Metrics of Organizational Performance that Are Independent of Cultural Effects

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ABSTRACT

A future goal for robot teams and agent-based models (ABMs) is to field organizations and systems derived from human counterparts, including systems based in different cultures. But a metrics of performance for organizations based on first principles should be independent of culture even though culture or any other source of social influence can have significant effects on organizational performance. Failure of traditional organizational theory from a lack of first principles has at the same time opened the way to innovative theories of organizations and change. Inspired by Bohr and Heisenberg in the application of interdependent uncertainty between action and observation in the interaction, making organizations bistable, we are formulating a theory of organizations based on the uncertainty of time--resource levels and belief--action consensuses, leading to preliminary metrics of organizational performance that we have tested in field studies. Our goal in this project is to address the problem posed by organizations with the development of new theory, field tests of new metrics for organizations, and development of ABMs set within a social circuit as a building block to simulate an organization(s). Should we be successful, our research would represent a fundamental departure from traditional observational methods of social science by forming the basis of a predictive science of organizations. We expect that to replace the traditional method of observation with a predictive science based on combining observation and action, the new method must account for when cognitive observations work and when they do not (e.g., performance illusions).

Keywords: Uncertainty, Metrics, Organizations, Culture

INTRODUCTION

Traditional theories such as the Social Learning Theory (SLT) or Game Theory have provided limited help in predicting valid social behavior (Sanfey, 2007). Unlike Engineering, first principles for organizational theory have not been established. It is easy to model social systems, but it is almost impossible with these models to predict actual behavior in the field. Sociology and organization theory focus on the social systems and organizational structures which may affect or enhance organizational learning. Some authors view learning as happening only at the individual level with no additional organizational benefits. Others see organizational learning as adding up to more than the sum of individuals' learning, i.e. the learning of and changes in individual members become encoded within the collective mind of the organization, resulting in more persistence in organizational memory, behaviors, norms and values (e.g., culture). The traditional model of an organization is predicated on the correspondence between reality and the aggregated observations reported by observers or its individual members. But the evidence indicates that observational data alone cannot reconstruct an organization's actual status (Levine & Moreland, 1998).

As an outline of the paper, in the literature review, we consider the difficulty with the prevailing theory of organizations, why a new theory is necessary, and what it may mean to the science of organizations to have an uncertainty principle, its characterization by bi-stable phenomena, and the uncertainty principle itself. We review field evidence to support the uncertainty principle for organizations and an application of it in the form of a metric. Finally, as a future project, we consider the use of agent-based models (ABM's) to explore the metric.

LITERATURE REVIEW

SLT is a general theory of human behavior. It is most associated with the work of psychologist Albert Bandura, who implemented some of the seminal studies in the area and labeled it social learning theory. SLT encompasses classical conditioning, association, positive and negative reinforcements, and modeling to explain how an organism gains socially "desirable" behavior by learning it. Observational learning or social learning occurs as a function of an individual's observing, retaining and replicating the behavior observed in others.

In SLT and game theory, cooperation is viewed to be more valuable than competition. Game theory is often described as a branch of applied mathematics and economics that studies situations where multiple players make decisions in an attempt to maximize their returns. The essential feature is that it provides a formal mathematical and modeling approach to social situations in which decision makers interact with other agents. Game theory extends the simpler optimization approach developed in neoclassical economics. In other words, game theory studies choices of optimal behavior when the costs and benefits of each option depend upon the choices of other individuals. Game theory focuses on this concept of "interdependence" between individuals but uses arbitrary, static values of cooperation and competition, limiting its ability to model or predict valid social behavior (Lawless et al., 2006b).

Game Theory

One approach to simulating organizations uses game theory to model interdependence. We regard its ability to model interdependence as its strength. But a weakness of game theory is the arbitrary value it assigns to cooperation and competition, exacerbated when the number of players is greater than two in complex and uncertain contexts (e.g., social welfare). A second, but much bigger problem with game theory is linking its predictions to outcomes in real-world behaviors. Kelley (1992) spent his career admittedly failing to link the prior expectations of subjects to the choices they later made while playing Prisoner Dilemma Games, concluding that individual subjects rarely acted as he or they expected once in a group.

Recently, Choi and Bowles (2007) used game theory in an attempt to "explain" war. In their simulations, artificial agents were genetically crafted with and without warlike dispositions and then allowed to evolve. They found that the combination of parochialism and altruism into one agent type could have evolved if this type contributed to its group's success during intergroup conflict. But Choi and Bowles state "there is no evidence that the hypothetical alleles in our model exist" (p. 638) to explain warlike predisposition "only that should one exist, it might have coevolved ... in the way that we have described." (p. 640) In review, Arrow (2007) concluded that the simulation of Choi and Bowles could "help in the quest to promote pro-social behavior while keeping the sharp end of altruism sheathed." (p. 582)

Simulations with agent-based models hold great promise (Bankes, 2002), as does game theory. But for now, while Körding (2007) wrote that game theory is a normative theory that formulates how animals "should decide" (p. 610), Sanfey (2007) concluded that game theory "does not conform to the predictions" (p. 599). One day, great fortunes and lives may well turn on the results of social simulations. That is why it is important to build theory-based models that predict social interactions for mixed teams of humans and robots. It is also why we propose to improve on game theory with an interdependent model of uncertainty determined by outcomes. Afterwards, once our theory has been sufficiently supported, then we plan to use ABM's to further explore our theory and its use in building organizational metrics.

Evidence for traditional models of organizations fails to meet the standard that Conant and Ashby (1970) proposed: "Every good regulator of a system must be a model of that system." We do not fully understand how decisions are made (Klein, 1999, Shafir & LeBoeuf, 2002) or how to make predictions of large groups (Conzelmann et at., 2004). There are many information systems designed to enhance decision making in business, but whether they are effective is debatable. Organization theories (Levine & Moreland, 1998) have not given us a consensus model of organization behaviors. Therefore, the traditional models (Weick & Quinn, 1999) cannot be used to predict or control organizational outcomes satisfactorily. Our model suggests, however, and counterintuitively, that the most robust consensuses are derived during competitive decision making; more learning occurs under competition (Dietz et al., 2003); and the more competitive a team when competing against others, the greater the cooperation will be among its members (Lawless et al., 2006b).

Inspiration/Background

The failure of traditional models has led Pfeffer and Fong (2005) to propose that belief illusions are a critical missing ingredient. We agree, and this inspired our view of the organizational uncertainty principle for this paper. Observations can be modeled with complex functions where only the real part corresponds with reality while the imaginary part does not (i.e., "illusions"). If the imaginary part is dependent on social-psychological influences (e.g., culture, roles) spread across a field of observations underpinning multiple perspectives embedded in physical space (Lewin, 1951), two incommensurable stories of the same social reality always exist (Wendt, 2005). Further, a key insight for future ABM model building is that the number of illusions affecting a decision corresponds with the number of oscillations occurring during the decision-making process (Lawless et al., 2008b).

The immediate implication of accepting the existence of illusions and multiple perspectives is that the traditional reliance on self-reported or observational information alone is insufficient to model or control organizations. We believe that a bistable model would be a better model of an organization when taking uncertainty or illusions into account. Illusions with two or more loci of stability, like the faces-vase illusion (see Figure 1 below), are bi-stable. This means that observers of the same data can see either the two faces or the single vase; however, they cannot view both perspectives simultaneously (Cacioppo et al., 1996).

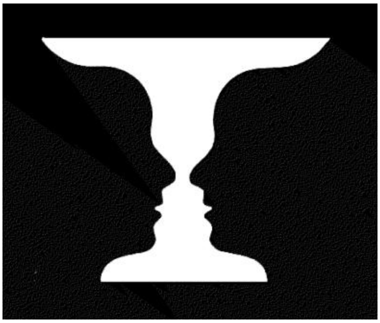

Figure 1: The Famous "Faces-Vase" Illusion.

We have constructed a bistable theory of reality interdependent between physical reality and observations. By proposing this model, we endorse the belief of Answorth and Carley (2007, p. 102) that computational organizational science has an opportunity to contribute to the discovery and validation of theory. Further, a theory of organizations with dual natures, such as Scott’s (2004) duality of production and social systems, supports our goal to construct a computational model that does not rely on the simple convergence processes inherent in traditional social science criticized by Campbell (1996).

The Organizational Uncertainty Principle

To understand how large/social organizations like the Department of Energy (DOE) can make significant environmental mistakes even when they have experts working for them or why USAF air combat fighter pilots who were experts in action but gave poor explanations of air combat maneuvers (Lawless et al., 2000), we have to recognize that bistable reality creates a measurement problem. We have constructed Figure 2 (see the next section) to illustrate the organizational uncertainty principle.

Measurement Problem

In Figure 2 (see below), uncertainty in the social interaction is represented by an interdependence between strategy, plans, or knowledge uncertainty (ΔK, where K is a function of the social location where it was learned; from Latané, 1981) and uncertainty in the rate of change in knowledge or its execution as $\Delta v = \Delta\ (\Delta K/\Delta t)$. This relationship agrees with Levine and Moreland (2004) that as consensus for a concrete plan increases (ΔK reduces), the ability to execute the plan increases (Δv increases). By extension, interdependence also exists in the uncertainty in the resources expended to gain knowledge, ΔR, and by uncertainty in the time it takes to enact knowledge, Δt (for proofs, see Lawless et al., 2006b). That these two sets of bistable factors are interdependent means that a simultaneous exact knowledge of the two factors in either set is precluded.

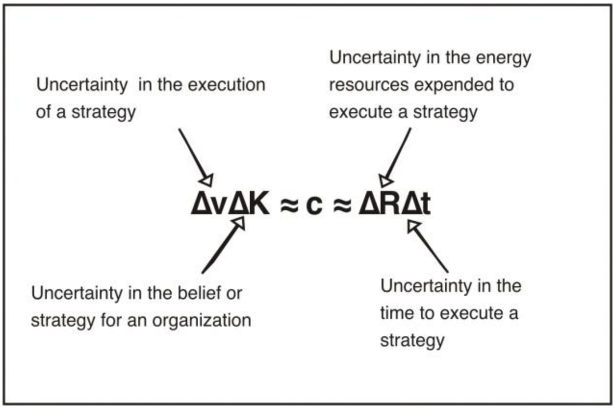

Figure 2: Measurement Problem

The measurement problem occurs as the result of the organizational uncertainty principle. The measurement problem arises from the interdependence between the two factors on each side of the equation. It states that both factors on either side of the equation cannot simultaneously be known exactly. For example, a decrease in the uncertainty in the strategy for an organization results in an increase in uncertainty for the execution of that strategy. In practice, decreasing strategic uncertainty increases action; increasing strategic uncertainty slows action. At the same time, the uncertainty principle informs us that only one of the factors on either side of the equation can be known with certainty.

Using a merger as an example to illustrate the model (bi-sided uncertainty relations exist for the acquiring and the target organization)**: Strategy**: after AT&T Wireless put itself on the auction block in 2004 and Cingular made the first offer, AT&T Wireless did not know whether bids would be received from other players such as Vodaphone, or how much more would be offered; **Execution**: Cingular expected that AT&T Wireless would execute its strategy by choosing the best bid by the deadline it had set, an expectation that turned out to be incorrect; **Resources**: AT&T Wireless did not know whether Cingular or Vodaphone would increase their bids to an amount it considered sufficient; **Time**: while the bidders believed incorrectly that the deadline was firmly established, AT&T Wireless was uncertain of the actual time when the bids would be offered. Finally, although power goes to the winner, it was not easy to determine who won and who lost in this auction at the moment that the deal closed. AT&T Wireless was unable to enact phone number portability and became the prey, but its CEO extracted a superior premium for his company and stockholders. While the merger on paper made Cingular the number one wireless company in the U.S., it may have overpaid for the merger. In addition, during the uncertainty of regulatory review (both the length of the regulatory review period and the regulatory decision), with AT&T Wireless losing customers as cable and other competitors exploited the regulatory uncertainty, it was unknown how costly the eventual merger would be based on the assets remaining once the merger had been consummated.

FIELD TEST

To test our measurement problem model, we studied citizen organizations in the field that were advising the Department of Energy (DOE) on its nuclear waste cleanup. We studied the two means of deciding on the advice to offer to DOE (Bradbury et al., 2003). These were primarily consensus rules and majority rules. There are local variations of both rules, but essentially consensus rules require unanimity or close to it for proposed advice to pass and be considered official (e.g., at Hanford in Washington State, the claim of consensus is permitted when no more than 4 of 31 members disagree). Majority rules mean that more than 50% of a quorum who endorse proposed advice are required for it to pass. Consensus rules are widely considered to be a form of cooperation; majority rules are widely considered to be a form of competition.

We have found that consensus rules (CR) compared to majority rules (MR) tend to promote risk perceptions ("illusions"), prolonging discussion (oscillations) but also avoiding concrete decisions (Lawless & Whitton, 2007). Under CR, consensus decisions are reached cooperatively; under MR, surprisingly, consensus decisions are reached competitively. Given that CR is designed to reduce the conflict associated with MR (Bradbury et al., 2003), we found that CR dampened the underlying motivation to marginalize opposing views as an organization attempts to create a culture around a single story (Atran et al., 2006).

In our first study in 2003 (Lawless et al., 2005), 13 specific recommendations were made by DOE Scientists to 105 participants of all 9 DOE Citizen Advisory Boards (CABs) to endorse accelerating Tru disposition at WIPP. As predicted by the organizational uncertainty principle shown in Figure 2 above, three-fourths of the CR CABs rejected these recommendations while four-fifths of MR CABs endorsed these recommendations. It showed interference or a lack of support from the CR CABs but support from the MR CABs. As also predicted, the time for CR to reach a decision was approximately 2 hours, but only 1/2 hour for MR.

Based on a second field study (Lawless & Whitton, 2007; Lawless et al., 2008b), whether advice is from a CR or MR decision process profoundly impacts Social Welfare as shown below in Table 1. Assuming that CR promotes cooperation and MR promotes competition, the end result in the field is the "Gridlock" that has been observed at

Hanford and "Acceleration" at SRS. These field tests established that illusions are the root cause of a "Measurement Problem". That is, the more illusions that dominate the discussions leading to a decision, the more likely oscillations in the discussion would occur, the less likely a group would marshal its resources to execute its decisions, and the longer these decisions would take. It is a measurement problem for the following reason: an organization can be ruled by consensus or majority rules, but not both; it cannot see the different effect as each decision is taken. Only an outside observer can make that determination.

In Table 1 below, ER stands for environmental remediation; HLW for high-level liquid radioactive wastes; and TRU for transuranic wastes. Across the three factors of ER, HLW, or TRU waste cleanup, it is obvious that SRS is outperforming Hanford. Many reasons are possible: a better workforce at SRS, but the workforces are comparable; more funding at SRS, but funds for both sites are roughly equivalent (about $1 billion each); or more public support at SRS, which is considerable. We attribute this public support for SRS in part to the competitive nature of the SRS Board, which strives to fully address each problem. Being competitive, only the best arguments presented to the SRS Board have a chance to win. In contrast, under consensus rule, any statement can be made and must be permitted, no matter how bizarre; this encourages the risk perceptions (illusions) that make it difficult to propose concrete solutions, which can be easily defeated under consensus rules (Lawless et al., 2005; Lawless et al., 2008b).

Table 1: DOE Citizen Advisory Board Decision-Making:
Consensus Rule (at DOE's Hanford Citizen Advisory Board) and Majority Rule (at DOE's SRS Citizen Advisory Board).

	Hanford/CAB (CR: cooperation)	**Savannah River Site/CAB (MR: competition)**
ER	ER about 7.1% complete in 2002	ER cleanup in 2005 at 62% complete
HLW	0/177 HLW tank closures postponed indefinitely HLW vitrification beginning in 8 years	2/51 HLW tanks closed 1997 [a], closing tanks 19 and 18 in FY2007 2023 of 5060 canisters of v-HLW (≈ 32 ci/gal) Low-curie salt processing from tanks ~ 6/2006
TRU	TRU ≈ 10% of SRS but w/much larger legacy (Gold Metrics, 2004) Battelle Columbus tru blocked	18,000 drums/33,000 legacy tru in WIPP w/Trupact II; Trupact III in 2008 implies that all legacy tru shipped in FY10; Battelle Columbus waste received at SRS in 2006
Results	"Gridlock"	Acceleration [b]

[a] V.P. Hammer Award, 1998: SRS HLW Tank Closure
[b] EPA Citizen Excellence in Community Involvement Award, Superfund sites 2007 given to the SRS CAB

Organisms live under uncertainty partly dispelled by social interaction (Carley, 2002). To survive, they form organizations as centers of cooperation (Ambrose, 2001) that marginalize opposing beliefs among members in exchange for a share of resources, but in a tradeoff between the loss of information from consensus-seeking and the gain of information from conflict associated with innovation and change. For organizations constituted of bistable agents existing in a consensus field, the loss means that control information must be generated from perturbations (Lawless & Grayson, 2004). Conant and Ashby (1970) have further posited that good regulation occurs when the available control variance is greater than the perturbation variance. If a fragmented market produces more information, a consolidated market reduces the information available. But in the transition between these extremes, caused for example by a hostile takeover in a fragmented market, controlled perturbations invoke a succession of rapid, complex tradeoffs during the acquisition process that invoke the measurement problem (Figure 2; from Lawless et al., 2005). Of course, "jolts" that produce discontinuous change arise naturally (Meyer, 1982). In contrast, we have argued that intuitively induced perturbations are used by managers as a tool to test opponents and potential targets in the contest for scale. But in our goal to replace intuition with rational control, it becomes necessary to be able to predict the outcome of these perturbations, invoking the measurement problem.

The loss of information opens a new area of study as indicated by the tradeoffs in two very different studies. It indicates that both static observation information and dynamic information co-exist in the form of tradeoffs. As the first example of this tradeoff, in a meta-analysis of over 30 years of research, Baumeister and his colleagues (2005) found that the self-esteem of individuals was strongly consistent with their worldviews but not with their academic or work performances, compromising the value of self-reports. Similarly, in a study with multiple regressions of USAF air-combat maneuvering (ACM) attempting to affirm the proposition that ACM educational courses improved air combat outcomes in machine space, we found no association (Lawless et al., 2000). We concluded that current machine "god's-eye-views" were limited to non-interdependent information. A god's-eye-view describes the situation where perfect information exists regarding the interactions occurring in machine space among artificial agents, humans or both (e.g., a computer's perfect access to the information produced by Swarm).

In addition, to recap the above stated field studies of the DOE-CABs, we have found that decisions by consensus-ruled CAB's were rationally consistent but not practical for their DOE sponsor, while decisions by majority-ruled CAB's were rationally inconsistent but practical (Lawless & Whitton, 2007). This result indicates that the problem with consensus comes not from arriving at one, but seeking it (Levine & Moreland, 2004).

Seeking consensus not only reduces information but also gives inordinate power to select individuals in a group, consequently permitting a group to be more easily controlled by subterfuge and making it a desirable means of governing citizens for autocrats (Kruglanski et al., 2006), but less desirable for organizations (e.g., Unilever has restructured away from dual CEO's, and Shell from dual power centers).

In contrast, we have found that majority rules not only generate information but produce as many action consensus decisions to act more quickly and with greater practical value (Lawless et al., 2006b). But while the latter result suggests that organizational outcomes can be controlled, its inconsistency violates the traditional definition of "rational" as normatively consistent (Shafir & LeBoeuf, 2002). Conflict increases information (Myer et al., 2006), while managed conflict improves learning and solution outcomes (Dietz et al., 2003). In the tradeoff between adaptability and innovation, firms that manage the conflict from paradox can simultaneously optimize existing product lines and innovate (Smith & Tushman, 2005). Conflict is driven by opposing views but is managed by having sufficient neutrals on hand to decide an issue (Kirk, 2003). We have hypothesized that opposing drivers of a decision are able to entangle neutrals into deciding an issue (Lawless et al., 2006b). But more importantly, the entangled system of managing conflict dampens the reliance on illusion. (For example, in 2006, the loss of neutrals presaged the split in the Episcopal Church.)

METRICS TO MEASURE ORGANIZATION PERFORMANCE

Inspired by Bohr and Heisenberg about the application of interdependent uncertainty in the interaction between action and observation, making organizations bistable, we have begun to construct a theory of organizations based on the uncertainty of time and resources as well as belief and action consensus, leading to preliminary metrics of organizational performance that we have validated in field studies. By inverting the measurement problem into two sets of linked metrics, we can predict organization behavior, measure organization performance and find rational ways to control organizations.

Our present research is directed at designing an organization composed of bistable agents. These agents should be able to reside in at least one of two states, either in a baseline or excited state or in an action or observational state. These agents should also be able to exist under the influence of incommensurable belief illusion "A" or "B". With roles as the anchors that build social structures like organizations, bistable agents under social psychological influences create a tension field between local and more global beliefs that is observable in democracies (information) but not in command decision-making or consensus-seeking systems, making democracies more successful than the latter in providing for the social welfare of their citizens but also less rational (Lawless & Grayson, 2004). For example, Sen (2000) has found that no modern democracy has ever experienced mass starvation.

We have applied the organizational uncertainty principle to the construction of a web-based metric for Marine Corps weather forecasters (Lawless et al., 2006a); to reorganize a Management Information System at a University in the European Union (EU-MIS; Lawless et al., 2006b); to a central business university's graduate school (CBU; Lawless et al., 2008a); and, in an ongoing application (see below), to measure the performance of an Army MDRC (Medical Department Research Center). In the USMC study of a web-based forecaster collaboration system, Marine forecasters were holding morning webcast briefings across their theater of operations, but without measuring agreement with the forecasts, making standardization impossible; we recommended the collection of data to test whether standardization was occurring and to assure the reduction of uncertainty in forecaster plans. In the EU University's MIS study, we recommended centralizing the control and purchases of computers and web-based systems to reduce corruption, which was subsequently reduced. For the CBU, we recommended an analysis of the publications being produced and grants being awarded prior to upgrading policies regarding publications and grants. In all of these cases, the uncertainty principle guided our recommendations.

This versatile metric derives from applying the organizational uncertainty principle to the social interaction (Wendt, 2005), the topic for a AAAI symposium at Stanford in 2007 (www.aaai.org/Symposia/Spring/sss07symposia) and a follow-on conference at Oxford in 2008 (ir.dcs.gla.ac.uk/qi2008).

The general applicability of this metric makes it versatile. Organizations are centralized to minimize disagreement in the preparation of a strategy or mission (Pew &

Mavor, 1998), but also to increase the likelihood of action, of resources to drive that action, and of timeliness for that action. However, the organizational uncertainty principle aspect indicates that information entangled among social objects once measured collapses into one of two observables, necessarily losing interdependent information from the non-observed variable. We can measure simultaneously, for example, strategy with certainty, but consequently losing certainty on action outcomes proportionately.

The following section outlines our on-going field research applying the metrics model derived from our organization uncertainty principle.

ON-GOING FIELD RESEARCH: MEDICAL DEPARTMENT RESEARCH CENTER (MDRC)

Army MDRC has had their Mission Statement for thirty years but our evaluation indicated that the seven organizational units were unable to measure clearly their ability to meet their mission. The primary purpose of the Army centers was to train physicians in research methods and to publish research findings. However, the Army centers had no standardized metrics or metrics of any kind to measure their performance. While significant amounts of data were being published in each center's annual reports, no analysis had been performed to indicate what proportion of the extensive publications produced each year at each center addressed any of the Army's mission (i.e., produce more research with greater impact; improve patient care; and reduce the costs of care), whether its mission was being improved or degraded, or even the impact of their publications (e.g., presentations at local conferences were judged equal in value to major journal articles, book chapters, or major grants being awarded, thereby discouraging excellence). While the Army centers could provide lists and aggregate numbers of publications, we concluded that the seven centers were unable to determine whether the Army's mission was being met to any degree by the research that was being published.

Our evaluation showed that the standing of MDRC within the Army research community could be improved by increasing its research productivity impact index with the:

1. Accurate capture of all scholarly products being produced by MDRC and their scholarly impacts,
2. Encouragement to increase the number and quality of research protocols and those scholarly products produced by each protocol,
3. Continued application for extramural funding, and
4. Linking each publication, presentation, and grant award directly to the mission or to a element of a mission (e.g., patient care or physician training).

A system that effectively captures all aspects of the research process, from protocol submission and processing to publication of scholarly products or novel therapeutics, will generate the highest quality data for productivity analysis and metric development. Based on field research, we believe this can best be achieved by developing an electronic protocol submission and management system with the capacity to generate real time metrics of productivity and quality (Lawless et al., 2006c). There are a number of commercial products available to meet some of these needs that address protocol submission and management. However, these products require modest customized re-engineering to permit metric tracking. On the other hand, a system could be developed that would process the necessary research documents and track productivity as well as provide a metric to assess the quality of research performed and publications from that research.

One of two primary goals that we have established with these seven MDRC training centers is to help them to become more productive in meeting and executing their mission (e.g., produce more research with greater impact). However, at the same time, the MDRC's want to become transformative; e.g., transform medical treatments in the field; transform physician education in research; and transform publication impacts. The two goals—to be more productive in meeting their mission and to be transformative—are not just different, but contradictory (Smith & Tushman, 2005). Attempting to satisfy these two goals has led us to propose Figure 3 as an interim solution designed to help the Centers be more productive today, but also to evolve into more transformative organizations in the future.

In Figure, 3 below, based on the feedback from a new system of electronic metrics currently being planned, administrators would have responsibility to enact the Mission as effectively and efficiently as possible; e.g., Lean Six Sigma plans. At the same time, a group internal to each MDRC and a national group of elite professionals from all MDRC units would gather regularly to transform the Mission, its goals, and its procedures and rules using the same feedback. As these two systems compete in a bistable relationship to control and revise the Mission, the two systems operate in tension, producing a natural evolution of the system

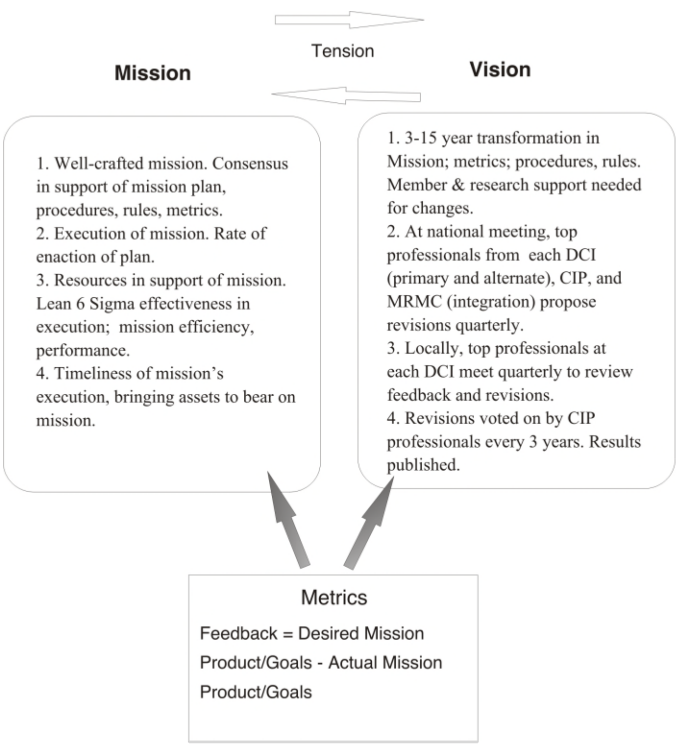

Figure 3: Preliminary Metric to Determine the Performance of a System of Seven Military Medical Department Research Centers

Future ABM Modeling

For our next project and as an extension of this one, we plan to model the MDRC solution proposed in Figure 3). Agent-based modeling of decision-making is best suited to complex problems with multiple maximization or optimization axes. By using agents that are endowed with models of the end goals of the system along with realistic models of utility functions, solutions can be found to these problems that accurately reflect the issues at hand and provide robust predictive power. As we mentioned before, validation is critical. Our ABM organizations will be constituted by bistable agents (viz., existing in 2 states: action or observation; and existing in multiple resource-time states).

CONCLUSION

In the new approach we have presented in this paper to modeling social relationships among humans, organizations, and agent systems, social welfare improves when the resources available to a society are utilized effectively to solve the problems confronted. Social welfare can also improve when society finds the most efficient means of fully exploiting its resources to fine-tune solutions to problems it has already solved (i.e., the fewest number of steps to solve a particular problem; von Baeyer, 2004). In both cases, the combination of competition between groups to find the best solutions to the problems that they face and cooperating to reach compromise between opposition drivers has been shown to make superior contributions to social welfare.

Acknowledgements. The last (corresponding) author thanks the Air Force Research Laboratory for partial support during the completion of this paper.

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