IT Risk and Chaos Theory: Effect on the performance of South African SMEs

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ABSTRACT

The purpose of the research was to investigate the relationship between information technology (IT) operations risk management (ORM) and small to medium enterprises' (SMEs) performance. Following a review of the literature, a questionnaire was developed with the aim of addressing the research purpose. A simple random sampling technique was used to sample 107 respondents in a financial SME. In order to determine the percentage contribution of some of the identified significant predictors of challenges posed by ORM solutions, multiple regression analysis was used. The percentage distribution revealed that only one variable made a significant contribution: "The way in which end-users deal with the implementation of IT projects". The results additionally revealed that the variable contributed approximately 88.4% of the variations in the level of variables that enhance SMEs' performance. The analysis of variance also revealed that the regression coefficients were real and did not occur by chance. The recommendation of the study is that SMEs should improve the way they deal with the implementation of IT projects in order to address ORM.

Keywords: Chaos theory; SMEs; IT risk; change management; operational risk.

1. INTRODUCTION

Various disciplines as well as organisations have tapped into the science of chaos theory to manage risky processes and procedures [1]. McBride [2] explains chaos theory as being ordered disorder and in the mid-2000s, the research of Stapleton, Jonathan and Ross [1] on "Enhancing supply chain solutions with the application of chaos theory" demonstrated that "when applied correctly, chaos theory shows potential to be a tool that can be instrumental in helping explain why unpredictability occurs within nonlinear systems". Ibid's study also found that "a better understanding of this phenomenon may help researchers to develop better, more accurate models to assist managers in making better supply chain management decisions, benefiting organizations and customers by simultaneously enhancing cost-effectiveness and improving customer service levels" [1].

Though not firmly established, previous research has shown a link between chaos theory "variables such as network visibility, predictability, and consistency…" and small to medium enterprises' (SME) performance levels [1]. Like the work of Stapleton, Jonathan and Ross [1], the current paper explores the information technology (IT) risk requirements for building successful systems in SMEs. IT risk in the current study is known to be the likelihood technological risk occurrences in SMEs. Subsequent to the work of Stapleton, Jonathan and Ross [1], the main tenet of the paper is to explore chaos theory as a management tool to enhance effectiveness of IT risk and chaos theory effect on SMEs. This is focused on risk monitoring and reporting in SMEs. As a consequence, it addresses findings related to the factors impacting on IT and operational risk management (ORM) in SMEs.

2. LITERATURE REVIEW: DRIVERS OF IT GOVERNANCE, ELEMENTS DEFINING IT ORM, SME PERFORMANCE

In the current study, the authors adapt the definition of SMEs from Section 1 of the National Small Business Act of 1996 which was amended by the National Small Business Amendment Acts of 2003 and 2004 (NSB Act) as: "…a separate and distinct business entity, including co-operative enterprises and nongovernmental organisations, managed by one owner or more which, including its branches or subsidiaries, if any, is predominantly carried on in any sector or sub sector of the economy mentioned in Column I of the Schedule 14." For this reason, it is noted that SMEs have a maximum number of 100 – 200 employees.

In 2009, it was reported that "Protection of information through appropriate risk analysis methods and risk management strategies has gained huge momentum" [3]. The authors argue that "a survey of IS risk management literature reveals that most risk analysis techniques are grounded in the classical probability theory" [3]. They further add that the scope of the theory is evident from its fundamental assumption that the past is an indication of the future [3]. Thus, the management side of IT governance is concerned with the way in which the stipulations for information security are formulated by executive management and implemented in an enterprise [4]. This makes

the chaos theory appropriate for the prediction of known risks, i.e. risks that have already occurred in the past. Nevertheless, the theory has been wrongly applied even to the prediction of unknown risks particularly in SMEs [3]. Notwithstanding and as applied in chaos systems such as SMEs, there are various elements of successful SMEs (See Table 1) as revealed in literature in relation to SMEs, IT risk and chaos theory [2] [3] [5]. Based on the reviewed literature and as considered in the current focus of the study, the below variables in Table 1 is the main explanation for successful SMEs, yet the question remains: Is the success of an SME explained by looking at all the variables or a combination thereof? [2] [3] [5].

Table 1: Elements defining IT ORM and SME performance [2]

A. There is a high failure rate among enterprise application projects because they require extensive organisational change that is often resisted by members of the organisation.
B. Enterprise applications are difficult to implement successfully because they usually require far-reaching changes to enterprise processes.
C. The success of organisational change can be determined by how well information system end-users deal with the various stages in the implementation of IT projects.
D. The success of organisational change can be determined by how well information systems decision-makers deal with various stages in the implementation of IT projects.

Many studies have identified (see Figure 1) strategic alignment, value delivery, risk management, resource management and performance management as some of the most important drivers of IT governance particularly in large enterprises [2] [3] [5].

Figure 1: Drivers of IT governance [5]

This is because some evidence suggests that the already applicable techniques of risk analysis are not sufficient to predict unknown risks such as in SMEs [5]. It is therefore argued that "a chaos theoretic view is also valuable because risks are inherently chaotic in nature" as in SMEs [3]. It is worth mentioning that McBride [2] adapted chaos theory as a model for exploring information systems and organisational environments. Furthermore, using chaos theory, Sharm and Dhillon [3] explain that "concepts such as initial conditions, strange attractors, edge of chaos and bifurcations can be used to develop a meaningful and coherent story that offers insights into the interactions between IS and organizations".

The building blocks for developing a good IT strategy are founded on the essential requirement that the enterprise has a sound, clear strategic plan. Thus "ultimately, the continued interaction among some events might eventually result in a massive security breach" in the SMEs' plan [3]. This plan should be structured in such a way that the strategies and, more importantly, the objectives of the enterprise are spelt out clearly and concisely. It may be difficult to connect IT strategy to a broad and far-reaching enterprise strategy unless the intent can be rendered as core salient points. This becomes vital as projects and initiatives need to be associative in features such as value delivery, risk management, and resource management [5].

Value Delivery – Delivering value is about executing the value proposition throughout the delivery cycle by concentrating on optimising costs [5]. In support of this, it has been found via a post-hoc analysis that "…documentation of relevant data allows the organization to understand the causal factors related to events" [3]. Ibid suggests that "the analysis also helps reveal preventative measures that would inhibit the reoccurrence of the event. If the same event were to reoccur, the organization would be able to improvise on its experience, increasing the likelihood that the event would be successfully managed" [3].

On the other hand, previous research investigating the barriers that affect the adoption of IT by SMEs has identified a variety of factors. These factors can be grouped into several categories by a number of authors [4] [5]. These have been categorised as: owner/manager characteristics, enterprise characteristics, and costs and return on investment.

The owner/manager plays an important role in decision making in IT. Though research is unclear, but it is documented that "the managerial guidelines proposed to cope with systems risk require managers to determine unacceptable risks and the countermeasures for these risks" [3]. Additionally, it is not clear how "it would be ensured that the managers have determined the complete list of unacceptable risks" [3]. Consequently, the King III Report [4] found that an owner's lack of awareness of technology and its perceived benefits is a major risk to the incorporation of IT in SMEs [4]. Other unconfirmed contributory factors include lack of knowledge on how to use technology as well as a lack of computer literacy. Two other factors that affect the value delivery of SMEs are a mistrust of the IT industry and a lack of time [4]. In addition, SME owners are concerned about the return on their investments, consequently being reluctant to make substantial investments particularly when short-term returns are not guaranteed.

There are further factors related to the value delivery of the enterprise that affect IT ORM. The King III report [4] suggests that the current level of technology usage in enterprises affects the process of IT adoption. In another study conducted by the ITGI [5], it was found that lack of awareness; uncertainty about the benefits of electronic commerce; concerns about the lack of human resources and skills; set-up costs and pricing issues, and concerns about security are the most significant barriers to value delivery for SMEs [4]. An anecdotal report adds that other factors include the insignificant use of IT by customers and suppliers; concerns about legal and liability matters, the high costs of development, high cost of computer and networking technologies for IT; limited knowledge of models and methodologies, and unconvincing benefits to SME [5]. This is due to that fact that SMEs have limited resources (finance, time, personnel), consequently resource poverty has an effect on the operation of IT risk in SMEs.

Risk Management - Risk management requires risk awareness by senior corporate officers and a clear understanding of the enterprise's appetite for risk. It also includes an understanding of compliance requirements, transparency about the significant risks to the enterprise, and the embedding of risk management responsibilities in the enterprise [5]. IT risk is a threat to operations, data, critical systems and enterprise processes [4]. However, it is not clear whether SME management has a responsibility to identify areas of control weakness. It is not also established firmly whether responding in a timely fashion to improve processes does augment controls and even reduce the cycle time [4].

The inherent risks in IT manifest in complex and subtle ways, making IT risk management a difficult concept to communicate and manage effectively [4] [5]. "While the arguments have been adequately justified through risk compensation theory, it is not very clear if in today's era, when information is considered the greatest asset, a company would be satisfied about its state of security by simply comparing its vulnerability status to that of others" [3]. Nevertheless, the current paper argues that by aggregating and reporting on the impact of security risk in IT and understanding how these risks affect the enterprise, professionals can become an integral part of the enterprise decision-making process and help guide the enterprise to a more risk-aware culture.

"Although chaos theory was founded on the mathematics of non-linear systems, it has found applicability in the area of social science" [3]. As used in chaos theory, performance measurements are used to monitor strategy implementation, project completion, resource usage, process performance, and service delivery. "Articles from the information systems [chaos theory] literature summarized the various risk conceptualizations as belonging to three main categories, namely, risk components, risk factors and probability of negative outcomes" [3]. For SMEs to engage in performance management successfully, this must relate to systems efficiency, coping with change, agility and capability, compliance and governance. The system refers to information systems, business applications, or other system paradigms.

Resource Management - Consistent with chaos theory, and like large organisations, by frequently monitoring the features, SMEs development can experience real-time situational awareness of compliance and IT risk processes [5]. As with SMEs, "chaotic systems have two important characteristics: 1) they are highly sensitive to changes in the initial conditions; and
2) they involve nonlinear feedback forces that can produce unexpected results" [1]. This suggests that unpredictability or uncertainty is always prevalent in certain systems though initial measurements are normally specified, thus such systems need constant monitoring, particularly when small in size. Thus, long gaps between measurements can potentially undermine both the validity of the numbers and the credibility of the security department. This is why it is important to automate wherever possible so as to ensure that SMEs obtain regular, good quality data without overburdening staff or using limited resources inefficiently.

Xu, Zhang and Barkhi [6] argue that there is a correlation between team perceptions of both IT infrastructure as well as capabilities and project success. In a chaos system, the authors noted that this correlation "subsequently affects team commitment that is crucial to IT project success" [6], and "propose[d] a direct-effect model that directly links all constructs to IT project success so that [one] can test the efficacy of the proposed model" [6]. This frequent measuring of IT risk models allows the enterprise to identify trends, thus highlighting under- or over performing areas of the enterprise. The enterprise can then target areas that are underperforming and remediate well in advance of an audit to show that management has insight into those areas and is exercising due care [5] [7]. This provides a platform from which to grow the SME's influence and involvement in guiding IT risk decisions and improving its overall risk position. By assigning a value to the tracking metrics, enterprises can build confidence for IT risk decisions in any dynamic system.

3. THEORETICAL FRAMEWORK: Chaos Theory and Dynamic Systems

Complex adaptive systems seem to be an ontological statement with already critical work available pointing to the danger of applying natural science concepts on social dynamics [2]. The essence of using complex adaptive, chaos/ dynamic theory (interchangeably used in this study) is articulated in the preceding paragraphs. This approach is consistent with Thiétart and Forgues [8] work on chaos theory in information systems. In simple terms, chaos is order without predictability. That is, there are systems (dynamic systems), physical and social, that are well understood (in the sense that they can be fully described by means of a finite set of conditions or rules) and yet are fundamentally unpredictable.

Although there are various management theories such as contingency theory, the current paper uses and builds on the notion of managing SMEs in turbulent environments using chaos theory. Consistent with the work of [6], the theoretical underpinning of this study "empirically validated the positive effect of IT infrastructure capabilities on IT project success, hence bridging an important gap in the literature". This is because like in chaos systems, SMEs are facing new and unexpected risks. This requires that one modifies business and strategic focuses in 'chaotic' conditions. One important contribution of using chaos theory as asserted by authors is the "consideration of both actual and perceived effects of IT infrastructure capabilities" [6]. When in a chaotic state just like SMEs, the impact of a change in a variable can be predicted only for the very short term because the behaviour of dynamic systems is inherently unstable and their properties make long- term forecasting impossible. This is particularly true because in a chaos system as in SMEs, the principal order of events may constrain the erratic behaviour and serve moderating variables of the system such as SMEs. Thus, in a chaos system, it is important to "consider how organizations can leverage IT infrastructure capabilities to improve IT project success rate, in addition to traditional project management and development methodology management approaches" [6].

4. RESEARCH METHODOLOGY

The purpose of the current paper to investigate the relationship between IT risk and SME performance, the main approach to the research was quantitative method. Thus, based on the research objectives and the data collected, the research used a positivist perspective. The research adopted a survey using a questionnaire administered to a financial company located in

the Eastern Cape, South Africa. All units within the study form part of the unit of analysis (e.g. managers, implementers and directors). A questionnaire was developed from the literature with the aim of covering the research purpose. The different categories of the questionnaire included demographics of the participant and questions related to the perceived use and effect of IT risk management in the SME. These effects were categorized according to Table 1, after which chaos theory was used as the theoretical foundation of the study. Due to the data analysis technique used, a sample of 107 respondents from the SME was selected according to a simple random sampling plan. In terms of sample size calculation, Tabachnick and Fidell [9] recommend a formula for calculating such requirements, taking into account the number of independent variables that a researcher wishes to use: "N≥ 50 + 8m (m= number of independent variables)." The questionnaires were sent to a minimum of n =90 respondents[1]of the SME according to a simple random sampling plan.

Data Analysis and Interpretation - The returned questionnaires were analysed using the Statistical Package for the Social Sciences (SPSS). Accordingly, multiple regression analysis was used to predict SMEs' performance. In line with the principles of multivariate data analysis, the researchers conducted a zero-order correlation of the independent and dependent variables.

Assumptions of Multiple Regression - In multiple regression it is assumed that the residuals (predicted minus observed values) are distributed normally (i.e. follow the normal distribution) [10]. Again, even though most tests (specifically the F-test) are quite robust concerning the violations of this assumption, before drawing final conclusions it is always a good idea to review the distributions of the major variables of interest. In this case, the Kolmogorov-Smirnov (K-S) test was done in order to inspect the distribution of the residual values [10] (Tests of Normality). During the analysis, IT operational risk was decomposed into a number of sub-risks using enterprise lines and risk categories defined by SME as depicted in Table 1.

Table 2: Tests of Normality

Tests of normality

Position	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Stats	Df	Sig.	Stats	df	Sig.
Middle Mgt	.392	13	.000	.628	13	.000
Senior Mgt	.397	38	.000	.678	38	.000
Operations	.313	56	.000	.771	56	.000

a. Lilliefors significance correction

The K-S test is denoted by D and Middle Mgt, D (13) = 0.39, p=0.000; Senior Mgt D (38) = .40, p=0.000 and Operations D (56) = 0.313, p=0.000, which were all found to be significantly normal. This is nevertheless regarded by [10] as being common in a large sample size. A bivariate analysis between the respondents' demographic characteristics and the relationship between (1) IT operational risk management and (2) performances of SME was performed. In order to understand the degree of association between SME performance and the independent variables, multiple regression, repeated-measures analysis of variance (RM-ANOVA) and repeated-measures multivariate analysis of variance (RM-MANOVA) were performed [11]. Where a significant value was observed, either betas of multiple regression or significant levels of RM- ANOVA or RM-MANOVA were used to ascertain these differences [10]. The correlation provided directional support for the predicted relationship and showed that collinearity among the independent variables was sufficiently low (> or = .6) so as not to affect the stability of regression analysis [10].

[1] n > 50 + 8m (m = 5 number of independent variables) = 90: Note that it was anticipated that more cases would be used to cater for any possible skewness for the dependent variable such that the distribution of data satisfies the assumptions of multiple regression related to sample size.

5. RESULTS OF THE STUDY

The aim of this study was to investigate the relationship between IT ORM and SME performance. This was based on the 4 criteria displayed in Table 1, each of which a hypothesis was tested for. The majority of respondents (86.9%, n= 93) agreed that information systems design should be managed as a planned enterprise change, while 13.1% (n= 14) disagreed. Similar to the current study, Nafukho, Graham and Muyia [7] found that leadership and culture had the highest correlations (r = .78, p< 0.001) in SMEs. The authors add that there was a strong correlation between recognition and communication (r = .73, p< 0.001). Multiple regression analysis was used to determine the percentage contribution of the criteria in Table 1. The distribution revealed that only one variable made a significant percentage contribution. This is C (as seen in Table 1) (β =0 .447, p< 0.01). It may thus be inferred that C [the way in which end-users deal with the implementation of IT projects"] (as seen in Table 1) is the variable prominent in explaining the variation in level of IT risk and SME performance. The results suggest that the variable contributed approximately 88.4% of the variation. The analysis of variance also revealed that the regression coefficients were real and did not occur by chance. It may therefore be inferred that, relatively, C [the way in which end-users deal with the implementation of IT projects] actively impacts on SMEs performance in terms of IT risk. A similar study revealed that "evaluation (M = 3.46, SD =0.625) reflected the highest mean score. This was followed by team (M =3.35, SD =0.730) and communication (M =3.22, SD =0.654) dimensions. The rewards and recognition (M =2.98, SD =0.67) dimension reflected the weakest mean scores [7].

6: DISCUSSION OF RESEARCH FINDINGS

The results of the study suggest that SMEs are sensitive to ICT changes – thus C [the way in which end-users deal with the implementation of IT projects]. This is particularly true with IT operational risk [8]. Literature suggests that "especially those working in scenarios with less than optimum resources in the small-size business enterprise, are obliged to remain flexible [7] [8]. Ibid adds "to create performance guidelines for their workers" [7], in which case "the focus should be related to the development of capacities that enhance learning and trying of new ways of doing things, new markets, new products and implementation of new ideas" [7]. Consistent with the work of Nafukho, Graham and Muyia [7], the study revealed that C [the way in which end-users deal with the implementation of IT projects] contributed approximately 88.4% of the variation in IT risk and SMEs performance. In support of this, Alexander, Walker and Naim [12] argue that decision-context is predominately characterized by inherent uncertainty, however, patterns may emerge. This is particularly true in the case of the

current research as there is evidence that C [the way in which end-users deal with the implementation of IT projects] made a significant percentage contribution - thus ($\beta = 0$ .447, $p < 0.01$).

The results of the current study confirm previous studies. Theorists in the management field now believe that enterprises are also non-linear dynamic systems, having the same characteristics as natural phenomena [13] [14]. An enterprise is often regarded as a complex adaptive system comprised of formal and shadow systems. Tabachnick and Fidell [12] suggest that as in all enterprises, SMEs inherently form decision-making heuristics. The authors argue that it thus helps in responding better to strategic issues [8] [12]. In support of the study of Tabachnick and Fidell [12], the current study found that majority of respondents (86.9%, n = 93) agreed that information systems design should be managed as a planned enterprise change in chaos environment, while 13.1% (n = 14) disagreed. Accordingly, an analogy is made between chaos in natural systems and chaos in social enterprises. McBride [2] addresses this issue by stating that managers learn how to manage IT failures that are on the edge of chaos. McBride [2] does, however, end on an optimistic note as the author maintains that although long-term outcomes are impossible for IT operations in SMEs, dealing effectively with change and challenge on a daily basis will ultimately result in success.

Consistent with the assertion of McBride [2] and the present research Nafukho, Graham and Muyia [7] found that leadership and culture had the highest correlations ($r = .78$, $p < 0.001$) in SMEs. Thus, in SMEs "the goal of leadership in learning organizations should be to focus on wholes and to influence employees to create systems and structures that interface and promote organization-wide learning" [7]. The empirical data suggests that there is indeed a reason for the pattern and structures of relationships within IT operations in SMEs. As evidenced in the current research, a previous study revealed that "evaluation (M =3.46, SD =0.625) reflected the highest mean score. This was followed by team (M =3.35, SD =0.730) and communication (M =3.22, SD =0.654) dimensions [7]. Thus, internal processes and procedures, such as production time, order processing, delivery methods and so forth, will have to be geared to achieving different expectations driven by change management requirements and IT risk. Ignoring the challenges and opportunities presented by an IT operational model could lead to the failure of some SMEs. Contrary to this view, previous studies suggest that the rewards and recognition (M =2.98, SD =0.67) dimension reflected the weakest mean scores [6] [7] [15]. Chaos theory suggests to the contrary that some systems are inherently risky as SMEs can never be fully understood, no matter how much effort or expense is devoted to trying [2]. It is suggested here that gathering more information or constructing more elaborate models about chaotic systems can become pointless. In fact, 'research' may even be counter- productive if it creates a false sense of security about planning and what it can do [2]. Moreover, in such cases, planning strategies that depend on foresight are inappropriate and sometimes misleading. Instead, managers should become used to working not with one or two forecasts of the future but rather with an ensemble of forecasts as required by chaos theory in the management of SMEs [13].

7. CONCLUSION

By implication there seems to be enough evidence to suggest that the challenges posed by ORM solutions control would be managed more effectively if efforts were targeted at the success of organisational change can be determined by how well information system end-users deal with the various stages in the implementation of IT projects. Thus, the hypothesis was accepted, while the other 3 hypotheses were rejected. Chaos theory suggests that SMEs do not have the resources to predict long term risk but must remain flexible in order to survive in the competitive business environment. Therefore, ORM is focused on short term risk and strategies how end-users can mitigate these risks. There is also the need to see SMEs as dynamic organizations which evolve over time as chaos suggests. For this reason, managers are required to understand the inherent complex patterns that evolve over time and devise policy that best fit particular circumstance.

8. FUTURE RESEARCH

The study made use of one case study and 90 participants to determine the results. This is a limitation of the study as the results cannot be generalized to other SMEs outside the financial sector or South Africa. Further research is needed to monitor these changes more closely in order to measure the changing strategies and the associated issues of insufficient or improper user participation in the systems development process, lack of management support, high levels of complexity and risk in the systems development process, and poor management of the implementation process, which have been identified as potential barriers to the effective adoption and implementation of IT operations.

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