IMPACT OF BEHAVIORAL FORCES ON KNOWLEDGE SHARING IN AN EXTENDED ENTERPRISE SYSTEM OF SYSTEMS

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Abstract: An extended enterprise is both a system of systems (SoS) and a complex dynamical system. We characterize government-run joint and interagency efforts as "government extended enterprises" (GEEs) comprising sets of effectively autonomous organizations that must cooperate voluntarily to achieve desired GEE-level outcomes. Our research investigates the proposition that decision makers can leverage four "canonical forces" to raise the levels of both internal GEE cooperation and SoS-level operational effectiveness, changing the GEE's status as indicated by the "SoS differentiating characteristics" detailed by Boardman and Sauser. Two prior papers described the concepts involved, postulated the relationships among them, and discussed the n-player, iterated "Stag Hunt" methodology applied to execute a real proof-of-concept case (the U.S. Counterterrorism Enterprise's response to the Christmas Day Bomber) in an agent-based model. This paper presents preliminary conclusions from data analysis conducted as a result of ongoing testing of the simulation.

1 INTRODUCTION

On Christmas Day 2009, 19-year old Farouk Abdulmutallab and a few supporters exposed significant flaws in an extended enterprise comprising at least "1,271 government organizations and 1,931 private companies" and a combined budget in excess of $75 billion (Priest and Arkin 2010). Yet, according to the findings in the Executive Summary of the Report of the Senate Select Committee on Intelligence (SSCI 2010), this leviathan failed because the odds were stacked against it; members chose not to share critical information that would have foiled the plot—they chose to not cooperate.

We believe the discipline of systems engineering — specifically, system of systems (SoS) engineering — has both the ability and the responsibility to help future decision makers understand why this happened and how to recognize and prevent similar failures in "networks of peers." A systems engineer might describe such a problem:

> *Consider a system of systems: a heterogeneous network of autonomous nodes, each with its own "private" goals, that exists to serve one or more "public" goals. The nodes must cooperate to produce preferred SoS-level outcomes, but it underperforms due to a lack of internal cooperation — intentionally or not, some nodes effectively place their goals ahead of the network's goals.*

While examples of networks that fit this description abound—in industry (e.g., standards consortia, corporate alliances), the non-profit sector (e.g., collections of community service organizations), the military (e.g., Services trying to jointly field capabilities or conduct operations), and government at all levels (e.g., cabinet departments or legislative committees with overlapping

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jurisdictions, collections of international, federal and/or state organizations working in one more domains) — decision makers appear to lack sound, theory-based approaches and methods to generate, promote and sustain the required level of cooperation in enterprises like them. This may be especially true for networks of high-level government organizations, where market forces cannot punish recalcitrant members.

2 BACKGROUND

Inspired by the works of Hume (2000 [1739-1740]) and Smith (1790), our first paper (John et al., 2011a) details cooperation-related concepts from many disciplines to investigate two propositions: 1. a set of "canonical forces" (Sympathy, Trust, Fear, and Greed) affects the dynamics of SoS operating under conditions of need and uncertainty; and 2. understanding these forces may enable network leaders to address SoS performance issues caused by lack of cooperation among the component systems.

Our unit of analysis is the "Government Extended Enterprise" (GEE). Our definition of a GEE extends concepts described in (Fine, 1998; Davis and Spekman, 2004) to include "the entire set of collaborating [entities], both upstream and downstream, from [initial inputs] to [end-use decisions, policies and actions], that work together to bring value to [the nation]". Thus, GEEs are sets of relatively autonomous government enterprises that must achieve enough "propensity to cooperate" (Axelrod, 1997) to produce the voluntary cooperation that is a prerequisite for coordinated action; they face the "Hobbesian paradox" that lies at the heart of social dilemmas (Van Lange et al., 2007).

2.1 Central Concepts

"Cooperation" is "individual behaviour that incurs personal costs in order to engage in a joint activity that confers benefits exceeding the costs to other members of one's group" (Bowles and Gintis, 2003) and "costly behaviour performed by one individual that increases the payoff of others" (Boyd and Richerson, 2009).

We postulate (John et al., 2011a) four "canonical forces:" Sympathy, conceived by Hume and Smith as the "fellow feeling," that brings individuals together (V. Ostrom, 2005); Trust, a three-part relationship (a trusts b with respect to x) (Hardin, 2006) reflecting "one's willingness to be vulnerable to another's actions with the belief that the other will perform as expected" (Jarvenpaa et al., 1998; Ridings et al., 2002), that was critical to primitive man's survival as a species (Bowles and Gintis, 2003, 2011); Fear, "the cognition of an expected deprivation," (Parsons and Shils, 2001), specifically of being viewed as a failure, or of incurring a business or political loss or cost, and loss of control (Van Dijk et al., 2008), which "induces … focus on events that are especially unfavourable" (Shefrin, 2002 citing Lopes, 1987) and erodes SoS cohesion by causing components to act to further their private goals in preference to the network's public goals; and Greed for success, power, budget or influence Simon (1997 [1945], (Skinner, 1965) that encourages on private goals, reducing propensity to cooperate, and reinforcing the effects of Fear.

Because they are open systems (Von Bertalanffy, 1950; Weiner, 1948), GEEs are subject to Need, primarily for resources through the competitive federal budget process (Garrett, 1998), and Uncertainty that produces both Fear and the potential for profit, subject to risk tolerance (Williams, 2002; Wohlstetter, 1962; Prange, 1981).

2.2 SoS Differentiating Characteristics

We leverage five characteristics by which Boardman and Sauser (2006, 2008) differentiate systems of systems from systems of components: Autonomy (A), both a component system's native ability to make independent choices (an "internal" system-level property conveyed by its nature as a holon), and more importantly, the fact that other members of the system of systems "respect" this ability by permitting the component to exercise it; Belonging (B), a direct reflection of the components' recognition of a shared mission or shared (but not merely coincident) interests; Connectivity (C), "the agility of structure for essential connectivity in the face of a dynamic problematique that defies prescience" (Boardman and Sauser, 2008, 158-159); Diversity (D), "noticeable heterogeneity; having distinct or unlike elements or qualities in a group," (Boardman and Sauser (2008, 157) that reflects the impact of the law of requisite variety (Ashby, 1956) on systems of systems; and Emergence (E): the ability to "match the agility of the problematique" by adding new responses based on "auxiliary mechanisms for anticipation" (Boardman and Sauser, 2008, 160-161).

Our prior paper (John et al., 2011a) discusses the postulated relationships between the forces and these characteristics in detail, summarizing them in a table that uses a five-point nominal scale to indicate both how strongly "positive," "neutral," or "negative" a force is with respect to a characteristic, and whether the characteristic requires or is inimical to the force. These values drive the cooperative model selected by the agents in the simulation described in Section 6, below, and support tracking the resulting chain of causality. Table II in the same paper describes the relationships between the levels of the Boardman-Sauser characteristics and a component's "Cooperation Model" — cooperate or "co-opetate" (attributed to Novell founder Ray Noorda).

John et al. (2001a, Table III) uses a five-point nominal scale to indicate the postulated impact of changes in the Boardman-Sauser characteristics levels on the "cooperation model" each agent uses in the game, expressed as the force "favouring" or "disfavouring" a choice. Our work captures and measures these changes and the resulting SoS-level behaviour. The same paper discusses the impact of two other potentially important factors: History of Behaviour and Leadership.

3 THEORY AND APPROACH

Recent research (Boardman and Sauser, 2006; 2008; DiMario et al., 2009; Gorod et al., 2008; Baldwin and Sauser, 2009; Epelbaum et al., 2011) has posited and attempted to quantify how collections of systems that should work together become more manifestly SoS as their levels of the characteristics rise. We theorize that in action situations that demand cooperation, assuming increasing the level of cooperation improves the operational performance of the SoS, each organization's Probability of Cooperation with an emerging coalition is the result of the interaction of the proposed forces, each organization's principles-based strategy and a set of behavioural factors.

Informed by noted cooperation scholars (Axelrod, 1997; E. Ostrom, 2005; 2007; Pacheco et al., 2009; Poteete et al., 2010; Gintis, 2009a; Bowels and Gintis, 2011) our methodology applies game theory in an agent-based simulation of a complex adaptive system and a real-world case (see John et al., 2011b for a detailed description). Our approach centres on a "Stag Hunt" game (Shor, 2010a; Skyrms, 2004) that treats information in the GEE as a "common-pool resource" (Poteete et al., 2010) and establishes payoff-driven (Hicks) and risk-dominant equilibria (Nash) that correspond with the GEE's public and private goals. The GEE cannot succeed if key nodes fail to cooperate by sharing information in ways that meet the requirements in the unclassified Executive Summary of the SSCI report (SSCI, 2010).

3.1 Hypotheses and Assumptions

Testing has led us to refine the previously declared set of hypotheses (John et al., 2011b). Given a SoS ("*S*") — the GEE — comprising Executive Agent "a_1" and autonomous components "a_2" though "a_n", operating under conditions of uncertainty and with knowledge of each others' history of behavior with respect to themselves:

Hypothesis 1. a_n's levels of Probability of Cooperation with a_1, will be:

1a. positively correlated with a_n's level of Risk Tolerance,

1b. positively correlated with a_n's level of Sympathy and Trust with respect to a_1,

1c. positively correlated with a_1's History of Behavior,

1d. negatively correlated with a_n's level of Greed

1e. negatively correlated with a_n's level of Fear.

Hypothesis 2. *S*'s level of Belonging will be:

2a. positively correlated with *S*'s level of Sympathy (where the value of Sympathy is the median of the values for *S*'s members)

2b. positively correlated with *S*'s level of Trust, (where the value of Trust is the median of the values for *S*'s members)

2c. negatively correlated with *S*'s levels of Greed (where the value of Greed is the median of the values for *S*'s members)

2d. negatively correlated with *S*'s level of Fear (where the values of Fear is the median of the values for *S*'s members).

Hypothesis 3. *S*'s level of EE Belonging, will be positively correlated with key components' aggregate Probability of Cooperation.

Hypothesis 4. *S*'s level of EE Connectivity, will be positively correlated with key components' aggregate Probability of Cooperation.

Hypothesis 5. *S*'s level of EE Diversity will be positively correlated with key components' aggregate Probability of Cooperation.

Hypothesis 6. *S*'s level of EE Emergence will be positively correlated with key components' aggregate Probability of Cooperation.

Continuing research has led us to add an eighth assumption — that all of the player's cooperate/defect decisions must comply with the letter and intent of U.S. law and policy — to our prior list (John et al., 2011b, Section III.B. The new assumption enables us to explicitly incorporate the deontic component of social decision making — rules about what one must, may not and should do (Stamper et al., 2000; E. Ostrom, 2005; Filipe and Fred, 2008).

3.2 Validation and Data Analysis Process

A Review Panel — a multi-disciplinary set of experts with long experience as both operators and executives in the organizations and domains — will set the model's initial conditions to account for the fact that agent-based models are sensitive to initial conditions (Windrom et al., 2007; Miller and Page, 2007).

Data analysis centres on the use of non-parametric statistical processes. These are appropriate for data generated by the agent-based model because one cannot make useful assumptions a priori about the distribution of the data.

3.3 Sample Case

Our second paper (John et al., 2011b provides a detailed explanation of the sample case, which covers an 18-month period comprising five discrete decision points where the SSCI Report found that components of the GEE could have foiled the attack by sharing information they already possessed. Figure 1 illustrates the core operational issue reported by the SSCI (example, at Event #1), in which solid blue arrows represent expected information flows with full information sharing, and dashed blue arrows represent desirable flows that did not occur.

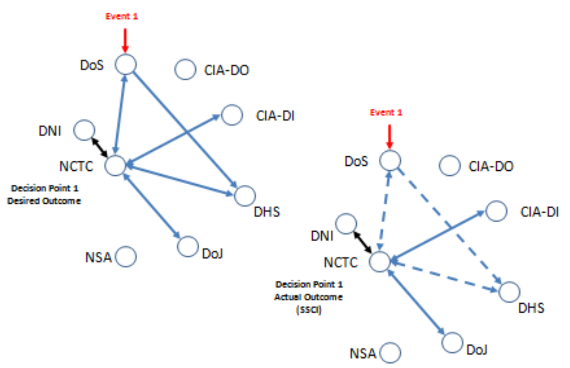

Figure 1: Desired and actual Information Flows for Decision Point #1.

3.4 Agent-based Simulation

Our second paper (John et al., 2011b) provides a detailed description of the computational agent based simulation used in our research, a process used in a wide variety of domains in the physical and social sciences, including studies of cooperation (Gintis, 2009a; Metrikopoulos and Moustakas, 2010) and complex adaptive systems (Gintis, 2009a; Miller and Page, 2007). Of note, we eliminate the potential impact of signalling issues (Gintis, 2009a) by assuming that all choices are made simultaneously, an assumption that approximates the impact of effective administrative information security procedures.

We chose the Stag Hunt over the more widely used iterated Prisoner's Dilemma (Axelrod, 1997; E. Ostrom, 2005; Mertikopoulos and Moustakas, 2010; Shor, 2010b) because the former provides two equilibria that can be viewed as "satisfactory" — one risk-dominant (the Nash equilibrium) that satisfies private goals, and one payoff-dominant (the Pareto-optimal Hicks equilibrium) that satisfies public goals — in a non-zero sum game (Pacheco et al., 2009; Poteet et al., 2010; Shor, 2010a; b). Similar decision making challenges exist in artificial intelligence and network switching (Wolpert, 2003).

3.5 Factors Governing Behaviour

Behaviour within and among organizations is governed by "institutional statements"—rules, norms and shared strategies (E. Ostrom, 2005, 2007; Gintis, 2009a, Bowles and Gintis, 2011), informed by knowledge — the deontic, axiological and epistemological components of social decision making (Stamper et al., 2000, Filipe and Fred, 2008). At a practical level they are embodied in a set of behavioural factors that represent key inputs to decision making, and can be described algorithmically. Our second paper (John et al., 2011b) presents our core algorithm (Equation 1), defines the eight factors that affect an agent's Propensity to Cooperate (P_c) and details the processes by which the model leverages them. The characteristics are: F1 Level of Risk, F2 Payoff to the Sharing Agent, F3 Payoff to the Receiving Agent, F4 History of Behaviour, F5 Risk Tolerance, F6 Perceived Level of Need, F7 Perceived Level of Damage Due to Disclosure (a powerful analogue to "Subtractability of Flow" in common-pool resource problems (E. Ostrom, 2010)), and F8 Sharing Agent's Perceived Level of Confidence in the Information.

$$P_c = (F4*F6)\ ((F1+F2+F3+F5)/4)\ ((F7+F8)/2) + 3 \quad (1)$$

3.6 Principle-driven Strategies

Principles — the sum of an organization's values, standards, ideals, precepts, beliefs, morals and ethics — drive the strategy that drives decisions by helping decision makers "to establish whether a decision is right or wrong" (Miner, 2006, 109-126); they are the axiological component of social decision making. Our second paper (John et al., 2011b) describes the process by which we leveraged aspects of Vroom's image theory (based on Maslow and Herzberg) (Miner, 2005, 94-113) to derive and leverage the six alternative (self-regarding, neutral or and self-regarding) principles that underlie the information sharing decision making strategies of US CT Enterprise components, thereby enabling us to create a game strategy profile (Gintis, 2009a; Mertikopoulos and Moustakas, 2010) consisting of 11 strategies and to establishing weighting coefficients for the behavioural factors used by Equation 1 to calculate P_c for each situation.

3.7 Simulation Toolset

This effort uses Systems Effectiveness Analysis Simulation (SEAS), an agent-based, complex adaptive systems simulation that is part of the Air Force Standard Analysis Tool Kit (SEAS, 2010). SEAS agents incorporate the components of social decision making by functioning at the physical, information, and cognitive levels to maintain awareness of their situations, and by leveraging a set of simple, principle-based behaviour rules that incorporate the impact of norms to make decisions "on the fly."

SEAS data will enable us to infer the impact of the forces on the Boardman-Sauser characteristics and set the stage for root cause analyses.

4 ANALYSIS

4.1 Boundary Conditions

Exploring boundary conditions (i.e., the outcomes produced by agents adopting extreme strategies) is a key step in the use of agent-based models (Miller and Page, 2007). Our initial exploration of the game matrices for agents employing a "pure" strategy (e.g., always share if it favors the GEE, or always favor their own organization), verifies that the "Stag Hunt" game is a good simulation for this problem. Extremely cooperation-friendly strategies produced payoff-dominant results, and cooperation-antagonistic produced risk-dominant results. We used the results of these initial analyses to select the applicable ranges and effects of the Decision Making Freedom Factors. Based on tests to date, a normalized P_c of 0.8 appears to represent a "ceiling" below which agents will always refuse to cooperate, while values above 1.225 represent a "floor" above which agents will always cooperate. Approximately 20% of calculated values fall in one of these two areas. In general, test data indicates that these values manifest at higher force levels.

4.2 Data Analysis Process

The team first conducted exploratory data analysis and a series of statistical tests to establish the presence of significant patterns within the data. The objective of the tests is to determine whether the observed outcomes vary as expected (i.e., directly with the changes in the levels of impact of the canonical forces) and reliably refute the null hypotheses. Because we expected the data generated by our experiment to take the form of nonparametric statistics (e.g., non-normal or multi-modal distributions), tests include the Mann-Whitney U test, used to determine if a difference exists between two groups, and the Kruskal-Wallis test, which, because it does not require an assumption of normality, is the non-parametric analog to a one-way analysis of variance. We are prepared to run other parametric and nonparametric tests as the data and emerging research questions require.

We began testing a limited version of the SEAS simulation in early March 2010. These tests focused on verifying that the simulation manipulates data and computes results in accordance with our design, and that the design itself contains no egregious errors. To this end, we chose a subset (43 cases) of the possible combinations (256 cases) of integer-value force levels, designed to support linear regression analysis of simulator results. The testing regime runs the entire five-event scenario for each strategy in 200 blocks, with each block including 112 opportunities for cooperation.

Table 1 is a small sample of the simulator output. A "1" in the "Share Sender?" and or "Share Receiver?" column indicates that the computed probability of cooperation resulted in that agent deciding to share ("cooperate"). The Score is the payoff the sharing agent earned from each decision.

Table 1: Simulator Output (Unprocessed).

Sharer	Receiver	Share Sender?	Share Receiver?	Score
DOS_CA	DHS_CBP	1	0	0
DOS_CA	NCTC	1	1	10

A macro cleans and orders the data, computes summary statistics (the number of "share" decisions; and minimum, maximum, mean and median values for probability of cooperation and payoff by block), then transfers the ordered data to another workbook with one tab per strategy (Table 2).

Table 2: Partial Simulator Output (Unprocessed).

ST_0	Trust = 1 all others = 0				ST_1
#	Sender Share Opps.	Receiver Share Opps.	Score		Sender Share Opps.
1	0.678571	0.660714	139		0.696429
2	0.625	0.758929	180		0.642857
3	0.723214	0.741071	179		0.767857

The macro computes additional summary statistics (minimum, 25th percentile, average, 75th percentile, and maximum $Prob_c$ values) for each case and plots them vs. force configuration using a "box and whiskers" format. It also counts the frequency of $Prob_c$ values in a series of ranges for plotting by force configuration and strategy in a three-dimensional "ribbon chart" format. We also use the "box and whiskers" format to plot linear regressions for the impact of forces on $Prob_c$ and line charts to plot the impact of strategies or forces on payoff.

We will follow a recommended best practice for computational simulations (Miller and Page, 2007) by running all 256 cases against the set of "practical" strategies chosen by the Review Panel to ensure we understand how the simulation behaves in all of the combinations the actual case study may present, and the root causes for these behaviors. We will also analyze comparative plots of the manually computed values of P_c versus the simulator-computed values of Probability of Cooperation based on integer values assigned to each of the force configurations to begin to illuminate the space between the data points to support interpolation in future versions of the simulation. Interpolation across strategies may be problematic.

4.3 Addressing Threats to Validity

Executing 200 Monte Carlo trials of each of force configuration (a "case") produces a statistical confidence above .95 for each set of results. John et al. (2011b, Section IV) discusses our approach to addressing internal and external validity, face and construct validity, criterion validity, and construct validity.

5 PRELIMINARY RESULTS

The following are preliminary conclusions, some of which may have significant implications for GEE members.

We are demonstrating the ability to encapsulate agents' belief systems in key model elements and leverage that encapsulation to produce internally self-consistent results. This means the experiment may offer a useful evaluation of the postulated relationship between the forces and the SoS characteristics.

The neutral strategies are, by their nature as firm, all-purpose decision making heuristics, essentially insensitive to the forces. While preliminary results demonstrate that the forces are capable of impacting decision making, the effect appears to be significant only when the decision makers's principles evidence some level of preference for public or private goals. In general when considering the force individually, Sympathy tends to have the greatest impact, followed in descending order by Greed, Trust and then Fear.

The neutral strategies produce results that are predictable, but uninteresting. Moreover, Kruskal-Wallis testing indicates that some strategies produce sufficiently similar results that we can eliminate some and reduce the mass of data to be analyzed. The combination of Trust and Sympathy at Level 3 (with other forces = 0) has produced anomalous results with two strategies; further investigation is required. We have yet to evaluate the interaction effects among the forces in complicated force configurations (for example, each force at a different level), but must do so, as we expect these conditions to be firmly in play in the case study.

We see preliminary indications of an unexpectedly dynamic relationship between the forces and strategies. Strategies tend to dominate Level 1 forces, but Level 3 forces (and, presumably, their interaction effects) dominate most strategies. Fear appears to play a major role only when added to other forces — it appears to dampen the impact of many strategies.

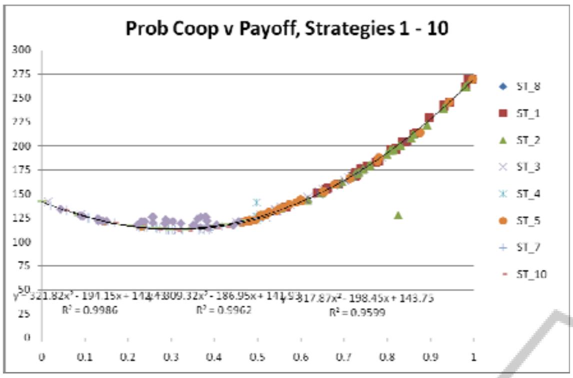

Figure 2: Median Payoff at Probability of Cooperation.

Figure 2 plots median gross payoff as a function of probability of cooperation by strategy (10 of 11 strategies). We believe it clearly indicates that agents engaged in repeated interactions within a Stag Hunt situation will generally earn higher cumulative payoffs if they choose to cooperate. One could also infer from this that (assuming no externalities to the contrary) the same is true of one-shot Stag Hunt situations, but further research is required. It must be noted, however, that the current version of the simulation does not feature live play of situational (Need and Uncertainty) and behavioral factors (detailed in Section VI.C.) that could have a profound impact on decision making. If the plotted results persist, however, they should lead GEE members who are uncertain of whether they should choose to cooperate to do so. Because the only strategies that produce better-than-minimum payoffs from defecting are those held by agents whose principles motivate strongly against cooperation, these results also indicate that GEEs seeking new members may be able to safely incorporate agents with principles that are uncertain or neutral.

6 LIMITATIONS AND FUTURE WORK

We recognize this effort is essentially a proof-of-concept, based on a single case. The case may not generalize as fully as we hope; other cases may lack a convenient set of findings to use as a measuring stick for evaluating the relationship of the forces to the characteristics, or the SSCI's root cause analysis may be flawed. It is also possible that the assumptions and abstractions we have used to simplify the problem may contain important complexities or factors our work fails to recognize. For example, this effort assumes that agents do not learn — they will not change decision making strategies in the course of a case. We also eliminate the effects of information transfer time, and differences in individual capabilities and authorities by assuming that when any member of an organizational element gains access to a piece of information, the entire element gains access and understanding immediately, and is authorized to act on that understanding. Moreover, the process used in our tests to date lacks explicit recognition of the individual fitness costs that qualify an act as one of altruistic cooperation (Bowles and Gintis, 2011).

The choice of game is not without some controversy. On 12 December 2009, Gintis posted a review (Gintis, 2009b) of Skyrms' (2004) view that "Many modern thinkers have focused on the prisoner's dilemma [as a simple exemplar of the central problem of the social contract], but I believe that this emphasis is misplaced. The most appropriate choice is not the prisoner's dilemma, but rather the stag hunt." Gintis' objection hinges on his view that Skyrms has fallen prey to the "Folk Theorem of Repeated Games" whose "central weakness is that it is only an existence theorem with no consideration of how the Nash equilibrium can actually be instantiated as a social process….Rather, … strategic interaction must be socially structured by a choreographer—a social norm with the status of common knowledge …." Following Simon's (1997 [1945]) view of the behaviour of individuals within an organization and leveraging a mechanism articulated in Bowles and Gintis (2011), we believe there is reason to view cultural transmission of norms within an agency as powerful enough to establish the Nash equilibrium.

Gintis' (2009a) discussion of "Epistemic Game Theory and Social Norms" summarizes what he views as a long-standing schism within the behavioral sciences and further emphasizes the importance of the socially-developed norm as the "choreographer" of individual and group behaviors. Earlier in the same book, Gintis also questions the need for those applying game theory to social dilemmas to eschew the "rational actor" model in favor of bounded rationality. He contends that explicitly accounting for each agent's beliefs, preferences and constraints allows for rational, self-regarding agents that operate with defined limits with respect to their knowledge and their own perspective (their utility function). Our model addresses this by explicitly including the impact of decision maker principles in the strategy formulation process.

Nevertheless, we remain convinced that this area presents fertile ground for important research, including the creation of a tool set and analysis process that can be useful in the continuing development of cooperation theory for systems of systems. Additional research into the sensitivity of P_c, $Prob_c$, and Payoff to the level of decision maker bias embodied in the strategies (self-regarding or other-regarding) may be very illuminating. For example, do one or more of these outputs vary in a linear fashion, a step function or some other way? We are working to identify other suitable cases involving both public and private extended enterprises so we can validate and expand our analytic capabilities.

This effort is only one step on a much longer journey toward what we call "The Science of Belonging." We believe the understanding that can be derived from such a science will be crucial in a world full of autonomous software systems. Future work must establish how decision makers can change the levels of the forces in their extended enterprises — the specific "levers" decision makers can pull — as well as how they can accurately measure the resulting amount of change in the Boardman-Sauser characteristics. We must also ascertain the existence and impacts of other useful forces and characteristics.

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