

Managing Complex Dynamical Systems

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ABSTRACT

Management commonly engages in a variety of research designed to provide insight into the motivation and relationships of individuals, departments, organizations, etc. This paper demonstrates how the application of concepts associated with the analysis of complex systems applied to such data sets can yield enhanced insights for managerial action.

Keywords: Complexity analysis; dynamical systems; chaos theory; boundary conditions; customer orientation; market orientation

INTRODUCTION

Complex dynamical systems are distinguished by the properties of nonlinear interdependence, the ability to self-organize, and interactivity with the environment. Chaos theory is an umbrella term often used to reference the study of complex systems. (Goerner 1995). Other complex system characteristics include sensitivity to initial conditions, transforming feedback, boundary conditions, coupling effects, butterfly effects, and the existence of attractors which drive system behavior. In fact, Chaos has been described as the geometry of behavior (Goerner 1995). It is precisely these characteristics that make complexity analysis a powerful tool for understanding human behavior in the organizational environment. In a previous study, the authors demonstrated an appropriate research approach to identify and isolate various attractors (values) that drive system behavior within university schools of business (Cox, Webster, and Hammond 2009). This study expands upon that work and suggests specific managerial actions that may be discovered by examining the organization through the lens of complexity analysis. Complexity theory provides a holistic versus a reductionist perspective for examining the functioning of the organization. Every organization is unique in its environment (Eoyang 1997). The DNA of an organization lies not in finance, marketing, management, or other functioning “components”; but in the values hierarchy that drives system behavior. The more scalable organizational values are across the entire organization, the more effectively the organization projects its values and responds appropriately.

THE STUDY

Part one of the study was designed to demonstrate that an attractor (values) landscape can be demonstrated for various hierarchal levels within an organization and for interactive components of the environment. Part two of the study demonstrates an approach to applying complexity theory to the data set, focusing primarily on three complexity theory characteristics: attractors (values), boundary conditions, and coupling. Attractors, in this case market orientation, can be measured and compared between administrative groups, and we can see how well they scale, or converge. If value scaling can be increased across the organization, all groups are working toward the same goal and efficiency is increased.

The research project is a part of a continuing study concerning market orientation in business schools in the U.S.A. The research includes survey input from academic vice-presidents, deans and accounting department chairs of AACSB International member schools. These academic administrators were asked about their market orientation perceptions toward students and employers of students.

RESEARCH QUESTIONS AND HYPOTHESIS FROM THE PREVIOUS STUDY

Although there are numerous customers or stakeholders that could be addressed in the university setting, this study limited our examination to accounting majors and other business students, as well as employers of students.

The objectives of the study were to answer the following research questions:

1. What are the mean levels of customer orientation and market orientation toward students and employers of students of schools of business administration as reported by academic vice-presidents, business school deans, and accounting department chairs of AACSB member schools?
2. How do the reported mean levels of customer orientation and market orientation toward students and employers of students of the academic vice-presidents, deans, and accounting department chairs compare to the levels reported toward customers as reported by business managers from previous research?
3. How do the mean levels of customer orientation and market orientation toward students and employers of students reported by the academic vice-presidents, deans, and accounting department chairs compare to each other?

To answer research question one, the reported customer orientation and market orientation mean scores of the academic vice-presidents, business school deans and accounting department chairs were collected and calculated from the survey responses for the four dimensions of market orientation (customer orientation, competitor orientation, internal coordination, and overall market orientation).

To answer research question two, the mean customer orientation and market orientation scores of the academic vice-presidents, business school deans, and accounting department chairs were compared to the mean market orientation scores of specialty business managers as reported by Narver and Slater (1990). A series of t-tests that compared mean scores of the academic vice-presidents, deans, and accounting department chairs to those of the business managers was conducted to determine if statistical difference existed.

To answer research question three, the mean customer orientation and market orientation scores of the academic vice-presidents, deans, and accounting department chairs were compared to each other using a series of t-tests to identify differences.

METHODOLOGY

A cover letter, survey instrument, and business reply envelope were mailed separately to academic vice-presidents, business school deans and accounting department chairs of schools of business holding membership in AACSB-International. After a follow-up letter, 141 useable responses were received from deans and 102 from both the academic vice-presidents and the accounting department chairs. As key informants, (Campbell 1995; Phillips 1981), the vice-presidents, deans and department chairs were asked to complete the survey and return it in the business reply envelope.

The questions to measure the three subscales (competitor orientation, customer orientation, and organizational coordination) in the Narver and Slater original scale were modified somewhat to conform to the vocabulary and the types of stakeholders prevalent in academic institutions. 30 questions were used in the collection of the data. Each of the questions were to be answered using a seven (7) point scale that was anchored with “not at all” (1) and “to an extreme extent” (7) so that the higher numbers represented a higher (or greater) perceived level of market orientation. The scales were subjected to reliability analysis, exploratory factor analysis and confirmatory factor analysis prior to use (Wheaton, Muthen, Alwin, & Summers 1997; Bentler & Bonett 1980; Marsh & Hocevar 1985; Bentler 1990; Browne & Mels 1992; and Browne & Cudeck 1993). Results of these analyses indicated satisfactory reliabilities (ranges from .73 to .91), satisfactory item-to-total correlations (ranges from 0.3 to 0.8), exploratory factor loadings ranging from 0.33 to 0.89, and confirmatory factor loading ranging from 0.36 to 0.82. Additionally, the confirmatory factor analysis demonstrated generally acceptable fit. These test results included comparative fit index measures ranging from .784 to 1.000, a Tucker-Lewis index ranging from .702 to 1.000, and

the CMIN/DF ranging from 2.05 to 2.56. The RMSEA low values at the 90% confidence interval fell below 0.10 for all scales.

Although the literature indicates (Berdie 1989) that the presence of nonresponse bias in mail surveys does not necessarily alter the survey findings, we nonetheless proceeded to test for nonresponse bias. We used Larson and Catton's (1959) proxy methodology wherein potential nonresponse bias between early and late respondents is examined. These tests indicated no statistically significant difference between the early and late responders.

Then, following the methodology of Narver and Slater, we combined the three subscales to form an overall, or composite, measure of market orientation. We then conducted separate t-tests for each of the four dimensions of market orientation to determine if a statistically significant difference existed between the various market orientation mean scores of the vice-presidents, deans, accounting department chairs, and the business managers.

RESULTS

Table 1 shows when students, as a customer group, are compared to business customers, there are significant statistical differences in levels of customer and market orientation between the business managers and the business school officials (the academic vice-presidents, deans, and accounting department chairs). The business managers reported market orientation mean scores that were higher in absolute terms than all of the school administrators in each of the four dimensions of market orientation. Of the scores, statistically significant differences at the 0.01 level were found between the business managers and the school administrators in 11 of the 12 comparisons. The only statistically insignificant difference between the business managers and the school administrators was in the dimension of interfunctional coordination between the business managers and the academic vice-presidents. Hence, we know that there are indeed differences between business managers and business school administrators in the levels of customer and market orientation.

Table 1: Means and t-test Results for Accounting Department Chairs, Business School Deans and Academic Vice Presidents versus Specialty Business Managers
Customer Group: Students

Market Orientation Measurements (7-point scale)

Market Orientation Construct:	Business Managers n=75	Accounting Chairs n=102	Business Deans n=141	Academic VPs n=102
	<i>M</i>	<i>M</i>	<i>M</i>	<i>M</i>
Customer Orientation	5.05	4.44*	4.55*	4.77*
Competitor Orientation	4.71	3.38*	3.71*	4.17*
Interfunctional Coordination	4.53	3.70*	4.13*	4.44^
Overall Market Orientation	4.77	3.84*	4.13*	4.46*

*significant at .01 compared to Business Managers

^ not statistically significant compared to Business Managers

Table 2: Means and t-test Results for Academic VPs and Business School Deans
Customer Group: Students

Market Orientation Measurements (7-point scale)

Market Orientation Construct:	Academic VPs	Business Deans	t-value	Significance
	<i>M</i>	<i>M</i>		
Customer Orientation	4.77	4.55	1.56	ns
Competitor Orientation	4.17	3.71	.25	<.01
Interfunctional Coordination	4.44	4.13	2.30	<.05
Overall Market Orientation	4.46	4.13	2.33	<.05

Table 2 shows there are differences in levels of market orientation toward students between the academic vice-presidents and the business school deans. The market orientation scores for each of the four dimensions of measurement are higher for the vice-presidents than for the deans. In three of the four dimensions, the differences in mean scores are statistically significant.

Table 3 reports the market orientation scores toward students of the academic vice-presidents and business school accounting department chairs. Additionally, the table shows t-test results for differences in the mean scores between the two groups of administrators. In these comparisons, vice-presidents were found to have higher and statistically different market orientation scores in all four components of market orientation.

Table 4 reports the market orientation scores toward students of the business school deans and the accounting department chairs. The table shows that the mean scores are higher for deans than accounting department chairs in each of the four market orientation dimensions. In three of the four dimensions, the scores of the deans were higher by a statistically significant amount.

Table 3: Means and t-test Results for Academic VPs and Accounting Departments Chairs
Customer Group: Students

Market Orientation Measurements (7-point scale)				
Market Orientation Construct:	Academic VPs	Accounting Chairs	t-value	Significance
	<i>M</i>	<i>M</i>		
Customer Orientation	4.77	4.44	2.32	<.05
Competitor Orientation	4.17	3.38	5.45	<.01
Interfunctional Coordination	4.44	3.70	5.10	<.01
Overall Market Orientation	4.46	3.84	4.28	<.01

Table 4: Means and t-test Results for Business School Deans and Accounting Departments Chairs
Customer Group: Students

Market Orientation Measurements (7-point scale)				
Market Orientation Construct:	Business Deans	Accounting Chairs	t-value	Significance
	<i>M</i>	<i>M</i>		
Customer Orientation	4.55	4.44	.82	ns
Competitor Orientation	3.71	3.38	2.46	<.01
Interfunctional Coordination	4.13	3.70	3.20	<.01
Overall Market Orientation	4.13	3.84	2.16	<.05

Table 5 shows when employers of students, as customers, are compared to actual business customers, there are significant statistical differences in levels of customer and market orientation between the business managers and the business school officials (the academic vice-presidents, deans, and accounting department chairs). The business managers reported market orientation mean scores that were higher in absolute terms than all of the school administrators in each of the four dimensions of market orientation. Of the scores, statistically significant differences at the 0.01 level were found between the business managers and the school administrators in all 12 comparisons. Hence, we know that there are indeed differences between business managers and business school administrators in the levels of customer and market orientation.

Table 6 shows there are significant statistical differences in levels of market orientation toward employers of students between the academic vice-presidents and the business school deans. The market orientation scores in all four dimensions of measurement are statistically higher for the academic vice-presidents than for the business school deans.

**Table 5: Means and t-test Results for Accounting Department Chairs, Business School Deans and Academic Vice Presidents versus Specialty Business Managers
Customer Group: Employers of Students
Market Orientation Measurements (7-point scale)**

Market Orientation Construct:	Business Managers n=75	Accounting Chairs n=102	Business Deans n=141	Academic VPs n=102
	<i>M</i>	<i>M</i>	<i>M</i>	<i>M</i>
Customer Orientation	5.05	3.94*	4.06*	4.51*
Competitor Orientation	4.71	3.36*	3.69*	4.11*
Interfunctional Coordination	4.53	3.91*	3.91*	4.22*
Overall Market Orientation	4.77	3.89*	3.89*	4.28*

*significant at .01 compared to Business Managers

**Table 6: Means and t-test Results for Academic VPs and Business School Deans
Customer Group: Employers of Students
Market Orientation Measurements (7-point scale)**

Market Orientation Construct:	Academic VPs	Business Deans	t-value	Significance
	<i>M</i>	<i>M</i>		
Customer Orientation	4.51	4.06	3.22	<.01
Competitor Orientation	4.11	3.69	3.00	<.01
Interfunctional Coordination	4.22	3.91	2.22	<.05
Overall Market Orientation	4.28	3.89	2.79	<.05

Table 7 reports the market orientation scores toward employers of students of academic vice-presidents and accounting department chairs. Additionally, the table shows tests for differences in the mean scores of the vice-presidents and the accounting department chairs. In these comparisons, academic vice-presidents were found to have higher market orientation scores in all of the four components of market orientation. The differences in mean scores were statistically significant for each of the four components of marketing orientation.

**Table 7: Means and t-test Results for Academic VPs and Accounting Departments Chairs
Customer Group: Employers of Students
Market Orientation Measurements (7-point scale)**

Market Orientation Construct:	Academic VPs	Accounting Chairs	t-value	Significance
	<i>M</i>	<i>M</i>		
Customer Orientation	4.51	3.94	3.49	<.01
Competitor Orientation	4.11	3.36	4.59	<.01
Interfunctional Coordination	4.22	3.57	3.98	<.01
Overall Market Orientation	4.28	3.62	4.04	<.01

Table 8 reports the market orientation scores toward employers of students of the business school deans and the accounting department chairs. In each of the four components of market orientation, the deans reported higher mean scores than did the accounting department chairs. Statistically significant differences were found in three of the four dimensions.

Table 8: Means and t-test Results for Business School Deans and Accounting Departments Chairs
Customer Group: Employers of Students
Market Orientation Measurements (7-point scale)

Market Orientation Construct:	Business Deans	Accounting Chairs	t-value	Significance
	<i>M</i>	<i>M</i>		
Customer Orientation	4.06	3.94	.82	ns
Competitor Orientation	3.69	3.36	2.25	<.05
Interfunctional Coordination	3.91	3.57	2.31	<.05
Overall Market Orientation	3.89	3.62	1.84	<.10

A synopsis of the tables show that business managers report higher levels of market orientation toward customers than the educational leaders report toward students and employers of students. This may be an indication that higher education administrators either do not view students and employers as customers or that the implementation of the marketing concept has not been embraced within business school administrations, or both. It is particularly interesting to note that the higher up the administrator is within the higher education hierarchy, the higher the levels of reported market orientation toward students and employers. This certainly indicates that the implementation or the perceived level of importance of the marketing concept differs across the various levels of higher education administration. For a strategy to be successful, the marketing theory suggests that a strategy must be implemented at all levels of the organization. This seems to be lacking in the case of business school administration.

CONCLUSIONS

These findings demonstrate that businesses perceive a greater importance and have made greater progress in the implementation of the marketing concept vis-à-vis university schools of business as perceived by their academic vice-presidents, deans and accounting department chairs. If, as previous research has found, organizations can improve their effectiveness by increasing levels of market orientation, university schools of business would seem to have ample opportunity to improve.

As the academic vice-presidents, deans and the accounting department chairs reported lower levels of market orientation in their organization than did their business counterparts, a significant opportunity would seem to exist for schools that will put more effort into their market orientation. As students of the university may be viewed as the most visible of the numerous markets served, market orientation efforts focused at students would seem to have the potential for the fastest and highest payoff.

Examples of such payoffs might include:

1. An increase in enrollment within the business school
2. An increase in the hit rate (increase in percent of applicants that actually enroll)
3. An increase in the number of business/accounting majors
4. An increase in the retention rate of current business/accounting students
5. An increase in future giving by alumni
6. An improvement in rankings by outside organizations

Payoffs expected, if more efforts were put into market orientation toward employers of students, may include:

1. An increase in the number of employers hiring business/marketing graduates
2. An increase in total business/marketing students placed in jobs upon graduation
3. An increase in the number of internship programs available to business/marketing students
4. Enhancement of the academic programs via input from employers
5. An increase in the number of endowed chairs/professorships funded by employers

In view of Narver and Slater (1990) and Kohli and Jaworski's (1993) findings that enhanced levels of market orientation will improve the competitive advantage of organizations, business schools appear to be organizations ripe to take advantage of the market orientation concept. Focus on creating market orientation culture should serve both schools and their various stakeholders in more effectively achieving the school mission.

Our conclusions are tempered by the findings of Noble, Sinha, & Kumar (2002) and Haugland, Myrtveit, & Nygaard (2007) that there appears to be no single strategic orientation that leads to superior performance in every case and, as previously stated, building a market orientation culture within an organization is not a quick fix, but rather a continuous process.

SUGGESTIONS FOR IMPROVING ORGANIZATIONAL PERFORMANCE

While focusing primarily upon marketing values, this study serves as a robust demonstration of a useful methodology for the construction of any organizational internal values landscape that can be matched to its environment. Concrete suggestions have been advanced to show how the organization can benefit from better scaling the values (market orientation) that drive organizational behavior across the organization, students, and employers.

Scaling of values is an example of the self-organizing characteristic of a complex system. System self-organizing frequently takes place at the boundaries. One method of improving values scalability across internal and external organizational boundaries is to pay attention to the coupling mechanisms. The coupling mechanisms affect the relations among the units and the permeability of information flow across the boundaries. Boundaries are generally either permeable or impermeable. Impermeable boundaries are often designed to permit negative feedback loops but block positive transforming feedback loops. Transforming feedback is the mechanism that induces self-organization. Tightly coupled boundaries usually exhibit frequent formal exchanges of information in defined format and content. Points of coupling tend to be restricted and well defined. This type of feedback is designed to permit negative feedback for purposes of maintaining system behavior. Tightly coupled systems are generally impermeable to positive transforming feedback. Value differences across system boundaries will generally be maintained and may be magnified as system components compete for attention and resources.

Loose couples that are permeable to positive transforming feedback may allow for gradual transformation or scaling of system values. Information flow across loose coupled boundaries is more informal and face-to-face in nature. The potential payoffs enumerated above can best be facilitated by the creation of opportunities for frequent and open informal communication to take place among the various groups. Increased informal opportunities to socialize among the various groups will lead to a gradual transformation of values that are more consistent across groupings.

The development of a scaled values culture within a complex dynamical system can be the result of system self-organization brought about through a process of socialization across hierarchical boundaries. System self-organization can be furthered through attention to the permeability of boundaries with the objective of allowing transforming feedback to flow across system and environmental boundaries. In the presence of transforming feedback, self-organization can take place resulting in the scaling of values across the system. By specifically focusing upon the creation of loose coupled open, permeable boundaries within and without the organization, management can facilitate the transforming feedback that promotes system wide scaling of values.

Further research into the possible application of complex systems analysis concepts to data sets generated using commonly understood statistical research methodologies would appear to be a fruitful area of investigation and lead to a better understanding of how organizations manage to survive in a dynamic environment.

AUTHOR INFORMATION

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APPENDIX

15 of 30 Survey Questions Sent to Accounting Department Chairs, Business School Deans, and Academic Vice-Presidents of AACSB Schools of Business Administration

1. Our objectives are driven by satisfaction of our students.
2. We measure satisfaction of our students systematically and frequently.
3. Those responsible for recruiting students regularly share information within our business school/institution concerning competitor's strategies.
4. Our market strategies (such as recruiting and retention) are driven by our understanding of the possibilities for creating value for our students.
5. We respond rapidly to competitive actions that threaten us.
6. We constantly monitor our level of commitment and orientation to students.
7. University administration regularly discusses competitors' strengths and strategies.
8. All levels of administration understand how the entire institution can contribute to creating value for students.
9. We give close attention to service of students after enrollment.
10. Our strategy for competitive advantage is based on our understanding of our students needs.
11. We encourage other staff and faculty outside of recruiting/administration to meet with our prospective students.
12. All of our departments are responsive to and integrated in serving students.
13. Information on recruiting successes and failures are communicated across functions in the business school/institution.
14. We share information and coordinate resource use with other units in the institution.
15. We target potential students where we have, or can develop a competitive advantage.

Each question answered on a 7 point scale: 1=Not At All, 7=to An Extreme Extent. Questions 1, 2, 4, 6, 9, and 10 relate to the Customer Orientation construct/dimension, Questions 3, 5, 7, 11, and 15 relate to the Competitor Orientation, Questions 8, 12, 13, and 14 relate to Organizational Coordination. The Overall Marketing Orientation score is computed by averaging the mean scores of the other three sets of questions.

The other 15 Survey Questions noted in the paper were as above except the word "students" was replaced by the phrase, "employers of students".