Power Implications within Command and Control Organizations: New Insights through Knowledge Measurement

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ABSTRACT

The concept *military power* is very clear: One military organization seeks to impose its will upon another, relying on its chosen command and control (C2) approach to plan, conduct, coordinate and refine warfare activities. This reflects power *of* a military organization. Aside from the obvious rank structure, however, the implications of power *within* such organization are tenuous: The concept *organization power* remains ambiguous, resists quantification and continues a longstanding lack of research attention. This applies in particular to the dynamics of organization power within a chosen C2 approach, which require additional theoretic development. The research described in this article builds upon recent C2 work to develop a system for visualizing and measuring dynamic knowledge in the organization. This enables us to interrelate more closely the dynamics of C2 knowledge with organization power, focusing in particular on how power is wielded and perceived in the military organization, and to measure the effects of C2 organization power on military knowledge, action and performance. We illustrate the use and utility of this approach through a measurement example in the C2 organization context. The research makes a theoretic contribution by advancing a coherent approach to dynamic knowledge measurement and by extending our understanding of C2 organization power. As such, it is likely to stimulate considerable thinking, discussion, debate and continued research.

Keywords: Command and control, competitive advantage; dynamics; knowledge; measurement; organization power.

INTRODUCTION

The concept *military power* is very clear (e.g., see van Creveld, 1985): One military organization seeks to impose its will upon another, relying on its chosen command and control (C2) approach (Alberts & Hayes, 2003) to plan, conduct, coordinate and refine warfare activities. This reflects power *of* a military organization. Aside from the obvious rank structure, however, the implications of power *within* such organization are tenuous: The concept *organization power* remains ambiguous, suffering from a plethora of theoretic perspectives (Jasperson, Carte, Saunders, Butler, Croes & Zheng, 2002), plus it resists quantification and continues a longstanding lack of research attention (Maas, 1979). This applies in particular to the dynamics of organization power within a chosen C2 approach, which require additional theoretic development (Blackler, 2011; Contu & Willmott, 2003; Marabelli & Galliers, 2017).

The research described in this article builds upon recent C2 work to develop a system for visualizing and measuring dynamic knowledge in the organization (Nissen, 2017; Gallup, Nissen & Iatrou, 2019). This capability is developed judiciously and analogically from our understanding of dynamic physical systems, as we leverage well-understood Knowledge Flow Theory (KFT) (see Grant, 1996; Spender, 1996; Preiss, 1999; Dierickx & Cool, 1989; Nonaka, 1994; Nissen, 2006b) and Measurement Theory (Krantz et al., 1971) for conceptualization and specification of a small set of constructs and relationships that enable measurement. One particularly important construct is *knowledge power*, which can be measured, interrelated and compared across different kinds of knowledge (e.g., tacit, explicit, individual, group, created, applied), a diversity of organizations (e.g., business, military, non-profit), and even a variety of organization processes and technologic implementations.

This enables us to interrelate more closely the dynamics of C2 knowledge with organization power, focusing in particular on how power is wielded and perceived in the military organization, and to measure the effects of C2 organization power on military knowledge, action and performance. We illustrate the use and utility of this approach through a measurement example in the C2 organization context. We begin in this research project with the traditional military hierarchy, which relies upon deconfliction and reflects a Level 2 C2 approach. Future research can extend these results to other C2 approaches (e.g., Coordinated, Collaborative, Edge).

The research makes a theoretic contribution by advancing a coherent approach to dynamic knowledge measurement and by extending our understanding of C2 organization power. As such it is likely to stimulate considerable thinking, discussion, debate and continued research.

BACKGROUND

Although we cast a relatively wide metaphoric net in terms of reviewing the C2 and organization literatures, here we focus on linkages between knowledge, C2 organization power and performance. This enables us to streamline the background discussion and highlight prior research that is linked most directly with our effort to quantify dynamic knowledge and power. We summarize key findings from this prior research in Table 1.

We begin with research on the Edge Organization (Alberts & Hayes, 2003), which conceptualizes and articulates a C2 approach that differs radically from the traditional hierarchy that has defined military organization ubiquitously for millennia. The Edge and Hierarchy differ fundamentally across three organization dimensions associated with the Approach Space: 1) allocation of decision rights (ADR), 2) patterns of interaction (POI), and 3) distribution of information (DOI). Whereas the Hierarchy maintains low ADR, limited POI, and constrained DOI, relying principally upon deconfliction as a C2 approach, the Edge opens up all three dimensions, relying instead upon agility, focus and convergence (Alberts, 2007). Particularly insightful is the idea that military and other organizations can *choose* from a variety of C2 organizations or approaches, only one of which is the traditional hierarchy, to improve fit and performance across a range of different mission-environment contexts (e.g., ground warfare, coalition operations, humanitarian assistance and disaster relief).

The Edge Organization operationalizes Complexity Leadership Theory (Hazy & Uhl-Bien, 2013) in the military. This explains how modern complex organizations divest decision making from a centralized leader to a competent functional expert. With increasing complexity and breadth of knowledge and information flows, a single leader—or small leadership suite—can no longer work sufficiently quickly and accurately to make informed and timely decisions. Rather, successful complex organizations exhibit distributed decision making. In the military this is displayed in the Edge Organization C2 model—often seen in high performing Special Operations commands, for instance.

Alberts and Nissen (2009) extend this C2 research appreciably by linking C2 with Organization and Management Theory (OMT), conceptualizing and articulating a metaphoric Rosetta Stone to help translate both theoretic and empiric concepts, constructs and interrelationships across historically separate disciplines of academic research and organization practice. They use the Approach Space to interrelate conceptually and visualize graphically a variety of C2 approaches and organization archetypes across the three dimensions noted above. This work serves to bridge historically disjoint domains, and it enables us to apply insights from the organization power literature to C2.

Considering the organization power literature at a comparatively broad level, Smith and colleagues (2017) discuss the paradox of innovation and change in an organization, referencing Taoism on the trials of attempting to explain the unexplainable. This tension between knowing and articulating what is known emphasizes the important distinction between tacit and explicit knowledge. Tacit knowledge derives from experience generally, underlies talent and skill, and can be difficult to articulate. Even many recognized experts express difficulty explaining how they accomplish skillful tasks well, a phenomenon that Polanyi (1967) characterizes as knowing more than we can say. Explicit knowledge derives from its tacit counterpart and is articulated through documents, graphs, charts, mathematic relations, software and like means. Such distinction between the tacit and the explicit affects the implication, inference and acceptance of power in the organization (Smith et al., 2017).

Narrowing the focus a bit, French and Raven (1959) identify five bases for social power (i.e., Reward, Coercive, Legitimate, Referential, Expert). Of these, the legitimate base receives great emphasis in the C2 and organization power literatures, most of which is set within the context of organization hierarchy. Legitimate power implies the tools of coercion and reward, however, hence the power bases are nested: the empowered can provide or deny resources, recognition and position, for instance.

Concentrating on legitimate power with our C2 focus, we see that much knowledge is shared explicitly and systematically (esp. via documents such as memos, directives, instructions, orders, policies, procedures, standards and the like) and that such sharing is predominantly unidirectional: knowledge flows principally from the empowered downward through the organization hierarchy (Heizmann, 2011; French & Raven, 1959). Indeed, Lawrence and colleagues (2012) assert that many hierarchical organizations embed power in explicit knowledge. Such knowledge is systemic, articulates who has legitimate power over whom, and specifies how things are to be done in the organization. This appears to be highly efficient and effective for routine operation in the organization context.

However, Lawrence and colleagues (2012) also juxtapose such explicit power with the kind of knowledge needed for non-routine operations and transformational change. They explain how episodic power, although enabled through legitimate authority, relies often on the experience based, tacit knowledge of experts to address novel and urgent organization challenges.

Table 1 Focused Background Research

Prior Research	**Linked Ideas**
Alberts & Hayes, 2003	Military and other organizations can *choose* from a variety of C2 organizations or approaches.
Hazy & Uhl-Bien, 2013	Modern complex organizations divest decision making from a centralized leader to a competent functional expert.
Alberts, 2007	Edge C2 contrasts with traditional hierarchy, opening up Approach Space dimensions, relying instead upon agility, focus and convergence.
Alberts & Nissen, 2009	Rosetta Stone: Approach Space to interrelate conceptually and visualize graphically a variety of C2 approaches and organization archetypes.
Smith et al., 2017; Polanyi, 1967	Tension between knowing & articulating what is known. Link to tacit & explicit knowledge & how it affects organization power.
French & Raven, 1959	Five bases of social power. Emphasis on legitimate base through hierarchy in the C2 & organization power literatures.
Lawrence et al., 2012	Organization power is embedded often in explicit knowledge. Juxtapose with tacit knowledge and episodic power.
Blackler, 2011	Linkage between knowledge and power can shift. Power can be situational, contextual & ephemeral.
Nonaka, 1994; Nissen, 2006b; Drucker, 1995; Nissen, 2014	Organization knowledge enables action. Action drives performance. Performance supports competitive advantage.
Nissen, 2006a	Knowledge represents a multifaceted concept. Knowledge must flow rapidly and powerfully through the organization.
Marabelli & Galliers, 2017	Hierarchical power can result in collaboration & institutionalization of joint decision making. Result centers on how power is wielded.
Jasperson et al., 2002; Heizmann, 2011	Wielding of power viewed via organization politics. Power is negotiated over time and across context. Power shifts dynamically.
Orr, 1990; 1996; Contu & Willmott, 2003	Legitimate power can center on explicit knowledge. Expert power can center on tacit knowledge. Power & knowledge bases in tension.
Bolman & Deal, 2003	Legitimate and expert power can be in conflict. “Winning” a power struggle can lead to disaster.
Bunderson & Reagans, 2011	Personal & collective modes of wielding power. Different modes can affect learning—and hence knowledge, action & performance.

Blackler (2011) provides an example through his Board of Directors case study, and we see how the linkage between knowledge and power can shift. In this case study, the board doesn't initially see the value of one member's knowledge. Only ten years later, when the business model is foundering, does the board see that his proposed, dramatic action was required from the beginning. This case reflects how integral context and timing are: absent a compelling and apparent threat, there is negligible collective knowledge acceptance, because no perceived need for course change becomes manifest to all participants. As such, episodic power can be situational, contextual and ephemeral: expert power—relying principally upon tacit knowledge—can rise to prominence but then subside as legitimate power holders—relying instead upon explicit knowledge—reestablish themselves in the organization. Once the organization novelty or challenge has been addressed, the linkage between knowledge and power shifts back to its previous, legitimate base.

This kind of knowledge based power shift elucidates an important linkage between knowledge and action in the organization. Although there is no universal definition of *knowledge* in the literature, Nonaka (1994) and Nissen (2006b) converge on its operationalization in the organization: knowledge enables action. Drucker (1995) and Nissen (2014) build upon such operationalization to link knowledge enabled action with performance and competitive advantage. Hence if knowledge is associated with power and competitive advantage, then we can seek to identify and quantify its effects through organization action and performance.

Nissen (2006a) elaborates further through research to suggest that *knowledge*—even operationalized as enabling action—represents a multifaceted concept: different kinds of knowledge (e.g., tacit, explicit, individual, group, created, applied) have qualitatively different properties and behaviors, and hence affect action, performance and competitive advantage differently. Neither can knowledge remain static in support of competitive advantage: it must move or flow rapidly and powerfully from where and when it is to where and when it is needed in the organization. This places particular importance on understanding the dynamics of knowledge and power in the organization.

Toward such end, Marabelli and Galliers (2017) note that hierarchal power, when used to engage and empower subordinates, can result in collaboration and the institutionalization of joint decision making. This begins to elucidate the importance of how power *is wielded* in the organization. For instance, were the same *amount* of hierarchical power not wielded in a manner that engages and empowers subordinates, then we would not expect to observe the same knowledge based organization actions; instead we would likely observe a *lack of* collaboration and *non*-institutionalization of joint decision making, along with corresponding, lower performance levels. Thus, simple possession of organization power seems insufficient to explain differential organization action and performance.

Further, how power is wielded can be viewed in terms of organization politics (Jasperson et al., 2002). A political lens is illuminating, for it reveals how power is negotiated over time and across contexts in the organization: a leader must necessarily have followers; someone with power must have something or someone that he or she can influence through it; and the relative roles—and degrees of power—can shift dynamically over time and through organization distance. Heizmann (2011), for instance, describes the struggle and resistance resultant from dynamic power shifts, illustrating further how organization power can be ephemeral and subject to ongoing negotiation.

In the classic study of copier technicians, Orr (1990; 1996), as recounted by Contu and Willmott (2003), describes how management holds and wields legitimate organization power through the hierarchy. For instance, management seeks to emphasize and rely upon explicit knowledge as articulated through copier repair manuals and defined repair processes. However, the technicians have acquired considerable, experience based, tacit knowledge, which they share liberally through their community of practice. Such tacit knowledge empowers them through superior shared knowledge and the corresponding action and performance that it enables. This elucidates an important dependency: although management has legitimate authority, it is dependent upon the technicians, who have tacit knowledge and expert power. Hence the technicians’ knowledge based, expert power enables them collectively to push back against and counter management’s legitimate hierarchical power: legitimate and expert knowledge and power bases are in tension.

Bolman and Deal (2003) discuss the space shuttle *Columbia* disaster to illustrate another case of power in tension. Engineers at the rocket booster contractor Morton Thiokol understood tacitly and experientially that freezing temperatures would make the internal O rings brittle and likely to fail, and leveraging their expert power, they pleaded with management to wait for warmer temperatures before authorizing a shuttle launch. Nonetheless, with funding at risk due to program delays, managers exercised their legitimate power and decided—without engineers present—to authorize an imminent launch. The disastrous results occurred within seconds, as the O rings failed and the launch vehicles exploded, just as predicted from tacit knowledge.

Bunderson and Reagans (2011) develop two frames of motivation for the wielding of power through knowledge: personal and collective. The former reflects personal or political gain at the expense of the organization, whereas the latter implies a collective betterment of organization position or fortune. They describe further how different modes of wielding power can affect learning—and hence knowledge, action and performance—in the organization by stifling three important processes: anchoring on shared goals, risk taking, and experimentation. Such stifling occurs in particular when organization actors, lacking legitimate power, perceive management and other higher level actors in the hierarchy to be wielding it in a personalized manner (esp. for personal or political gain). This establishes a strong, direct link between how power is wielded and how knowledge accumulates and flows via learning and sharing in the organization. Alternatively, where power is wielded in what is perceived to be a collective or socialized manner (e.g., directed toward collective goals and interests), such alternate use of power can mitigate the stifling effects from above.

Thus, through our focused review of these literatures, we begin to see an important linkage: the manner in which power is wielded by management (and other higher level actors) affects learning in the organization; learning drives the accumulation and sharing of knowledge; and knowledge enables action and performance. Moreover, we begin to see also that such linkage is dynamic: management can choose to wield power through different modes over time, which impact learning, knowledge, action and performance dynamically as a result. This offers insight into how the wielding of power may represent an additional aspect of an organization's C2 approach. We build upon and leverage this linkage through development of a system to visualize and measure dynamic knowledge.

KNOWLEDGE VISUALIZATION AND MEASUREMENT

In this section we summarize and extend recent research that enables the visualization and measurement of dynamic knowledge (Nissen, 2017). Such recent research builds upon our understanding of dynamic physical systems to outline a simple set of equations that characterize the dynamics of motion in physical space and time (e.g., including constructs *force, work, friction, energy, time, power*). This recent work then draws from Measurement Theory (Krantz et al., 1971) and leverages KFT to develop an analogic set of equations to characterize the dynamics of knowledge as it flows through the organization (e.g., including constructs *knowledge force, knowledge work, knowledge friction, knowledge energy, flow time, knowledge power*). We link the dynamic knowledge measurement system that emerges with visualization techniques to illustrate how such system is consistent with theoretic predictions. This sets the metaphoric stage for visualizing and measuring dynamic knowledge and power within the C2 organization.

This is done with full understanding and upfront admission regarding the limitations of analogic reasoning: In no way do we assert that the dynamics of knowledge follow or mirror the dynamics of physical systems precisely. Every analogy breaks down when stretched too far, and even some of the most basic physical concepts may have little meaning in terms of dynamic knowledge. Notwithstanding such limitations, however, we gain considerable insight from the deep understanding and mathematic representation of dynamic physical systems, which are adapted analogically to enable the measurement of dynamic knowledge.

Physical System

To recapitulate the approach, which is described in detail through research by Nissen (2017), a simple physical system is represented mathematically through the basic Newtonian equations summarized in Table 2. Such equations can be found in any introductory Physics textbook, yet they enable quantitative measurement, analysis, prediction and simulation of dynamic physical systems. Here we interrelate *force* (mass x acceleration; expressed in Newtons), *work* (force x distance; expressed in Joules) and *power* (work / time; expressed in Watts). We include three variations of *time*, *distance* and *acceleration* interrelationships (Equations 3a-3c).

Table 2 Physical System Equations

Construct	**Description**	**Equation**	**Units**
Force (F)	Effort required to accelerate mass	(1) $F = m \times a$	Newton
Work (W)	Force applied through distance	(2) $W = F \times d$ (= E)	Joule
Time (t)	Time for a mass to move its distance	(3a) $t = \sqrt{(2d/a)}$	Second
Distance (d)	Distance that a mass moves	(3b) $d = \frac{1}{2} at^2$	Meter
Acceleration (a)	Change in velocity	(3c) $a = 2d/t^2$	Meters per second^2
Power (P)	Work done per unit time	(4) $P = W / t$	Watt

We note also (parenthetically) in the table how *work* (W) and *energy* (E) are exchangeable and expressed in the same units (Joules): energy is required to perform work, and work performance involves the expenditure of energy. We leverage such exchangeability below through analogic reasoning for knowledge systems.

We note further how friction affects many physical systems by opposing motion and acceleration. An ordinary shopping cart, for instance, requires greater effort (i.e., more force) to push along a store aisle with a rough floor than a smooth one: the greater friction associated with the rough floor opposes motion and acceleration of the cart, hence it requires more force to push.

Considering friction in support of our analogic reasoning, a simple, linear, negative relationship between *force*—including that required to overcome friction (F_{Fr})—and floor *smoothness* (fs) is delineated in Figure 1. Here force can be measured in Newtons, and smoothness is expressed on a [0,1] continuum between rough and smooth endpoints, respectively.

Specifically as depicted in the figure, a rough floor is characterized here as requiring ten times the force to push a shopping cart as that needed on a smooth floor ($F_{Fr} = 10 - 9fs$). This downward sloping relationship between force and smoothness is representative, with specific slopes, intercepts and functions highly likely to differ across various carts, stores, aisles and floors. Nonetheless, the relationship makes intuitive sense and is consistent with many physical observations and measurements.

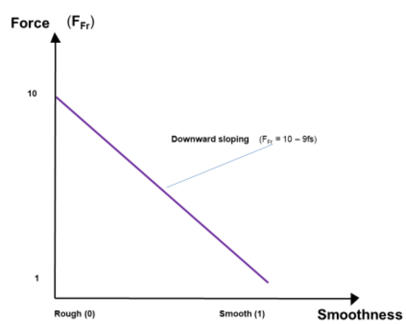

Figure 1 Force and Smoothness

For illustration, say that some researchers go into a store and take three measurements: They observe a cart laden with 10 kg of groceries that takes 20 s to be pushed to the end of a 10 m aisle. The researchers use a scale to weigh the groceries, a stop watch to time the cart, and a tape measure to gauge the aisle length. This simple system of equations enables one to calculate all of the other parameters.

Using Equation (1) to find the force, the mass (10 kg) is known, and acceleration is calculated from Equation (3c), knowing distance (10 m) and time (20 s), at 0.05 m/s^2. Hence the corresponding force is 0.5 N. From Equation (2), work and energy are 5 J, and from Equation (4), the average power exhibited is 0.25 W. Thus, the researchers are able to discover much about this system from only three measurements. Figure 2 delineates velocity (v), acceleration (a) and distance (d) over the first five seconds of movement down the aisle.

Moreover, now that this system of equations has been parameterized with measured and calculated values, one can understand and predict myriad changes and variations to the system without having to observe and measure it again physically. Say, for several instances, that researchers want to know what would happen if someone were to double or halve the mass of groceries on the cart (i.e., 20 kg, 5 kg), if the aisle were to double or halve in length (i.e., 20 m, 5 m), or if the cart were pushed to the end in double or half the time (i.e., 40 s, 10 s). Calculating such changes is straightforward with our parameterized system of equations: different values are substituted simply, and additional measurements in the field are not required.

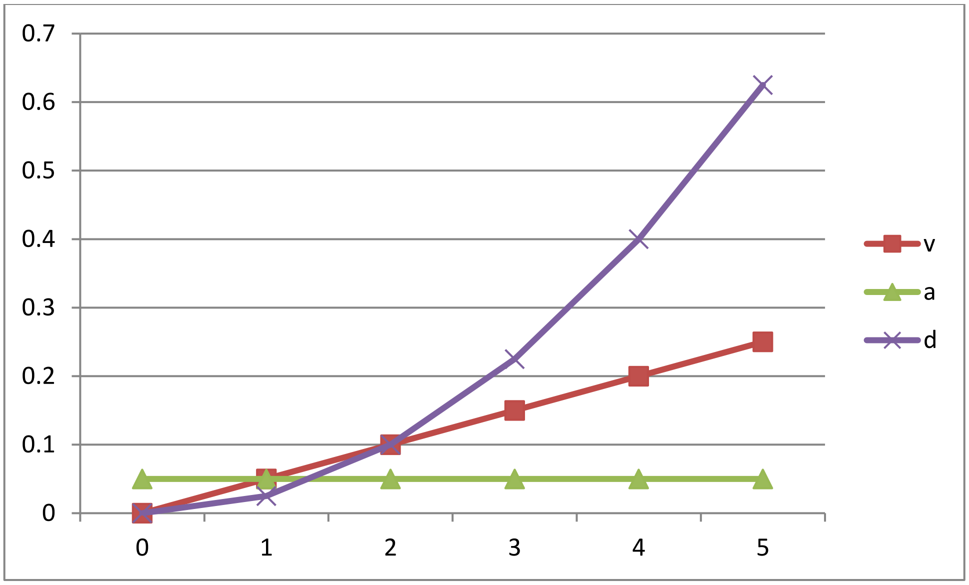

Figure 2 Physical System Dynamics

Basic Knowledge System

In this section we recapitulate development of a basic knowledge system via analogic reasoning with respect to the simple physical system summarized above. Details of such knowledge system are found in Nissen (2017). As summarized in Table 3, we outline an analogic knowledge system and include each mapping from the physical constructs presented in Table 2 above. Briefly, *knowledge force* (K-Force or KF) is analogous to physical force and represents the effort required to accelerate knowledge in an organization. From KFT, it is expressed as a function of the knowledge *chunks* (C) being accelerated and the *explicitness* (E) of such knowledge.

In this conceptualization, each chunk (see Simon, 1996) of knowledge can enable the performance of one atomic action in the organization. *Explicitness* derives from Nonaka's (1994) epistemological dimension and represents the degree to which a knowledge chunk has been articulated in explicit form. Chunks and explicitness both represent continuous dimensions that can be measured using ratio scales. The greater the number of chunks being accelerated (analogous to physical mass), and the more tacit the corresponding knowledge (analogous to physical friction), the greater the K-Force required. Notice also the **o** vector representing a number of other, unspecified factors (e.g., communication skill, motivation, stress, organization climate, IT support, experience), which are likely to play a role, but which have yet to be integrated explicitly or analogically.

Table 3 Analogic Knowledge System

Construct	Description	Analogy	Mapping
K-Force (KF)	Effort required to accelerate knowledge	f(C, E, **o**)	Force
K-Work (KW)	K-Force applied through reach	KF x R	Work
Flow Time (FT)	Time required for knowledge to flow	FT	Time
K-Power (KP)	K-Work done per unit flow time	KW / FT	Power

Reach (R) derives from Nonaka's (1994) ontological dimension and represents the number of people able to utilize the knowledge chunks from above (analogous to physical distance). Reach combines with K-Force to specify *knowledge work* (K-Work or KW) accomplished in the organization (analogous to physical work). Analogous to the exchange between and common units of *work* and *energy* in physical systems, we also conceptualize a correspondence between *knowledge work* and *knowledge energy* (K-Energy or KE): K-Energy is required to perform K-Work, and K-Work performance involves the expenditure of K-Energy.

In turn, *flow time* (FT) represents the time required for such knowledge chunks to flow from one person (e.g., an expert), group (e.g., a sales team), place (e.g., West Coast office) or time (e.g., night shift) to another. As a time measure, it combines with KW to specify *knowledge power* (KP), which represents the knowledge work accomplished (and knowledge energy expended) per unit time (analogous to physical power).

Continuing to draw analogically from the dynamics of physical systems, and considering friction, which opposes acceleration, a simple, linear, negative relationship between *knowledge force* (KF) and *explicitness* (E) is delineated in Figure 3. Consistent with KFT, this relationship indicates that tacit knowledge, which is notably "sticky" (Szulanski, 2000) and difficult to move through the organization, requires more effort (i.e., greater KF) to accelerate than its explicit counterpart.

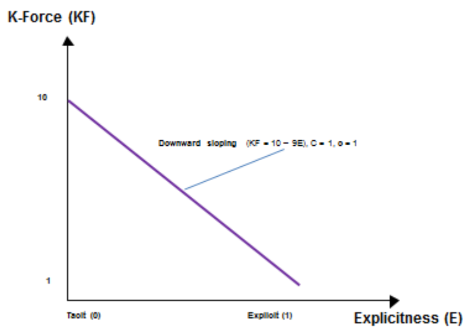

Figure 3 Knowledge Force and Explicitness

Specifically as depicted in the figure, a chunk of tacit knowledge is characterized here as requiring (analogously) ten times (10x) the K-Force needed to get a chunk of explicit knowledge flowing (KF = 10 - 9E). Here we choose a factor of ten times (10x) somewhat arbitrarily and to match the slope of the friction relationship delineated for the physical system in Figure 2 above. Space prohibits a long discussion of sensitivity analysis, but results are highly robust to differences in slope (e.g., 2x, 100x), linearity (e.g., x^2, $x^{1/2}$) and other factors. Indeed, this downward sloping relationship between K-force and explicitness is representative, with specific slopes, intercepts and functions highly likely to differ across various organizations, people, processes, technologies and kinds of knowledge. Nonetheless, the relationship makes intuitive sense and is analogous to physical friction.

Further, we can use this representative relationship to specify the set of dynamic knowledge equations summarized in Table 4. In Equation (5) we specify K-Force as a multiplicative function of knowledge chunks (C), explicitness (10 - 9E), and vector of unspecified other factors (**o**). We specify this as a multiplicative function to parallel the multiplicative specification of physical force expressed as Equation (1) (i.e., F = m x a). We refer to units of K-Force as "Nonakas" (N), acknowledging the seminal knowledge flow research done by Nonaka (1994). K-Work (and K-Energy) then follows in Equation (6) as the product of K-Force and Reach (R). This specification is multiplicative likewise to parallel the multiplicative specification of physical work expressed as Equation (2) (i.e., W = F x d). We refer to units of K-Work as "Polanyis" (P), for the keen insight into tacit knowledge provided by Polanyi (1967). K-Power is specified in turn through Equation (7) by dividing K-Work (or K-Energy) by flow time, the latter of which must be measured (e.g., using a stopwatch, measured in seconds). As above, this specification parallels that of physical power expressed as Equation (4) (i.e., P = W / t). We refer to units of K-Power as "Bacons" (B), acknowledging Sir Francis Bacon, to whom many scholars attribute the aphorism, "knowledge is power."

To reiterate from above, this analogic reasoning is not strict, and we recognize its limitations. Nonetheless, we gain insight from the deep understanding and mathematic representation of dynamic physical systems, which are adapted here to address the measurement of dynamic knowledge, and even this simple set of equations enables us to begin measuring knowledge as it flows through the organization. This represents a substantial step forward in terms of knowledge measurement.

Table 4 Knowledge System Equations

Construct	**Equation**	**Unit**
K-Force	(5) KF = C x (10 - 9E) x **o**	Nonaka
K-Work	(6) KW = KF x R (= KE)	Polanyi
Flow Time	Measure	Second
K-Power	(7) KP = KW / FT	Bacon

Knowledge Visualization

Here we illustrate the basic knowledge system from above through a multidimensional approach to the visualization of dynamic knowledge as it flows through the organization. Refer to Figure 4. The vertical axis represents *explicitness*, which is one of the knowledge measurement constructs from above and derives from Nonaka (1994). The horizontal axis represents *reach*, which is another of the knowledge measurement constructs from above and derives from Nonaka also. The third axis represents *life cycle*, which is helpful for visualization and used to extend Nonaka's model (Nissen, 2002). *Life cycle* pertains to what is being done with knowledge (e.g., *create*, *share*, *apply*).

Flow time is not delineated via separate axis, but it is another of the knowledge measurement constructs from above and used to extend Nonaka's model further (Nissen, 2002). Within the context of this multidimensional visualization scheme, *flow time* represents the time required for knowledge to flow between any two coordinate points in the space (e.g., Points A and B in the figure). When knowledge flows quickly through an organization (i.e., when flow time is short), for instance, we delineate the corresponding flow with a relatively thin vector arrow, whereas a comparatively thick one is used when knowledge flows slowly. Our expectations from KFT are that tacit knowledge, which is notably "sticky" and difficult to move through the organization, will flow more slowly than its explicit counterpart, *ceteris paribus*. Hence tacit flows would be represented generally by relatively thick arrows, whereas comparatively thin ones reflect explicit flows better.

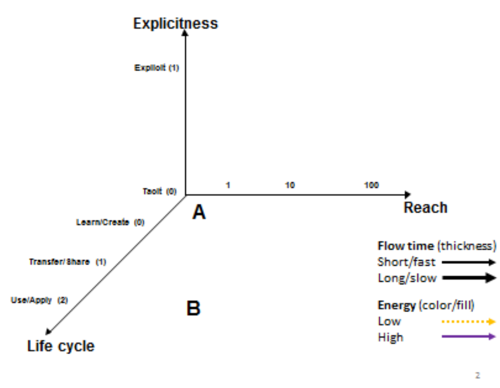

Figure 4 Knowledge Visualization Space

Finally, we also utilize different arrows to delineate *knowledge energy*, which is noted above with correspondence to the measurement construct *knowledge work*. A useful way to interpret K-Energy visually is through both the quantity and efficacy levels of K-Work that can be accomplished in the organization: high K-

Energy flows enable high quantities of K-Work to be performed at high efficacy levels. We combine quantity and efficacy into the single term *performance* and indicate that high K-Energy enables K-Work at high performance levels.

Higher energy knowledge flows (i.e., which enable higher levels of knowledge work performance) are delineated with solid (purple) vector arrows, for instance, whereas dotted (orange) arrows are used for lower energy knowledge. Our expectations from KFT are that tacit knowledge, which can enable higher performance levels (Polanyi, 1967; Nissen, 2014), will flow with greater energy than its explicit counterpart, *ceteris paribus*. Hence tacit flows would be represented generally by solid (purple) arrows, whereas dotted (orange) ones reflect explicit flows better. In theory, *flow time* and *knowledge energy* represent orthogonal dimensions, but in practice, they may covary.

In terms of measurement, *explicitness* can be represented as a continuous dimension, with tacit and explicit endpoints on a ratio scale (e.g., [0, 1]). Measurement is achieved by examining the knowledge chunks associated with a flow: To the extent that such chunks have been articulated in explicit form, explicitness takes on the value 1. To the extent that such chunks have not been articulated, explicitness takes on the value 0. To the extent that they have been articulated partially in explicit form, explicitness takes on a value between 0 and 1, with the specific value representing an empiric concern.

This implies that various combinations of tacit and explicit streams may comprise some knowledge flows. Such conceptualization as a continuous dimension also serves to extend much prior research (e.g., Nonaka, 1994), which views tacit and explicit knowledge more as a categorical contrast than endpoints of a continuum. *Reach* can be measured along an integer scale (e.g., 1, 10, 100), enumerating the number of people who can utilize knowledge. *Life cycle* represents an iterative sequence of activities, with a somewhat arbitrary ordinal scale (e.g., 0, 1, 2) referring to what is being done with knowledge. *Flow time* can be measured along a ratio scale using a stopwatch, calendar, employee timecard, or like instrument. As noted above, *K-Energy* (and *K-Work)* is calculated as the product of K-Force and Reach.

Together, this multidimensional framework enables the visualization of dynamic knowledge and is very general. Theoretically, any dynamic flow of knowledge can be characterized in terms of these dimensions and delineated in this space, and in theory, knowledge can flow via an infinite number of different paths between any two points.

Consider, for example, Points A and B in the figure. Say that an individual worker in the organization discovers some new and useful knowledge (Point A), and management is interested in having all ten people in a group learn and apply such knowledge (Point B). There are clearly many different organization sharing processes available to enable this new knowledge to flow between such individual and group members, hence equally many corresponding knowledge flow paths through the multidimensional space are possible too.

Consider, for instance, the archetypical knowledge flow from the literature (see Nissen, 2017 for discussion) labeled “Explicit Path” in Figure 5. This knowledge flow archetype is associated most closely with technologic implementations (e.g., C2 systems), as it centers on making knowledge explicit and using technology for sharing. The path is comprised of three flow segments or vectors: A-M, M-N and N-B. Each segment or vector simply depicts the movement of knowledge from one point in the flow space to another, with no deeper physical analogy implied. (As noted above, our analogic reasoning is not strict.)

Say that the individual worker (Point A) expends time and energy to articulate his or her knowledge in explicit form (e.g., written instructions, graphic depictions, mathematic relations, solved examples). This is represented by Point M in the figure. Then this individual could encode such explicit knowledge digitally within a computer network (e.g., via email attachment, website resource, document repository), which could be shared very quickly with all ten coworkers, wherever in the world they happen to be located. This is represented by Point N in the figure.

After sharing as such, each of the coworkers could apply the knowledge directly to his or her work activities (Point B). This organization process and corresponding knowledge flow path are illustrated by light (orange) dotted vector arrows in the figure to represent the explicit nature of the dynamic knowledge. The first segment (i.e., A-M) is delineated with a relatively thick vector to indicate that the process of articulating tacit knowledge into explicit form can be time consuming, particularly when compared to the segment corresponding to explicit knowledge sharing (i.e., M-N). The explicit knowledge application vector (i.e., N-B) completes a loop as the explicit flow returns to the tacit plane at comparatively low energy[1]. By using a stopwatch, calendar, employee timecard or like instrument, researchers or managers could measure the time required for this knowledge to flow from A to B, and hence obtain a measured value for flow time. Moreover, the equations from above could enable such researchers or managers to measure K-energy and K-Power also.

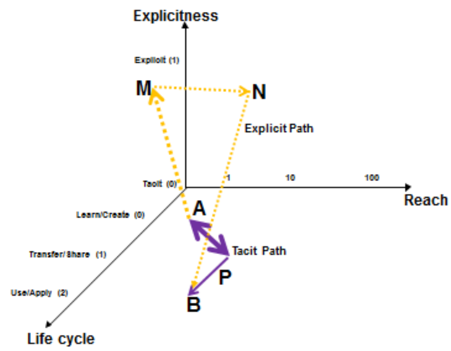

Figure 5 Knowledge Flow Archetypes

Consider, as a contrasting example, the archetypical knowledge flow from the literature (see Nissen, 2017 for discussion) labeled "Tacit Path" in Figure 5. This is the archetype associated least closely with technologic implementations, as it centers on sharing tacit knowledge through interpersonal interaction (e.g., team communication). Say that the individual worker interacts interpersonally with the group members, working closely with these people, soliciting and answering their questions, observing and correcting the coworkers as they practice, and both mentoring and coaching them until everyone in the group has learned the knowledge. This is represented by Point P in the figure.

With such learning accomplished effectively, all ten coworkers would be able to apply the knowledge directly to their work activities (Point B). This Tacit Path differs greatly from the Explicit Path above, and the corresponding knowledge flow is illustrated by dark (purple) solid vector arrows in the figure to represent the tacit nature of the dynamic knowledge.

The first segment (i.e., A-P) is delineated with a relatively thick arrow to indicate that the process of sharing tacit knowledge can be especially time consuming, particularly when compared to the other segment corresponding to tacit knowledge application (i.e., P-B). This first segment is delineated with a double headed arrow also to indicate that knowledge sharing goes both ways: the individual worker (Point A) is learning (e.g., group norms) from the other members as they interact interpersonally, and the coworkers are learning (esp. the new knowledge) from this individual.

As above, researchers or managers could use the same stopwatch, calendar, employee timecard or like instrument to measure the time required for knowledge to flow from A to B, and hence obtain a measured value for flow time along this alternate, tacit path. As above also, our system of equations could enable such researchers or managers to measure K-energy and K-Power too. Since these two, contrasting, archetypical knowledge flow paths are very different—both in their paths through multidimensional space and their reliance upon C2 implementations—one would expect for the corresponding flow times and energy levels to differ accordingly.

Indeed, using the dynamic knowledge measurement system articulated above, we find that measured values are highly consistent with theoretic predictions (Nissen, 2017). Knowledge flows much more quickly through the Explicit Path, for instance, than through the Tacit Path. However, the former knowledge flows at considerably lower energy levels, as another instance, suggesting correspondingly lower performance levels. Theoretic consistency

[1] Following Nonaka (1994), knowledge is presumed to be tacit when put into action (i.e., applied). However, absent another knowledge flow vector, we do not presume that such action necessarily involves learning; hence the relatively low K-Energy.

along these lines gives us considerable confidence in the measurement system, with no deeper physical analogy implied. (Again, our analogic reasoning is not strict.).

DYNAMIC KNOWLEDGE AND ORGANIZATION POWER

In this section we work to interrelate more closely the dynamics of knowledge with organization power. This enhances our insight into knowledge power within the C2 organization. We begin by extending our dynamic knowledge measurement system to address how power is wielded and perceived in the organization. We then illustrate the use and utility of this approach through a measurement example.

Model Extension

The central insight stems from McClelland's (1975) differentiation between personalized and socialized power, which we discuss above in the context of work by Bunderson and Reagans (2011). Reiterating briefly here for reference, this work describes how wielding power in a personalized manner (esp. for personal or political gain) can inhibit learning in the organization by stifling three important processes: anchoring on shared goals, risk taking, and experimentation. Alternatively, where power is wielded in what is perceived to be a socialized manner (e.g., directed toward collective goals and interests), such alternate use of power can mitigate the stifling effects on organization learning.

Moreover, because organization learning relates clearly and directly to dynamic knowledge—and in turn action and performance—it can be considered in terms of a first derivative with respect to time: the higher the learning rate, the faster the corresponding knowledge accumulation. Thus, if personalized versus socialized organization power, for instance, impacts learning—which impacts knowledge accumulation—then the manner in which organization power is wielded should impact the associated knowledge dynamics also, and we may be able to visualize and measure the effect.

This establishes a direct link between how power is wielded and how knowledge accumulates and flows via learning and sharing in the organization. Especially within the context of hierarchical organization (Scott, 1981), it follows that Reach, K-Force, K-Energy and K-Power will be lower in knowledge flows under personalized than socialized power. Consider, for instance, the stifling of risk taking, and say for example that fewer people in an organization are willing to take risks to learn new knowledge when power is wielded in a personalized versus a socialized manner. With fewer people involved in the associated knowledge flows, this suggests that the corresponding knowledge will reach fewer people in the organization, which decreases the corresponding K-Energy and K-Power. Likewise, as another instance, consider the stifling of experimentation, and say for example that the amount of new knowledge gained via experimentation is less when power is wielded in a personalized versus a socialized manner. With less organization learning, fewer chunks of new knowledge accumulate, which decreases the corresponding K-Force and K-Power. This link—between how power is wielded and how knowledge accumulates and flows via learning and sharing in the organization—can be understood more clearly via knowledge measurement example.

Knowledge Measurement Example

Here we illustrate the use and utility of dynamic knowledge visualization and measurement through an example reflecting different modes of C2 organization power. Specifically, we consider both socialized and personalized modes of organization power in the context of the two archetypical knowledge flows from above for instantiation. We begin by building upon Nissen (2017) to summarize basic measurements for the Explicit Path and Tacit Path knowledge flows. Then we expand upon the work by Gallup and colleagues (2019) to examine how a shift in the wielding of organization power would affect such measurements in the context of counter insurgency operations.

For either of these flow paths, let's say that new knowledge created over some period of time (e.g., during one patrol mission in the field) involves 100 chunks (e.g., pertaining to one person's situational awareness [SA] or experience [XP] on patrol). Let's say also that we focus on, for example, one Marine infantry company deployed overseas. This company is comprised of three infantry platoons (in addition to the Headquarters and Weapons Platoons), each of which is comprised of three squads, each of which is comprised in turn of three fire teams, with four people assigned to each fire team. This would total nine squads, each with an experienced noncommissioned officer (NCO) in the lead. Let's say further that the Company Commander values the creation and sharing of new knowledge gained on patrol. As such, this leader would like for the NCO of each squad to share knowledge gleaned from every patrol with all of his or her peers across the company (i.e., the eight other squad NCOs). Thus, each NCO would be expected to share patrol knowledge with eight people. Assuming that everyone in the organization is diligent about maintaining records of how they spend their time at work (e.g., from orientation planning to after action reports), researchers or leaders can obtain flow time measurements directly.

Recall from Figure 5 above how the Explicit Path delineates knowledge flowing via three vectors (i.e., A-M, M-N, N-B). This is the archetype associated most closely with C2 technology implementations (e.g., online reporting), as it centers on making knowledge explicit and using technology for sharing. In contrast, knowledge flows through the Tacit Path via two alternate vectors (i.e., A-P, P-B). This is the archetype associated least closely with C2 technology implementations, as it centers on sharing tacit knowledge through interpersonal interaction (e.g., mentoring and storytelling).

Measurements corresponding to the Explicit Path are summarized in Table 5 for one squad NCO sharing knowledge gleaned from one patrol (i.e., one NCO sharing SA/XP knowledge with eight peers in the company). Notice that we divide the measurements into three parts corresponding to each of the flow vectors. Walking across columns in the table, for the 100 chunks (C = 100) moving through the first flow vector (A-M), one can see explicitness is listed as a fractional value (E = 0.5) in Column 2. This denotes that the SA/XP knowledge associated with the flow begins as tacit (E = 0) and ends as explicit (E = 1), as an individual Squad Leader (R = 1) articulates tacit SA/XP knowledge into explicit form (e.g., via an Online After Action Report [OAAR]). Using the KF equation (5), this results in KF of 550 N (KF, KE and FT are expressed in thousands in Table 5), and with unitary reach (i.e., the individual Squad Leader), Equation (6) indicates KE (and KW) of 550 P. The Squad Leader's time records indicate that just over 30 minutes are invested in articulating the knowledge in explicit form and making it available on the C2 network (i.e., via OAAR), which corresponds to 1800 s flow time (FT = 1800s).

Table 5 Explicit Path Measurement

Flow	E	KF	R	KE	FT	KP
A-M	0.5	0.55	1	0.55	1.8	
M-N	1.0	0.10	8	0.80	0.1	
N-B	1.0	0.10	8	0.80	1.0	
Sum				2.15	2.9	0.74

Calculations for the other two flow vectors (M-N, N-B) involve the same 100 SA/XP knowledge chunks and follow the same logic and procedure. Notice that knowledge is indicated as explicit (E = 1.0) for these latter flow segments and that both involve the same reach (R = 8) across the other eight Squad Leaders. In the first of these vectors (M-N), explicit knowledge flows very quickly (FT = 100 s) and simultaneously to all eight people via OAAR. In the second (N-B), all eight people absorb and learn to apply such explicit knowledge[2] directly and in parallel, through actions (e.g., SA/XP-informed route planning) requiring nearly 17 minutes (1000 s) to complete. KE (and KW) is half again as large (i.e., 800 P) for these explicit flows because of the greater reach (8 vs. 1) across Squad Leaders. Summing KE (2150 P) and flow time (2900 s) for the process as a whole, (average) KP of 0.74 B obtains from the KP Equation (7).

Measurements corresponding to the Tacit Path are summarized in Table 6. They involve the same 100 SA/XP knowledge chunks and follow the same logic and procedure described above. Notice that knowledge for both flow vectors (i.e., A-P, P-B) comprising this latter process is tacit (E = 0.0). This reflects the kind of interpersonal, iterative, experiential interaction that is associated widely with tacit knowledge sharing (e.g., mentoring and storytelling across Squad Leaders). As such, and as above, the system of equations is used to obtain the measurement values in this table for the tacit knowledge flow path, and flow time is measured directly.

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[2] Although the M-N-B vectors complete a loop through (principally) tacit application at Point B, without incorporating some kind of learning process, the corresponding knowledge remains (almost completely) explicit (E = 0.999) as it is applied by the team at Point N.

Table 6 Tacit Path Measurement

Flow	E	KF	R	KE	FT	KP
A-P	0.0	1.0	8	8.0	3.6	
P-B	0.0	1.0	8	8.0	0.5	
Sum				16.0	4.1	3.90

Notice further that more time (i.e., roughly one hour; FT = 3600 s) is required for this tacit SA/XP knowledge to be shared (A-P). This is consistent with the “sticky” nature of tacit SA knowledge that is shared through mentoring and storytelling associated with route planning. Alternatively, once learned, application of such tacit SA/XP knowledge is comparatively very quick (i.e., FT = 500 s) for the group of Squad Leaders (P-B).

Comparing measurements for the Explicit and Tacit Path archetypes, KE through the tacit flow is more than seven times that of its explicit counterpart (16,000 vs. 2150 P), but flow time is considerably longer (4100 vs. 2900 s). The KP metric reveals that the Tacit Path completes the knowledge flow at over five times the power level (3.90 vs. 0.74 B) of its Explicit counterpart. Thus, the Explicit Path, leveraging C2 technologic implementations for explicit knowledge sharing, flows with substantially less knowledge energy in the infantry company (esp. across squads), but the corresponding knowledge flows more quickly. The opposite applies to the Tacit Path, which relies more on interpersonal interaction than technology for knowledge sharing. These measurements provide a basis for examination of organization power effects.

Organization Power Effects

Consider again the archetypical knowledge flows delineated and measured above corresponding to the Squad Leaders across the company. Say, for example, that organization power in this team is wielded in a socialized manner. This could take the form of the Company Commander, who as mentioned above is interested in sharing SA/XP knowledge gleaned from patrols with the NCOs of other squads across the company. We use our measurements from above as a baseline for comparison, which we present in Table 7. The first row repeats summary measurements (i.e., KE = 2150 P, KP = 0.74 B; expressed in thousands) from above for the Explicit Path, which we label “Explicit Socialized” to reflect this baseline example.

Table 7 Organization Power Comparison

Path	KE	KP
Explicit Socialized	2.150	0.74
Explicit Personalized	**0.675**	**0.23**
Tacit Socialized	16.000	3.90
Tacit Personalized	**4.000**	**0.98**

Now we examine the effect on knowledge flows corresponding to the same Squad Leaders, across the same infantry company, when power shifts to more of a personalized mode. Such power shift could result, for instance, from a change in leadership (e.g., new Company Commander) or even flow hierarchically down through change from higher levels in the organization (e.g., the Battalion). For purpose of this example and comparison, say that the impact of stifled risk taking cuts reach of the knowledge flows in half (i.e., Reach = 4). This could result, for example, from Platoon Leaders—based on the new Company Commander's priorities—discouraging the explicit sharing of SA/XP knowledge gleaned from patrols. Say further that the impact of reduced experimentation cuts the number of new knowledge chunks in half as well (i.e., Chunks = 50). This could result, for example, from Squad Leaders—again, based on the new Company commander's priorities—feeling less latitude to experiment with different techniques for acquiring SA/XP knowledge.

Following the same measurement procedure summarized above, and assuming the same flow times, the second row reports summary measurements corresponding to the same SA/XP knowledge flowing in a case of personalized organization power. We label the corresponding flow path "Explicit Personalized" to reflect this alternate example, and we highlight the corresponding measurements in bold font for emphasis. Notice the dramatic effect: Team knowledge flowing through this same Explicit Path suffers roughly a 70% reduction in terms of both KE (i.e., 675 vs. 2150 P) and KP (i.e., 0.23 vs. 0.74 B). This implies that a shift to personalized organization power reduces the energy level of knowledge flows to only a fraction of that attainable via socialized power, and our measured knowledge power level decreases abruptly as well. The manner in which organization power is wielded appears to have pronounced and measurable effects on knowledge flow, action and performance. Even within the same hierarchical C2 organization, something as routine as a new Company Commander with different priorities can have a considerable effect of SA/XP knowledge sharing across companies, which can impact route planning and ultimately degrade operational efficacy throughout the company.

The last two rows of Table 7 include comparable measurements for the Tacit Path. As above, the baseline (i.e., in the third row, labeled "Tacit Socialized") reflects organization power wielded in a socialized manner and repeats summary measurements (i.e., KE = 16,000 P, KP = 3.90 B; expressed in thousands) from above for the Tacit Path. As above also, the fourth row (i.e., labeled "Tacit Personalized") reports summary measurements corresponding to the same knowledge flowing in a case of personalized organization power, and we highlight the corresponding measurements in bold font for emphasis here also. The shift from socialized to personalized power wielding could stem from the same sources (e.g., new Company Commander with different priorities, discouraging the tacit sharing of SA/XP knowledge gleaned from patrols, feeling less latitude to experiment with different techniques for acquiring SA/XP knowledge).

Notice even more dramatic effect in terms of both KE (i.e., 4000 vs. 16,000 P) and KP (i.e., 0.98 vs. 3.90 B). Again, the manner in which organization power is wielded appears to have pronounced and measurable effects on knowledge flow, action and performance. Moreover, we see from these relationships that the organization power shift has an even greater impact on tacit knowledge sharing through interpersonal interaction than explicit knowledge shared via technology. With knowledge visualization and measurement techniques along the lines of those described in this article, a Battalion Commander may come to anticipate knowledge sharing issues—and the corresponding problems—that stem from something as routine as a new Company Commander joining the organization. As such, he or she may see the need to brief the new officer on the importance of SA/XP knowledge sharing, through both explicit and tacit means.

These measurements clearly reflect several assumptions, and different results would likely obtain from different units (e.g., other infantry companies), organizations (e.g., Navy crews onboard ship), kinds of knowledge (e.g., SA/XP from standing watch) and other factors (e.g., Phase 0 operations). Nonetheless, the measurements are consistent with KFT, and they integrate theorized effects of socialized versus personalized organization power. Moreover, these measurements quantify the dynamics of knowledge, and they also quantify some dynamic effects of shifts in how organization power is wielded. Further, we reveal through example how routine changes in officer personnel can impact the wielding of power, which can impact in turn knowledge sharing along with the organization action and performance that it enables.

Thus, we both quantify and increase insight into an important linkage: the manner in which power is wielded by management (and other higher level actors) affects learning in the organization; learning drives the accumulation and sharing of knowledge; and knowledge enables action, performance and competitive advantage. Hence, the wielding of power can affect organization performance and competitive advantage in an indirect but understandable and quantifiable manner. Moreover, we also see that such linkage is dynamic: management can choose to wield power through different modes over time, for instance, which in turn can impact learning, knowledge, action, performance and competitive advantage dynamically as a result. Further, through numeric measurement, we begin to increase the precision of *organization power* as a construct through its quantifiable and dynamic effect on knowledge flows. These represent substantial steps forward.

CONCLUSION

The concept *military power* is very clear: One military organization seeks to impose its will upon another, relying on its chosen command and control (C2) approach to plan, conduct, coordinate and refine warfare activities. This reflects power *of* a military organization. Aside from the obvious rank structure, however, the implications of power *within* such organization are tenuous: The concept *organization power* remains ambiguous, resists quantification and continues a longstanding lack of research attention. This applies in particular to the dynamics of organization power within a chosen C2 approach, which require additional theoretic development.

The research described in this article builds upon recent C2 work to develop a system for measuring and visualizing dynamic knowledge in the organization. This enables us to interrelate more closely the dynamics of C2 knowledge with organization power, focusing in particular on how power is wielded and perceived in the military organization, and to measure the effects of C2 organization power on military knowledge, action and performance.

Indeed, after casting a relatively wide metaphoric net in terms of reviewing the C2 and organization literatures, we focus on linkages between knowledge, C2 organization power and performance. This enables us to streamline the background discussion and highlight prior research that is linked most directly with our effort to quantify dynamic knowledge and power. We find, for instance, linkages between different bases of organization power—set predominately within the organization hierarchy—and their roots in tacit versus explicit knowledge. We find also, as another instance, how such linkages can shift across varying situations and contexts. Understanding that knowledge enables action as a multifaceted, dynamic concept, we find further, as a third instance, how the manner in which power is wielded can affect learning, and hence knowledge, by stifling three important processes: anchoring on shared goals, risk taking, and experimentation.

We then advance recent research that enables the visualization and measurement of dynamic knowledge. Such recent research builds upon our understanding of dynamic physical systems to outline a simple set of equations that characterize the dynamics of motion in physical space and time (e.g., including constructs *force, work, friction, energy, time, power*). This recent work also draws from Measurement Theory and leverages Knowledge Flow Theory to develop an analogic set of equations to characterize the dynamics of knowledge as it flows through the organization (e.g., including constructs *knowledge force, knowledge work, knowledge friction, knowledge energy, flow time, knowledge power*). We link the dynamic knowledge measurement system that emerges with visualization techniques to illustrate how such system is consistent with theoretic predictions.

This enables us to extend the research summarized above through techniques to interrelate more closely the dynamics of knowledge with C2 organization power. We begin by extending our dynamic knowledge measurement system to address how power is wielded and perceived in the organization. We then extend this system further to quantify the organization power effect, the application of which we illustrate in turn through a measurement example in the C2 context.

We find that the manner in which organization power is wielded can have pronounced and measurable effects on knowledge flow, action and performance. For instance, a shift from socialized to personalized organization power can dramatically decrease the amount of knowledge energy flowing through an organization, with concomitant decrease in the level of performance, in addition to a comparable reduction in knowledge power. We find further that the organization power shift has an even greater impact on tacit knowledge sharing through interpersonal interaction than explicit knowledge shared via technology.

Drawing from our C2 example of SA/XP knowledge gleaned from infantry patrols in the field, with knowledge visualization and measurement techniques along the lines of those described in this article, a Battalion Commander may come to anticipate knowledge sharing issues—and the corresponding problems—that stem from something as routine as a new Company Commander joining the organization. As such, he or she may see the need to brief the new officer on the importance of SA/XP knowledge sharing, through both explicit and tacit means.

These measurements clearly reflect several assumptions, and different results would likely obtain from different units (e.g., other infantry companies), organizations (e.g., Navy crews onboard ship), kinds of knowledge (e.g., SA/XP from standing watch) and other factors (e.g., Phase 0 operations). Nonetheless, the measurements are consistent with KFT, and they integrate theorized effects of socialized versus personalized organization power. Moreover, these measurements quantify the dynamics of knowledge, and they quantify some dynamic effects of shifts in how organization power is wielded. Further, we reveal through example how routine changes in officer personnel can impact the wielding of power, which can impact in turn knowledge sharing along with the organization action and performance that it enables.

Thus, we both quantify and increase insight into an important linkage: the manner in which power is wielded by management (and other higher level actors) affects learning in the organization; learning drives the accumulation and sharing of knowledge; and knowledge enables action, performance and competitive advantage. Hence the wielding of power can affect organization performance and competitive advantage in an indirect but understandable and quantifiable manner. Moreover, we also see that such linkage is dynamic: management can choose to wield power through different modes over time, for instance, which in turn can impact learning, knowledge, action, performance and competitive advantage dynamically as a result. This offers insight into how the wielding of power may represent an additional aspect of an organization's C2 approach. Further, through numeric measurement, we begin to increase the precision of *organization power* as a construct through its quantifiable and dynamic effect on knowledge flows. These represent substantial steps forward.

The research described in this article makes a theoretic contribution by advancing a coherent approach to dynamic knowledge measurement and by extending our understanding of C2 organization power. As such, it is likely to stimulate considerable thinking, discussion, debate and continued research.

Nonetheless, this research suggests abundant opportunity for continued work along these lines. There are clearly aspects of the dynamic knowledge measurement system that merit deeper examination and refinement. For instance, we have the **o** vector of still unspecified factors that are theorized to affect knowledge flows, each of which could be articulated and interrelated with extant aspects of our measurement system. As another instance, the measurements fail to differentiate well between inputs (e.g., resources consumed) and outputs (results produced), hence some kind of efficiency measure could be conceived and integrated as well. Further interconnections between the C2 organization power literature and Knowledge Flow Theory are clearly possible too, and research toward this end offers potential to enrich and mutually inform both literatures.

Much empirical work appears to be warranted as well. In this article we illustrate application of our dynamic knowledge measurement system through an example in the C2 context, but our knowledge could advance substantially through future empiric research to measure C2 organization power in the field, to measure dynamic knowledge flows in operational organizations, and to interrelate the two. There is so much to do. We welcome others in the community to assist.

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