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Measuring the Impact of Knowledge Loss: More Than Ripples on a Pond?

Abstract *The impact of knowledge loss on an organization is a largely unexplored area of strategic management. This article reports the findings from an in-depth case study of an organization within the Australian Department of Defence, which suggest that lost human capital may produce decreased organizational output and productivity; lost social capital may reduce organizational memory; lost structural capital may diminish organizational learning; and lost relational capital may produce disrupted external knowledge flows. The study contributes a conceptual framework that measures the impact of knowledge loss on surviving employees. **Key Words:** employee turnover; knowledge loss; measuring resources*

Introduction

What happens when someone leaves an organization? Is their loss felt? Most people's exit may be seen as ripples on a pond: it causes a slight disturbance for a few days, but things soon return to normal. For many years, employee turnover has been considered normal organizational behaviour and employees were simply replaced by others with similar skills and experience. Some people cause more of a splash than others. The pond surface may take a little longer to settle after the exit of indispensable employees (Starke et al., 2003). These employees possess rare or difficult-to-imitate knowledge which makes them important to the organization's success. Determining what happens when these valuable employees leave may help us to better understand the impact of knowledge loss and formulate appropriate action.

Traditionally, human resource management addresses employee turnover by recruiting new employees or training existing employees as replacements. Employee exit was not considered a significant problem, in terms of knowledge loss, by assuming that a 'quasi-equilibrium' was reached through employee replacement. Three recent organizational developments prompt us to question this.

First, researchers argue that knowledge is now the organization's most valuable resource (Grant, 1996; Zack, 1999). Employees with valuable knowledge (human capital) may take this with them when they leave. The knowledge may be unique or difficult to imitate, making replacement difficult. Second, employee turnover rates are increasing (Arthur and Rousseau, 1996) and often, employees are not replaced. This suggests a reduction in the organization's overall knowledge, because the stock of knowledge resources is not replenished. Third, the average age of the workforce is increasing. Over the next 18 years, a baby boomer will reach retirement age every 18 seconds (Beazley et al., 2002). This means that organizations are increasingly at risk of losing valuable human capital.

To examine the impact of knowledge loss, we must go beyond the human capital construct (that is, individual knowledge) and examine how employees create value for the organization—through the intellectual capital (IC) construct. IC is intellectual material—knowledge, information, intellectual property, experience—used to create wealth (Stewart, 1998), and is commonly analysed in terms of three sub-constructs: human, structural and relational capital (Bontis, 1998). Some researchers also identify a fourth sub-construct: social capital (Youndt and Snell, 2004). The key to measuring the impact of knowledge loss is identifying how indispensable employees create value in each area, and how survivors use that knowledge in their work.

This article identifies whether the knowledge loss caused by the exit of valuable employees affects the organization and its surviving employees, and if so, how. The first section briefly reviews the relevant concepts regarding knowledge loss. The second section describes the research strategy, including details about the case study organization, and how data were collected and analysed. The third section presents the main findings of the study. The final section summarizes the research and discusses the wider implications of the study's findings.

Measuring Knowledge Loss

Previous research identified a range of negative impacts caused by knowledge loss, including reduced organizational output (Droege and Hoobler, 2003) and productivity (Osterman, 1987), and lost organizational memory (Shah, 2000). Cascio (1993) examined the economic and organizational consequences of downsizing—the planned elimination of positions or jobs—and found negative impacts in terms of organization functioning, human resource costs, productivity and employee morale and motivation. Research on the remaining employees (termed 'survivors'), shows negative psychological impacts, such as job insecurity and anger, which manifests itself in areas such as performance, motivation, job satisfaction and organizational commitment (Brockner, 1988). Cascio (1993) calls this the 'survivors' syndrome', characterized by low morale, low productivity and distrust of management.

Some researchers argue that employee exit has a positive affect on the organization. A study by Starke et al. (2003) on indispensable employees (IE) found that organizational performance did not suffer following the loss of a key employee; rather, employees were 'as surprised as the researchers that the sudden departure

of the IE had caused no short-term ill effects on the overall performance of the organization' (Starke et al., 2003). Instead of a negative impact, this study shows a possible *positive* impact, because remaining employees may develop the confidence to fill some of the gaps left by the IE. Other research claims that the valuable knowledge of 'masters', or 'key subject matter experts', may be diffused throughout the organization in their work with others (e.g. the master–apprentice relationship), or in codified forms (e.g. operating manuals) (Cook and Yanow, 1993), thereby limiting the impact of knowledge loss. Starke et al. (2003) suggest that each organization has, tacitly embedded within it, the totality of the knowledge to produce its products or services. Replacement employees may then access the knowledge embedded in the organization's social or structural capital. Several researchers also identify positive effects of employee turnover, for example, eliminating poor performers (Dalton et al., 1981), reducing costs (Dalton and Todor, 1982), improvements in innovation (Abelson and Baysinger, 1984) and reduction in stagnation (Schneider, 1987).

We now examine the impact of knowledge loss within the context of intellectual capital theory.

Lost Human Capital

The predominant theoretical approach to examining organizational-level consequences of voluntary turnover is human capital theory (Dess and Shaw, 2001). Human capital is the knowledge possessed by employees, and is aggregated at the organizational level in terms of their combined competence and experience. Its value is measured in terms of the activities it enables employees to perform and the tacit knowledge resources available to the organization to create new knowledge, solve problems or develop employee capability. When an employee leaves, all their knowledge also exits, including their specific functional expertise, experience, skills and contacts. This may produce two direct impacts: decreased organizational output (Osterman, 1987) and decreased organizational productivity (Droege and Hoobler, 2003).

Lost Social Capital

Social capital is seen as a public good (organizational resource), rather than a private good (individual resource) (Dess and Shaw, 2001), and creates value through relationships which offer the opportunity to create, share and combine knowledge resources (Granovetter, 1992; Kogut and Zander, 1996; Nahapiet and Ghoshal, 1998). Previous research argues that important elements of a social network are lost by employee exit (Dess and Shaw, 2001). Organizational memory is an important network element of social capital, defined as the social network's accumulated experiences gained through learning by doing within the unique construct of the organization itself. The capacity to draw on accumulated past knowledge provides valuable insight for solving current problems, and is also considered a type of tacit social capital. Cascio (1993) provides an example from a Fortune 100 company which had downsized, where a bookkeeper earning \$9 an hour was let go. Unfortunately, the company later discovered that it had lost

valuable organizational memory because the bookkeeper knew how to answer important questions (where, why and how to) which apparently no one else did. The company then hired the bookkeeper back as a consultant at \$42 an hour! The exit of members of a social network may have a direct impact: reduced organizational memory (Shah, 2000).

Lost Structural Capital

Structural capital packages human capital and enables an organization to reuse it repeatedly. It therefore belongs to the organization, can be reproduced, shared and even sold (Stewart, 1998). Structural capital's value may be explained by the learning organization construct: learning organizations build capacity to learn, create knowledge in individuals and enable the distribution of this knowledge throughout the organization (Thomas and Allen, 2006). It provides codified knowledge necessary to support the creativity and innovation underlying learning organization processes (Kanter, 1989). Employees turn to it as a source of knowledge when they do not know what to do or want to learn something new. Thus, structural capital represents a basic building block of knowledge used to increase the individual's, and ultimately the organization's, capability. The exit of employees contributing to the organization's structural capital may have a direct impact: reduced capacity as a learning organization.

Lost Relational Capital

Relational capital is knowledge gained through an organization's relationship with the people it does business with (Stewart, 1998), and is therefore the knowledge embedded in the relationships with customers and suppliers, and broadly includes stakeholders and strategic alliance partners (De Pablos, 2002). Relational capital's value is in its feedback: it shapes human capital by introducing suppliers, customers, contractors and partners' opinions to the employee's perspective. Previous research identifies that lost relational capital may disrupt or terminate the knowledge flow between the interacting organizations (De Pablos, 2002). Some relationships between individuals involve additional personal commitment exceeding the formal requirements of their organizations to work together. This tacit dimension of relational capital ties the knowledge flow to the individual, rather than the position. The exit of employees with valuable tacit relational capital may have a direct impact: decreased knowledge flows with the external organization.

Research Strategy

Method

The study aims were addressed through the case study method of empirical enquiry. The reasons for this are twofold. First, exploratory fieldwork is essential in 'new' areas of research that lack an extant body of both theory and data (Eisenhardt, 1989; Glaser and Strauss, 1967). Second, qualitative studies are

necessary where organizational processes are involved (such as the relationship between knowledge loss and organizational outcomes) which do not lend themselves easily to quantitative measures (Van Maanen, 1979).

The Case Study Organization

The case organization is part of the Australian Department of Defence and provides engineering services for the Royal Australian Navy (RAN), referred to as EngServ, and is important in identifying and managing technical risk within the RAN. As with any defence force, the RAN is involved in many activities that are considered risky. The RAN controls a large and expensive physical infrastructure, for example, ships playing a crucial role in Australia's national security. The consequences if something goes wrong are significant. In managing these risks, the RAN has traditionally focused on the technical integrity of naval materiel during all aspects of design and construction (acquisition) and sustaining and maintenance stages (in-service support). Much of the management of technical risk has been outsourced to industry. EngServ represents the last remnants of the RAN's internal engineering capability for surface ships, so plays a crucial role in ensuring the RAN is an 'intelligent customer' of industry.

Unpacking the Context: Declining Capability

For many years, the Australian government employed a capability to design, build and maintain ships. However, policy changes have gradually eroded the RAN's engineering capability, including the privatization of government-owned factories and dockyards and the contracting out of in-house engineering, design and maintenance services. RAN engineering and technical staff numbers have decreased dramatically. In the early 1990s approximately 700 naval engineers worked for the Department of Defence; currently there are fewer than 100, with significant implications for the RAN's risk management.

First, the navy's stock of technical knowledge decreased substantially. Second, there was a heavy dependence on contractors (private industry) to do the work previously done by the RAN. Third, there were concerns about the capability of industry to maintain technical integrity of RAN materiel. Fourth, the RAN's ability to be an intelligent customer of industry was declining to the point where some worried whether it could still ensure contractors were performing their role. The shift in technical responsibility from the public to the private sector raised concerns. Critics of the outsourcing argued that contractors misunderstood the operational requirements of naval vessels (which were very different from commercial vessels), and that contractors had shallow knowledge and understanding of the complexity of naval vessels and their operational environment.

The RAN's Response: The Technical Regulatory System

In 2001, the RAN responded to the need for improved risk management by introducing its Technical Regulatory System (TRS). The TRS was intended to assure the Chief of Navy (CN) that the technical integrity of naval materiel

was maintained from design inception to disposal—for the full life of the asset. EngServ was the RAN's only internal engineering resource. While most of the technical risk was outsourced to industry, EngServ's role was to ensure that the RAN was an 'intelligent customer' of industry.

Being an 'intelligent customer' requires specialist understanding of how specifications are met by suppliers, especially if the goods or services are outsourced. The RAN faces numerous challenges in the purchase and maintenance of its ships from industry: naval vessels cost hundreds of millions of dollars, and the consequences of not getting what we (the taxpayers) pay for and need (in terms of national security) are substantial. Therefore, RAN is a peak example of an industry whose knowledge losses through employee exit can be measured by this research project.

The Threat of Knowledge Loss at EngServ

EngServ has a very stable workforce. When asked a series of questions about their career plans over the next 10 years, only two respondents (7%) indicated they were likely to move outside the RAN in the next 12 months. Two-thirds of the respondents (20) indicated they would never leave the RAN. Eight respondents (28%) indicated they were likely to leave EngServ to work in other parts of the RAN in the next 12 months. While seven respondents (22%) indicated they were likely to change jobs within EngServ. Interestingly, 10 respondents (32%) felt they would never change their current job and would continue doing their current work until they retired. The majority of respondents had very strong occupational (as opposed to organizational) commitment.

Given this stable workforce at EngServ, the threat of knowledge loss might seem relatively low. However, the reverse is actually true. The stability of the workforce is one factor contributing to its vulnerable position. The lack of employee turnover has led to a lack of recruitment of young people, and the stable workforce has slowly aged together. Retirement is now the organization's biggest threat. Seven respondents (22%) indicated they would retire within the next two years, and they will take with them a combined 174 years of service to EngServ (and the RAN). Further evidence of the gravity of this problem is that the average age of respondents was 51, and the youngest staff member was 41. The typical retirement age in Australia is 55. EngServ's workforce, the last remnant of naval engineering for surface ships in the RAN, is due to retire *en masse* over the next five years. Australian society is ageing, and retirement has replaced normal employee turnover as the biggest threat to the sustainability of many organizations.

Data Collection, Coding and Analysis

The study's objective was to identify the impact of knowledge loss—at the individual and group levels—and to link these to the organization's outcomes through the association between activities and resources. We held a series of workshops with 31 EngServ employees (94% of the organization's employees). Each workshop lasted a full day (7.5 hours). Interviewees were briefed on the workshop objectives (to identify the impact of knowledge loss) and the interview

process. The workshops were facilitated by the author. Interviewees completed a detailed questionnaire that covered the themes and questions (outlined in Appendices I and II). Thus, an interview protocol ensured that the same themes were covered with each interviewee. The questionnaire had two parts: knowledge value and knowledge loss.

This article focuses on the results of the second part of the questionnaires—knowledge loss—to fit the research question, which was to identify the impact of losing valuable knowledge. The first part of the questionnaires derived measurement constructs from the field of strategic human resource management (Allee, 1999; Wall et al., 2004; Youndt et al., 2004; Youndt and Snell, 2004) to identify EngServ's most valuable employees. We then simulated a hypothetical situation in which we 'withdrew' these six most valuable employees from the organization to examine what might happen if they actually exited the organization.

Research Findings

The results are presented in the following way. First, we examine the impact of knowledge loss in each of the four capital types. The results are presented in a series of episodes that simulate what might happen if the valuable employees leave, using the methods proposed in the section 'Data Collection, Coding and Analysis'. Second, the results are discussed within the context of their contribution to the existing literature. Third, we present a preliminary conceptual model.

Measuring the Impact of Lost Human Capital

Episode 1: Decreased Organizational Output Previous research (Osterman, 1987) argues that decreased organizational output will occur if work done by exiting employees is no longer done. If the work is important, the organization will probably fill the gap with a replacement employee, often an existing staff member who has relevant task experience—that is, they do the same or similar work. However, this could still affect output, because the replacement's workload would have to be adjusted. The staff member cannot be expected to do their existing work *and* the work of the exiting employee. Given these circumstances, we formulated a three-step method to predict the level of reduced output that will occur. First, determine what work the exiting employees do. This identifies the risks associated with decreased output by activity. Second, determine the number of remaining employees (survivors) who also do this work. This determines the likelihood of the exiting employees' work being done by survivors. Third, identify the amount of time spent on the activity that would be lost if the survivors' workload was readjusted to do the exiting employees' work. This identifies the consequences of decreased output by activity.

The most significant evidence of decreased organizational output at EngServ resulted when the workload of survivors was readjusted to fill the gap left by the exiting employees. The top six employees perform the activities listed in Table 1, which also includes the average time spent by these employees on each activity and the proportion of time they spend of the overall time the organization spends on the activity (output).

Table 1 Top six employees' tasks

Activity	Average	Output
Engineering policy and requirements management	21%	22%
Managing employees	10%	43%
Engineering advice	9%	13%
Certification of material	8%	55%
Technical support network management	6%	21%
Strategic planning and direction	6%	42%

Table 2 Perception of activity importance

Activity	Rank	Reduction
Engineering policy and requirements management	first	30%
Engineering advice	second	27%
Design of certification basis and validation processes	third	16%

The activities at highest risk are certification of material, managing employees, and strategic planning and direction, because they represent the highest proportion of output that may potentially be lost. This risk may be managed by having survivors who can replace the exiting employees: 27 percent of survivors (seven employees) do certification of material; 38 percent (ten employees) manage employees and 35 percent (nine employees) do strategic planning and direction. It is possible that the exiting employees' work will be done by survivors.

Next, we simulated a scenario where the survivors who did the vulnerable activities were asked to fill the gap left by the exiting employees. After readjusting the survivors' workload, the results indicate a significant reduction in organizational output in key activities (Table 2). The 'rank' in Table 2 represents respondents' overall perception of the importance of this activity.

This method identifies the consequences of decreased output by activity. It shows that employee exit may have a direct impact on activities where these employees spend proportionately more time, and an indirect impact on activities performed by survivors who suffer through readjusted workload. This method's value is in its identification of the risks and consequences by activity, allowing managers to plan for knowledge loss scenarios.

Episode 2: Decreased Organizational Productivity Decreased organizational productivity will occur if work done by exiting employees is done less well (Droege and Hoobler, 2003). Replacement employees may not have the same level of knowledge as the employees they replaced, leading to a net reduction of human capital. We formulated a two-step method to predict the level of reduced productivity that will occur. First, determine whether the exiting employees are considered subject matter experts in the work they do. This identifies the likelihood that productivity decline will occur by activity. Second, determine whether survivors' knowledge search cycle behaviour (see Liesch and Knight, 1999)

becomes less efficient. Search cycle behaviour refers to whether individuals who need help can find necessary knowledge quickly. These two steps identify the consequences of productivity decline by activity.

The results show that the high proportion of survivors considered to be subject matter experts at EngServ and efficient knowledge search cycle behaviour would minimize the impact on organizational productivity caused by the exit of the top six employees. Only a minor risk would be associated with productivity decline at EngServ, because surviving employees do not depend heavily on the human capital of the top six employees. Eleven employees (35%) were considered subject matter experts in various activities performed by EngServ, but these were only three of the top six employees. Further, only two of the top six employees used their human capital to provide a high level of support to others, that is, provide examples for others to help *solve* the problem. Eight 'surviving' EngServ employees were also considered subject matter experts. All of these survivors were able to provide a reasonable level of support, that is, provide examples to help *understand* the problem. This suggests that the organization would retain sufficient subject matter experts to minimize the impact of lost productivity caused by the exit of the top six employees.

The results also indicate a high degree of knowledge search cycle efficiency within EngServ and limited dependence on the top six employees. Slightly more than half (55%) of respondents indicated their main source of knowledge was their own experience and knowledge (human capital); while their second main source of knowledge was structural capital. Only 10 percent of all respondents (three) indicated their main source of knowledge was one of the top six employees; and their second- and third-ranked sources of knowledge were other social capital (that is, other survivors), which means their knowledge search cycle efficiency would not change significantly.

These results suggest only a minor risk is associated with overall productivity decline at EngServ, but the consequences may be significant in some activities. The top six employees were considered subject matter experts in seven of EngServ's main 18 activities. Of these seven activities, four may be vulnerable because there would be few or no subject matter experts left if the top six employees left: managing staff, strategic planning and direction, customer management, and investigation and audit assistance. Customer management and staff management may be significant losses of knowledge because these represent important management activities.

Measuring the Impact of Lost Social Capital

Episode 3: Decreased Organizational Memory Lost social capital may be measured in terms of lost organizational memory (Shah, 2000), which is a type of tacit understanding unique to the social network. We formulated a three-step method to predict the level of reduced organizational memory that will occur. First, determine the membership of the exiting employees' social networks. This identifies who may be affected by reduced organizational memory. Second, determine the strength of relationships between the exiting employees and network members using network density and connectivity measures (Nahapiet and Ghoshal, 1998). This identifies the exiting employee's strongest relationships. Third, determine

the direction and type of knowledge flows between the exiting employee and network members (Schulz, 2001). This identifies the degree of dependence within the social network.

The results show that while the exit of the top six employees at EngServ might produce decreased organizational memory, the impact of this knowledge loss would be minimized by survivors' low dependence on their social network's tacit knowledge. The results of the analysis of the top six employees' social networks are presented in Figure 1. Individuals are identified by numbers. For example, individual 1 is a superior within the social network of top six employees 1, 2 and 4. This highlights individuals common to the social networks of the top six employees and also shows the unique membership characteristics of each network. The numbers in brackets indicate a relationship dependence score: the higher the number, the stronger the individual's dependence on the top six employees. The dependence score is based on two inputs: the type of flow (see the legend on the bottom left) and the direction of the knowledge flow (see the legend on the bottom right). Relationships mapped with short, thick, bidirectional arrows represent the greatest risk of lost social capital; relationships mapped further away from the top six individual represent weaker relationships and lower knowledge risk. For example, top six employee 1 (top left-hand corner in Figure 1) has a very strong relationship with their supervisor (1) and a relatively weak relationship with a supplier (6).

We analysed each of the individuals mapped in Figure 1 to identify which, if any, might be affected by the exit of one or more of the top six employees. In this analysis, we looked for individuals who had either a very strong relationship with an exiting employee or relationships with more than one of the top six employees. Thus we identified four survivors who appear to be the highest risk of being affected by lost organizational memory based on the social network analysis in Figure 1: individuals 1, 4, 5 and 7. Table 3 provides case summaries of these four individuals.

Table 3 shows that disruption of social networks through the exit of the top six employees would have limited impact at the organizational or individual levels. At the organizational level, three of the case study employees were performing important work for EngServ and, therefore, there may be an indirect impact on the organization's capability through lost social capital. However, examining how these employees work, solve problems and learn shows that only one would be significantly affected by lost social capital, and therefore the impact may be isolated to the work output of this one individual. Two of the survivors in Table 3 rely on codified, rather than tacit, knowledge. In this sense, the lost social capital would have little impact, as long as the organization's structural capital was sufficient to solve their problems. An indirect impact may occur if the exiting employees were valuable sources of structural capital, because this knowledge resource would then suffer. However, we found that the loss of these employees would have little impact on the ability of the organization to codify its knowledge (that is, create structural knowledge) because these employees were not likely to transfer their knowledge to the organization before leaving. We may then conclude that the employees that rely on structural capital would not be affected by the loss of these employees.

Figure 1 Social network analysis

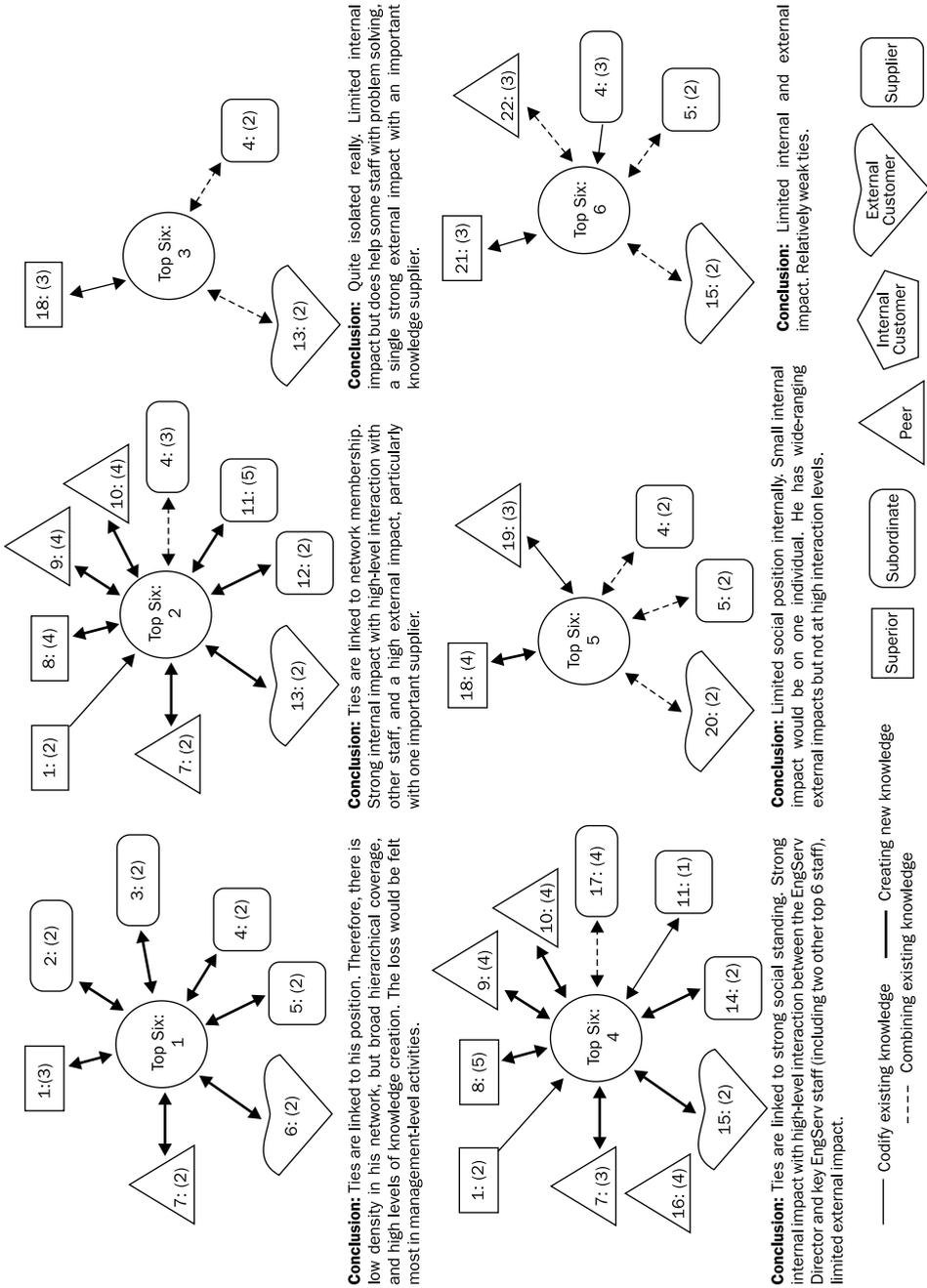


Table 3 Summary of results of impact of social capital loss—mini case studies

Importance of work	Impact on management activities	Impact on technical activities	Impact on learning	Impact on problem solving	Summary of impact
<p>Case study 1: Assistant Director, 14 years of service, not planning to leave the EngServ within 10 years, manages computer modelling and technical documentation (e.g. handbooks).</p> <p>Important: the activity on which he spends most time (engineering and policy requirements) was the first-ranked technical activity; while his main management activity (manage employees) was ranked third among the management activities.</p>	<p>He tends to rely on his own experience and knowledge, and if he does not know the answer, he seeks the help of his supervisor and then policies and procedures.</p>	<p>He is likely to go straight to his supervisor for help. There is a close relationship between these two individuals in solving problems.</p>	<p>Main source of learning at work is his supervisor.</p>	<p>Significant heavily on his supervisor (who is one of the top 6 to exit in our simulation), particularly for his main activity.</p>	<p>His work is important to the EngServ, and therefore disruption of his social network is likely to have a significant impact on the overall performance of the organization.</p>
<p>Case study 2: Technology Manager, 14 years of service, not planning to leave the EngServ within 10 years, investigates new technologies that affect ship design, development and certification.</p> <p>Unimportant: the activity on which he spends most time (managing employees) was ranked third among the management activities; while his main technical activity (engineering product reviews) was the seventh-ranked technical activity.</p>	<p>He is likely to go straight to his supervisor for help.</p>	<p>He relies on a knowledge supplier to help.</p>	<p>Main source of learning is his own experience, followed by his supervisor.</p>	<p>Some impact: he relies heavily on his supervisor (who is one of the top 6 to exit in our simulation), particularly for his main activity, but there would be no impact for his technical activities.</p>	<p>His work is relatively unimportant to the EngServ. The main impact area (management of employees) could be easily covered by others. Therefore, disruption of his social network is likely to have only a minor impact on the overall performance of the organization.</p>

Case study 3: Assistant Technology Manager, 13 years of service, not planning to leave the EngServ within 10 years, performs computer modelling, documentation drawing.

<p>Important: the activity on which he spends most time (engineering and policy requirements) was the first-ranked technical activity; while his main management activity (facility management) was ranked eighth among the management activities.</p>	<p>He relies on codified knowledge, standard operating procedures, or policies.</p>	<p>He relies on his own experience or codified knowledge.</p>	<p>His main source of learning is training courses, followed by policies.</p>	<p>Little impact: he relies on structural capital, rather than social capital.</p>	<p>His technical work is important, but he relies mainly on codified knowledge, so disruption of his social networks likely to have only a minor impact on the overall performance of the organization.</p>
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Case study 4: Senior Professional Engineer, 24 years of service, planning to leave the EngServ within three years, provides engineering advice.

<p>Important: the activity which he spends most time (engineering and policy requirements) was the first-ranked technical activity; while he spends very little time on management activities.</p>	<p>He relies on his own experience or codified knowledge.</p>	<p>He relies on his own experience or codified knowledge.</p>	<p>He learns on the job or from knowledge suppliers.</p>	<p>Little impact: he relies on structural capital, rather than social capital.</p>	<p>No real impact on the organization for the same reasons as Case study 3.</p>
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We found only one employee at EngServ who might be significantly affected by the exit of the top six employees. Interestingly, this employee was in a management position, while the other three employees that were part of the top six employees' social networks (Table 3) but would not be significantly affected by their exit, were at lower levels in the organization. This might suggest that management is more likely to be affected by lost social capital than employees, perhaps because the nature of their work relies more on networking and other socialization of knowledge. Or, management employees may be more likely to draw on organizational memory in doing their work compared with other employees.

Measuring the Impact of Lost Structural Capital

Episode 4: Decreased Organizational Learning The impact of lost structural capital may be measured in terms of reduced organizational learning capacity. We formulated a two-step method to predict the impact. First, determine the currency of structural capital to assess whether employees use it to do their work and learn. This identifies the degree to which structural capital contributes to learning organization capacity. Second, determine the role of exiting employees in contributing to the stock of structural knowledge. The risks associated with reduced organizational learning capacity may be identified by the number of exiting employees who frequently contribute to the organization's structural capital in activities where this capital is perceived to have currency. We then need to examine how survivors use structural capital to do their work. This identifies the consequences of organizational learning capacity decline by activity.

The results show that the exit of the top six employees at EngServ might produce only a minor impact on organizational learning capacity, due to the limited importance of learning and the way employees learn. EngServ employees do not often need to learn. The workforce is very stable, with little employee turnover, and recruitment of new employees is rare. Therefore, EngServ employees tend to rely on their own human capital to do their work. If they need to learn, they prefer to 'learn by doing'—by applying their existing knowledge to new problems. While these results suggest the risks associated with organizational learning decline at EngServ are relatively low, some activities are at risk. Activities are vulnerable where structural capital is seen as a relatively important source of learning, has high currency and exiting employees contribute to this currency. Only one EngServ activity met this criterion: managing employees. The consequences of lost structural capital are significant because managing employees is considered the third-most important management activity. Another activity, defence record management, has some associated risk, because structural capital is the main source of learning. However, the structural capital has low currency (it is outdated) and the exiting employees do not contribute to its currency, so the risk is low.

Measuring the Impact of Lost Relational Capital

Episode 5: Disrupted or Terminated External Knowledge Flows The impact of lost relational capital may be measured in terms of the tacit knowledge flows tied to the individuals, rather than to the position. The tacit dimension of relational

capital may be explained by combining Schulz's (2001) depth of knowledge flow construct with depth of personal relationship construct from Maister et al. (2000). Schulz's (2001) framework on type of knowledge flows identifies levels of tacitness. Maister et al. (2000) measure levels of relationship in terms of honesty, trust and openness in both communication and knowledge flows. When complex knowledge flows combine with a deep personal relationship, this may create a tacit dimension to the inter-organizational relationship which cannot be simply transferred to a replacement employee, because deep relationships take time and must be earned. We formulated a two-step method to predict the level of reduced tacit relational capital that would occur. First, determine whether exiting employees had relationships with important external organizations. Second, determine the type of relationship between the exiting employees and these important external organizations, using the framework presented earlier. Using this method, we propose that the risks associated with reduced tacit relational capital may be measured by identifying the number of exiting employees whose relationships with external organizations are tied to the individual rather than the position. We then need to examine how survivors use the tacit relational capital to do their work.

The results show that the exit of the top six employees at EngServ would produce only minor impact on external knowledge flows, due to the high degree of formality associated with its inter-organizational relationships. The majority of the relational capital at EngServ is tied to the position, rather than to the individual. The organizations are motivated to interact, and will invest in replacement employees to maintain necessary stocks of relational capital—therefore, minimizing the impact of employee exit. The results show that the top six employees did spend more time with the most important external organizations compared with other employees. However, the risk of knowledge loss is explained by the nature of these relationships—that is, the tacit dimension.

For the top six employees, some relationships involved a simple, transaction-based information exchange with an external government agency. This knowledge flowed from the external organization to EngServ in the form of employee training, including processes such as how to write a technical standard, or how to use updated computer systems. A similar relationship also existed with internal customers, where EngServ provided their basic service, that is, 'engineering advice' and 'up-to-date technical information'. This inter-organizational relationship creates little or no knowledge loss impact: barely a ripple on the pond. The organizations need only an access point and a liaison person. The knowledge flow is one way, and is tied to the position.

Two of the top six employees had relationships with overseas navies which may be defined as a recombined knowledge flow. These relationships involved updating international requirements necessary to implement engineering and technical standards. The knowledge flow was mainly one way—from overseas to EngServ—reversed occasionally through knowledge created by local operating conditions. These relationships are also largely tied to the position.

Some relationships involved risk because the knowledge flows were tied to the individual, rather than the position. Two of the top six employees had relationships with industry (ship builders and contractors) which involved a *complex* knowledge flow. These relationships involved a two-way flow of knowledge which created new knowledge. The knowledge creation combined the external

organization's knowledge of the ship systems and equipment with EngServ's knowledge of the RAN's technical regulatory system and standards. The new knowledge created is considered important to maintain currency of the systems knowledge for the interacting organizations. Therefore, the exit of two of the top six employees could have significant consequences because their relationships with ship builders and contractors are deep—the relational capital helps perform important activities, and it creates new knowledge.

Despite this risk, the impact of lost tacit relational capital is lessened by the formality of the relationships. These organizations must interact, and therefore the individuals work with positions, rather than other individuals. The tacit knowledge of the informal component of the relationship is relatively unimportant because people accept that they must build new relationships. This is particularly evident in organizations such as defence, where there is traditionally a high employee turnover rate (e.g. due to the posting cycle for uniform employees). Individuals in such sectors understand that relationships rarely endure and that they must work with new people when employees exit.

A Preliminary Conceptual Model

The findings of this case study analysis of the impact of knowledge loss at EngServ allow us to propose a preliminary conceptual model. Figure 2 continues with our theme of 'ripples on a pond' to illustrate the differing levels of impact by knowledge capital type. The knowledge of the exiting employees spills over the edge of the pond, the outer circle in Figure 2, and is lost to the organization for ever. Therefore, the impact of knowledge loss is conceptualized in terms of multiple layers of impact, with the weakest impact towards the centre of the 'pond' and strongest impact at the farthest edge.

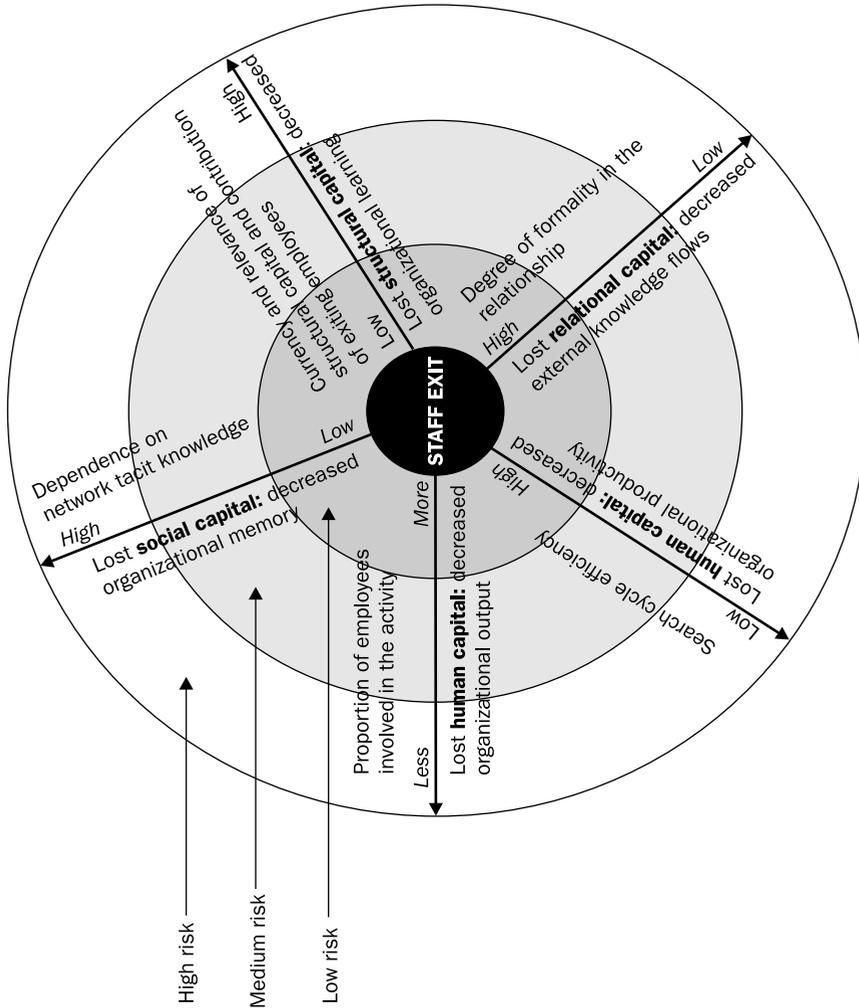
Figure 2 offers a framework to map the impact of knowledge loss, which allows us to identify and isolate the nature of the problem and the level of risk involved. Figure 2 illustrates five 'spikes' in the wheel, each of which represents a type of knowledge capital, with human capital having two spikes. The top of each spike describes the factors influencing the level of impact. Underneath each spike is the measure of impact of knowledge loss. The nature of the impact depends on the organizational context. Each organization faces different levels of risk and consequences along each of the five dimensions of knowledge loss, presented in Figure 2.

The method and measures proposed by this article allows organizations to plot their own knowledge loss profile. Similarly, the model may be applied at micro levels to identify the specific impacts at the levels of business units, social networks, individuals and activities. This might be an area that could be empirically tested in further research.

Conclusion

The article proposes a theory that may be used to measure the impact of knowledge in four types of capital: human, social, structural and relational. Figure 2

Figure 2 Preliminary conceptual model: knowledge loss impact



summarizes a preliminary conceptual framework. The research has two main contributions. First, it offers a relatively rich description of the potential impact of knowledge loss in a particular organization, EngServ. Second, it suggests the way knowledge loss affects the organization through the work behaviour of its remaining employees, the 'survivors'. Third, it explains why these employees will be affected by capital type and activity—for example, the impact of lost organizational memory may be traced to individuals in a social network, and the way they use this social capital to perform activities, solve problems, learn and create new knowledge. This enhances the model's managerial application by isolating the nature of the problem of knowledge loss.

While some organizations may feel they have a good understanding of which employees have the most valuable human capital (e.g. organizational charts), the constructs of tacit social capital (organizational memory), tacit structural capital (learning organization contribution) and tacit relational capital (knowledge tied to the individual, rather than to the position) introduced by this research offer a deeper level of insight. The preliminary conceptual model in Figure 2 draws together the findings in a way that can guide managers and researchers to implement or test the posited causal links in the loss of knowledge caused by the exit of valuable employees.

The framework has several acknowledged limitations. First, it is based on a positivist paradigm which suggests it is possible to analyse, understand and predict the impact of knowledge loss. Some may find this notion confronting, in particular the idea that we may assign a value to the knowledge of individuals, that is, their indispensability. Second, it is based on the study of a single defence organization which suggests caution in application to other organization types. These reservations highlight that the present study was an exercise in model development which, naturally, should be followed by additional studies of model testing.

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Appendix I

Interview Themes

1. Background of the interviewee.
2. The interviewee's career plans.
3. What the interviewee does at EngServ.
4. The interviewee's knowledge.
5. The interviewee's social relationships at work.
6. The interviewee's perception of the impact of knowledge loss.

Appendix II

Interview Questions—Areas of Inquiry

1. Role within the organization
 - Name, position, rank, years of service, contact details.
 - When do you intend retiring or leaving EngServ?
2. Activities
 - What do you do at EngServ?
 - How much time do you spend on these activities?
3. Knowledge
 - What do you know that makes you valuable to EngServ?
 - Rank EngServ's activities, in terms of what you know most about.
 - What type of knowledge is required to perform these activities, that is, qualifications, contacts, policies?
 - When you perform an activity, where does your knowledge come from?
 - If you do not know how to do the activity, where do you go for help?
 - Levels of knowledge, posed by questions on cause and effect, how to improve the activity, and how the interviewee would train someone to do this activity.
4. Relationships
 - Who are your most important internal and external contacts?
 - What is the nature of the relationship with these contacts?
 - Who do you go to for help on: technical problems, management problems, customer problems, and contractor or supplier problems, personnel issues?
5. Knowledge loss
 - Whose departure has had the biggest impact on your work at EngServ?
 - Why?