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The Survey on the Effective Dimensions of Chaos Theory on Agricultural Extension Sector Using Structural Equation Modeling

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ABSTRACT: The aim of the survey is to study the effective dimensions of chaos theory on agricultural extension sector. This study is the first attempt using chaos theory to improve agricultural extension. The target population was agricultural specialists in Fars province of Iran. 100 agricultural specialists were selected. A questionnaire was developed used fixed - choice questions. Validity of the instrument was established using an expert panel. A pilot study was conducted to determine the reliability of the questionnaire for the study. A Cronbach's alpha, Average variance extracted and Composite Reliability was calculated. The statistical analysis used the structural equation modeling, with SPSS ver.16 and smart PLS softwares. Using advisability and flexible programming in decision making, stakeholders' tendency, considering long term missions and self-control are the most important factors in chaos theory in relation to agricultural extension. Factors of self-organizing, strange attractors and butterfly effect explained about 30 percent of variance in chaos theory. The findings of this study will help to produce effective programs.

Key words: Strange attractors, Butterfly effect, Self-organizing, Chaos theory

INTRODUCTION

The concept of deterministic chaos has been greatly influencing not only science but also engineering, technology, and even arts along with substantial progress in our understanding of deterministic chaos since 1970's (Aihara, 2012). The most general definition of chaos referred to as'on-scheme and unpredictable situation' is defined as 'irregularity pattern' in science. Perhaps, the most satisfactory definition of chaos concept is that: "Chaos is irregular and unpredictable behavior of complex linear dynamic systems" (Demir, 2013).

Chaos theory offers a number of insights about changes that appear non-predictable and non-linear (Wong, 2013) that has grown into a collection of analytical tools can be applied across all sciences. It is a set of non-linear mathematical tools. Chaotic systems appear in many fields of science and engineering such as mechanical engineering, biology, chemistry, physics and laser science and economics (Salarieh and Alasty, 2009). Aspects of chaos theory have been drawn from the world of mathematics and brought into the social sciences, predominantly in the study of economics and financial markets (Musselwhite and Herath, 2001, Musselwhite and Herath, 2004) and it has been used to examine a range of general educational issues and specific themes in the professional development of teachers and curriculum and instruction (Wong, 2013).

A chaotic system is the system highly sensitive to initial conditions. A very small change in initial conditions may cause system to create very large fluctuations in long term. The dynamics seems to be random in chaotic system may be the outcome of a deterministic system (Wei and Leuthold, 1998).

Although chaos shows unstable behavior between variables, it is not stochastic. Randomness may, however, hide a particular pattern. Although chaotic behavior is unpredictable, it depends on the initial conditions of the model. The hidden pattern is called the strange attractor. An attractor shapes the dynamic behavior of a non-linear model into a certain order. Attractors guide behavior but do not determine it completely (Staveren, 1999). The concept of self-organization as the other key characteristic of living and open dynamical systems becomes a central determining factor in chaos non-equilibrium theory.

Fascinated by the notion, as if it were a really new discovery, some social scientists (see, for example, Wheatley, 1999) explain several features of self-organization, such as self-reference, open-interaction and interdependence between organizations and environments, stability over time, and the importance of freedom for self-organizations to develop in nature (Farazmand, 2003).

Demir *et al* (2013) in the study with the aim to examine the existence of chaotic structure in agricultural production in Turkey by using Chaotic Dynamic Analysis (CDA) and to provide accurate forecast of agricultural production shows that the supply of the selected agricultural products (wheat, barley and rice) has chaotic structure. The dynamic system constructed predicted the supply of year 2010 with % 0.5 error for wheat, %5 errors for barley, and %2.5 error ratios for rice.

Astuti *et al* (2011) show that chaos could occur anytime in agriculture sector and that some occurrences will be predictable and some will not, so it needs early warning system that could detect early chaotic conditions and take action for crisis recovery. Chavasand and Holt (1993) in his study examining the deterministic chaotic structure of pork production found evidence the existence of chaotic structure by using GP correlation. Similarly, Chiarella (1988) found chaotic behavior in the parameters of Cobweb model that used to determine the price dynamics in fully competitive markets. Cromwell and Labys (1993) examined the movements of monthly cocoa, coffee, rice, sugar, tea and wheat prices between the years of 1960-1992 and found nonlinear dependence in the cocoa, tea and sugar prices. Moreover with the help of the Lyapunov exponent, they show that wheat price has a chaotic structure. Burton (1993) showed the existence of chaos in the model of agricultural products with the help of the logistic map.

Perhaps the first study investigating the chaotic structure of variables in agriculture, crop production or ecological system is May's (1976) discrete logistic model showing the chaotic structure of the ecological system. However, the one-dimensional discrete models derived from ecological data to determine the chaotic behavior wasn't very successful (Sakai, 2001). Sakai (2001) determined low dimensional deterministic chaotic structure in a corn production series. Similarly, Tilman and Wedin (1993) identified the chaotic surge in grass production. Sakai *et al* (2008) examined the chaotic dynamics in the ecological time series with a very few data and found that the system has a chaotic structure. In the same study, they found that tangerine production exhibit chaotic behavior.

Agricultural extension, or agricultural advisory services, comprises the entire set of organizations that support people engaged in agricultural production and facilitate their efforts to solve problems; link to markets and other players in the agricultural value chain; and obtain information, skills, and technologies to improve their livelihoods (Davis, 2008). Kidd *et al* (2002) in their general assessment of extension notes that agricultural extension is widely regarded as playing an important role in improving agricultural systems worldwide and its provision has been seen for many years as a principle responsibility of the state. The general feeling is now that for offering services to farmers and adequately addressing their needs, these administrations are too inflexible and unresponsive, with the high cost brining insufficient benefit.

Qamar (2003) names the general impression about public extension system such as large number of staff, consuming substantial government budget yet neither too efficient nor too effective, top-down organization and operations, farmers complain because extension agents do not visit them often enough, and low adoption of improved technologies owing to poor extension services.

On the other hand governments are facing new extension challenges: meeting the need to provide food for all, raising rural incomes and reducing poverty, and sustainably managing natural resources. These critical challenges exist in a rapidly changing world. Globalization, new technologies, the new relationships developing between the public and private sectors, the multi-disciplinary nature of agriculture, heterogeneity between and within countries, the geographic dispersion of rural people - all these realities are putting new pressure on the developing countries in their efforts to develop (Rivera, 2001).

Of course most public extension systems are still top-down in structure, inadequately funded (especially for field-level programs) and have done little or nothing to keep and upgrade their extension staff (Swanson, 2008).

Agricultural extension is in crisis throughout the world (Wejnert, 2002) and this subsection of agriculture in Iran has not been effective, too.

While there is quite enough study modeling the chaotic structure in price or returns of goods or asset in agriculture, and chaotic structure in crop production series there are quite few studies investigating the chaos in agricultural extension, so it's an opportunity to study about the effective dimensions of chaos theory on agricultural extension sector using structural equation modeling.

MATERIALS AND METHODS

The research design for this study employed descriptive and analytical methods. The target population was agricultural specialists in Fars province of Iran. 100 agricultural specialists were selected. A questionnaire was developed from a review of literature, and interviews with agricultural specialists in Fars province.

The questionnaire used fixed - choice questions. Face and content validity of the instrument were established using an expert panel, consisting of faculty from the department of agricultural extension and education at Islamic Azad University. A pilot study was conducted with 30 agricultural specialists in a township (not included in the sample population), to determine the reliability of the questionnaire for the study. A Cronbach's alpha, Average variance extracted and Composite Reliability was calculated. The statistical analysis used the structural equation modeling, with SPSS ver.16 and smart PLS software.

RESULTS

The results of the study showed the most respondents were in the age category 30-40 and 79.4 percent of the respondents were men and 20.6 percent were women. 73.7 percent of the respondents have Bachelor of Science and 26.3 percent were Master of Science. Respondents were asked to determine their opinion about chaos theory and its dimensions. Respondents were asked to determine their opinion about chaos theory. The highest priority refers to Using advisability and flexible programming in decision making and the lowest was Availability of participation culture in society (Table 1).

Respondents were asked to determine their opinion about butterfly effects. The highest priority refers to stakeholders' tendency and the lowest was stakeholders' motivation (Table 2).

Respondents were asked to determine their opinion about strange attractors. Table 3 shows the results. Respondents were asked to determine their opinion about self-organization. The highest priority refers to self-control and the lowest was Reciprocal relationship between organization and environment (Table 2).

Table 1: Respondents' views of their opinion about chaos theory (1= very little; 5=very much).

Statements	**Mean**	**Standard deviation**	**C.V**	**Priority**
Using advisability and flexible programming in decision making	4.28	0.82	0.19	1
Using collective wisdom in designing extension programs	4.38	0.91	0.2	2
Making welfare in agricultural society	4.38	0.93	0.21	3
To brisk up agricultural capitals	4.37	0.92	0.21	3
Improvement agricultural productivity	4.36	0.96	0.22	4
Making temporary structures and systems	4	0.90	0.22	4
Improvement efficiency of economic activities in agricultural markets	4.34	0.99	0.23	5
Enthusiasm in attitudes of agricultural managers	4.29	0.97	0.23	5
Consider priorities in programs	4.25	1	0.23	5
To disseminate team working	4.28	1.02	0.24	6
To be thoroughly acquainted with agricultural environment	4.15	1.07	0.26	7
Availability of participation culture in society	4.06	1.15	0.28	8

Table 2: Respondents' views of their opinion about butterfly effects (1= very little; 5=very much).

Statement	Mean	Standard deviation	C.V	Priority
Stakeholders tendency	4.58	1.05	0.22	1
Stakeholders participation in program performance	4.29	1.06	0.24	2
Stakeholders background activities	4.11	1.19	0.28	3
Stakeholders Rivalry	4.33	1.25	0.28	3
Availability of facilities	4.33	1.27	0.29	4
Need assessment	4.42	1.32	0.3	5
Appropriate method of program priority	4.19	1.33	0.31	6
Program implementation in order to priorities	4.29	1.37	0.31	6
Considering social-cultural conditions of stakeholders	4.24	1.37	0.32	7
Stress reduction in stakeholders	4.27	1.42	0.33	8
Stakeholders motivation	3.86	1.35	0.34	9

Table 3: Respondents' views of their opinion about strange attractors (1= very little; 5=very much).

Statement	Mean	Standard deviation	C.V	Priority
Considering long term missions	4.28	1.2	0.28	1
Using systemic thought in program codify and implementation	4.24	1.22	0.29	2

Table 4: Respondents' views of their opinion about self-organization (1= very little; 5=very much).

Statement	Mean	Standard deviation	C.V	Priority
Self-control	4.02	0.95	0.23	1
stability over time	3.67	0.98	0.26	2
Self-assessment	3.85	1.03	0.26	2
Open interaction with agricultural sections	4.34	1.18	0.27	3
Reciprocal relationship between organization and environment	4.18	1.16	0.28	4

Smart PLS is one of the prominent software applications for Partial Least Squares Structural Equation Modeling (PLS-SEM). It was developed by Ringle, Wende & Will (2005). The software has gained popularity since its launch in 2005 not only because it is freely available to academics and researchers, but also because it has a friendly user interface and advanced reporting features (Wong, 2013). Partial Least Squares used to study the effects of strange attractors, self-organization and butterfly effects. Validity and reliability were assessed. If the indicators are highly correlated and interchangeable, they are reflective and their reliability and validity should be thoroughly examined. In order to assessed significance of effects used bootstrapping and t-value.

The results of Partial Least Squares include in composite reliability, Average Variance Extracted and factors loading were assessed (chart 1). In order to the results, the values show the acceptable parameters of convergent validity. It means factor loadings, Average variance extracted and composite reliability upper than 0.5, 0.5 and 0.7, respectively (table 5).

Discriminant validity assessed using correlation matrix. Table 6 shows the acceptance of the correlations because of the lower unit than square of average variance extracted (Table 6).

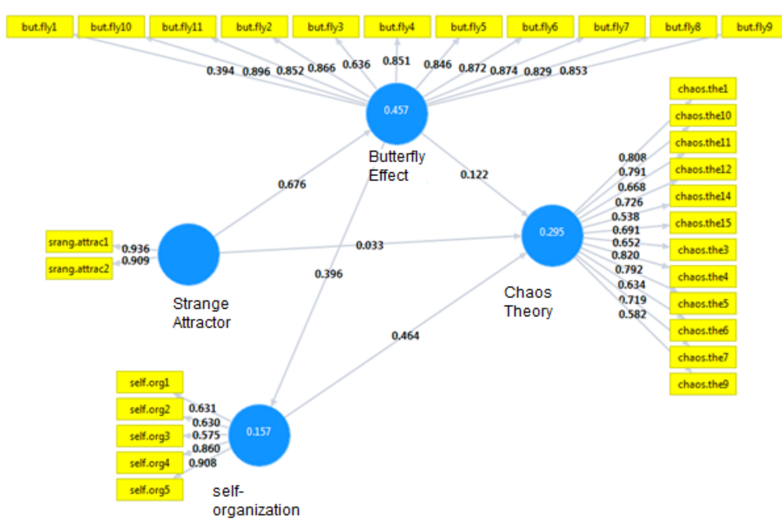

Chart 1: Factors loading and coefficient paths in reflective model of chaos theory.

Table 5: The validity of chaos theory parameters.

Variable	CR	AVE	Factor loadings
Butterfly effects	0.960	0.710	0.902
			0.861
			0.860
			0.643
			0.849
			0.848
			0.881
			0.871
			0.826
			0.856
Strange attractors	0.919	0.851	0.936
			0.908
Self-organization	0.848	0.536	0.622
			0.619
			0.578
			0.836
			0.911
Chaos Theory	0.922	0.500	0.790
			0.672
			0.729
			0.694
			0.649
			0.818
			0.806
			0.709
			0.543
			0.630
			0.718
			0.583
			0.718
			0.802
			0.577
			0.782

Table 6: Discriminant validity of chaos theory sections.

Variable	Butterfly effects	Strange attractors	Self-organization	Chaos theory
Butterfly effects	**0.842**			
Strange attractors	0.661	**0.922**		
Self-organization	0.386	0.462	**0.732**	
Chaos theory	0.342	0.329	0.530	**0.707**

Table 7: Path coefficient and t-value for chaos theory.

Hypothesis	Significant level	T-value	Standard Error
Self-organization-Butterfly effect	0.005	2.804	0.138
Chaos Theory-Butterfly effect	0.555	0.591	0.263
Butterfly effect-Strange attractors	0.000	5.596	0.118
Chaos Theory- Strange attractors	0.965	0.044	0.269
Chaos Theory- Self-organization	0.053	1.937	0.240

Chart 1 shows the path coefficient and squared R to identify the effects. The three mentioned factors explained about 30 percent of variance in chaos theory (Table 7).

CONCLUSION

Chaos theory suggests that it is possible to influence change but not to completely control it. The predictive variables in the forecasting model once identified and deemed to be statistically significant could be incorporated in an outcomes based planning framework that informs short term decision making. This paper argues that chaos theory provides a useful theoretical framework for understanding the dynamic evolution of agricultural extension. By conceptualizing agricultural extension as chaotic systems, a number of implications can be developed. If a system (agricultural extension) exhibits chaos, decision making should consider the system characterization parameters from a chaos theory perspective such as using advisability and flexible programming in decision making, stakeholders' tendency, considering long term missions and self-control are the most important factors in chaos theory in relation to agricultural extension. Factors of self-organizing, strange attractors and butterfly effect explained about 30 percent of variance in chaos theory. This study, by proposing a new model of the agricultural extension, will help to produce effective programs to improve conditions in this section. Nevertheless, due to the exploratory nature of this study, it is needed to go deeper into the analysis of the model used in programming agricultural extension.

REFERENCES

Aihara, K. (2012). Chaos and its applications. IUTAM Symposium on 50 Years of Chaos: *Applied and Theoretical, Procedia IUTAM* **5**,199 - 203.

Astuti, P., Eriyatno., Arkeman, Y. & Nasution, M. (2011). Early warnings system in agroindustry: A chaos theory based analysis. *International journal of engineering and technology IJET-IJENS*, Vol. **11**. No: 05. Pp: 99-104.

Burton, M. (1993). Some illustrations of chaos in commodity models, *Journal of Agricultural Economics*, **44**(1), 38-50.

Chavas, J. P. and Holt, M. T. (1993) Market instability and nonlinear dynamics, *American Journal of Agricultural Economics,* **75**, 113-120.

Chiarella, C. (1988). The cobweb model, its instability and the onset of chaos, *Economic Modelling,* **5**(4), 376-384.

Cromwell, J.B. and Labys, W.C. (1993). Testing for Nonlinear Dynamics and Chaos in Agricultural Commodity Prices, Institute for Labor Study, West Virginia University.

Davis, K. (2008). Extension in sub-Saharan Africa: Overview and assessment of past and current models, and future prospects. *Journal of International Agricultural and Extension Education* **15**(3): 15-28.

Demir, B., Alptekin, N., Kilicaslan, Y., Ergen, M. &Uslu, N.C. (2013). Forecasting agricultural production: a chaotic dynamic approach.

Farazmand, A. (2003). Chaos and transformation theories: A theoretical analysis with implications for organization theory and public management. *Public organization review*: *A global journal* **3**, pp: 339-372.

Kidd, A., Lamers, J., Ficarelli, P. & Hoffmann, V. (2002): 'Privatizing Agricultural Extension: Caveat Empto', *Journal of Rural Studies*, vol.**16**, pp.95-102.

May, R. (1976) Simple mathematical models with very complicated dynamics, *Nature,* **261**, 459-467.

Musselwhite, G and Herath, G. (2004). A chaos theory interpretation of community perceptions of Australian forest policy. *Forest Policy and Economics* **6**, pp: 595-604.

Musselwhite, G and Herath, G. (2001). An analysis and prediction of Australian stock market behaviour using chaos theory, Proceedings of the 2001 Hawaii conference on Business, (eds): T. Gregson and D. Yang. College of Business Administration. University of Hawaii, pp. M289-M300.

Qamar, M.K. (2003). Agricultural extension in Asia and the pacific: time to revisit and reform. APO Seminar on Enhancement of Extension Systems in Agriculture held in Pakistan, 15-20 December 2003.

Rivera, W.M. (2001). Agricultural and Rural Extension Worldwide: Options for Institutional Reform in the Developing Countries. Food and agriculture organization of the United Nations.

Sakai, K. (2001) Nonlinear Dynamics and Chaos in Agricultural Systems, Elsevier, the Netherlands.

Sakai, K., Noguchi, Y. and Asada, S. (2008) Detecting chaos in a citrus orchard: reconstruction of nonlinear dynamics from very short ecological time series, *Chaos, Solutions and Fractals,* **38**, 1274-1282.

Salarieh, H and A, Alasty. (2009). Control of stochastic chaos using sliding mode method. Journal of Computational and Applied Mathematics. N, 225. Pp: 135-145.

Staveren, I.V. (1999). Chaos theory and institutional economics: metaphor or model? *Journal of Economic Issues* **33**, 141- 167.

Tilman, D. and Vedin, D. (1993) Oscillation and in the dynamics of a perennial grass, Nature, **353**, 653-655.

Wei, A, and Leuthold, R. M. (1998). Long agricultural futures prices: ARCH, Long Memory Chaos Processes? OFOR Paper Number 98-03.

Wejnert, B. (2002): 'Integrating Models of Diffusion of Innovations', *Annual Review of Sociology*, vol.**28**, pp.297-326.

Wong, M. (2013). Developing integrated arts curriculum in Hong Kong: chaos theory at work?, The Ontario institute for studies in education of the University of Toronto curriculum inquiry, **43**(2): 210-232.