

The other side of the coin: How organizations manage their old and obsolete knowledge

Keywords: unlearning, knowledge types, obsolete knowledge

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Abstract

This paper examines how organizations deal with the possible negative impacts of their obsolete knowledge (unlearning) and how the pattern of unlearning actions differs based on different types of knowledge. Based on a comparative cases study in four software companies, we identify seven unlearning approaches with 32 associated sub-approaches. We examine the pattern of applying these approaches to five types of knowledge (embrained, embodied, embedded, encultured, and encoded). The results show that three categories of factors explain this pattern: the characteristics of *knowledge*, the characteristics of the *container* of the knowledge, and the *contextual* factors. We extract theoretical insights and comment on practical implications.

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1. INTRODUCTION

Day after day, companies are facing more situations where a radically new knowledge is replacing the existing one, requiring organizations actively and intentionally deal with the possible negative impacts of their obsolete knowledge (Hedberg 1981; Afuah 2001; Foster and Kaplan 2001; McKnight, Vaaler et al. 2002). However, it seems that our fascination about learning and accumulation of new knowledge (Nonaka and Takeuchi 1995) has pushed the other knowledge dynamics to the background: knowledge obsolescence.

Obsolete knowledge, such as outdated technologies, incapable techniques, and dubious theories can create numerous problems to organizations. The *existence* of such knowledge in the organizational memory can cause confusions, inconsistencies, and unnecessary costs for its maintenance and upgrading. Once organizations need to change, the *persistence and linkages* of obsolete knowledge can create organizational inertia and rigidity (Leonard-Barton 1992), can distort new learning actions, for example by limiting the scope and the depth of learning. More seriously, the *application* of some obsolete areas of knowledge can be harmful, either because the content of that knowledge is problematic (Fauchart 2006) or the old knowledge does not fit to the new context (Turner and Gray 2009). Unlearning, as approached in this paper, is defined as any course of action that organizations adopt in order to reduce the possible negative impacts of obsolete knowledge.

The literature has emphasized that knowledge is sticky (Van-Den-Bosch, Volberda et al. 1999; Schneider 2007) to organizational members (Walsh 1995), systems, structures (Prahalad and Bettis 1986), and even artefacts (Orlikowski 2007). The wider and stronger are the organizational dependency on the old knowledge, the more difficult is for organizations to detach themselves from the obsolete knowledge, and hence, more serious actions are required to manage its possible negative impacts. Therefore, theorizing about unlearning is dependent on a proper understanding of how old knowledge is linked to organizations. Considering the different types of organizational knowledge, these linkages can be different and can have different unlearning implications. Accordingly, the aim of this paper is to examine how various types of knowledge, with their different organizational linkages, require different unlearning approaches.

Reviewing the literature on organizational unlearning, we identify a preliminary list of unlearning approaches that are mentioned in the literature. Then, we explore various typologies and views of knowledge in order to choose a typology that suits our research framework. Accordingly, we construct our theoretical framework by crossing the taxonomy of unlearning approaches and typologies of knowledge. In the following section, we report our exploratory multiple case study to examine how unlearning approaches are applied differently to various types of knowledge. Subsequently, we report the main findings and explain them in the light of the contextual factors. We conclude by commenting on some major theoretical contributions and practical implications of the study.

2. LITERATURE REVIEW

2.1. On the concept of unlearning

The first insights about unlearning and its importance emerged in the original texts of management (Cyert and March 1963). For example March and Cyert (1963) argue that firms follow a pattern of “problemistic search” near the problem, meaning that they only start to search for solutions when they face a problems and they search for solutions close to the problems. Later on, they articulated this idea as the tension between exploration of new ideas and exploitation of existing knowledge (March 1991). Hedberg’s (1981) famous manuscript on “how organizations learning and unlearn” is perhaps the first explicit assertion about unlearning and its importance in the field. Since that time, numerous, but scattered, pieces of work have referred to unlearning as a critical organizational dynamics, as well as managerial practice (Nystrom and Starbuck 1984; Starbuck 1996; Martin de Holan and Philipps 2005; Akgün, Byrne et al. 2007; Tsang and Zahra 2008; Casillas, Acedo et al. 2009; Yildiz and Fey 2010).

However, this concept has remained unclear and loosely defined (Tsang and Zahra 2008). Various terminologies, such as unlearning, forgetting, and abandoning, used to address this concept, reflect heterogeneous views about unlearning. For the sake of concept clarity (Suddaby 2010), four questions should be addressed in defining unlearning: 1) What is the aim of unlearning? 2) Is unlearning a natural organizational dynamics, or it is a rather deliberate managerial action? (Martin de Holan and Phillips 2010), 3) What is the subject of unlearning?, and 4) how unlearning contrasts with other similar concepts such as “learning”, “unfreezing” (Lewin and Cartwright 1951), and “double-loop learning” (Argyris 1999).

The ultimate goals of unlearning are defined as facilitating the process of change (Becker 2003), avoiding cognitive or structural rigidities (Prahalad and Bettis 1986; Bettis and Prahalad 1995), and preventing or controlling the negative impacts of some existing technologies or routines (Fauchart 2006). Overall, unlearning serves the aim of avoiding some perceived and potential negative impacts (Hedberg 1981). However, some other authors limited the aim of unlearning to *abandoning* obsolete technologies and routines (Tsang 2008; Tsang and Zahra 2008) which seems a specific mechanism for applying unlearning.

Martine-Deholan & Philips(2005) clearly distinguishes between unlearning, as a deliberate action that organizations adopt to discard part of their organizational memory, and “memory decay” which is an unintended and natural dynamics that takes place in organizations (Martin de Holan and Philipps 2005). Nevertheless, some unlearning actions are semi-deliberate in the sense that although they are intended for some other reasons *rather* than unlearning aims, but they might serve unlearning aims as well. For instance, downsizing, which might be pursued for the sake of cost reduction, can also serve unlearning aims as organizations can get rid of obsolete mentalities (Hamel and Prahalad 1994).

The literature has suggested many organizational aspects as the *subject* of unlearning. For instance, unlearning is defined based on organizational knowledge (Martin de Holan and Phillips 2010), structure (Bettis and Prahalad 1995), routines (Barkema and Vermeulen 1998; Akgün, Byrne et al. 2007), behaviour (Yildiz and Fey 2010), value systems (Yildiz and Fey 2010), technology (Starbuck 1996), and artefacts (Fiol and Lyles 1985). Recent lines of research pay more attention to the differences that different subject can bring about for the unlearning process. For instance, Yildiz & Fey (2010) distinguish between

cognitive, behavioural, and normative unlearning, depending on the subject of unlearning (knowledge, behavioural patterns, and value system, respectively). Whatever is the subject of unlearning, first, it is crucial to notice that unlearning is focused on the *old* or *existing* aspects of the organization, vs. new ones. For instance, unlearning the obsolete technologies (Starbuck 1996) and routines (Akgün, Byrne et al. 2007) is contrasted with learning and adoption of the new ones. Second, the more focused is our subject of study, the more accurate account of unlearning can be expected. For example, it seems the unlearning of organizational knowledge could be different from the unlearning of only outdated artefacts, as knowledge and artefact are inherently different (Fiol and Lyles 1985).

Based on these clarifications, unlearning as approached in this paper, is defined as *an intentional process of managing old and obsolete knowledge in order to reduce its possible negative impacts*. To emphasize, the ultimate aim of unlearning is not necessarily abandoning (Tsang and Zahra 2008), but reducing possible negative impacts. We conceptualise it as an intentional and deliberate action in the sense that it is distinguished from natural dynamics of organizations. Finally, we only focus on old *knowledge* as the subject of unlearning, ruling out other possible subjects.

According to this definition, unlearning is different from learning basically based on the fact that learning is often focused on the *new* cognitions, behaviours, structures, systems, and artefacts (Fiol and Lyles 1985), while unlearning merely focuses on the *old* ones. Focusing on the knowledge as the main subject, Autio, Sapienza, & Almeida (2000) assert that learning is “the process of assimilating new knowledge into the organization's knowledge base” ((Autio, Sapienza et al. 2000), p. 911), whereas unlearning focuses on the *old* and established cognitions. However, there are some broad conceptions of learning that encompasses unlearning as a specific element in the whole process of learning. Another closely related notion to unlearning is unfreezing which is suggested by Lewin (Lewin and Cartwright 1951) in his field theory of organizational change. Unfreezing aims at unbundling the established and rigid organizational forces before any new changes would be introduced. Unlearning and unfreezing, both aim at reducing the possible hampering effect of the *old* and *established* situation. However, unfreezing is mainly conceptualised based on an institutionalism point view where the main subject is the established organizational structures, while, unlearning, as we approached here deals with old and obsolete cognitions. Second, the aim of unfreezing is rather temporal and secondary; adding some flexibility to the context of change. Unlearning, can be approached as a prerequisite for other changes, or be concerned only to control the possible negative impacts of some obsolete or dysfunctional knowledge (Fauchart 2006). The concept of unlearning will be clarified further once contrasted with double-loop learning (Argyris 1999). Although both unlearning and double-loop learning are applied to the outdated cognitions, the focus of double-loop learning is basically at individual level through a process of explication and reflection. However, unfreezing, goes beyond and not only covers collective knowledge but also includes actions to reduce the possible negative impacts of obsolete knowledge (Martin de Holan and Phillips 2010).

2.2. Unlearning approaches

Most of the literature shaped around unlearning deals with either its importance or its conceptualisation (Tsang and Zahra 2008). Although some recent works have made attempts to measure unlearning (Akgün, Lynn et al. 2006; Yildiz and Fey 2010), a cursory glance at these works reveals that still there should be many works done on clarifying the concept and assuring the construct validity. As these authors also confessed, we still need to know more about “how firms can” run the process of unlearning (Yildiz and Fey 2010). More specifically, which sort of actions do organizations adopt to deal with obsolete knowledge?

Reviewing the literature we could identify five categories of actions (= approaches) that organizations adopt to achieve unlearning aims. Using the notion of “approach”, we mean a series of typified actions which are classified based on their similarities. Accordingly, each approach can be more specified into sub-approaches. The first type of unlearning actions refers to active and intentional application of communicative tools not only to identify which areas of knowledge are obsolete, but also to specify possible negative impacts that might emerge from them, *awareness*. Awareness can be pursued actively, by critical analysis of existing cognition, or can start once organizations face serious failures which reveal possible defects in their organizational knowledge (Baumard and Starbuck 2005). Sometimes awareness starts from the technical level of companies as experts are more used to rapid and radical changes and are more attentive to the state of obsolescence and possible problems of the existing knowledge than top managers (Hamel and Prahalad 1994). In some cases, it requires a tough process of debate, negotiation, experimentation (Fauchart 2006), and using rhetorical elements.

The second approach towards managing obsolete knowledge is to stop any further development and learning on it. In fact, organizations stop accumulating knowledge on areas that either are outdated or are committed to some sort of negative impacts. Stop development can be implemented in as many ways as learning and knowledge accumulation can take place. Terminating R&D projects (Brockhoff 1994; Balachandra, Brockhoff et al. 1996), removing some training items, and not buying licenses or patents on those areas are some formal actions in this line.

The third approach deals with stopping problematic knowledge to be used and applied. In the case of Therac-25, when it turned out the technology is damaging to patients, the first action was to stop operating it (Fauchart 2006). Although the cognitive reflection on the obsolescence or negative impacts of knowledge areas could be a way for getting experts stop using that cognition (Argyris 1999), there are other ways that could lead to stop using such as changing the structural context or simply playing with the artefacts that are essential elements in practicing such knowledge.

The fourth category of actions that organizations adopt to manage the impact of their obsolete knowledge is isolation of the old knowledge and its containers from the rest of the organizational memory. For example, after several unsuccessful trials for designing personal computers, IBM realized that the dominant mindset of existing designers is biased towards mainframe. Hence, IBM created a separate design center in a different location in order to isolate the knowledge of mainframe from the knowledge of PC (Bettis and Prahalad 1995). This strategy comes to effect often when the presence of both old and new knowledge domains are still needed, but they have negative impacts on each other.

Finally, *abandoning* the old knowledge in order to wipe it out from the organizational memory is another unlearning approach (Martin de Holan and Philipps 2005; Tsang and Zahra 2008). Although this approach might appear radical and painful, especially when it is applied in the form of firing or downsizing, in some cases, it might be the only effective approach (Hamel and Prahalad 1994).

It's worth emphasizing that these approaches, though they are conceptually distinct, are not practically exclusive, necessarily. In fact, organizations can (and do) apply a combination of several approaches in any case of unlearning. In addition, the identified approaches should *not* be considered as *stages* or steps in the unlearning process. Moreover, each unlearning actions can also be applied in many different ways. Hence, each approach can be sub-classified into sub-approaches. Furthermore, this list is by no means exhaustive. We use this tentative list that as a starting point. Part of the aims of our exploratory investigation is to complete this list and specify each approach based on empirical insights.

2.3. Organizational knowledge and unlearning

Organizational knowledge, as the subject of unlearning, it is inherently different from other organizational aspects, such as structures, artefacts, and value systems. Knowledge is characterized as an intangible, heterogeneous, and dynamic (Nonaka and Takeuchi 1995) entity (Spender 1996; Tsoukas and Vladimirov 2001; Gherardi and Nicolini 2006; Schneider 2007) that is sticky to the context of organization (Von Hippel 1994).

Among various views of knowledge (Orlikowski 2002), we adopt the container based view which conceptualises knowledge as an *asset* which can be *possessed* by companies. Regarding the intangibility of knowledge, this view emphasizes on the *container* of knowledge (Blackler 1995) where knowledge resides. In this view, knowledge can be *embrained* and *embodied* in the mind and body of human agents, *embedded* in organizational processes, routines, and structures, *encultured* as the shared symbols and values among various communities, and *encoded* in documents. Accordingly, the process of codification (containing knowledge in documents and codes) (Cowan, David et al. 2000), routinization and standardization (embedding knowledge in organizational processes and routines) are of great importance. This view has been criticized as it is based on a rather positivistic view of knowledge (Marshall 2008) which not only overlooks the very subjective nature of knowledge, but also moves to the background the importance of practice and daily actions in the constitution and persistence of knowledge (Orlikowski 2002; Nicolini 2010). In addition, this view can be criticized due to its atomic approach towards knowledge that might overlook the contextual and interconnected nature of knowledge.

Despite these criticisms, the container-based view of knowledge suits our analytical aim because first, it brings to the fore the cumulative nature of knowledge and its stability in organizations (Dosi 1988). Second, by focusing on various containers of knowledge, we can examine how knowledge can be linked to organizational aspects (Orlikowski 2002). In this view, the stickiness of knowledge can be explained because it is attached to its containers and because these containers are linked to other organizational aspects. Third, the container view of knowledge helps us to identify the obsolete knowledge more easily

and more objectively because the containers, as rather objective organizational elements, can serve the function of a proper unit of observation. Although the main threat is that we stay at the level of container and not properly address the main unit of analysis which is the underlying *knowledge*. In fact, as the containers are tangible elements, we can better *identify* the old and obsolete knowledge area *through* them.

We rely on the five types of knowledge that are articulated by Blackler (1995) (Blackler 1995) based on the original taxonomy suggested by Collins (1993) (Collins 1993): embrained, embodied, embedded, encultured, and encoded knowledge. Accordingly, the embrained knowledge is linked to individuals' cognition and mentalities. Even in the absence of any physical actions, the link between the knowledge and individuals' mind can be sustained based on the capability of human's memory and cognitive mechanisms such as creating new cognitive linkages. Apart from that, these links are subjected to a natural individual's forgetting which naturally happens especially when the knowledge is not remembered for a while.

Embodied knowledge, is also linked to individuals, but the link is created through human actions which requires physical elements of the human practices. In this view, the link between knowledge and individuals sustains and strengthens as long as the actor actively involves in the related practices (Brown and Duguid 2001). Subsequently, this link can be untangled or loosened by avoiding or reducing the frequency of the related practices. The difference between embrained and embodied knowledge is not that the former is stored in the brain and the latter is stored in body, but it is because the embrained knowledge is directly linked *to* the mind, and the embodied knowledge is linked to both body and mind, *through* individual practices.

Encultured knowledge is linked mainly to organizational members through social and cultural linkages. The most obvious type of links that constitutes and maintains encultured knowledge is the interpersonal communication and dialogue. At a more aggregate level, similar links can be shaped between teams, communities, and divisions. Moreover, encultured knowledge can be sustained when some cultural artefacts such as symbols or stories (Miettinen, Lehenkari et al. 2008) mediate this linkage. Accordingly, unbundling the encultured knowledge requires organizations to play with underlying social relations and linkages. For instance, physical isolation which can impede social interactions can loosen the links between the encultured knowledge and the organization.

Embedded knowledge focuses on the links that organizational cognition has created with structural aspects of organizations such as technologies, processes, and routines (Blackler 1995). Here the heterogeneity of organizational aspects that knowledge is linked to makes us to differentiate between various types of links. Some links are formed through institutional and structural mechanisms. For instance, formally approving a specific process as *the* appropriate process makes (some specific) knowledge linked to that process. Another important category of links is through technical and materialistic relations.

Encoded knowledge brings to the fore the relations between knowledge and *codes* (Cowan and Foray 1997; Cowan, David et al. 2000). In a wide definition code includes text, visual (such as figures, charts, and maps, audio elements), and multi-medial (such as movies and animations) elements. They can be digitalized or non-digitalized. In fact, the codes can link organizational knowledge to individuals, communities, and even technologies. The way in

which the code is linked to these aspects can influence the extent to which the organization is attached to encoded knowledge. The summary of five types of knowledge and their related linkages to organizational aspects is presented in Table 1.

Table 1: Types of knowledge and associated knowledge linkages

Knowledge Type	Related Organizational aspects	How knowledge is linked
Embrained	Individuals' mind	Cognitive mental links through the individuals' memory
Embodied	Individuals' body-mind	Knowledge is linked to individuals through their active involvement in organizational practices
Encultured	Social agents (such as individuals, teams, communities, and departments)	Knowledge is linked through social and cultural linkages such as interpersonal interactions, dialogue. It can be mediated by cultural artefacts as well.
Embedded	Technologies, processes, routines, organizational structure, technologies, and artefacts	The knowledge can be linked and sustained through institutional and structural mechanisms such as formalization and standardization, as well as technical and material linkages
Encoded	Code (including textual, visual, audio, and multi-media elements)	The knowledge is linked to codes depending on how the code is linked to organizational aspects.

Knowledge is sticky to organizations because it is attached to its containers. Moreover, the containers are linked to each other. For instance, embrained knowledge is linked to embodied knowledge as the mental cognition maintains the pattern of practices and the very practice of a specific task can maintain the related mental abstract knowledge. In an architectural point of view (Henderson and Clark 1990), the overall couplings and linkages between these types of knowledge is another source of knowledge stickiness.

2.4. Theoretical framework

To sum up, the extant literature confirms the importance of organizational unlearning, but still we need more in-depth investigations about *how* unlearning is actually implemented by organizations. Framing knowledge in a container based view, we focus on five types of knowledge in order to examine how organizations deal with them when they become obsolete. More specifically, we investigate how the pattern of unlearning actions can be different based on different types of links that the obsolete knowledge has with different organizational aspects. Accordingly, the theoretical framework of this study is based on two dimensions: unlearning approaches and knowledge types. As depicted in Table 2, we are examining which unlearning approaches are used for each type of knowledge. Moreover, as we keep the both dimensions open, we also opt to complete the identified list of unlearning approaches based on our exploratory enquiry. Extracting the pattern of unlearning actions for different types of knowledge, we can analyse the differences and similarities in order to suggest theoretical propositions.

Table 2: The theoretical framework for the study

		Knowledge Types				
		Embrained	Embodied	Embedded	Encoded	Encultured
Unlearning Approaches	Awareness					
	Stop-Dev.					
	Stop-Using					
	Isolation					
	Abandoning					
	Other ...					

3. RESEARCH QUESTION AND DESIGN

3.1. Overall design

Two research questions are formulated as “what are the typified unlearning approaches that organizations adopt in dealing with their obsolete knowledge?”, and “how are these approaches differently applied depending on the types of knowledge?”

Following the aim of this study, which is to attain a deep understanding of the process of unlearning, a qualitative interpretative approach is adopted. Being qualitative, we can collect rich data about the unlearning process (Eisenhardt and Graebner 2007). The interpretative approach helps us to examine the subjective aspects of organizational knowledge and unlearning process (Schutz 2005).

We designed an embedded multiple case study (Yin 2002) in order to examine different types of knowledge and different unlearning actions applied to them. The comparative design increases the chance of studying different types of knowledge and different unlearning actions and allows us to analyse the role of contextual factors (firm-level) in explaining the results. More specifically, our main unit of analysis is unlearning actions applied to obsolete knowledge. Hence, the selected companies have to be knowledge intensive in order to allow us to observe different types of knowledge. Moreover, companies had to have experienced serious cases of knowledge obsolescence, allowing us to observe unlearning actions. We selected the software industry because not only it is deeply knowledge based, but also has experienced significant technological shifts in the last decade. The software sector in Iran is dominated by private companies that are working at the edge of technology. Some of them are actively involved in exporting software packages to other countries. Focusing on a specific sector helps us to fix the sectoral and national level factors in our analysis and better focus on the role of organizational factors.

Technological shifts are often important triggers for making some areas of organizational knowledge obsolete. Accordingly, we defined our cases based on radical technological shifts that companies experienced. For each case, the obsolete knowledge areas had to have significant histories of stability and persistency in the company, making sure that the company is attached to them. Second, the selected technological shifts should occur in last 10 years, in order to assure proper access to data. Hence, we selected three cases: 1) the shift from DOS to Windows, 2) from command-based languages to visual languages, and 3) from client-server technology to web-based technologies. Due to these technological shifts, a wide range of knowledge areas associated to the old technologies became obsolete. For instance, once DOS became obsolete, the knowledge of low-level programming, creating and managing the fonts and graphical elements based on non-graphical operating systems, and some areas of knowledge required for optimising the memory and process became no longer useful.

We selected four private companies based on organizational size and product diversification. In the literature there is an emphasis on the role of organizational slack in the process of unlearning (Hedberg 1981). Normally large organizations have more organizational slack in order to maintain their resilience. On the other hand, large organizations might experience more serious rigidities compared with small firms. According to European Commission², one of the companies is small with 40 employees, the second company is medium size with 100 employees and the other two companies are large with 450 and 1000 employees (see Table 3). Moreover, comparing companies based on the level of product diversification can be theoretically insightful. High level of diversification can hamper the process of unlearning because the underlying knowledge that must be unlearned is linked to a wide range of products. However, it can provide the firm with opportunities to apply the process of unlearning in a more incremental way, for example by starting from less sensitive products. Two companies are focused and the other two companies are highly diversified as they deliver a wide range of different products (Table 3).

Table 3: Selected companies and their specifications for purposeful sampling

Company*	Size (No. of Employees)	Product Strategy (No. of products)
SMFC	Small (40)	Focused (3)
MEDFC	Medium (100)	Focused (4)
LRGDV1	Large (450)	Diversified (31)
LRGDV2	Large (1000)	Diversified (29)

* For the sake of confidentiality, we used pseudonyms for the companies and also represent the basic characteristics of the company. SMFC: small and focused; MEDFC: medium and focused, LRGDV1 and LRGDV2 the two large and diversified companies. More details about the four companies are presented in Table 4.

² European Commission (2003-05-06). "[Recommendation 2003/361/EC: SME Definition](#)". This standard for classification of companies is preferable for high-tech sectors.

Table 4: The description of selected companies

	SMFC	MEDFC	LRGDV1	LRGDV2
Foundation date	1991	1998	1987	1988
No. of Products	3 (document management)	4 (office automation) + 8 (peripheral systems)	31 (enterprise systems)	29 (core systems on enterprise solutions)
No. of Employees	40	100	450	1000
No of Active/major customers	400	400	1000	6000
Overall product strategy	Focus on Office automation	Focus on Office automation, but a few other systems such as HRM and Financial	Diversified total solutions (Integrated systems and ERP)	Diversified total solutions (Integrated systems and ERP)
Customer base	Balanced between private and public, small and medium size	Mainly large and public companies	Large companies mainly from manufacturing sectors	A wide range of large and small companies from almost all kinds of sectors

3.2. Data collection method and process

We collected data mainly through semi structured interviews with key actors of the technological shifts, including top manager who was actively and directly involved in the process of unlearning, middle manager, who were directly responsible for these changes, technical experts experienced these changes. We tried to cover informants with different views and involved in different aspects of the unlearning process. We asked each interviewee to introduce other informants with different views and also we took advantage of informal hearings to identify opposing groups. In addition, we used document analysis and on-site observations as complementary data collection methods. For instance, we had the chance of working with the obsolete technologies and directly observe the practices of related experts. All interviews were recorded and transcribed verbatim.

We collected data in three stages. First, we collected contextual information about the whole company, the case of technological shift, relevant informants and their characteristics based on 10 interviews with independent experts, industrial analysts, ex-employees, and current managers and employees of companies. Accordingly, we customized interview questions and ran informal and preliminary interviews. Moreover, we studied all available documents and digital content such as news, websites, bulletins and reports related to these companies and these cases. We collected the main data in the second stage. Asking semi-structured question, we tried to identify the obsolete knowledge areas based on two strategies: starting from a wide exploration inquiring about what became obsolete in each technological shift and identifying obsolete knowledge areas based on the five types of knowledge. We avoided using technical term such as “embrained”. Instead, we broadly asked informants about the specific knowledge

containers (see table 1) such as experts whose expertise became obsolete, technologies that became no longer useful, and organizational routines. The assertions included many ideas about obsolete knowledge as well as other issues rather than knowledge. As for unlearning approaches, we first broadly asked managers and experts “what did they do to the obsolete issues”? We tried to document the detailed story of unlearning by forward and backward questions (what did they do *before* and *afterwards*). Later on, we used the five unlearning approaches as a guide to ask more specific question to see if any action related to each unlearning approach were adopted. In addition, we asked the managers to specify the target of each unlearning approach. This information was crucial to attribute each unlearning actions to each type of knowledge. During this stage, the data of each interview was analysed after the interview session in order to identify lacking information, inconsistencies, ambiguities, or insights for further inquiry. The main focus of the third stage was on detecting and clarifying ambiguities, inquiring about differences and peculiarities between companies and between cases, and cross validating the findings. We collected data based on 39 interviews (see Table 5). The average time of interviews was 68 minutes. The shortest and longest interviews lasted for 15 and 140 minutes respectively. Transcribing all interviews verbatim resulted in 520 pages of transcribed data.

Table 5: The number of interviews in each stage by companies, and by categories of informants

	Data Collection Stage			Total
	Stage 1	Stage 2	Stage 3	
No. of Interviews by Companies				
SMFC	1	5	2	8
MEDFC	1	6	2	9
LRGDV1	2	5	1	8
LRGDV2	4	4	2	10
No. of Interviews by different categories of informants				
Top Managers	0	12	2	14
Technical Managers	3	6	3	12
Experts	5	2	2	9
Total No. of Interviews in each Stage	8	20	7	35

To assure the validity of findings, we, first tried to use an inclusive framework to avoid limiting the scope of exploration. More specifically, we inquired about other unlearning actions that might not fit to the five original categories. Second, we tried to cross check the results of data collection by asking the same question at least twice from two informants. Third, in some cases we formulated some sensitive questions in a *counter-leading* form. For instance, some managers hesitated to reveal using firing as an unlearning action. Hence, we asked them “it is a quite common managerial practice that you terminate your cooperation with some experts. How did it happen here?” Fourth, two researchers collected data in parallel. The contradictions and inconsistencies between the findings of these two researchers were continuously discussed and dissolved. Fifth, we tried to diversify the sources of information as we asked managers at different levels of organizational hierarchy, as well as informants from various departments. The process of data collection continued till no further significant insight appeared in the last interviews.

3.3. Data analysis

Apart from the on-going analysis of findings from each interview, we analysed the collected data based on an exploratory thematic analysis (Boyatzis 1998). We used the original categories of unlearning approaches and the five types of knowledge as the preliminary and the most abstract level of constructs. Then, we tried to complete and specify theme-trees related to unlearning approaches and knowledge types. In this stage, had several iterations with academic experts in the field of unlearning in order to specify the final theme trees. Extracting the completed and detailed them-tree in this stage, then we ran confirmatory thematic analysis to map each unlearning action to its underlying unlearning approach(es) and knowledge type(s). We used ATLAS.ti package version 5.0.66. Two researchers coded data in parallel. Comparing the results of these two parallel analyses, we discussed the differences and resolved conflicts. The inter-rater reliability was around 25% based on the *exact appearance* of codes and 90% based on the *occurrence* of codes (Boyatzis 1998).

4. FINDINGS

4.1. The results of exploratory analysis

We coded any *action* that organizations adopted with the aim of alleviating the possible negative impacts of the obsolete knowledge as unlearning actions. The result was a list of around 600 quotations and 200 memos. For instance, a coded unlearning action was “we intentionally assigned tasks related to both client-server and web-based systems to any single designer to motivate the old experts to keep working on the old systems”. Then, this list was classified inductively into a list of around 32 typified unlearning actions (sub-approaches). For instance, the category that this unlearning action was attached to was “task integration”. Sub-approaches, then, categorized into major categories as unlearning approaches, for instance, “integrating old knowledge with other aspects”. The preliminary theme tree (both approaches and sub-approaches) and its description were sent to 5 academic experts in the field of unlearning and knowledge management in order to check if 1) each approach and sub-approach is clearly defined, 2) approaches and sub-approaches are conceptually distinct, 3) approaches and sub-approaches are practically insightful and understandable. Eventually, we extracted 7 unlearning approaches with 32 associated sub-approaches. In addition to the five approaches identified in our literature review, two new approaches emerged. Also, all approaches were specified at the level of sub-approaches. Due to the space limitations, we only explain the two new approaches emerged in our analysis. The detailed list of approaches and related sub-approaches and illustrations from the cases are summarized in Table 6.

The sixth identified approach is *transforming*, which refers to unlearning actions that change the *content*, *structure*, or the *form* of the obsolete knowledge. Changing the content means that a new state of knowledge emerges which is different from what it was before. For example, when firms tried to improve their knowledge on the obsolete areas in order to keep their old technologies viable in the short term, they tried to change the content of their

obsolete knowledge. As a design manager in MEDFC said, “at that time, DOS couldn’t support Unicode fonts. We used the characters upper than 256 in order to define Persian characters. In fact, we created a built-in Persian font in DOS. We changed this functionality by learning a lot about working with these characters”. A more complex way of transformation appeared when companies mainly changed the structure of knowledge that they had. More specifically, some companies tried to standardize and modularize their knowledge around DOS firstly because it helped them to make it more consistent with the knowledge of Windows and second, they could easily come back and reuse it whenever necessary. The third sub-approach of transformation was to change the form of knowledge, basically codifying tacit knowledge. “Especially in the shift from client-server to web-based, we had a large number of experts who were quite eager to switch to the new technology. But they had a lot of valuable knowledge on the old technology, which were still viable and crucial for the maintenance and support of the old systems. We couldn’t move these experts to the new team, unless we make sure that their knowledge is properly transferred to a new team that could support the old systems. Therefore, we asked them to codify their knowledge on the design, improvement, and support of the old systems”, stated the deputy of production at MEDFC.

Another approach emerged from our analysis which appeared counterintuitive but satisfies all characteristics of an unlearning approach: *integration*. Unlike disconnection, in some cases companies tried to creating new links and interactions between the old knowledge, on the one hand, and other organizational aspects, on the other. It happened when companies faced a situation that although in long term it was almost certain that the old knowledge is obsolete, but they had to keep it viable in short term. Especially as the dominant experts of these companies are young and have a voracious appetite to learn new technologies, most of the companies had a hard time to keep them working on the old areas of knowledge, because they were arguing that this knowledge is obsolete! In these cases, companies had to create and maintain some new linkages between the old knowledge. However, even for detaching from the obsolete knowledge areas, creating some links helped the organizations to do it more easily. For instance, in the shift from DOS to Windows, programmers had to know how to work with needle printers. This knowledge was obsolete because most of the drivers of these printers were built-in in Windows. As a connecting action, SMFC technically linked all DOS applications to needle printers meaning that these applications could technically work with such printers. Once the needle printers become obsolete and companies had to abandon them, because of this link, they had to renounce the application of associated DOS systems, which in turn helped SMFC to unlearn such obsolete knowledge areas more easily. In some cases, integration approached was applied in order to alleviate the side effects of other unlearning approaches. For instance, some companies tried to socially and physically integrate old experts with new ones in order to motivate the old experts to abandon the old ways and techniques, and also to avoid the loss of viable knowledge that old experts had. “They (production team) had a better sense as they conceived themselves in a single production team which works on both the old and new technology, even those experts who were assigned to the old technology. At least they were learning from each other, and even more, they knew that if we want to assign more experts to the new technology, they will be our first options”; explained by a CEO. This approach pursued at the individual level when both obsolete and new knowledge areas were assigned to a single expert. As mentioned the product manager of LRGDV2 “We found it much better in terms of motivational aspects to assign tasks related to both the old and new systems to a single expert. For instance, in the morning, they were

working on web-based systems, and in the afternoon, they were working on the Delphi systems. It was a kind of relief for them. They felt that they are still valuable for the company. They could learn the new knowledge, while they were giving service on the old systems”.

It is worth emphasizing that these approaches although are conceptually distinct, companies often used a combination of them simultaneously. Moreover, the order of the presentation of these approaches has no relation with the sequence or timing of their implementation. Moreover, our analysis showed that each approach and sub-approach is subjected to some general variations. First, they can be implemented in a planned and formal way, or in a rather informal and emergent way. Second, they can be implemented gradually taking a long time, or be applied in a very short period. Third, the scope of application of (sub) approaches can be as wide as the whole organization, or limited to a specific department, project or team. Some approaches are adopted in the early stages of the technological shifts, while others were implemented in the final stages. Finally, although most of these approaches helped the firm to detach from obsolete knowledge, some others were applied to avoid too fast detachment from the old knowledge. In fact, in both cases, companies tried to avoid some possible negative impacts of the obsolete knowledge. Hence, they all represent *unlearning* approaches.

Similar exploratory thematic analysis applied to knowledge types. The early insights from analyzing the data showed that the five categories of our knowledge typology requires to be specified into further sub-types mainly because there were different instances of knowledge categorized, for example, as embrained, but they were treated differently in the process of unlearning. Through a process of logical analysis and iterations with academic experts in knowledge management, we could classify them into 18 sub-types of knowledge associated to the five main categories. These sub-categories and illustrations from the cases are summarized in Table 7.

Table 6: Description of unlearning approaches and sub-approaches

Approach	Sub approaches	Examples
1. Awareness	- Giving information	Lectures, formal discussions, seminars, conferences, formal trainings about the old knowledge
	- Persuasion	Devaluation of the old knowledge; valuation of the old knowledge but in short term; reflecting on incidents caused by the old knowledge
2. Stop Development	- Stopping the development of new products / productions	Not contracting any new project on the old K
	- Stopping basic improvement of the existing systems	Not applying the basic changes in the existing systems that require new learning
	- Not supporting the application of the old system	Not being involved in learning practical aspects of the old systems
	- Stopping R&D / NPD projects	Not continuing products that were under development
	- No training on the old technology	Removing the contents related to the old K
	- Not hiring new experts on the old technology	Avoiding hiring new experts in the old K
	- Limiting the scope of possible learning	Focusing all learning activities on the old domains to a small team / unit
	Limiting the depth of learning on the old domains	Shifting learning opportunities towards more superficial learning options
3. Stop Using	- Not developing any new product / production in the old technology	Even when there is no need for new learning
	- Not selling the old systems	
	- Not improving the old system	Even when there is no need for new learning
	- Not Supporting the old systems	Not helping the customers to solve their problems
	- Stopping the operation of the old systems in the customer's site	Switching off the old system; making the old system read-only
	- Using organizational forces to stop using the old knowledge	Banning the use of obsolete technologies
	- Using technological forces to stop using the old knowledge	Using test systems that check for outdated habits of programmers
4. Disconnecting	Physical isolation	Situating the old team of experts in a geographically distinct location.
	Social isolation	Reducing interpersonal interactions and creating distinct communities
	- Structural and institutional isolation	Collocating old experts in a separate organizational unit
	- Human based disconnection	Codifying the old and obsolete knowledge by the old experts and using them for their still viable knowledge
	- Technological / system separation	Disconnecting the dependency of the new database design on the old design
5. Abandoning	- Technological abandoning	Abandoning the source code or tools
	- HR abandoning	Firing; facilitating nature turnover of HR
	- Structural and organizational abandoning	outsourcing; creating spin-offs; selling out
	- Abandoning of the documents	Discarding documents
6. Transforming	- Improving old Knowledge	Creating intermediary technologies
	- Formalization and codification	Codifying the old knowledge
7. Integrating	- Changing the structure of the old knowledge	Making the old knowledge more structured and modular
	Technological and system integration	Linking the old knowledge to another obsolete hardware technology
	HR integration	Enriching the tasks of the old experts with tasks on the new knowledge
	Structural and organizational integration	Collocating teams on the old and new knowledge in a single organizational unit

Table 7: Description of five knowledge types and their associated sub-types

Knowledge Type	Sub-Types	Illustrations from obsolete knowledge
Embrained	Assumptions	“The user has access to a wide-band local network” became no longer valid as companies shifted from client-server to web-based technology
	Concepts	“Structured programming” as a fundamental concept become obsolete in the shift from command-based to visual Languages
	Theories	“The more centralized is data, the more secure it is” became obsolete by moving towards web-based technologies
	Rules	“Try to distinguish data from code to reduce the bugs of software” was no longer viable in the visual languages based on object-oriented approach
	Experiences	“The steps that I used to follow for creating a report” radically changed when most of the products became web-based
Embodied	Habits	“I used to press Enter key to navigate among options” become obsolete as this function had to be done by pressing Tab key in new systems.
	Skills	“I could easily install the DOS systems”, but once the new Windows applications came, this skill was no longer useful for the support staff
Embedded	In Products	“The design” of products became partially outdated during the technological shifts.
	In Technologies	“The logic and design of production and test technologies” become no longer applicable for the new alternative technologies
	In Organizational Aspects	“The logic behind production processes reflected the state of isolated production” which became obsolete when companies moved towards integrated production
Encultured	Understandings	“Software package is a <i>technical support</i> for organizational activities” was a shared understanding in some companies which had to be replaced by “software package is a <i>crucial organizational element</i> ”.
	Values	“good programmer is the one who writes every module from the very basic codes in a very sophisticated way” was a viable shared value among managers which become obsolete by the advent of visual languages
Encoded	Documents	“user manuals and technical documents of systems” become outdated during these technological shifts
	Databases	“the knowledge about products’ bugs and how to solve it stored in the database of support and maintenance divisions” become no longer applicable as products changed

4.2. The results of the confirmatory analysis

For extracting the pattern of unlearning actions, we used the matrix created by 32 unlearning sub-approaches and 18 knowledge sub-types. Each identified unlearning action was attributed to related cells of the matrix. We identified three states of cells depending on the frequency of unlearning actions assigned to each cell: empty, low frequency (1 or 2 occurrence), and high frequency (more than 2 occurrence) cells. In case of empty cells, we first had iteration with data to check and correct for possible missing unlearning actions. Then we checked if such unlearning approach is *logically* applicable to that knowledge type. For instance, abandoning documents, by its definition, cannot be applied to knowledge types rather than encoded knowledge. Those cells that passed these two tests showed that the company did not use such approach for that knowledge type. In order to analyse these cases, we went back to data and explored the reasons behind such *inaction*. In some cases it was due to the fact that managers did not notice the possibility of such action, while in some other cases they avoided such action due to some side effects or

contextual limitations. Going back and forth with data and comparing across companies we tried to extract insights about these cases. The distinction between low and high frequency was *only* to check for possible mistakes in coding. Hence, we checked the cells with low frequency to make sure that the actions attributed to them were really observed in the data. In some cases, we spotted mistakes due to data analysis and fixed it. For cells with a high frequency, we checked if this frequency is only due to multiple questioning by researchers or over-stating by the informants, or it is because this action was frequently used. The main insights were accrued by analysing the content of data and comparisons across companies. We first explain the insights resulted from analysing at the aggregate level (integrating all four companies), and then we comment on the differences between companies.

4.2.1. Results at the aggregate level

At the aggregate level, there are clear distinctions between knowledge types in terms of using various unlearning approaches. We first analyse the pattern of unlearning actions applied to different types of knowledge by going through each unlearning approach, and then we comment on some important overall patterns.

Awareness: Companies used awareness mostly to address knowledge embedded in products and technologies because they are less personal and more tangible. In fact, companies and managers tried to focus mainly on those types of knowledge that are more subjective and important for the audiences. For instance, even in cases that the knowledge embedded in technology is obsolete, they tried to find a link in the product and focus on it as the subject of awareness. Using rhetorical tools for embrained and encultured knowledge appeared to be politically sensitive. The overall pattern shows the dominance of informative mode of awareness over the persuasive mode.

Stop Development: Stop development was widely applied to all types of knowledge except the organizationally embedded, encultured, and encoded knowledge. The most applicable and influential methods for stop development were stopping the improvement and support of the old systems, and not developing new products based on the obsolete domains of the knowledge. Stop development was mostly applied to experiences and skills because most of the learning processes in these companies were through experiential learning at individual levels. This approach was not extensively used for other types of embrained knowledge because these types of knowledge are basically learned in academic ways such as reading, and once the technology becomes obsolete, the experts proactively stop reading these materials. As internal formal R&D was quite unusual in most of the companies, stopping R&D projects took place in a patchy way. The companies did not use this approach significantly for encultured knowledge mainly because this approach has been pursued more technically and its potential for the non-technical knowledge was less tapped.

Stop using: The companies extensively applied a wide range of strategies to stop the application of various knowledge types, especially technical and specific knowledge types such as experiences, skills, and the knowledge embedded in products and technologies. Stop using was less applied to collective knowledge types such as organizationally embedded and encultured knowledge, mainly because stopping them not only requires a strong organizational force, but also, needed a deep understanding of its methods and possible side-effects. However, most of the organizations lack such capabilities.

Disconnecting: Disconnecting was actively applied to most of the knowledge types except encultured and organizationally embedded knowledge because applying this approach at that level of aggregation required extensive structural separations, resulting in serious structural and political tensions. However, some organizations tried to apply this approach by creating some structural distances and creating structures that are more specialized. This sub-approach was mainly feasible in large companies with enough resources in order to allocate to different structural units. Similarly, organizations had to create serious social and structural barriers in order to disconnect the collective encultured knowledge from the rest of the company. This action either was impossible for the small companies or was not desirable, as it could create serious internal tensions at both technical and managerial levels. Hence, disconnection was mostly applied at individual level focusing on embrained and embodied knowledge simultaneously. Among all sub-approaches of disconnection, organizations used more structural disconnection because it can facilitate and justify other types of disconnecting actions. For instance, it is more justifiable to physically isolate teams associated to different divisions, than teams in the same structural unit.

Abandoning: Abandoning was frequently used for most of the knowledge types, except for encultured knowledge. Abandoning the collective and widely distributed encultured knowledge requires an extensive action to abandon teams and communities, which was rather impossible in all companies. Although organizations used this approach to abandon some organizationally embedded knowledge, especially in the form of outsourcing or creating spin-offs, they were quite conservative in this case. Firstly, it was because most of the organizations had little experience in managing the obsolete organizationally embedded knowledge. Secondly, these sub-approaches were risky in terms of creating new rival companies or losing their control over valuable knowledge. Companies used a moderate and gradual version of abandoning for embrained knowledge by facilitating the natural outflow of experts. Moreover, the more concrete and solid is the carrier of knowledge, the easier is its abandoning. For instance, although the embrained knowledge is quite abstract and subjective, it can be easily abandoned through HR firing.

Transformation: The application of transformation was significantly used for embedded knowledge in the old products and technologies, when these types of knowledge were improved in order to be viable for a longer period or be operable with the new products and technologies. However, in some cases, companies used this approach in order to codify the embrained knowledge of experts.

Integration: Integration was mostly applicable in cases that companies tried to avoid an immature and hasty detachment from their old knowledge. This approach was used extensively for embrained and embodied knowledge, mainly by focusing on creating human and structural links. For integrating the old knowledge embedded in products and technologies, the most applicable sub-approach was creating technological links in terms of developing intermediary technologies such as middle-wares.

4.2.2. Some overall patterns

Tacit vs. explicit knowledge: Using the five types of knowledge, Lam (Lam 2000) argues that embrained and encoded knowledge are explicit while embodied and embedded

knowledge are tacit. Although she does not refer explicitly to encultured knowledge, based on her logic, encultured knowledge can be considered as tacit. Accordingly, when we compared the pattern of tacit with explicit knowledge, it revealed that there is no clear overall difference. In fact, both tacit and explicit sides were addressed by numerous unlearning approaches. For instance, embrained knowledge (explicit) and the knowledge embedded in products and technologies (tacit) were actively addressed by most of unlearning approaches. In fact, the differences between types of knowledge were not directly attributable to the state of being tacit or explicit. Instead, the characteristics of the *container* of the knowledge played more influential role in explaining the pattern of using unlearning approaches. For instance, comparing the embedded knowledge in products and technologies with organizationally embedded knowledge, one can conclude that although all of them are tacit knowledge, the former type are more feasible to be managed by unlearning approaches than the latter.

Individual vs. collective knowledge: Lam also identifies embrained and embodied knowledge as individual knowledge and considers embedded, encoded, and encultured as collective (Lam 2000). Comparing the patterns of using unlearning approaches based on this distinction, it turned out that organizations applied more unlearning approaches for individual knowledge than collective knowledge. The main reason is that dealing with individuals as the containers of obsolete knowledge is more feasible for organizations. However, a clear exception is our data is the knowledge embedded in products and technologies. Although these two types of knowledge were collective and extensively distributed, companies aptly applied most of unlearning approaches to them because they were critical for them and they had enough knowledge and capability to deal with these types of technical knowledge.

Technical vs. Non-Technical knowledge: Analysing the content of these five types of knowledge, we found that in our cases the knowledge embedded in organizational aspects and encultured knowledge are mainly non-technical, while the knowledge embedded in products and technologies were fundamentally technical. The distinction here is if the content of the knowledge is about producing software (technical) or is not. This comparison shows that companies tend to apply unlearning approaches to technical knowledge more frequently than non-technical knowledge. The main reason was that managers had more cognitive familiarity with technical knowledge, when and how they can become obsolete. Hence, they could easily formulate solutions to manage this type of knowledge when it became obsolete. Even in cases that unlearning some organizational knowledge was crucial, they tried to solve this problem by applying unlearning acts to some related technical knowledge.

4.2.3. Cross-corporate comparisons

Comparing the pattern of using unlearning approaches between four companies, we could extract three insights. First, large firms could apply some unlearning approaches, such as structural disconnection, that small firms could not. This difference was not because they had more organizational slack, but mainly because their structure was diverse and specialized enough that allowed them to apply some unlearning approaches. Second, firms with diversified product portfolio had to deal with the challenge of interdependencies between their knowledge elements. Not only the scope of presence of obsolete knowledge was broader for them, but also applying unlearning approaches to a specific part of their

organizational memory required them to sort out the turbulences and conflicts created in other parts. Third, another important factor that distinguished between companies in terms of the pattern of unlearning approaches was the composition of their customer base. Companies such as MEDFC with a relatively few but large customers had less freedom to apply unlearning approaches especially when it had direct impacts on their customers.

5. CONCLUSIONS

In this paper we explored how organizations use different unlearning approaches for different types of knowledge. We identified seven unlearning approaches, as typified actions that organizations adopt to manage possible negative impacts of obsolete knowledge. Our exploratory inquiry helped us to specify these approaches into 32 sub-approaches. On the other hand, we could identify 18 different types of organizational knowledge categorized under five major categories, in order to grasp the differences between them in terms of unlearning approaches. By analysing the data we could extract various insights on how organizations apply these unlearning approaches to different types of knowledge.

Our findings testified that the characteristics of knowledge types have direct bearings on the feasibility and effectiveness of unlearning approaches. More specifically, there are clear distinctions between technical and non-technical knowledge, and between individual and collective knowledge in terms of the pattern of unlearning approaches. Furthermore, our results suggest that the characteristics of knowledge *container* can also play a pivotal role in this regards. In fact, the pattern of unlearning approaches varies when we move from tangible to intangible and from personal to impersonal containers.

5.1. Main contributions

Unlike other conceptions that either over-limit this concept to only discarding (Tsang 2008; Tsang and Zahra 2008) or sacrifice the construct validity in their zeal to quantify it (Yildiz and Fey 2010), we adopted three strategies simultaneously in defining and operationalizing unlearning. First, we tried to focus on the ultimate *goal* of unlearning (reducing the possible negative impacts), instead of the *mechanism* of its implementation. Second, we tried to be specific in terms of the subject of unlearning. Thirdly, we tried to clearly explain the conceptual relations between unlearning and other closely related concepts such as learning, double-loop learning, and unfreezing. In addition, grounding this conceptual framework into the empirical data we could increase the clarity of this concept by identifying a taxonomy of unlearning approaches. As a result, the identified approaches and sub-approaches can help researchers to operationalize this construct for empirical investigations.

Theoretically, our findings confirm the insights stressed in the literature that unlearning can be pursued in wide range of approaches (Starbuck 1996; Martin de Holan and Phillips 2010). Moreover, our findings suggest a theoretical relation between knowledge types and the pattern of using unlearning approaches which has not been elaborated before. Owing to

the qualitative approach, we could extract insights on *how* knowledge by identifying three sorts of factors affecting the pattern of unlearning approaches. First, the characteristics of *knowledge* itself can make some unlearning approaches to be less feasible or less effective. More specifically, being subjective or objective, the level of collectiveness, and being technical or non-technical have direct bearing on how organizations use unlearning approaches. Second, the characteristics of the *container* of the knowledge are crucial factors in explaining the pattern of unlearning. In particular, whether the container of the knowledge is personal or not and the structural and systemic links between the containers might make some unlearning approaches hardly applicable. Third, the *contextual* factors, especially the level of structural specialization, the size of the company, and the portfolio of customers were three important contextual factors identified in our analysis. Unlike the extant literature we found that being tacit or explicit does not necessarily affect the pattern of unlearning approaches. In fact, this distinction was originally made for the aim of analysing the creation and sharing of knowledge (Polanyi 1966; Nonaka 2004), which might require some modifications to be applicable in studying unlearning.

As our analysis showed, the applicability and effectiveness of unlearning actions highly depends on how knowledge is *linked* to organizational aspects. Hence, unlearning, requires shaking and unbundling the links that obsolete knowledge has with cognitive, structural, and physical aspects of organizations (Brown and Duguid 2001; Tsang 2008). However, the link-based view is mainly theorized for explaining how knowledge sustains (Orlikowski 2002; Nicolini 2010) and is transferred and transformed (Von Hippel 1994; Carlile 2004). We think the potential of the link-based view of knowledge in explaining how organizations are attached to obsolete knowledge and how they can detach themselves from it is relatively untapped. We tried to make a small step in this line by showing how different links between knowledge and its containers can explain the pattern of unlearning actions.

Practically, this study draws attentions of managers towards a wide range of practical approaches that they can adopt to deal with obsolete knowledge. The other practical message of this study is that choosing appropriate combination of unlearning approaches is also important and should be done with regard to the characteristics of the obsolete knowledge, characteristics of organizational entities that knowledge is linked to them, and contextual factors such as organizational size and structure.

5.2. Limitations and further research

This study has limitations which can be completed in further studies. Firstly, the focus on software industry could limit us to capture other unlearning approaches, as well as some theoretical insights. The dominance of technological knowledge and experts in this field, characterized by a high pace of technological changes not only enhanced the necessity of unlearning, but also might be influential in terms of which unlearning approaches are adopted by companies. A comparative study focused on low-tech sector, such as automotive, can be theoretically insightful. Secondly, it was beyond the scope of this study to analyse the interactions between unlearning approaches. In fact, each unlearning approach can facilitate or hamper the application of other approaches. Thirdly, a

complementary study can focus on the evolution of unlearning actions over time and how they are adopted over the process of unlearning.

6. References

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