Organizational Case Study: Theory and mathematical specifications for an Agent Based Model (ABM)

W.F. Lawless
Paine College
1235 15th Street
Augusta, GA 30901-3182
706-821-8284 office
706-664-8148 cell
lawlessw@mail.paine.edu
homepage.mac.com/lawlessw

Joseph Wood, Ph.D., M.D., LTC, MC
Chief, Department of Clinical Investigation
Endocrine, Diabetes and Metabolism Service
Eisenhower Army Medical Center
Ft. Gordon, GA 30905
706-787-2875
Joseph.Wood@amedd.army.mil

Stephanie Everett
Navy Center for Applied Research in Artificial Intelligence
Naval Research Laboratory, Code 5512
Washington, DC 20375
202-767-9003 office
Everett@aic.nrl.navy.mil

William Kennedy
Navy Center for Applied Research in Artificial Intelligence
Naval Research Laboratory, Code 5512
Washington, DC 20375
kennedy@itd.nrl.navy.mil

Abstract:

This case study found that a military medical department research center (MDRC) with access to advanced information technology was struggling to determine the quality of the residents it trains and to measure their scholarly productivity. Yet snapshots in time and inevitable researcher biases restrict case studies to hindsight rather than proactive sources of organizational solutions. Case studies guided by theory, however, have illuminated and tested many of the organizational principles that have been discovered. Unlike simple Newtonian mechanics, interactions among organizational members are interdependent with the interviews that a case study collects to establish a base line. Consequently, case study measurements collapse organizational interactions, losing enough information to elude a science of the fundamental interaction. But first principles can be discovered if

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the uncertainty left from the collapse of interactions can be predicted and exploited for key interdependent variables: planning and execution; or resources and time.

Introduction

Organizational theory has failed to produce predictable (Pfeffer & Fong, 2005) or replicable results (Weick & Quinn, 1999). Traditional organizational theory, generally based on methodological individualism (MI; e.g., game theory; in Nowak & Sigmund, 2004), assumes that information from individuals is stable and accessible (Baumeister, 1995), making an organization into a rational aggregation of the contributions from its individual members. In what we believe is related, many agent-based models (ABM's) are based on MI with the same assumption about rational aggregation, but discounting the value of prediction as a consequence: "the value of a [computational] model is not prediction but insight" (Bankes, 2006). Defining rationality as "normative consistency", Shafir and LeBoeuf (2002) concluded that neither average humans nor experts make consistent choices, preferences, or justifications, undercutting the traditional model of rationality. But to successfully operate an autonomous computational organization in the field, a rational process of prediction is necessary.

In contrast to MI, we have had limited success by importing the quantum uncertainty relations as first suggested by Bohr (1955) and Heisenberg (1958) to address interdependent uncertainties in human social interaction (Lawless et al., 2000) and to predict decision-making among human organizations in the field (Lawless et al., 2005) and more recently in the laboratory (Lawless et al., 2006b). With our limited success, we have begun to develop metrics based on the “measurement paradox” (Lawless & Grayson, 2004).

The paradox indicates that measuring an interaction or organization collapses the existence of its interdependent information into strictly classical information that cannot be re-aggregated to reconstruct the organization (Levine & Moreland, 1998; 2004), nor apparently even for the individual—despite more than 30 years of research, no better than a weak link has been confirmed between self-esteem and actual performance at school or in the workplace (Baumeister et al., 2005). Surprisingly, the measurement paradox suggests that the collapse of interdependent information can be exploited to favor one of two interdependent states in our mathematical model of interdependence to produce predictable outcomes under certain rather extreme conditions, such as the difference between consensus (CR) versus majority rule (MR) decision processes in organizations (Lawless et al., 2005): We have predicted and found that CR leads to less concrete decisions less welcomed by an organization’s customers, but at lower energy expenditures that take longer to process; in contrast, MR leads to more practical decisions more welcomed by customers, but with more conflict and energy expended that quicken decisions.

The relationship between decision processes and organizations is itself complex, especially for CR. The purpose of CR is to convert the neutrals in a group into active individual participants (Bradbury et al., 2003). However, the process in CR that suspends criticism of beliefs no matter how bizarre lends itself to being hijacked: “The requirement for consensus in the European Council often holds policy-making hostage to national interests in areas which Council should decide by a qualified majority.” (WP, 2001, p.

29). Organizations are primarily hierarchical and governed by a single leader under command decision-making (CDM); the link to CR becomes more obvious under the control of multiple leaders (e.g., the crisis at Unilever prior to 2005; the current crisis at Europe's aerospace EADS group), however, single leaders using intimidation or even violence can convert an organization or system into a quasi CR process that stifles criticism; e.g., Germany's response to Hitler's "Night of the Long Knives", in 1934 (Benz, 2006, p. 54). Counterintuitively, when competition can be managed to preclude conflict, we have found that the most robust consensuses are derived from competition (i.e., MR); more learning occurs under competition (Dietz et al., 2003); and the more competitive is a team, the greater the cooperation among its members.

Since our laboratory studies, we have further exploited the paradox to propose the first mathematical set of interdependent metrics designed to measure the real-time performance for a system of military forecasters in the field (Lawless et al., 2006a). We recently revised and extended these metrics to analyze the reorganization of the Management Information Service Center (MISC) at a major university in Europe to further establish organizational principles that were then used to reverse model terrorist organizations (Lawless et al., 2006b). Mindful that a case study reflects a static snapshot in time, exposing our results to confirmation bias (Eagly & Chaiken, 1993) which we countered with a theoretical foundation directed at four interdependent variables (in Figure 1, planning and execution; energy and time), we found that MISC and its university had been operating without a structured business model (BM). The lack of a focused BM for the university had led to a disorganized assemblage of faculty, staff and students that discouraged innovation, promoted administrative malfeasance, impeded student progress and faculty research, and significantly reduced opportunities for MISC and its university. We concluded that a loose aggregation in the limit approaches a CR process in that less information is processed by the organization than some of its members but on an ad hoc basis, consequently precluding organizational learning and change in response to environmental perturbations (Dietz et al., 2003).

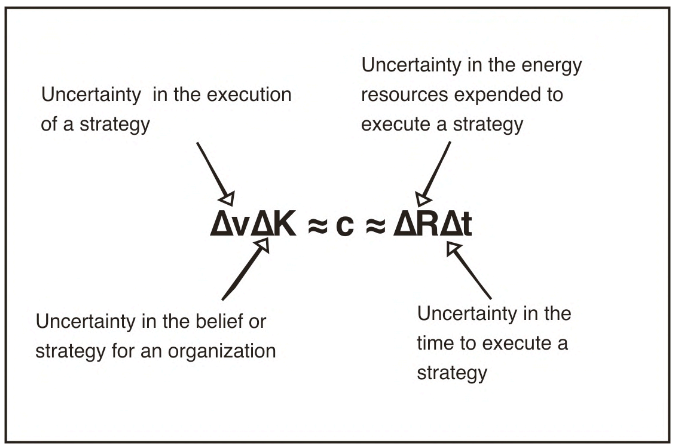

Figure 1. The measurement problem was derived from case studies of the Department of Energy's (DOE) program to cleanup the widespread waste and environmental contamination at its sites (Lawless & Grayson, 2004; in the above equations, "*c*" is an unknown constant). Here it was applied to Arcelor Steel's response to Mittal Steel's hostile merger bid for Arcelor in 2006: Strategy: How focused was Arcelor's strategy to protect its resources; operationally, how widespread was the consensus among its members and stockholders in support of its strategy? Execution: How motivated or effective were the members-stockholders to execute Arcelor's plan; operationally, how many supporters were collected per unit of time as a result of the strategy? Resources: How effective was the strategy (plan or algorithm) in growing Arcelor by

gathering new organizational resources (increasing free energy to increase choices); secondarily, how efficient was the strategy at saving existing resources (contracting by reducing wastes to increase predictability)? Time: How time consuming was implementing the strategy; secondarily, how quickly was feedback captured by Arcelor's leadership to refine or tune its plan; alternatively, how opportunistic was the plan?

Overview of MDRC

In 2006, a new director assumed command of a military Medical Department Research Center (MDRC) at a regional military medical hospital (Note: Fictional names have been used in this case study). MDRC supports clinical and basic research for its staff and all hospital personnel including family practitioners, internal medicine, general and orthopaedic surgery, and dentistry (endodontics, peritonitis, oral maxillofacial, orthodontics, and nurse anaesthesiology). In addition to providing basic research support for the hospital, MDRC is responsible to teach the fundamentals of experimental research to the hospital's medical residents (categorical residents working within a specialty, residents rotating among the hospital's different specialties, and transitional interns; in JWO, 2005, p. 4), provide continuing education for more experienced care providers, and train dentists in research methods. One of the goals of the training by MDRC is to help the hospital's Graduate Medical Education (GME) candidates become certified by their respective American specialty boards, in what is becoming a matriculation requirement for many training programs. GME trainees are supervised by about 150 teaching staff members who are all board certified in their respective specialties (JWO, 2005, p. 4).

Over the remaining two years of his administration, the Chief, MDRC, wants to establish Metrics of Effectiveness (MOE) to measure his organization's success and to craft a plan with MOE's to improve the performance of scholarly activities (i.e., plan or Business Model, BM). Some resident trainees start their research rotation prepared with a line of investigation derived from their own interests, collaboration with peers, or previous mentors. But if they are not presently working in research or have a research interest, a mentor is assigned to them by MDRC staff. One problem with using MOE's is that much of the research proposed in the MDRC protocols has lasted or may last for a number of years before scholarly products can be published, whereas other research protocols may last under one year, giving the less complex Protocols an advantage in the generation of scholarly products. As the complexity of a Protocol increases, the time necessary to complete a program of research also increases. The Chief wants to increase the complexity of protocols but remain able to measure the impact of complexity on scholarly productivity. (For the entire case study along with a full list of all of the recommendations, see Lawless et al., 2006c).

Brief summary of the results and recommendations for MDRC

Planning uncertainty for the organization's Business Model (BM, or ΔK)

In the MDRC Chief's opinion, attracting better quality residents will require an increase in the quality of publications and in receiving help from other Division Chiefs, plus having a stronger program. Then better graduates will begin to attract other quality candidates, adding credibility to the BM.

A focused, concrete plan of action (BM) should be designed by MDRC to gain wide support among its staff, mentors, and trainees (possibly circulated in draft, but higher Command's support is crucial). The MDRC Chief observed that the support provided by his organization is satisfactory from all accounts, but that it should be better organized and more focused (INC, 2006, p. 3-4). The revised BM (ΔBM) should permit everyone to work under the same roof (INC, 2006, p. 7), gain more extramural funds, improve scholarly productivity, and keep education as the primary goal of MDRC (INC, 2006, p. 5). As part of an innovation plan, new resources or funds must be sought (INC, 2006, p. 5; $-\Delta A$) from State, Federal and industrial sources. If successful, the plan should produce a qualitative shift among mentors and GME trainees under the new system; trainees will also learn new professional techniques that should help them to find better jobs afterwards.

Currently, as the complexity of a protocol increases, the time necessary to complete a program of research also increases, implying CR and a lack of CDM control. The new plan must focus organizational resources to produce high quality research executed under a sense of competitive urgency. The goal should not be to seek complexity but instead publishable research that helps to drive more and more competitive scholarly productivity and the search for extramural funds. Complexity should be a byproduct of the plan.

Planning Execution (Δv)

The goal of executing the BM should be to increase the number of customers per period (new grant funds; new trainees; and new recognitions of quality).

The lack of focus at MDRC has primarily arisen from an internal lack of competition among its organization's members in the execution of its current BM. However, a lack of focus again suggests that an implicit CR exists to block the execution of a revised BM. Resistance to implementing a new BM can be anticipated ($exp\ (-\Delta A / <A>)$), implying that barriers must be anticipated and overcome, as well as an average rise in activation ($<A>$) that should be exploited to increase the rate of execution.

With support from his fellow Division Chiefs, colleagues, and staff (n_D), eventually the barriers that arise can be overcome among new mentors and new trainees (n_N) around which a new culture should be encouraged to become established and grow.

The MDRC and hospital staff should be educated to understand the need for regular professional training to improve research performance, especially the quality and the quantity of scholarly productivity; and the need for new information channels to distribute technical information about research opportunities. Numerous messages about the change (v_L) should be given to trainees in seminars provided by MDRC and designed to revise the culture to match the new BM (σ_{RL})

Resource uncertainty (free energy, or -ΔA)

The goal of the plan of action (BM) is to maximize the resources (free energy) available to MDRC to execute its BM in the minimum of time. Such a BM, however, will likely reduce innovation, but practices instituted to seek innovation can offset this shortfall (e.g., including in the BM a strategy to continually seek new partners to obtain extramural grants, along with MOE's of grant progress)

One measure of progress is the level of teamwork across the organization (MDRC staff, mentors and trainees) to increase the competitiveness of MDRC's performance in completing its protocols as an indirect measure of the overall effort by its research teams; however, teamwork must not be simply commanded, but encouraged as a part of the competitive process and demonstrated to work.

As innovation increases from the gathering and expenditure of resources (free energy, $-\Delta A$) derived from the discovery of new resources (new trainees and new faculty become more attracted by new skills and the initiation of new industrial-state-federal projects) and a reduction of costs (less waste), planning complexity increases correspondingly as the ability to direct these freed funds to a random exploration of new projects for MDRC and the hospital with success determined by a reduced effort (practice effects; stochastic resonance) in discovering new sources of free energy.

Time uncertainty

The goal is to reduce the time to execute a BM, gain new resources, and discover new opportunities.

As the available resources are increasingly directed by MDRC to the completion of existing projects with the ultimate goal of freeing resources (free energy, $-\Delta A$) for new projects, the average time to complete and execute existing projects should decrease. At the same time, if and only if an innovation circuit has been established, the time to innovate should decrease correspondingly as new opportunities arise.

As new opportunities become available and exploited by MDRC, they will provide new opportunities to trainees, adding incentives that should further improve the quality of future trainee candidates.

Summary

The present case study of MDRC indicated that fragmentation among its processes and researchers had reduced control over its future plans. Fragmentation in an organization is associated with increased innovation at the individual level (e.g., Benz, 2006), but at the expense of the organization. Enforcing cooperation, however, can be counterproductive unless it is managed by organizational members and leaders together (Gürek et al.,, 2006). Successful organizations are constructed by Command Decision-Making (CDM) into becoming entangled as centers of cooperation (Lawless et al., 2000; Lawless et al., 2006a) that execute quickly a focused BM to gain wide support, new resources with minimal waste, but also that tend to reduce innovation from marginalizing the available knowledge as a consequence of making the organization, in this case MDRC, more competitive in its marketplace. This reduced innovativeness can be countered with a BM of practices to increase innovation.

The MISC case study also served to mathematically extend our model of organizations with improved specifications estimated for a nonlinear agent-based model. In this new case study, we continued to develop theory, tested it in a case study of a military Medical Department Research Center (MDRC), and, based on our recommendations to MDRC, refined our proposed model of an ABM computational organization from the results of theory and this latest case study (see Table 1). For the next stage of our research, we plan to pursue a case study of a department at a national military research laboratory (MRL) in its attempts to secure more extramural research funds.

Table 1. Specifications for an ABM of Figure 1 as derived from the MDRC Case Study.

	CR	MR
Beliefs, ΔK	• By definition, consensus is achieved: $CR_{time} = \sum_i^N \Delta K_i = min$ $CR_{agents\text{-}org} = \sum_i^N \Delta K_i = max$ • More risk perceptions • Algorithm steps = $f(N)$ • Probability of new K is low	• By definition, conflict is initiated: • $MR_{time} = \sum_i^N \Delta K_i = max$ $MR_{agents\text{-}org} = \sum_i^N \Delta K_i = min$ • Fewer risk perceptions • Algorithm steps = $f(D=N\text{-}M)$ • Probability of new K is high
Execution, Δv	• Less execution steps per unit time • Produces N customers (fewer) • Least customer satisfaction.	• Most execution steps per unit time • Produces N customers (most) • Greatest customer satisfaction.
Energy, ΔE	• Least E saved • Entropy high • Least practical steps per unit of time • Most agents at E_0 (resonance), fewer at E_1 (drivers), fewest at E_2.	• Most E saved • Entropy low • Most practical steps per unit of time • Fewest agents at E_0, most at E_1 (attention), fewer at E_2 (drivers)
Time, Δt	• More time required to solve a problem (exponential time) • Time = $f(N)$	• Less time required to solve a problem (polynomial time) • Time = $f(D)$

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