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GETTING PREPARED FOR THE 21ST CENTURY COMMAND AND CONTROL ENTERPRISE

Topic 7: C2 Approaches and Organization

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GETTING PREPARED FOR THE 21ST CENTURY COMMAND AND CONTROL ENTERPRISE

ABSTRACT

Abundant research on the effects of the information age on the modern military indicates that network centric warfare (NCW) and the associated concept of C2 are driving transformational changes on the way war is conducted. Novel approaches point out that the services must develop new capabilities in the physical, information, cognitive and social domains, in order to successfully apply C2 practices and meet 21st century mission challenges.

This paper draws upon theories from the fields of cognitive science, knowledge management, organizational learning, decision making, military sociology, and organizational memory, to identify key processes and organizational elements that services have to develop in order to get prepared —mainly at the cognitive domain— for utilizing C2. The fundamental organizational aspects we identify are aimed at developing and sustaining the body of knowledge that provides the basis for accomplishing shared awareness, shared understanding and high quality sense making.

Our results include the proposal of a knowledge management cycle specially tailored for information age military organizations. The central role of this cycle is played by a set of knowledge bins, which should storage the explicit and tacit notions that come to bear in combat situations. These findings are supported by real world data.

A. BACKGROUND

In order to climb up the Command and Control (C2) maturity level hierarchy[1], innovation in organizational processes is needed, so that new technology is appropriately utilized to deliver cognitive and social domain outputs[2] that generate force agility. A central part of these new approaches refers to the processes of "sensemaking" whereby preexisting knowledge is combined with real-time information to develop appropriate action plans during military operations[3,4]. According to Alberts and Hayes[5], key elements of sensemaking are individual and collective awareness, understanding, prediction and decisions. At the individual level these perceptions are generated through associations between the current situation and preexisting mental models and knowledge. While at the collective level, they emerge when interactions among individuals and groups take place. We believe that accomplishing individual and collective sensemaking is an extremely challenging objective that should be tackled through knowledge management (KM) practices.

[1] This hierarchy is part of CCRP research work. It appears in Moffat, 2007.
[2] These outputs are described in Alberts and Hayes, 2006, pp. 57-60.
[3] Alberts et al., 2001.
[4] Alberts, 2002.
[5] Alberts and Hayes, 2006, p. 65.

KM encompasses a number of organizational processes that integrate an organization's approach to organizing and applying its knowledge assets[6]. The theory on which KM is based borrows ideas from a variety of fields such as cognitive science, organizational learning and sociology, among others. Our propositions in this paper are based on the notion that human beings acquire and utilize knowledge by paying attention to the more demanding and novel aspects of a situation while relying on a complete background —most of which is tacit and embedded in the individual's mind— to manage the more common and well-known part of the problem at hand[7].

The notion above is crucial in a Network Centric Warfare (NCW) environment, where the hastened pace of operations becomes paramount, and where naturalistic decision making is a prevalent practice. Within this context, decisions are made at the edge of the organization, where operations take place, while lower hierarchical levels have to be granted increased degrees of power and freedom[8]. However, decision makers in this setting have to be "experts", who are capable of recognizing familiar patterns and devising a feasible course of action to attain command objectives within harsh situations[9]. Therefore, commanders' preparation and analytic skills, along with collective understanding of codes, mental models, values, behaviors and motivational roots, are key elements for attaining C2 improvements within a networked environment.

Consequently, the path through the C2 maturity level ladder demands managerial actions aimed at developing individual and collective knowledge and skills, which lay in the KM field.

B. THEORY AND HYPOTHESES

More than a decade ago, intangibles in general, and more specifically intellectual capital, were identified as the most important assets of organizations, while relegating physical resources to a secondary role[10]. As a consequence, knowledge was identified as the primary source of competitive advantages[11], giving birth to the novel discipline of KM. Like several previous researchers, we approach KM through a KM cycle[12], which we describe in the next section.

1. Knowledge Management Cycle

Implementing KM requires a strategy that distinguishes knowledge as the most relevant resource for attaining organizational objectives and that regards knowledge as an intellectual form of capital to be leveraged. The growth of this capital must be a

[6] Waltz, 2003.

[7] These ideas have been developed in the cognitive field by Polanyi (1962); in the management field by Nonaka and Takeuchi (1995) and, more recently, in the neurobiological field by Edelman (1992, 2005); Damasio (1994) and Searle (2000).

[8] Alberts and Hayes, 2003.

[9] Klein,1998; Lipshitz et al., 2001; Ross et al., 2004.

[10] Quinn, 1992; Drucker, 1993.

[11] Prahalad and Hamel, 1990; Kogut and Zander, 1992; Nonaka, 1994; Grant, 1996 a; Grant 1996 b.

[12] Wiig, 1993; Meyer and Zack, 1996; Dalkir, 2005.

commitment ingrained in organizational values[13]. For this purpose, we view KM as an array of processes that lets knowledge evolve from mere static data or information to structured understanding of meaning that is applicable in dynamic situations. A useful way to organize KM processes is as a sequential cycle that depicts separate, though interrelated, efforts[14].

For military organizations, and following earlier researchers, we have developed a KM cycle that concentrates KM efforts in four main processes (See Figure N°1): acquisition[15], retention[16], dissemination[17], and utilization[18]. Simply stated, this cycle indicates that knowledge is acquired, either through practice or through information exchange, then, if this knowledge is deemed valuable, it is assimilated and therefore it is retained and diffused, which makes it available for utilization by many agents throughout the organization. For simplicity, this cycle intentionally hides some other important relationships between this four constructs, however it emphasizes some elements that are especially relevant for military organizations.

(i) *Knowledge acquisition*: encompasses both creation of knowledge and importing knowledge from external sources. Knowledge creation is a common practice implemented through lessons learned processes[19] and battlefield research, whereas importing knowledge is an efficient learning mode for the military, since these organizations spend most of the time training and rather short periods in real deployments[20]. Consequently, experiences form other militaries are usually welcomed.

(ii) *Knowledge retention*: includes developing a set of knowledge bins where the intellectual capital is stored and nurtured. This is the central process of our model as it influences each of the other three processes of the cycle (dotted lines in Figure N° 1). This process consists of developing the physical, social and cognitive infrastructure where knowledge resides and flourishes. We term this infrastructure Organizational Memory (OM).

(iii) *Knowledge dissemination*: refers to information and knowledge diffusion within the organization. It includes the many efforts and technical infrastructure dedicated to make information and knowledge comprehensively available.

(iv) *Knowledge utilization*: is the process by which background knowledge is applied in military activities and decision making — either in training or real deployments. An outstanding feature of this process is knowledge reuse, which is targeted to improve problem solving skills in novel situations.

[13] Waltz, 2003.
[14] Several KM cycles by different authors are described in Dalkir (2005).
[15] Nonaka, 1994; Cook and Brown, 1999; Huber, 1991.
[16] Walsh and Ungson, 1991; Sandoe and Olfman, 1992; Morrison, 1997; Jennex and Olfman, 2004.
[17] Albino, Claudio and Schiuma, 1990; Hendricks, 1999; Argote and Ingram, 2000; Kalling, 2003.
[18] Nonaka and Takeuchi, 1995; Wiig, 1993; Dalkir, 2005; Markus, 2001.
[19] US Army Regulation 11-33, 2006.
[20] Irwin, 2005.

These four processes represent organizational KM efforts[21]. Among them, *knowledge utilization* is the one of primary interest for this research, since this is the process where previous understanding and sensemaking are applied for course of action selection.

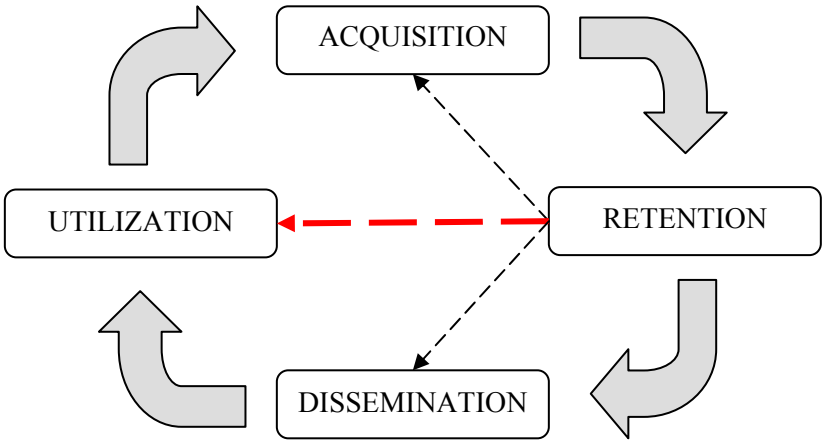

Figure N°1. Knowledge Management Cycle and relationships of interest.

Additionally, we argue that *knowledge retention* is the key enabler process within this cycle. On the one hand, according to the theory of absorptive capacity (ACAP), the stock of previous knowledge in the area of interest is one of the key elements for knowledge transfer either from the external environment (*knowledge acquisition*) or among internal units (*knowledge dissemination*)[22], for only prior related preparation enables individuals or groups to "*recognize the value of external knowledge, assimilate it, and to apply it to organizational ends*"[23] (black dotted lines in Figure N° 1). And on the other hand, the theories of naturalistic decision making[24] and improvisation[25], consider previous preparation and background knowledge the most relevant means to adequate decision making *(knowledge utilization*). Following this line, Zsambok[26] argues that "*naturalistic decision making is the way people use their experience to make decisions in field settings*". Whereas Ross et al.[27] apply this concept to the military field by arguing that "*a commander's knowledge, training, and experience generally help in correctly assessing a situation and developing and mentally wargaming a plausible course of action…*" (red dotted lines in Figure N° 1). These arguments indicate that the process of *knowledge retention* plays a central role in KM practices, therefore this process is of high interest for this research.

In order to narrow the scope of this research, we will concentrate on the most relevant part of the KM cycle, that is, the relationship between *knowledge retention* —which we will operationalize through organizational memory— and *knowledge utilization*.

[21] Wiig,1993; Dalkir, 2005.
[22] Cohen and Levinthal, 1990; Zahra and George, 2002; Van den Bosch et al, 2003.
[23] Cohen and Levinthal, 1990, p. 128.
[24] Klein, 1997; Zsambok, 1997; Klein, 1998; Lipshitz et al., 2001.
[25] Wieck, 1993; Hutchins 1996; Moorman and Miner, 1998a.
[26] Zsambok, 1997, p. 5.
[27] Ross et al. 2004, p. 6.

2. Organizational Memory (OM)

OM is the set of repositories of information and knowledge that enable organizations, groups or individuals to bring knowledge from the past to bear in present activities and decision-making[28]. Thus, a complete background of knowledge is utilized to understand and make sense of information related to a current situation and so make decisions.

Nevertheless, reusing knowledge from the past may yield either improved or degraded results, since a partial loss of the knowledge context is inevitable, which may seriously affect knowledge validity in a new setting. Therefore, reusing knowledge in the demanding environment of the battlefield takes a great amount of expertise that combines concrete (explicit) and abstract (tacit) knowledge[29]. Both of these types of knowledge are distinct; but complementary and inseparable[30], and they are both accumulated in OM repositories.

Accordingly, two types of organizational memory are identified in the relevant literature, concrete and abstract OM[31]. Concrete OM includes capturing structured information and knowledge in databases, documents and artifacts. This can be done through data collection and filling in of forms, reports and records. This OM can be partially automated through IT[32]. Abstract OM, on the other hand, involves retaining unstructured information and knowledge, which is more difficult to accomplish, since documents, databases and artifacts can only capture part of these notions. For this kind of OM, individuals' minds and the social context are the receptacles for knowledge accumulation.

Following the arguments above and keeping in mind NCW purposes, we have identified four main knowledge bins where military organizations' knowledge resides, these are: personnel, doctrine, culture and information systems (IS).

We believe that implementing Edge Organizations[33] requires a particular organizational setting, where decision makers, at the operational level, are real experts, who have profound expertise in their field; but also share an important part of their background with their counterparts, so that whenever they make decisions in a hastened fashion —because of a situational requirement— they are understood and accompanied by the rest of the players in the game. This is nicely explained by Moorman and Miner[34], who compare this capability with that of jazz players. These musicians usually conduct their interpretation following the "skeleton" of the original chord (common known background), however they constantly include melodic improvisations (taken from their personal expertise) that have internal patterns unrelated to the original harmonic, rhythmic, or melodic structures. Yet, these non preplanned modifications are clearly understood by the rest of the players in the band and they are also able to complement them to produce a totally new and tuneful piece of music (shared values, cognitive maps and mental models).

[28] This definition has been taken from previous definitions of OM by Stein & Zwass (1995) and Walsh & Ungson (1991).
[29] Jennex and Olfman, 2004.
[30] Jassimudin et al., 2005.
[31] Morrison, 1997.
[32] Dalkir, 2005.
[33] Alberts and Hayes, 2003.
[34] Moorman and Miner have developed relevant research on the theory of "improvisation". See Moorman and Miner 1998a and 1998b.

If organizations, groups and/or individuals utilize knowledge from OM bins in performing their activities and decision-making, like in jazz playing, then the influence of each knowledge bin on knowledge utilization should be strong. We believe that the better developed (or managed) are the OM bins, the more useful knowledge they accumulate, and thus the more this knowledge is utilized.

To back our arguments empirically we have developed two models and a set of hypotheses, which we describe in the next paragraphs. The first model is depicted in Figure N° 2.

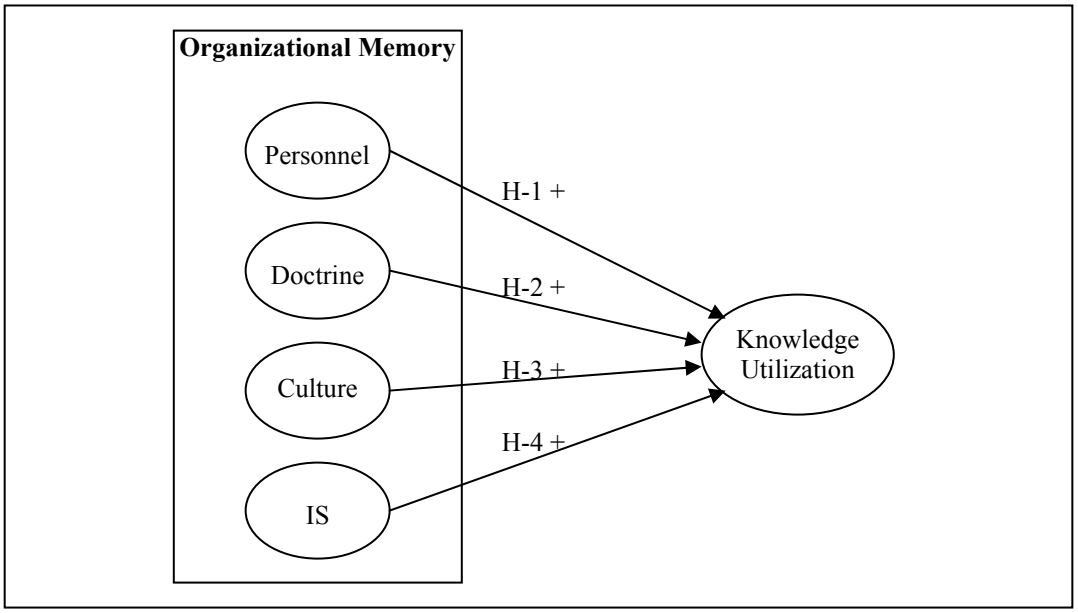

Figure N° 2. Structural Model "A". Relationship between OM bins and Knowledge Utilization.

i) Personnel.

People accumulate knowledge in an instinctive manner because this is a natural ability of the human mind[35]. In military organizations people build up knowledge as they receive education and training. Every individual keeps live remembrances of his or her work experiences[36], which may be retained within an explicit memory or at a subtler repository such as beliefs, values and assumptions[37]. Thus, OM resides in the individual's ability to recall and articulate experiences and courses of actions taken in different situations[38]. Furthermore, the widespread practice of teamwork in military activities provides collective value to individuals' memory, and so coordination and synergies are attained[39]. In this regard, personal skills acquired through training activities represent an important part of OM stored in military personnel. Finally, we believe that when people are highly motivated —which is usually the case in the

[35] Edelman, 1992; Damasio, 1994
[36] Argyris and Schon, 1978.
[37] Walsh and Ungson, 1991.
[38] Jennex and Olfman, 2004.
[39] Weick and Roberts, 1993.

military— they tend to get the best of the knowledge they have retained. Based on these arguments we propose:

Hypothesis 1 (H-1): *A high level of development of personnel OM is positively related to knowledge utilization.*

ii) Doctrine.

Doctrine, as defined by the Canadian Army, is "*the formal expression of military knowledge and thought that the Army accepts as being relevant at any given time, which covers the nature of conflict, the preparation of the Army for conflict and the method of engaging in them for success. Doctrine includes tactics, techniques and procedures, SOPs, and battle task standards"*[40]. Accordingly, doctrine is, by definition, a body of knowledge that has been developed to provide the forces with a framework of guidance for the conduct of warfare. It is dynamic and it is constantly updated for relevance[41]. Since doctrine is purposefully developed to be applied in the field in combination with situational information, we state:

Hypothesis 2 (H-2): *A high level of development of doctrine is positively related to knowledge utilization.*

iii) Culture.

Edgar H. Schein, who is recognized as the father of organizational culture[42], provides the following definition: organizational culture "*is the pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems*"[43]. Culture is also viewed as a multi-faceted dimension that includes artifacts, behaviors, values, emotions, and motivational roots[44]. Hofstede *et al*.[45] characterize culture as being holistic, historically determined, socially constructed, and difficult to change. Although every organization has its own culture, strong or weak, most organizations do not create their culture consciously; instead it is built and ingrained unconsciously[46].

The characterization of culture above lets us view it as a significant amount of knowledge historically accumulated and intrinsically accepted by individuals, which has become a collective cognitive background to be applied in an unconscious manner. If the cultural imprint on organization's members is strong enough, this tacit knowledge will be frequently utilized in problem solving activities, while interpretation may be shaped by the uniformity of prior cognitive maps possessed by organizational units[47] or

[40] Canadian Army, 2009.
[41] British Ministry of Defence, 2001.
[42] Dalkir, 2005.
[43] Schein, 2004, p. 17.
[44] Hawkins, 1997.
[45] Hofstede *et al*., 1990.
[46] Schein, 1999, 2004; Kayworth and Leidner, 2004; Dalkir, 2005.
[47] Huber, 1991.

the degree of shared context between interchanging agents[48]. This leads to the following research hypothesis:

Hypothesis 3 (H-3): *A strong culture is positively related to knowledge utilization.*

iv) Information Systems.

Information systems are defined as "*Interrelated components working together to collect, process, store, and disseminate information to support decision making, coordination, control, analysis and visualization in an organization*"[49]. Consequently, one of the main purposes of information systems is to act as an OM component. There exists abundant literature highlighting the supportive function for OM performed by IS[50]. Actually, there is a special kind of IS —termed OMIS, Organizational Memory Information Systems— that is designed for this purpose[51]. Information systems usually store explicit knowledge, and their contents tend to overlap with that of doctrine and the more concrete part of personnel knowledge, however we have modeled IS separately because these systems are essential for overcoming spatial, temporal and organizational barriers, which hinder background knowledge utilization in current activities and decision making. Thus, we expect that the usage and development of IS will benefit existing knowledge utilization. These arguments lead us to the following research hypothesis:

Hypothesis 4 (H-4): *An advanced development of information systems is positively related to knowledge utilization.*

All of the four hypotheses above are intended to test the effect of each knowledge bin on the construct of Knowledge Utilization as shown in Figure N° 2. These knowledge repositories are represented as one-dimensional variables and their effect on Knowledge Utilization is measured independently. Therefore, testing of model "A" and the hypotheses above will only illustrate the influence of each bin on Knowledge Utilization. Although we believe this information is valuable for assessing the relative impact of each repository, we believe that an integrated measurement of the effects of OM is also necessary.

In this regard, we acknowledge that there is content overlapping between knowledge bins. For instance, part of the doctrine's content becomes embedded in culture as its utilization develops into habitual practices. Besides, usually parts of doctrine become a component of personnel's background as people learn and train, whereas culture is indeed ingrained in both the social and the individual context. We also acknowledge that there are interdependencies among knowledge bins. IS, for example, play a supportive role for the whole OM, while culture shapes what is included in all other bins. These partial overlapping and interdependencies indicate that it would also be illustrative to perform a complementary measurement where OM is represented as a second order multidimensional construct, that is, a construct encompassing a number of different but interrelated

[48] Alavi and Leidner, 2001.
[49] Laudon and Laudon, 2006.
[50] See for instance: Stein and Zwass, 1995; Morrison, 1997; Jennex and Olfman, 2004.
[51] Stein and Zwass, 1995; Morrison, 1997.

dimensions that must be treated as only one theoretical concept. This additional measurement is depicted by model "B" in Figure N° 3.

In model "B" OM is conceptualized as having multiple dimensions (OM bins), with each dimension representing an important aspect or facet of the construct[52]. According to Podsakoff et al.[53], this modeling is appropriate to characterize constructs having several "*areas that complement each other and collectively represent"* the construct. In this case, OM is the result of the combination of all four knowledge bins[54].

Consequently, model "B" will provide information of the integrated effect of OM —composed of all four knowledge bins— on Knowledge Utilization, which is not possible to obtain from model "A".

For this purpose, we formulate the following hypothesis, which is depicted in Figure N° 3:

Hypothesis 5 (H-5): *An advanced development of organizational memory is positively related to knowledge utilization.*

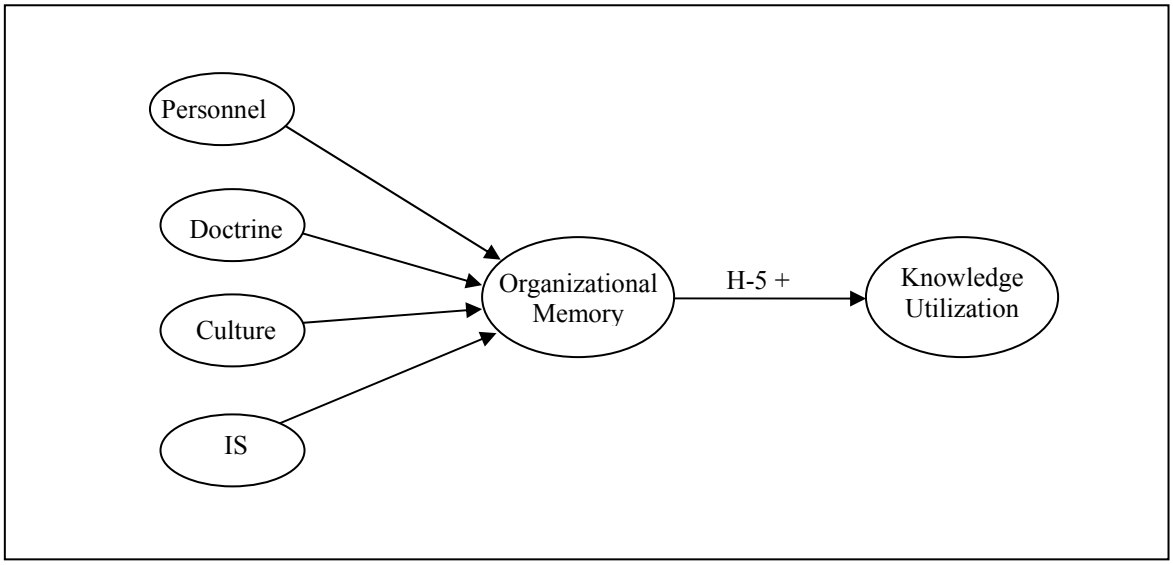

Figure N° 3. Structural Model "B". Relationship between OM and Knowledge Utilization.

C. METHOD AND DATA

1. Method

Our empirical work was based on subjective evaluation of variables by experienced active military officers. It was carried out through a measurement instrument (questionnaire) especially prepared for this research.

[52] Bollen and Lenox, 1991.
[53] Podsakoff, Shen and Podsakoff, 2001, p. 207.
[54] Law et al., 1998; Podsakoff et al., 2001.

The methodology we applied consisted of the following steps: (i) defining each construct's conceptual domain; (ii) reviewing literature in search for previous measurement of similar constructs; (iii) specifying construct dimensions when necessary; (iv) indicators selection; (v) measurement instrument preparation; (vi) instrument validation by experts; (vii) instrument distribution; (viii) data collection; (ix) statistical analysis of data; and (x) discussion and conclusions.

2. Measures.

In order to overcome measurement difficulties, as long as possible we tried to use —or adapt— indicators from previous research where they had exhibited high reliability and validity figures. Some of the indicators we used had even been used several times before. This is the case of the constructs related to personnel OM; culture OM; and information systems OM. For doctrine OM and knowledge utilization we developed our own indicators.

The conceptual domain of each construct and the source of the indicators we used are shown in table N° 1.

Table N° 1. Conceptual domain of constructs and indicator surces.

Construct	***Conceptual Domain***	***Source of Scales***
Personnel OM	The construct is intended to measure the amount of knowledge residing in individuals. It includes items related to formal education; personal skills; training in specific jobs; motivation and willingness to work for common objectives.	Minbaeva et al. 2003; Bassi and McMurrer, 2007.
Doctrine OM	The construct is intended to measure the level of development of institutional doctrine for force deployments and combat activities. It includes items related to doctrine completeness, currentness, and pervasiveness.	Authors.
Culture OM	The construct is intended to measure the presence a culture that favors knowledge accumulation, and the emergence of shared meanings, values and mental models, that is, a strong culture. It includes items related to organizational values, stories and rites. These items were taken from the instrument called "Cultural Strength Index".	Barnes et al, 2006.
IS OM	The construct is intended to measure the extent to which organizations have implemented information systems that enable OM development. It includes items related to infrastructure development, content quality and accessibility.	Perez 2005.
Knowledge Utilization	The construct is intended to measure the extent to which people in the organization utilize background knowledge for present activities and decision making. It includes items related to knowledge utilization in decision making, and training activities.	Authors

3. Data.

Our data were collected at three military organizations, each from a different country. We will not identify these organizations in this paper for security reasons. All three

organizations have a well organized training system where more than 30,000 men and women are prepared for combat. Besides, all three deal with modern military technology and operate in different international settings and coalition environments. Two of these organizations are NATO member country services that have participated in several of the most demanding military deployments during the last ten years. The third institution is a service from a non NATO member country that deploys units mostly in peacekeeping operations, which range from teams and squads up to battalions. We term the first "*Organization Alpha*", the second "*Organization Beta*" and the third "*Organization Gamma*".

To run our data collection effort, we selected a sample of 443 officers with more than ten years of service and with some experience as small unit commanders (platoon and company commanders). For this purpose we personally approached staff colleges and units of Alpha, Beta and Gamma; presented our research; and asked for an opportunity to run our data collection among students and/or experienced officers. Our measurement instrument was distributed through electronic means in April and May, 2008. Our responses were collected during four months. We received 134 answers out of which 121 were valid, a 27.31% response rate. We felt comfortable with this response rate as no special incentive was put in place for officers to fill out the survey besides their leadership indication to voluntarily respond.

Some characteristics of the survey respondent group are the following:

- 74% of the respondents were officers of NATO member country services.
- 57% of the respondents were Army officers, 24% were Navy officers, and 19% were Air Force officers. The difference in the number of officers from each branch was foreseeable due to the typical composition of joint staff courses in most countries. Usually about half of the students in these courses come from the Army.

4. Statistical Analysis

The statistical analysis method we used is Structural Equations Modeling (SEM), and the specific technique we selected is Partial Least Squares (PLS). This is an appropriate approach for this research for the following reasons[55]: (i) PLS is a recommended technique for predictive research models; (ii) PLS is best suited for exploratory analysis; (iii) PLS is not highly demanding in terms of sample size; and (iv) PLS is especially appropriate for data sets that do not necessarily follow a normal distribution. The statistical analysis software package we used is PLS-Graph (3.11 version). In table N° 2 we summarize the model evaluation criteria

[55] Barclay et al., 1995; Chin et al., 2003; Chin, 1998.

Table N°2. Partial Least Squares model evaluation criteria and parameters**.**

PLS MODEL EVALUATION CRITERIA AND PARAMETERS
MEASUREMENT MODEL
Item reliability. The parameter to examine for item reliability ―that is, consistency or repeatability― is its "loading". Commonly accepted value for this parameter is 0.707. However values of 0.5 and 0.6 are also acceptable for new items or for items applied in new contexts[56]. Given the characteristics of our measurement, we have used a reliability lower limit value of 0.6.
Construct reliability. It verifies internal consistency of indicators, that is, whether the indicators are measuring the same latent variable. The parameter to examine in this case is "composite reliability" (ρ_c). The lower limit value suggested for ρ_c is 0.7[57].
Convergent Validity. It verifies that the items used to measure a construct really reflect it. The parameter to examine in this case is "Average Variance Extracted" (AVE) and its recommended lower limit value is 0.5[58].
Discriminant Validity. Indicates that the items measuring one construct are not related to other constructs. In this case the AVE value shared by one construct and its own items should be greater than the AVE value shared with other constructs in the model[59].
Relevant Parameters for Formative indicators (arrows pointing towards the construct)[53]. When formative indicators are used, the relevant parameters are (i) Weights, which indicate the relative influence of each indicator on the composition of the construct; and (ii) Variance Inflation Factor (VIF), which indicates whether there is multicollinearity among variables (suggested value is under 5.0).
STRUCTURAL MODEL
Structural model evaluation is performed by examining three parameters: (i) Path coefficients (β), which indicate how much variance of an endogenous variable is explained by each predictive variable (lower limit value suggested is 0.2); (ii) Total Explained Variance (R^2), which reflects how much variance of an endogenous variable is explained by the model (lower limit value suggested is 0.1); and (iii) Parameter t-statistics values, which show parameters statistical significance. Since we are only interested in testing whether there exists a positive influence between the exogenous variables and the endogenous one (unidirectional relationships) we use one tailed $t_{(499)}$ Student test (n=500 subsamples: *p< .05; **p< .01; *** p< .001 (lower limits suggested values are: $t_{(0.05;\ 499)}$= 1.6479; $t_{(0.05;\ 499)}$=2.3338; $t_{(0.05;\ 499)}$= 3.1066)[60]. An additional evaluation can be performed to assess the model's predictive relevance. This is done through the Stone-Geisser test. The relevant parameter here is "Crossvalidated Redundancy (Q^2) (lower limit value suggested is $Q^2 > 0$)[61].

D. RESULTS

1. Structural Model A

After verifying that the measurement model satisfies the requirements exposed in Table N° 2 (see the figures presented in Annex N° 1), we ran a PLS evaluation of the Structural Model A, where the relationships between each storage bin and Knowledge Utilization constructs were analyzed. The results of these evaluations are shown in Figure N° 4.

[56] Chin, 1998.
[57] Nunnally, 1978.
[58] Fornell and Larker, 1981.
[59] Cepeda and Roldan, 2004.
[60] By using a one-tailed test, we are testing for the possibility of each relationship in one direction and disregarding the possibility of a relationship in the other direction. We adopt this position because a relationship in the opposite direction is not in the interest and scope of this research.
[61] Cepeda and Roldan, 2004.

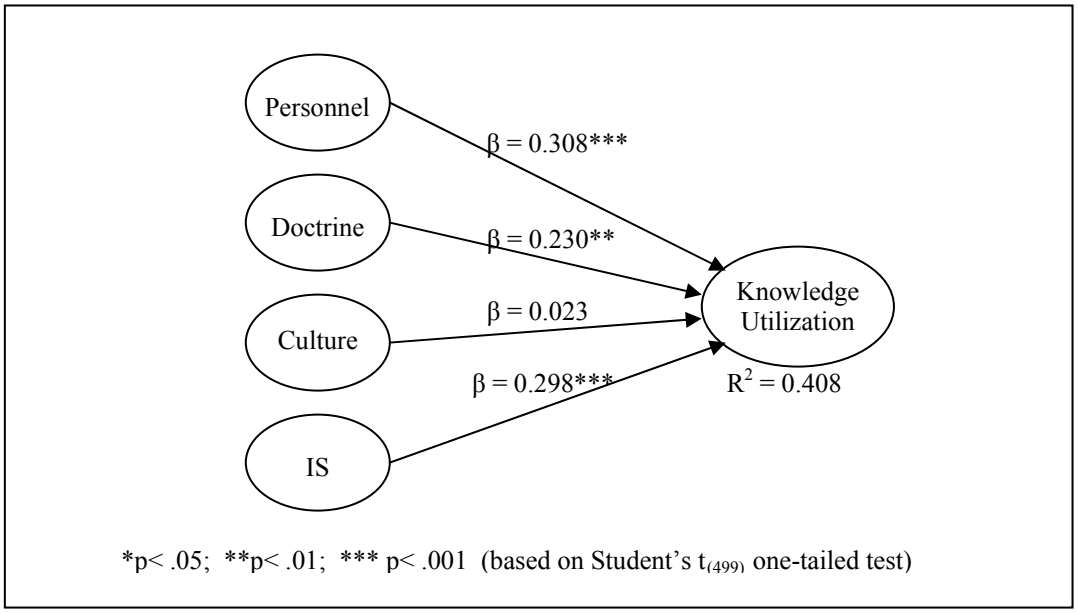

Figure N° 4. Results for Structural Model "A". Relationship between OM bins and Knowledge Utilization.

We also ran a Stone-Geisser test on Structural Model A and obtained a value of Q^2 = 0.1077, therefore we can state that this model is predictive enough.

Accordingly, Hypotheses N°1, N°2, and N°4 are confirmed, while Hypothesis N°3 does not hold. Hence, according to our results, the development of Personnel OM, Doctrine OM and IS OM have a positive impact on Knowledge Utilization.

2. Structural Model B

After verifying that the measurement model satisfies the requirements included in Table N° 2 (see the figures presented in Annex N° 1), we ran a PLS evaluation of the Structural Model B, where the relationships between OM and Knowledge Utilization constructs were analyzed. In this case OM was modeled as a second order construct that is the result of combining its four knowledge bins, which were modeled as formative indicators of OM[62]. The results of this evaluation are shown in Figure N° 5.

We also ran a Stone-Geisser test on Structural Model A and obtained a value of Q^2 = 0.1138, therefore the model is sufficiently predictive.

Our outcomes indicate that Hypotheses N°5 is confirmed by Structural Model B. Hence, according to our results, the advanced development of OM has a positive impact on background Knowledge Utilization.

[62] Formative indicators are the causes of the construct —not its expression like it is in reflective indicators— that is why the arrows are pointing to the construct and not to the indicators. See Diamantopoulos and Winklhofer (2001), Podsakoff, Shen and Podsakoff (2006).

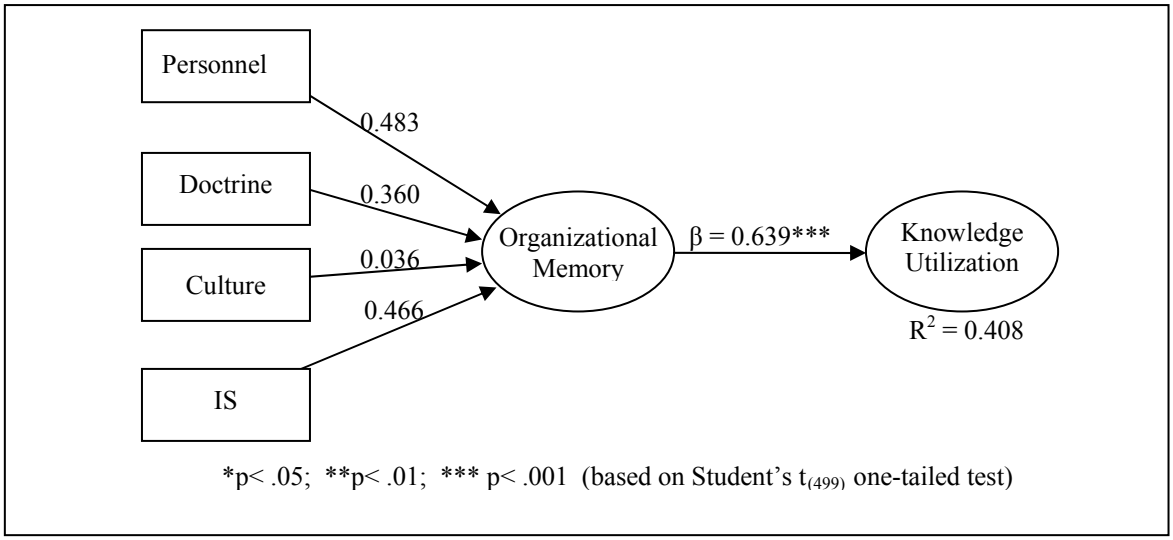

Figure N° 5. Results for Structural Model "B". Relationship between OM and Knowledge Utilization.

E. DISCUSSION

1. Interpretation of empirical results

Our results show that there is a strong relationship between the development of knowledge bins and background Knowledge Utilization. When tested separately, Personnel OM, Doctrine OM and Information Systems OM, exhibited a strong causal effect on Knowledge Utilization (confirmation of Hypotheses N°1, N°2 and N°4 through the testing of Structural Model A). This indicates that the development of these knowledge bins will benefit background knowledge usage by themselves. Hence, managerial efforts aimed at improving them are highly recommended for Edge Organization implementation.

Efforts to strengthen Personnel OM might include formal education within and across institutional boundaries; training and its constant evaluation, improvement and support with new technologies; and fostering a challenging and motivating environment, where men and women are willing to perform their best.

On the doctrine side, managerial efforts should point to monitoring content richness, and its pervasiveness. The former refers to the quality of the information included in doctrine, which is expressed through its completeness, correctness, currency, accuracy, and consistency across subunits[63]. The latter, refers to the degree of familiarity with doctrine content that people in different units have, which includes both the access to the explicit expression of doctrine and the access to experts who are able to show its tacit complementary value.

Regarding information systems, we argue that OM is strengthened by a strong IT infrastructure, populated with high quality information, endowed with widespread accessibility, and provided with effective knowledge detection and access tools (codes,

[63] For further details on information quality see Alberts et al. 2001, p. 95.

classification, and terminology). In this regard, it is important to mention that people do not share knowledge naturally; therefore it is a leadership challenge to harvest good quality knowledge from individuals and make it available at the organizational level.

Our results also show that strong cultures ―which are said to foster knowledge accumulation― are not by themselves a strong generator of knowledge utilization (rejection of Hypotheses N°3, through testing of Structural Model A). We interpret this outcome as a signal indicating that the sole characteristic of strong culture may help to create uniformity in the way external stimuli are perceived; however the content part ―the notions and its surrounding reasoning― is lacking when other knowledge bins are not acting in parallel. We argue that this happens because of the content overlapping that exists between culture and other OM bins, as we have previously mentioned.

The arguments above are supported by our results on the evaluation of Structural Model B, where Hypothesis N°5 is confirmed. This evaluation also exhibits a strong relationship between OM and Knowledge Utilization (this relationship is stronger than any of the ones tested in Model A). This outcome reflects that Organizational Memory is an integrated system of storage bins of both concrete and abstract memory. Therefore, OM bins reveal mutual interdependencies and content overlapping indicating that managerial efforts should target to develop organizational memory as a whole and in a coordinated manner. We would finally add that the more abstract part of OM is more difficult to manage, since it is difficult to measure and evaluate.

2. Implications for NCW/C2

According to Alberts[64], sensemaking in a network-centric setting requires the "*understanding of individual and collective processes by which tacit knowledge is combined with real-time information to identify, form and articulate appropriate points in an ongoing military operation*" which, in turn, enables "*appropriate decision making*".

In this research we have identified those organizational elements where the knowledge applied in decision making resides. Such elements ―which we term OM bins― are developed and nurtured incrementally over long periods, primarily in peacetime. Consequently, we are herein indicating where military leaders should target their long term managerial efforts to ensure that decisions at the battlefield are made utilizing rich and high quality background knowledge along with situational information provided by C2 information systems.

If all four OM bins are developed over time and their content is the product of a combination of theoretical notions application; live experiences that repeat over time (training) in different environments; and social context that eloquently informs what the correct way to proceed is, then the participating agents gradually become "experts". These are commanders and soldiers who are capable of recognizing familiar patterns and situations and devising a feasible course of action to attain command's intent in hash situations[65].

[64] Albers, 2002, p. 137.
[65] Klein, 1998; Lipshitz et al., 2001; Ross et al., 2004.

Such experts are people who clearly embody each of the four capabilities that Alberts[66] describes as the enablers to correctly combine situational information and background knowledge at the operational environment. A rich background knowledge enables them to "*extract meaningful activities and patterns from battlespace picture and share it with appropriate participants*"[67], that is, they are able collaborate to create shared situation awareness. Besides, their expertise enables them to "*project* [those] *activities and patterns* […] *to identify emerging opportunities and threats*"[68]; therefore, they can extract congruent understanding out of situations and generate predictions. Further, because they possess both of the capabilities above, they can make "*timely decisions that proactively and accurately respond to these emerging opportunities*"[69], accordingly, they are effective decision makers. Finally, because they recognize the action patterns of their major unit and their own function within it, they are capable of "*articulating decisions in terms of desired goals/effects, constraints and priorities that are functionally aligned* […] *with other participating organizations*"[70], consequently, they can consistently act according to the command's intent.

We argue that the better developed the OM bins, the more capable commanders and soldiers become. Hence, only when OM knowledge bins have been developed over time and have received permanent and meticulous attention, can one think that commanders are making progress in attaining the above capabilities. More important, only when commanders and soldiers become competent enough is their organization capable of starting to climb up the C2 maturity ladder, because maturity is largely a matter of good decision makers that keep in mind collective purposes and coordination needs, and that is typically a skill and knowledge affair.

3. Implications for KM

Our findings represent important challenges for KM administrators and policy makers in military organizations. It has become a common practice that KM efforts aim towards "information" management instead of "knowledge" management, so leadership tends to concentrate on IS/IT while relegating the social and cultural part to secondary priorities. Our results show that this flaw may hinder expert development, since our empirical work shows that the highest impact of OM on Knowledge Utilization is achieved when the former is conceptualized as a combination of all four bins. This means that OM is not dividable if maximum leverage is to be obtained. Accordingly, expert formation is a matter that combines technology exploitation with a number of human and social factors, which also have to be taken care of.

It is also important to note that, from the general perspective of KM, this research has focused only on two out four KM processes that are relevant for military organizations, therefore there might exist a number of other challenges and complexities to tackle on the knowledge acquisition and dissemination side. Nevertheless, because of the central role that

[66] Albers, 2002, pp. 137 – 138.
[67] Ibidem.
[68] Ibidem.
[69] Ibidem.
[70] Ibidem.

OM plays within the KM cycle —according to our previous explanations— we foresee that by carefully developing the OM bins, part of the extra effort becomes already tackled.

F. CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

1. Conclusions

This research has explored the preparation process that military organizations should follow in order to get ready for NCW/C2 introduction and exploitation. Several key points that will assist military leadership to make progress within this path have been identified:

- NCW/C2 requires long term preparation in which every force member is a player.
- Hastened decision making at lower organizational levels —namely, Edge Organizations— require "experts".
- Becoming an "expert" involves hard work, both individually and collectively, aimed at acquiring specialization founded on a wider knowledge base.
- From the managerial standpoint, military organizations should take care of four KM processes: Knowledge Acquisition, Retention, Dissemination and Utilization.
- Among these processes, Knowledge Retention —operationalized through OM— plays a central role. This process heavily affects Knowledge Utilization, the process by which knowledge is applied in the battlefield, therefore its development is key for force preparation.
- OM is formed by four knowledge bins that interact and complement each other to form the knowledge base that come to bear in combat situations. These bins are: personnel, doctrine, culture and information systems.
- The better developed these knowledge bins, the more capable commanders and soldiers become in applying quality knowledge in the battlefield.

2. Research Limitations

The most relevant limitation of this research is the fact that the empirical work is based on questionnaire answers that come mainly from army officers. This limitation may imply that the results of this study are more suitable for land military organizations than they are for the two other types of armed forces.

3. Further Research

This study calls for further research targeted to validate the whole KM cycle, so that a more general picture is provided for military leadership to devise KM long term strategies. In this context, both the causal relationships among KM processes and the organizational efforts and/or elements involved in their implementation have to be explored. A more complete picture will strengthen the validity of our propositions in this study.

The suggestion above is an effort that the authors of this paper have already started to work on, since this study is part of a larger work-in-progress.

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ANNEX N° 1
STATISTICAL ANALYSIS RESULTS

A. MODEL "A"

1. Measurement model

a. Items reliability, constructs reliability and convergent validity.

CONSTRUCTS AND INDICATORS	ITEM RELIABILITY (λ)	CONSTRUCT RELIABILITY (ρ_c)	CONVERGENT VALIDITY (*AVE*)
MO-PER[71] (Personnel MO)		0.865	0.517
MO-PERS3	0.6703		
MO-PERS4	0.7127		
MO-PERS6	0.8105		
MO-PERS7	0.7232		
MO-PERS8	0.6676		
MO-PERS9	0.7187		
MO-DOC[72] (Doctrine MO)		0.765	0.52
MO-DOC3	0.6707		
MO-DOC4	0.6476		
MO-DOC5	0.8387		
MO-CUL[73] (Culture MO)		0.899	0.50
MO-CULT1	0.6539		
MO-CULT2	0.6883		
MO-CULT3	0.7102		
MO-CULT4	0.6525		
MO-CULT5	0.6932		
MO-CULT8	0.7535		
MO-CULT9	0.7720		
MO-CUL10	0.7342		
MO-CUL11	0.6750		
MO-IS[74] (IS MO)		0.896	0.59
MO-IS2	0.7115		
MO-IS3	0.8033		
MO-IS4	0.8304		
MO-IS5	0.7165		
MO-IS6	0.8311		
MO-IS7	0.7029		
UT[75] (Knowledge Utilization)		0.817	0.53
UT1	0.7843		
UT2	0.6189		
UT4	0.7477		
UT5	0.7470		

[71] **MO-PER** is the code for Personnel OM. MO-PERi is the code for each item associated to Personnel OM.
[72] **MO-DOC** is the code for Doctrine OM. MO-DOCi is the code for each item associated to Doctrine OM.
[73] **MO-CUL** is the code for Culture OM. MO-CULi is the code for each item associated to Culture OM.
[74] **MO-IS** is the code for IS OM. MO-ISi is the code for each item associated to Culture OM.
[75] **UT** is the code for Knowledge Utilization. UTi is the code for each item associated to Knowledge Utilization.

b. Discriminant validity.

CONSTRUCTS	UT	MO-PER	MO-DOC	MO-CUL	MO-IS
UT	**0.7272**				
MO-PER	0.4740	**0.7187**			
MO-DOC	0.4700	0.3150	**0.7240**		
MO-CUL	0.3120	0.4720	0.3070	**0.7048**	
MO-IS	0.4930	0.2760	0.4550	0.2450	**0.7680**

2. Structural model

a. Path coefficients and T- Statistics.

RELATIONSHIP	PATH COEFFICIENTS (β)	T-STATISTICS
Personnel OM ⟶ Knowledge Utilization	0.308	4.0765 (***)
Doctrine OM ⟶ Knowledge Utilization	0.23	2.5678 (**)
Culture OM ⟶ Knowledge Utilization	0.023	0.2682
IS OM ⟶ Knowledge Utilization	0.298	3.8748 (***)
For n=500 subsamples: *p<0.05; ** p<0.01; *** p<0.001 (based on Student's $t_{(499)}$ one-tailed test) $t_{(0.05;\ 499)}$=1.64791345; $t_{(0.01;\ 499)}$=2.333843952; $t_{(0.001;\ 499)}$=3.106644601		

b. Explained variance and predictive relevance.

CONSTRUCT	EXPLAINED VARIANCE (R^2)	PREDICTIVE RELEVANCE (Q^2)
Knowledge Utilization (UT)	0.408	0.1077

B. MODEL "B"

1. Measurement model

a. Weights, VIF, item reliability, constructs reliability, convergent validity.

CONSTRUCTS AND INDICATORS	WEIGHTS	VIF	ITEM RELIABILITY (λ)	CONSTRUCT RELIABILITY (ρ_c)	CONVERGENT VALIDITY (*AVE*)
OM					
MO-PER	0.4829	1.361			
MO-DOC	0.3596	1.356			
MO-CUL	0.0362	1.341			
MO-IS	0.4661	1.299			
UT				0.817	0.5287
UT1			0.7842		
UT2			0.6188		
UT4			0.7478		
UT5			0.7469		

b. Discriminant validity.

Construct	UT	OM
UT	**0.7271**	
OM	0.639	**(n.a.)**

2. Structural model

a. Path coefficients and T- Statistics.

RELACIÓN	PATH COEFFICIENTS (β)	T-STATISTICS
Organizational Memory → Knowledge Utilization	0.639	12.5029 (***)
For n=500 subsamples: *p<0.05; ** p<0.01; *** p<0.001 (based on Student's $t_{(499)}$ one-tailed test) $t_{(0.05;\,499)}$=1.64791345; $t_{(0.01;\,499)}$=2.333843952; $t_{(0.001;\,499)}$=3.106644601		

b. Explained variance and predictive relevance.

CONSTRUCT	EXPLAINED VARIANCE (R^2)	PREDICTIVE RELEVANCE (Q^2)
Knowledge Utilization (UT)	0.408	0.1138