The Effect of Change on Management Planning: Applying Chaos Theory

Dean Frear, Ph.D.
The Jay S. Sidhu School of Business and Leadership
Wilkes University
84 West South Street, Wilkes Barre, PA 18766, USA.
E-mail: dean.frear@wilkes.edu, Phone: 570-408-4715

Abstract

Chaos theory has been applied qualitatively to the planning process. This paper develops a set of equations that help further define planning and chaos theory. A model is developed that illustrates the planning process and changes in the planning process. For the purposes of this model, planning is viewed as a procedure that occurs prior to implementation of the plan and is therefore discrete and not continuous.

Keywords: Planning, Decision-making, Chaos theory, planning process

Introduction

Chaos theory is usually related to scientific studies. Originating with the work of Einstein, Bohr, Poincare and others and was brought to light by Lorenz in 1961 when running a computer program trying to help predict the weather (Gleick, 1987; Thietart & Forgues, 1995). Lorenz had a computer set up, with a set of twelve equations to model the weather. It did not predict the weather itself. However this computer program did theoretically predict what the weather might be (Rae, 2004). In mathematics and physics, chaos theory describes the behavior of certain nonlinear dynamical systems that under specific conditions exhibit dynamics that are sensitive to initial conditions (popularly referred to as the butterfly effect). The butterfly effect is a phrase that encapsulates the more technical notion of sensitive dependence on initial conditions in chaos theory. Small variations of the initial condition of a nonlinear dynamical system may produce large variations in the long-term behavior of the system (Gleick, 1987).

Linear systems are very predictable and measurable. This is because they are either unchanging or the system is not affected by change. Business systems such as management planning have a need to be responsive. A responsive system means that the plans must be by their very nature changeable. This type of changeability is called “sensitivity dependence”. Sensitivity dependence occurs when “tiny differences in input could quickly become overwhelming differences in output…the Butterfly Effect” (Gleick, 1987: 8). The Butterfly Effect is classically defined as “the notion that a butterfly stirring the air in Peking can transform storm systems next month in New York” (Gleick, 1987: 8). Levy, (1994) and Thietart & Forgues, state that it is only possible to predict the effect of changes in the short term and that a small change “can lead to an entirely different evolution” (1995: 23).

The purpose of this paper is to develop mathematical models that illustrate the processes associated with planning. Further, a model is developed that illustrates changes in planning. Cartwright (1991) stated that although the scientific theories surrounding chaos theory are very important for the outcomes of planning, there has been little attention been paid to the two. Planning is the procedure managers use to “identify objectives and to structure major tasks of the organization to accomplish them” (Gomez-Mejia, Balkin, & Cardy, 2008: 184). Managers try to create stability in the planning process using long range planning (Tetenbaum, 1998: 70). The problem that exists with long range planning is, according to Lorenz in 1960, the further we get from today, the more inaccurate the prediction (Gleick, 1987). Much like a prediction, the planning process hopes to be able to predict the steps necessary to complete the project.

> Uncertainty is an inevitable aspect of most projects…unforeseen uncertainty can't be identified during project planning… projects subject to unforeseen uncertainty start out with reasonably stable assumptions and goals, projects subject to chaos do not. Even the basic structure of the project plan is uncertain… Often the project ends up with final results that are completely different from the project's original intent (De Meyer, Loch, & Pich, 2002: 62).

Chaos theory provides “planners insight on where, when, and how predictability and controls are possible.” They ask whether the unpredictability found in “non-linear feedback” can be transformed into the kind of behavior essential to certainty (Djavanshir & Khorramshahgol, 2006: 18). Changes in the organizational environment can create change when planning. Systems that can create change include economic, technological, sociocultural, demographic, and political. Other sources of instability include experimentation, innovation and individual initiative (Thietart & Forgues, 1995). Managers must be able to transform the feedback from these sources into useable information to aid in planning.

The review of the literature indicated that almost all of the research dealing with chaos and management is qualitative and that all of the research regarding chaos and planning is qualitative. This paper fills the gap between research in qualitative and quantitative decision-making. The quantitative research reviewed attempts to explain the decision-making process using stochastic modeling and does not try to develop a model to illustrate planning or the affect of chaos in planning. Prior model development dealt with trying to forecast outcomes using probability and verify predictability using statistics.

This paper develops a mathematical model that illustrates the processes associated with discrete planning. The development of the model assumes that there are stages in planning prior to implementation. The model builds on the idea that plans are developed in some sequence. As learning occurs, plans change. Decision makers are adaptable and will change plans when needed. The first model illustrates a sequential decision process. Then, building on the first model, the second model illustrates changes in planning. In the model, the planning process is expressed as a linear model. When changes in information occur, changes in the formula occur. This model adds to the literature by presenting a conceptual framework of how chaos affects the planning process.

Mathematical Model

Assuming that planning happens in stages then each part of the planning process may be represented as a separate item i.e., p_1, p_2, p_3, ... and so forth. Each of the factors could then be assigned an amount of planning time p_1t or a value as to the importance of the factor p_1v in the plan. Of course, this process style is cumbersome. Therefore, the formula needs to be simplified in such a way as to first generalize the planning process. Generalizing the planning process allows for application of the formula by multiple and diverse users irrespective of the type of planning. After generalizing the process, substitutions are made which further reveal extensions of the model.

In this model, planning occurs prior to implementation of the plan and is therefore discrete and not continuous. Planning is not continuous because it is assumed to be completed prior to implementation. Once the plan is underway, other breaks in continuity occur due to intermittent feedback. Intermittent feedback or conditional information causes the manager to make changes and corrections at various times throughout the process. Planning is identified symbolically with the letter P. Next, there is an adjustment for individual process periods. The planning process is represented by the following general model:

$$P_t = f\left(\sum_{i=1}^{n} w_i \, P_i\right) \tag{1}$$

where: P_t is the planning process, w_i is a weight for each individual process, and P_i is each individual part of the planning process.

This simple formula then represents the entire planning phase that happens prior to any implementation of the plan. The problem faced by most organizations is that the management plans may need to be altered in response to certain environmental changes. These changes can be influenced by competition, alterations in service or manufacturing processes and procedures, complications created by suppliers and so forth. While not endless, the list of possible reasons for change is too numerous to mention in this paper. Given that most plans change at some point for some reason, we need to explain this variability.

Next, the idea of sensitive dependence is used to help explain this variability. For theoretical purposes, a plan is sensitive dependent when the outcome changes if a planning variable in the planning process changes. It is assumed that most outcomes do change and adapt based on changes in planning variables. Each planning decision is based on a certain set of conditions that pre-exist in the company. It is with this knowledge that the manager makes plans for the completion of the company projects. The decision criteria, (d) are contingent on current factors known about the business environment and specific to the firm. Each part of the planning process is based on many small and some large decisions that help to design the overall plan. If one of the decisions were changed, then this could start a chain reaction that would affect the entire process from the change point. Accordingly, when one change occurs, this may cause a series of unforeseen changes to occur (De Meyer, Loch, & Pich, 2002).

The individual planning process is a function of different decisions required for this process,

$$P_i = f\; E(d_i | I_i) \tag{2}$$

Where, $E(d_i|I_i)$ are the expected decisions conditional on information (I_i) available.

Then,

$$P_t = f\,[\sum_{i=1}^{n} w_i\, E(P_i \mid I_i)] \quad (3)$$

And

$$P_t = f\,\{\sum_{i=1}^{n} w_i\, E\,[\,f\, E(d_i \mid I_i)]\} \quad (4)$$

Changes in information cause the expected outcome to change. The manager expected A, but, B was the outcome. This is the beginning of chaos in the total plan; the butterfly effect is in play. Small changes create the need to make other changes and these changes may require other changes.
This is illustrated using the following assumptions:

$$P_t = f(\sum_{i=1}^{n} w_i\, P_i) \quad (1)$$

Next, managers receive new information that is a surprise. This news is different from previously expected when the plans were made. Therefore, information (I) has to change in our equation and become I' which contains the new information. If I and I' are the same, then no change in the planning process would occur.

Where, $E(d_i|I_i)$ are the expected decisions conditional on information available and information has changed, then changes in information cause changes in the individual decision.

$$E(d_i|I_i) \rightarrow E(d_i|I_i') \quad (5)$$

So,

$$P_i' = f\; E(d_i \mid I_i') \quad (6)$$

Then,

$$P_t' = f\,[\sum_{i=1}^{n} w_i\, E(P_i' \mid I_i')] \quad (7)$$

And substituting then,

$$P_t' = f\,\{\sum_{i=1}^{n} w_i\, E\,[\,f\, E(d_i' \mid I_i')]\} \quad (8)$$

Conclusion

This paper developed a mathematical model to illustrate planning as a discrete process i.e. $P_t = f(\sum_{i=1}^{n} w_i\, P_i)$.

The early stages of the planning process may be shown as a linear process. Plans have a direction based on predictable outcomes. Managers plan using available knowledge and resources. Company vision helps to direct the goals of management. The first set of formulas attempted to explain the planning process. They illustrated the planning process in mathematical terms. Chaos theory applied to planning is about unplanned change brought about by unstable environmental factors. New information brings about nonlinear dynamical change.

Unplanned change is created when previously unknown information is discovered. When this happens, the new information replaces the old information and is used to revise the old plan into a new plan. The new plan also alters the ability to predict adequately the new outcome in the long-term. If the outcome is predictable, it may be very different from the originally desired outcome. The new plan is explained by a sequence of changes in the formula. This change concept is illustrated by the second set of formulas numbered 5-8.

The formulas create a new paradigm for the discussion of planning. They illustrate mathematically the changes in the decision-making process post-implementation. The author encourages other researchers to develop practical applications using both the theory as well as the formulas. This might be accomplished using higher-level mathematical substitutions. There was no attempt at substitution in this paper as a secondary purpose of this paper was to lay the groundwork for such future work.

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