – Component correlation matrix

Component Correlation Matrix			
Component	1	2	3
1	1,000	-,570	-,527
2	-,570	1,000	,541
3	-,527	,541	1,000

Extraction Method : Principal Component Analysis.
Rotation Method : Oblimin with Kaiser normalization.

Table B8: SL – Correlation matrix

SL/Correlation Matrix[a]												
		Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q20	Q22	Q23
Correlation	Q10	1.000	.640	.219	.238	.301	.287	.344	.281	.322	.177	.153
	Q11	.640	1.000	.220	.247	.369	.345	.341	.324	.311	.243	.253
	Q12	.219	.220	1.000	.520	.569	.463	.278	.345	.314	.130	.089
	Q13	.238	.247	.520	1.000	.534	.569	.363	.346	.347	.210	.235
	Q14	.301	.369	.569	.534	1.000	.725	.287	.291	.286	.231	.229
	Q15	.287	.345	.463	.569	.725	1.000	.423	.311	.375	.291	.233
	Q16	.344	.341	.278	.363	.287	.423	1.000	.436	.485	.246	.245
	Q17	.281	.324	.345	.346	.291	.311	.436	1.000	.521	.147	.177
	Q20	.322	.311	.314	.347	.286	.375	.485	.521	1.000	.199	.155
	Q22	.177	.243	.130	.210	.231	.291	.246	.147	.199	1.000	.689
	Q23	.153	.253	.089	.235	.229	.233	.245	.177	.155	.689	1.000
Sig. (1-tailed)	Q10		.000	.000	.000	.000	.000	.000	.000	.000	.001	.004
	Q11	.000		.000	.000	.000	.000	.000	.000	.000	.000	.000
	Q12	.000	.000		.000	.000	.000	.000	.000	.000	.012	.062
	Q13	.000	.000	,000		.000	.000	.000	.000	.000	.000	.000
	Q14	.000	.000	.000	.000		.000	.000	.000	.000	.000	.000
	Q15	.000	.000	.000	.000	.000		.000	.000	.000	.000	.000
	Q16	.000	.000	.000	.000	.000	.000		.000	.000	.000	.000
	Q17	.000	.000	.000	.000	.000	.000	.000		.000	.005	.001
	Q20	.000	.000	.000	.000	.000	.000	.000	.000		.000	.004
	Q22	.001	.000	.012	.000	.000	.000	.000	.005	.000		.000
	Q23	.004	.000	.062	.000	.000	.000	.000	.001	.004	.000	

a. Determinant = .013

Table B9: SL – Communalities matrix

SL - Communalities		
	Initial	Extraction
QU1. In my fire department, firefighters persevere to become more competent.	.438	.487
QU2. In my fire department, firefighters make significant efforts to use their knowledge, training, and skills.	.474	.498
QU3. Being a firefighter promotes personal enrichment, self-expression, a sense of accomplishment, social interactions, and a sense of belonging.	.412	.468
QU4. Being a firefighter means to develop a distinctive identity in society and be part of a group that share values, beliefs, and goals.	.442	.513
RW1. Being a firefighter encourages personal development by developing abilities and knowledge.	.621	.646
RW2. Being a firefighter encourages self-expression by developing abilities and knowledge.	.615	.647
RW3. In my fire department, firefighters see as a reward their contribution to maintaining and developing the group.	.374	.382
TF1. In my fire department, firefighters have the feel competent during fire fighting.	.361	.344
TF4. In my fire department, firefighters feel a deep sense of involvement during fire fighting.	.390	.378
DW2. Fire fighting offers a significant opportunity for creative and innovative work which favors personal expression.	.500	.655
DW3. Fire fighting allows to demonstrate imagination in the application of abilities and knowledge.	.503	.723
Extraction Method: Principal Component		

Table B10: EFA/SL – Total variance explained

EFA/SL - Total Variance Explained							
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
Component	Total	% of variance	%	Total	% of variance	%	Total
1	4.325	39.314	39.314	4.325	39.314	39.314	3.216
2	1.459	13.263	52.577	1.459	13.263	52.577	1.905
3	1.266	11.514	64.090	1.266	11.514	64.090	2.943
4	1.014	9.214	73.304				
5	.614	5.581	78.885				
6	.512	4.657	83.542				
7	.480	4.361	87.903				
8	.464	4.221	92.124				
9	.342	3.108	95.232				
10	.304	2.759	97.991				
11	.221	2.009	100.000				
Extraction Method: Principal Component Analysis							

Table B11: SL Structure matrix

SL Structure Matrix			
	Factors		
	1	2	3
RW1. Being a firefighter encourages personal development by developing abilities and knowledge.	.802		.448
RW2. Being a firefighter encourages self-expression by developing abilities and knowledge.	.789	.316	.495
QU4. Being a firefighter means to develop a distinctive identity in society and be part of a group that share values, beliefs, and goals.	.714		.430
QU3. Being a firefighter promotes personal enrichment, self-expression, a sense of accomplishment, social interactions, and a sense of belonging.	.679		.383
DW3. Fire fighting allows to demonstrate imagination in the application of abilities and knowledge.		.850	
DW2. Fire fighting offers a significant opportunity for creative and innovative work which favors personal expression.		.808	
QU2. In my fire department, firefighters make significant efforts to use their knowledge, training, and skills.	.353		.701
QU1. In my fire department, firefighters persevere to become more competent.	.312		.691
RW3. In my fire department, firefighters see as a reward their contribution to maintaining and developing the group.	.458		.597
TF4. In my fire department, firefighters feel a deep sense of involvement during fire fighting.	.459		.596
TF1. In my fire department, firefighters have the feel competent during fire fighting.	.446		.565
Extraction Method: Principal Component Analysis. Rotation Method: Oblimin with Kaiser normalization			

Table B12: SL Pattern matrix

Pattern Matrix[a]				
	Factors			
	1- Personal development	2- Creativity	3- Commitment	Communality
RWD1. Being a firefighter encourages personal development by developing abilities and knowledge.	**.800**	.049	-.020	.62
RWD2. Being a firefighter encourages self-expression by developing abilities and knowledge.	**.749**	.088	.0417	.62
QUAL3. Being a firefighter promotes personal enrichment, self-expression, a sense of accomplishment, social interactions, and a sense of belonging.	**.692**	-.089	.022	.42
QUAL4. Being a firefighter means to develop a distinctive identity in society and be part of a group that share values, beliefs, and goals.	**.685**	.050	.026	.44
DEWO3. Fire fighting allows to demonstrate imagination in the application of abilities and knowledge.	-.010	**.852**	.003	.50
DEWO2. Fire fighting offers a significant opportunity for creative and innovative work which favors personal expression.	.027	**.797**	.012	.50
QUAL1. In my fire department, firefighters persevere to become more competent.	-.112	-.022	**.761**	.44
QUAL2. In my fire department, firefighters make significant efforts to use their knowledge, training, and skills.	-.073	.073	**.718**	.47
TPF4. In my fire department, firefighters feel a deep sense of involvement during fire fighting.	.182	-.020	**.500**	.39
RWD3. In my fire department, firefighters see as a reward their contribution to maintaining and developing the group.	.166	.075	**.478**	.37
TPF1. In my fire department, firefighters have the feeling of being competent during fire fighting.	.190	-.031	**.468**	.36
Eigenvalue	4.325	1.459	1.266	
% of variance	39.314	13.263	11.514	
α	.833	.816	.763	
Extraction Method: Principal axis factoring				
Rotation Method: Oblique				
a. Rotation converged in 6 iterations				

Table B13: SL – Component correlation matrix

Component Correlation Matrix			
Component	1	2	3
1	1,000	,285	,565
2	,285	1,000	,335
3	,565	,335	1,000
Extraction Method : Principal Component Analysis. Rotation Method : Oblimin with Kaiser normalization.			

ANNEX C: INTERVIEWS' SCRIPTS, CONFIDENTIALITY/ETHICAL FORM

Guide d'entrevue – gestionnaires des services d'incendie

Merci de participer à cette entrevue qui a pour but de:

- Comprendre les stratégies et les pratiques de gestion des connaissances de votre service d'incendie
- Recueillir votre perception quant à l'impact des stratégies de gestion des connaissances sur le service aux citoyens
- Identifier les sources de connaissances de votre service d'incendie
- Comprendre si la culture des pompiers a des effets sur la gestion des connaissances

Questions sur l'individu:

a) Quel est votre grade au service?
b) Depuis combien de temps êtes-vous pompier?
c) Pourquoi avez-vous joint le service d'incendie?

1. La gestion des connaissances dans votre service d'incendie

1.1 Pourriez-vous me nommer toutes les sources de connaissances utiles aux pompiers?

1.2 Comment gère-t-on le maintien et le développement des compétences au service?

1.3 À quoi peut-on attribuer le fait que les pompiers partagent beaucoup leurs connaissances entre eux?

1.4 Arrive-t-il que les pompiers fassent des apprentissages jugés importants lors d'interventions ou à d'autres moments? Si oui, lorsque des apprentissages importants, voire cruciaux, sont faits par les pompiers, consignez-vous les connaissances pour en garder des traces?

1.5 Comment votre service développe-t-il les connaissances nécessaires pour faire face aux différents risques auxquels il est confronté?

1.6 Quels sont les enjeux relatifs à la gestion des connaissances dans votre service? (Pérennité, développement, perte, maintien, etc.).

1.7 Quel est le principal défi ou la principale difficulté que vous rencontrez dans la gestion des connaissances de votre personnel?

1.8 Est-ce que votre service a mis en place un programme de formation et d'entraînement structuré? Si oui, est-ce que le service dispose d'infrastructures d'entraînement? (S'il y a une infrastructure) Voyez-vous un impact de l'entraînement dans une cette infrastructure sur le service aux citoyens?

1.9 Comment mesurez-vous l'amélioration des services aux citoyens?

2. La culture organisationnelle de la sécurité incendie

2.1 Qu'est-ce qui caractérise principalement la culture des pompiers?

2.2 Est-ce que ces caractéristiques aident ou nuisent au développement des connaissances chez les pompiers?

2.3 Quelles sont les caractéristiques qui favorisent le développement des connaissances?

2.4 Quelles sont les caractéristiques qui nuisent au développement des connaissances?

3. Se comparer aux autres services

3.1 Qu'est-ce qui vous différencie des autres services d'incendie dans la gestion des connaissances de votre personnel?

3.2 Est-ce qu'il y a une façon de faire en gestion des connaissances d'un autre service d'incendie que vous souhaiteriez importer dans votre service?

3.3 Est-ce que les services partagent leurs connaissances entre eux? Si oui, qu'elles connaissances avez-vous transférées ou partagées?

3.4 Par rapport aux autres services d'incendie, est-ce que votre service se positionne davantage en leader ou en suiveur relativement au développement des connaissances? Pouvez-vous donner des exemples?

3.5 Souhaiteriez-vous qu'il y ait davantage de partage de connaissance entre les services d'incendie? Si oui, de quelle(s) façon(s) est-ce que ce serait faisable, selon vous?

4. Les sources externes de connaissances

4.1 Comme tous les rapports sur les décès de pompiers au Québec, le rapport du Coroner relativement à l'incendie de l'Ile-Verte identifie des problématiques liées à la gestion des connaissances comme des causes de cette tragédie. Quel a été l'impact de cet événement sur votre gestion des connaissances?

4.2 Est-ce que vous intégrez les résultats de la recherche académique ou appliquée dans la gestion de votre service? Si oui, comment le faites-vous? Si non, comment cela pourrait-il se faire?

4.3 Quelle place faites-vous à l'innovation au service?

5. Maturation du management des connaissances

5.1 Quelle place faites-vous à l'amélioration continue au sein de votre service?

5.2 Depuis les dix dernières années, jugez-vous que votre service a progressé en termes de connaissances? Si oui, comment?

5.3 Y aurait-il même place à l'innovation?

5.2 Comme gestionnaire du service, avez-vous dû développer des connaissances particulières et, si oui, lesquelles? Si non, pourquoi?

5.3 Est-ce qu'il y a des connaissances que vous auriez apprécié recevoir lorsque vous avez été promu à votre poste?

5.4 Est-ce que votre service dispose de plans de développement professionnel pour son personnel?

5.5 Qu'est-ce que vous souhaiteriez réaliser en gestion des connaissances de votre personnel que vous n'êtes pas en mesure de faire présentement?

5.6 Souhaitez-vous apporter des améliorations à votre façon de gérer les connaissances pour votre personnel?

5.7 Ce que vous venez de me décrire pourrait-il devenir des objectifs dans une planification stratégique?

5.8 En quelques mots, quel serait le service d'incendie idéal?

L'entrevue est terminée. Est-ce qu'il y a d'autres informations ou commentaires que vous souhaitez partager à propos de la gestion des connaissances dans votre service d'incendie? Si, toutefois, j'avais des précisions à vous demander, puis-je vous contacter de nouveau?

Guide d'entrevue – pompiers et officiers

Merci de participer à cette entrevue qui a pour but de:

- Comprendre les stratégies et les pratiques de gestion des connaissances de votre service d'incendie
- Recueillir votre perception quant à l'impact des stratégies de gestion des connaissances sur le service aux citoyens
- Identifier les sources de connaissances de votre service d'incendie
- Comprendre si la culture des pompiers a des effets sur la gestion des connaissances

Questions sur l'individu:

d) Quel est votre grade au service?
e) Depuis combien de temps êtes-vous pompier?
f) Pourquoi avez-vous joint le service d'incendie?

1. Quelles sont les principales sources de connaissances dans votre service?

1.1 Quelles sont les sources de connaissances sur la sécurité incendie les plus importantes pour vous?

1.2 Si vous cherchez à connaître quelque chose sur la sécurité incendie, quelle est la première source d'information que vous consultez?

1.3 Est-ce que les connaissances sont facilement accessibles dans votre service?

1.4 Qu'est-ce qui vous a été transmis comme connaissances à votre arrivée au service? Par qui?

1.5 Est-ce que le service s'assure de transférer les connaissances d'un pompier à l'autre? Si oui, comment?

1.6 À quoi peut-on attribuer le fait que les pompiers partagent beaucoup leurs connaissances entre eux?

1.7 Est-ce que votre service a mis en place un programme de formation structuré? Si oui, est-ce que le service dispose d'infrastructures d'entraînement? (S'il y a une infrastructure) Voyez-vous un impact de l'entraînement dans une cette infrastructure sur le service aux citoyens?

1.8 Quels sont les apprentissages les plus importants que vous avez faits en joignant le service?

1.9 Y a-t-il d'autres apprentissages que vous souhaiteriez faire? Si oui, en avez-vous parlé avec votre gestionnaire?

1.10 Est-ce que les gestionnaires du service vous informent des nouveautés en sécurité incendie?

2. Quel est l'impact de la culture organisationnelle de la sécurité incendie sur la gestion des connaissances dans votre service?

2.1 Qu'est-ce qui caractérise principalement la culture des pompiers?

2.2 Est-ce que ces caractéristiques aident ou nuisent au développement des connaissances chez les pompiers?

2.3 Quelles sont les caractéristiques qui favorisent le développement des connaissances?

2.4 Quelles sont les caractéristiques qui nuisent au développement des connaissances?

2.3 On dit des pompiers qu'ils doivent déployer un effort significatif pour maîtriser un ensemble important de connaissances. Êtes-vous d'accord?

3. Quelles sont les pratiques concrètes mises en place dans votre service pour gérer les connaissances?

3.1 Est-ce que le partage des connaissances est encouragé entre les pompiers? Si oui, comment cela se fait-il?

3.2 Est-ce que les connaissances essentielles pour réaliser les opérations sont documentées et facilement accessibles? Si oui, de quelles manières?

3.3 Est-ce que votre service utilise un système de commandement? Si oui, est-ce que tous les pompiers en comprennent bien le fonctionnement?

3.4 Est-ce que votre service utilise le retour d'expérience (post-mortem) après les interventions? Si oui, est-ce qu'on y identifie des connaissances à développer?

3.5 Comment votre service développe-t-il les connaissances nécessaires pour faire face aux différents risques auxquels il est confronté?

4. Est-ce que les connaissances sont partagées entre votre service et d'autres organisations?

4.1 Est-ce que les connaissances sont partagées entre les services d'incendie de la région? Si oui, pouvez-vous me donner des exemples? De quelle manière sont-elles partagées?

4.2 Est-ce que votre service échange ses pratiques gagnantes avec les autres services d'incendie ou vice-versa? Si oui, pouvez-vous me donner des exemples?

4.3 Est-ce que votre service utilise des connaissances de d'autres organisations (police, ambulance, etc.) pour améliorer le service qu'il offre aux citoyens?

4.4 Par rapport aux autres services d'incendie, est-ce que votre service se positionne davantage en leader ou en suiveur relativement au développement des connaissances? Pouvez-vous donner des exemples?

5. Dans votre service, comment sont utilisées les connaissances qui proviennent de la recherche appliquée/académique sur la sécurité incendie?

5.1 Est-ce que la recherche actuelle sur la sécurité incendie est connue dans votre service? Si oui, pouvez-vous en donner des exemples?

5.2 Est-ce que ces connaissances sont incorporées dans la formation ou les opérations?

5.3 Est-ce que ces connaissances ont un effet sur les façons de faire de votre groupe de pompiers?

5.4 Au final, pourquoi êtes-vous pompiers?

L'entrevue est terminée. Est-ce qu'il y a d'autres informations ou commentaires que vous souhaitez partager à propos de la gestion des connaissances dans votre service d'incendie? Si, toutefois, j'avais des précisions à vous demander, puis-je vous contacter de nouveau?

École nationale
d'administration publique

Formulaire de consentement et informations préalables pour une recherche menée sous la responsabilité des chercheurs de l'École nationale d'administration publique (ENAP)

Document d'information préalable au *Formulaire de consentement*

Nom du projet :

Playing with Fire: Knowledge Management in the Quebec Fire Service

Nom et coordonnées du chercheur principal :

Nom : M. Claude Beauchamp

Adresse postale : [redacted]

N° de téléphone :

Adresse courriel : claude.beauchamp@enap.ca

Dans le cas d'un étudiant, veuillez compléter l'information en donnant le nom du professeur qui supervise le travail :

Mme Lilly Lemay, Ph.D.

Vous êtes invité à participer à une étude pour :

Comprendre comment s'effectue le management des connaissances dans les services d'incendie à temps partiel du Québec.

Buts de l'étude ***(le cas échéant, signaler le fait que l'étude pourra fournir des matériaux à un mémoire ou à une thèse)*** **:**

Cette étude est la première à s'intéresser au management des connaissances en sécurité incendie en Amérique du Nord. Elle vise à mieux comprendre les mécanismes du management des connaissances dans ce domaine. En particulier, l'étude vise à déterminer à quel niveau de maturité du management des connaissances se situent les services d'incendie. Les données recueillies serviront de matériel pour une thèse de doctorat.

Déroulement de l'étude (*Description du déroulement et des activités auxquelles le sujet sera soumis*) :

Le sujet sera invité à participer à une entrevue semi-dirigée ou à un groupe témoin ou les deux.

Durée prévisible de l'étude

Date de début : 2016-06

Date de fin : 2017-12

Risques et effets secondaires (*Mentionner ici les risques, le cas échéant*) **:**

Aucun risque ou effet secondaire anticipé.

Avantages et compensation financières (*Préciser ici, le cas échéant, les avantages pour le sujet de participer à l'étude*) :

Aucun avantage ou compensation financière.

Confidentialité (*Préciser ici les règles de confidentialité et la qualité des personnes qui auront un droit d'accès à l'information – chercheurs, assistants de recherche, commanditaires, etc.*) :

Toute information sera traitée de manière strictement confidentielle. Tous les renseignements seront dépersonnalisés. Le chercheur principal, la directrice de thèse et les membres du comité de supervision de thèse auront accès aux informations.

Participation volontaire et droit de retrait :

Votre participation à l'étude est volontaire. Vous êtes libre d'y participer ou de ne pas y participer de même que de vous retirer en tout temps sur simple avis verbal. Toute nouvelle information survenant durant le déroulement de cette étude qui pourrait affecter votre participation vous sera transmise par le responsable de l'étude.

Le cas échéant, vous pouvez aussi vous abstenir de répondre à une question qui vous sera adressée.

Les données (*Mentionner ici la manière dont les données seront recueillies (enregistrements, notes), conservées et détruites, le cas échéant*) :

Les données seront recueillies par enregistrement et par notes manuscrites. Les données seront conservées en lieu sûr afin d'en permettre la vérification.

Initiales du sujet : ____

Chercheur principal et responsable de l'éthique (*Mentionner ici le nom du chercheur principal ainsi que le nom des autres membres de l'équipe avec qui le sujet peut avoir à communiquer*) :

Si vous avez des questions au sujet de cette étude, vous pouvez rejoindre :

Nom : M. Claude Beauchamp

Adresse postale :

N° de téléphone :

Adresse électronique : claude.beauchamp@enap.ca

Éthique

Ce protocole a été étudié par le Comité d'éthique de la recherche de l'ENAP. Si vous avez des questions sur vos droits en tant que sujet participant à cette étude, vous pouvez rejoindre le président du Comité, le professeur Jacques A. Plamondon, au 641-3000 au poste 6149 ou par courriel à : jacques.plamondon@enap.ca.

Initiales du sujet : ____

École nationale
d'administration publique

Formulaire de consentement

Nom du projet :

Playing with Fire: Knowledge Management in the Quebec Fire Service

Acceptation de la participation à l'étude

J'ai bien compris ce qui suit :

- J'ai lu et compris le document d'information _____;
- Ma participation à cette recherche est volontaire;
- La durée de l'étude est de _____;
- Je peux me retirer à n'importe quel moment de cette étude;
- Je recevrai une copie du document d'information et du formulaire de consentement, signés et datés par le responsable de l'étude et répondant éthique;
- J'autorise les personnes citées à la section « Confidentialité » à consulter les pièces qui contiennent des informations obtenues du fait de ma participation.

J'accepte de participer à l'étude et je signe en date du _____

J'accepte, le cas échéant, que mes réponses soient enregistrées : oui : ◯ non : ◯

Le cas échéant, je souhaite recevoir un sommaire des résultats : oui : ◯ non : ◯

Sujet participant à l'étude

Nom : _____

Signature : _____

Je réponds de l'application du respect de cette entente :

Responsable de l'étude et répondant éthique :

Nom : Claude Beauchamp

Signature : _____

Projet préparé par :
CER-ENAP
cer@enap.ca

Enregistrer le formulaire

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