# How to Determine the Existence of Chaos in Retail IT Projects?

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***ABSTRACT* – Exploration of the applicability of Complexity science theories to IT software development projects in the Retail industry requires a combination of quantitative and qualitative methods. Determining the existence of chaos, the edge of chaos, or of unorder, commences with the application of an iterative grounded theory analysis, categorising a sample data set against one of many frameworks that purport to aid in identifying the existence of complexity in projects. Proving the existence of chaos in this environment will validate the necessity of developing a new project management framework, one that is more aligned to complex organisational realities than the traditional quantitative project management approaches currently in use.**

***Keywords*— Retail IT, Project Management, Chaos Theory, Edge of Chaos, Grounded Theory**

## INTRODUCTION

The existence of chaos and complexity within IT software development project management in the Australian Retail industry is frequently presented as a justification for schedule and cost overruns, poor quality deliverables, and multiple variations to the project baseline. This paper presents a proposal for analysing historical and in-flight projects in the study organisation for the existence of chaos; for the 'edge of chaos'; and for the degree of order. This study will build on previous research that indicated chaos, complexity and constraints are inherent in the organisation's IT project domain, resulting in outcomes across scope, schedule and cost that differ to initial plans [1]. A model is proposed wherein the application of mathematical determinants of chaos and complexity are validated against independent outcomes from grounded theory analysis of the available big data. The model will aid in the determination of whether chaos is in existence and applicable to this organisation and the Australian Retail environment.

## LITERATURE REVIEW

### *A. Chaos Theory*

The field of Chaos, and Chaos Theory as a discipline, has emerged in the latter half of the twentieth century due in large part to increases in computational capabilities able to process large volumes of raw data [2]. Definitions of chaos generally align on a disordered and sustained evolution over time [2], "…'uncertainty' and 'instability' as opposed to stable conditions" [3]; or "…bounded instability, in between stable equilibrium and explosive instability" [4]. The concept 'edge of chaos' has been introduced and preferred by authors who may hesitate the apply the label of pure chaos, acknowledging the existence of a transitional and potentially organisationally disruptive state where both order and disorder co-exist [4-7].

Chaos theory is a mathematical field of study that applies analysis, mathematical criteria, and principles that underpin chaos [2]. Singh and Singh [4] refer to Chaos Theory as "…the science of chaos". Whether a purely scientific or mathematical field of study, or inextricably linked; chaos, the edge of chaos, and chaos theory have experienced a surge of interest as significant work is undertaken to attempt to apply the theoretical concepts to organisational realities.

Evidencing the existence of chaos requires adherence to the underlying principles and assumptions of the theory. Chaos requires satisfying "…certain special mathematical criteria…" which occurs in a "…deterministic nonlinear system" [2], while Singh and Singh [4] include the third dimension of criteria; that of 'dynamical systems. Defining the concepts of 'nonlinearity', 'deterministic', and 'dynamical' are imperative for a study of the applicability of chaos and chaos theory as they are the key determinants of whether chaos exists or not [1]. Nonlinearity is seen when the output of the system is not "…directly proportional to the input, or that a change in one variable doesn't produce a proportional change in the related variable(s)" [2]. By way of graphing a systems nonlinear quotation as attractors, Singh and Singh determined that a chaotic system may be seen to "…settle down into patterns over time," [4]. The existence of nonlinearity measured in behaviour over time, responses to small changes, and local pulses in the system can be viewed as evidence of chaos in a system if dynamics and determinism is additionally present. When a system is deterministic, it demonstrates the properties of completely and accurately specified initial conditions that can be measured by way of mathematical equations [2]. The third underlying principle that must exist for chaos to be present is that of Dynamics, which refers to anything that moves or changes over a period [2]. Putting chaos into perspective; nonlinearity, dynamism and deterministic properties must be present in a system to prove the existence of chaos.

A theme of assuming the existence of chaos in corporate contexts is emerging as a management problem to be solved by operating at the edge of chaos, as discussed, at the junction of order and disorder. At issue is the actual existence or not of chaos in the business world and, as applicable to the IT software development project management domain. Determining a lack of order as chaos is a narrow and potentially misleading statement which may only diminish the problem and serve to redirect research from the real problems of the domain. Studies of chaos applied to corporate systems vary in the extent of mathematical chaos theory applied to justify the application of the chaos definition. Is the current research paradigm inaccurate to label it as chaos or the edge of chaos when emergent order or 'un-order' would be a more accurate term? The notion of 'un-order' is introduced by Kurtz and Snowden [8] to demonstrate that the apparent lack of discernible order in a given state is not necessarily due to the existence of chaos or of being on 'the edge of chaos'. Courtney, Merali, Paradice and

Wynn [9] further question the existence of chaos in the IS domain, "Chaos consists of well-specified models whose behaviour gets less predictable over time because of nonlinearities, The two do not seem to be isomorphic" [9].

A literature review of the current applications of chaos theory to IT software development project management will be completed to determine whether variations across scope, schedule, and cost across the duration of the project may be attributed to the effects of chaos. The research that follows will then utilise quantitative measures of chaos to determine its existence in the retail IT project management domain based on a current and large data set. According to Williams and Garnett, there are benefits to applying mathematical chaos theory measurements, "Applying chaos analysis to a set of data (even if those data are not ideal) can reveal many important features that other, more traditional, tools might not disclose" [2]. It will also reveal the "…behaviour of systems under certain imagined or ideal conditions…insights that may or may not be meaningful or practical" [4]. Contrary to what many articles would suggest, it is imagined that one cannot simply apply chaos equations to a dataset and determine the existence or lack thereof, of chaos, as its existence is "…extremely difficult to identify in real-world data" [2]. The author justifies this obstacle to obtaining 'easy' confirmation of the existence of chaos from running mathematical equations against data sets by stating "One of the biggest problems is that, when applied to ordinary data, the present methods often give plausible but misleading results, suggesting chaos when in fact there isn't any" [2]. This will be accounted for further in the contexts of grounded theory.

*Grounded Theory*

A parallel stream of research will focus on the application of qualitative methods based on an underlying interpretive epistemological philosophy [6] [8] [10-12] [13]; in which the researcher is deeply embedded within the social and organisational construct of the IT project management business unit, able to understand the pre-structured words and data existing in the organisational project environment in question [10]. The double hermeneutic principle [10] recognises the researcher as a subject, making subjective interpretations in the same manner as those being studied or interviewed, focusing on contextualized meaning-making for situation definition and understanding. Charmaz's interpretation of grounded theory – Constructivist Grounded Theory – firmly embeds the researcher as a participant in the construction of knowledge, generating both data and theory [13].

Randomised, multi-stage cluster sampling of projects in various stages of the project life cycle will be undertaken, underpinned by the qualitative research method of the grounded theory which will assist in associating outcomes from the data with explanations of the organisational phenomena [10]. Utilising retrospective quantitative datasets within a Grounded Theory qualitative proposal is a deviation from the usual approach of purposive sampling however acceptable in a research proposal to provide a contextualized framework for the data and qualitative analysis to commence.

The Grounded Theory concept allows a theory to emerge from successive conceptual analyses of empirical data [12], requiring iterative data mining and analysis of IT project artefacts, determining successes and failures based on original baselined scope, schedule and cost against the number of variations and project closure scope, schedule and cost. This methodology "…[enables] a theory that describes the phenomena to arise or emerge from the data…", therein allowing the researcher to build a theory based on "…results and findings grounded in the empirical world" and is "…an effective methodology for pragmatic research-based on rationalism (a reason-based approach to rationalism)" [13].

The application of grounded theory to this research is expected to allow the research question to be refined as analytical approaches are either proven or disproven. Figure 1 depicts a framework of integrating grounded theory for determining the existence of chaos in IT projects. It reveals that the application of grounded theory will be followed by using a five-step process:

1. Define the research problem
2. Define the research question
3. Iterative sampling and review process
    a. Initial Coding
    b. Theoretical Sampling
    c. Data Collection
    d. Detailed data analysis (through the application of machine learning and data mining algorithms)
    e. Coding
    f. Constant comparison
4. Selective Coding
5. Theory Development

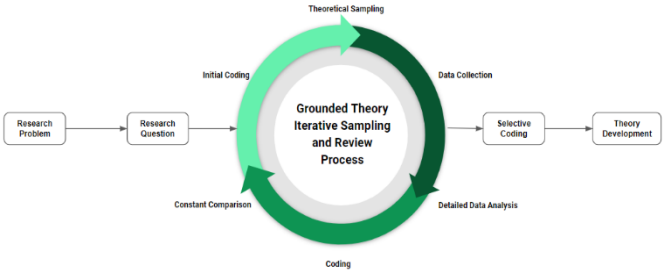


Fig. 3 A framework of how Grounded Theory is to be used

The full research study will assess projects closed within the previous five years, and in-progress IT projects, reviewing the past projects to determine whether commonly associated theories or frameworks make sense when applied to the project. Assessment of failures will be undertaken with the potential application of the model as a preventative on in progress and future initiatives. The projects and key decisions within each will be mapped onto the Cynefin framework [8]. A parallel assessment of a subset of IT project managers will be undertaken via stakeholder questionnaires and in-flight project satisfaction surveys, with positive correlation expected between leadership ranking according to the Cynefin framework and projects reported with successful outcomes expected.

Decision making within the projects will be assessed via an analysis of the 'Decisions Made' and 'Assumptions' artefacts, relying on interpretive generalisations derived from researcher experience within the organisation, allowing acceptable reconstruction of facts based on a shared understanding of

meanings and intentions in the organisation [10]. The plausibility of the logical reasoning employed in this research will be validated with the original authors of the documents and artefacts if such persons remain within the organisation. A series of interactive workshops will be held to facilitate the classification of projects across the Cynefin domains [8], eliciting shared group understanding of project outcomes and further contextualizing the research within the organisational construct.

Grounded theory is the most suitable methodology to address this proposed research area, where the study of the data will iteratively evolve and inform the research question, particularly given the proposed intersection of multiple analytical approaches. According to Burnham's study [13], the grounded theory provides a suitable method of inquiry when "…researching several bodies of knowledge to produce a theory for a new class of system solutions". Complexity Theory, Theory of Constraints, and Chaos Theory will be applied in this research against historical data to evaluate the strengths and weaknesses of each in relation to an application for sense and decision-making in IT software development projects in the Retail sector and the potential for improving project outcomes by employing a combination of analytical approaches and frameworks beginning with the initial categorization of both the project and the project manager using the Cynefin framework.

## EMPIRICAL RESULTS AND DISCUSSION

### Sample Data

A private cloud-based project management application solution is utilised within the organisation to manage IT projects. This application is integrated with the organisation's ERP solution to allow a single source of truth of project management information. For the purposes of this research study, the project artefacts stored on the application database will be analysed. Additional information is provided in the form of Google sheets which are used for tracking the status of project submissions for the initiation, variation, and closure. Within the organisation, changes to a project's baseline require submission to weekly or monthly forums for review and decision. A summary of these decisions is captured within this Google sheet and will be matched against, and utilised in conjunction with, the available application data to form a complete picture of the variations in a project across its lifecycle. Sample data for this proposal was limited to projects with variations in FY20, and to Steps 1 to 3d in the grounded theory defined process.

### Results from the procedural analysis

Grounded theory process generally "…begins with low level substantive concepts and works towards high-level theoretical concepts using a series of analytic techniques" [13].

The two distinct variants of grounded theory belong to Glaser and Strauss [15,16] and for the purposes of this research, the variant proposed by Strauss and Corbin [17] is used, with the coding broken down into distinct stages. Stage 1 – Open Coding results are outlined in Table 1.

1. Open Coding - During this phase, the data is analysed, identified, and categorised with the expectation of continual comparison of codes being produced until "The differentiated concepts become categories" [10] This process of categorising assists in the identification of "...properties and causal conditions that influence phenomena..." [13], allowing ongoing iterative analysis to be pursued against the application of subsequent analytical approaches to assess complexity, chaos and constraints.

Fig. 1 A framework of how the grounded theory is to be used.

A risk inherent in grounded theory is that of not having a starting point to guide the initial categorisation for coding. For the purposes of this research, initial categorisation will be in accordance with factors identified by Singh and Singh [4]. These factors comprise those commonly changing variables with the potential to impact a project's outcomes.

The results from Phase 1 of the sample analysis - Open Coding, are categorised and recorded in the following table where initial coding has revealed all FY20 variations can be attributed to one of the defined project complexity factors.

TABLE X
VARIATIONS CATEGORISED ACCORDING TO PROJECT COMPLEXITY FACTORS

| Sources of Complexity - Categorisation | FY20 - Variations |
|---|---|
| Leadership | 1 |
| Procurement | 5 |
| Technology | 5 |
| Customer Orientation | 2 |
| Communication | 3 |
| Education and Training | 1 |
| Quality | 3 |
| Project Controls | 4 |
| Long-Range Planning | 4 |
| Resources | 2 |
| Management Skills | 4 |
| Risk Analysis | 0 |
| Productivity | 0 |
| Culture | 0 |
| Organisational Structure | 0 |

## CONCLUSION AND FUTURE ITERATIONS

An initial conceptual analysis of sample data indicates variations in IT software development projects may be related to categorisations typically associated with the inherent complexity in projects. Thus the applicability of chaos, complexity and constraints theories appears justified in future iterations of analysis.

The next cycle of research will expand the dataset, categorising variations and utilising machine learning and data mining techniques including decision tree (see Rahman [18,19]), on the entire dataset extending from 2014 through 2020, seeking to extract patterns from the data. Once this review of the expanded dataset has been completed, the grounded theory process will continue as follows:

2. Axial (selective) coding - An interpretation of the defined categories will begin to emerge, with research seeking to refine and explain the interactions across and between identified categories [10]. Any of the initial categories has the potential to steer a project off course and align with the Chaos

theory concept of "...the butterfly effect..." [4] wherein small or minor changes in any of the parameters has the potential to significantly impact any of the other parameters.

3. Theoretical coding - At this stage of data analysis, it becomes possible to formulate hypotheses based on the categories and inferences output from the previous two coding phases by "...specifying explicit causal and/or correlational linkages between individual interpretive constructs" [10]. This stage of coding is successively repeated for each of the analytical approaches identified as applicable to complexity and chaos with comparisons across the outcomes to influence additional or subsequent data sampling requirements.

4. Theoretical sampling – Progression of data analysis will require additional data gathering and analysis to assist the emergence of theory. This process assists in the definition of the research problem [10] and continues until the point of saturation, an idea from the grounded theory that data collection naturally ceases "...when gathering fresh data no longer sparks new insights or reveals new properties" [5].

The completion of coding will result in the researcher "...articulating a theory to explain the phenomena" [13]. Such theory will have application across a range of sectors and specialisations, delivering significant material improvements to the management and execution of IT software development projects within the Retail industry specifically, and to the IT sector more broadly.

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