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Strategic Information Systems Alignment: A Longitudinal Investigation

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STRATEGIC INFORMATION SYSTEMS ALIGNMENT: A LONGITUDINAL INVESTIGATION

By

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ABSTRACT

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The alignment between business and information systems' strategies (strategic IS alignment) has occupied researchers' and practitioners' interest over the past two decades. This is due to the belief that strategic IS alignment positively affects business performance. However, despite the concerted effort in seeking to understand the alignment phenomenon, executives in organizations continue to complain of the difficulty in achieving and sustaining alignment. This may be due to a lack of a comprehensive model of alignment that takes into account its dynamic nature and the factors that affect it over time. Therefore, this study seeks to add to our accumulated knowledge by proposing a functional form for the alignment trajectory and identifying some factors that may affect or predict the dynamic changes between organizations' alignment trajectories. The study used longitudinal data drawn from several public databases and developed and tested a random coefficients model of strategic IS alignment. The results indicate that alignment is a nonlinear, dynamic phenomenon that is affected by prior IS success, and change in CIO, organizational size, and industry uncertainty. The findings suggest that prior IS success is associated with high initial magnitudes of strategic IS alignment and low rates of change in the strategic IS alignment trajectory. In addition, the findings suggest that CIO turnover is associated with higher initial levels of strategic IS alignment and high (and negative) rates of change in the strategic IS alignment trajectory. The results also show that larger organizations are associated with higher magnitudes of strategic alignment and that firms in stable industry environments, on average, have higher initial magnitudes of strategic IS alignment than firms in uncertain industry environments.

Keywords: Strategic IS alignment, IS strategy, Business Strategy, Power law, Random coefficients Model, Punctuated equilibrium model, longitudinal analysis.

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Chapter 1

INTRODUCTION

1.1 Background

Strategic information systems (IS) alignment is a topic of enduring significance in the management of information systems (Niederman et al., 1991, Brancheau et al., 1996, Watson et al., 1997). Strategic IS alignment, which refers to "applying IT in an appropriate and timely way, in harmony with business strategies, goals and needs"(Luftman et al., 1999, p.3), remains a major issue for information technology (IT) and business executives because it is widely believed to impact business performance (Sabherwal and Chan, 2001).

Alignment between IS and business strategies (strategic IS alignment) leads to greater IS and business performance (Byrd et al., 2006, Chan et al., 1997, Chan et al., 2006, Croteau and Raymond, 2004, Sabherwal and Chan, 2001, Sabherwal and Kirs, 1994), as well as greater use of IT for competitive purposes (Kearns and Lederer, 2003). Strategic IS alignment provides shared understanding and a better sense of the needs of the organization (Reich and Benbasat, 2000). This enables management to plan and invest wisely in IT leading to gains in efficiency, better coordination and more flexibility in operations (Byrd et al., 2006, Croteau and Raymond, 2004).

However, strategic IS alignment is not a static phenomenon (Sabherwal et al., 2001, Hirschheim and Sabherwal, 2001, Luftman and Brier, 1999). Changes in various antecedent factors such as prior IS success (Chan et al., 2006), IT budget (Papp, 1999), and personnel (Sabherwal et al., 2001), necessitate efforts to sustain strategic IS alignment. The purpose of this study is to examine the dynamics of strategic IS alignment using longitudinal data and to understand the impact of changes in key antecedents on the dynamics of strategic IS alignment. In particular, this study will seek to answer the following questions:

1. *Since strategic IS alignment is a dynamic phenomenon, what is the form of the strategic IS alignment trajectory over time?*
2. *What is the dynamic relationship among changes in performance, leadership, resources, organizational size, and industry with changes in strategic IS alignment?*

Addressing these questions would benefit both researchers and practitioners. In particular, answering these issues would advance strategic IS alignment theory in two ways. Firstly, it would enhance our understanding of the strategic IS alignment construct itself and how it evolves over time. This would help researchers to predict the behavior of the strategic IS alignment phenomenon and, based on that knowledge, to develop a more dynamic model of strategic IS alignment. Secondly, it would clarify the dynamic relationship between strategic IS alignment and the factors that are suggested as antecedent or causal factors. This is especially important for theory building because prior research has recommended these factors based on their relationship to strategic IS alignment at a point in time. Additionally, addressing these issues would provide a clearer picture of strategic IS alignment for practitioners. Business and IT executives require guidance on the external and internal factors that affect strategic IS alignment in order for them to make good decisions concerning resources.

This chapter continues with a discussion of the research problem, the research objectives, and the relevance of the research.

1.2 Statement of the Problem

Despite a long and rich tradition of research in IS alignment, a comprehensive theory of IS alignment continues to elude researchers (Weiss et al., 2006). This, in part, is due to a dearth of empirical longitudinal studies that appropriately represent the dynamic nature of the IS alignment problem (Sabherwal and Chan, 2001, Sabherwal et al., 2001). With few exceptions (Hirschheim and Sabherwal, 2001, Sabherwal et al., 2001) which have used multiple case studies, the bulk of IS alignment studies have used a cross-sectional design, thereby only capturing a static picture of alignment at a point in time. This kind of analysis, although valuable, does not guide us with respect to the issues of causality or modeling of the growth trajectory (Bentein et al., 2005, Bollen and

Curran, 2006). Therefore, this research study seeks to add value by providing a longitudinal change model of strategic IS alignment.

Furthermore, it is not clear how the antecedent factors identified through cross-sectional research affect the dynamics of strategic IS alignment. Prior research has determined that IS alignment requires the involvement of both IT and business executives (Gupta et al., 1997, Hussin et al., 2002, Kearns and Lederer, 2003, Reich and Benbasat, 2000). In particular, the roles of, and relationships between, the chief executive officer (CEO) and the chief information officer (CIO) are seen as crucial to the success of alignment efforts (Earl and Feeny, 1994, Feeny et al., 1992). While prior research has examined many factors that affect this relationship, the impact of a change in either executive (that is, change in CEO or CIO due to turnover or any other cause) has not been studied. This dissertation examines the impact of CIO change on strategic IS alignment.

This dissertation also examines the effects of two factors that have been proposed as important antecedents or moderators in prior literature. Prior IS success (Chan et al., 2006) and changes in IT investment (Byrd et al., 2006) have been shown to be associated with change in strategic IS alignment. These factors, along with personnel change, are posited to explain the strategic IS alignment trajectories.

Furthermore, this dissertation explores the effects of organizational size and industry (Chan et al., 2006, Sastry, 1997, Tushman and Romanelli, 1985) on the IT alignment trajectory. Based on the punctuated equilibrium model, both organizational size and industry affect the level of inertia, which in turn affects the possibility of having major changes in the organization (Tushman and Romanelli, 1985). Using a governance perspective, Chan et al. (2006) also argued that as organization size increases formal arrangements to enforce functional alignment are more likely to be in place. They found that organization size had a significant influence on alignment in business firms but not in academic institutions. Therefore, industry is also an important factor in tracing the alignment trajectory.

1.3 Purpose of the Study

There has been enduring interest in, and attention to, research on achieving and sustaining strategic IS alignment over the past two decades. The lack of empirical longitudinal approaches may account for the difficulties encountered by researchers in building a dynamic theory of strategic IS alignment. The limitations of cross-sectional results and case study research necessitate alternative approaches in strategic IS alignment studies. Thus two general research objectives were formulated.

The first objective of this current study is to identify the latent trajectories for strategic IS alignment. The latent trajectories are the continuous underlying evolutionary paths that are based on information from the pattern of change in the observed repeated measures (Bollen and Curran, 2006, p2). This will facilitate the understanding of the dynamics of strategic IS alignment (Bollen and Curran, 2006) and add to the formulation of a comprehensive theory of alignment. Most of the frameworks developed to explain alignment have been tested through cross-sectional analysis. Therefore, a longitudinal perspective is needed to provide information about the general trajectory of strategic IS alignment in the group of organizations (fixed-effects), as well as information on individual organizational change, that is, interorganizational differences in intra-organizational change (random-effects).

Knowing the strategic IS alignment trajectories of the individual organizations is only the first step toward explaining the dynamic nature of the phenomenon. Therefore, the second objective relates to the issue of prediction, that is, can we identify variables to predict these individual trajectories? Sabherwal et al. (2001) found that environmental shifts, sustained low performance, influential outsiders, new leadership and perceptual transformation are important triggers for revolutionary change in alignment. This study will focus on performance (prior IS success and organizational performance), new leadership (change in CEO or CIO), resources (IT investment), organizational size, and industry as predictors of strategic IS alignment trajectories.

1.4 Relevance of the Research

The importance of strategic IS alignment has already been widely recognized. However, the process of achieving and sustaining strategic IS alignment, though well conceptualized, requires more theoretical and practical work to be of sufficient help to business and IT executives.

We expect this research study to be beneficial to both researchers and managers. The attempt to model the long term trajectory of group and individual organization's strategic IS alignment will help researchers to better conceptualize and find "laws" of development (Bollen and Curran, 2006) with respect to strategic IS alignment. Fitting growth processes to mathematical forms increases prediction and aids understanding of the behavior of the phenomenon under examination. This is obviously an important goal for research and practice.

Furthermore, understanding the causes and regulatory factors of growth and how these interact with time also constitutes an important research goal. Achieving and sustaining strategic IS alignment can be greatly helped by studying the outcomes of changes in key antecedent factors. Having a framework that identifies the impact of different external and internal factors on strategic IS alignment over time, and how these interact with strategic IS alignment, is a matter of practical significance.

This chapter has introduced the concept of strategic IS alignment and discussed the motivation for, and relevance of, this research study. The next chapter provides an overview of the literature relating to strategic IS alignment and its evolution over time.

Chapter 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

The subject of alignment or fit has been studied in many different literatures including strategy, industrial organization, and population ecology (Doty et al., 1993, Gresov, 1989, Sastry, 1997, Tushman and Romanelli, 1985, Venkatraman, 1989b, Venkatraman and Prescott, 1990). The central premise of this vast and varied literature is that an organization with consistency between its strategy, structure, processes and environment has high performance. Therefore, external and internal consistencies are necessary to achieve and sustain high performance. As IT has taken on a strategic role, aligning it with the business needs has become a priority (Kearns and Lederer, 2003). The literature on alignment in IT has examined different types of alignment including strategic IS alignment, and structural alignment. Strategic IS alignment concentrates on the strategy-environment (context) fit (Henderson and Venkatraman, 1993, Miles and Snow, 1978, Sabherwal and Chan, 2001, Sabherwal et al., 2001), that is, the external consistencies. Strategic IS alignment is important because it defines how well an organization performs in its product markets and the wider environment. **Appendix A** and **Appendix B** provide a summary of prior cross-sectional and longitudinal research, respectively, on strategic IS alignment.

This chapter does not attempt a comprehensive review of the literature on alignment. Instead, it describes some of the pertinent literature in regard to business and IS strategies, as well as prior research on strategic IS alignment and its dynamics. The next section introduces the concept of business strategy and its relation to strategic IS alignment.

2.2 Business Strategy

Business strategy is a necessary component in planning for, and implementing, an aligned IS strategy (Henderson and Venkatraman, 1993). Prior literature on strategic IS alignment conceptualized business strategy in terms of the popular Miles and Snow (1978) typology of prospectors, defenders, and analyzers (Chan et al., 1997, Chan et al., 2006, Gupta et al., 1997, Miles and Snow, 1978, Miles et al., 1978, Sabherwal and Chan, 2001). This typology has been empirically examined in many studies leading to the development of theoretical profiles for each strategy (Sabherwal and Sabherwal, 2007).

The prospector continually seeks new product-market opportunities, creates change, seeks innovativeness and flexibility in technology, and therefore encounters the greatest uncertainty from the environment (Doty et al., 1993, Sabherwal and Sabherwal, 2007). In contrast, the defender is a less dynamic form of organization operating in a more stable and predictable environment. The defender focuses on efficiency and relies on routine technologies (Doty et al., 1993). The analyzer is a combination of prospector and defender, and therefore has a dual focus (Miles and Snow, 1978). There is a fourth ideal type that Miles and Snow (1978) proposed – the reactor. However, many strategic IS alignment studies have excluded this strategic type from their analysis, arguing that "the reactor strategy is not really a strategy at all" (Daft and Weick, 1984, p.292). Therefore, the reactor type is excluded from this study.

Business strategy is a multidimensional construct. Sabherwal and Sabherwal (2007) used prior literature to identify attributes of prospectors, defenders, and analyzers and to classify firms into the three strategic types. The attributes identified were scope, product-market dynamism, firm-level uncertainty, liquidity, asset efficiency, fixed-asset intensity and long-range financial liability. Scope refers to the diversity of a firm's lines of business, which is similar to Porter's "competitive scope" (Porter, 1985), that is, the domains in which competition takes place (segment, vertical, geographic & industry). Product market dynamism is that dimension of strategy that captures the rate of change among a firm's lines of business (Doty et al., 1993, Smith et al., 1989). Firm-level uncertainty resembles "environmental turbulence" (Doty et al., 1993) and measures the uncertainty encountered by the firm because of changes in its technologies, market shares, prices, and so on. Liquidity has regard to the availability of current assets needed to meet a firm's short-term needs (Segev, 1989). Asset efficiency is the ability of the firm to utilize its assets in an efficient way to increase sales (Doty et al., 1993, Miles and Snow, 1978). Fixed asset intensity refers to the "capital intensiveness" of the firm, which is the extent to which the firm invests in fixed assets rather than current assets (Hambrick, 1983, Segev, 1989). Finally, long-range financial liability can be defined as the firm's long-term debt relative to its equity (Segev, 1989). Table 2.2.1, below, provides more information about these attributes and their ideal values for the three strategies (Sabherwal and Sabherwal, 2007). In general, the prospector is low in scope but high in product-market dynamism and encounters higher levels of uncertainty (Doty et al., 1993, Segev, 1989, Shortell and Zajac, 1990, Smith et al., 1989). The prospector is also inefficient in its utilization of fixed assets, tending rather to rely more on current assets and long-term debt to finance its operations (Delery and Doty, 1996, Doty et al., 1993, Hambrick, 1983, Segev, 1989, Smith et al., 1989). The defender is on the opposite end of the spectrum from the prospector. The defender favors stability leading it to choose a wide scope and low product-market dynamism. The defender also emphasizes planning and efficiency, leading to high ratios of asset efficiency and fixed asset intensity, and low ratios of liquidity(Delery and Doty, 1996, Doty et al., 1993, Hambrick, 1983, Segev, 1989, Smith et al., 1989). Unlike the prospector, the defender is a little more cautious in its long-term financial liability requirements. The analyzer is more moderate in all these areas than either the prospector on the one hand or the defender on the other hand. The analyzer seeks to gain the advantages of being both proactive in building new markets and being efficient in utilizing its assets (Miles et al., 1978).

Table 2.2.1. Attributes and Ideal Values for Defenders, Analyzers and Prospectors (Source: Sabherwal and Sabherwal, 2007)

Construct	**Explanation**	**Ideal Values**			**References**
		Defenders	**Analyzers**	**Prospectors**	
Scope	Diversity of the firm's lines of business	High	Medium	Low	Doty et al. 1993
Product-Market Dynamism	Rate of change in a firm's lines of business	Low	Medium	High	Doty et al. 1993, Segev 1989, Shortell & Zajac 1990, Smith et al. 1989
Firm-level Uncertainty	Uncertainty encountered by a firm due to changes in the firm's technologies, market shares, prices etc	Low	Medium	High	Doty et al. 1993
Liquidity	Availability of current assets, such as cash, needed to meet the firm's short	Low	Medium	High	Smith et al. 1989, Segev 1989

	term obligations				
Asset Efficiency	The firm's ability to utilize its assets in an efficient fashion so as to generate greater sales	High	Medium	Low	Doty et al. 1993, Segev 1989
Fixed-asset Intensity	The extent to which the firm invests in fixed assets, such as plant and machinery, rather than current assets	High	Medium	Low	Segev 1989, Hambrick 1983
Long-range Financial Liability	The firm's long term debt relative to its equity. A high value of long-term financial liability reflects lower long-term financial strength (which refers to the firm's ability to raise financial resources for long term investments through owner's equity or debt at a minimal price)	Medium	Low	High	Smith et al. 1989, Segev 1989, Delery & Doty 1996

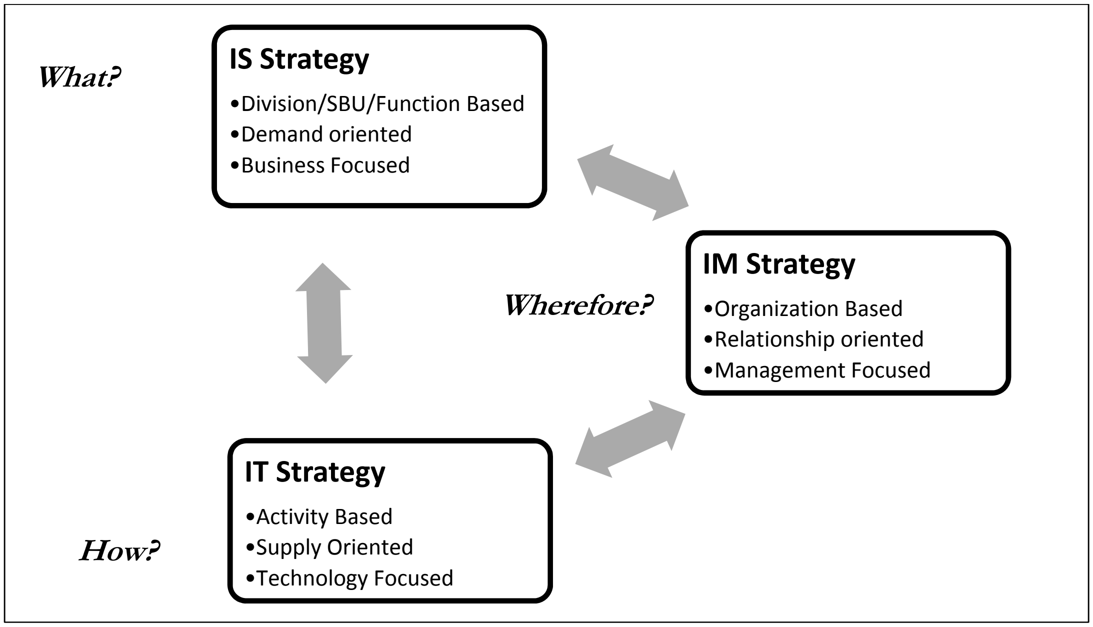
2.3 Information Systems Strategy

IT strategy has been conceptualized in different ways in prior literature. Earl (1989) distinguished between three types of strategies involving the IS department:

1. IS strategy: is primarily concerned with aligning IS development with business strategy and competitive advantage. This is usually done at the strategic business unit (SBU) level but most organizations also have a corporate IS strategy.
2. IT strategy: concentrates on technology policies, that is, questions of architecture, risk attitudes, vendor policies, and technical standards.

3. Information management (IM) strategy: is concerned with the role and structure of IT activities in the organization, such as, management control of IT, performance measurement and relationships between specialists and users of IT.

Figure 2.3.1 Three levels of strategy in IT (Source: Earl, 1989, p.64)



As pointed out in Sabherwal and Chan (2001), it would be infeasible to examine all three strategies in one study, and like them the focus in this study is on the IS strategy. Alignment between IS strategy and business strategy has been shown to impact business performance (Sabherwal and Chan, 2001) due to the fact that IS strategy concentrates on developing applications and systems that are in correspondence with business needs (Earl, 1989). Chan et al. (1997) created a research instrument to assess the strategic orientation of the existing information systems portfolio. The instrument measured "the extent to which IS used in a business unit facilitates aggressive, analytical, future-oriented, proactive, risk-averse, innovative, and internally and externally defensive company action" (Chan et al., 1997, p.131). The emphasis of this instrument was on realized rather than intended IS strategy (Mintzberg and Waters, 1985). This distinction is important because intended strategy represents the as yet unrealized ideals of management whereas realized strategy is what the organization actually did (Mintzberg, 1978, Mintzberg and Waters, 1982, Mintzberg and Waters, 1985). Sabherwal and Chan (2001) and

Chan et al. (2006) used a more summarized profile that reduced the eight factors of the Chan et al. (1997) instrument to four broad categories: operational support systems, market information systems, interorganizational systems, and strategic decision support systems. Table 2.3.1 provides more information on the dimensions and the ideal values of the IS strategies, which map onto the three business strategies.

Table 2.3.1. Dimensions and Ideal Values for IS Strategy (Source: Sabherwal and Chan, 2001)

	Defender	*Prospector*	*Analyzer*
IS Strategy Attribute	**Efficiency Strategy**	**Flexibility Strategy**	**Comprehensiveness Strategy**
Operational Support Systems	High	Low	Medium
Market Information Systems	Low	High	High
Interorganizational Systems	High	Medium	High
Strategic Decision Support Systems	High	High	High

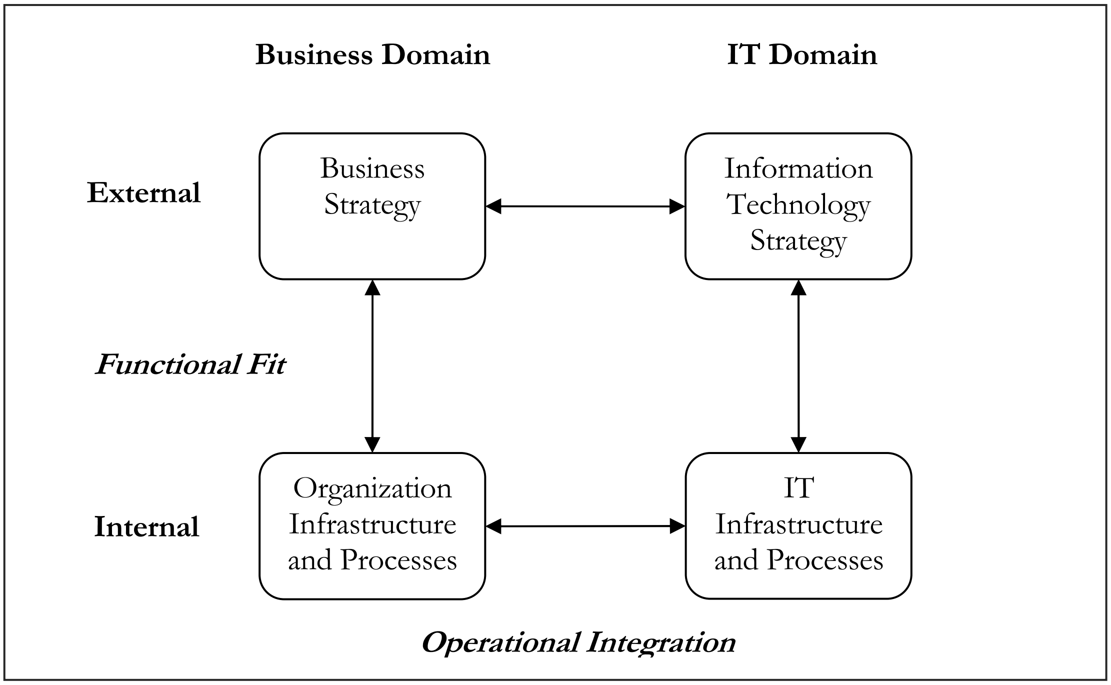
Operational support systems refer to the use of IT for day-to-day activities, that is, using IT to facilitate efficiency. Segev (1989) rated the importance of operational efficiency as high, medium and low for defenders, analyzers and prospectors respectively (Sabherwal and Chan, 2001, Segev, 1989). This rating is consistent with other studies (e.g. Miles and Snow, 1978, Miles et al., 1978) that have argued that defenders are ideally suited to generating efficiency while prospectors sometimes underutilize or even misapply resources in their quest for flexibility and rapid market response. The same argument can be applied to IS for operational support since increased use of such IS should lead to gains in operational efficiency. Hence, use of IS for operational support should be high, medium and low for defenders, analyzers and prospectors respectively. *Market information systems* focus on supporting the company's market and product sales. Miles et al. (1978) have suggested that the prospector is geared toward flexibility or rapid response toward market changes by closely monitoring product and market trends, while market response is the greatest risk for the defender. The analyzer has also been shown to have a high level of marketing surveillance (Miles and Snow, 1978). Translating this into the IS for market information support, we expect that both prospectors and analyzers will have a high use of these systems while defenders will have a low use of IS for market information systems. *Interorganizational systems* emphasize links with customers and suppliers. Due to the prospector's need for flexibility, it is expected that they would use formalized, interorganizational systems less than defenders (Doty et al., 1993, Hambrick, 1983). The defender's need for efficiency makes it a prime candidate for interorganizational systems that seek to coordinate, and thus make efficient, the links between the firm and its customers and suppliers. Doty et al. (1993) also note that analyzers would make greater use of interorganizational systems due to their relatively greater stability and formalization. This leads us to rate defenders, analyzers and prospectors as high, high and medium respectively on the use of interorganizational systems. *Strategic decision support systems* are systems that support futurity, pro-activeness, and analysis. Sabherwal and Chan (2001) argued that strategic decision support systems "play a major role in all three configurations" (p.17). In defenders, strategic decision support systems help in futurity, an important characteristic of that configuration, while in prospectors, these systems aid in proactiveness, and in analyzers, strategic decision support systems contribute to both internal and external analysis. Therefore, we expect the use of such systems to be high for all three business strategies.

The foregoing discussion suggests that defenders follow an *IS for efficiency* strategy in which efficiency in internal operations, interorganizational linkages and planning behavior is the key ingredient (Camillus and Lederer, 1985). Prospectors, on the other hand, are more concerned about flexibility, that is, they follow an *IS for flexibility* strategy where they emphasize market flexibility and quick strategic decision-making (Sabherwal and Chan, 2001). Analyzers seek to combine the efficiency of the defender and the flexibility of the prospector thus following an *IS for comprehensibility* strategy.

2.4 Strategic Information Systems Alignment

Alignment between two or more organizational dimensions, which refers to "the extent to which these dimensions meet theoretical norms of mutual coherence" (Sabherwal et al., 2001, pg. 179), has been found to enhance performance. A number of prior studies proposed different frameworks for studying alignment. However, Henderson and Venkatraman (1993) were the first to develop a widely-used comprehensive model of alignment between business and information technology (IT) domains that conceptualized different types of alignment based on both external and internal dimensions of business and IT. The strategic alignment model proposes two types of integration between business and IT domains, namely strategic integration, or the link between business strategy and IT strategy reflecting the external components, and operational integration, which deals with the corresponding internal domains of organizational and IT infrastructure and processes. Only the former is examined in this study[1]. Figure 2.4.1 below depicts the strategic alignment model as proposed by Henderson and Venkatraman (1993).

Figure 2.4.1. The Strategic Alignment Model (Adapted from Venkatraman et al., 1993, Henderson and Venkatraman, 1993)



Strategic IS alignment occurs when there is a fit or congruence between the business strategy and IT strategy (Henderson and Venkatraman, 1993). However, a difficulty encountered in the strategic IS alignment literature concerns the consistency of measurement of fit or alignment. Prior literature has used different approaches to measure alignment including profile deviation approach, and moderation approach (Chan et al., 2006, Hussin et al., 2002). Venkatraman (1989) proposed six measurement approaches to alignment: matching, moderation, mediation, co-variation, profile deviation, and gestalts. For constructs with multiple dimensions such as business strategy and IS strategy, profile deviation is recommended for the following reasons:

[1] A discussion of operational integration is out of the scope of this study, which deals only with the realized strategies of both the business and IT domains.

a) it retains the holistic and systemic nature of the environment-strategy co-alignment thereby avoiding the error of logical typing

b) the scheme is flexible in terms of varying the theoretical conceptualizations of co-alignment, and

c) a multivariate (interval-level) measure of co-alignment is obtained that can be used to examine relationships with a variety of criterion measures (Venkatraman, 1989b, Venkatraman and Prescott, 1990). The profile deviation approach is used to develop a multivariate, composite measure of alignment (Sabherwal and Kirs, 1994), which can be compared to the ideal profile in order to find the degree of deviation. The measure can also be traced over several periods to determine its trajectory and the factors that affect this trajectory.

2.5 Dynamics of Strategic Information Systems Alignment

Strategic IS alignment is not a static phenomenon (Sabherwal et al., 2001). It is an emergent process that incorporates adjustments to strategy components in response to changes in internal and external factors (Jarvenpaa and Ives, 1993, Thompson, 1967). Most prior literature, however, has treated strategic IS alignment as a static end goal (Byrd et al., 2006, Chan et al., 1997, Chan et al., 2006, Hussin et al., 2002, Sabherwal and Chan, 2001). This treatment has resulted in charges that "alignment research is mechanistic and fails to capture real life" (Chan and Reich, 2007a, p.298). Indeed, a cursory look through Chan and Reich's (2007b) helpful annotated bibliography reveals that there is little prior empirical work on the dynamics of strategic IS alignment (Chan and Reich, 2007b). This dissertation study seeks to add to the work on the processes that affect and shape the strategic IS alignment trajectory from a longitudinal perspective.

The dynamic nature of strategic IS alignment has been studied mainly through case study research. For example, Sabherwal et al. (2001) used a multiple case study approach to examine the dynamics of IS alignment. Basing their work on the punctuated equilibrium model (PEM), they found support for the proposition that IS alignment follows a PEM pattern as changes from the environment, changes in management and other resources are incorporated into the strategy and structure of the organization. However, Sabherwal et al. (2001) note that future research should empirically test their findings using other methods and data. This study seeks to respond to this challenge by using secondary data to construct a model of the dynamics of strategic IS alignment. The strategic IS alignment trajectory is affected by factors that trigger both incremental and revolutionary change. Sabherwal et al. (2001) found that the revolutionary change needed to achieve and sustain high IS alignment is triggered by five types of factors: environmental shifts, sustained low performance, influential outsiders, new leadership, and perceptual transformation. Prior research in IS alignment provides support for these findings (Chan et al., 2006, Hu and Huang, 2006, Hussin et al., 2002, Johnston and Carrico, 1988). The organizational theory literature also proposes that organizational size and environmental turbulence affect alignment (Sastry, 1997, Tushman and Romanelli, 1985). Hirschheim and Sabherwal (2001) found that the ideal IS alignment trajectory was affected by several managerial choice related factors that included organizational inertia, knowledge gaps, sequential attention to goals, split responsibilities, and underestimation of problems. Managers have control over how they respond to the challenges posed by strategic IS alignment. This lends weight to the argument that the managers involved in strategic IS alignment (represented from the business side by the chief executive officer (CEO) and from the IT side by the chief information officer (CIO)) have a significant influence on the value and development of the strategic IS alignment construct. These findings are also supported by prior literature (e.g. Earl and Feeny, 1994, Feeny et al., 1992, Luftman and Brier, 1999, Luftman et al., 1999, Reich and Benbasat, 2000). Table 2.5.1 provides a summary of the variables that have been found to affect the IS alignment trajectory.

Table 2.5.1. Factors that affect the Strategic IS alignment Trajectory

Category	Construct	Relationship	References
Performance	Business Performance	Strategic IS alignment is positively related to business performance	Chan et al. (1997), Sabherwal & Chan (2001), Sabherwal & Kirs (1994), Croteau & Raymond (2004)
	Prior IT Success	Prior IS success is positively related to strategic IS alignment	Chan et al. (2006), Reich & Benbasat (1996; 2000), Hu & Huang (2006)
New Leadership	CIO Change	New leadership affects strategic use of IT and introduces pressures for revolutionary change which temporarily lower strategic IS alignment	Sabherwal et al. (2001), Johnston & Carrico (1988), Hussin et al. (2002), Kearns & Lederer (2003)
Resources	IT Investment (or IT Budget)	Strategic IS alignment mediates the relationship between IT investment and performance	Byrd et al. (2006), Grant (2003)
Organizational Inertia	Organizational Size	Organization size is positively related to strategic IS alignment	Chan et al.(2006)
Environmental Uncertainty	Industry	Environmental uncertainty is positively related to strategic IS alignment	Chan et al.(2006), Johnston & Carrico (1988),

2.6 Summary

This chapter has introduced some important literature tying business and IS strategies to strategic IS alignment. The chapter also discussed the conceptualization of strategic IS alignment and its dynamics. The next chapter deals with the theoretical development of the research study by looking at the evolution of strategic IS alignment through the framework of the punctuated equilibrium model.

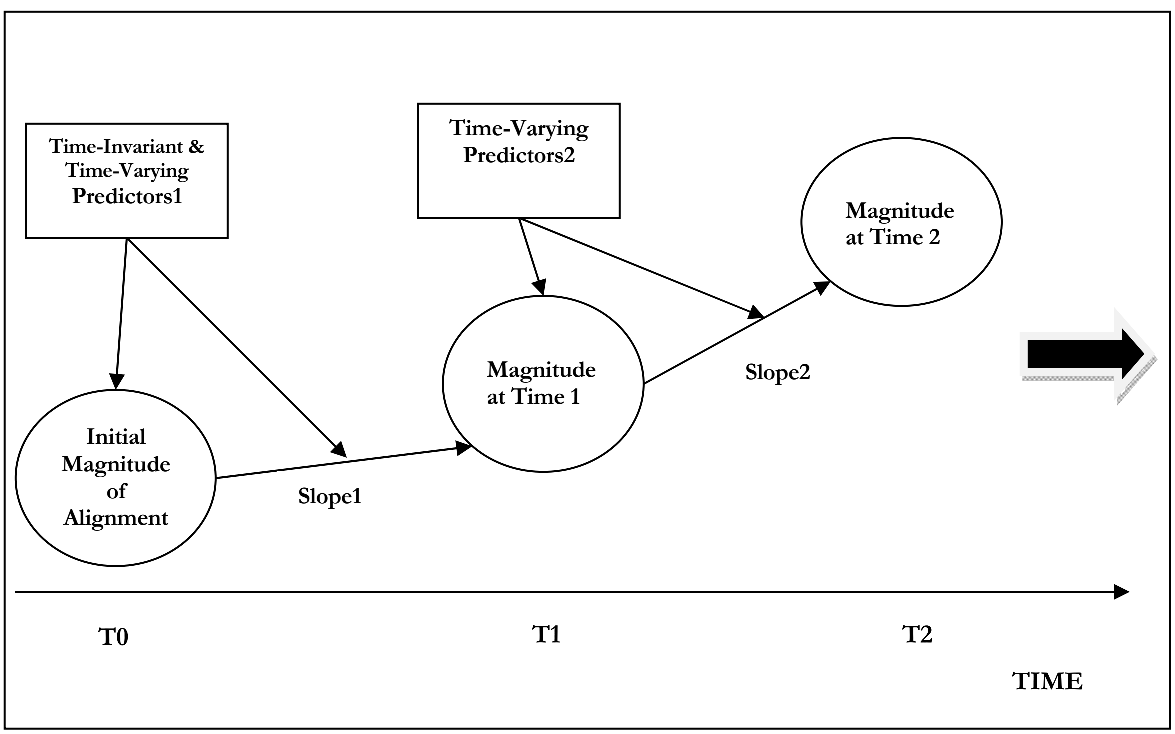
Chapter 3

CONCEPTUAL MODEL AND HYPOTHESES

3.1 Introduction

This dissertation study focuses on modeling the dynamic nature of the strategic IS alignment construct and looking at the factors that predict its trajectory as depicted in figure 3.1.1. In seeking to achieve this goal, the dissertation uses the punctuated equilibrium model as its theoretical base. Some organizational scholars suggest that the dynamics of strategic IS alignment follow a trajectory very similar to that described by the punctuated equilibrium model (Sabherwal et al., 2001). They posit that strategic IS alignment grows incrementally during periods of stability but becomes discontinuous when the organization experiences a period of revolution triggered by factors including sustained low performance, changes in key personnel, environmental uncertainty, organization size, and changes in organization resources devoted to IT.

Figure 3.1.1. Conceptual Model



Other organizational scholars have challenged the appropriateness of using a punctuated equilibrium perspective to study strategic IS alignment arguing that the punctuated equilibrium model is premised on the importance of stability and assumes an equilibrium seeking condition (Benbya and McKelvey, 2006b, Benbya and McKelvey, 2006a, Lichtenstein, 1995, Orlikowski, 1996). Benbya and McKelvey (2006b) suggest that the best perspective to use to study an issue such as strategic IS alignment would be co-evolutionary theory. They argue that prior research has neglected the co-evolutionary and emergent nature of IS strategic alignment (Benbya and McKelvey, 2006b, p.284). Co-evolution is defined as "mutual causal changes between a firm and its competitors, or other elements of its niche, that may have adaptive significance" (McKelvey, 1999, p.299). Lewin and Volberda (1999) have summarized five properties that characterize co-evolutionary models: 1) multi-levelness, that is, co-evolutionary effects occur at multiple levels in firms, 2) multidirectional causalities, implying that organizations and their parts co-evolve with each other and with their environments, 3) nonlinearity, stemming from the indeterminacy of feedback paths such that changes in one variable produce unexpected changes in another, 4) positive feedback, which leads to a recursive bidirectional view of mutual causality, and 5) path and history dependence, that argues that variation in adaptations among firms in a population may reflect heterogeneity in the population of firms at earlier points in time. However, the punctuated equilibrium model can be thought of as a co-evolutionary model because it meets the five properties identified above (Benbya and McKelvey, 2006b, Lewin and Volberda, 1999). The weakness of the punctuated equilibrium model is that it is a single-lens perspective which might not take account of the complexity of interactions between variables the way a multi-lens perspective would. Nevertheless, the punctuated equilibrium model satisfies the conditions for building co-evolutionary models.

More importantly, prior research has suggested that the punctuated equilibrium model subscribes to the basic tenets of complexity theory (Dooley and Van de Ven, 1999, Sastry, 1997, Tushman and Anderson, 1986), a major basis for co-evolutionary theory. Complexity theory, which is more of a perspective than a theory, focuses on the study of non-linear dynamic systems (Anderson, 1999, Benbya and McKelvey, 2006b, Dhillon and Ward, 2002, Dooley and Van de Ven, 1999, Levy, 1994). Complexity theory suggests that complex systems, consisting of many interactions among highly differentiated parts, can produce surprisingly simple, predictable behavior while less complex systems can sometimes generate behavior that is impossible to forecast, though they feature simple laws and few actors (Anderson, 1999, p.217). Some important insights gained from complexity theory include the following. Firstly, dynamical systems do not all reach equilibria or fixed-points. Secondly, processes that may appear random may actually be chaotic, that is, they may be deterministic around certain identifiable *attractors* (attractors are limited areas in the state space of a system from which it never departs). Thirdly, complex processes may be sensitive to initial conditions so that two entities with similar initial states can follow very different paths. Fourthly, complex systems resist simple reductionist analyses because of interactions and feedback loops making it difficult to hold some subsystems constant while studying others in isolation. Fifthly, complex patterns can arise from the interaction of agents that follow relatively simple rules. Sixthly, complex systems tend to exhibit self organizing behavior in which they evolve from a random starting state toward an ordered state rather than a disordered state (Bak and Sneppen, 1993, Bak et al., 1988). These insights are now scientifically well established (Anderson, 1999). The punctuated equilibrium model can explain seemingly random patterns of change in organizational events and tie macro and micro factors to these changes. As Gould and Eldredge point out, the goal of punctuated equilibrium is “the full development of a comprehensive, non-reductionist hierarchical theory (with independent, though interacting, levels and complex effects in upward and downward causation between them)” (Gould and Eldredge, 1986, p.147). Thus, the punctuated equilibrium model is a powerful tool in studying the dynamics of change from a complexity perspective. Nevertheless, this dissertation is aimed at modeling the trajectory of strategic IS alignment and not explaining the broader, complex, multilevel, circular processes that affect strategic IS alignment. Therefore, this dissertation study presents a parsimonious longitudinal model of strategic IS alignment for which the punctuated equilibrium model would be suitable.

This chapter provides a theoretical discussion of strategic IS alignment from a punctuated equilibrium perspective. The first section is a brief introduction of the PEM theory, the second section is a discussion of the dynamic nature of the strategic IS alignment trajectory, and the third section develops hypotheses based on PEM reasoning to explain the latent trajectory and predictors of strategic IS alignment.

3.2 Punctuated Equilibrium Model

Organization theory has borrowed many metaphors and analogies from the biological sciences, among which evolution is an established and useful one. Evolutionary theory has had a big impact on our understanding of how organizations and organizational fields begin, change and, sometimes, die. Punctuated equilibrium is an evolutionary model that posits a different tempo (rate of change) and mode (mechanism of change) of evolution in contrast to Darwinian or gradual evolution (Eldredge and Gould, 1972, Gould, 1989, Gould and Eldredge, 1977). Whereas Darwinian evolution hypothesizes a slow, steady evolutionary process based solely on natural selection, punctuated equilibrium suggests that evolution occurs as short episodes of change against a backdrop of long periods of stability. This pattern infers the higher level process of species selection as an extra mode of evolution (Eldredge and Gould, 1972, Gould and Eldredge, 1977). Gould and Eldredge clearly delineated the scope and conditions under which punctuated equilibrium would hold (Gould and Eldredge, 1977). Their initial goal was to explain the evolution of sexually reproductive biospecies based on the fossil record. However, they later acknowledged the potential for the application of punctuated equilibrium to other fields such as information theory. It is important to note this because the use of punctuated equilibrium to explain organizational phenomena has been criticized (e.g. Lichtenstein, 1995) for 1) incorrectly applying or completely leaving out mechanisms for selection (i.e. mode, which is a key element in evolutionary theories), and 2) not clarifying the notion of speciation since the unit of analysis is usually singular (i.e. the organization). Thus organizational theorists are accused, and rightly so, of not applying the punctuated equilibrium theory correctly and fully. However, as Gould and Eldredge note, "the punctuational metaphysic may prove to map tempos of change in our world better than any of its competitors – if only because systems in steady state are not only common but also so highly resistant to change" (Gould and Eldredge, 1977, p.146). The punctuated equilibrium model provides a general organizing principle for many naturally occurring systems other than biological ones. Although there might indeed be difficulties in applying the punctuated equilibrium model wholesale, its usefulness in helping to explain dynamic phenomena cannot be questioned. Therefore, application of punctuated equilibrium to obtain the tempo of change, leading us to infer the mode of change, is a valid undertaking.

The punctuated equilibrium model is an alternative explanation for the evolution of phenomena. (Gersick, 1991, Sabherwal et al., 2001, Sastry, 1997, Tushman and Romanelli, 1985). Gersick (1991) provides a useful analysis of the differences between the punctuated equilibrium model and other organizational theories. Three main distinctions have been suggested. First, the punctuated equilibrium model opposes the gradualist change proposal inherent in Darwinian evolution that implies that systems can accept any change anytime as long as it is small enough. In contrast, the punctuated equilibrium model proposes that for most systems, there are limits beyond which change is actively resisted. Second, the punctuated equilibrium model disputes the ideas that individual systems of the same type all develop along the same path and that systems develop in "forward" directions. These ideas are mainly propagated by universalistic life cycle theories such as stage models. The punctuated equilibrium model proposes that punctuated equilibria are not smooth trajectories toward pre-set ends but discontinuous trajectories that are unpredictable and can improve or worsen the state of a system. Third, punctuated equilibrium suggests that conflicting theories about organizational adaptability, and organizational rigidity are applicable at different times, based on the state of the system, therefore a contingency perspective is preferable over a universalistic perspective.

There are three main components of the punctuated equilibrium model: deep structure, equilibrium periods and revolutionary periods.

1. The "deep structure is the set of fundamental choices a system has made of (1) the basic parts into which its units will be organized and (2) the basic activity patterns that will maintain its existence" (Gersick, 1991, p.14). Organizational deep structures include core beliefs and values, structures, distribution of power, and nature, type and pervasiveness of control systems (Tushman and Romanelli, 1985). The strategic orientation of an organization would fit into this classification (Tushman and Romanelli, 1985) as it exposes the philosophical underpinnings of organizational behavior, that is, the organization's core beliefs and values. This dissertation study uses the strategic orientation of the organization as a proxy for the deep structure.

2. The equilibrium periods are periods in which the system maintains and carries out the basic organizational activity patterns. During equilibrium periods, incremental change and adaptation are used to "elaborate structure, systems, controls, and resources towards increased co-alignment"

(Tushman and Romanelli, 1985, p.173). This increases inertia and decreases competitive vigilance. In equilibrium periods, strategy undergoes only incremental or gradual change. This is not true for revolutionary periods in which wholesale change of the deep structure takes place.

3. The revolutionary period is a transition period where the organization reorients itself both internally and externally. Tushman and Romanelli (1985) propose two categories of revolutionary change. First, reorientations, which "are relatively short periods of discontinuous change where strategies, power, structure, and systems are fundamentally transformed toward a new basis of alignment" (p.173). Second, recreations, which are reorientations that also involve discontinuous change in the core values that govern decision premises (p.179). Recreations are the most radical type of change possible and are rare due to the fact that organizations resist making these types of changes (Sabherwal et al., 2001).

The dynamics of organizational change captured by the punctuated equilibrium theory are complex and difficult to map. Based on chaos theory and complexity theory, the pattern of behavior of a system that follows a punctuated equilibrium model is described as "pink noise", which is a type of random noise that describes a system with a high number of independent variables that are constrained in some way, whether by rules or other interdependencies among the variables, and which interact in a nonlinear manner (Dhillon and Ward, 2002, Dooley and Van de Ven, 1999, Thiétart and Forgues, 1995). This description fits organizational and social systems where individuals are the interacting agents and the constraints may be in the form of rules, routines, laws, structures etc. Systems with a "pink noise" trajectory belong to a family of systems that are defined as colored noise systems or the so-called $1/f$ noise systems or "flicker noise" (Bak et al., 1988). Such systems display an inverse power law relationship in which the probability of occurrence of major events is proportional to the probability of occurrence of minor events. The inverse power law between two variables $\boldsymbol{y}$ and $\boldsymbol{x}$ is given by:

$$y_{ij} = \beta x_{ij}^{\alpha} \qquad (3.2.1)$$

where α has a negative value and β is some constant. The $1/f$ noise patterns such as white noise, pink noise, brown noise and black noise represent many naturally occurring systems and are associated with power law spectra of the form $S(f) \propto 1/f^{\alpha}$ where $0 \leq \alpha \leq 2$ (Pimm and Redfearn, 1988, Goldstein et al., 2004, James and Plank, 2007, Mitzenmacher, 2003, Newman, 2006, Rohani et al., 2004, Pilgram and Kaplan, 1998, Cromwell et al., 2000, Halley, 1996, Clauset et al., 2009). The different noise patterns can be distinguished based on their power law exponent α (Pilgram and Kaplan, 1998, Cromwell et al., 2000). White noise represents a completely random noise process (no predictability) with no temporal correlation and has a power law exponent α =0. On the other hand, brown noise (also called Brownian motion) describes a random walk, where increments, Δ , are independent of past history (Cromwell et al., 2000). Brown noise is consistent with ideas such as market efficiency and prediction. Between these two noises we find pink noise whose power law exponent $\alpha \approx 1$. Pink noise is associated with hyperbolic behavior found in nonlinear models and occurs often in physical phenomena including music. Values of $\alpha > 2$, that is, black noises, are associated with catastrophic events such as hurricanes and drought. Table 3.2.1 provides a summary of the differences between the $1/f$ noises.

Table 3.2.1. Classification of Noises by Power Law exponent (Adapted from Cromwell et al., 2000)

$1/f$ Noise Category	Power Law $f^{-\alpha}$	Phenomena Represented
White	0	Completely random/unpredictable process
Pink	1	Physical phenomena, music
Brown	2	Market efficiency, martingales, prediction
Black	$\lvert\alpha\rvert > 2$	Catastrophes e.g. drought, hurricane

According to Dooley and Van de Ven (1999), the "punctuated equilibrium theory reflects an inverse power function among organizational change events" (Dooley and Van de Ven, 1999, p.362). The punctuated equilibrium model has been posited to trace a "pink noise" trajectory which is neither completely random (as in white noise) nor too predictable in its path (short memory). This means that the *path*, that is the moment-by-moment trajectory, cannot be predicted whereas the *pattern*, or the temporal shape that emerges when one traces the path over a long period of time, may be predicted (Dooley and Van de Ven, 1999). This has great implications for modeling systems that follow a punctuated equilibrium pattern. For example, generating a mathematical model of the path of a punctuated equilibrium model system is virtually impossible (Dhillon and Ward, 2002, Thiétart and Forgues, 1995). However, the pattern of the system's trajectory can be defined by equation (3.2.1) above. Systems that follow inverse power laws are considered as time irreversible, that is, they cannot find themselves in the same conditions as they were in initially (non-replicability of past situations) (Thiétart and Forgues, 1995). Therefore, the outcome of punctuated equilibrium model systems cannot be predicted in the short term although in the long run, a pattern emerges which is quite predictable. These systems are also highly sensitive to initial conditions such that a small change in any one of the variables may lead to huge changes over time. This also explains the revolutionary periods, which are an accumulation of small or incremental changes that cascade through the organization (like multiple avalanches, Bak and Sneppen, 1993) and affect the deep structure in a discontinuous fashion (Tushman and Anderson, 1986). Therefore, punctuated equilibrium systems may be identified by their adherence to a power law with $\alpha \approx 1$, that is, much of the variance in a punctuated equilibrium system will be accounted for by an inverse power law defined by equation (3.2.1).

3.3 Dynamics of Strategic Information Systems Alignment

The dynamic nature of strategic IS alignment has been recognized in prior literature (Henderson and Venkatraman, 1993, Hirschheim and Sabherwal, 2001, Sabherwal et al., 2001). Henderson and Venkatraman (1993) noted that "strategic fit is inherently dynamic … strategic alignment is not an event but a process of continuous adaptation and change" (p. 5). The strategic IS alignment of an organization is expected to develop or "grow" from low levels as the organization begins to learn what actions are appropriate to successfully get resources from the environment, to higher levels as the organization develops competency and structures to handle the environmental co-alignment problem (Sastry, 1997, Tushman and Romanelli, 1985). This pattern of development is referred to as the strategic IS alignment trajectory. In order to study this trajectory, we need to consider two important dimensions of dynamic behavior. The first is the magnitude of change, that is, the "amount of the variable at each point in time" (Monge, 1990, p410). The magnitude allows us to compare the strategic IS alignment trajectories of different organizations, and groups of organizations, against other organizations' trajectories and the mean trajectory. The second dimension of dynamic behavior is the rate of change (or slope), which "specifies how fast the magnitude increases or decreases per unit of time" (Monge, 1990, p410). A rapid rate of change defines a steep slope, that is, a large increase or decrease in the magnitude of change per unit of time. A slow rate of change, on the other hand, defines a shallow slope (approaching a horizontal line). Tied to the slope is the concept of directionality, which is given by the sign of the slope factor. A negative slope stands for a diminishing magnitude while a positive slope depicts a rise in magnitude. Furthermore, in nonlinear trajectories, a zero slope stands for an inflection point (point where the slope function changes sign) and provides valuable information concerning the behavior of the trajectory (Kline, 1998). For example, such points could tell us whether this is maximum (magnitude2) or minimum (magnitude1) magnitude and whether the improvement or decline is bounded and cannot go beyond that point. Figures 3.3.1 and 3.3.2 provide a visual representation of these concepts.

Figure 3.3.1. A simplified depiction of steep and shallow slopes

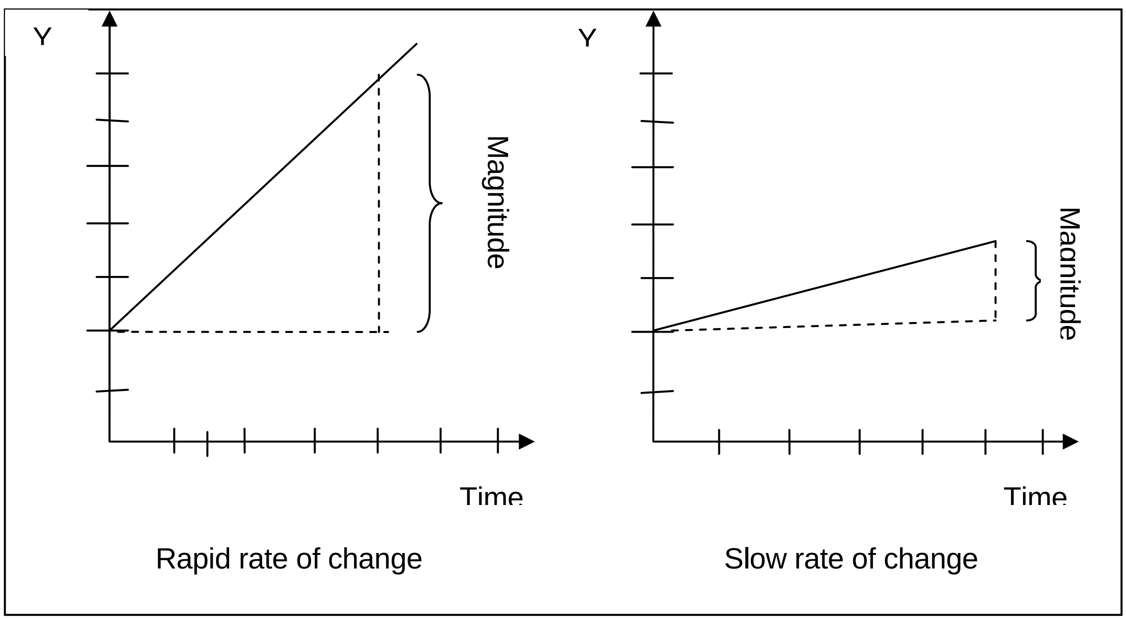
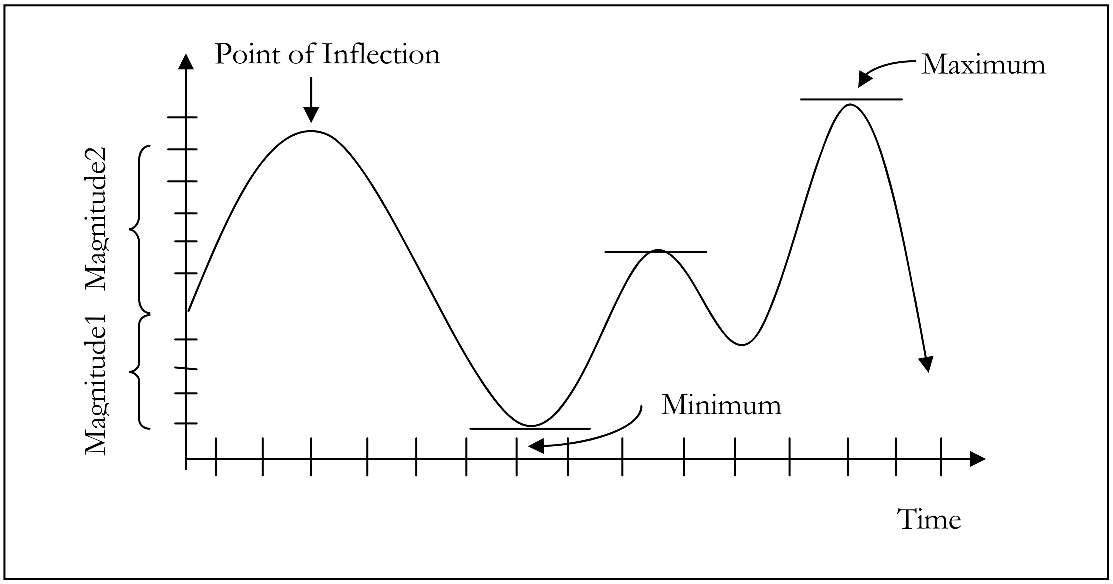


Figure 3.3.2. A simplified depiction of inflection points, maxima and minima



The assumption in this dissertation, based on prior literature (e.g. Sabherwal et al., 2001), is that the strategic IS alignment of an organization follows a punctuated equilibrium pattern. The punctuated equilibrium model implicitly proposes that the rate of change will be greatest at the start of the alignment process as the system seeks equilibrium (Sastry, 1997, Tushman and Romanelli, 1985). Incremental change and adaptation will take place more rapidly in the beginning while organizational inertia is low and competitive vigilance is high, that is, the magnitude of change in the first period will be higher than that of subsequent periods, and the magnitude of change in the second period will be greater than that of subsequent periods, and similarly for all periods until revolutionary change or some other event disturbs the pattern (Monge, 1990, Sastry, 1997, Tushman and Romanelli, 1985). However, as organizational inertia increases, change will be resisted more and more leading to an asymptotic drop in the rate of change. From a mathematical modeling perspective, the punctuated equilibrium model proposes a low initial mean value for strategic IS alignment, and a decreasing rate of change between successive time points defining a nonlinear trajectory (Bollen and Curran, 2006). This behavior is captured by the dynamic equation (3.2.1), which defines pink noise (Dooley and Van de Ven, 1999). Based on the punctuated equilibrium model, the strategic IS alignment traces a random moment to moment path that is unpredictable but the pattern or "growth" traces a pink noise trajectory.

This section has discussed the theoretical underpinnings of the dissertation by looking at the punctuated equilibrium model as a guide for interpreting the dynamic behavior of strategic IS alignment. The next section uses these concepts to derive hypotheses to be tested on the data collected for the study.

3.4 Statement of Hypotheses

This dissertation seeks to answer two broad questions:

1. What is the *form* of the strategic IS alignment trajectory

The form of the trajectory affects the tools and types of behaviors that IT and business managers would use to effect strategic IS alignment (Chan and Reich, 2007a, Sabherwal et al., 2001). This question will be tested through hypotheses 1 and 2.

2. What is the dynamic relationship between changes in *performance, leadership, resources, organizational size,* and *industry* with strategic IS alignment?

The dynamics of alignment are important to know but it is more helpful to know how we can beneficially influence the strategic alignment process through managerial action. This question tests the effect of each of these five factors on strategic IS alignment (hypotheses 3 through 9).

3.4.1 Form of Punctuated Equilibrium Trajectory

The punctuated equilibrium model suggests that change occurs in incremental steps during equilibrium periods punctuated by short revolutionary periods characterized by rapid change (Eldredge and Gould, 1972, Gould and Eldredge, 1977, Sabherwal et al., 2001, Tushman and Romanelli, 1985). Sabherwal et al. (2001) posited and tested the proposition that strategic IS alignment follows a punctuated equilibrium trajectory. Using three case studies they found support for using the punctuated equilibrium model as a theoretical basis to argue for patterns of change in strategic IS alignment. Since other literature has argued that punctuated equilibria follow a pink noise trajectory, we expect the strategic IS alignment trajectory to be mathematically defined by an inverse power law as in equation (3.2.1). This leads us to our first hypothesis.

H1: The mean trajectory of the strategic IS alignment function will be defined by the dynamic equation $y_i = \alpha_i + \beta_{ij}\lambda^{\gamma} + \varepsilon_{ij}$*, which defines a growth trajectory with a "pink noise" behavior, and where* α_i *is the initial value,* β_{ij} *is the slope of the trajectory,* λ^{γ} *is the time variable with* γ *being the inverse power, and* ε_{ij} *is the error term.*

However, the punctuated equilibrium model opposes a universalistic application of developmental trajectories (Gersick, 1991). While hypothesis 1 proposes a general functional form for strategic IS alignment development, the theory suggests that there would be great variability in the paths taken by individual systems. Punctuated equilibria are discontinuous trajectories that have no pre-set ends or direction (Gersick, 1991). In a latent curve mathematical model (Bollen and Curran, 2004, Bollen and Curran, 2006), the variability around the mean trajectory allows us to answer the question of interorganizational differences in intra-organizational change. That is, are there enough significant differences among individual organization's strategic IS alignment trajectories of intra-organizational change to warrant case-by-case modeling as opposed to group modeling? The greater the fluctuation of individual organizational values for strategic IS alignment from the mean values, the greater the evidence there is for individual organizational trajectories (Bollen and Curran, 2006). According to Gersick (1991), both the "specific composition of a system and the 'rules' governing how it's parts interact may change unpredictably during revolutionary punctuations" (p.12). This view suggests that each organization may have a unique pattern, which means that the mean trajectory may not be representative of all the organizations as a group. This leads to our second hypothesis.

H2: The initial values (α_i*) and rates of change (*β_{ij}*) for strategic IS alignment of a significant number of organizations will be outside of the sampling fluctuations of the mean value of the strategic IS alignment trajectory, thus distinct trajectories for each organization will be needed.*

According to our second hypothesis, there will be statistically significant variability of the individual organizational strategic IS alignment trajectories to warrant modeling distinct trajectories for each case. This provides us with the opportunity to address whether we can find variables that can explain the variability observed in the individual trajectories. A number of factors have been proposed as having an impact on strategic IS alignment (Byrd et al., 2006, Chan et al., 1997, Chan et al., 2006, Croteau and Raymond, 2004, Grant, 2003, Hu and Huang, 2006, Hussin et al., 2002, Johnston and Carrico, 1988, Kearns and Lederer, 2003, Reich and Benbasat, 2000, Sabherwal and Chan, 2001, Sabherwal and Kirs, 1994). Five factors, delineated in table 2.5.1, are considered in this study: performance, new leadership, resources, organizational size, and industry. These factors met the following criteria. Firstly, they have been mentioned as factors that affect the evolution of organizational phenomena in the punctuated equilibrium theory (Sastry, 1997, Tushman and Romanelli, 1985). Secondly, they have support in the strategic IS alignment literature; especially in the longitudinal studies that seek to offer a dynamic perspective of strategic IS alignment (Grant, 2003, Hirschheim and Sabherwal, 2001, Johnston and Carrico, 1988, Sabherwal et al., 2001). Lastly, each factor could be measured using secondary data from public databases such as *InformationWeek*, and COMPUSTAT. The next few subsections discuss these factors and draw hypotheses based on the punctuated equilibrium perspective.

3.4.2 Performance

Performance is one of the most important triggers for change. Business performance is tied to the survival or failure of the organization. The punctuated equilibrium model suggests that sustained low business performance may lead to lack of alignment and create pressure for change (Gersick, 1991, Sastry, 1997, Tushman and Romanelli, 1985). However, change can also result from negative prior IS success history (Chan et al., 2006). The history of IS success affects the relationship between IS and the business units. An unfavorable IS success history tends to create pressures for change.

The link between strategic IS alignment and organizational performance has been established in the literature (Byrd et al., 2006, Chan et al., 1997, Chan et al., 2006, Croteau and Raymond, 2004, Sabherwal and Chan, 2001, Sabherwal and Kirs, 1994). It has been shown that there is a positive relationship between strategic IS alignment and organizational performance (Chan et al., 1997, Chan et al., 2006, Sabherwal and Chan, 2001). Therefore, sustained low performance is related to a low level of strategic IS alignment. According to the punctuated equilibrium model, this misalignment introduces pressures for change that reduce the organizational inertia and move the organization toward revolutionary change (Sastry, 1997). This movement introduces a sharp fluctuation in the rate of change of the strategic IS alignment trajectory. Therefore, organizations with sustained low performance will most likely have lower levels of strategic IS alignment and higher rates of change in the strategic IS alignment trajectory in order to compensate for the low performance. This leads to our third hypothesis.

H3a: Higher (lower) values of organizational performance will be associated with higher (lower) initial values of the strategic IS alignment trajectory over the time period under consideration.

H3b: Higher (lower) values of organizational performance will be associated with lower (higher) rates of change in the strategic IS alignment trajectory over the time period under consideration.

The IS literature also proposes that the history of success in the IS function affects the attitudes of top management and IS users toward IS (e.g. Chan et al., 2006). Success in prior projects and other commitments builds credibility and affects the working relationship between IS and other functions. A history of failure has the opposite effect. Consequently, the strategic IS alignment trajectory is affected by history of IS success. Organizations in which prior IS success is high would be expected to have higher levels of trust, and greater partner relationships between IS and other functions, than organizations in which prior IS success is low. That is, higher values of prior IS success will be related to higher levels of strategic IS alignment. Also, higher levels of prior IS success will signify an IS function that consistently meets business expectations and needs. This means that there will be fewer changes needed to increase the alignment between the business and IS strategies. Therefore, the rate of change in strategic IS alignment will be less than that needed in an organization with lower levels of prior IS success. This leads us to our fourth hypothesis.

H4a: Higher (lower) values of prior IS success will be associated with higher (lower) initial values of the strategic IS alignment trajectory over the time period under consideration.

H4b: Higher (lower) values of prior IS success will be associated with lower (higher) rates of change in the strategic IS alignment trajectory over the time period under consideration.

3.4.3 New Leadership

Changes in the chief executive officer (CEO) and the senior executive team, as well as the organizational impacts of these changes, have been extensively studied in organization theory (e.g. Brown, 1982, Dalton and Kesner, 1983, Keck and Tushman, 1993, Miller, 1993, Shen and Cannella Jr., 2002, Tushman and Rosenkopf, 1996, Virany et al., 1992, Wiersema, 1992). Studies have found that CEO succession and senior executive team changes have associations with several variables such as organization size (Dalton and Kesner, 1983), successor type (Brown, 1982, Dalton and Kesner, 1983, Shen and Cannella Jr., 2002, Wiersema, 1992), environmental stability (Keck and Tushman, 1993, Tushman and Rosenkopf, 1996, Virany et al., 1992), organizational performance (Brown, 1982, Miller, 1993, Shen and Cannella Jr., 2002, Tushman and Rosenkopf, 1996, Virany et al., 1992), and strategy (Wiersema, 1992). Using longitudinal methods, Brown (1982) found that CEO change follows a pattern – there is a performance slide leading to CEO succession and then a subsequent return to pre-succession performance. Similarly, Wiersema (1992) and Miller (1993) found that there is significant strategic and organizational change after a CEO succession. In other words, replacing the CEO leads to organization changes that may impact IS strategic alignment.

From a punctuated equilibrium perspective, the executive leadership are responsible for the organization's strategic orientation (Tushman and Romanelli, 1985). During equilibrium periods, inertial forces operate to maintain the status quo (Wiersema, 1992). Tushman and Romanelli (1985) note that "only executive leadership can initiate and implement the set of discontinuous changes required to affect a strategic reorientation" (p.180). However, executives themselves may be constrained in their personal commitments and interdependencies by inertial forces so that revolutionary change is most often initiated by outside successors (Keck and Tushman, 1993, Tushman and Romanelli, 1985, Tushman and Rosenkopf, 1996, Virany et al., 1992). That is, revolutionary change is most likely possible when there is a change in executive leadership in both the business and the IT department. Executive succession is associated with major change in the composition and working relationships of the executive team. Sabherwal et al. (2001) found that changes in leadership played a critical role in triggering revolutionary change. A new chief information officer (CIO), particularly one from outside the organization, will most likely not be tied to the prevailing traditions and will be a force for change. However, Tushman and Rosenkopf (1996) note that merely changing the CEO without a concomitant change in executive team as a whole, will only trigger incremental change in the system (p.940). Organization transformations are often executed through dramatic change in the executive team. Therefore, the change in CIO alone is hypothesized to lead only to incremental change.

One of the key factors in strategic IS alignment is the relationship between the CEO and CIO (Earl and Feeny, 1994, Feeny et al., 1992). Earl and Feeny (1994) found that CEOs who support their CIOs and include them in their top leadership teams gain value from their IT departments. Feeny et al. (1992) suggested that an excellent relationship between the CEO and the CIO would be expected to correlate with progress in exploiting IT. Hence, strategic IS alignment is high where the CEO/CIO relationship is excellent. This alignment is disturbed once either one of the executives is changed. The level of IS strategic alignment drops due to the departure of either or both of these executives, and the new executives may change the direction of this relationship entirely. This means that the initial level of strategic IS alignment after a change in leadership will be low. Also, due to the resistance from the rest of the executive team, implementing change in IS strategic alignment will take place more slowly. However, if there is support for IT from the executive team, the pace of change will be faster (Chan and Reich, 2007). This leads us to the fifth hypothesis.

H5a: The period following a change in CIO will be associated with lower initial values of the strategic IS alignment trajectory than in the previous period.

H5b: The period following a change in CIO will be associated with higher rates of change in the strategic alignment trajectory than in the previous period.

3.4.4 Resources

Organizations seek a good return on their IT investment (Weill, 1992). Many studies have been conducted to discover the factors that affect the value of IT (Byrd et al., 2006). Byrd et al. (2006) proposed that strategic IS alignment is one such factor. They argued that closer alignment, which indicates a closer working relationship between IT and business, should lead to the development of more effective systems (p.309). They found that coordination alignment, outcome matching alignment, and outcome moderating alignment had a positive influence on the relationship between IT investment and firm performance. This means that high levels of alignment are expected to enhance the effect of IT investment in providing performance outcomes. Chan et al. (2006) also argued that firms with more resources will "focus more wealth on identifying and implementing technologies that support business strategy" (p.30). The level of IT investments will therefore affect the motivation of a firm's management to align IS with the business, as well as the ability to focus on alignment issues within the firm(Chan et al., 2006, Grant, 2003). Therefore, more IT investment should be necessary for a firm to maintain higher levels of strategic IS alignment. The initial layout of IT investment should be high in order to build the infrastructure that is a necessary part of the strategic IS alignment process. As the IT competency grows, and strategic IS alignment develops, greater IT investment will be required to maintain a high level of alignment. However, "firms in any one industry invest different amounts of their available capital to achieve different levels of information technology investment intensity" (Weill, 1992, p. 310). This means that there will be a lot of variability between organizations in the value of their IT investment due to their size and the industry they compete in. This leads us to the sixth hypothesis.

H6a: Controlling for industry and organization size, higher levels of IT investment will be associated with higher initial values of strategic IS alignment

H6b: Controlling for industry and organization size, higher levels of IT investment will be associated with lower rates of change in the strategic IS alignment trajectory

3.4.5 Organizational Size

As organizations grow in size, their structures become more elaborate and complex (Tushman and Romanelli, 1985). Increased size is associated with increased differentiation and specialization of subunits and with a dispersion of power (Thompson, 1967). Therefore, larger organizations tend to have more formal arrangements to meet environmental contingencies than smaller organizations. Chan et al. (2006) argue that organizational size affects strategic IS alignment partly through its influence on IT governance, that is, larger organizations more commonly introduce formal processes and structures to ensure alignment where smaller organizations do not either have the capacity or the motivation to do so. This means that we would expect higher levels of alignment in larger organizations than in smaller ones.

Furthermore, Tushman and Romanelli (1985) argue that larger organizations emphasize incremental as opposed to discontinuous change. Larger organizations are more efficient at coordination through formalized and ritualized behavior where organizational inertia builds to high levels and there is firm-wide resistance to all but incremental change. Thus, holding environmental conditions constant, larger organizations will have higher alignment profiles than their smaller counterparts who are more prone to engage in revolutionary change. This behavior will translate into higher initial alignment values for larger organizations and lower rates of change, as well as significantly less fluctuations in the strategic IS alignment trajectory. Our seventh hypothesis is:

H7a: Controlling for industry and level of IT investment, larger organizations will be associated with higher initial values of the strategic IS alignment trajectory.

H7b: Controlling for industry and level of IT investment, larger organizations will be associated with lower rates of change in the strategic IS alignment trajectory over the time period under consideration.

3.4.6 Industry

The strategy literature has argued for the importance of recognizing industry as a key variable in strategy research (Harrigan, 1985, Hrebriniak and Snow, 1980, Mpoyi, 2003). Hrebriniak and Snow (1980) advanced both substantive and methodological reasons for studying organizations in their industrial context. Industry is a key factor in distinguishing both the type of external issues faced by top management and the strategies used to adapt to the environment (Hrebriniak and Snow, 1980).This dissertation study explicitly recognizes industry as a major factor in strategic IS alignment.

Environmental uncertainty involves the degree of uncertainty and instability in a firm's environment with respect to political, legal and social factors (Chan et al., 2006). Firms in the same industry face similar environmental uncertainty which is likely to be different than that of firms in other industries (Johnston and Carrico, 1988). Johnston and Carrico (1988) discussed three environmental factors that accounted for the variation of strategic use of IT among industries: significant information content in key relationships, limited life of products and services, and increased competitive pressures within the industry. These factors make each industry's environment different hence exposing organizations to different contexts with respect to strategic IT use. These factors also introduce a lot of turbulence into a firm's environment.

Turbulence in the environment affects a firm's building of competence and appropriate activities thereby increasing the pressure for change. Tushman and Romanelli (1985) propose that effective organizations will engage in reorientations which correspond to technological, legal or social conditions. That is, effective organizations will be more in tune with their environment than their less effective peers. Low performing organizations will either not attempt to reorient or will reorient too frequently as they try to align themselves to environmental conditions. Therefore, high performing organizations will consistently have higher strategic IS alignment values than low performing organizations in any given time period. This leads us to our eighth hypothesis.

H8a: High performing organizations will have higher initial values of strategic IS alignment than low performing organizations in the same industry environments.

H8b: High performing organizations will have lower rates of change of the strategic IS alignment trajectory than low performing organizations in the same industry environments.

Chan et al. (2006) also argued that organizations in uncertain environments will be more likely to place greater reliance on IT and give more attention to strategic IS alignment. Their reasoning, based on the information processing theory, proposes that organizations in uncertain environments will require more information, which in turn will increase their information processing needs. This will make information systems important and strategic tools as the organization seeks to expand its information processing capabilities to reduce uncertainty. Hence, strategic IS alignment will be higher in firms facing an uncertain environment than in firms facing stable environments. However, firms in an uncertain environment will have to expend more effort to sustain their IS alignment than firms in stable environments. Due to the rapidly changing environment, the rate of change of IS alignment for a firm in an uncertain industry environment is expected to be higher than that in a firm whose environment is stable. Chan et al. (2006) found mixed results with respect to the effect of environmental uncertainty on alignment. However, they state that the results of their study might reflect the difficulty in aligning two dynamic phenomena, that is, alignment and uncertainty. This study uses a longitudinal method to map the relationship between environmental uncertainty and strategic IS alignment trajectory. This leads us to the ninth hypothesis.

H9a: High performing organizations in uncertain industry environments will have a higher initial value for strategic IS alignment than high performing organizations in stable industry environments.

H9b: High performing organizations in uncertain industry environments will have higher rates of change in the strategic IS alignment trajectory than high performing organizations in stable industry environments.

In summary, the model I am proposing, based on the punctuated equilibrium theory, hypothesizes that the strategic IS alignment trajectory will trace a pink noise trajectory and will be affected by the five factors discussed. Figure 3.3.1 captures the two dimensions of dynamic behavior that the model will be testing, that is, the magnitude and slope (rate of change) of the strategic IS alignment trajectory. The model suggests that the magnitude and the slope will be associated with the predictor variables at different time points.

In this chapter, the theoretical background of the model in figure 3.1.1 has been discussed beginning with a brief overview of the punctuated equilibrium model on which this research is based. Hypotheses were then developed in order to test the theory. The hypotheses are summarized in table 3.4.1 below. The next chapter provides the research method and approach that will be undertaken in this study.

Table 3.4.1 Summary of Hypotheses and Tests

#	**Hypothesis**	**Statistical Test**
1	The mean trajectory of the strategic IS alignment function will be defined by the dynamic equation $y_i = \alpha_i + \beta_{ij}\lambda^{\gamma} + \varepsilon_{ij}$, which defines a growth trajectory with a "pink noise" behavior, and where α_i is the initial value, β_{ij} is the slope of the trajectory, λ^{γ} is the time variable with γ being the inverse power, and ε_{ij} is the error term.	Power Law Analysis Random Coefficients Modeling

2	The initial values (α_i) and rates of change (β_{ij}) for strategic IS alignment of a significant number of organizations will be outside of the sampling fluctuations of the mean value of the strategic IS alignment trajectory, thus distinct trajectories for each case will be needed.	Random Coefficients Modeling
3a	Higher (lower) values of organizational performance will be associated with higher (lower) initial values of the strategic IS alignment trajectory over the time period under consideration.	Random Coefficients Modeling
3b	Higher (lower) values of organizational performance will be associated with lower (higher) rates of change in the strategic IS alignment trajectory over the time period under consideration.	Random Coefficients Modeling
4a	Higher (lower) values of prior IS success will be associated with higher (lower) initial values of the strategic IS alignment trajectory over the time period under consideration.	Random Coefficients Modeling
4b	Higher (lower) values of prior IS success will be associated with lower (higher) rates of change in the strategic IS alignment trajectory over the time period under consideration.	Random Coefficients Modeling
5a	The period following a change in CIO will be associated with lower values of the strategic IS alignment trajectory than in the previous period	Random Coefficients Modeling
5b	The period following a change in CIO will be associated with higher rates of change in the strategic alignment trajectory than in the previous period	Random Coefficients Modeling
6a	Controlling for industry and organization size, higher levels of IT investment will be associated with higher initial magnitudes of strategic IS alignment	Random Coefficients Modeling
6b	Controlling for industry and organization size, higher levels of IT investment will be associated with lower rates of change in the strategic IS alignment trajectory	Random Coefficients Modeling
7a	Controlling for industry and level of IT investment, larger organizations will be associated with higher initial mean magnitudes of the strategic IS alignment trajectory.	Random Coefficients Modeling
7b	Controlling for industry and level of IT investment, larger organizations will be associated with lower rates of change in the strategic IS alignment trajectory over the time period under consideration.	Random Coefficients Modeling
8a	Within each industry, high performing organizations will have higher initial values of strategic IS alignment than low performing organizations.	Random Coefficients Modeling
8b	Within each industry, high performing organizations will have lower rates of change of the strategic IS alignment trajectory than low performing organizations.	Random Coefficients Modeling

9a	High performing organizations in uncertain industry environments will have a higher initial value for strategic IS alignment than high performing organizations in stable industry environments.	Random Coefficients Modeling
9b	High performing organizations in uncertain industry environments will have higher rates of change in the strategic IS alignment trajectory than high performing organizations in stable industry environments.	Random Coefficients Modeling

Chapter 4

RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

This chapter has four main sections. First, the research design is discussed. Second, the measures are operationalized from secondary data. Third, the data collection approach is explained, and fourth, the sample characteristics are presented.

4.2 Research Design

The focus of this study is on the development of strategic IS alignment over time, and on the potential predictors of this trajectory. In order to examine this issue, a longitudinal research methodology is necessary. This is because the dynamic nature of a phenomenon cannot be captured through cross-sectional research designs. Similarly, case study research, though usually longitudinal, has very serious limitations in terms of generalizability of findings. Therefore, the study uses a quantitative, empirical, longitudinal approach. Furthermore, rather than use simulated data, the study uses real data collected from well known and well regarded business and IT databases such as Standard and Poor's COMPUSTAT and *InformationWeek*[2] . This enabled the research to accomplish its objectives of studying change in the strategic IS alignment construct over time.

4.3 Measures

4.3.1 Introduction

Measures for each variable used in this dissertation study were operationalized based on prior research to the greatest extent possible. Business strategy was operationalized after Sabherwal and Sabherwal (2007). We used well known accounting ratios to measure Business performance. Prior

[2] I am grateful to Ms. Lisa Smith, a senior research manager at InformationWeek, for providing the data for this dissertation.

IS performance was operationalized as the annual ranking in the *InformationWeek 500* list of innovative users of IT. A dummy variable was used to show the presence or absence of new leadership. The resources construct was measured by the monetary investment in IT as a percentage of the total organizational budget. Organization size and industry used the usual measures from prior literature. However, a new measure of IS strategy was formulated based on the IT investments made by the firms. This measure and its derivation is explained in detail in section 4.3.3. Table C1 in appendix C provides a summary of the different measures used and their operationalizations.

4.3.2 Business Strategy

Business strategy attributes were measured using secondary data from the COMPUSTAT database as well as the annual reports and 10K reports of organizations.

Table 4.3.2.1 below provides a summary of all the business strategy related measures, based on the work of Sabherwal and Sabherwal (2007), which were used in this study. Six variables (scope, product-market dynamism, liquidity, asset efficiency, fixed asset intensity, and long-range financial liability) were used to classify firms into Prospectors, Analyzers and Defenders. Two additional variables (firm size, and R&D intensity) were used to validate the classification.

Table 4.3.2.1 Measures used to classify and validate Business Strategy (Source: Sabherwal & Sabherwal, 20073)

Variables	Data Sources	Measures
Classification Variables		
Scope	COMPUSTAT	Natural log of the average of the number of four-digit SIC codes in the year of the alignment computation as well as the year before the alignment computation
Product-Market Dynamism	COMPUSTAT	Mean of: (a) the change in the number of four-digit SIC codes from two years prior to the alignment computation to one year prior to the alignment computation, and (b) the change in the number of four-digit SIC codes from the year prior to the alignment computation to the year of the alignment computation
Liquidity	COMPUSTAT	Current Ratio = Current Assets/Current Liabilities
Asset Efficiency	COMPUSTAT	Total Asset Turnover = Sales/Total Assets
Fixed Asset Intensity	COMPUSTAT	Fixed Assets/Total Assets
Long-Range Financial Liability	COMPUSTAT	Debt to Equity Ratio
Validation Variables		
Firm Size	COMPUSTAT	Natural Log of market value of equity
R&D Intensity	COMPUSTAT	R&D expense/Net Sales

The COMPUSTAT database provides information on business strategy, performance, organizational environment and size (see table C1 in appendix C). The business strategy is necessary for the computation of the strategic alignment construct, which is obtained via the profile deviation calculation (Sabherwal and Chan, 2001). The variables from the COMPUSTAT database are transformed into business strategy components that are then used as a basis for drawing up the company's business strategy profile. Table 4.3.2.2 provides a key to understanding

[3] Sabherwal and Sabherwal (2007) used five more variables Firm-level uncertainty, a classification variable, and Correlation between firm and market returns, decentralization, executive's age, and executives' tenure, which are validation variables, in their analysis. The first two were derived from the CRSP database to which the current study had no access. Therefore, only six classificatory variables and two validation variables are used in this study.

the variables that make up the business strategy components. Table 4.3.2.3 presents the COMPUSTAT data items and the variable transformation formulas.

Table 4.3.2.2. Variable Codes for Business Strategy Variables

Code	Description
ROA	Return on Assets
ROE	Return on Equity
ROI	Return on Investment
FAI	Fixed Asset Intensity
ASE	Asset Efficiency
LFL	Long-Range Financial Liability
RDI	Research and Development Intensity
LIQ	Liquidity
SIZE1	Log of Number of employees of the firm
SIZE2	Natural log of Market Value of Equity
DEC	Decentralization
SCO	Scope
PMD	Product-Market Dynamism

Table 4.3.2.3. COMPUSTAT data items and the variables in which they are used

COMPUSTAT Item	Description	Used in Variable	Formula
IBCOM	Income before extraordinary items and discontinued operations; less preferred dividends but before adding savings due to common stock equivalents (in millions)	ROA ROE ROI	$\left(\frac{IBCOM}{AT}\right)\times 100$ $\left(\frac{IBCOM}{CEQ}\right)\times 100$ $\left(\frac{IBCOM}{ICAPT}\right)\times 100$
AT	Total assets (in millions)	ROA FAI	(see above)

		ASE	$\left(\frac{PPENT}{AT}\right)$ $\left(\frac{SALE}{AT}\right)$
CEQ	Total shareholders (common shareholders) interest (in millions)	ROE LFL	(see above) $\left(\frac{DLTT+DLC}{CEQ}\right)$
ICAPT	Sum of total long-term debt, preferred stock, minority interest, and common equity (in millions)	ROI	(see above)
SALE	Total annual sales (in millions)	ASE RDI	(see above) $\left(\frac{XRD}{SALE}\right)$
ACT	Cash and other current assets expected to be realized in next 12 months (in millions)	LIQ	$\left(\frac{ACT}{LCT}\right)$
LCT	Liabilities due in one year including portion of long term debt (in millions)	LIQ	(see above)
EMP	Total number of employees (in thousands)	SIZE1 DEC	$\log(EMP)$ $\left(\frac{\#EXECOfficers}{EMP}\right)$
DLTT	Long term debt (in millions)	LFL	(see above)
DLC	Debt in current liabilities (in millions)	LFL	(see above)
PPENT	Cost, less accumulated depreciation, of tangible fixed property used in the production of revenue (in millions)	FAI	(see above)
MKVAL	Monthly market value calculation based on all common shares whether actively	SIZE2	$\ln(MKVAL)$

	traded or not (in millions)		
XRD	Costs related to the development of new products and services (in millions)	RDI	(see above)
PSIC	Primary standard industry classification codes for lines of business (4 digit code)	SCO	$\ln\left(\frac{\sum_{i=year-1}^{year}\left(SIC_i\right)}{2}\right)$
SSIC	Secondary standard industry classification codes for lines of business (4 digit code)	PMD	$\left(\frac{\left(SIC_{year-2}-SIC_{year-1}\right)+\left(SIC_{year-1}-SIC_{year}\right)}{2}\right)$

In order to clarify how IS alignment is calculated, a company TECH1 is used as an illustration. Since the same calculations are done for each year in the data set, the example will only use the year 2002 figures. Table 4.3.2.4 below presents the components used to calculate the business strategy and the other COMPUSTAT-related constructs for TECH1.

Table 4.3.2.4. Business Performance, Industry and Firm Size Data Items from COMPUSTAT

Variable Name	Variable	COMPUSTAT Data 2002	TECH1 Values 2002	Mean 2002	STDev 2002
Return on Assets	ROA	IBCOM: -$230m AT: $1653m	-11.1568	1.4022	15.8973
Return on Equity	ROE	CEQ: $1719m	-13.3884	4.3576	220.9663
Return on Investment	ROI	ICAPT: $1719m	-13.3884	1.4374	80.3308
Industry	IND	SIC: 35	35		
Firm Size1	SIZE1	EMP: 3000	1.1939	2.6348	1.3503
Firm Size2	SIZE2	MKVAL: $1806m	7.4988	7.9872	1.8081
R&D Intensity	RDI	XRD:$113m SALE:$933m	0.1212	0.0573	0.0915

The steps used in the transformation of COMPUSTAT data items into business strategy components for TECH1 are as follows.

First, the business strategy variables for TECH1 are calculated using the data items extracted from the COMPUSTAT database and enumerated in table 4.3.2.3 above. Using these formulae the values in table 4.3.2.4 are obtained (the means and standard deviations for the sample are included in the table).

The **second** step is to standardize the variables. This is accomplished by using the following formula (4.3.2.1):

$$z = \frac{x - \mu_x}{\sigma_x} \quad \text{.....................} \ (4.3.2.1)$$

where z represents the normalized or standardized variable, x represents the raw score, μ_x stands for the population mean, and σ_x represents the population standard deviation. For TECH1, this information is included in table 4.3.2.5 below.

Table 4.3.2.5. Business Strategy Example Calculation using TECH1 Data

Variable Name	Variable	COMPUSTAT Data	TECH1 Value 2002	Mean 2002	StDev 2002	Normalized Values (2002)
Scope	SCO	#SIC2001: 19 #SIC2002: 13	2.7726	2.1764	0.9797	0.6085
Product Market Dynamism	PMD	ΔSIC1: 15 ΔSIC0: 6	9.0000	5.0960	4.6078	0.8473
Liquidity	LIQ	ACT: $1659m LCT: $339m	4.8742	1.6481	0.9874	3.2674
Asset Efficiency	ASE	SALE: $933m AT: $2062m	0.4523	1.0677	0.8812	-0.6983
Fixed Asset Intensity	FAI	PPENT: $249m AT: $2062m	0.1206	0.2821	0.2220	-0.7276
Long-Range Financial Liability	LFL	DLTT: $0 DLC: $0 CEQ: $1719m	0.0002	2.1352	17.5945	-0.1213

The **third** step is to identify the ideal profile for each strategy type and operationalize the high, medium and low as 1, 0, and -1 respectively thus giving table 4.3.2.6 below. Using this information, the **last** step is to compute the distance from the standardized values of TECH1 variables to each of the ideal profiles using the formula (4.3.2.2) below:

$$d_E = \sqrt{\sum \left(x_i - I_i\right)^2} \qquad (4.3.2.2)$$

where *i* represents the ith item in the profile. For example, to calculate the distance from TECH1 in 2002 to the analyzer strategy:

$$d_{Analyzer} = \sqrt{\left(0.6085\text{-}0\right)^2 + \left(0.8473\text{-}0\right)^2 +}\left(3.2674\text{-}0\right)^2 + \left(\text{-}0.6983\text{-}0\right)^2 + \left(\text{-}0.7276\text{-}0\right)^2 + \left(\text{-}0.1213\text{-}(\text{-}1)\right)^2$$
$$= 3.6759$$

Similarly, $d_{Defender} = 5.2541$ and $d_{\Pr ospector} = 3.0242$. Since the distance to the prospector strategy is the shortest distance, we conclude that TECH1 is more inclined toward a prospector type of strategy.

Table 4.3.2.6. Ideal Profile for each of the three generic business strategies

DEFENDER			**ANALYZER**			**PROSPECTOR**		
H	M	L	H	M	L	H	M	L
1				0				-1
		-1		0		1		
		-1		0		1		
1				0				-1
1				0				-1
	0				-1	1		

4.3.3 Information Systems Strategy

IS strategy was measured as realized strategy, that is, strategy evident in IS investment decisions and IS deployments as contrasted with intended IS strategy (Chan et al., 1997, Mintzberg, 1978, Mintzberg and Waters, 1982, Mintzberg and Waters, 1985). The attributes of IS strategy were measured from secondary data contained in the *InformationWeek 500* database using the strategy components derived from the work of Sabherwal and Chan (2001), that is, operational support systems, interorganizational systems, market information systems, and strategic decision support systems. However, the classificatory framework used was proposed by Chan et al. (1997) and was meant to be a parallel to the strategic orientation of business enterprises (STROBE) classification of business strategy (Venkatraman, 1989a). Chan et al. (1997) derived IS strategy from decisions that managers had used to leverage and support the business strategy. Although this is a legitimate way to derive the IS strategy for the organization, some critics have argued that IT should often challenge business and not just follow and support it (Chan and Reich, 2007). The business and IS strategies should co-evolve rather than having the IS strategy being derived from the business strategy (Benbya and McKelvey, 2006b, Henderson and Venkatraman, 1993). Table 4.3.3.1 below provides a mapping of the elements of the two classifications using questionnaire items.

Table 4.3.3.1. Survey Items in support of the mapping of STROEPIS onto IS Strategy Defined By Sabherwal and Chan (2001)

STROEPIS (Chan et al., 1997)	**IS Strategy (Sabherwal and Chan, 2001)**	
Internal Defensiveness IS deployments used by the business unit to improve the efficiency of company operations.	1. Our IS improve the efficiency of our day-to-day business operations. 2. Our IS support effective coordination across functions (e.g., marketing, manufacturing) and product lines.	**Operational Support Systems**
Analysis IS deployments used by the business unit when conducting analyses of business situations.	1. Our IS provide us with the facts and figures we need to support our day--to-day decision making. 2. Our IS enable us to develop detailed analyses of our present business situation. 3. Our IS provide sufficiently detailed information to support prudent decision making. 4. Our IS provide sufficiently detailed information to support prudent decision making. 5. Our IS support detailed analyses of major business decisions.	
External Defensiveness IS deployments used by the business unit to strengthen marketplace links.	1. Our IS enable us to develop stronger links with suppliers. 2. Our IS enhance our ability to negotiate with our suppliers. 3. Our IS enhance our ability to negotiate with our customers. 4. Our IS enable us to develop stronger links with customers.	**Interorganizational Systems**
Aggressiveness IS deployments used by the business unit when pursuing aggressive marketplace action.	Our IS assists us in setting our prices relative to the competition.	**Market Information Systems**
Innovativeness IS deployments used by the business unit to facilitate creativity and exploration.	Our IS help us introduce new products and/or services in our markets.	
Proactiveness IS deployments used by the business unit to expedite the introduction	1. Our IS help us monitor changes in our market share. 2. Our IS permit us to rapidly adjust our prices.	

of products/services.		
Risk Aversion IS deployments used by the business unit to make business risk assessments.	Our IS facilitate strategic business planning.	**Strategic Decision Support Systems**
Futurity IS deployments used by the business unit for forecasting and anticipation purposes.	1. Our IS help us model possible future outcomes of alternative courses of action. 2. Our IS are used to forecast key indicators of business performance.	

The classification of the categorical (1,0) technology investments data (shown for 2002 in table 4.3.3.2) into strategy profiles was done through a ranking process akin to a Delphi study. All the technologies appearing in the survey between 1999 and 2007 were listed and then mapped onto the *str*ategic *o*rientation of the *e*xisting *p*ortfolio of *i*nformation *s*ystems applications (STROEPIS) framework (Chan et al., 1997) by three PhD students independently (including the author) based on whether the IT supported the given categories of Internal defensiveness (ID), Analysis (AN), External Defensiveness (ED), Aggressivenes (AG), Innovativeness (IN), Proactiveness (PR), Risk Aversion (RA) or Futurity (FU) enumerated in table 4.3.3.1 above. An interrater reliability analysis using the Kappa statistic was performed to determine consistency among raters. Since there were more than two raters and the data were categorical, Fleiss' kappa was used (Fleiss, 1971) and found to be κ = 0.702 (p <.0.001), 95% CI (0.556,0.817) which is considered high (Landis and Koch, 1977). The disagreements have been worked out through discussions. This was done to ensure some validity and reliability in the classification. This is a new method of deriving the IS strategy and it will need to be validated. However, there is a precedent for this method in the strategy literature. Mintzberg and Waters (1982) in their study on tracking strategy in an entrepreneurial firm, inferred the firm's strategy from the documents and records that showed investments that the firm had actually made. They called this realized strategy (where intentions have been realized). We followed similar reasoning in coming up with this IS strategy derivation scheme. Indeed, what better way to know what managers intended (deliberate strategy) or even did not intend (emergent strategy) than to examine the pattern of their IT investment decisions? This method of inferring the IS strategy should be very highly correlated with survey data and even data collected in an interview.

Table 4.3.3.2. Deployed Technologies List and TECH1 data values for 2002

Deployed Technology List	**TECH1 Data**
01 [] ERP and back office integration	1
02 [] Customer-resource management (CRM) systems	1
03 [] Electronic commerce applications	1
04 [] Electronic business: extranet or supply chains	1
05 [] Data warehousing software	1
06 [] OLAP or data mining tools	0
07 [] Knowledge Management and Collaborative Software	0
08 [] Networked Storage (SANs)	1
09 [] Linux-related tools or applications	0
10 [] Windows 2000 server/ 2003 server	0
11 [] Windows 2000 /XP /Vista	0
12 [] Wireless technology	1
13 [] Unix multiprocessing servers	0
14 [] Java programming tools	1
15 [] XML-based applications	1
16 [] Handhelds (using technologies such as Windows CE, Palm OS)	0
17 [] Internet application servers (PC or RISC CPUs)	0
18 [] Enterprise application integration software	0
19 [] Virtual Private Network	0
20 [] Telecommunications Services such as leased lines, WAN, Internet	0
07 [] Business-intelligence tools	1
08 [] Internal collaboration tools	1
09 [] B-to-B collaboration tools	1
16 [] Fiber-optic local area networks	0
18 [] Web services (applications using Soap, UDDI, XML)	1
19 [] Applications constructed of reused components or objects	1
20 [] Mobile commerce	1
03 [] Business process-management software	0
21 [] Remote-access tools	0
22 [] Instant messaging	0
15 [] Wireless Fidelity	0
04 [] Business performance-management software	0
05 [] Supply-chain software	0
14 [] Voice-over-IP applications	0
16 [] Content filtering/anti-spam software	0
17 [] Intrusion-detection software	0
18 [] Content-management software	0
19 [] Product lifecycle management software	0
20 [] Grid computing	0
21 [] RFID (Radio Frequency Identification) technology	0
23 [] Project-portfolio management software	0
24 [] Mapping/Global Positioning System technologies	0

25 [] Asset-management software	0

Table D1 in appendix D summarizes the measures used for IS strategy and table 4.3.3.1 above presents the basis for transforming the STROEPIS classification into the Sabherwal and Chan (2001) categorization.

To illustrate the process, table 4.3.3.2 above provides the complete list of technologies that were surveyed over the 8 year period and the technologies that were deployed in 2002 by TECH1(denoted by 1 in the table). Using the maximum number of technologies that could be mapped into STROEPIS for that year (i.e. ID=12, AN=4, ED=3, PR=2, AG=1, IN=2, RA=1, FU=3) as the denominator, we count the number of technologies deployed in TECH1 that fit into each category and we use that as the numerator to find the proportion of deployed technologies that help the firm in each of the strategy areas. For TECH1 the proportions come to: ID=0.75, AN=1, ED=1, PR=0.5, AG=0, IN=1, RA=1, FU=1. These values are then translated into the four generic strategies through averaging. The values for TECH1 are Operational systems (OSS) 0.88, interorganizational systems (IOS) 1, market information systems (MIS) 0.5, and strategic decision support systems (SDS) 1. The means and standard deviations for these systems in 2002 are: OSS (0.69, 0.22), IOS (0.58, 0.35), MIS (0.55, 0.34), and SDS (0.69, 0.37). As with the business strategy components, these variables are then standardized to produce normalized scores as given in table 4.3.3.3.

Table 4.3.3.3. Standardized Scores for TECH1 Technology Data Items in 2002

OSS 2002	IOS 2002	MIS 2002	SDS 2002
0.81	1.21	-0.2	0.83

4.3.4 Strategic Information Systems Alignment

The **strategic IS alignment** construct itself was calculated using the profile deviation approach. The steps to obtaining the strategic IS alignment value are reviewed in the works of Sabherwal and Kirs (1994), Sabherwal and Chan (2001), and Chan et al. (2006). Appendix E presents a summary of the steps involved in calculating the strategic IS alignment value.

The business strategy in conjunction with the theoretically derived ideal IS strategy profile is used to calculate the Euclidean distances from the ideal strategy to the actual strategy. The high, medium, and low values for the ideal IS strategies were operationalized as 1, 0, and -1 as in table 4.3.4.1 below.

Table 4.3.4.1. Ideal Strategy Profiles for IS Strategy

	DEFENDER Efficiency Strategy	**ANALYZER Comprehensiveness strategy**	**PROSPECTOR Flexibility Strategy**
OPERATIONAL SUPPORT	1	0	-1
INTERORGANIZATIONAL	1	1	0
MARKET INFORMATION	-1	1	1
STRATEGIC DECISION SUPPORT	1	1	1

Using formula (4.3.2.2) above, the distance between the ideal profile (in the case of TECH1 in 2002, it was the Prospector business strategy which translates into an IS strategy for flexibility) and the actual profile is computed. For TECH1 this is:

Distance to flexibility strategy,

$$d_{fs}=\sqrt{\left(0.81\text{-}(\text{-}1)\right)^2+}\ \left(1.21\text{-}0\right)^2+\left(\text{-}0.2\text{-}1\right)^2+\left(0.83\text{-}1\right)^2=2.4789\,.$$

Smaller Euclidean distances indicate a higher degree of alignment and in keeping with Sabherwal and Chan (2001, pg. 23) and many other researchers, the distance was subtracted from 1 to convert it into a deviation score which indicates the degree of misalignment (distance from 1) with 1 indicating perfect alignment. Negative deviation scores indicate that the Euclidean distance is greater than one. The degree of alignment for TECH1in 2002 is given by 1 – 2.4789 = -1.4789, which was not very good considering the degree of alignment in 2001 was -0.4832. However, the mean degree of alignment in 2002 for all firms was -1.3727.

4.3.5 Performance

Prior research has utilized objective **performance** indicators from secondary data (Bharadwaj et al., 1999, Hitt and Brynjolfsson, 1996). Although "researchers in economics have long expressed concern over the use of accounting rates of return as proxies for the economic rate of return" (Bharadwaj et al., 1999, p1009), IT researchers continue to use the historical accounting measures due to their ease of access and interpretation. Accounting rates of return are easy to calculate and due to their standard format, easy to compare between companies. More importantly, Accounting measures are available for longitudinal analyses. Therefore, this study uses the common accounting measures: return on equity (ROE), return on assets (ROA) and return on investment (ROI).

4.3.5.1 Business Performance

Business performance is measured in terms of the three accounting ratios ROE, ROA and ROI. The formulas for calculating these ratios are given in table 4.3.2.3 and the values for these ratios for TECH1 in 2002 are given in table 4.3.2.4. In order to reduce on the complexity of the data analysis, the three business performance measures were turned into a latent score (Campbell et al., 2007). Campbell et al. (2007) provide a computationally robust way to calculate the latent score. The resulting index provides a reliable measure of a company's business performance.

4.3.5.2.Prior Information Systems Success

Prior IS success (a measure of **IS performance**) has been measured in different ways including perceptual measures (Chan et al., 2006). This study uses the *InformationWeek* 500 ranking of the organization to capture IS success. In years where only the first 250 organizations are ranked, organizations ranking between 251 to 500 were coded 375 (denoting the midpoint between 251 and 500), while organizations that were not ranked for that particular year were coded $500 + 0.5X_i$ where X_i = number of firms in *InformationWeek* 500 beyond the 500 for year i.

4.3.6 New Leadership

The **new leadership** construct was represented by a dummy variable that will be coded 0 for no change in leadership or 1 for change in leadership. Data for the CIO change measure is in the *InformationWeek* 500 database. The data provide the highest ranked executive in charge of IT, therefore, the CIO designation may not apply to all the firms. Some firms have chief technology officers (CTOs), others have non-IT executives leading their IT departments. However, the measure used in this study concerns the effect of a change in the highest ranked IT executive. The data presents names of the IT executive for each year that the firm appears in the *InformationWeek* 500 list. For TECH1 between 2000 and 2007, the following individuals were the highest ranked IT executives D. Starr (CIO), J. Kenan (Acting CIO and Senior Vice President) and A. Bose (CIO). The first change took place in 2001, therefore, the CIO variable has a value of 1 for 2001. The second change took place in 2002, which was also coded as 1. The rest of the appearances by TECH1 in the dataset are coded 0, reflecting the fact that no change in IT executive took place in each of those years. The data, including the coding of change, are shown in table 4.4.5.1 below. Also included are the total numbers of CIO change events for each year in the sample, that is, all CIO changes for all 728 organizations in the sample per year.

Table 4.3.6.1. CIO change data for TECH1 from InformationWeek

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
IT Exec	D. Starr	J. Kenan	A. Bose	A. Bose	A. Bose	A. Bose		
Title	CIO	Acting CIO & Sr. VP	CIO	CIO	CIO	CIO		
Coding	0	1	1	0	0	0	Missing	Missing
Total CIO Change Events (Sample)	181	149	128	116	64	140	135	108

4.3.7 Resources

The **resources** construct was measured using the IT investment variable, which is the ratio of dollar investment in information technology in the prior year to the total sales in the prior year (Bharadwaj et al., 1999). The items used in calculating the IT investment measure are also derived from *InformationWeek 500* database. The information is found in the IT investment question in the survey. The executives are asked what percentage of the firm's annual sales revenue their IT budget represents. This provides a ratio that is comparable across firms. For TECH1 in 2002, this ratio is: IT Investment ratio = INV_{01} = 3% or 0.03. Table 4.4.6.1 provides the means and standard deviations for all the firms from 2001 through 2007. The year 2000 is excluded because the year 1999 values were not available at the time of completion of this study.

Table 4.3.7.1 TECH1 data Items for IT Investment and Means and Standard Deviations for the sample

Year + 1	2001	2002	2003	2004	2005	2006	2007	2008
Mean (INV)	4%	3%	4%	3%	4%	3%	5%	5%
Standard Deviation	9%	2%	9%	4%	6%	4%	8%	6%
Sample size	328	321	327	343	241	216	237	213
TECH1	11%	3%	5%	Missing	4%	4%	Missing	Missing

4.3.8 Organization Size

Organization size utilized two measures, which are, the natural logarithm of the market value of equity and the logarithm of the number of employees of the firm. This is reflected in the computations for SIZE1 and SIZE2 in table 4.3.2.4. The size variable is used often in prior literature. However, it is mainly used as a control variable, which provides us with only a general idea of how size actually affects strategic IS alignment. This dissertation explicitly includes size as a main test variable.

4.3.9 Industry

Finally, the **industry** variable used two different measures: primary industry and two digit standard industry classification (SIC) code obtained from the *InformationWeek* and COMPUSTAT databases respectively. An illustration of the value of industry is given in table 4.3.2.4 above.

In addition, a measure of environmental uncertainty based on industry was used. Following Harrigan (1985) and others, sales growth was used as a measure for the phase of industry development, that is, new entrepreneurial phase, speculative (competitive) phase, or mature and stable phase (Harrigan, 1985, Hrebriniak and Snow, 1980). There has been a long-standing debate about the nature of environmental uncertainty. Some researchers have accepted the validity of perceptual measures as opposed to objective measures. However, traditionally objective measures have been used as described in Tosi et al. (1973):

> "The nature of uncertainty may be subject to several interpretations. A reasonable interpretation would be the degree of accuracy with which one can predict the future. Where there is less variance, there is more certainty. In terms of sales or income those firms or industries that have more stable patterns would be in more certain environments. This measure, dealing with the range of fluctuations of revenues or expenditures, is generally called volatility. Similar measures have traditionally been used as estimates of risk." (Tosi et al., 1973)

In this dissertation, environmental uncertainty was measured as the variance in sales growth within each industry (Stanley et al., 1996). This measure was recognized and used in Harrigan (1985). Tosi et al. (1973) also used Compustat data to compute volatility. This measure was used in testing hypothesis 9. The sales figures were first deflated to 2000 prices using the GNP price deflator to remove the effects of inflation (Bureau of economic Analysis, 2008). Sales growth was calculated using the simple formula below:

$$\mathbf{R} = \mathbf{S}_0 / \mathbf{S}_1 \qquad (4.3.9.1)$$

where $\mathbf{R}$ stands for the firm's annual growth rate, and, $\mathbf{S}_0$ and $\mathbf{S}_1$ are the firm's sales in two consecutive years (Stanley et al., 1996). However, due to insignificant variability in industry average sales growth, I substituted average sales growth with variability in sales growth. Table 4.3.9.1 below provides details of the measure. The uncertainty level was calculated by trichotomizimg the range of the variance in sales growth. This produced 4 industries considered as high in environmental uncertainty, and 15 industries considered as stable industries. Only 1 industry, construction and engineering, was found to be moderate in uncertainty.

Table 4.3.9.1. Industry by Environmental Uncertainty

Industry Description	Mean	Variance	Uncertainty	Status
Banking & Financial Services	0.898997	0.267011	1	High
Consulting & Business Services	0.929826	0.297487	1	High
Energy & Utilities	0.891407	0.346581	1	High
Insurance	0.904779	0.322678	1	High
Automotive	0.891415	0.107901	3	Low
Biotechnology & Pharmaceuticals	0.831616	0.096829	3	Low
Chemicals	0.870949	0.108775	3	Low
Consumer Goods	0.88003	0.082184	3	Low
Distribution	0.882623	0.098475	3	Low
Electronics	0.885176	0.122858	3	Low

Health Care & Medical	0.851663	0.082397	3	Low
Hospitality & Travel	0.887229	0.085414	3	Low
Information Technology	0.916051	0.116422	3	Low
Logistics & Transportation	0.868879	0.10499	3	Low
Manufacturing	0.876632	0.111844	3	Low
Media & Entertainment	0.889018	0.117283	3	Low
Metals & Natural Resources	0.854222	0.116561	3	Low
Retail: General Merchandising	0.91344	0.060239	3	Low
Telecommunications	0.877662	0.115365	3	Low
Construction & Engineering	0.894242	0.155102	2	Med

The tables below (4.3.9.2 and 4.3.9.3) provide descriptive statistics and correlations among the variables. In the descriptive statistics, size is in logarithmic units and the IS performance measure has a high mean due to the replacement of missing data with mean values as described in the measurement section. The business performance measure is an index of ROA, ROI, and ROE obtained using the latent variable score method. The CIO measure represents the number of CIO change events per firm in the 8 year period of the study.

Table 4.3.9.2 Descriptive Statistics

Descriptive Statistics			
	Mean	Std. Deviation	N
ALIGN	-1.399	1.1587	2511
SIZE	2.684	1.3537	5366
INVEST	3.871	6.5806	2327
ISPERF	456.000	208.0000	7280
R&D	0.053	0.0863	2490
BPERF	-0.002	0.9798	4809
CIO	0.301	0.4586	3739

Table 4.3.9.3. Correlations Among The Study Variables

Correlations							
	ALIGN	SIZE	INVEST	ISPERF	R&D	BPERF	CIO
SIZE	0.087**						
INVEST	0.040	0.026					
ISPERF	-0.313**	-0.109**	-0.095**				
R&D	0.071*	-0.211**	0.124**	0.031			
BPERF	0.010	0.073**	0.010	-0.002	-0.125**		
CIO	-0.082**	-0.005	0.021	-0.074**	0.067*	-0.010	
INDUS	-0.005	0.054**	-0.034	0.030**	-0.141**	-0.018	0.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

This section has provided information about the variables and how they were computed from the data items found in the COMPUSTAT and *InformationWeek* databases. Table C1 in appendix C summarizes all the measures used as predictor variables in this study. The next section discusses the data collection approach.

4.4 Data Collection Approach

Prior research on strategic IS alignment has used various approaches to collect data for their analyses including surveys (e.g. Byrd et al., 2006, Chan et al., 1997, Chan et al., 2006, Croteau and Raymond, 2004, Hussin et al., 2002, Kearns and Lederer, 2003, Sabherwal and Chan, 2001, Sabherwal and Kirs, 1994), and interviews (e.g. Boddy and Paton, 2005, Grant, 2003, Hu and Huang, 2006, Johnston and Carrico, 1988, Reich and Benbasat, 2000, Sabherwal et al., 2001). While each of these approaches have their merits, they do not fit our research objective of modeling the trajectory of strategic IS alignment over time. Therefore, we use archival data to both provide factual data that does not depend on informants recollections and to provide a big enough sample size to enhance generalizability of results. To our knowledge none of the strategic IS alignment research has exclusively used archival data.

Archival data provides a wide array of variables and a long enough time history to perform causal analysis. When the data is obtained from independent data consolidation research organizations such as *InformationWeek* and *Standard and Poor's*, there is a degree of reliability of the data that might be lacking in internal documents. Another benefit is that this type of data is usually consistent across organizations and time periods making it possible to perform comparative analyses. The main weakness of archival data is that the data constrains the type of analysis that can be performed. The weaknesses are mitigated, somewhat, by using a flexible and robust data analysis method.

4.5 Sample

The main sources of the data are: 1) Standard and Poor's COMPUSTAT database of company financial data, 2) *InformationWeek 500* annual lists of innovative users of information technology, and 3) 10K documents from companies' SEC filings. The combination of COMPUSTAT and *InformationWeek 500* surveys provide a consistent, longitudinal view of companies' evolution in IT use. The many data elements collected make it possible to have a rich view of the context of, as well as the potential factors that affect, IT use. This study uses data from 2000 through 2007 of companies that appear in both *InformationWeek 500* and COMPUSTAT. A questionnaire survey for 2002 has been included in appendix F.

Tables 4.5.1, 4.5.2, and 4.5.3 below provide some descriptive information about the sample. Manufacturing is the best represented industry in the sample with a total of 102 companies, and construction and engineering is the least represented, having only 16 companies in the sample.

Table 4.5.1. Sample by Industry Classification

Industry	Firms	Mean Revenue Per Industry (Millions)							
		2000	2001	2002	2003	2004	2005	2006	2007
Automotive	22	30,932	28,334	29,907	30,904	33,397	33,349	38,334	34,638
Banking & Financial Services	71	14,828	14,293	13,435	14,672	15,893	18,587	23,976	27,503
Biotechnology & Pharmace-uticals	17	12,598	13,691	14,829	15,040	16,267	17,377	18,900	20,721
Chemicals	30	6,116	6,035	6,224	6,810	7,863	8,790	9,850	10,076
Construction & Engineering	16	3,355	3,733	4,474	4,917	5,687	6,856	7,331	6,301
Consulting & Business Services	40	6,165	6,632	6,446	6,640	7,111	7,138	8,490	8,370
Consumer Goods	46	7,270	7,901	8,201	9,029	10,088	10,867	11,687	12,929
Distributor	27	10,426	10,108	10,773	11,936	13,281	14,204	15,552	17,153
Electronics	26	7,016	6,348	6,546	7,436	8,088	8,115	9,103	11,073
Energy & Utilities	66	11,855	13,869	10,174	11,619	13,387	16,491	17,910	19,157
Health Care & Medical	27	5,644	7,721	8,133	8,962	10,295	12,294	14,476	17,888
Hospitality & Travel	18	4,356	4,235	4,107	4,292	4,851	5,656	6,587	7,404
Information Technology	47	10,380	9,634	9,661	10,799	12,024	13,134	15,428	19,232
Insurance	34	9,790	9,750	10,015	10,967	12,139	13,248	14,791	15,393
Logistics & Transportation	31	7,708	7,472	7,928	8,459	9,480	10,710	11,322	11,826
Manufacturing	102	7,997	7,795	7,527	7,992	8,995	9,481	10,663	11,489
Media & Entertainment	25	4,715	5,935	6,306	6,477	6,981	7,048	7,701	8,660
Metals & Natural Resources	18	6,075	6,098	5,801	6,536	8,787	9,389	10,479	10,539
Retail	44	15,512	16,655	18,054	19,092	20,822	23,304	25,431	29,133
Telecommunic ations	22	14,837	14,567	13,914	13,940	14,842	16,375	19,414	24,837

Table 4.5.2. Number of Business Following an Ideal Strategy Profile Per Year

Business Strategy	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Analyzer	482	492	488	510	343	327	330	348
Prospector	150	115	102	101	163	159	182	156
Defender	96	108	130	113	201	201	195	189
Missing Data	0	13	8	4	21	41	21	35
Total	728	728	728	728	728	728	728	728

Since this is a longitudinal study, it is expected that there will be missing data through attrition and other causes. This means that the sample is constituted as an unbalanced panel of data. However, missing data is not expected to be a major issue. It's effect will primarily be on the sample size. The effective sample sizes for the years 2000 through 2007 are 331, 327, 345, 339, 254, 305, 281, and 331, respectively. Depending on the pattern of missing data (that is, whether data are missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR)) the analytic method chosen has different treatments available for the missing data (Bollen and Curran, 2006).

Chapter 5

ANALYSIS OF DATA AND RESULTS

5.1 Introduction

This chapter presents the analysis of the archival data. The data were merged into a spreadsheet file and checked for errors. A total of 728 usable data cases were obtained. Of these, only 58 had alignment data for all 8 years as is shown in table 5.1.1 below. This means that most organizations fail to make it consistently in the ranks of the most innovative users of IT.

Table 5.1.1. Number of Cases By Number of Years

Number of Years	Number of Cases
8	58
7	41
6	44
5	80
4	82
3	103
2	139
1	181

The analysis proceeded as follows: Firstly, the business strategy construct was validated using organization size and research and development (R&D) intensity. Secondly, the first two hypotheses were tested in sequence using two methods: a power law analysis of the probability density function of the alignment data (Clauset et al., 2009) and the random coefficients modeling (RCM) technique (Bliese, 2009, Ployhart et al., 2002), which is a powerful longitudinal data analysis method that provides information on the level and rate of change in a construct. Thirdly, the rest of the hypotheses were tested using maximum likelihood estimation in the R statistical and graphing environment (the NLME procedure).

5.2 Validation of Business Strategy

There have been concerns raised in prior literature that strategy groupings are rarely validated in research studies that use categorizations such as the Miles and Snow's (1978) classification of business strategy (Zahra and Pearce, 1990). Validation is important to provide assurance of the validity of the construct. Six variables (scope, product-market dynamism, liquidity, asset efficiency, fixed asset intensity, and long-range financial liability) were used to classify firms into Prospectors, Analyzers and Defenders. Two additional variables (firm size, and R&D intensity) were used to validate the classification. One variable (R&D Intensity) is a strategy variable while the other (firm size) is a contextual variable. Prior studies have found that firms pursuing a defender strategy tend to be larger than firms following analyzer and prospector strategies, and also that analyzers tend to be larger than prospectors (Doty et al., 1993). Defenders "obtain efficiency by relying on routine technologies and economies of scale gained from largeness"(Doty et al., 1993). Analyzers have a dual focus that leads them to engage in both mass production (like the defender) and research and development (like the prospector). Therefore, the analyzer's dual focus may lead to increased size. The prospector focuses on flexibility. Consequently, prospectors are structurally organic with few hierarchical levels, that is, they tend to be small organizations(Doty et al., 1993). Prior studies have also suggested that defenders and prospectors differ on the intensity of their R&D investments (Doty et al., 1993, Hambrick, 1983). Hambrick (1983) found that defenders have low levels of R&D intensity while prospectors have high levels of R&D intensity. Sabherwal and Sabherwal (2007) did not find any significant difference in R&D intensity between defenders and analyzers or between analyzers and prospectors. Table 5.2.1 below provides the expected relationships among the variables.

Table 5.2.1. Validation of Business Strategy Classification.

Variable	**Defender**	**Analyzer**	**Prospector**	**References**
Firm Size	Large	Medium	Small	Doty et al. (1993)
R&D Intensity	Low	?	High	Hambrick (1983)

Validation of the classification of business strategy was done using the analysis of variance (ANOVA) method with the Tamhane multiple comparison test. Each year of data were entered separately into the ANOVA calculation. The data were found to have unequal variances; therefore a Brown-Forsythe robust test of equality of means was used to ensure that the test statistic was not biased. The results for all the years were quite consistent.

5.3 Data Analysis and Results

5.3.1 Power Law Analysis

Many empirical quantities cluster around a mean value and follow a Gaussian normal distribution in which there is a negligible amount of probability for values far removed from the mean. However, there are many distributions that do not fit this pattern(Andriani and McKelvey, 2009). One such distribution is the power law distribution which is associated with many social and physical phenomena including the world wide web, journal reference networks, population of cities, intensities of earthquakes and the number of species per genus (Goldstein et al., 2004, James and Plank, 2007, Mitzenmacher, 2003, Newman, 2006, Clauset et al., 2009). In the power law distribution, the probability of extreme events occurring is not negligible. In fact, the tails of the distribution hold a lot of interest from a mathematical perspective[4] (Clauset et al., 2009). Strategic IS alignment has been argued to follow a power law distribution (Dooley and Van de Ven, 1999). In particular, the strategic IS alignment trajectory has been hypothesized to follow a "pink noise" trajectory where the inverse power α (known as the exponent or scaling parameter) has a value close to 1.

[4] The power law distribution and other non-Gaussian distributions with "fat"-tails have been considered problematic by those that follow a General Linear Model philosophy Newman, M. E. J. (2006) *Contemporary Physics,* **46,** 323 - 351.. However, Clauset et al. (2009) argue that it is precisely for its mathematical properties that do not fit into a Gaussian model that the Power Law is interesting. The mathematical properties of Power Laws, which sometimes lead to surprising physical consequences, appear in a diverse range of natural and man-made phenomena Clauset, A., Shalizi, C. R. & Newman, M. E. J. (2009) *SIAM Review,* **51,** 661 - 703.. Pierpaolo and McKelvey (2009) advise that organization science would do well to include Pareto or Zipf distributions in theory building.

Power law distributions of continuous data are described by the probability density function (PDF) $p(x)$ such that:

$$p(x) = \Pr(x \le X < x + dx) = Cx^{-\alpha} \qquad (5.3.1.1)$$

where X is the observed value and C is a normalization constant [5] (Goldstein et al., 2004, Mitzenmacher, 2003, Newman, 2006, Clauset et al., 2009). Mathematically, it is clear that this density function diverges as $x \to 0$ therefore there must be a lower bound to the power law behavior, which we will denote by $x_{\min}$ such that $x_{\min} > 0$. Newman (2006) determined that provided $\alpha > 1$, it is straightforward to calculate the normalizing constant C and then rewrite equation 5.3.1.1 as:

$$p(x) = \frac{\alpha - 1}{x_{\min}} \left(\frac{x}{x_{\min}} \right)^{-\alpha} \qquad (5.3.1.2)$$

In many instances it is also useful to consider the complementary cumulative distribution function (CDF) of the power law distributed variable defined as:

$$P(x) = \int_{x}^{\infty} p(x')dx' = \left(\frac{x}{x_{\min}} \right)^{-\alpha+1} \qquad (5.3.1.3)$$

This CDF is useful in quantifying the differences between the data and the power law model. The distance between the CDF of the data and the CDF of the fitted model is measured using the Kolmogorov-Smirnov statistic D defined as:

$$D = \max_{x \ge x_{\min}} \left| S(x) - P(x) \right| \qquad (5.3.1.4)$$

where $S(x)$ is the CDF of the data and $P(x)$ is the CDF for the power law model that best fits the data where $x \ge x_{\min}$.

There are other common statistical distributions that do not fit the Gaussian pattern and may be considered as alternatives to the power law distribution. Table 5.3.1.1 below shows the functional form ($f(x)$) and the normalization constant C for the power law and a number of other distributions.

---

[5] The normalization constant C is found by solving the equation $\int_{x_{\min}}^{\infty} Cf(x)dx = 1$ for continuous data

Clauset, A., Shalizi, C. R. & Newman, M. E. J. (2009) *SIAM Review,* **51,** 661 - 703, Newman, M. E. J. (2006) *Contemporary Physics,* **46,** 323 - 351.

Table 5.3.1.1. Power law and similar distributions (source: Clauset et al. 2009)

Distribution Name	Functional Form $f(x)$	Normalization Constant C
Power Law	$x^{-\alpha}$	$(\alpha-1)x_{\min}^{\alpha-1}$
Power Law with cutoff	$x^{-\alpha}e^{-\lambda x}$	$\frac{\lambda^{1-\alpha}}{\Gamma(1-\alpha,\lambda x_{\min})}$
exponential	$e^{-\lambda x}$	$\lambda e^{\lambda x_{\min}}$
Stretched exponential (Weibull)	$x^{\beta-1}e^{-\lambda x^{\beta}}$	$\beta\lambda e^{\lambda x_{\min}^{\beta}}$
Log-normal[6]	$\frac{1}{x}\exp\left[-\frac{(\ln x-\mu)^2}{2\sigma^2}\right]$	$\sqrt{\frac{2}{\pi\sigma^2}}\left[erfc\left(\frac{\ln x_{\min}-\mu}{\sqrt{2}\sigma}\right)\right]^{-1}$

In order to test hypothesis 1, the following steps, taken from Clauset et al (2009), were followed:

1. Estimate the parameters $x_{\min}$ and α using the methods described in subsection 5.3.1.1 below.
2. Calculate the goodness-of-fit between the data and the power law model using the p-value as enumerated in subsection 5.3.1.2 below.
3. Compare the power law with alternative hypotheses via a likelihood-ratio test as described in subsection 5.3.1.3 below.

5.3.1.1 Fitting the Power Law Model to the Data

Most published research that fits power law models use a simple histogram. By taking the logarithm of both sides of equation 5.3.1.1 we note that the power law follows a straight line

[6] erfc is the complementary error function defined by $erfc(z)=1-erf(z)=\frac{2}{\sqrt{\pi}}\int_{z}^{\infty}e^{-t^2}dt$

plotted on logarithmic scales and defined by $\ln p(x) = \alpha \ln x + C$ where C is a constant. A common way to test for power law behavior is therefore to measure a quantity of interest, x, construct a histogram representing its frequency and plot that histogram on logarithmic scales (Clauset et al., 2009). Using linear regression on the logarithm of the histogram, the scaling parameter, α, can be calculated. Unfortunately, as Clauset et al. (2009) note, this procedure is fraught with systematic errors and provides an unreliable test of a power law distribution.

Figure 5.3.1.1. Plot of Alignment Data Points

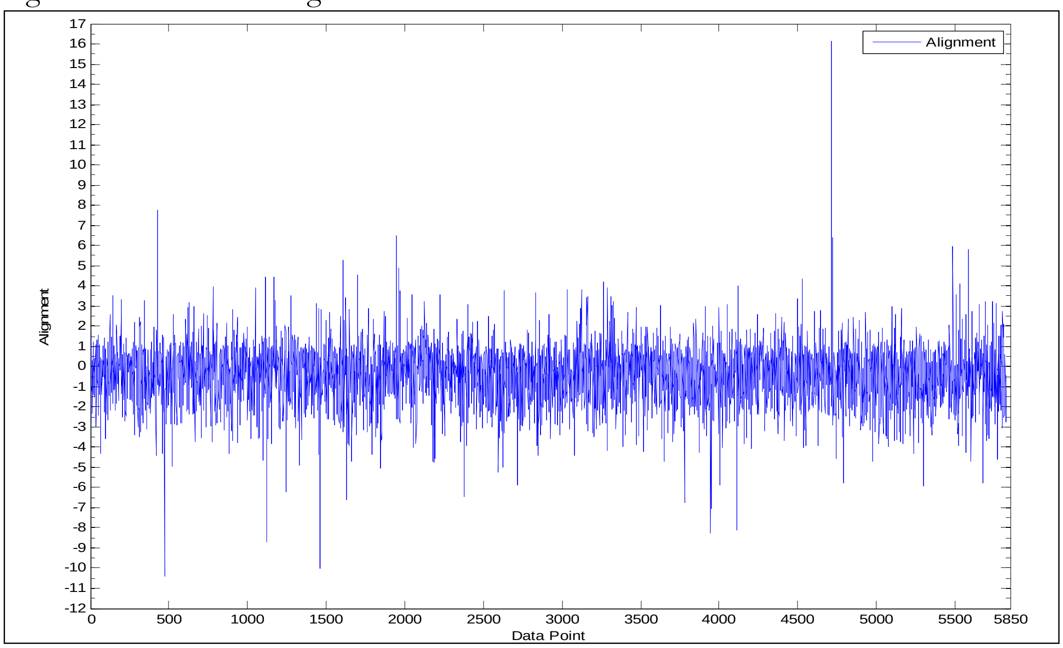
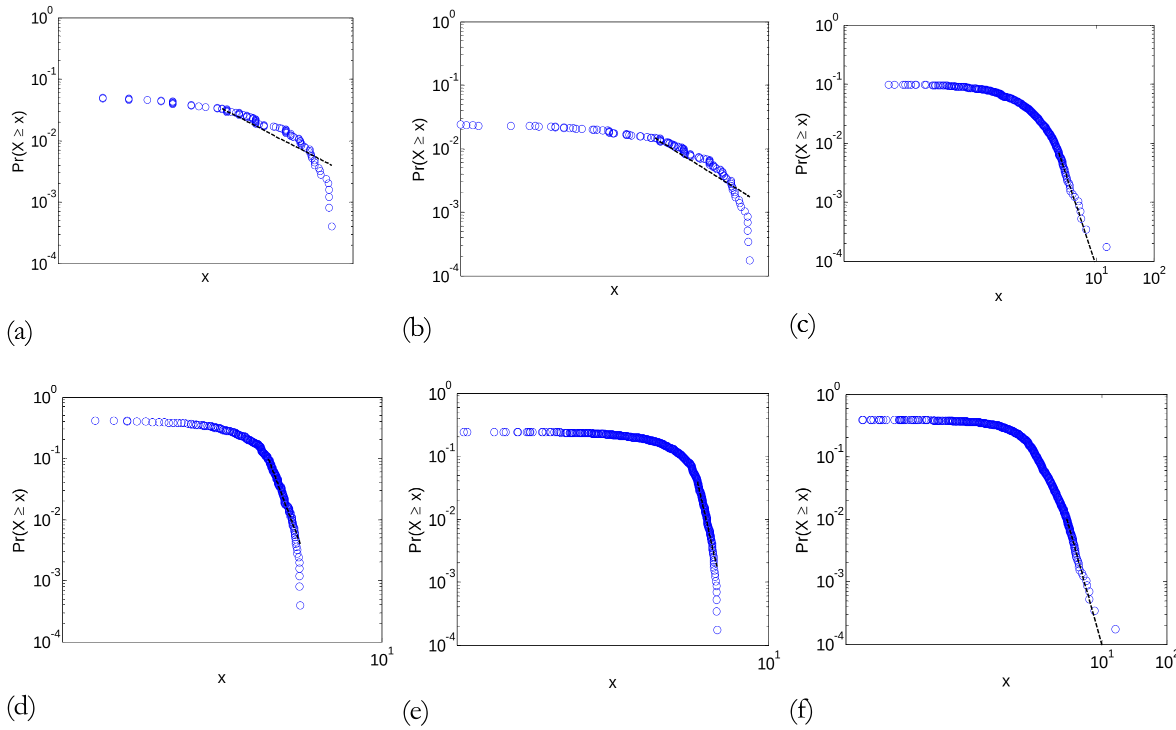


Figure 5.3.1.2. Graphs of Power Law Behavior in the Tails of the Data Distribution

Original Data	*EM Replacement*	*Regression Replacement*



Figures 5.3.1.1 and 5.3.1.2 provide a visual perspective on this problem. Figure 5.3.1.1 is a plot of the data points (n=5850) against the alignment value. Although the number of data points is large, only a small fraction is used in the analysis since $x > 0$ and most of our data points are less than zero (however, in this study several forms of the data are used to try and increase the sample size). The data plot is converted into a frequency histogram and used to construct probability density functions and cumulative density functions. Figure 5.3.1.2 presents the probability density functions (PDF) of the data where $x \geq x_{\min}$. This is in the tail of the PDF which is our primary area of interest. In each of the graphs, both axes are on logarithmic scales, that is, the PDFs are plotted on log-log graphs. The fit of the power law model is most often arrived at by visually comparing a straight line (in black) with the tail end of the distribution (in blue). Graphs (a), (b), and (c) represent PDFs with alignment data after subtracting the misaligned data from 1, while graphs (d), (e), and (f) represent PDFs with alignment data before subtracting from 1. Using visual comparison alone, graph (c) seems to be the best representation of a power law.

Visual methods of categorizing and fitting power law distributions introduce errors in the process and lead to inaccurate results. Clauset et al. (2009) have shown that many distributions that were thought to follow power law patterns do not in fact do so. A better way to estimate the scaling parameter is to use maximum likelihood estimators (MLE) which have been proved to give accurate parameter estimates in the limit of large sample size (Pilgram and Kaplan, 1998). The estimated scaling parameter using maximum likelihood can be obtained using the expression:

$$\hat{\alpha} = 1 + n\left[\sum_{i=1}^{n} \ln \frac{x_i}{x_{\min}}\right]^{-1} \qquad (5.1.3.5)$$

where x_i, i=1… n are the observed values of x such that $x_i \geq x_{\min}$. Since the value of the scaling parameter is of the utmost importance in classifying the distribution to which the data are compared, a measure of uncertainty in the estimate should be obtained to provide confidence in the accuracy of the estimate. Clauset et al. (2009) use the standard error as the measure of uncertainty[7]. To estimate the standard error of $\hat{\alpha}$ for reasonably large n and $x_{\min}$ the following expression is used:

$$\sigma = \frac{\hat{\alpha} - 1}{\sqrt{n}} + O\left(\frac{1}{n}\right) \qquad (5.1.3.6)$$

where the O notation expresses an infinitesimal asymptote[8] of the error term as $n \to \infty$.

Using functions written in MATLAB R2009a by Clauset and Shalizi based on their paper (Clauset et al., 2009) the values of $\hat{\alpha}$ and $x_{\min}$ were calculated as given in table 5.3.1.2 below. Values of other statistics that are important for establishing the fit of our data to the power law distribution are also given. Furthermore, estimates of the uncertainty in these parameters are given in parentheses. Three different forms of the data were tested. The first was the original alignment data with missing values removed, the second had missing data replaced using the EM algorithm

[7] We are aware that statisticians have argued for the use of confidence intervals as opposed to standard errors due to some undesirable characteristics of standard errors Neal, M. C. & Miller, M. B. (1997) *Behavior Genetics,* **27,** 113-120.. However, the procedures proposed by Clauset et al (2009) report and use standard errors and not confidence intervals.

[8] The formal definition of the big O notation states that if two functions $f(x)$ and $g(x)$ are some subset of the real numbers, then $f(x) = O(g(x))$ as $x \to \infty$ iff $\exists \ M \in \Re^+$ and $x_0 \in \Re$: $|f(x)| \leq M|g(x)|$ $\forall x > x_o$

while the third had missing data replaced using regression methods. Both the deviation score and the data before subtracting from 1 were tested. This table enables us to select **Regression** data as the best model based on a wholistic interpretation of the statistics, that is, the effect of error (size of standard errors), the sample size (tail size), and the p-value. Clauset et al.(2009) argue that the power law tests are very sensitive to sample size. Small sample sizes do not provide confidence in the estimates of the scaling parameter due to significant decay biases. Furthermore, the value of $x_{\min}$ affects the estimation of the scaling parameter. Estimates that are too low effectively force us to fit a power law to non-power law data thus introducing error into our model fitting. Therefore, the best results are for the **Regression** model. However, this model has a p-value below the cutoff, that is $p \leq 0.1$, which means that the distribution does not follow a power law form. Furthermore, the scaling parameter, $\hat{\alpha} \neq 1$, thereby not providing support for our first hypothesis.

Table 5.3.1.2 Calculated values of the scaling parameter $\hat{\alpha}$ and the lower bound $x_{\min}$ and other statistics

	Original Data	**1-Original Data**	**EM Algorithm**	**1-EM**	**Regression**	**1-Regression**
Scaling Parameter ($\hat{\alpha}$)	2.18 (0.0906)	3.42 (0.0447)	2.27 (0.1024)	5.33 (0.0873)	2.41 (0.0716)	5.49 (0.1060)
Lower Bound ($x_{\min}$)	0.124 (0.0043)	1.919 0.0003)	0.133 (0.0043)	2.42 (5.2E-13)	0.68 (0.0023)	3.31 (5.4E-13)
Log Likelihood (L)	34.21	-1820.00	39.50	-1420.00	-210.81	-1170.00
Tail Size[9] (n_{tail})	84 (9)	1543 (24)	85 (9)	2196 (37)	214 (14)	1274 (31)
p-value (p)	0.001	0.000	0.001	0.001	0.001	0.000
Kolmogorov-Smirnov (D)	0.1629	0.0821	0.1552	0.0315	0.0987	0.0634

[9] n_{tail} stands for the number of elements of the distribution $x: x \geq x_{\min}$

5.3.1.2 Calculate the Goodness of Fit of the Power Law Model to the Data

Fitting data to a power law form does not tell us the goodness of the fit. Almost any "fat" tailed distribution can be fit to a power law model. Most studies have used visual techniques to decide whether the model fits the data. This has led to spurious categorizations of distributions as following power law patterns. Therefore, Clauset et al (2009) suggest using the p-value to provide a quantitative test of the plausibility of the hypothesis that the data are close to the model. In this instance the p-value is used to confirm (rather than rule out) the hypothesis that the data follow a power law distribution, hence high values, not low, are good (Clauset et al., 2009). The p-value, which denotes the probability of getting by chance a fit as poor as the one observed, is obtained through a process of generating synthetic data sets with similar characteristics to the empirical data and fitting power law distributions to those data sets. The MATLAB functions written by Clauset and Shalizi allow for semiparametric repetitions of the fitting procedure and in this case 10000 repetitions were utilized in order to get an accurate p-value. Clauset et al. (2009), suggest a cut-off for the p-value at $p \leq 0.1$, that is, a distribution is ruled out if there is a probability of 1 in 10 or less that we could obtain a data set that fits the model as poorly as the data we have. The test statistic on which the p-value is based is the Kolmogorov-Smirnov distance (D) which is calculated using equation 5.3.1.4. Table 5.3.1.2 above provides the p-values and D's for each of the forms of the data. The p-values indicate that the data does not follow a power law model. Although IS alignment has been hypothesized to follow a pink noise pattern, the results of our test does not support the hypothesis.

5.3.1.3 Compare the Power Law Model to Alternative Models

It is important to note that although our data may not fit a power law distribution, it is possible that it could fit another "fat" tailed distribution (Pareto distribution or Zipf distribution). We could use our power law model to test whether other paretian distributions would have a better fit with our data by using the *likelihood ratio test*. The test computes the ratio of the likelihoods (or the logarithm of the ratio of the likelihoods), R, of the data under two competing distributions giving a positive or negative number depending on which distribution is better, or zero if the distributions fit equally. The test procedures are based on the work of Vuong (1989) and encompass both nested and non-nested models (Vuong, 1989). The steps include calculating the likelihood ratio, R, and using the standard deviation and p-value to see whether the observed sign of R is statistically significant.

Table 5.3.1.3 gives the results of the procedures described by Vuong(1989) after being applied to our data set. Only the regression replacement data before subtracting from 1 were used in the model comparisons. For each of the comparisons between two distributions, the log likelihood ratio, mean, standard deviation and normalized log likelihood ratio, as well as the one tailed p-value are given. The alternate distributions used are enumerated in table 5.3.1.1. Of the four alternate distributions, only the power law with exponential cut off uses Vuong's nested procedures.

Table 5.3.1.3. Log Likelihood Ratio Test Results

Model 1	**Model 2**	**LLR**	**Mean LLR**	**SD LLR**	**Normalized LLR**	**p-value (1-tailed)**
Power Law	Power Law with cut off	-11.2092				0.0000
Power Law	Exponential	-7.1368	-0.0333	0.7113	-0.6859	0.2464
Power Law	Weibull	-12.0251	-0.0562	0.3354	-2.4509	0.0071
Power Law	Log Normal	-12.6806	-0.0593	0.3339	-2.5963	0.0047

All of the alternate models, except the exponential model, perform better than the power law model as can be seen from the sign and value of the LLR, and the p-value. The log normal model seems to have a better chance of fitting the data. The power law model is not the best model to explain the variance in the data. This finding does not support our first hypothesis.

5.3.2 Random Coefficient Modeling

There are a number of statistical methods that can be used to analyze random-effects growth models of which the three primary ones are the hierarchical linear modeling (HLM) (Bryk and Raudenbush, 1987, Bryk and Raudenbush, 1992), the latent curve analysis (LCA) (Curran et al., 2004), and the random coefficients model (RCM) (Bliese and Ployhart, 2002, Pinheiro and Bates, 2000, Ployhart et al., 2002, Rabe-Hesketh and Skrondal, 2008). However, "the focus of procedure selection should be on the match of the statistical procedure to the nature of the dataset and to the analytic needs of the researcher" (Garson, 2002, p.163). HLM is useful in situations where each case is observed at different time points, or if the repeated measure is a count variable, or it has three or more levels of analysis. LCA, on the other hand, is more adept at handling measurement error, and providing alternative estimators and fit indices for continuous, dichotomous, or ordinal repeated measures (Bollen and Curran, 2006, p54). LCA also provides efficiency in modeling intra-individual change as well as inter-individual change and its predictors (Bentein et al., 2005, Bollen and Curran, 2006, Curran et al., 2004, Curran and Muthen, 1999, Meredith and Tisak, 1990, Ployhart and Hakel, 1998). Meredith and Tisak (1990) used a factor analytic approach to model growth curves thus building LCA on a structural equation modeling (SEM) foundation. However, this dissertation study uses the RCM method due to the following reasons (Bliese and Ployhart, 2002):

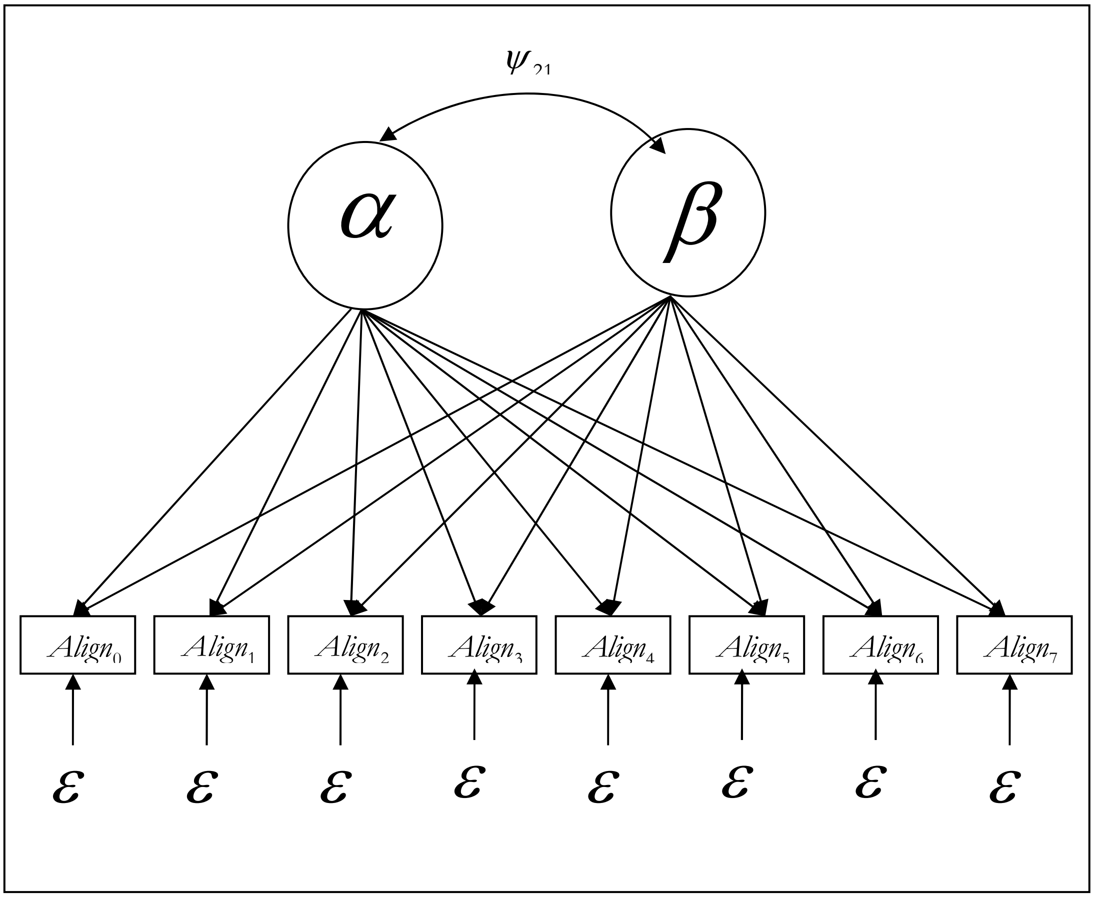
1) RCM is generally considered more robust in cases where there is missing data.
2) RCM is more flexible when incorporating, and modeling, time.
3) It is easier to incorporate multiple levels of nesting in RCM models than in LCA models.

In addition to all this, the RCM method is based on regression, which is easier to understand and use than SEM or HLM.

The RCM method is used to test both hypotheses 1 and 2, that is, the unconditional model where there are no predictor variables, and the rest of the hypotheses using conditional models. Figure 5.3.2.1 presents the unconditional model of IS alignment used in this study. In the unconditional model, only the link between the construct of interest, in our case strategic IS alignment, and time is explored. Our aim is to find out the form of the IS alignment trajectory and the amount of unexplained variability in the initial value and the rate of change of IS alignment over time. Therefore, the unconditional model provides us with information on the "growth" of strategic IS alignment over time. In particular, we are interested in finding out whether the trajectory of the strategic IS alignment construct is the same for all cases or not. We are also interested in knowing what percentage of change is owing to factors within each organization.

Although there are many commercially available software packages that offer an RCM module, such as STATA, SAS, SPSS and others, the analysis of the model was carried out using the open-source R computing environment and the nonlinear and linear mixed-effects models (NLME) package written by Pinheiro and Bates (Pinheiro and Bates, 2000).The R platform is freely available on the web (http://cran-r-project.org) and is supported by the community of users. An advantage of R is that its code is very succinct, hence it is easy to use.

Figure 5.3.2.1. Simplified Path Diagram of Unconditional Linear Latent Curve Model[10]



5.3.2.1 Growth Modeling: The Unconditional Model

[10] The ε 's represent the error in the strategic IS alignment construct $Align_i$ (where i = time period), and the α and β represent the initial magnitude of strategic IS alignment and the rate of change in strategic IS alignment (slope) respectively.

Growth modeling using RCM is similar to both multivariate hierarchical linear modeling and latent curve analysis. The general equation for an unconditional model is given in equation 5.3.2.1.

$$y_{it} = \alpha_i + \lambda_t \beta_i + \varepsilon_{it} \qquad (5.3.2.1)$$

where y_{it} is the value of the strategic IS alignment variable y for the i th case at time t, α_i is the random intercept for case i, β_i is the random slope for case i, and λ represents time (Bollen and Curran, 2006). Figure 5.3.2.2 below clarifies these concepts. In order to be consistent with the RCM literature, we will use the notation found in Bryk and Raudenbush (1992). Thus, equation 5.3.2.1 will be written as:

$$Alignment_{ij} = \pi_{00} + \pi_{10}\left(Time_{ij}\right) + r_{ij}$$

with: $\pi_{00} = \beta_{00}$ being the intercept fixed effect, and

$\pi_{10} = \beta_{10}$ being the slope fixed effect, and

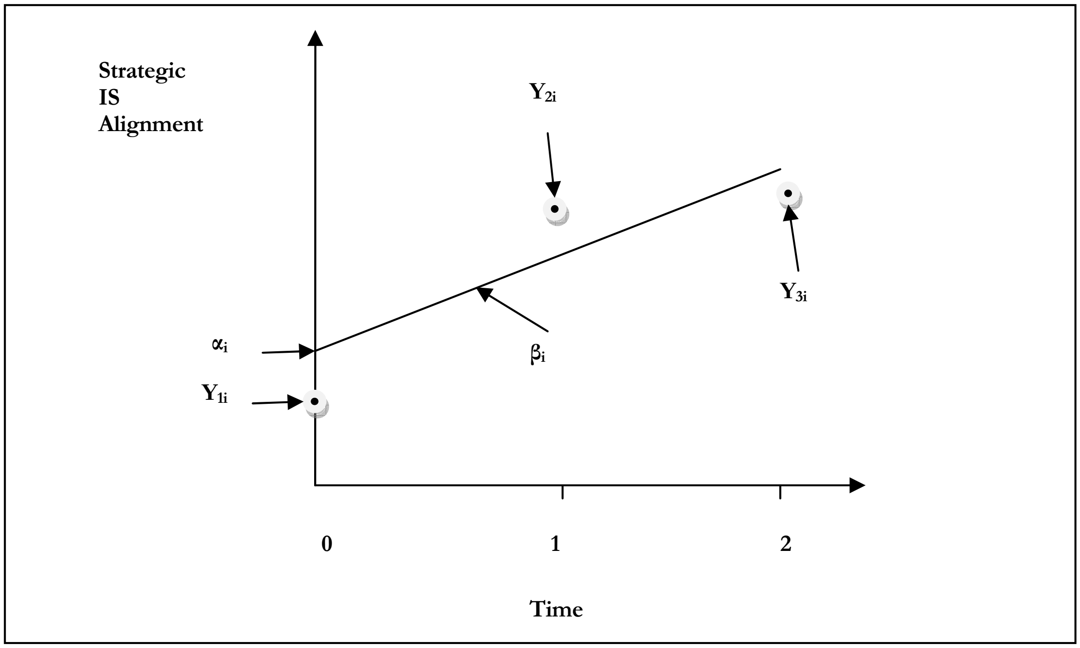
r_{ij} being the residual. (which together with other residual terms gives the random effect)

Putting all these together we get equation 5.3.2.2 below:

$$Alignment_i = \beta_{00} + \beta_{10}\left(Time_i\right) + r_i \qquad (5.3.2.2)$$

with the β symbols having the same meaning as α and β in equation 5.3.2.1 and ε being equivalent to r.

Figure 5.3.2.2. Hypothetical growth trajectory fit to three observed measures of strategic IS alignment (Curran, 2000)

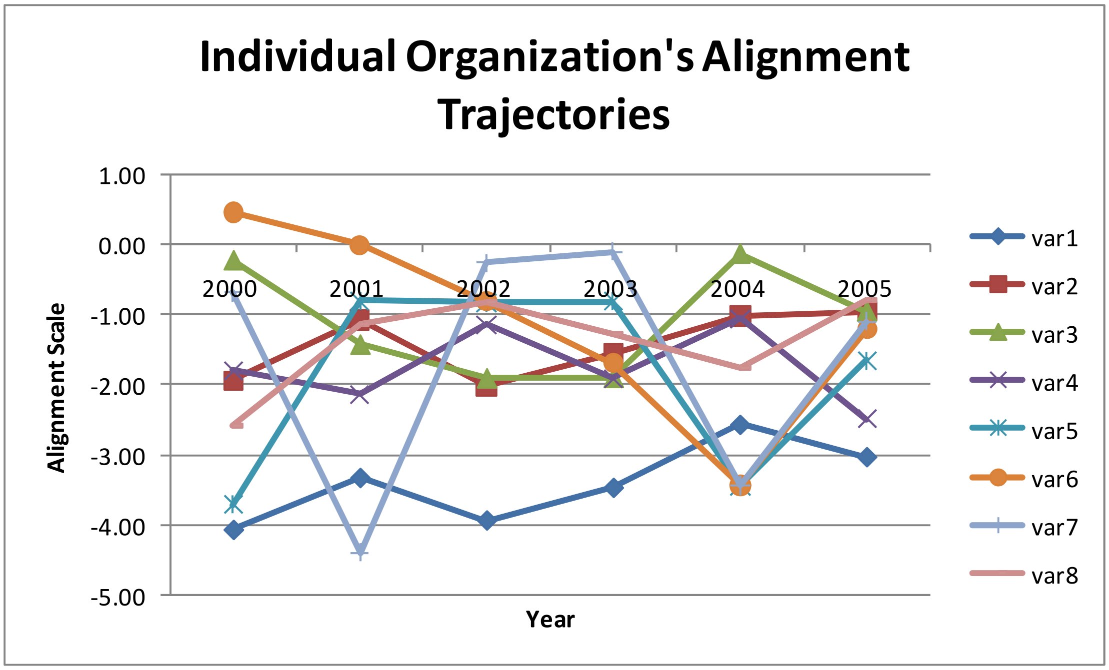


However, looking at figure 5.3.2.3 below, it is clear that the intercepts and slopes of the individual organizations vary randomly. Therefore, in building the unconditional model, the variance around the intercept and slope is tested for statistical significance. This necessitates the addition of extra residual terms to equation 5.3.2.2. If u_{0j} and $u_{1j}\left(Time_{ij}\right)+u_{2j}\left(Time_{ij}^{2}\right)$ represent the variance around the intercept and variance around the slope respectively, then equation 5.3.2.2 can be rewritten as:

$$\begin{aligned} Alignment_{ij} = &\left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right)\right] \\ &+\left[u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) + r_{ij}\right] \end{aligned} \qquad (5.3.2.3)$$

where the first term in square brackets represents the fixed part of the equation and the second term stands for the random part of the equation.

Figure 5.3.2.3. Individual IS Alignment Trajectories of 8 Companies



Ployhart et al. (2002) and Bliese and Ployhart(2002) have proposed a model building approach for RCM models that takes at least four steps:

Step 1. Establish baseline model.

The null model considered in this study is a regression model with only an intercept term, that is:

$$Alignment_i = \beta_{00} + r_i \qquad (5.3.2.4)$$

This model examines the properties of the dependent variable, Alignment, and provides information about the variability of Alignment in the individual company through the intra-class correlation coefficient (ICC). The ICC is calculated as follows:

$$ICC = \frac{u_{0j}}{\left(u_{0j} + \sigma^2\right)} \qquad (5.3.2.5)$$

with u_{0j} representing the variance of the intercept term, and σ^2 the variance of the residual error term. Table 5.3.2.1 provides the results of the null model including the value of the ICC.

Table 5.3.2.1. Results of the Null Model of IS Alignment

Variable	Estimate	SE	t Value	p-value	ICC
Intercept	-1.435	0.030	-47.640	0.000	0.210

The ICC indicates that 21 percent of the variance in IS Alignment can be explained by the properties of the individual company. Hence, there are differences among individual companies as reflected in figure 5.3.2.3.

Step 2. Model Time

Step two involves modeling the fixed relationship between time and IS alignment as depicted in equation 5.3.2.2. Model1 assumed a linear relationship and regressed time as a fixed variable onto IS alignment. The time variable was modeled with year 2000 being time 0 and year 2007 being time 7. The results in table 5.3.2.2 show that time does not have a statistically significant relationship with IS alignment, that is, the IS alignment data does not have a linear relationship with time. Two further models, Model2 and Model3, with a quadratic and a cubic term for time, respectively, were tested. Model2 resulted in a significant relationship for both the linear and quadratic trends as shown in the results table below and in figures 5.3.2.4 and 5.3.2.5 below. Model3, on the other hand, only had a significant quadratic term and non-significant linear and cubic terms. Higher powers of time were entered using the power polynomial method which has the advantage of orthogonalizing the different power effects, thus reducing multicollinearity (Bliese, 2009). IS alignment has a nonlinear relationship with time, which seems to be adequately captured by a quadratic trend. However, this is simply an approximation since the fitting of a power law model suggested that the relationship between IS alignment and time follows some form of Paretian distribution(Andriani and McKelvey, 2009). In any case, we conclude that time has a nonlinear relationship with IS alignment.

Table 5.3.2.2. Growth Model Parameter Estimates for Time Variable

Model	Variable	Estimate	SE	t Value	p-value
Model1	Intercept	-1.477	0.045	-33.003	0.000
	TIME	0.012	0.010	1.258	0.209
Model2	Intercept	-1.390	0.054	-25.526	0.000
	TIME	-0.079	0.034	-2.327	0.020
	$TIME^2$	0.013	0.005	2.802	0.005
Model3	Intercept	-1.438	0.030	-47.744	0.000
	TIME	1.425	1.122	1.270	0.204
	$TIME^2$	3.012	1.077	2.797	0.005
	$TIME^3$	0.932	1.064	0.876	0.381

Figure 5.3.2.4. Plot of Raw IS Alignment Data Against Time

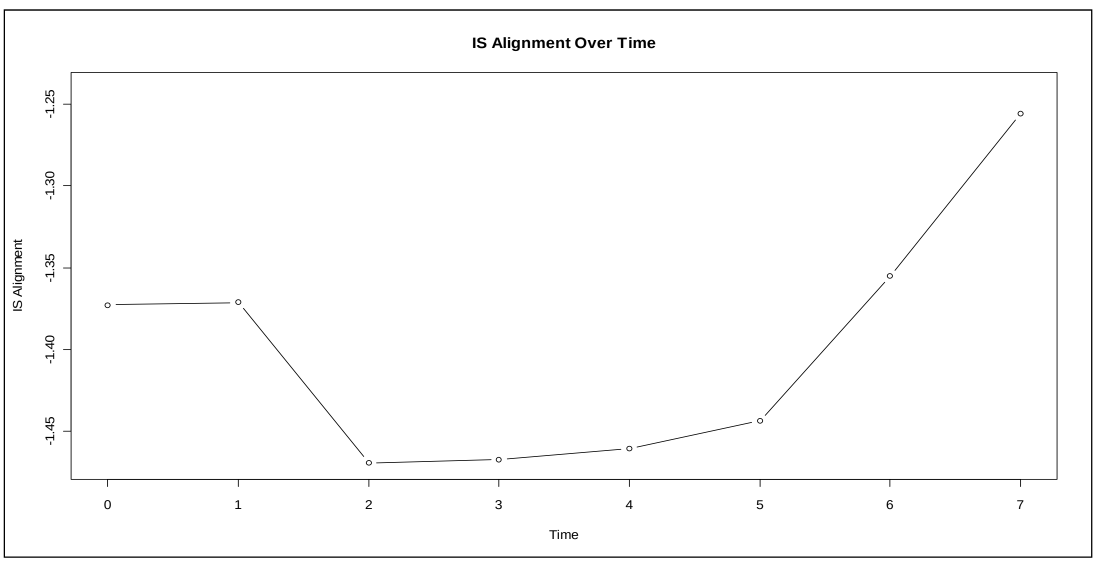
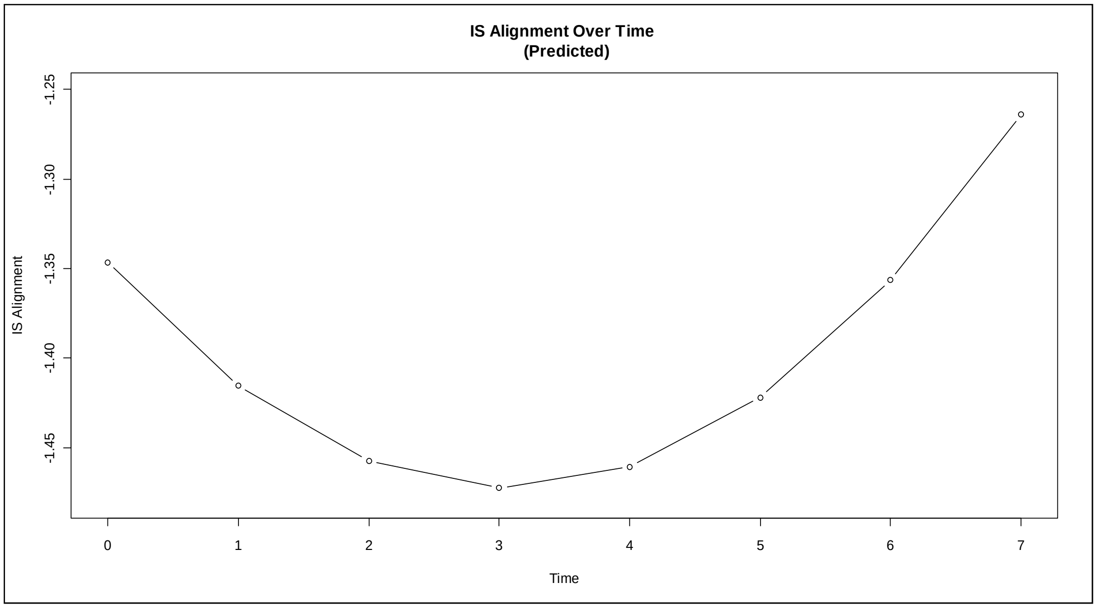


Figure 5.3.2.5. Plot of the Predicted IS Alignment From the Final Time Model



Step 3. Model Slope Variability

Model2 in step two assumes a constant relationship between time and IS alignment for every company in the sample. Specifically, Model2 assumes that each company decreases IS alignment by 0.079 points each year and that the rate of decrease (deceleration in the slope) is 0.013 points per year^2. However, given the variability in figure 5.3.2.2, I tested two alternative models, Model4 and Model5, which allow the slope to randomly vary. In Model4, the linear slope is allowed to vary and in Model5, the quadratic slope is allowed to vary. This step utilizes equation 5.3.2.3. Since the only change is in the random part of the equation, the fixed part has negligible differences between Model2 and Model4, and Model4 and Model5. Therefore, the fixed portion of the results are not reported. Instead, Table 5.3.2.3 gives the results of the log likelihood test between Model2 and Model4, and between Model4 and Model5. The log likelihood distribution closely follows a Chi Square distribution, hence it is possible to test nested models to see which model fits the data better. The results show that Model4, with random slope, is significantly better than Model2, with fixed slope. Similarly, Model5 with random quadratic term is significantly better than Model4. The table also reports the overall model fit using Akaike's information criterion (AIC) and its counterpart, the Bayesian information criterion (BIC). The AIC is calculated as:

$$AIC = 2k - 2\ln(L) \qquad (5.3.2.6)$$

where k is the number of parameters in the model and L is the maximized value of the likelihood function of the estimated model. The BIC is calculated in a similar way:

$$BIC = -2\ln(L) + k\ln(n) \qquad (5.3.2.7)$$

but with a more punitive effect on additional parameters than the AIC. Unlike the AIC, the BIC also takes the sample size, n, into account.

The results support hypothesis 2 which says that the variability in the intercepts and slopes will be statistically significant. They show that both the linear slope and the quadratic slope varied greatly among the companies. The results also suggest that the second research question is a valid undertaking since the variability in the intercept and slope must have some explanatory variables.

Table 5.3.2.3. Significance of Random Linear and Quadratic Slopes

Name	Model	df	AIC	BIC	LogLik	Test	L.Ratio	p-value
Model2	1	5	7752.921	7782.058	-3871.461			
Model4	2	7	7694.694	7735.484	-3840.347	1 vs. 2	62.228	<.0001
Model5	3	10	7680.358	7738.630	-3830.179	2 vs. 3	20.336	0.0001

Step 4. Modeling Error Structures

It is important to ensure that the correct error structures are modeled because they greatly affect the significance tests (Bliese, 2009). Autocorrelation and, to a lesser extent, heteroscedasticity, are often present in longitudinal data, therefore, it is imperative to check for the effect of both on model fit. Model6 allowed the residual error terms to be correlated using an autoregressive structure with a one year time lag, that is, the error term for year 0 was correlated with the error term for year 1, and the error term for year 1 was correlated with the error for year 2, and so on according to the autocorrelation function:

$$r(k) \equiv \frac{c(k)}{c(0)} = \frac{\sum_{t=1}^{n-k}\left(y_{t+k} - \bar{y}\right)\left(y_t - \bar{y}\right)}{\sum_{t=1}^{n}\left(y_t - \bar{y}\right)^2} \qquad (5.3.2.8)$$

with $\bar{y} = \frac{1}{n}\sum_{t=1}^{n} y_t$ and k lag. A summary of Model6 indicates that the lag 1 autocorrelation estimate (phi) is 0.069. The first order structure (AR1) specifies that the lag 2 correlation is estimated to be 0.069^2 or 0.004. This suggests a low degree of autocorrelation among the data points. The non-significant results of a likelihood ratio test between Model5 and Model6 confirm this finding.

Model7 tested the effect of heteroscedasticity on the unconditional IS alignment model. Heteroscedasticity occurs when the variance within the error terms increases or decreases over time. Regression analysis assumes homoscedastic error terms. However, this assumption is usually violated in a longitudinal context. The R statistical package allows for a test of the variance components over time using the `tapply` command with the `var` function. The error variances for each time period were: t_0 =1.545, t_1 =1.461, t_2 =1.300, t_3 =1.244, t_4 =1.094, t_5 =1.131, t_6 =1.750, and t_7 =1.200. The error variances seemed to have a decreasing trend, therefore, I used a decreasing weight function to model heteroscedasticity. The results of a log likelihood ratio test confirm the presence of heteroscedasticity in the data. The results are reported in table 5.3.2.4 below.

Table 5.3.2.4. Effect of Error Structures on Model Fit

Name	Model	df	AIC	BIC	LogLik	Test	L.Ratio	p-value
Model5	1	10	7680.358	7738.630	-3830.179			
Model6	2	11	7680.210	7744.309	-3829.105	1 vs. 2	2.148	0.1427
Model7	3	11	7672.073	7736.172	-3825.036	1 vs. 3	10.285	0.0013

The foregoing tests inform us about the relationship between strategic IS alignment and time. In particular, strategic IS alignment seems to have a quadratic relationship with time. The results also show that autocorrelation is not a significant problem although heteroscedasticity was found to be a problem. We also note that companies vary in both the intercept, that is, initial level of strategic IS alignment, and the linear and quadratic slopes, or their rate of change. This supports hypothesis two and leads us to the second phase of growth modeling, which is, testing for explanatory variables for the observed variation in initial values and rates of change.

5.3.2.2 Growth Modeling: The Conditional Model

In hypotheses 3 through 9, I proposed five factors: performance, personnel change, IT resources, organizational size, and industry as explanatory factors for the variability in the IS alignment construct. Each of these factors was tested twice to find out if they affected the variability in: (1) the intercept and (2) the slope. The following sections provide the results of these tests.

1. Business Performance

Business Performance is known to have a positive relationship with strategic IS alignment (Chan et al., 1997, Chan et al., 2006, Croteau and Raymond, 2004, Sabherwal and Chan, 2001). However, the relationship reported in prior research emphasizes the effect of strategic IS alignment, as a predictor variable, on business performance. In this study, business performance was hypothesized to be the predictor variable that affects strategic IS alignment. Before testing for this relationship, business performance was lagged by one period and a plot of the mean of strategic IS alignment against high, medium, and low values of business performance was obtained as depicted in figure 5.3.2.6 below. It can be noted that, generally, high levels of business performance correspond with high levels of IS alignment. However, the 95 percent confidence intervals for both high and low levels of business performance overlap quite heavily, indicating a lack of distinction between the levels.

In order to test for the effect of business performance on intercept variation, business performance was added to the fixed effects portion of equation 5.3.2.3.

$$\begin{aligned} Alignment_{ij} = & \left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(Bu\sin ess\_Performance_{ij}\right)\right] \\ & + \left[u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) + r_{ij}\right] \end{aligned} \tag{5.3.2.9}$$

The results show that business performance has a non-significant effect on the variability of the initial levels of strategic IS alignment. The p-value for business performance was 0.8817 indicating a non-significant result. Table 5.3.2.5 below provides these results.

Figure 5.3.2.6. Relationship between IS Alignment and Business Performance

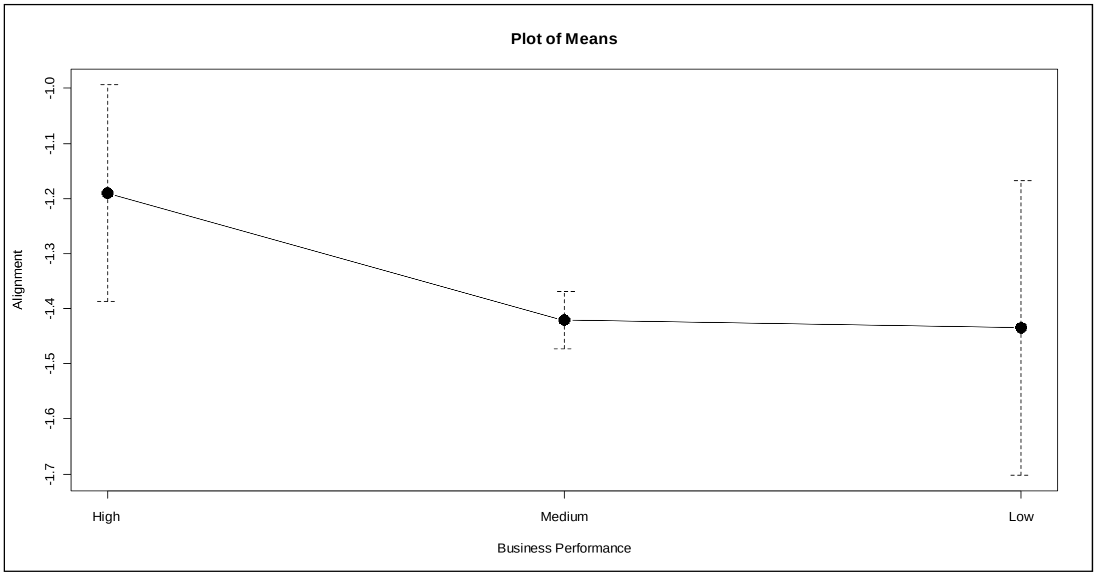


Table 5.3.2.5. Results of Intercept and Slope Variability Tests for Business Performance

Model	Variable	Estimate	SE	t Value	p-value
Random	Intercept	-1.374	0.062	-22.317	0.0000
Intercept	BPF[11]	0.004	0.024	0.149	0.8817
Random	BPF	-0.009	0.043	-0.197	0.8439
Linear	BPF×Time	0.005	0.014	0.332	0.7400
Random	BPF	0.0003	0.032	0.008	0.9936
Quadratic	BPF×Time^2	0.0004	0.002	0.149	0.8818

Testing for the effect of business performance on the variability of the slope was done in two models, one targeting the linear slope and the other testing for interaction with the quadratic component (or acceleration) of the slope. In mathematical terms, the interaction is in the form of some extra terms to the random part of equation 5.3.2.9.

[11] BPF stands for Business Performance.

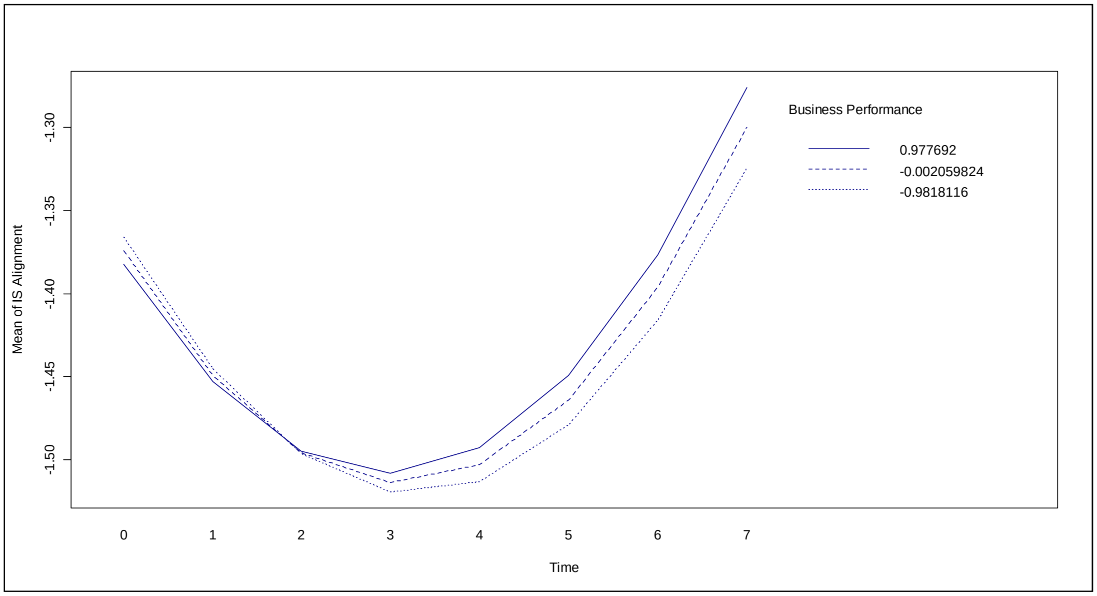
$$Alignment_{ij} = \left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^2\right) + \beta_{30}\left(Business\_Performance_{ij}\right)\right] + \begin{bmatrix} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^2\right) \\ +u_{3j}\left(Business\_Performance_{ij}\right)\left(Time_{ij}\right) + r_{ij} \end{bmatrix} \quad (5.3.2.10)$$

$$Alignment_{ij} = \left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^2\right) + \beta_{30}\left(Business\_Performance_{ij}\right)\right] + \begin{bmatrix} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^2\right) \\ +u_{3j}\left(Business\_Performance_{ij}\right)\left(Time_{ij}^2\right) + r_{ij} \end{bmatrix} \quad (5.3.2.11)$$

As can be seen in table 5.3.2.5 above, both these models are statistically insignificant. Business performance affects neither the linear slope nor the quadratic component. However, it is useful to plot graphs of the interaction between the variables because it aids in interpretation and comprehension of the situation (Cohen et al., 2003). An interaction occurs when the effect of one predictor variable, x, on a dependent variable, Y, varies as a function of a second predictor variable, z (Cohen et al., 2003, Curran et al., 2004, Aiken and West, 1991). Interaction effects create difficulties in interpretation especially in the case of nonlinear models (Norton et al., 2004). In modeling the interactions, I followed the advice from Aiken and West (1991) as summarized by Preacher in his primer on interaction effects(Preacher, 2006). The resulting interaction plots incorporate that advice. Figure 5.3.2.7 below provides a visual representation of the interaction between business performance and IS alignment.

All the three levels of business performance had insignificant and nonlinear relationships with IS alignment. The difference in figures 5.3.2.4 and 5.3.2.7 are quite minimal. Both the main effects and the interaction effects of business performance are insignificant (Cohen et al., 2003). Therefore, hypotheses H3a and H3b are not supported by the results.

Figure 5.3.2.7. Business Performance Effects



2. IS Performance

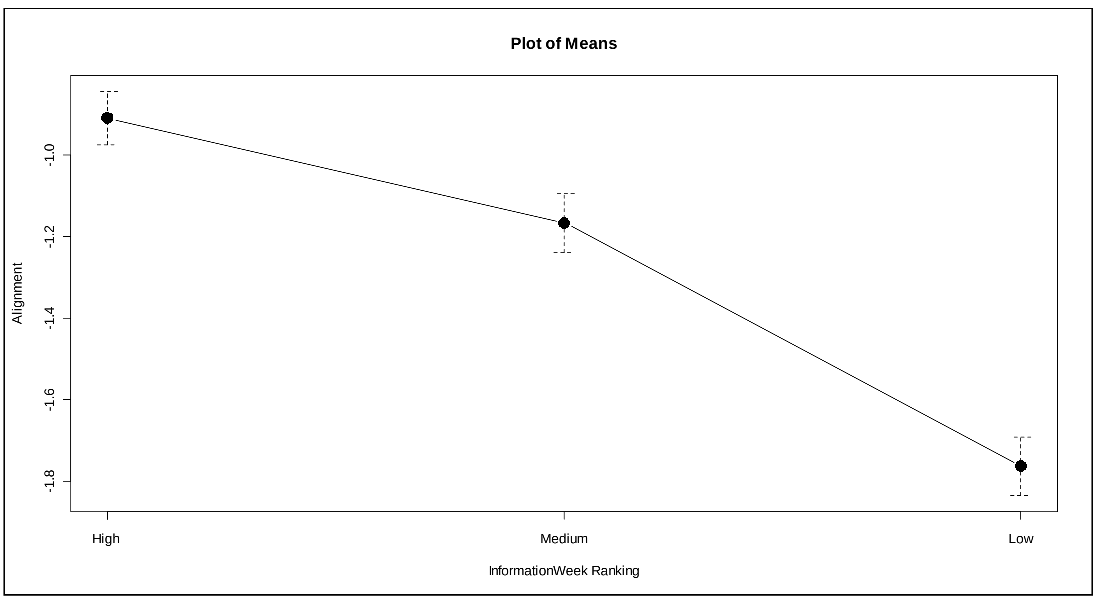
The history of success of the IS department affects how it is perceived and what type of relationships it builds with strategic business units (Chan et al., 1997). A good history of IS performance is hypothesized to lead to stronger ties with business units and thus to a high degree of alignment. IS performance was represented by the firm's *InformationWeek* 500 ranking. Figure 5.3.2.8 below gives a visual picture of the mean values of IS alignment for high, medium and low rankings. This seems to support the hypothesis that high values of IS alignment will be positively related to high rankings in the *InformationWeek* 500. The hypothesis was tested using three models identical to equations 5.3.2.9, 5.3.2.10, and 5.3.2.11 but with Business performance replaced with IS performance. The results provided in table 5.3.2.6 below support hypothesis 4. In particular, the average intercept is not common to all levels of IS performance (significant IS performance fixed effect) which supports hypothesis H4a, that is, IS performance levels have different initial alignment values. Figure 5.3.2.8 shows that high IS performance is positively related to high IS alignment. The results also show that the slope of change in high IS performance organizations is lower than that in low IS performing organizations (smaller, although marginally significant, fixed effect for High IS performance than for low IS performance). This result supports hypothesis H4b.

$$Alignment_{ij} = \left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(IS\_Performance_{ij}\right) \right] + \left[u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) + r_{ij} \right] \quad (5.3.2.12)$$

$$Alignment_{ij} = \left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(IS\_Performance_{ij}\right) \right] + \left[\begin{array}{l} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) \\ + u_{3j}\left(IS\_Performance_{ij}\right)\left(Time_{ij}\right) + r_{ij} \end{array} \right] \quad (5.3.2.13)$$

$$Alignment_{ij} = \left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(IS\_Performance_{ij}\right) \right] + \left[\begin{array}{l} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) \\ + u_{3j}\left(IS\_Performance_{ij}\right)\left(Time_{ij}^{2}\right) + r_{ij} \end{array} \right] \quad (5.3.2.14)$$

Figure 5.3.2.8. Relationship Between IS Alignment and Prior IS Success



The relationship between IS alignment and prior IS success seems to be a positive one with high rankings leading to high levels of alignment and low rankings suffering some loss in level of IS alignment. The analysis of means suggests that the variability around the mean for highly ranked, medium ranked and lowly ranked companies is fairly stable. The confidence intervals around the means do not overlap, giving added support to the idea of statistically significantly different mean values for the various groups.

Table 5.3.2.6. Results of Intercept and Slope Variability Tests for IS Performance

Model	Variable	Estimate	SE	t Value	p-value
Random Intercept	Intercept	-0.519	0.092	-5.665	0.0000
	High ISPF[12]	-0.002	0.000	-15.213	0.0000
Random Linear	ISPF	-0.005	0.000	-19.350	0.0000
	High ISPF × Time	0.0492	0.026	1.889	0.0591
	Low ISPF × Time	0.1942	0.025	7.860	0.000
Random Quadratic	ISPF	-0.004	0.000	-19.831	0.0000
	ISPF × $Time^2$	0.0001	0.000	12.564	0.0000

The estimates for IS performance and the interaction effects for IS performance with time were both highly significant at the $p<.001$ level. Although it is not possible to directly compare the three models using the log likelihood test, the model fit statistics can be helpful in selecting the best model for fitting IS performance data. The model fit results are given in table 5.3.2.7 below. From the results, the model with an IS performance and time interaction seemed to fit the data best.

Table 5.3.2.7. Model Fit for IS Alignment and IS Performance

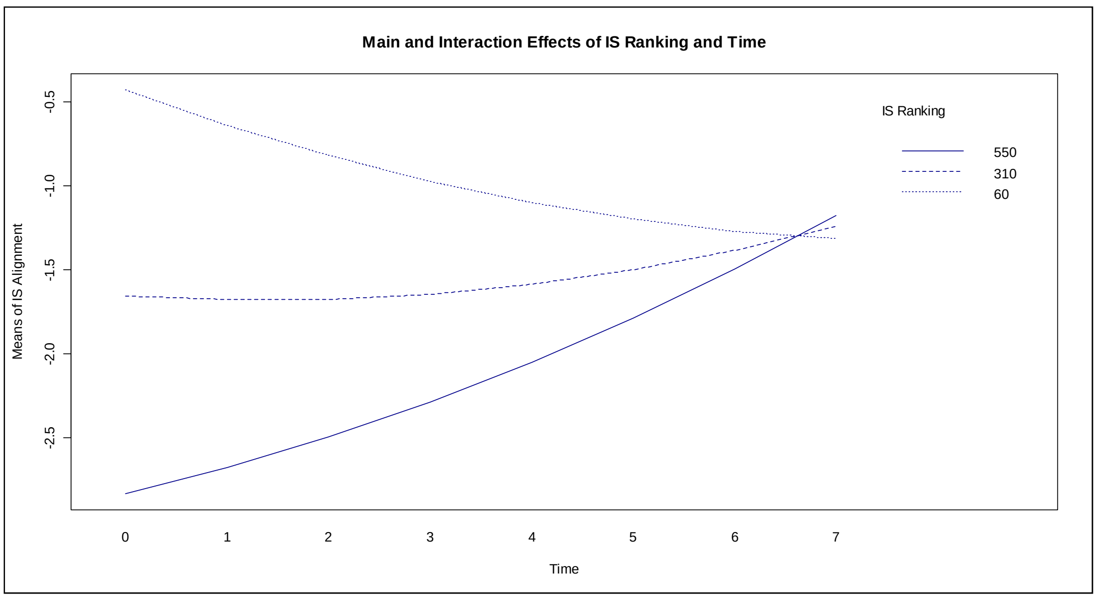
Model	AIC	BIC	LogLik	varExp	Residual (σ)
Intercept	7492.988	7562.910	-3734.494	-0.0014	0.9194
ISPF × Time	7349.258	7425.002	-3661.629	-0.0056	0.9027
ISPF × $Time^2$	7366.754	7442.498	-3670.377	-0.0020	0.8958

Figure 5.3.2.9 provides a visualization of the main and interaction effects of IS performance and time on IS alignment. The effects of IS performance seem to be heavily influenced by time.

[12] ISPF stands for Information systems unit performance

IS alignment and IS performance seem to have a slightly non-linear relationship due to the changes in rate of change (significant TIME2 fixed effects) with high levels of IS performance having an initially high level of IS alignment while low levels of IS performance begin with a low level of IS alignment. Although both the high and low IS performance organizations are changing, the low IS performance organizations change at a faster rate (highly significant slope for low ISPF) toward high IS alignment. The figure clearly shows that the effect of IS performance on IS alignment depends on time.

Figure 5.3.2.9. Effects of IS Performance and Time on IS Alignment.



3. Personnel Change

IS alignment depends, in part, on the relationship between the CIO and the CEO (Earl and Feeny, 1994, Feeny et al., 1992). Many studies have looked at the impact of CEO turnover (Miller, 1993, Shen and Cannella Jr., 2002) but few, if any, have examined the impact of CIO turnover. In this study CIO change was represented by a dummy variable. The measure was lagged by 1 period in order to line up the effects of CIO change and time. This study hypothesized that a change in CIO would adversely affect IS alignment. This hypothesis was tested using similar methods as were used in testing for the longitudinal relationship between IS alignment and both business performance and IS performance. Three models were run to test the effects of CIO change on initial IS alignment, linear slope, and quadratic slope. The models were:

$$Alignment_{ij} = \left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(CIO\_Change_{ij}\right)\right] + \left[u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) + r_{ij}\right] \quad (5.3.2.15)$$

$$Alignment_{ij} = \left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(CIO\_Change_{ij}\right)\right] + \left[\begin{array}{l} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) \\ +u_{3j}\left(CIO\_Change_{ij}\right)\left(Time_{ij}\right) + r_{ij} \end{array}\right] \quad (5.3.2.16)$$

$$Alignment_{ij} = \left[\beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(CIO\_Change_{ij}\right)\right] + \left[\begin{array}{l} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) \\ +u_{3j}\left(CIO\_Change_{ij}\right)\left(Time_{ij}^{2}\right) + r_{ij} \end{array}\right] \quad (5.3.2.17)$$

The results of this analysis were not in line with the expected impact as depicted in tables 5.3.2.8 and 5.3.2.9. The change in CIO had a positive and significant relationship with the level of IS alignment as shown in the positive β for CIO change and the highly statistically significant p-value. Figures 5.3.2.10 and 5.3.2.11 below visually represent this finding.

The plot reveals that high levels of IS alignment are significantly related to CIO change events while the opposite is true for low levels of alignment. The results show that CIO change significantly explains the variance in the initial IS alignment value and also in the slopes of the IS alignment trajectory. The plot of main and interaction effects shows that there is a substantial interaction effect between CIO change and time. The effect of CIO change seems to be dependent on the effect of time. In figure 5.3.2.11, the two mean trajectories interact over time. The trajectory for CIO change, labeled 1 in the legend, begins on a high note and then becomes as stable as the trajectory for no CIO change. The two lines have a very different trajectory, that is, the effect of CIO change is significantly different than that of no CIO change over time. Table 5.3.2.8 indicates that IS alignment decreases faster where there has been a CIO change event (significant, negative CIO:TIME fixed effect)

Figure 5.3.2.10. Relationship Between IS Alignment and CIO Change

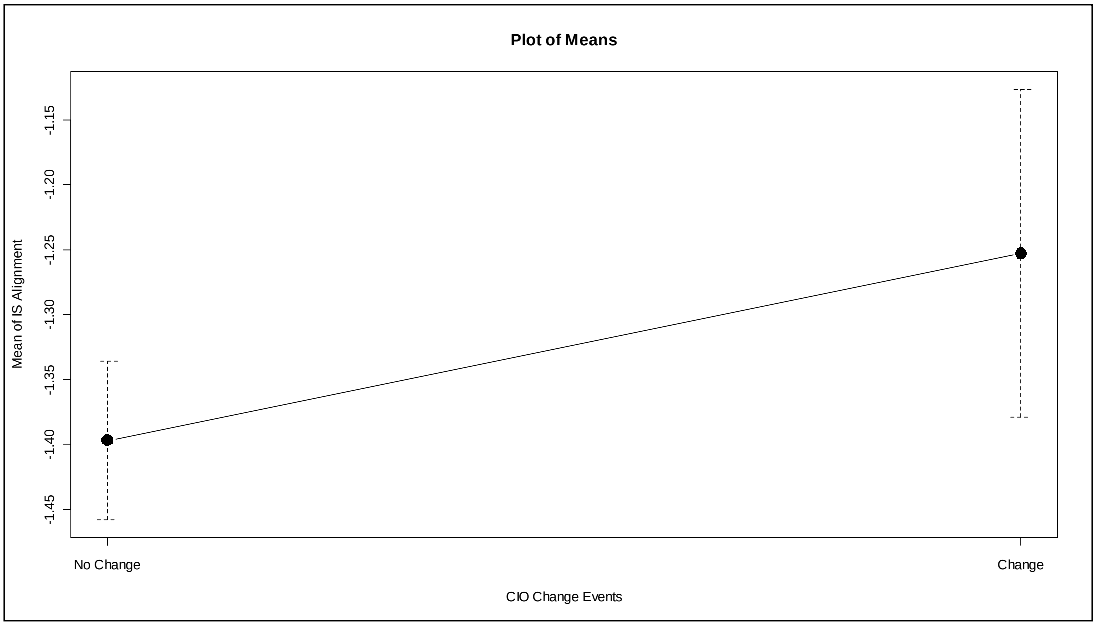
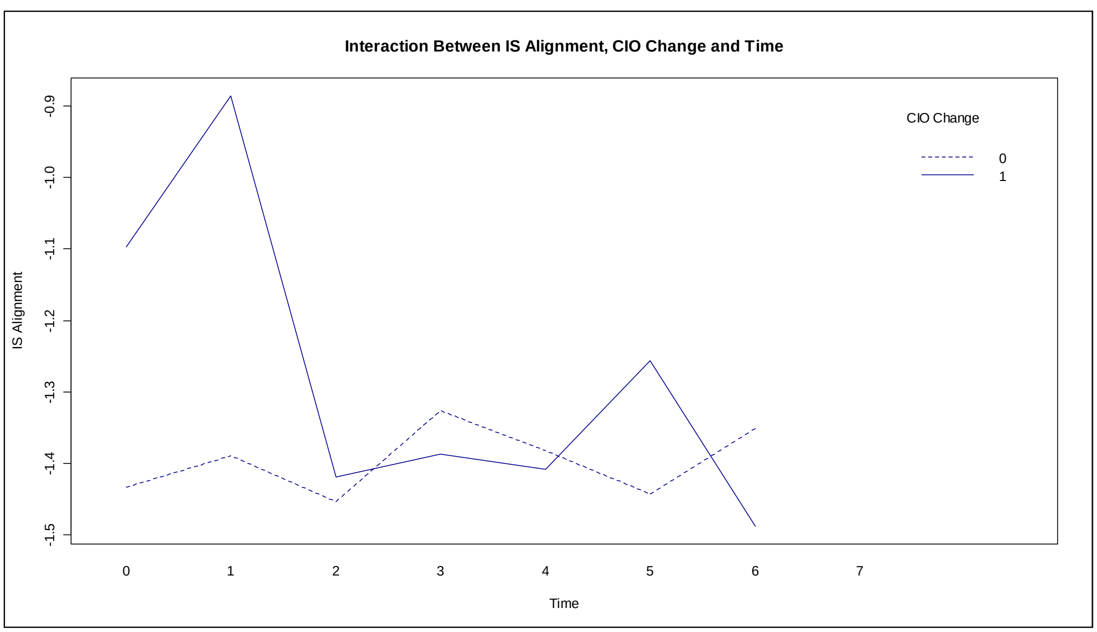


Figure 5.3.2.11. Effects of CIO Change on IS Alignment.



As the tables below show, the intercept model provides the best fit to the data. Both the AIC and log likelihood favor the intercept model. The interaction term only adds complexity to the model without any improvement in model fit, therefore, the simpler intercept model is used to test the hypothesis.

Table 5.3.2.8. Results of Intercept and Slope variability Tests for CIO Change

Model	Variable	Estimate	SE	t Value	p-value
Random Intercept	Intercept	-1.412	0.068	-20.663	0.0000
	CIO[a]	0.191	0.064	2.965	0.0031
Random Linear	CIO[a]	0.400	0.113	3.534	0.0004
	CIO[a] × Time	-0.073	0.032	-2.256	0.0242
Random Quadratic	CIO[a]	0.326	0.092	3.544	0.0004
	CIO[a] × $Time^2$	-0.011	0.005	-2.070	0.0387

[a] The CIO dummy variable here represents change

Table 5.3.2.9. Comparison of Three Models of CIO Change

Model	AIC	BIC	LogLik	varExp	Residual (σ)
Intercept	5040.303	5105.234	-2508.152	-0.0253	0.9362
CIO × Time	5042.326	5115.661	-2508.163	-0.0233	0.9309
CIO × $Time^2$	5046.724	5117.058	-2510.362	-0.0237	0.9321

The results of this hypothesis test contradicted hypothesis H5a but supported hypothesis H5b. CIO change led to higher IS alignment, at least in the short term while the rate of change in the CIO change group had statistically significant β values depicting faster change in the slopes (both linear and quadratic). It seems that organizations experiencing a CIO change event had both an increase in the rate of change of their IS alignment as well as an increase in the acceleration of their rate of change of IS alignment.

4. IT Resources

There have been suggestions in prior literature that IT investment, that is, the IT budget and resources, should have a positive relationship with IS alignment (Byrd et al., 2006, Dewan et al., 1998, Kohli and Devaraj, 2004, Weill, 1992). However, it is important to control for organizational size and industry when testing for the effect of investment on IS alignment. This was done by including Organization size and industry as variables in the fixed part of the model. Testing for the effect of IT investment on IS alignment followed a similar pattern to that of business performance, IS performance, and CIO change. The random coefficients model equations are:

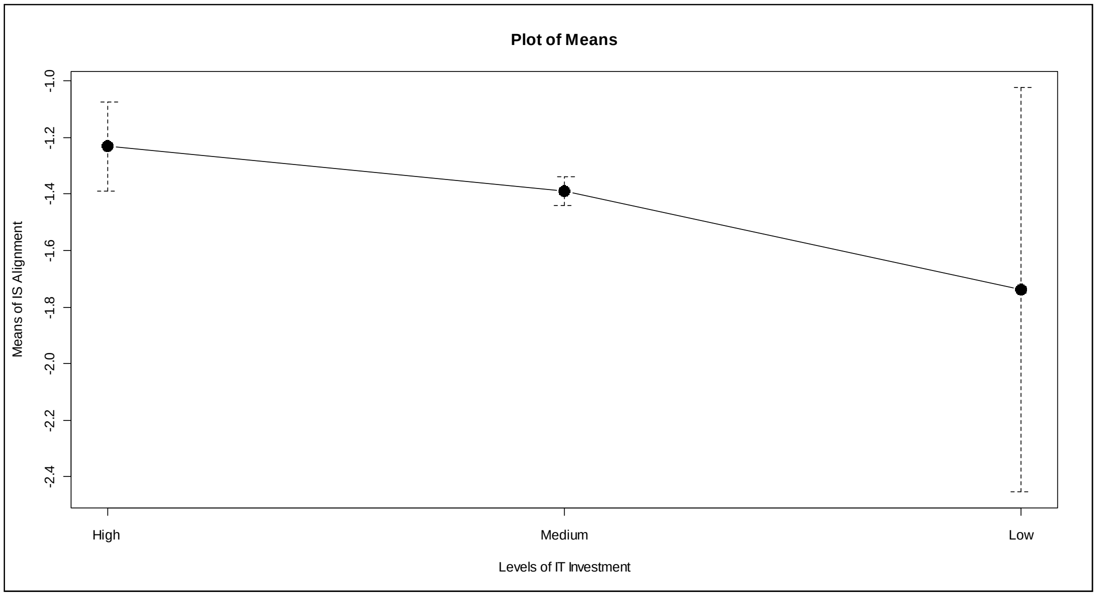
$$Alignment_{ij} = \begin{bmatrix} \beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^2\right) + \beta_{30}\left(Industry_{ij}\right) \\ +\beta_{40}\left(Size\right) + \beta_{50}\left(IT\_Investment\right) \end{bmatrix} + \left[u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^2\right) + r_{ij}\right] \quad (5.3.2.18)$$

$$Alignment_{ij} = \begin{bmatrix} \beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^2\right) + \beta_{30}\left(Industry_{ij}\right) \\ +\beta_{40}\left(Size\right) + \beta_{50}\left(IT\_Investment\right) \end{bmatrix} + \begin{bmatrix} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^2\right) \\ +u_{3j}\left(IT\_Investment_{ij}\right)\left(Time_{ij}\right) + r_{ij} \end{bmatrix} \quad (5.3.2.19)$$

$$Alignment_{ij} = \begin{bmatrix} \beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^2\right) + \beta_{30}\left(Industry_{ij}\right) \\ +\beta_{40}\left(Size\right) + \beta_{50}\left(IT\_Investment\right) \end{bmatrix} + \begin{bmatrix} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^2\right) \\ +u_{3j}\left(IT\_Investment_{ij}\right)\left(Time_{ij}^2\right) + r_{ij} \end{bmatrix} \quad (5.3.2.20)$$

The results of applying the models indicate that IT investment has no direct relationship with IS alignment thus the results do not support hypotheses 6a and 6b. The following two figures and table give us the results of testing for IT investment impact on IS alignment.

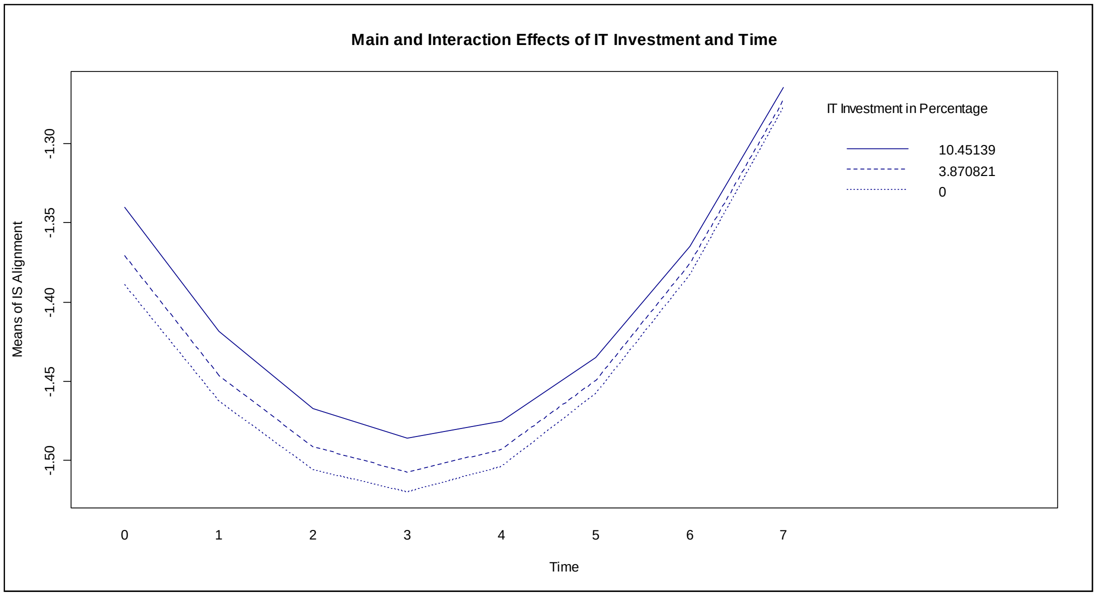
Figure 5.3.2.11. Relationship between IT Investment and IS Alignment



The mean plot shows a great overlap between the confidence intervals of the mean IS alignment level for the low level of IT investment and that for the high level of IT investment. This provides additional support for the notion that the difference in means is not statistically significant. The p-values for each of the three models, shown in table 5.3.2.10 below, also provide a measure of the statistical non-significance of a direct relationship between IT investment and IS alignment.

Figure 5.3.2.12 also provides evidence of both a lack of main effect and interaction effect for IT investment with time. The three lines representing the high, medium, and low levels of IT investment hardly move from the position where the predicted values of IS alignment with just the time variable are found. Furthermore, the effect of industry as a main variable is also not significant as indicated in table 5.3.2.10. However, the effect of organizational size is highly significant thereby providing support for hypotheses 7a and 7b.

Figure 5.3.2.12. The Effect of IT Investment on IS Alignment Controlling for Industry and Size



Due to the non-significance of all the three models of IT investment, I only reported the results of the intercept model.

Table 5.3.2.10. Results of The Intercept Model for IT Investment.

Model	Variable	Estimate	SE	t Value	p-value
Random	Intercept	-1.669	0.113	-14.810	0.0000
Intercept	Time	-0.090	0.040	-2.270	0.0234
	Time^2	0.015	0.006	2.625	0.0087
	Industry	0.002	0.006	0.384	0.7009
	IT Investment	0.004	0.004	0.861	0.3892
	Size	0.097	0.025	3.832	0.0001

5. Organizational Size

Organizational size was hypothesized to have a positive effect on IS alignment, that is, we expect larger companies to have higher levels of IS alignment than smaller companies (Chan et al., 2006).

However, the effects of IT investment and industry need to be taken into consideration since they might affect the effect of organizational size on IS alignment. Three models were used to test this hypothesis. In each model industry and IT investment were used as control variables[13]. The models were:

$$Alignment_{ij} = \begin{bmatrix} \beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(Industry_{ij}\right) \\ +\beta_{40}\left(Size\right) + \beta_{50}\left(IT\_Investment\right) \end{bmatrix} + \left[u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) + r_{ij}\right] \quad (5.3.2.21)$$

$$Alignment_{ij} = \begin{bmatrix} \beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(Industry_{ij}\right) \\ +\beta_{40}\left(Size\right) + \beta_{50}\left(IT\_Investment\right) \end{bmatrix} + \begin{bmatrix} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) \\ +u_{3j}\left(Time_{ij}\right)\left(Size_{ij}\right) + r_{ij} \end{bmatrix} \quad (5.3.2.22)$$

$$Alignment_{ij} = \begin{bmatrix} \beta_{00} + \beta_{10}\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) + \beta_{30}\left(Industry_{ij}\right) \\ +\beta_{40}\left(Size\right) + \beta_{50}\left(IT\_Investment\right) \end{bmatrix} + \begin{bmatrix} u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) \\ +u_{3j}\left(Time_{ij}^{2}\right)\left(Size_{ij}\right) + r_{ij} \end{bmatrix} \quad (5.3.2.23)$$

As table 5.3.2.11 below shows, organizational size has a statistically significant relationship with IS alignment. However, both interactions between organization size and the linear and quadratic slopes for time are not significant. The results indicate that the relationship between organizational size and IS alignment is not significantly affected by time.

[13] Models testing the effect of industry and IT investment on organizational size resulted in a marginally significant relationship between IT investment and Organizational size (estimate=0.002, p-value=0.0661), and a non-significant relationship between industry and organizational size (estimate=0.011, p-value=0.2224)

Table 5.3.2.11. Results of Intercept and Slope Variability Tests for Organizational Size

Model	**Variable**	**Estimate**	**SE**	**t Value**	**p-value**
Random Intercept	Intercept	-1.378	0.065	-21.343	0.0000
	Large Size	0.180	0.079	2.286	0.0224
	Small Size	-0.161	0.086	-1.866	0.0622
Random Linear	Size	0.046	0.041	1.121	0.2624
	Size×Time	0.0165	0.010	1.589	0.1122
Random Quadratic	Size	0.070	0.033	2.114	0.0347
	Size×Time^2	0.002	0.001	1.222	0.2220

Figure 5.3.2.13 graphically shows the relationship between IS alignment and organization size. The means of IS alignment support the notion that large organizations tend to have higher levels of IS alignment while smaller organizations tend to have lower levels of IS alignment.

Figure 5.3.2.14 below presents a visual perspective of the effect of organization size on IS alignment. The graphs show a significant main effect and a non-significant interaction effect. There seems to be a significant difference between the initial values of IS alignment of large and small organizations. The coefficients for large and small organizations in table 5.3.2.11 indicate that large organizations had a higher level of IS alignment and smaller organizations had a lower level of IS alignment in comparison to the intercept value which represents the average initial IS alignment value for medium sized organizations after factoring in the effects of time, industry, and IT investment. This result provides support for hypothesis H7a. From figure 5.3.2.13, it is also clear that the slopes of the three levels of size do not vary at any point in time. It is interesting to note that the three levels of organizational size seem to follow a similar pattern. The trajectories of the three mean levels of organizational size seem to have a constant difference among them. This indicates that the effect of time is the same for all levels of organization size, that is, there is no interaction between these two predictor variables. These results do not support hypothesis H7b which expected different rates of change in IS alignment due to organizational size. The rate of change is similar in large and small organizations. The non-significant interaction terms between size and time, and size and time^2 in table 5.3.2.11 confirms this result.

Figure 5.3.2.13. Relationship Between IS Alignment and Organizational Size

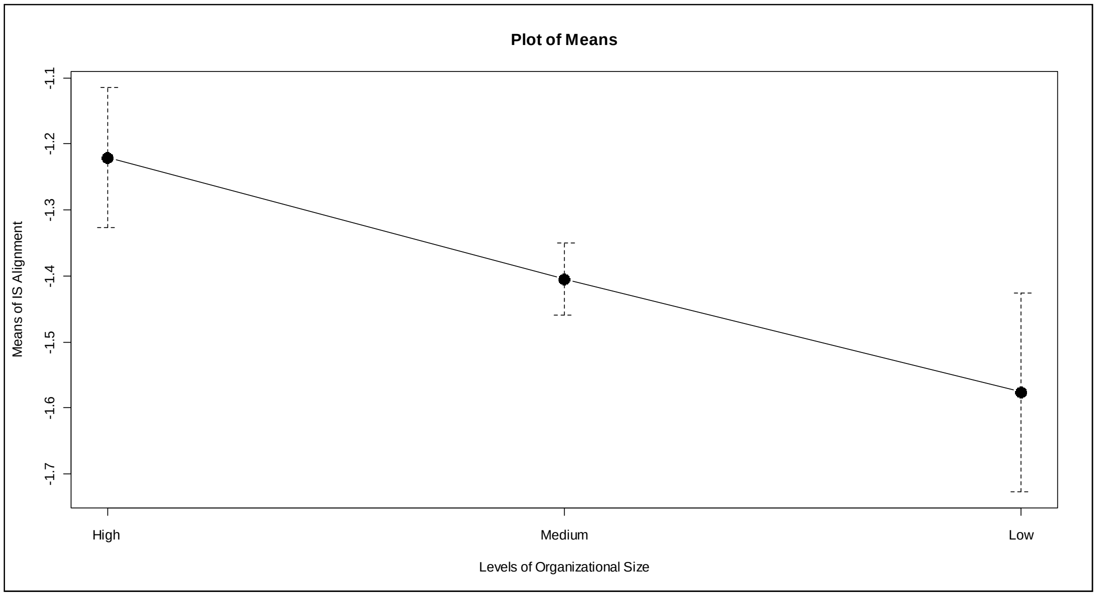
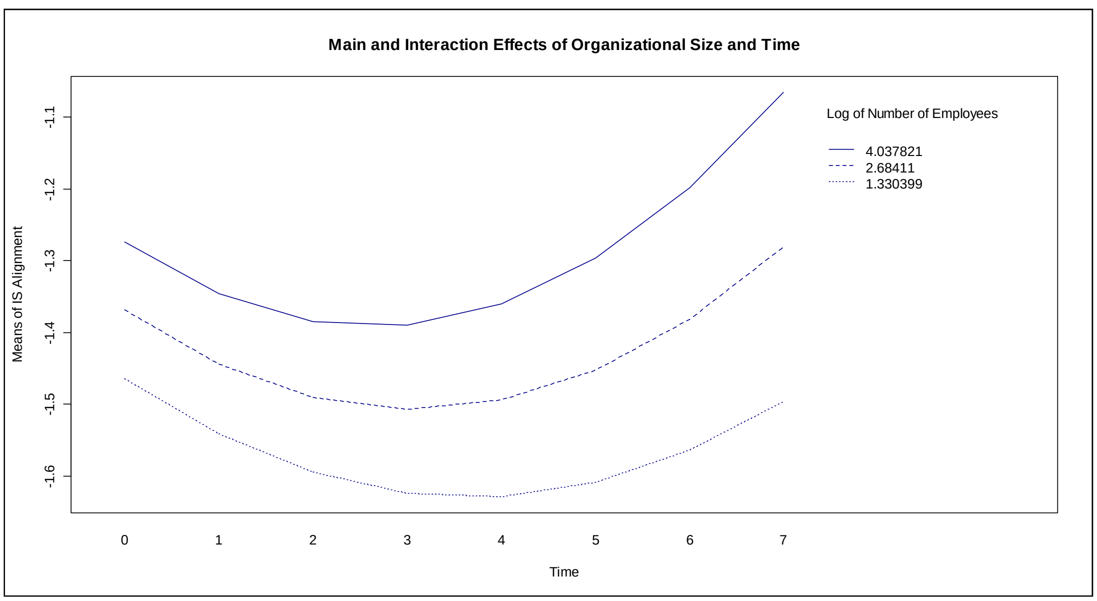


Figure 5.3.2.14. Main and Interaction Effects of Size and Time on IS Alignment



6. Environmental Uncertainty

The environmental uncertainty variable was divided into high, medium and low uncertainty environments. There were 20 different industries obtained from the *InformationWeek 500* data. Using these categories to test hypotheses 8 and 9 presented challenges and non-converging models. The best models would have been ones in which all the combinations of business performance, industry, and time, were included. The compromise was to use industry as a continuous variable. This aggregating of industry leads to loss of information. Therefore, the results for hypotheses H8a and H8b should be interpreted cautiously.

Two models were tested in this category. The first model was aimed at testing hypotheses 8a and 8b, which suggest a relationship between business performance levels, industry and time, and IS alignment. The following model was used:

$$Alignment_{ij} = \begin{bmatrix} \beta_{00} + \beta_{01}\left(Industry_{ij}\right) + \beta_{02}\left(Business\_Performance\right) \\ +\beta_{10}\left(Time_{ij}\right) + \beta_{11}\left(Time_{ij}\right)\left(Industry_{ij}\right) \\ +\beta_{12}\left(Time_{ij}\right)\left(Business\_Performance_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) \\ +\beta_{21}\left(Time_{ij}^{2}\right)\left(Industry_{ij}\right) + \beta_{12}\left(Time_{ij}^{2}\right)\left(Business\_Performance_{ij}\right) \end{bmatrix} + \left[u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) + r_{ij}\right] \quad (5.3.2.24)$$

Table 5.3.2.12 provides results from running this model. All the interaction terms were non-significant at $p<0.05$. Both business performance and industry also had a non-significant relationship to IS alignment over time. Although the industry by performance coefficients for high and low business performance had different signs meaning that the slopes had different rates of change, the overall effect was not statistically significant. The results show that both the intercept and slope had non-significant differences. Based on this we might cautiously venture to say that hypotheses H8a and H8b are not supported.

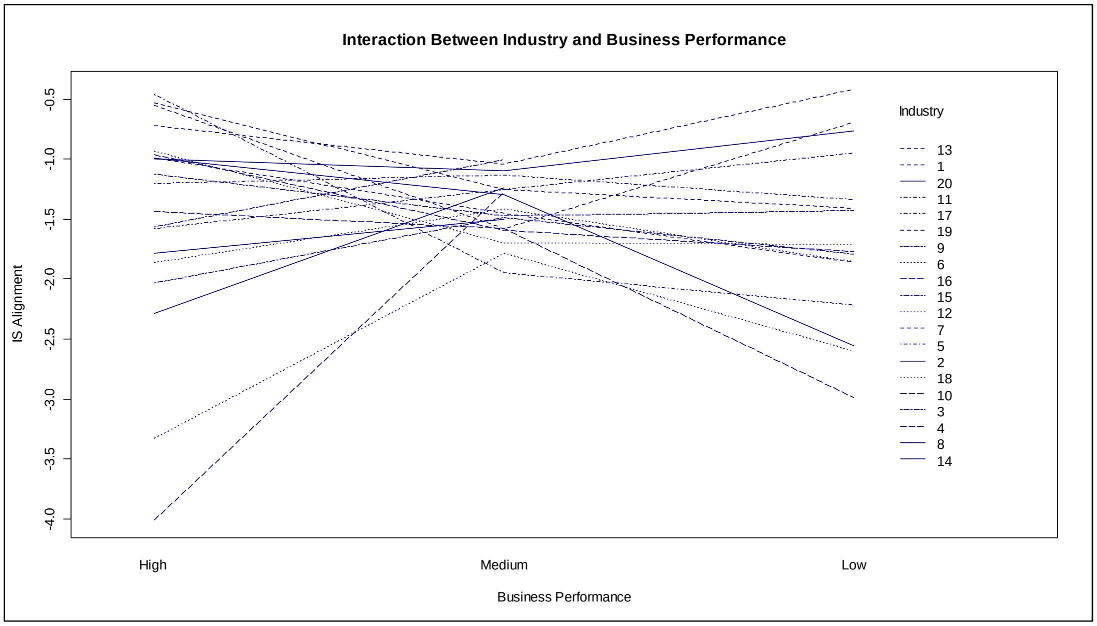
Table 5.3.2.12. Results of Intercept and Variability Tests for Business Performance and Industry

Variable	Estimate	SE	t Value	p-value
Intercept	-1.493	0.117	-12.711	0.0000
TIME	-0.068	0.055	-1.232	0.2181
TIME2	0.015	0.008	1.923	0.0547
High Performance	0.668	0.741	0.902	0.3673
Low Performance	-0.295	0.680	-0.434	0.6640
Industry	0.011	0.009	1.186	0.2359
TIME × High Performance	-0.112	0.172	-0.649	0.5163
TIME × Low Performance	-0.065	0.171	-0.382	0.7023
TIME × Industry	-0.003	0.003	-1.041	0.2980
Industry × High Performance	-0.024	0.063	-0.387	0.6986
Industry × Low Performance	0.016	0.046	0.346	0.7294
TIME × High Performance × Industry	0.005	0.015	0.351	0.7253
TIME × Low Performance × Industry	0.007	0.012	0.622	0.5338

In seeking to have a clearer picture of the relationship between the three variables: business performance, industry and IS alignment, a plot of the 20 industries was obtained. This plot, however, does not contain the time variable.

As the figure shows, the interaction effects among the variables are not significant. Notice that the pattern of relationships at the high business performance level is almost identical to that at the low business performance level.

Figure 5.3.2.15. Effects of Industry and Business Performance on IS alignment



The second model was aimed at testing hypotheses 9a and 9b which argue that firms in uncertain industries will have higher values of IS alignment than firms in more stable industries. The form of the model was:

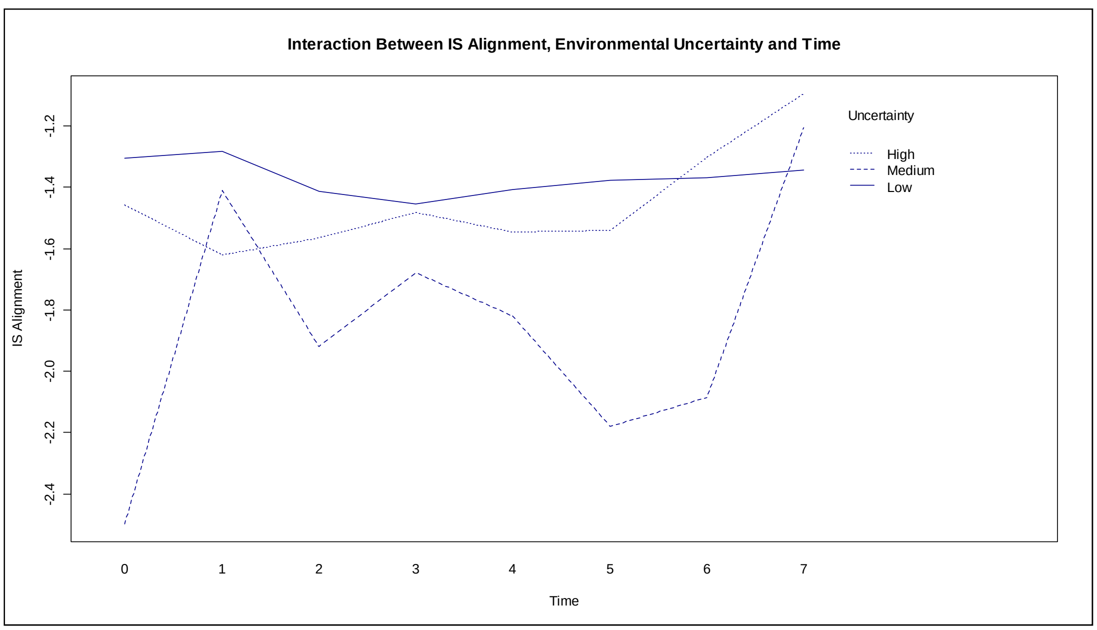
$$Alignment_{ij} = \begin{bmatrix} \beta_{00} + \beta_{01}\left(Environmental\_Uncertainty_{ij}\right) \\ +\beta_{02}\left(Business\_Performance_{ij}\right) + \beta_{10}\left(Time_{ij}\right) \\ +\beta_{11}\left(Environmental\_Uncertainty_{ij}\right)\left(Time_{ij}\right) \\ +\beta_{12}\left(Business\_Performance_{ij}\right)\left(Time_{ij}\right) + \beta_{20}\left(Time_{ij}^{2}\right) \end{bmatrix} + \left[u_{0j} + u_{1j}\left(Time_{ij}\right) + u_{2j}\left(Time_{ij}^{2}\right) + r_{ij}\right] \qquad (5.3.2.25)$$

The more accurate model containing both an industry and a performance term did not converge. The simplified model was used as a substitute. The results indicate that a low uncertainty environment has a significant positive relationship with IS alignment while a high uncertainty environment has a non-significant relationship. Table 5.3.2.13 below presents these results for the simplified model and figure 5.3.2.16 provides a visual perspective of these relationships.

Table 5.3.2.13. Intercept and Variability Tests for Environmental Uncertainty

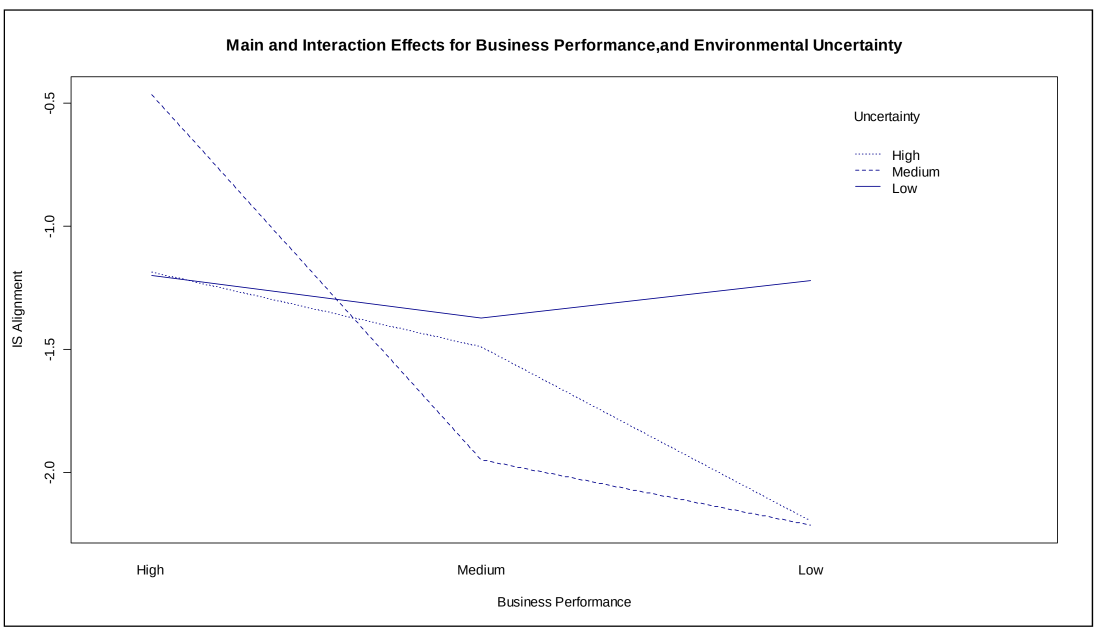
Variable	Estimate	SE	t Value	p-value
Intercept	-1.979	0.312	-6.348	0.0000
TIME	-0.065	0.092	-0.707	0.4797
TIME2	0.015	0.005	2.968	0.0030
High Uncertainty	0.445	0.326	1.364	0.1728
Low Uncertainty	0.684	0.316	2.163	0.0309
TIME × High Uncertainty	0.009	0.090	0.097	0.9229
TIME × Low Uncertainty	-0.045	0.088	-0.516	0.6062
Performance × High Uncertainty	-0.234	0.297	-0.790	0.4299
Performance × Low Uncertainty	-0.288	0.284	-1.014	0.3110

Figure 5.3.2.16. Effects of Environmental Uncertainty on IS Alignment



The figure presents a picture of turbulence in the mean of IS alignment among the firms in an industry with medium, and to a lesser extent, high, uncertainty. This means that firms in high uncertainty industries start off with a lower level of alignment and work to remove the uncertainty thus creating unpredictable swings in their rate of change in IS alignment. This partially supports hypothesis 9. However, the results in table 5.3.2.13 suggest that any differences in initial values and in rates of change are statistically non significant. Therefore, both hypothesis H9a and H9b are not supported. In order to get a better idea of the relationship between business performance, environmental uncertainty and IS alignment, a three-way interaction plot was obtained. This is shown in figure 5.3.2.17 below. The graph shows that the pattern of change in IS alignment is consistent across business performance levels in industries with low uncertainty. In industries with medium level of uncertainty, the performance of firms seems to be inconsistent, with high IS alignment levels for high business performers and very low IS alignment levels for low business performers.

Figure 5.3.2.17. Effects of Business Performance and Environmental Uncertainty



A summary of the tests of the hypotheses and the results are provided in table 5.3.2.14. This study has proposed and tested a longitudinal model of change in the IS alignment trajectory using analytical techniques that take account of the random variation within the data. There was support for some of the hypotheses but other hypotheses were either contradicted or not supported at all.

Table 5.3.2.14. Hypothesis Tests and Results

Hypothesis	**Expected Relationship**	**Result**
H1	Distribution follows power law	Not Supported
H2	Significant variance in intercept and slope	Supported
H3a	Business Performance $\xrightarrow{+}$ intercept	Not Supported
H3b	Business Performance $\xrightarrow{-}$ slope	Not Supported
H4a	IS Performance $\xrightarrow{+}$ intercept	Supported
H4b	IS Performance $\xrightarrow{-}$ slope	Supported
H5a	CIO Change $\xrightarrow{-}$ Alignment magnitude	Contradicted
H5b	CIO Change $\xrightarrow{+}$ slope	Supported
H6a	IT Investment $\xrightarrow{+}$ intercept	Not Supported
H6b	IT Investment $\xrightarrow{-}$ slope	Not Supported
H7a	Organizational Size $\xrightarrow{+}$ intercept	Supported
H7b	Organizational Size $\xrightarrow{-}$ slope	Not Supported
H8a	Business Performance + Industry $\xrightarrow{+}$ intercept	Not Supported
H8b	Business Performance + Industry $\xrightarrow{-}$ slope	Not Supported
H9a	Business Performance + Environment $\xrightarrow{+}$ intercept	Not Supported
H9b	Business Performance + Environment $\xrightarrow{-}$ slope	Not Supported

Chapter 6

DISCUSSION, IMPLICATIONS AND CONCLUSION

6.1 Introduction

This chapter presents a discussion of the results and provides possible explanations for the discrepancies between the hypotheses proposed and the results of the data analyses. The objective of this study was to examine the form of the relationship between IS alignment and time, and to find factors that would explain the IS alignment trajectory. This was accomplished though fitting mathematical forms to longitudinal data. The results provided support for 5 hypotheses out of a total of 16 hypotheses. These results are discussed, by hypothesis, in the next section.

6.2 Discussion of Individual Hypotheses

6.2.1 Power Law and Punctuated Equilibrium

I hypothesized that the generative mechanism behind IS alignment followed a punctuated equilibrium pattern which has been shown mathematically to be represented by a "pink noise" trajectory (Bak and Sneppen, 1993, Dooley and Van de Ven, 1999). However, the result did not support the hypothesis.

Although the data had a nonlinear pattern, the power law method suggested that the data did not follow a power law model, but probably followed a different paretian distribution such as the power law with cut off, the exponential, or even the Weibull distribution. The results suggest that IS alignment may not follow a punctuated equilibrium model. This finding may have been due to a small sample size since most of the data points have a negative value after subtracting 1 to complete the alignment calculation and thus do not meet the requirement that $x_{\min} > 0$. It is also possible that the sample might have had some undesirable characteristics such as a non-random sample selection bias(Heckman, 1979), or a systematic missing data pattern (Bollen and Curran, 2006).

The hypothesis (H1)was tested using a method developed by Clauset et al. (2009).The value of the scaling exponent was found to be significantly above 1, the cut off for a pink noise trajectory (Cromwell et al., 2000, Pilgram and Kaplan, 1998). The estimate of the scaling exponent, 5.63, suggests a "black noise" model, which according to Cromwell et al.(2000) is associated with catastrophes that exhibit constrained or regulated, explosive, and persistent behaviors such as droughts, hurricanes etc. However, testing this hypothesis will require using Clauset et al.'s(2009) method on a number of suspected distributional forms to generate the scaling exponent that fits a better model. Thus, even though Sabherwal et al. (2001) found a strong link between the punctuated equilibrium model and IS alignment, this study did not find support for that link.

The data were also tested for nonlinear relationships with time using the random coefficients growth model (Bliese and Ployhart, 2002). It was found that a quadratic term for time was able to fit the data quite well. This supports the idea that IS alignment follows a nonlinear trajectory.

6.2.2 Variability in the IS Alignment Trajectory.

Hypothesis 2 (H2) suggested that there is statistically significant variability in both the initial magnitude and the slope of the IS alignment trajectory. The results supported this hypothesis. Both the variance around the initial magnitude and that around the slope were statistically significant. This means that individual companies are so different in their IS alignment trajectories that a mean trajectory does not represent all of them well (Bollen and Curran, 2006). Bollen and Curran (2006) explain that this provides an opportunity to look for factors that can explain the significant differences. Based on prior literature, I tested five such factors with some giving the expected results (IS performance: H4a and H4b, CIO change: H5b, and Organizational size: H7a), one contradicting the expected result (CIO change: H5a), and others not supporting the hypothesized expected results (Business performance: H3a and H3b, IT investment: H6a and H6b, Organizational size: H7b, and Industry: H8a and H8b, H9a and H9b).

Some researchers have proposed that IS alignment may be affected by business performance (Chan et al., 1997). Based on prior literature, I hypothesized that the initial value of IS alignment would vary depending on the prior business performance (H3a) and that the variability in the IS alignment slope could be explained by prior business performance (H3b). The results do not support both hypotheses. The prior business performance factor had a statistically non-significant impact on both the intercept term (representing the initial value of IS alignment) and the slope factor (both the linear and the quadratic terms). It may be possible that this result is due to the censored nature of the data, that is, the data have an arbitrary cut off that does not reflect the actual beginning of the phenomenon under study (Bollen and Curran, 2006). Another possible explanation is that the time period did not extend far enough for recording a significant event of this type. According to the punctuated equilibrium model, it is sustained low business performance that would lead to the breaking of inertia (Gersick, 1991, Tushman and Romanelli, 1985). The tests carried out in this study used a 1-year lag in business performance. It may be possible that longer lags may reveal an association that cannot be observed using the 1-year lag.

Prior literature also proposes that past IS performance has a positive effect on both the initial level and the rate of change of IS alignment (Chan et al., 2006, Sabherwal and Kirs, 1994). Based on these studies I hypothesized a positive relationship between initial value of IS alignment and prior IS success (H4a), and a negative relationship between the rate of change in the IS alignment trajectory and prior IS success (H4b). Both of these hypotheses received support. The results show that the initial value of IS alignment was statistically significantly higher for firms that were high in prior IS performance than for those that were low in prior IS performance. This confirms the findings from prior literature that a history of success in dealing with IS issues engenders positive attitudes in non-IT staff and provides the opportunity to view the IS department as a partner (Chan et al., 2006, Reich and Benbasat, 2000). However, the rates of change in IS alignment for the two groups were significantly different and in opposite directions. Our hypothesis that higher IS performance would be related to lower rates of change was supported. The firms with a high initial magnitude of IS alignment had a decaying magnitude of IS alignment over the time period under review. On the other hand, those that started off with a low level of alignment improved their status at a high rate. This is consistent with the punctuated equilibrium model's predictions that sustained low performance would galvanize people to action leading to evolutionary and revolutionary change (Romanelli and Tushman, 1994, Sabherwal et al., 2001, Sastry, 1997). This change happened in short time intervals which leads us to suggest that the nature of the change was more evolutionary and adaptive than revolutionary (Orlikowski, 1996). The results are consistent with the literature that argues against viewing IS alignment as an "end state" rather than an adaptive process over time (Chan and Reich, 2007a).

The impact of a CIO on the nature of IS alignment is undeniable (Earl and Feeny, 1994, Feeny et al., 1992). Sabherwal et al. (2001) argued that a change in leadership might trigger revolutionary change. Based on these and other studies, I hypothesized that a change in CIO would lead to lower levels of alignment (H5a) and high rates of change as the organization adapts to a new CIO (H5b).The results do support hypothesis H5b but contradict hypothesis H5a. The change in CIO seems to be positively related to the initial IS alignment value. In fact, the results show that firms that change their CIO have a higher initial level of IS alignment than firms that do not. Prior literature has not examined this issue except for a few studies dealing with the IS leader's rank and role which impact the authority invested in the CIO and thus the effect of turnover of such a person (Chan and Reich, 2007a, Chan and Reich, 2007b, Earl and Feeny, 1994). I propose that the reason for most CIO turnover would be related to low performance of the IS department. This would explain the positive reaction to the changing of the CIO. On the other hand, there is statistically significant support for the notion that organizations that had experienced a CIO change would on average have a sharper slope to compensate for their temporary loss. Table 4.3.6.1 provides details of the number of CIO change events for each year. The year 1999 had 104 CIO change events which affected the IS alignment trajectory in 2000. The numbers of CIO change events seem to have a direct effect on the trajectory of IS alignment. However, the effect of CIO change has significant variability. This means that some firms benefit from it while others do not.

Bird et al. (2006) proposed that IT investment acts as a moderator variable for the relationship between IS alignment and business performance. Weill (1992) and others also suggested that IT investment could lead to higher firm performance depending on some contextual factors. Based on these studies I hypothesized that IT investment would positively affect the initial value of IS alignment and be negatively related to the rate of change of IS alignment (controlling for industry and organizational size). The results of the tests did not support these hypotheses. IT investment did not have a statistically significant relationship with IS alignment. This may be due to the fact that there may not be a direct relationship between IT investment and IS alignment as noted in prior literature. However, since a moderating effect was found in the Byrd et al. (2006) study, I expected at least the interaction effects to be statistically significant. The results show that all the interaction effects are non-significant.

The size of an organization has been argued to affect alignment through formalization and availability of resources (Chan et al., 2006). Hypothesis H7 proposed that organizational size positively affects the initial value of IS alignment and also has a negative relationship with the slope of the IS alignment trajectory. Hypothesis H7a was supported. The results showed that larger organizations tend to have higher IS alignment values than smaller organizations. Chan et al. (2006) argued that larger organizations have more resources that they can commit to making IS alignment work such as having managers in charge of making formal arrangements for IS alignment. Therefore, the results are consistent with prior literature. Hypothesis H7b, however, did not receive support. The random effects for the interaction terms between time and organizational size were all not significant. Even the plot of the large, medium and small firms against IS alignment provides no support of a difference in rates of change according to size.

Hypotheses H8a, H8b, H9a, and H9b tested the effects of industry on the IS alignment trajectory. In hypothesis H8, the concern was to point out that higher performing companies in any industry will have a higher initial level of IS alignment and will have a lower rate of change. This hypothesis did not find support. However, this result needs to be taken with caution because the model that could have given results for each industry failed to converge and a simpler model was used instead. However, the results show that industry does not distinguish between high business performers and low business performers with respect to IS alignment. This means that industry has no statistically significant effect on IS alignment, that is, there are no industries that have consistent high performers while other industries have consistent low performers. Hypothesis H9 sought to test the effect of environmental uncertainty on the initial magnitude and the rate of change of the IS alignment trajectory. I expected to find firms operating in uncertain industry environments having higher levels of IS alignment (Chan et al., 2006, Sabherwal and Chan, 2001, Sabherwal and Kirs, 1994). The results do not support this hypothesis. The difference in means for high performing organizations in uncertain environments and high performing organizations in stable industry environments was found to be statistically non significant. High performing organizations in stable industries perform marginally better than high performing organizations in uncertain industries although the difference is not statistically significant. Figure 5.3.2.16 provides a visual perspective to this situation. This result has to be interpreted with caution as well since the intended model did not converge.

6.2.3 Summary of Discussion

This study has found that the trajectory of the IS alignment construct follows a nonlinear form that is not Gaussian. Although the power law model did not fit the data, the degree of misfit was within sampling error thus supporting the notion that the data might fit a different Paretian distribution. It was also found that several factors affect the form of the IS alignment trajectory. Specifically, IS performance, CIO change, organizational size and environmental uncertainty were found to have statistically significant effects on the IS alignment trajectory. The study found the following:

1. IS alignment may not be generated by an evolutionary mechanism but by a catastrophic mechanism whose mathematical form is yet to be determined.
2. There is significant difference in how firms experience the IS alignment process. Most firms have unique experiences that cannot be captured by a mean value. This leads us to search for explanatory variables that affect the IS alignment process.
3. Prior business performance is not a good explanatory variable for the IS alignment trajectory.
4. Prior IS success on the other hand is very relevant in shaping the development of IS alignment within the firm.
5. A change in CIO helps the firm to reset its IS alignment processes and reduce some of its inertia. On average, CIO change was accompanied by an increase in IS alignment albeit not in a sustained manner.
6. IT investment is not directly related to the IS alignment trajectory. IS alignment seems to be more about how resources are managed rather than just the amount of resources.
7. Organizational size explains some of the variability in IS alignment between firms. Larger organizations tend to begin with a higher level of IS alignment than smaller organizations.
8. High business performers may not be distinguished on the basis of industry. The same IS alignment dynamics seem to occur in different industries.
9. Firms in stable industry environments tend to have marginally better IS alignment trajectories than firms in uncertain industry environments.

6.2.4 Limitations

The findings in this research study should be viewed in the light of some limitations.

Firstly, the nature of the data may not allow for capturing of the phenomenon at periods of theoretical significance. For example, the study could have been more robust if the data were collected from organizations that had experienced periods of equilibrium as well as periods of revolution. This limitation was mitigated somewhat by using data that covers a long enough period so that all these phenomena could be included.

Secondly, the data may have had some significant selection bias due to two main issues. Firstly, the data were biased toward larger organizations since companies are only included in the *InformationWeek 500* database if they have annual revenues of $500 million or higher. Smaller and medium sized companies are therefore excluded and may have a different IS alignment pattern. Secondly, the data may favor companies that have better IS performance or that are innovative in their use of IT. Therefore, the value of IS alignment may be inflated. This limitation affects the generalizability of the findings. The results apply only to organizations that fulfill the above two conditions.

Thirdly, the measures may lack reliability and validity since they are self reported and most are single indicator measures. This may be a serious problem for robustness of results. However, the study uses data from several different sources, most of which can be verified using regulatory (e.g. securities and exchange commission (SEC) reports) and other sources. Also, some of these measures have been used by other researchers and found to be reliable (Bharadwaj et al., 1999).

Fourthly, this study only concentrates on one piece of the alignment complex. Henderson and Venkatraman (1993) suggested that to fully understand the alignment process both strategic and operational fit must be studied simultaneously. This means that strategic IS alignment might behave differently in the presence of other factors such as organizational structure (Chan et al., 1997). Nevertheless, this study will provide a much needed dynamic perspective to strategic IS alignment.

Fifthly, the models that were run had to be simplified and tailored to the strengths of the statistical software that was used. The combination of data and software limitations presented a lot of difficulties in modeling and analyzing the data. Complex dynamic models could not be run due to limitations on the number of factors that can simultaneously be processed. Specifically, latent curve models could not be run due to software constraints. However, random coefficients models provide very close or even similar results as the more sophisticated LCA method.

6.3 Conclusion

This dissertation study had two goals: 1) to find the form of the dynamic IS alignment trajectory, and 2) to find factors that affect this trajectory. To answer the first goal of this dissertation, data were gathered from the *InformationWeek 500* and COMPUSTAT databases. These data were then converted into emergent business strategy and IS strategy profiles. The strategies were used to obtain an alignment measure that became the basis for a power law analysis. The hypothesis was that the data should follow a pink noise trajectory to support the proposition that IS alignment follows a punctuated equilibrium pattern. Applying the steps outlined in Clauset et al. (2009) for testing a power law form, it was revealed that in fact our data did not follow such a form. The p-value was much below that required for statistical significance; therefore, we can conclude that the data do not follow a power law model even though they may follow some other form of Paretian distribution.

The second goal was accomplished by testing the significance of each of five factors that had been identified from prior literature as having some impact on the development of IS alignment. A relatively new method, the random coefficients model, was used to test the hypotheses that business and IS performance, CIO change, IT investment, organizational size and industry affected both the initial level (intercept) and the rate of change (slope) of the IS alignment trajectory. These procedures revealed that IS performance, CIO change, and organizational size are factors that have a statistically significant effect on the IS alignment trajectory. The other factors: business performance, IT investment, industry and environmental uncertainty (industry) were found to have little direct influence on IS alignment.

6.4 Implications

The research study has offered several contributions.

6.4.1 Implications for Research

For theory building, the dissertation has provided both a longitudinal perspective of the behavior of the strategic IS alignment construct, and the dynamics of the interaction of strategic IS alignment with theory suggested factors such as performance, resources and new leadership. This should provide a deeper understanding of the longitudinal behavior of strategic IS alignment, and a foundation for further research. It is important to ascertain the generative mechanism of a phenomenon so that we can build theory that captures the causes of the behavior of a system. Therefore, it is essential that we know the form of the IS alignment trajectory. This dissertation is among the first in the information systems field to argue for fitting of mathematical forms to longitudinal data. Since the power law model did not fit the data, future research can continue the search for a generative mechanism for IS alignment.

The study also proposed a method to convert IT deployments into an emergent strategy profile. This is a new method to get usually sensitive data about a firm's IS strategy from secondary data sources. This is an important contribution to the IS field as it will allow researchers to access data that they normally would not, and it would provide another dataset for comparison purposes. Since the method is new, it requires testing to find out the correlation between constructs obtained through perceptual and archival data on IS strategy.

Additionally, the research has shed light on the appropriateness of using the punctuated equilibrium theory to model changes in strategic IS alignment (Benbya and McKelvey, 2006b). The processes that the punctuated equilibrium model proposes may not offer the best explanation for the behavior of IS alignment. Alternatively, the mathematical model underpinning the punctuated equilibrium model may not capture the theory as well as it should. Additional modeling and testing will be required to find the best fitting explanatory and predictive theory for IS alignment.

6.4.2 Implications for Practice

For practice, this dissertation has offered insights into the factors that affect the magnitude of change, and the rate of change, in the strategic IS alignment construct. This should help executives to understand the likely trajectory of strategic IS alignment for their particular context, which will aid in the decision-making process.

The study uncovered the factors that have an impact on the trajectory of IS alignment. One of the most important of these, is the changing of the CIO, which has a huge impact on IS alignment. Although the changing of the CIO was seen as positive in many firms in the sample, the spikes in the trajectory suggested that it was a short-term measure that did not produce any long lasting value. The study's findings caution organizations against having high CIO turnover. Moreover, the number of CIO change events were extremely high in the earlier part of the study period which accounts for the high spike in IS alignment. The improvement in IS alignment might have been due to other factors and not necessarily because a new person came into the firm.

Another important finding was that IT investment has an insignificant direct impact on IS alignment. It is very common for organizations to spend on IT with the view that more resources will result in higher IS alignment. This study found that IS alignment is not based on the size of the IT budget. Weill (1992) found that IT investment provides value in the presence of effective IT management processes. Therefore, the focus should be on the importance of the management of IT resources, with the amount of IT resources playing a smaller role.

The findings of this study suggest a few things for IS and business leaders:

1. IS alignment has a significant relationship to change in IT leadership. CIO turnover provides a short-lived positive change in IS alignment. However, the long-term IS alignment trajectory shows a downward trend after every CIO change.
2. The IS literature has suggested that a good reputation for the IT group is a necessary ingredient to obtaining higher levels of IS alignment (Chan, 2002, Reich and Benbasat, 2000). IT leaders need to concentrate on internally marketing their departments rather than focusing on bigger budgets. The findings of this study show that prior IS success has a significant relationship with IS alignment.

3. The study also shows that firms need to put in place formal arrangements aimed at achieving IS alignment. Larger firms that have devoted human resources to obtain IS alignment get rewarded. Firms should consider developing positions such as IS Alignment Process Manager to devote serious attention to the problem of IS alignment.
4. Although the power law model did not fit the data, indications are that a model closely akin to the power law model would fit the data. From the value of the scaling factor we can surmise that a "black noise" model would be a good fit. This means that achieving IS alignment is a complex process where simple acts may lead to catastrophic consequences (Anderson, 1999, Grobman, 2005, Thiétart and Forgues, 1995). Executives need to know that sometimes fine-tuning a system may lead it to collapse but also that not putting in enough effort may lead to a downward spiral that is out of proportion with the act committed. Executives need to find a balance between aligning their IS strategy to follow business strategy and allowing IS strategy to lead business strategy (Chan and Reich, 2007a).

IS alignment is an important aspect of a company's benefit from the use of IT. This dissertation study has proposed a functional form for IS alignment and tested several factors that may affect the IS alignment trajectory.

APPENDIX A

Table A1. Cross sectional Strategic IS alignment studies

Authors	Nature Of Alignment	Antecedents	Outcomes	Type Of Study	Theory	Method	Findings
Byrd, Lewis & Bryan (2006)	Alignment between IT and business strategy and how it affects the IT investment-business performance relationship	Business strategy IT strategy	IT investment Business performance	Empirical cross sectional study of 84 privately held metal manufacturing plants in Southeast USA	Contingency Theory Strategic IS alignment	Moderated Regression	Process coordination alignment positively influences the relationship between IT investment and firm performance Process integration alignment was not found to significantly influence the relationship between IT investment and firm performance Outcome matching and moderating alignment of business and IS strategies positively influence the relationship between IT investment and firm performance
Chan, Sabherwal, & Thatcher (2006)	Antecedents and outcomes of strategic IS alignment	Shared domain knowledge Planning sophistication Prior IS success Organizational size Environmental uncertainty	Organizational success	Empirical cross sectional study based on two prior studies' data	Miles & Snow (1978) typology of business strategies Contingency Theory Fit	Profile deviation	Of greatest importance to alignment are factors directly related to IS management (i.e. shared knowledge & planning sophistication), followed by the credibility or track record of the IS group (i.e. prior IS success), and then factors most remote to IS and IS management (i.e. organizational size & environmental uncertainty) Alignment is more difficult to achieve in prospectors as compared to analyzers and defenders Size affects alignment in business firms more than in academic organizations Environmental uncertainty affects alignment in academic institutions more than in business firms Prior IS success affects alignment in defenders

							but not in analyzers or prospectors
Croteau & Raymond (2004)	Alignment between strategic and IT competences	Strategic competencies IT competencies	Business Performance	Empirical cross sectional study of 104 large firms in Canada	Strategic IS alignment Model Contingency Theory	Structural Equation Modeling (using EQS)	As firms tend toward a co-alignment of their strategic and IT competencies, higher levels of performance are likely to be attained
Kearns & Lederer (2003)	Organizational processes that affect IT alignment	Information intensity of value chain	IT for competitive advantage	Empirical cross sectional study based on a questionnaire survey of 161 firms	Resource-based View (RBV)	SEM using EQS	Information intensity was found to be positively and significantly associated with participation of CIO in business planning and participation of CEO in IT planning Participation of CIO in business planning is associated with both IT plan reflects business plans and business plan reflects IT plan Participation of CEO in IT planning is strongly associated with business plan reflects IT plan but not strongly related to IT plan reflects business plan The outcome IT plan reflects business plan, but not business plan reflects IT plan, was positively and significantly related to the use of It for competitive advantage
Hussin, King, & Cragg (2002)	Alignment between content of Business and IT strategies	IT sophistication CEO commitment to IT External IT expertise	IT Alignment	Empirical cross sectional study based on a questionnaire survey of 256 small manufacturing firms	Porter's (1980) generic business strategies Fit	Moderation approach (i.e. Interaction between IT and business strategies)	Alignment is related to aspects of both IT sophistication and IT management CEOs commitment to IT is positively related to IT alignment. CEOs participation is not as important as CEO involvement when it comes to alignment There was little support for the relationship between external IT expertise and IT alignment
Sabherwal & Chan (2001)	Alignment between Business and IS strategies		Business performance	Empirical cross sectional study based on a questionnaire	Miles & Snow (1978) typology Contingency Theory	Profile deviation	There was no significant relationship between business strategy and industry Alignment was significantly associated with perceived performance

				survey of 226 firms in 4 industries	Fit		Alignment was significantly associated with perceived performance in analyzers and prospectors but not in defenders
Chan, Huff, Barclay & Copeland (1997)	Alignment between business and IT strategic orientations	Business strategic orientation IS strategic orientation	Business performance IS effectiveness	Empirical cross sectional study of 170 manufacturing and financial services firms	Miles and Snow topology (1978) Systems View Venkatraman (1989)	Principal Components Partial Least Squares SEM	Systems models of alignment provide more useful information that do bivariate models Alignment is a better predictor of perceived performance than realized strategy Creating and realizing an IS strategy are crucial steps Best performing companies appear to have high alignment between realized IS and business strategies A comprehensive realized IS strategy need not be a complex IS strategy Realized business and IS strategies are both related to business success
Gupta, Karimi & Somers (1997)	Alignment of Competitive strategy and IT management sophistication	Firm size	IT management sophistication	Empirical cross sectional study based on 213 managers in financial services firms	Miles & Snow (1978) typology Technology-assimilation model	t-tests ANOVA	Firms differ on their emphasis on the dimensions of IT management sophistication depending on strategic orientation
Sabherwal & Kirs (1994)	Alignment between organizational CSFs and IT capabilities	Environmental uncertainty Integration IT management sophistication	Perceived IS success Organizational Performance	Empirical cross sectional survey of 244 large academic institutions	Rockart's (1979) critical success factors Contingency Theory	Profile deviation Factor analysis Cluster analysis Multiple Regression	Alignment between CSFs and IT capability is positively associated with both perceived IT success and organizational performance Environmental uncertainty is positively associated with perceived IIT success IT management sophistication is positively associated with both alignment and IT success

APPENDIX B

Table B1. Longitudinal studies on Strategic IS alignment

Authors	Nature of Alignment	Type of Study	Theory	Findings
Hu & Huang (2006)	Strategic IS alignment	Single case study of a mid-sized biopharmaceutical company with interviews of 6 informants	Social dimension of alignment Balanced scorecard	1. The strategic planning model adopted by BIOCO achieved high alignment on both the communication and connections drivers 2. shared domain knowledge and successful IT history played significant roles in alignment at BIOCO 3. Active relationship management by IT managers contributes to alignment through enhanced communications, and positive influence on the shared domain knowledge and perception of successful IT history 4. The balanced scorecard plays an important role in the IT-business alignment at BIOCO by contributing positively to communications and connections
Boddy & Paton (2005)	Business, Strategic, Structural, IS, Cross alignment	single case study of Kwik-Fit company (over 20 years), with 37 interviews targeting four phases of a project	Organizational theory Dynamic capabilities	1. alignment is not static but evolves with changing circumstances 2. unintended consequences of change require post revolutionary adjustment to restore high alignment 3. using semi-structures helps to achieve and maintain IS alignment
Grant (2003)	Strategic IS alignment	Single case study in a large global organization. 15 interviews with senior managers in Canada, USA & Europe over a 9 month period	Strategic IS alignment model	1. Lack of a comprehensive corporate vision for the role of IT inhibits alignment 2. Lack of well defined IT vision leads to a fragmented IS investment strategy 3. Misalignment between the business operating model and information IT execution model 4. There must be a clear fit between the information requirements of the business and the information architecture and infrastructure for organizations to derive

				value from IS investments 5. Integrated IT governance 6. Internal IS/IT management capabilities
Hirschheim & Sabherwal (2001)	Strategic IS alignment	Three illustrative case studies	Ideal types and trajectories Logical incrementalism	1. Paradoxical decisions, that is decisions that change some components of alignment in one direction and others in another direction, may be due to inertia, sequential attention to goals or gaps in knowledge 2. Excessive transformations in which change in one or more alignment components is excessive, are likely due to split responsibilities and underestimation of problems 3. Uncertain turnaround, or a reversal of a recent change to move back toward an original position, is due mainly to inertia and underestimation of problems
Sabherwal, Hirschheim, & Goles (2001)	Strategic, IS, Business, Structural, & cross-Dimensional alignment	Multiple case studies (3) with 30 interviews & examination of internal documents	Punctuated equilibrium model Strategic IS alignment model	1. Evolutionary periods may continue due to high alignment or inertia 2. There is a reluctance to resolve misalignment by redesign (incremental change is preferable to revolutionary change) 3. Triggers of revolutionary change: environmental shifts, sustained low performance, influential outsiders, new leadership & perceptual transformation 4. Resolution by redesign is not always effective 5. Ineffective revolutionary changes trigger post revolutionary adjustments
Reich & Benbasat (2000)	Linkage of IS plans with organizational objectives Social alignment	Case studies in 10 business units within three large Canadian life insurance companies. 57 interviews with 45 informants.	Resource dependency model Social construction of reality Interpretivist theory	1. shared domain knowledge predicted long-term alignment 2. shared domain knowledge may moderate the relationship between IT implementation success and level of communication as well as connections in panning 3. planning practices are not predicted by intra-unit factors (such as shared domain knowledge or IT implementation success), but by macro organizational level policies, and, in some cases, by senior individuals within business units
Johnston & Carrico (1988)	IT strategic IS alignment	Field study with 90 interviews & examination of public information from 11 large companies	Value added chain model	1. Industry environmental factors influence the direction and pace of strategic deployment of IT 2. Companies vary substantially in the extent to which IT has integrated with the primary strategies 3. Several internal conditions are consistently present in those

				organizations that are most successful in strategic utilization of IT (leadership, integration of IT & strategy, direct contact between IS function & line divisions, capability in IS function, and mechanisms for line influence on IT)

APPENDIX C

Table C1. Operationalization of Key Variables

Factor	**Constructs**	**Variables**	**Measures**	**Data Source**	**Type**
Performance	Business Performance	ROA ROA ROI	Return on Equity Return on Assets Return on Investment	COMPUSTAT	Continuous **Reflective**
	Prior IS Success	Prior IS Success	The *InformationWeek 500* ranking of the organization in the current year	InformationWeek	
New Leadership	CIO Change	CIO Change	A dummy variable with zero signifying no change in the executive and one indicating a change in the executive	InformationWeek	Categorical **Reflective**
Resources	IT Investment	IT Investment	Ratio of dollar investment in Information technology in prior year to the total sales in the prior year	InformationWeek	Continuous **Reflective**
Environmental Uncertainty	Industry	Industry Industry	Primary industry Two digit SIC code	InformationWeek COMPUSTAT	Categorical **Reflective**
	Uncertainty	Sales Growth	Ratio of current sales over sales in immediate prior period	InformationWeek COMPUSTAT	continuous **Reflective**
Organization Size	Organization Size	Firm Size1 Firm Size2	Natural log of market value of equity Log of number of employees	COMPUSTAT	Continuous **Reflective**

Alignment	IS Alignment	Business Strategy IS Strategy	Scope, Product market Dynamism, Liquidity, Asset Efficiency, Fixed Asset Intensity, Long-Range Financial Liability Operational Support Systems, Interorganizational Systems, Market Information Systems, Strategic Decision Support Systems	COMPUSTAT InformationWeek	Continuous **Formative**

APPENDIX D

Table D1. Measures used to classify and validate IS Strategy

Strategy Components	Variables	Data Sources	Measures
	Classification Variables		
Operational Support Systems	Internal Defensiveness	InformationWeek	Proportion of group of deployed IT focused on improving efficiency in operations and supporting effective coordination across functions e.g. Asset Management software
	Analysis	InformationWeek	Proportion of group of deployed IT focusing on supplying information for analysis of the business e.g. Business performance software
Interorganizational Systems	External Defensiveness	InformationWeek	Proportion of group of deployed IT focused on linkages with suppliers, customers and partners e.g. electronic business supply chain tools
Market Information Systems	Aggressiveness Proactive	InformationWeek	Proportion of group of deployed IT focused on market competition (such as price setting) e.g. business intelligence tools
	Innovativeness	InformationWeek	Proportion of group of deployed IT focused on helping to introduce new products/services in the market e.g. product lifecycle management software
Strategic Decision Support Systems	Risk Aversion	InformationWeek	Proportion of group of deployed IT focused on facilitating business planning e.g. enterprise resource planning (ERP) systems
	Futurity	InformationWeek	Proportion of group of deployed IT focused on modeling the future and forecasting e.g. OLAP and data mining tools

APPENDIX E

Based on the work of Sabherwal and Chan (2001), the following steps were followed in calculating the IS alignment of firms in the sample:

Step 1. Normalization

The values for the business strategy variables and the IS strategy variables were standardized.

Step 2. Classification of firms into Defender, Analyzer and Prospector categories

Each firm was classified in each year into one of the Miles and Snow (1978) business strategy categories. Firstly, each category's ideal strategy profile was identified from the literature as summarized in table C1 in appendix C. The High, Medium and Low values were the operationalized as 1, 0 and -1 respectively. Secondly, the Euclidean distance from the each firm's business strategy to each of the three ideal business strategy profiles was calculated using the formula:

$$Distance\ (Ideal\ profile) = \sqrt{\sum (X_i - I_i)^2}$$

where X_i = the normalized score for the *i*th business strategy attribute, and I_i = the ideal normalized score (that is, 1, 0 or -1) for the *i*th attribute in the ideal strategy profile from which the distance is being measured. Thirdly, after computing the distances to each of the ideal strategy profiles, the shortest distance was picked and the ideal profile to which it belonged became the business strategy being pursued by the firm. For example, if the Euclidean distances to defenders, analyzers and prospectors for a firm were 2.01, 1.02 and 3.32, then the firm would be pursuing an analyzer strategy because the distance to the analyzer ideal profile is the shortest.

Step 3. Computation of alignment between business strategy and ideal IS strategy

The business strategy calculated in step 2 is used to identify the ideal IS strategy that is theoretically best suited to it. First, the ideal IS strategies are standardized with High, Medium and Low values being operationalized as 1, 0 and -1 respectively. Secondly, the distance of each companies IS profile from the ideal IS strategy for its identified business strategy is computed using the formula in step 2. Thirdly, the alignment is computed as one minus the distance computed. This alignment value is then used in the testing of the hypotheses.

APPENDIX F

2002 *INFORMATIONWEEK* 500 QUALIFYING SURVEY

Congratulations on being named a candidate for *InformationWeek's* 14th Annual *InformationWeek 500* listing of the nation's leading IT innovators! You must complete the questionnaire to become a finalist for the *InformationWeek 500*, which will be published on Sept. 23rd. Your completed survey also makes one senior executive in your organization eligible to attend the *InformationWeek* Conference at the Westin La Paloma resort in Tucson, Arizona Sept. 22nd-25th. You're invited to mail, overnight, fax, or E-mail this questionnaire back to us at your earliest convenience. If you are really in a crunch but want your company considered, you can call 800-854-8281 ext.2172 (9 a.m.–7 p.m. E.T.) and a representative will conduct the survey over the phone with you.

As in previous years, we have included three brief essay questions, which will enable you to tell us about initiatives that may not otherwise be referenced in the survey. You're welcome to E-mail these responses to us at iw500@cmp.com in ASCII text or as a Microsoft Word attachment. Or you can click on the 2002 *InformationWeek* 500 Resource Center at http://www.informationweek.com/iw500/2002 to submit your essays online. We don't publish them verbatim.

Fax: 858-410-2175 Phone: 800-854-8281, ext. 2172
E-Mail: iw500@cmp.com
Resource Center: http://www.informationweek.com/iw500/2002
Resource Center Password:iw500 Resource Center ID:candidate
Address: *InformationWeek* Research, Harte Hanks, 3344 North Torrey Pines Court, La Jolla, CA 92037

IT organizations that completely fill out the questionnaire score consistently higher in the *InformationWeek 500*. Note: *InformationWeek* does not disclose individual contact information or IT budget data to third parties; however, we do study selected data in conjunction with several leading management schools. Please answer the questions to the best of your knowledge and do not hesitate to consult with other IT executives for current information.

To find out more about this year's annual conference, please visit our Web site at www.informationweekevents.com.

Best wishes, *The Editors of InformationWeek*

Please tell us about yourself.

[] Please send me the *InformationWeek 500* issue.

___________________________ Name
___________________________ Officer Title (EVP of IT, VP of IS, Director, etc.)
___________________________ Descriptive Title (CIO, CTO, etc.)
___________________________ Your Company
___________________________ Parent Co. (If different)
___________________________ Mailing address line 1
___________________________ Mailing address line 2
___________________________ Location (City, state, zip)
___________________________ Telephone number (Very important)
___________________________ Fax number (Very important)
___________________________ E-mail address (Very important)

__________________________ URL (Primary, parent co.)

Please confirm for us the name of your organization's highest ranking U.S.-based IT or IS executive and provide us with contact information for fact-checking purposes.

__________________________ Name
__________________________ Officer Title (EVP of IT, VP of IS, Director, etc.)
__________________________ Descriptive Title (CIO, CTO, etc.)
__________________________ Company
__________________________ Parent Co. (If different)
__________________________ Location (City, state)
__________________________ Telephone number
__________________________ Fax number (Very important)
__________________________ E-mail address (Very important)

Please answer the following questions to the best of your knowledge. Do not hesitate to ask other members of your IT organization to contribute more precise answers as needed.

TECHNOLOGY STRATEGY

1. Which of the following products or technologies are **widely** deployed in your organization? [Choose ALL that apply]

01 [] ERP – enterprise resource planning
02 [] Customer-resource management (CRM) systems
03 [] Electronic commerce applications
04 [] Electronic business: supply chains
05 [] Data warehouse
06 [] Business intelligence tools
07 [] Internal Collaboration tools
08 [] B2B Collaboration tools
09 [] Networked Storage (SANs)
10 [] Linux-related tools or applications
11 [] Windows 2000 server
12 [] Windows 2000/XP
13 [] Wireless network services
14 [] Fiber-optic local area networks
15 [] Java based applications
16 [] XML-based applications
17 [] Web Services (Applications using SOAP, UDDI, XML)
18 [] Applications constructed of reused components/objects
19 [] Mobile commerce or custom remote access tools

2. What percentage of your IT application budget, including development and maintenance and labor, is spent on the following? (Combined numbers must total 100%)

01 _________% building new applications
02 _________% maintaining old applications
03 _________% integrating applications

3. How does your organization use XML if at all? (Choose ALL that apply)
01 [] To extend Web site functionality
02 [] For electronic data exchanges or transactions with customers or suppliers
03 [] Content management
04 [] Pilot testing/evaluating
05 [] Not currently using XML

4. What steps, if any, has your company taken in the past 12 months to improve the quality of its portfolio of in-house or custom applications? (Choose ALL that apply)
01 [] We prepare and follow a formal QA test plan
02 [] We typically use our best instincts, rather than testing
03 [] We use a formal application development model
04 [] We rely upon pre-tested components
05 [] We use best of breed development tools
06 [] We use outside expertise, consultants
07 [] None of these

5. What percentage of your organization's corporate data, if any, is contained on storage-area networks?
01 _______%(0-100%)

6. How often, if ever, does your organization encrypt its most sensitive data files or records? (Choose ONE)
01 [] Never
02 [] Hourly
03 [] Daily
04 [] Weekly
05 [] Monthly
06 [] Annually
07 [] Other (please specify) _____________

Electronic Business Strategy

7. Which of the following types of e-business applications does your company **currently** operate to serve your company's outside customers? (Choose ALL that apply)
01 [] E-learning or certification training
02 [] Customer service and support
03 [] Product or service marketing and information
04 [] Dealer locator
05 [] Product or service sales transactions (E-commerce)
06 [] Product distributed or fulfilled via the Web
07 [] Product or service configuration and customization
08 [] Negotiation of prices or discounts
09 [] Community or threaded discussions
10 [] Personalization (like My Yahoo!)
11 [] Tracking customer loyalty or satisfaction

12 [] Multilingual communications
13 [] Cross-selling (personalized marketing offers)
14 [] Automated auction or bidding process
15 [] None of these
16 [] Other (please specify)_____________________

8. Does your company give its suppliers electronic access to one or more of the following applications or data types? (Choose ALL that apply)
01 [] Order management
02 [] Production schedules
03 [] Sales forecasts
04 [] Marketing plans
05 [] Sales/Campaign results
06 [] Customer demographics
07 [] Customer loyalty/satisfaction metrics
08 [] Product development specifications
09 [] Cost structure data
10 [] Inventory levels
11 [] Accounts payable/receivable status
12 [] Does not apply to us (why?) _____________________
9. Does your company's online team engage in E-business usability testing with one or more of the following groups? If so, how many times per year?
01 [] Customers. . . . . . .How often in the past 12 months? _____
02 [] Suppliers. . . . . . .How often in the past 12 months? _____
03 [] Business partners. . .How often in the past 12 months? _____

10. For each of the following E-Business initiatives, please indicate how frequently the following business practices are conducted. (Choose ONE for each option)

	Standard	Occasionally	Rarely	Never
01 Information sharing with customers				
02 Information sharing with suppliers				
03 Information sharing with business partners				
04 Customized solutions for customers				
05 Customized solutions for suppliers				
06 Customized solutions with business partners				

11. When will your organization's E-business operations turn a profit? 01 [] Already profitable
02 [] Not yet profitable, but have timeframe
03 [] Unknown

12. To the best of your knowledge, what percentage if any of your company's current U.S. sales revenue comes from its electronic business transactions? (No ranges please)
01 _______% (0-100%)

13. What percentage, if any, of your organization's suppliers,-customers and business partners are included in its electronic supply chain?
01 ________ % of customers (0-100%)
02 ________ % of suppliers (0-100%)

03 ________ % of business partners (0-100%)
04 [] Not applicable
14. Does your organization believe mobile or wireless E-commerce will contribute to its E-business revenue stream within the next 12 months?
01 [] Yes, major contribution
02 [] Yes, minor contribution
03 [] No/We don't participate
04 [] Don't know

BUSINESS PRACTICES

15. Thinking of your organization's most important new customer-facing IT investment in the past 12 months, what was the primary project justification? [Choose One]
01 [] Projected topline revenue gain
02 [] Cost savings
03 [] Process/Operational improvement (time savings or enhanced quality)
04 [] Customer satisfaction improvement
05 [] Employee satisfaction improvement
06 [] Supplier satisfaction improvement
07 [] Improvement in intangibles (specify) ___________________
08 [] Other (specify) _____________________

16. Which of the following metrics, if any, does your organization use to measure ROI on technology investments? [Choose ALL that apply]
01 [] Payback Analysis
02 [] Return On Investment (profitability determined by amount of net revenues or operational cost reductions that exceed investment)
03 [] Net Present Value (present value of the expected future cash flows minus cost)
04 [] Internal Rate of Return (the discount rate at which net present value is zero)
05 [] Economic Value Add (operating profit minus the capital and debt used to generate profit)
06 [] Worker productivity/output
07 [] Analysis of intangibles
08 [] Increase in stock price
09 [] Don't measure ROI

17. What percentage of your company's entire workforce has completed either third party or internally developed electronic training or certification courses? (0-100%)
01 ______ % of employees completed third-party E-learning courses
02 ______ % of employees completed company developed E-learning courses
03 ______ % of employees that have received skill certifications via electronic courses

18. Does your IT organization directly produce or sell products or services to other companies that contribute to your company's bottom line? (Choose ALL that apply)
01 [] Yes, non-IT products (customer data, processes)

02 [] Yes, IT products (software, hardware, networking, ASP contracts)
03 [] Yes, services
04 [] No/Not applicable

19. How many hours each month, if any, does your IT executive management team devote to collaborating with line-of-business or department managers on technology strategy?
01 ________ number of work hours

20. In what ways do your organization's senior IT executives study outside customer behavior? (Choose ALL that apply)
01 [] Attend annual customer meetings
02 [] Meet one-on-one with customers
03 [] Respond to customer requests or complaints
04 [] Tracking customer complaint behavior
05 [] Analyze Website traffic patterns
06 [] Analyze purchase habits
07 [] Use business intelligence tools
08 [] Conduct focus groups
09 [] Conduct usability testing
10 [] Survey customer attitudes, preferences
11 [] None of these
21. Which of the following are the most effective technology steps managers in your organization have made in the past 12 months to raise worker productivity? (Choose ALL that apply)
01 [] Deploy customer relationship management/front office solutions
02 [] Call center software
03 [] Allow more workers Internet access
04 [] Moving legacy processes to E-business applications
05 [] Implement enterprise applications such as ERP
06 [] Boost network bandwidth/performance
07 [] Upgrade desktop PCs with newer models
08 [] Outfit workers with laptop PCs
09 [] Upgrade desktop operating systems
10 [] Upgrade desktop productivity software
11 [] Wireless devices such as handheld PCs and cell phones
12 [] Train workers to master key software programs
13 [] Deploy collaborative software tools such as Intranet or e-mail
14 [] Deploy collaborative hardware such as video conferencing
15 [] Deploy business intelligence tools
16 [] E-learning
17 [] None of these

22. Which of the following opportunities and rewards do you provide to your IT staff? (Choose ALL that apply)
01 [] Telecommuting
02 [] Company-paid educational/training opportunities
03 [] Potential for promotion
04 [] Recognition for work well done
05 [] Encouragement for innovative new IT solutions

06 [] Increased responsibilities to keep the work challenging
07 [] Career path planning
08 [] Opportunities to achieve cash/stock bonuses
09 [] Stock options
10 [] E-learning

23. How long ago did your organization's senior IT executive start his or her current position? (Note: Please translate years into months)
01 Month _____ (example: Feb) Year _____ (example: 1998)

24. At what dollar threshold, if any, are managers required to seek IT or E-business project approval from your organization's senior executive management or board of directors?
01 _______ (please specify dollar amount, not range)

25. Please rank each of the following elements of your organization's corporate culture from 1-10, where 1 is most important element and 10 is the least important. Note there can only be one Number 1, one Number 2, etc.
01 [_] Training/skills growth
02 [_] Ethics policy
03 [_] Personal/family needs
04 [_] Innovation
05 [_] Risk management
06 [_] Collegial atmosphere
07 [_] Customer collaboration
08 [_] Focus on customer satisfaction
09 [_] Competitive compensation
10 [_] High productivity

26. Which forms of outside consulting or IT services does your organization currently use? (Choose ALL that apply)
01 [] Strategic IT consulting/planning
02 [] E-business strategic consulting
03 [] Internet/Web site hosting
04 [] IT integration/application development
05 [] Outsource significant portions of IT functions
06 [] Offshore application development/maintenance
07 [] Application Service Provider (ASP)
08 [] Temporary or contract IT workers (from agency)
09 [] None of these

27. Has your company actively recruited and hired new IT workers from the ranks of top postgraduate university management or engineering schools in the past 12 months?
01 [] Yes
02 [] No

CUSTOMER KNOWLEDGE

28. What are the systems, if any, used in your organization's knowledge management strategy? (Choose ALL that apply)
01 [] Group memory/context management
02 [] Expertise profiling
03 [] Data mining tools
04 [] Groupware
05 [] Data warehouse
06 [] Relational databases
07 [] Teamware
08 [] Text/document/online search
09 [] Expert databases/artificial intelligence tools
10 [] None

29. What are the most important benefits, if any, your organization receives from its investment in customer management tools and applications? (Choose ALL that apply)
01 [] One-to-one marketing
02 [] Improved customer loyalty
03 [] More marketing or cross-selling opportunities
04 [] Quicker response to customer inquiries
05 [] Fewer customer service reps required
06 [] Increased efficiency through automation
07 [] Deeper knowledge of customer
08 [] Lower operating costs
09 [] Information to share with partners
10 [] Identifying most profitable customers
11 [] Feedback from customers results in development of new or improved products/services
12 [] None/not yet

30. What percentage, if any, of your company's "knowledge" workers use business intelligence tools such as OLAP or data mining to access data stored on your company's enterprise-class servers and mainframes or data warehouse systems?
01 _______% (0-100%)

31. Has your organization sought to patent, trademark or copyright any IT-driven business processes, products or services in the past 12 months?
01 [] Yes 03 If yes, please explain ________________
02 [] No

32. Are customers involved in the development or customization of your company's products or services? (Choose ALL that apply)
01 [] Customers participate in focus groups or formal user feedback
02 [] Customer opinion is solicited, analyzed
03 [] Call center data is analyzed in data warehouse
04 [] Customers can custom configure products or services on the Web
05 [] Key customers drive product and service development
06 [] Customers opinions are not formally solicited or analyzed
07 [] None of these/Doesn't apply

Your Worldwide IT Organization

Note: Please be thorough in completing this section. The aggregated information will enable your organization to compare itself versus its peers.

33. Please confirm for us your organization's **primary** industry from the following list. If you're a subsidiary name your parent company's primary industry. (Choose ONE)
00 [] Automotive
01 [] Biotech/Biomedical/Pharmaceutical
02 [] Consulting and Business Services
03 [] Chemicals
04 [] Consumer goods
05 [] Construction/Engineering
06 [] Distributor
07 [] Electronics
08 [] E-marketplace (portals, auction, vet.)
09 [] Energy
10 [] Financial services/Banking
11 [] Food/Beverage
12 [] Healthcare/Medical
13 [] Hospitality/Travel
14 [] Insurance/HMOs
15 [] IT Vendors
16 [] Logistics/Transportation
17 [] Manufacturing/Industrial (non-computer)
18 [] Media/Entertainment
19 [] Metals & Natural Resources
20 [] Non-profit
21 [] Retail/E-commerce
22 [] Telecommunications/ISPs
23 [] Utilities
24 [] Other (please specify) __________________

34. Please confirm for us the number of full-time IT employees in your worldwide and/or U.S. organization? Please do not include consultants, part-timers or contract workers. (Enter whole number estimates, no ranges please)
01 ___________ IT organization in U.S.
02 ___________ IT organization outside U.S.
03 ___________ Estimated number IT employees who are not part of a formal decentralized or centralized IT structure but work wholly within business units

35. What percentage of your company's worldwide **2001** annual sales revenue did its total 2001 worldwide IT budget represent? The budget figure should include **capital and operating expenses** for infrastructure including telecom, networking, hardware; applications (maintenance and development and packaged); Internet-based costs; salaries and recruitment; IT services/outsourcing; and training. U.S. only figures are acceptable. (May be rounded to nearest ½%)

01 _______% (0-100%)

36. What percentage of your company's worldwide **projected 2002** annual sales revenue does your total 2002 worldwide IT budget represent? (The budget should include the same elements as above. May be rounded to nearest ½%)
01 _______% (0-100%)

IMPORTANT: [Please check one]
02 [] Percentage is a global figure
03 [] Percentage is U.S. only or primarily U.S.

37. What percentage of your organization's **projected 2002** worldwide IT budget including capital and operating expenses is devoted to: [**Estimates must equal 100%;** Note: Will only be published in aggregate, by industry, **not attached with your organization**.]
01 _____% Hardware technology purchase? (including hardware, networking gear and peripherals)
02 _____% IT services/outsourcing? (including temp workers)
03 _____% Research & Development? (not including salaries)
04 _____% Salaries & benefits? (staff only)
05 _____% Applications? (development, maintenance, packaged, E-business)
06 _____% Everything else combined? (maintenance/admin., etc.)

38. Regarding your organization's 2002 IT spending plans, what percentage is for capital expenses such as new hardware and what percentage is for operating expenses such as labor? (Combined percentages must equal 100%)
01 _____% capital expenses
02 _____% operating expenses

39. What type of organization do you belong to and did you answer for throughout the questionnaire?
A. Your organization type (Choose ONE)
01 [] A subsidiary or division
02 [] A holding/parent company

B. Organization you answered for (Choose ONE)
03 [] My subsidiary or division
04 [] Multiple subsidiaries/divisions
05 [] All subsidiaries/divisions

40. Please specify your organization's annual revenue for its most recent fiscal or calendar year. If your company is privately held, please give your best estimate.

U.S. Dollar Amount: __________ _____________

Fiscal/Calendar Year Ends When: _____________ (month)

Year: 2001/2002 (circle one)

URL or contact information
for revenue confirmation: ____

41. Please specify your organization's annual net income (profit) for it most recent fiscal year. If your company is privately held, please give your best estimate.

U.S. Dollar Amount: __________
Fiscal Year Ends When: _____________ (month)Year: 2001/2002 (circle one)
URL or contact information
for net income confirmation: ____

ESSAY SECTION May be used as fax entry or submitted by electronic mail to iw500@cmp.com.
Fax:858-410-2175

For additional points, *InformationWeek* editors invite you to E-mail (iw500@cmp.com) your responses to the following brief essay questions. We request that you send the file either in ASCII text or as a Microsoft Word attachment. Be sure to identify yourself, your title, your company, and include your preferred contact method such as phone, fax, and e-mail address. Or if you would prefer, click on the 2002 *InformationWeek* 500 Resource Center at http://www.informationweek.com/iw500/2002 to submit your essays online. **We may reference your achievements in *InformationWeek*.**

Essay A: What is the most significant accomplishment your IT organization has made in the past 12 months? (Please explain in 500 words or fewer.)

Essay B: Describe how your company's relationships with its partners, suppliers, and customers have changed in the past 12 months because of Internet technology? (Please explain in 500 words or fewer.)

Essay C: How has your IT organization maintained employee morale and productivity during these difficult economic times? (Please explain in 500 words or fewer.)

Thank you very much for participating in the annual *InformationWeek 500* survey! We will be contacting your senior ranking IT executive in the near future to confirm estimates by non-VP-level respondents. If you have any questions, comments, or concerns, contact iw500@cmp.com or click on the 2002 *InformationWeek* 500 Resource Center at http://www.informationweek.com/iw500/2002.

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