

**Complex Social Systems:  
Rising Complexity in Business Environments**  
*an exploratory discussion*

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## Abstract

Attempts to simulate the effects of environmental complexity changes in business yielded the realization that much exploratory work needs to be done to (a) demonstrate that complexity has increased universally, and (b) to elucidate what contributory factors are at work in this environment. Accordingly, the team decided to undertake exploratory work to see if universal factors that increase complexity could be identified. The method involved brainstorming ideas, formulating a hypothesis, and conducting a literature review and analysis. We conclude that the effects of globalization and the widespread adoption of technology are indeed universal factors that profoundly increase complexity. This may be considered a partial list, and much more work in this area remains to be done.

## Introduction

In class we learned that the successful business needs to have a structure that matches the complexity of the environment. We also learned that there has been a corresponding shift from hierarchical structures to network structures to cope with increased environmental complexity. A successful example was presented in class involving the US Navy departing from a large scale hierarchical structure to smaller independent nodes to adapt to the complexity of a hidden, distributed foe.

Our purpose here is to extend the class content in an exploratory way to unpack and understand the notion that business organizations have faced rising complexity, where there has been an increasing need to shift from hierarchical structures to networked structures. The question to be addressed is: can universal factors be identified to account for a general increase in business environment complexity?

There are three premises upon which our discussion is presented. **First**, because we seek universal factors, we are not focusing upon a particular business or industry. Rather we seek to identify (relatively) universal factors in the business environment for which complexity can be shown to increase and where concomitant shifts from hierarchical to networked structures can be seen. **Second**, as an exploratory effort, this should be understood as *pre-simulation* work: an attempt to identify parameters and variables which could then be used to build a model. **Third**, consistent with consideration of complex social systems, we use a definition of complexity as the proportion of wrong choices for every correct choice that can be made. This is not an absolute measure, but a relative one: if an increase of an order of magnitude of incorrect possible choices per correct choice can be shown, a rise in complexity is said to occur.

This paper will first provide a historical perspective as a backdrop against which evolutionary change can be compared, and will enumerate some practical ways in which organizations today attempt to measure the complexity of their own structures. We then suggest two main universal factors that have increased the environmental complexity for business: globalization and the adoption of rapidly changing technology.

The conclusion to be reached is that there is strong support for the notion that the business environment has become more complex and that therefore a transition from hierarchy to network is not only desirable but a necessary adaptation for business.

## **Historical Perspectives: Increasing Complexity**

The relevance of historical perspectives to our central question is the notion that our ways of organizing businesses (real life experience-practice) and our ways of understanding organizing principles (management theory) have become increasingly complex in a process that mutually support each other. Thus understanding the evolution of organization theories is a way to understand the increasing complexity in organizational reality. The brief history of organizational theory presented here clearly shows a transition from simple to complex.

Early theory is characterized by Frederick Taylor's scientific determinism in the early part of the 20<sup>th</sup> century. Taylorism was founded upon standardizing tools and methods according to scientifically deduced optimization. Maximum emphasis was placed on homogeneity, and the practice of each workman having his own, individualized tools was replaced by collective standards. By the 1930s, the Human Relations School developed in response to the dehumanizing criticisms of Taylorism. The well-known Hawthorne experiments, where workers' well-being was recognized as important (however flawed the approach turned out to be) characterized this movement. The Carnegie School of management theory characterized the post-war boom of the 1950s; social psychology was introduced as the centerpiece of emphasis on the individual, not just the collective. The 1960s were characterized by the Contingency School, which for the first time marked a shift of attention from structural to process variables, and a careful consideration of contextual influence. In particular, Contingency Theory recognized differing levels of uncertainty in business situations, noting that where uncertainty increased, loosened control, worker participation, and enhanced communication was necessary. The Institutional perspective of the 1970s (which persists today as Walter Powell's neo-institutionalist theory) emphasized the complexity of the individual, pointing to cultural, social dynamics, world views and symbols as key to understanding how work gets done. More recently, Business Process Reengineering (BPR) (Hammer & Champy, 1993) swept like a zeitgeist through the corporate world, advocating wholesale and radical restructuring from hierarchical, traditional systems to a distributed, networked approach.

It should be clear from the preceding timeline that the scale of emphasis has shifted steadily from large to small, from the institution to the individual, and this is the direction of increasing complexity. Whether management theory has led or followed practice is secondary to the notion that they occur together. This can be taken as strong evidence that complexity has steadily increased in the business environment.

## **Measuring Complexity in the Organization**

Increasing recognition of the complex nature of organizations has led to the development and use of new tools to measure and describe them. In order for organizations to evaluate performance potential and self re-design accordingly in a complex environment and with complex internal structures there must be methods with which the level of complexity can be described in a qualitative and/or quantitative way. The task becomes understanding not only how complex an organization is but also being able to describe the complexity of the system in such a way that meaningful business decisions can be made. With this in mind, both qualitative and quantitative evaluation measures are valuable. These tools may be analytical, simulation modeling based and might use either qualitative and quantitative information.

One such approach would be to use a meta-matrix representation of the organization where organization structure is a set of interlinked graphs (Carley & Krackhardt, 2001). This approach considers not only the personnel and the links between them, but personnel, resources, and tasks, as well as the connections between each of the sets of components. Analysis of organizational networks might involve the use of a tool like the UCI NET software package. Some complexity relevant metrics within the package are structural holes, centrality, network density, openness/closedness, and instability. Surprisingly, however, much of the program uses linear statistics and analysis methods in the application of a complex system. Simulation tools might include the use of multi-agent computational organizational studies. These tools remove the requirement of the designer having to understand the complete nature of the interactions and the collective, resultant behavior.

It is possible to look at specific examples of where organizations have used different methodologies in order to deal with increasing complexity within their area of operation. A current example in air traffic control is illustrative of the use of a specific metric (dynamic density) that is used as a measure of the air traffic complexity. The work is a joint project with the William J. Hughes Technical Center (ACT-540), NASA Ames Research Center, Wyndemere, CSSI, CAMI, and CAN. The goal of the project is to accurately determine and predict sector complexity based on various dynamic and static sector complexity characteristics. The approach looks at complexity not simply as the function of number of planes, but also traffic flows, conflicts, sector geometry, weather. A more precise measurement and prediction of dynamic density will help to make decisions about, (1) balance of workload among controllers, (2) adjustment of sector configurations, (3) staffing requirements for sectors, (4) restriction of free flight operations, (5) holding restrictions.

Another example is a system dynamics project undertaken by the Strategic Planning and Modeling (SpaM) consulting team at Hewlett-Packard whose goal was to develop methods for gaining insight into a complex organization (Campbell 2001). Developed both a descriptive model at the qualitative level and a simulation based on quantitative information about the organization. The model allowed for the organization to better deal with complexity that was beyond the understanding of the management team. The work done from a systems dynamics viewpoint allowed for: (1) model served as guide toward specific but not restrictive strategic decision areas, (2) an increased understanding of the dynamics of the organization without the requirement for understanding of the details, (3) allowed for organization of data in a more meaningful manner.

### **Globalization: an external force that drives increased organizational complexity**

Globalization has been defined as the increased mobility of goods, sources of labor, technology and capital throughout the world (Government of Canada). While it could be argued that “globalization” as just defined has been occurring for hundreds of years, few would argue that the phenomena has been greatly accelerated over the past two decades. But what impact does this have on the complexity of business organizations? Globalization opens up a number of new possibilities, both as new ways to perform functions and by introducing completely new functions, i.e., the number of choices increases and the number of decisions increases. So the environmental demands on the organization increase, and if we define the complexity of a task as

the number of wrong possibilities compared to the number of right possibilities, then one could argue that globalization would increase the complexity of operating the organization. For example, a transnational business has the option of opening its new manufacturing plant in a foreign country. While the decision to do so could provide many benefits, such as reduced production costs, it would also require the organization to make many decisions regarding construction, creating new supply chains, addressing potential cultural issues with the workers (to name just a few) all while dealing with multiple governments. Another complicating factor is that these decisions must be addressed at many different levels of the organization. While top management would interface with government and regulatory bodies, decisions regarding employee relations would be dealt with lower levels of the organization.

Corporate globalization not only increases the number of possibilities for an organization, it also sets up greater numbers of interdependencies between various organizations. For example, setting up supply chains that involve many foreign partners means that events in those countries can now directly influence the organization's ability to function. This was clearly illustrated in 1998, when an earthquake in Taipei disrupted the world's supply of computer chips and effectively shut down the production lines for several PC manufacturers in the US.

While the definition of globalization above clearly focuses on the economic issues involved, there is implicitly the notion of cultural and even political influences that attach themselves to the economics involved. One of the major criticisms against globalization is that it will serve to create a more homogeneous, multi-national culture with a requisite loss of variety and local cultures. The fact that it would require corporations to become more complex to effect this change on global culture would appear consistent with our discussions regarding the complexity profile of systems in which higher levels of complexity at one scale can lead to lower levels of complexity at a higher level.

### **Impact of New Technology on Complexity in Organizations**

*“Mistakes and problems in one part of a complex technical system can have disastrous, unanticipated consequences.” --Travis (1990)*

We found evidence that as work environments get more complex, workers prefer decidedly non-technical communication. Weeks and Chapanis (1976), Kraut et al. (1992), Rice (1992), and Strauss and McGrath (1994) were all paraphrased in Hines and Kiesler (1995): “People working on complex, non-routine, 'unanalyzable' problems prefer and benefit from working face to face, or if that is not possible, from talking on relatively 'rich' technology such as telephone.”

***Two key questions:*** *Does modern office technology (voice mail, email, etc.) make the workplace more complicated? If so, does technology contribute to a byproduct of complexity, namely, less-hierarchical organizations?*

Few authors answer *both* key questions. Hinds and Kiesler (1995) paraphrased Powel (1990) and Barley (1994): “Rise of technical work and horizontal organizational structure of technical workers increases collaboration and non-hierarchical communication.” They also summarize Miles and Snow (1986), Walton (1989), Malone and Rockart (1991), Sproull and Kiesler (1991), and Nickerson (1992): “Collaboration and information sharing imply employees communicate whenever and however they need to in order to solve problems and exchange know-how.”

## **Evidence that today's organizations are less hierarchical and more networked.**

*We found many references that suggests key question 2 is true (modern organizations are less hierarchical). We let the reader decide if it is a result of complexity.*

Hinds and Kiesler (1995) give phrases four authors used to describe today's teams between 1986 and 1990--“network organization”, “heterarchical organization”, “post-bureaucratic organization”, “communication crosses organizational boundaries or formal authority and department”.]

Nohria and Eccles (1992), and Hinds and Kiesler (1995) suggest the modern ideal type of organization is greatly different from traditional hierarchies “characterized by relations that are based on neither hierarchical authority nor market transactions.” Many other quotes from the 1960's, 70's, 80's and 90's include:

- High tech industries (as well as others) have poorly defined boundaries, overlapping work roles, ties across teams and members of other organizations. - from Powell (1990).
- Perrow (1967), Wickesberg (1968), Randolph and Finch (1977), Ancona and Caldwell (1992) and Wilson (1992) have argued that when work is not routine, employees communicate both laterally and diagonally outside the chain of command.
- Pelz and Andrews (1966), Adams (1976), Allen (1977), Tushman (1977), and Lave (1988) suggest that technical worker coordination occurs directly through direct communication among different specialists, within and across departments.
- Hinds and Kiesler (1995) paraphrased Nohria and Eccles (1992), “The modern ideal type of organization is 'radically' different from traditional hierarchy 'characterized by relations that are based on neither hierarchical authority nor market transactions...”

Today's organizations are more networked and less hierarchical, an indication of more complicated work environments.

## **Conclusion**

The preceding discussion has established two important points. First, the history of management theory clearly shows a trend toward increasing environmental complexity through the 20<sup>th</sup> century, and current efforts to measure complexity provides additional evidence of this fact. Second, regardless of the homogeneity/heterogeneity of the output of a business, complexity has been driven higher by globalization and the increased use of technology. These are held to be universal environmental impacts, that increase interdependencies and the proportion of incorrect possible choices for each correct choice. Remembering that this paper can only claim to represent early exploratory work, it is possible that more universal factors can be identified. Indeed more work must be done before useful simulations can be undertaken to better explicate the phenomenon of rising complexity in the business environment.

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