Academic

The Complexity of Complexity Theory: An Innovative Analysis

Steven E. Wallis
Independent Organizational Consultant, USA

As more scholars join the conversation around complexity theory (CT), it seems a useful time to ask ourselves if we are talking about the "same thing?" This concern is highlighted by the present survey, which finds more conflict than agreement between definitions. In contrast to the conflict, a path toward common ground may be found by applying the idea of a "robust" theory. A robust theory is expected to be more effective in application and more reasonably falsifiable. In this paper, Reflexive Dimensional Analysis (RDA) is used to analyze existing definitions of CT. These definitions are deconstructed, redefined as scalar dimensions, combined, and investigated to identify co-causal relationships. The robustness of CT is identified as 0.56 on a scale of zero to one. Paths for advancing the theory are suggested, with important implications for complexity science.

Introduction: Seeking the Core of Complexity Theory

Given the breadth, depth, and growth of the current conversation, it seems reasonable to ask—exactly what is this thing called "complexity theory?" For although there are many definitions of CT, it has been suggested, that there is no unified description (Axelrod & Cohen, 2000: 15; Lissack, 1999: 112). While this plurality may reflect the many voices engaged in the conversation, it also calls into question the validity of the theory because there is no common sense as to what the theory "is." Indeed, the general assumption seems to be that we are all talking about the "same thing." Like blind men discussing an elephant, such assumptions may lead to false conclusions and unnecessary conflict.

While the academic process thrives on the differences between points of view, the extent of those differences calls into question whether scholars are, indeed, talking about the same thing. After all, if one author states that CT may be understood through concepts "A, B, and C" while another author states that the relevant concepts are "C, E, and F," there is some conceptual overlap, but there are also inherent contradictions. Although according to their authors, these descriptions fit under the general rubric of CT, these differences may be seen as representing a conflict in the common understanding of CT, and so reflect differences in our understanding of systems from atoms to institutions.

The issue of understanding of a body of theory has been of concern for decades. In one attempt to make sense of the issue, theories are described as having of a "hard core" of unchanging assumptions, surrounded by a more changeable "protective belt" (Lakatos, 1970). When a theory is challenged, a theorist may rise to defend it with a new concept that changes the belt, but presumably leaves the core intact. In the present paper, I seek to identify the core of CT. This effort will provide general and specific support for the continued development of CT.

If the core is defined as "that which is generally accepted," it might be easy to define the core of CT. Unfortunately; no such commonality seems to exist (as will be explored in greater depth below). Some other indicator is then needed for the core.

Where the social sciences might be generally said to have highly variable protective belts of theory, it should be noted that Ohm's I=E/R is a robust theory. I use the term robust in the same way that it is used in physics and mathematics, to describe a theory where each dimension of the theory may be determined by the other dimensions (this will be discussed in greater detail below). In the present article, I will identify how an understanding of CT might be shifted from the shifting obfuscation

of Lakatos's outer belt, toward an enduring and useful law. When our theories attain this level of advancement, we may anticipate meaningful changes in the way we study institutions.

Leaving that lack of effective theory unquestioned is like ignoring our fundamental assumptions. And, as Lichtenstein (2000a: 539) suggests, "…since these assumptions are rarely discussed, many of the potential insights from complexity science have not been fully developed."

Although a complete study is beyond the scope of the present paper, it may be suggested that a more robust version of CT may prove more effective in application. This claim is based on the idea that robust theories of physics are more effective than the ever-flexible theories commonly found in the social sciences.

"A proposition is a declarative sentence expressing a relationship among some terms." Van de Ven (2007: 117). Further, a proposition may be of three types. Atomistic propositions are very simple, essentially claiming, "A is valid." Linear propositions are more complex noting a causal linkage between two concepts such as, "Change in A causes change in B." More complex relationships are found in concatenated proposition. In this, I use the sense expressed by Van de Ven (2007) where two aspects of a theory are shown to influence the third aspect. For an abstract example, a concatenated proposition might state that changes in A and B will cause changes in C. Similarly, a theory may be generally understood as a collection of interrelated concepts—an idea that will be explored in depth below.

In this process, I will adopt a Knowledge Management (KM) approach. KM includes the study of creating, transferring, and sharing knowledge (Kakabadse, Kouzim & Kakabadse, 2001). Codification is seen as a critical step in the process of social interaction (Leydesdorff, 2002). Codified knowledge is considered more easily transmittable, although it may seem less related to a given context. The following analysis might also be seen as a form of scientometrics and bibliometrics. The concise descriptions of CT as found in the study of organizational theory (OT) will be taken as codified knowledge and this paper may be seen as another step in the process of codification.

Although the present studies will avoid a historical approach to the analysis of theory, it may be useful to note here that Van Dijkum (1997) suggests that CT is closely related to cybernetics as both include questions of subjectivity, self-organization, and self-steering founded primarily on the work of Prigogine, Haken, and Casti. In the present paper, the focus will be on eight publications.

Although each author studied in the present paper is writing within the organizational field, they draw their influences from a variety of sources. Pascale (1999) traces his influences to the interdisciplinary work at the Santa Fe Institute. Frederick (1998) draws on mathematics, chemistry, biology, and Darwinian evolution. Axelrod and Cohen (2000) pull from Darwin, Smith, Simon, and "many fields of study," while Brown & Eisenhardt (1998) mention physics, biology, economics, and strategy. Stacey, *et al.* (2000) note their preference for the works of Prigogine, Kaufman, and Goodwin, and against the works of Gell-Mann and Holland. Kernick (2006) suggests that the study of complexity began with computer-based models and spread to other disciplines, while Hurtado (2006) draws primarily on more recent works from organizational theory. Finally, Dagnino (2004) suggests the origins were in biology and physics and that these origins represent the Santa Fe approach and the European approach.

It should be noted here that the diversity of sources, including fields of study and specific authors, does not seem to suggest a shared sense of what CT is.

Drawing on Davidson and Layder, Romm (2001) suggests that researchers use "triangulation" (where multiple research methods are used to reduce subjectivity in research). In the present paper, I provide two studies of CT, where both studies use the same source of data found in those eight publications.

In the first study, I draw on techniques of content analysis to identify the range of concepts found in the theory. Content analysis (e.g., Hjørland, 2002; Hood & Wilson, 2002)

essentially involves looking at the words used by the authors as reasonable representations of the concepts that they convey. Grasping the range of concepts helps to identify the similarities and differences between the various versions of theory. The first study identifies a high level of disagreement between authors.

The second study is informed by narrative analysis (e.g., Pentland, 1999) to focus on the propositions found in CT. In this study, I use an innovative, though easily replicable, method of analysis (inspired by insights from CT) to identify relationships between propositions and calculate an objective measure of the robustness of CT. Importantly, an objective path for developing a more robust CT is suggested. A robust version of CT may be expected to provide meaningful benefits to academics and practitioners alike.

Study #1—The Atomistic Concepts of Complexity Theory

This study identifies the range of concepts of CT within organizational theory (OT) and analyzes that collection of concepts from two perspectives. As developed by Wallis (2008), these diverse views, in some sense, may be seen as reflecting the existing diversity in the field of CT. With each perspective, a different view of CT is provided. The new versions of CT created here may be seen as schools of thought, or as newly evolved versions of CT. In addition to identifying the range of concepts present in CT, this study also suggests that more differences than similarities exist between versions of the theory. And, these differences represent an inherent conflict.

Based on a word-search of the ProQuest™ database, I found 683 matches for "complexity theory" with "definitions." By focusing on those papers within the subject area of organizational theory, this number was reduced to 85 matches. Additionally, I followed promising leads and reviewed books from my own shelves. Next, the versions of CT were tested for conciseness to see if they were of a reasonable level of complexity for this kind of study. They should not too long (extending across many pages because such extensive descriptions of CT might suggest a study that would not be of suitable length for this publication.

From this search, I found eight definitions of CT in the field of OT where those definitions were relatively concise (less than one page). For this paper, I will analyze CT based on relatively concise definitions developed by scholars working in the area of OT. The authors drawn on for this study are: (Axelrod *et al.*, 2000; Brown *et al.*, 1998; Dagnino, 2004; Frederick, 1998; Hurtado, 2006; Kernick, 2006; Pascale, 1999; Stacey *et al.*, 2000).

From that collection of writings, I deconstructed each description into the authors' component concepts. For example, Dagnino (2004: 61) suggests (in part), "These subsystems are therefore subject to evolutionary pressures." From such a statement, the concepts of nested systems, and evolutionary pressures may be drawn. While another reader might develop a different list, it is expected that such lists would be substantively similar to the one developed in this study.

From the above eight sources, I found 47 easily differentiable concepts—from the idea that Agents act, to the existence of Unexpected change. The complete set of concepts will not be listed, due to limitations of space. That list of concepts might be seen as representing the whole of CT as found in OT from a conceptual perspective. It should be noted that at this "survey" stage, no concept appears to be closer to the core of CT than any other. The next task is to search for concepts held in common by the authors. It may be assumed that greater commonality represents some shared acceptance of some core concepts, and less conflict, around the question of what CT is. The following is a list of the concepts that seemed most popular among the eight descriptions, each concept being noted by three or more authors:

- Meta systems have midi agents;
- Connections are of varied types;
- Firm behavior changes;
- Evolutionary pressures;
- Agents act;

- Unexpected change occurs, and;
- Agents are of varied types.

These seven concepts stand in stark contrast to the 47 concepts that comprise the complete list of concepts discussed as CT. Also, it is worth noting that a new version of CT has been created based on this focus.

Moving from one form of popularity to another, of the eight publications in this study, two could clearly be seen as the "most cited" according to Google Scholar™. The version of CT developed by Axelrod and Cohen (2000), as well as the version by Brown and Eisenhardt (1998) were each cited well over 500 times suggesting a certain level of authority in the field. The next less frequently cited source received about 280 citations while others were much lower. While this division may be somewhat arbitrary, it serves to provide a useful observation.

Focusing on the two "most cited" versions of CT, there are significant differences and no similarities. The Axelrod and Cohen version takes note of eleven concepts focusing on agents, their variations, interactions, strategies, and success. In contrast, the Brown and Eisenhardt version notes only three concepts, focused tightly on the idea of the "edge of chaos." While it is possible to infer a connection between the two definitions, such an inference would require the interpretation of the authors' works—and so beyond the scope of the present article.

Rather than creating what might be considered a single "authoritative" version of CT, this comparison essentially creates two new description of CT, where each publication may be seen as representing its own school of thought. The lack of overlap (finding zero concepts in common) stands in stark contrast to the 14 concepts that the two do not share. Rather than creating a useful consensus, this study suggests bifurcation and implied conflict between versions. Either version, it should be noted, has less conceptual breadth than the whole body of CT.

There are obvious limitations to this study such as sample size and the amount of interpretation applied to understand exactly what the authors meant to convey with each specific word. However, it should also be noted, that any discussion around investigating some deeper level of understanding must consist of still more concepts. Therefore, a deeper exploration might be expected to produce more concepts and so more levels of conflict.

The present study may stand as an example of an expansion of Lakatos's outer belt. The number of theories was easily increased, yet this expansion does not seem to have increased the understanding of the core.

Of course, many such studies are possible. For example, a new study of this sort might be conducted based on the authors' influences, field of origin, date of publication, and so on. The point to be taken here is that each focus seems to create a new version of CT; and, that new version will have fewer conceptual components than the body of CT as a whole. Further, each new theory will similarly lack a discernible core. In short, it may be concluded that CT is a highly contested field of study, where each new theory adds to the conflict.

This form of study may be understood as useful to the extent that it identifies the range of concepts within a body of theory. This form of study is also useful because it highlights the difficulty of working with disconnected (atomistic) concepts. In the following study, I will use an innovative methodology to investigate the same body of data. Rather than focusing on atomistic concepts, however the focus will be on connected concepts found in the causal propositions of the theories. Before that study, the importance of such a focus is explained in the following section in a discussion on the structure of theory.

The Structure of Theory

Understanding the structure of theory is foundational to understanding the second study, and to identifying the core of CT. Given the diverse versions of CT, the question presents itself: is it possible to ascertain the legitimacy of a theory through its structure? The answer would seem to be in the affirmative because Popper's arguments for falsification include the idea that the structure and composition of a theory will add to the testability of that theo-

ry (Popper, 2002: 111-114). The concept is of such importance, however, that some explication seems suggested.

In the validation of theory, Kaplan (1964) describes three norms (correspondence, coherence, and pragmatism). A pragmatic test (one which is tested through application) is beyond the scope of this paper. A norm of coherence suggests that we question whether a theory fits within the existing body of theory. As the present analysis and theory development draws entirely on existing theory, there should be little difficulty in maintaining that norm. Then, there is the norm of correspondence. Kaplan takes pains to note how, for this norm, the truth is plainly useless because every appeal to the facts rests on presuppositions. Therefore, he suggests, what counts in the validity of a theory is the "concatenation" of the evidence. As noted above, concatenation is seen where two aspects of a theory are shown to influence the third aspect In this, I use the sense expressed by (Van de Ven, 2007). For an abstract example, a concatenated proposition might state that changes in concept A and concept B will cause changes in concept C.

In the present study, however, I found few propositions that were concatenated. The second study, therefore, will use Reflexive Dimensional Analysis (RDA) as an analytical tool to "shift" propositions toward increasing levels of concatenation (Wallis, 2006a, b).

Generally, RDA begins with a set of linear propositions. A linear proposition might be seen abstractly in a causal relationship between the aspects of the theory such as, "Changes in A cause changes in B." The propositions found in a body of theory are investigated to determine how they may be combined to create concatenated propositions. For example, one linear proposition (e.g., Changes in A cause changes in B) may be conceptually related with another linear proposition (e.g., Changes in C cause changes in B) to suggest a concatenated proposition (Changes in A and C cause changes in B).

The increasing concatenation may be understood as representing increasing levels of interrelationship, or increasing levels of structure. Dubin (1978) suggests that there are four levels of efficacy in theory; and, these levels seem to reflect the structure of the theory, they are:

1. Presence/Absence—what concepts are contained within a theory;
2. Directionality—what are the causal concepts and what are the emergent concepts within the theory;
3. Covariation—how several concepts might impel change in one another, and;
4. Rate of change—to what quantity does each of the elements within the theory effect one another.

The first study (above) tested for the presence/absence of concepts. In the second study, I will use RDA to combine causal propositions as a means of advancing the structure of CT toward the third level, that of covariation. Achieving the fourth level is beyond the scope of this paper.

In a view that seems similar to Dubin's, Weick (1989) suggests that a theory may be understood as an, "ordered set of assertions." Viewing Weick's statement as a concatenated proposition seems to suggest that more assertions with more order between them, will tend to result in better theory—where better theory may be generally understood as having some preferable aspects of quantity and quality. If a theory is held to be useful in practice, we may infer that a better theory might be more useful in practice. Therefore, the structure of a theory may be said to have some bearing on the efficacy of that theory when it is applied in practice.

If we are looking at the assertions or propositions of a theory as being "interrelated," the propositions of that theory might be seen as, "reciprocally or mutually related" (Dictionary, 1993: 998). With such a view, a body of theory might be seen as a kind of system and, "…any part of the system can only be fully understood in terms of its relationships with the other parts of the whole system" (Harder, Robertson & Woodward, 2004: 83, drawing on Freeman). It seems, therefore, that every concept within a theory would best be under-

stood through other concepts within that body of theory. This view seems to fit some assumptions of CT with regards to importance of the interrelated nature of varied components.

An objective level of relationship is easily calculated by identifying the total number of concepts within a theory as well as the concatenated aspects of the theory, then dividing the number of concatenated aspects by the total number of aspects. This method provides a measure of "robustness" between zero and one Wallis (2008). Briefly, those aspects of a theory that are more closely related to one another may be understood as being closer to the core of the theory.

As an example, Ohm's law (I=E/R) contains three aspects. Each of those aspects is concatenated from the other two. Therefore, Ohm's law has a robustness of one (the result of three divided by three. In contrast, a theory that simply lists its component concepts, without identifying how the concepts are related to one another, would have a robustness of zero. For example, in the above study, the new version of theory is a list of concepts and, as such, has a static robustness of zero because no conceptual aspect is said to have any effect on any other.

Comparing the great usefulness of Ohm's law (fully robust), with the limited usefulness of many social theories (low robustness) suggests important implications for practice.

In the following section, study #2 will use RDA to develop the concatenated set of propositions and to measure the level of interrelationship between propositions in CT.

Study #2—Investigating Relational Propositions

In this section, I analyze CT using RDA. The process of RDA consists of six steps:

1. Define a body of theory;
2. Investigate the literature to identify sources that define it;
3. Code the sources to identify relevant components;
4. Clump the components into mutually exclusive categories;
5. Define each category as a dimension, and;
6. Investigate those dimensions—looking for a robust relationship.

For the first step, the body of theory chosen for this analysis is defined as those concise versions of CT as found in the study of OT. The second step (investigation of definitional literature) was accomplished by a survey of the ProQuest ™ database and additional sources as described above. The third step (coding propositions) proved more difficult than expected. The sheer variety among the propositions meant that few were found to be identical. Also, the complexity of some (long and convoluted) propositions inhibited the coding process.

To facilitate the process, I bypassed coding and went to the fourth step where related propositions were grouped into mutually exclusive categories. By mutually exclusive, for example, we might see that agents cannot be understood as interactions (and visa versa). Many of the categories developed were of that sort of straightforward variety. Others were more challenging. For example, there seems to be considerable congruence between concepts of adaptation, evolution, emergence, and change. Frederick (1998) links concepts of self-organization, emergence, and complexity.

The goal of RDA is to identify the fewest possible dimensions that may be used to relate the greatest range of understanding that may be attributed to a body of theory. I was able to combine a number of terms without loss of conceptual sense-making capacity by first noting the essential similarity between the concepts of evolution and adaptation as both are said to be maximized at the EOC (Brown *et al.*, 1998; Pascale, 1999). Then too, each may be understood as emergence because both are described as causing and resulting from change to a system in the context of its environment. Therefore, the concepts of evolution and adaptation may be seen as dimensions that have been "renamed" or perhaps "derived," rather than as dimensions that are essential to the model. There also appears to be general congruence between the concepts of complexity and emergence, because both may be explained as causing unpredictability at some level.

In this way, I combined the wide variety of concepts. Through the clumping process, at least one concept did not fit neatly with the others. That is the negative result of a fitness test. The propensity of a firm to exit a market is not well understood in CT, perhaps because of a more appreciative approach to firm creation and survival. We seem limited to the idea that firms may disintegrate in chaos (Dagnino, 2004) or fail through excessive stability (Pascale, 1999). Both are possible, however a greater understanding would be beneficial. Again, in the interest of parsimony, it may be said that the destruction of a firm may be described as a lack of emergence based on the idea that a firm that is created, changed and sustained through emergence will fail if the level of emergence drops below a critical level. Or, from another view, if emergence is maximized at the EOC (Brown *et al.*, 1998), it may be suggested that emergence is minimized at the extremes of stability and chaos. If firms fail at those extremes, we may conclude that extinction is the opposite of Emergence. Or, that a certain level of emergence is required to maintain a firm (nourished by a flow of people, ideas, capital, etc.).

Within the causal propositions of these eight definitions, nine mutually exclusive categories are suggested. These may be seen as mutually exclusive in that (for example) systems might engage in action, but no action seems possible without systems; therefore, the two (as concepts) are mutually exclusive.

Although space restrictions preclude a full investigation, this step of the RDA process may be summarized as identifying the mutually exclusive dimensions of CT as:

1. Predictability;
2. Emergence;
3. Fitness;
4. Systems;
5. Action;
6. Information;
7. Goals;
8. Strategies, and;
9. Time.

The fifth step of RDA is to define each categorical cluster as a dimension. That means the category is understood as a dimensional representation of the relevant data and/or observations. So, for example, in observing a firm, a consultant might characterize that firm as having greater or lesser Fitness. This may create perceptual difficulties in the understanding of systems. If we have a dimensional representation of systems, do we say the dimension is said to represent "more" and "fewer" systems or does the dimension represent a single system that is "larger" and "smaller?" The most general answer may prove, in the long run, to be the most useful. That is to say for the present model, what is really being represented is not so much any existing conceptualization of systems, rather a broader sense of systems. That, as yet undefined, sense of "system-ness" is the unexpected result of combining the perspectives of multiple theorists. For the purpose of the present analysis, we may hold such a dimension to represent some sense of systems that is, as yet, undetermined. The explication must be left to a future study.

In the final step of the RDA process, the interrelationships between all dimensions are investigated to identify the relationships between them—what we have been calling "concenated." In this step, the concepts and propositions within each dimensional category may be "translated" to better match the shared terminology of the dimensions. The intent of this process is not to alter the meaning of the original authors, rather it is to identify how dimensions might be related to one another as they exist within a shared body of theory and so suggest paths toward greater testability and falsifiability.

The statements of the eight authors suggest the interrelationships diagrammed in Figure 1. In this figure, each arrow represents a causal direction and each box represents a scalar dimension. For example, more Information results in more Fitness and more Predictability. This creates a richer, and we hope, more accurate view of the aspects of complexity theory than could have been obtained by any analysis of the atomistic concepts, or the linear propositions of any one author.

This model may (or may not) be an accurate representation of the "real world." However, such is not the goal of the present analysis. This model is only intended to be a representation of CT as it is found in the realm of OT. This clarification of the core of CT may serve as a solid foundation for scholarly conversation around the nature of that theory.

From Figure 1, it may be seen that there are nine aspects within CT. Of these nine, there are five that may be understood as concatenated. That is to say, changes in each of those five aspects may be understood as resulting from changes in two or more other aspects. Therefore, the robustness of this model is 0.56—the result of five (concatenated aspects) divided by nine (total aspects). This measure of robustness may serve as a benchmark for the advancement of CT.

As the atomistic version of CT from the present study #1 has a robustness of zero (because it is a list), and the RDA version of CT has a higher robustness than the atomistic versions of CT, the RDA version may be seen as an improvement and a significant step toward robustness, and the present paper serves as an example of advancing theory towards a robust form. Further, the closely related nature of the included aspects suggests that this model may be a good representative for the core of complexity theory.

Conversation

With Figure 1, two challenges become immediately apparent. First, there are three aspects that appear to be strictly causal (Time, Information, and Goals). As such, these aspects are essentially undefined from the view of the model. Where

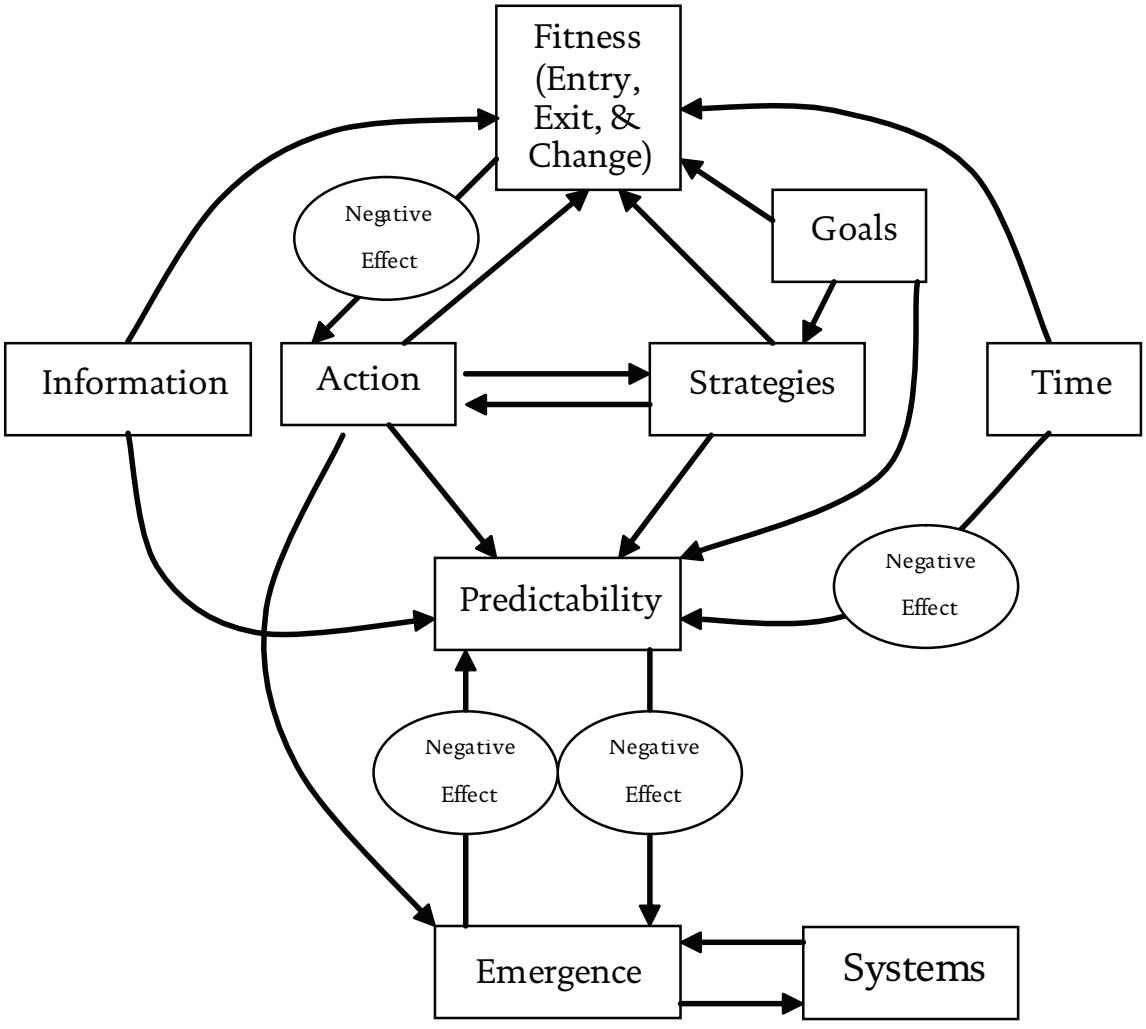

Figure 1 *Causal Relationships Between Aspects of Complexity Theory*

more Strategies may be enabled by increased in Goals and Actions, nothing causes an increase in Goals. They seem to simply exist.

In order to improve the robustness of the CT model, Time, Information, and Goals should be described as concatenated in relation to two or more causal aspects. If those aspects may be legitimately found among the existing aspects of the present model, so much the better. We may retain some level of parsimony.

The second clear challenge to this model is that Systems seems to be both caused by, and be causal to Emergence, and nothing else. This relationship seems to suggest that the concept of Emergence and Systems may be synonymous. If they do indeed represent the same thing, than one aspect may be removed, which will increase the overall robustness of the model. If they are different, that difference must be described in terms of the causal relationships between those aspects and other aspects.

When those two challenges are met, the CT model may achieve full robustness. And, as such, may be more readily falsified, and so more rapidly improved.

Practice

CT is often applied for organizational change efforts as a vague metaphor that is useful for stimulating thought and conversation (Fuller & Moran, 2000). As such, it may be seen that every aspect of the metaphor is indeterminate. The usefulness depends on what aspects the client finds interesting. As a result, the client understands only a portion of the metaphor and does not get a picture of the whole system.

As the concept of non-linear dynamics is an important aspect of CT (e.g., Dent & Holt, 2001; Lichtenstein, 2000b), it may be worth noting that the relationship between the co-causal aspects of this model. For example, the level of Predictability might be completely deterministic if one possesses knowledge of the causal aspects (Information, Action, Strategies, Goals, Time, Emergence). If one of these is unknown, Predictability becomes less determinate. Having a model where a consultant understands which aspects of the model are more determinate and which might be less so, suggests that this kind of model may be developed into a useful tool for practitioners.

Consultants might provide a robust model, and help the client organization to "fill in the blanks." Such a process would provide a roadmap for the client that would suggest different areas for exploration. This way, unknown aspects may be inferred from known aspects. As every client has limited resources, it behooves the consultant to help the client apply those resources in the most effective way possible. If the client wants to gain a CT perspective of its situation using the present model, we might imagine that the client has more knowledge of some aspects than others.

Let us say that the client wants to gain a CT based understanding of their Fitness in an uncertain market. Let us also say, that they are well aware of their Actions, Strategies, and Goals. According to the present model, they might, instead of investigating Fitness directly, choose in investigate Information. This is because Information might be more easily investigated than Fitness, and because by knowing those five aspects, Fitness may be inferred.

Wholeness of Analyses

A theory of low robustness seems to suggest the opportunity for authors to choose which concepts they use as from a menu. This may be thought of as cognitive prejudice, attentional bias, or simply a case of the author not explicating the reasons for choosing those particular concepts. In contrast, a robust model suggests the need to include all aspects of the model in each investigation because each aspect is clearly connected to the other. In other words, a robust theory may be effective in removing the blind spots from analysis. Essentially, when using a theory as a whole model, researchers would be impelled to include descriptions of each part of the model.

The dimensional relationships presented in this model suggest new requirements for the study of CT. For example, if organizational Fitness may be seen as caused by five other dimensions (Goals, Information, Action, Strategy, and Time), a study of Fitness should be reducible to those five dimensions and no others. If it is determined that this is not the case, the

theory will be successfully falsified and should be modified appropriately.

Although this form of study would be necessarily more difficult, it is certainly within the realm of expertise of most contributing scholars. Importantly, by the efforts of authors, reviewers and editors, such an effort has the potential to rapidly accelerate the advancement of theory for the benefit of scholars, practitioners, and society at large.

Summary and Conclusion

There are two primary contributions of this paper, one theoretical, the other metatheoretical. The metatheoretical contribution of this paper includes arguments that link the structure of theory with the potential efficacy of the theory. The theoretical contribution of this paper is seen in the advancement of CT from a non-robust model towards a level of greater robustness.

Where previously a reader might have believed that authors conversing around the topic of CT are describing the same thing, the present paper has suggested that is not the case.

In the present paper, I've presented two analyses each drawing on the same eight versions of CT. The first study focused on the 47 conceptual components found in those eight versions. This study found more conflict than commonality between authors. Further, this study found that approaching the whole body of CT from various perspectives resulted in more versions of the theory, but did not seem useful in identifying the core of CT.

In the second study, the focus shifted to the relationship between concepts based on the idea that more complex relationships suggest a higher level of structure—and therefore the opportunity for greater efficacy in theory. The second study used RDA to shift linear propositions of CT into concatenated propositions with higher internal integrity. In this study, I found that the robustness of CT is 0.56 on a scale of zero to one.

In a sense, it may be said that the core must be found from "within" the theory, rather than from any particular point of view from "outside" the theory. The belt, then, may be understood to consist of the 47 concepts that are relatively linear or atomistic, and so less concatenated than those at the core. It is suggested in the second study that the core of CT consists of those concepts that are concatenated. The present study suggests that the core of CT include five aspects (Action, Fitness, Strategies, Predictability, and Emergence), and, importantly, the specific causal relationships between them.

It may be seen by this analysis that a dimensional representation is a more useful tool for analysts than atomistic representations because an atomistic report might say simply whether a firm is fit or not, while a dimensional report could relate a level of fitness, or reflect how one firm were may be more fit than another. Thus, in a sense, a dimension may be said to "contain" (or support the communication of) more information than its atomistic counterpart. Thus, it may be said, that the process of "dimensionalizing" the information supports further investigation in to CT because it allows and encourages theorists to quantify their observations and insights.

In this same way, the dimensional perspective supports observations and analysis for practitioners. For example, a consultant facilitating a conversation among executives might encourage an organizational analysis from a CT perspective by asking atomistically, "Do you see emergence occurring in this firm?" The answer, according to the definitions explored here, should be yes (otherwise, the firm would not exist). In comparison, a more generative conversation would be result if the facilitator were to ask dimensionally, "How *much* emergence do you see in this firm now compared to last year (or compared to our competitors or our clients)?" The atomistic question might lead to a check mark on the flipchart paper, while the dimensional question will more likely lead to conversation, comparative analysis, and action.

While the present study suggests lines of investigation for advancing CT toward robustness, there are also limitations. Most notably, the sample size of eight concise versions of theory might not be considered statistically significant. The validity and usefulness of this

line of research may be improved by repeating the study with a larger sample.

Second, it is assumed by the present author that this method of analysis is repeatable—that if performed by others, it would lead to substantially similar results. That assumption should be tested.

Finally, in this paper, I deepen the conversation on structure of theory to suggest that there may be a correlation between the robustness of a theory, and the efficacy of that theory in application. However, using robustness to measure of the potential of a theory for testability and applicability is itself untested. Further investigation will need to occur to test the a priori assertions developed in this paper—perhaps through innovative modeling techniques.

Within academia, it has been generally understood that theory is advancing due to some natural evolution of ideas emerging from the back-and-forth between scholars. Applying a measure of robustness to these theories suggests an objective method for testing that assumption.

Conversations on the structure and construction of theory seem likely to continue and increase as the general understanding of theory increases. It remains an open question, for example, whether the same level of conflict exists in other branches of CT. Measures of robustness, inspired by insights from CT, will provide useful tools for advancing that conversation.

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Glossary

Aspect
A broad term relating to the part of theory that represents a concept, idea, or other representation of something that is used in a model. May be represented by a scalar, atomistic concept.

Atomistic
Refers to any reductive proposition representation such as "A is valid."

Concatenated
More complex relationships are found in concatenated proposition. In this, I use the sense expressed by Van de Ven (2007) where two aspects of a theory are shown to influence the third aspect. For an abstract example, a concatenated proposition might state that changes in aspect A and aspect B will cause changes in aspect C.

Dimension or scalar dimension
An aspect of theory that represents quantitative or qualitative variations. For example, a dimension of "size" might be used to represent whether a system is smaller or larger.

Linear
Refers to propositions that describe causal relationship between two concepts. Such as, "Changes in A cause changes in B."

Proposition
"A proposition is a declarative sentence expressing a relationship among some terms." (Van de Ven, 2007: 117).

Reflexive Dimensional Analysis (RDA)
Six step process for analyzing a body of theory and shifting the component propositions of that theory from linear to concatenated.

Static Robustness
Ratio describing the interrelatedness between aspects of a theory on a scale of zero to one. Robustness is calculated by dividing the number of concatenated aspects by the total number of aspects in a theory.

Theory
An ordered set of assertions. Weick (198: 517. Drawing on Southerland).

Steve Wallis is a Fellow of the Institute for Social Innovation, which helps individuals and organizations address societal problems via research, leadership, and organizational development. As an organization development consultant he has a decade of experience in Northern California across a wide range of industries. He earned his Ph.D. in 2006 from Fielding Graduate University. As the founder and director of the Foundation for the Advancement of Social Theory (FAST), a non-profit venture under the auspices of ISI and Fielding, Steve is dedicated to supporting scholars and practitioners as they identify and pursue objective methods for advancing theory across the spectrum of the social sciences. His papers and chapters serve to advance the metatheoretical conversation and identify innovative paths for advancing social theory. He is the editor of "*Cybernetics and Systems Theory in Management: Tools, Views and Advancements*" (in press) and guest editor for a special issue on Emerging Perspectives on Metatheory and Theory, with the "*Integral Review*" (forthcoming).