The decay of corporations and an analysis of their business fitness landscapes

Geoffrey P. Forster

Southern Cross University
THE DECAY OF CORPORATIONS
AND AN ANALYSIS OF THEIR
BUSINESS FITNESS LANDSCAPES

by

Geoffrey P. Forster
BE, FAICD.

Being a dissertation submitted in fulfillment
of the requirements of the degree of
DOCTOR OF PHILOSOPHY

Southern Cross University

August 2010
ABSTRACT

Large, established, and once successful corporations and their associated brands continually emerge and disappear in any healthy, competitive business environment. However an important trend is emerging in that the average survival time for large established corporations is getting shorter and shorter. This observation is of critical importance to business analysts, investors, executives and corporate directors, for it is a core parameter in determining the long term valuation of a business. More than ever, effective strategic management needs improved tools to aid in the analysis and forecasting of the corporate life cycle, especially in a business environment undergoing rapid, discontinuous change.

This research provides a detailed study of corporate survival trends, and examines and extends the existing landscapes, tools, models and indexes used to monitor the corporate life cycle. The research results in the creation of a new business fitness landscape model, introduces two new business risk parameters, creates a new business diversity fitness index, completes a macro analysis of the extinction rates associated with the 100 largest public corporations in the United States from 1955 to 2008, and applies the new tools and models to selected Fortune 100 corporations.

The research finds that the mean lifetime of the United States’ largest corporations has decreased significantly over the last 53 years and that there appears to be a 15 year periodic cycle in peak decay rates. Furthermore the research establishes a new theoretical model for viewing the mean-life and half-life of large corporations and for studying the impact that related and unrelated diversification in industry participation has on a corporation's effective lifespan. In conclusion, the research suggests that established corporations don’t survive just by being the fittest, but that they survive rapid discontinuous change by finding a new optimum position in a new business fitness landscape. In a very dynamic and changeable business fitness landscape, the largest corporations which have multiple, viable, but not necessarily the fittest positions in the fitness landscape, should experience lower rates of decay.
DECLARATIONS

This thesis does not incorporate without acknowledgement, any material which has been previously accepted for a degree or diploma by the University or any other institution, and to the best of my knowledge and belief, it contains no material previously published or written by another person, except where due acknowledgement is made in the text of the thesis.

Signed: ……………………………

Geoffrey P Forster, Student Number: 21464881

Dated: 1st June, 2009
ACKNOWLEDGEMENTS

I wish to thank and acknowledge the excellent support, counsel and constructive criticism that I have received throughout this study from my supervisor, A/Prof. Allan Ellis. Allan’s advice on how to transform my ideas and research, and translate that into a cohesive dissertation, is especially appreciated.

I want to thank the staff and academics at Southern Cross University’s School of Commerce and Management, as well as Southern Cross University’s Division of Research, for all their support. Also, my thanks go out to the staff and academics at the University of California San Diego, University of California Santa Barbara, San Diego State University and California State University San Marcos, for their time, patience and support during this study.

Many thanks to Wind River Systems, Inc., and SunKosi Capital, LLC., for all their support and funding that helped so much to make this research possible. To the late Dr. Philip Tighe, whose enthusiasm, friendship and inspiration will never be forgotten. Thanks to my parents, Mary and Peter, for their foundations of love and excellence. And a special thanks to my sister Anne for her initiative, encouragement, and support. Most importantly, I wish to thank my wife, Lorraine Pfahl, for her unselfish support, encouragement, and love, throughout this long endeavor. I must also thank my son, Alexander for his precocious feedback and his willingness to listen to my “outlandish” ideas with an open heart and an open mind. And thanks to my daughter, Mercedes, for her uncomplaining patience during my regular academic absence.

Lastly, many thanks to all my colleagues who read the drafts and provided valuable comments, questions and suggestions. This feedback came from numerous discussions with many people, including: Alexander Forster, Prof. Anne Forster, Brandon Christensen, Brian Keathley, Catherine Forster, Charlie Bulkeley, Dr. Claude Cahen, Eva Cahen, Ian Seacombe, Dr. Ivan Vachovsky, Jacqueline Arsivard, Dr. James Cresser, Dr. Jean-Marie Hamel, John Forster, Lorraine Pfahl, Martin Pacak, Mercedes Forster, Dr. Philippe Spiberg, Rhonda Nelson, Robert Forster, Prof. Roslyn Taplin, Dr. Stephen Zeigler, Steven Pacak, Sue Blanche, and Dr. Thomas Gibson.
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<td>Australian and New Zealand Academy of Management</td>
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<td>BE</td>
<td>Bachelor of Engineering</td>
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<td>BCE</td>
<td>Before Common Era</td>
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<td>Birth phase in the life cycle of a corporation</td>
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<td>Business Diversity Fitness Index</td>
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<td>U</td>
<td>University</td>
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<td>VBA</td>
<td>Visual Basic for Applications</td>
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<td>V</td>
<td>Volume</td>
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# GLOSSARY OF MATHEMATICAL SYMBOLS

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LIST OF APPENDICES

The following appendices are attached to the end of this dissertation:

APPENDIX A: Fortune 100 Detailed Data Analysis Report

APPENDIX B: The Business Fitness Landscape Modeling Workbench
The following formatting comments should be noted:

1. American English spelling is used throughout the dissertation. This reflects the fact that most of the research was carried out in the U.S., and the majority of the research is focused on U.S. corporations.

2. The page layout and margins have been set up for printing on ISO-216 A4 paper. This was selected as the printed copies will be reviewed in Australia. If it is required to print the dissertation on American Letter size paper, it is recommended that you set up the printing so that scaling from A4 to Letter is activated in your printer’s dialog box.

3. Many of the original figures and tables use shading for information and emphasis. It should be noted that the shading has been selected so that the figures and tables are easily readable when printed in a grayscale format. The majority of the PDF version of the dissertation has therefore been formatted in grayscale. A few pages, however, associated with the Business Fitness Landscapes in Chapter 6, have been formatted for color.
1 INTRODUCTION

At the time of writing this introduction in January, 2009, the world is in the midst of a global financial crisis that is seen by many to be the most serious global economic crisis since the Great Depression (Wall Street Journal, 2009). Major business bankruptcies and bank closures in the United States are becoming a daily event (FDIC, 2009), the rate of growth of unemployment is increasing at a rate not seen in decades (BLS, 2009), Government budgets are in tatters (ca.gov, 2009), consumer confidence is at a record low, and credit markets have become ineffective (Economist, 2008).

One significant characteristic of this current economic crisis is the impact it is having on many of the largest, most established corporations. At the start of 2009, governments, regulators, financial analysts, and shareholders, have serious concerns about the stability of major organizations such as Citicorp, AIG, Bank of America, and General Motors. In the last six months alone, Fannie Mae and Freddie Mac have been seized by Federal regulators, the Government has effectively nationalized the insurance giant, American International Group (AIG), General Motors and Chrysler have been given Government bail-out funds to survive, Microsoft has slashed jobs as sales fall (New York Times, 2009), Lehman Brothers Holdings has filed for bankruptcy, Goldman Sachs Group and Morgan Stanley have been forced to become bank holding companies, and Washington Mutual was seized by the Federal Deposit Insurance Corporation (FDIC). It should be noted that all these organizations are, or were, Fortune 100 corporations (CNN, 2008a), that is, they were all ranked in the 100 largest businesses in the U.S., based on gross revenue. It is becoming clear, that at least with respect to the U.S. economy, we are in the middle of a significant business extinction event, and the largest most established corporations are not immune from its impact.

The events of the last six months were not the driving force behind this research. However, for many people, the events of the last six months may give this research a
significance that was not so clearly perceived when the research began three years earlier. What was reported in the public media three years earlier, and noticed by some, was the following, relatively low profile, but not insignificant comment:

Our size will not be our savior (Ballmer, 2006a).

This quote, from Steve Ballmer the CEO of Microsoft, speaking at the Institute of Directors’ Conference in London in April 2006, captures the significance of this research. Today, business observers are well aware that past success does not guarantee future success. Many business observers would probably go one step further, and say that past success does not even guarantee future survival. The interesting observation is, however, that the survival time of the largest, most successful corporations is getting shorter and shorter (Foster and Kaplan, 2001), and as Ballmer so clearly points out, their size, or recent past success, provides little in the way of guarantees of future long term survival.

When the CEO of one of the most successful corporations in recent US history admits that they may need help to survive, then the real crisis is not just Microsoft’s, but a crisis that is facing nearly every corporation in today’s increasingly dynamic business environment. What does a successful, established, dominant corporation need to do to survive in today’s business environment? At what rate should we expect large corporations to “decay”? If the largest, most successful corporations do have an expected rate of decay, than what is the half-life of a corporation? It is the aim of this research to provide some tools that will assist in responding to these kinds of questions.

The following quote, also from Ballmer, speaking to financial analysts in London at approximately the same time as the earlier quote, introduces an important concept that is examined in detail in this research:

The most important decision you make in the technology industry is whether to participate in the hot markets of the future or stay wedded to the hot markets of the past. Very few, I might argue that no big technology company has ever really been able to be multicore, until we did. I'd argue that even the great companies generally wind up having a single core, and that core either dies, or gets humdrum, and somebody [else] does the new thing. We're trying to be the company that also does the new thing. For years we were a "desktop" company, and people said you'll never be more than a - let me use
the American colloquialism - one-trick pony. Today, we do have two cores. (Ballmer, 2006b)

According to Ballmer, no matter how successful you are, you need “to be prepared to be multicore, multiple pillars of capability and multiple pillars of performance”. This theme, namely the need for diversity of capability as a key to surviving rapid discontinuous change, is a key underlying thesis of this research.

Microsoft’s need for diversification is unlikely to be seen as unique. The need for diversification applies to any large corporations when exposed to disequilibrium in their business environment, and therefore this need actually goes beyond any one corporation or any one industry. The need for diversification is cross-industry, and as such has application to most, if not all of our largest most successful corporations.

It should be noted however, the qualification that was applied to the importance of diversification in the previous paragraph, namely: “as a key to surviving rapid discontinuous change”. During periods of relative equilibrium, the inherent risk and cost of diversification may well outweigh the advantages (Matsusaka, 2001). However, in a period of disequilibrium, in which there is rapid discontinuous change, corporate extinctions can be expected to increase, and those corporations with diverse capabilities should have a higher probability of reaching one of the new emerging fitness peaks in the rapidly changing business fitness landscape.

Business disequilibrium events are not only associated with periods of economic expansion and contraction, but are also tied to the increasing occurrence of industry and cross-industry dislocations. These dislocations may be brought about by all sorts of extreme and not so extreme events, including events such as economic change experienced during the great depression, the saving and loans crisis, and the sub-prime loans crisis. Geopolitical change such as China’s move away from communism to Chinese capitalism, the fall of the Soviet Union, and war in the Middle East. Technological change brought about by the introduction of the microprocessor, containerization, the introduction of the 747 airliner, the growth of the internet, and the use of genetically modified crops. Government decisions such as mandatory health care, telecommunications deregulation, or carbon cap and trade. Even
global environmental change such as global warming, volcanic activity, and water shortages, are all actual or potential business environment disequilibrium events that may have serious consequences for one or more industries, and pose significant challenges and opportunities for corporations, both large and small. It is this disequilibrium which is a key pre-requisite for Schumpeterian creative destruction (Jacobson, 1992; Nelson and Winter, 1982; Schumpeter, 1939; Schumpeter, 1943; Sombart, 1929) in the same way that environmental change is an important pre-requisite for genetic based evolution (Earl and Deem, 2004; Moxon et al., 1994).

Trying to precisely predict when periods of disequilibrium will appear, is of course an impossible challenge for any business strategist. This does not however preclude them from statistical analysis, as any actuary who has just priced earthquake or fire insurance would likely endorse. However evidence suggests that the rate of change in the business environment is increasing and that the time period between periods of disequilibrium is shortening (Davis and Meyer, 1998; Mankiw, 1989; McKinsey, 2006; Strebel, 1992). If that is indeed the case, then planning for the expectation of a disequilibrium event is becoming increasingly important. Of course not all disequilibrium events impact all industries, the majority can be assumed to impact one or just a few related industries at any one time. The other important question is exactly how many disequilibrium events can the average large corporation absorb, and expect to continue to thrive. Assuming that the majority of economic disequilibrium events don’t apply to all industries at a given time, it suggests that a well diversified corporation should be better placed to withstand, or to leverage more of these business disequilibrium events. If that is indeed the case, then maybe the cost reward trade-off (Lins and Servaes, 1999; Matsusaka, 2001) concerning diversification needs to be re-evaluated, especially for our largest, most successful corporations. Those corporations that is, that are less focused on finding a position of market leadership, and more focused on maintaining a position of leadership.

In summary, although there are well documented disadvantages to business diversification (Lins and Servaes, 1999; Markides, 1999; Markides and Williamson, 1994; Markides and Williamson, 1996; Matsusaka, 2001; Palich et al., 2000; Ramanujam and Varadarajan, 1989), for very large established corporations, possibly exposed to one or more destabilizing, business environment disequilibrium events, the benefits of long term survival
that leverages the insurance of diversification, may well outweigh the disadvantages associated with the costs of diversification. For an analogy, the large pension fund may well deem it essential to have a diversified portfolio, while an individual person with a marginal retirement account, may well be best advised to invest in a focused and conservative portfolio, with a minimal expense overhead.

Returning back to the Microsoft case study, compare Microsoft to say IBM, Dell, Apple and Google. Consider, for example, a possible business disequilibrium event in which there was say a sudden market-move to cloud computing, and a move away from client-server computing due to the role-out of say a Government subsidized gigabit broadband network. Such an event may have a significant, even disastrous impact on Microsoft and Dell with their heavy reliance on client server software and hardware respectively. IBM would probably be less affected due to its diversification into enterprise services. Apple would probably experience little negative impact due to its diversification into mobile and media services, while Google would probably opportunistically thrive and become increasingly dominant, given its focus on web-based cloud computing.

1.1 Background to the research

Foster and Kaplan (2001) examined the issue of corporate survival in detail. Their research was driven by the question of why corporations that are built to last, typically end-up under-performing key market indexes such as the S&P 500 and the Dow Jones Industrial Average. They describe, for example, the Forbes 100 list of 1917 and compare it to the Forbes 100 list of 1987. The Forbes 100 list ranked the 100 largest American corporations by assets. The changes observed in the Forbes 100 list during this 70 year period make for a sobering assessment. This assessment is well summarized in the following quotation:

…Of the original group, 61 had ceased to exist…Of the remaining thirty nine, eighteen had managed to stay in the top one hundred. These eighteen companies – which included Kodak, DuPont, General Electric, Ford, General Motors, Proctor and Gamble, and a dozen other corporations…They survived. But they did not perform… Only two of them, General Electric and Eastman Kodak performed better than the (market) averages, and Kodak has since fallen on harder times (Foster and Kaplan, 2001, pp.7-8).
Few business analysts, if any, would be surprised by the fact that companies continually emerge and disappear. After all, isn’t business survival in a competitive market economy all about survival of the fittest? The important observation, however, is that the survival time for corporations appears to be getting shorter and shorter. And this change appears to apply to all types of corporations, including the most successful and most established corporations.

In the 1920s, for example, the turnover rate in the Standard & Poor’s (S&P) list of largest corporations based on market capitalization, averaged 1.5% per annum (Foster and Kaplan, 2001). This meant that a new member of the S&P could expect to remain on the list for more than 60 years. In the late 1990s, however, the turnover rate in the S&P was close to 10%. This means that the average lifetime on the S&P had dropped from over 60 years to approximately 10 years. It is this observation, namely the apparent decrease in the survival time of the leading corporations, which is the driving force behind this research.

The economic approach underlying this business strategy research is more closely aligned with the Austrian School (Hayek, 2001; Jacobson, 1992; Nelson and Winter, 1982; Schumpeter, 1939; Schumpeter, 1943) approach of Menger, Mises, Hayek, Kirzner and Schumpeter, versus the Industrial Organization (Buzzell and Gale, 1987; Jacobson, 1992; Porter, 1980a; Porter, 1998) approach of Caves, Porter, Buzzell, Gale, and Aaker. In particular, as reviewed in the previous section, it should be noted that the research focuses on the disequilibrium, heterogeneity, and entrepreneurial discovery that characterizes the Austrian School versus the equilibrium, empirical regularities, and planned strategy execution that dominates, for example the PIMS (Buzzell and Gale, 1987) Industrial Organization approach.

1.2 The research objectives

The observation that there are important and profound trends occurring in the survival rates of the largest, most successful corporations, is of utmost importance, and has profound repercussions to government, investors, fund managers, directors, and managers. It can therefore be considered to be of some significance that this research is focused on
developing a new set of tools for analyzing corporate survival in today’s environment of increasingly rapid, discontinuous change.

In particular, the following research objectives were identified:

1. What is an effective definition for the decay of a corporation?
2. What is the average life of a modern large corporation?
3. Is the rate of decay of corporations changing?
4. If the rate of decay of corporations is changing, what may be some of the key factors to explain this change?
5. Given a portfolio of corporations, can we predict a half-life or equivalent, in which a given portion of the portfolio will have disappeared or decayed?
6. Since the 1930s, multi-dimensional adaptive landscape models, and fitness landscape models, have been used in the study of the rise and fall of species. Are there modeling techniques helpful in studies of the life spans of well established corporations?
7. Some corporations appear to be better equipped to have a longer survival time compared to other corporations. Corporations survive or decay for many reasons. In an environment in which the business fitness landscape in undergoing rapid discontinuous change, that is a business environment that is in a state of disequilibrium, is unrelated diversification a significant attribute of these longer surviving corporations? Note that for the purposes of this research, unrelated diversification (Ramanujam and Varadarajan, 1989) refers to diversification of the corporation into relatively unrelated businesses as often defined by a significant difference in their SIC or NAICS industry codes. This kind of diversification is often sought for the purposes of vertical integration, a hedge against technological or regulatory change, or for securing financial resources. Unrelated diversification is contrasted to related diversification in that related diversification refers to diversification of the corporation into closely related businesses, often for the
purposes of capturing market share, marketing synergies, or for new operational resources and processes.

8. Can an effective business fitness landscape model be created that helps to view, describe, and better understand the overall business environment in which corporations survive or collapse due to unrelated diversification?

9. What new information can the corporation’s business fitness landscape tell us about the likely lifespan of the corporation?

10. What are the benefits of the new model versus the existing alternative models?

11. What can the corporation’s business fitness landscape tell us about the likely lifespan of the corporation?

12. How can these tools be applied to analyze a selected business?

13. What does the application of these tools tell us about selected businesses?

1.3 Some comments on what the research will not be covering

The documentation of the previous two section provides a detailed summary of the objectives of the research. It is probably worthwhile, however, especially given the broad sweep of the research topic “The Decay Of Corporations”, to explicitly state what the research is not attempting to cover. In summary the research:

1. Does not cover all corporations. The focus is only on the largest most successful corporations and as such many of the conclusions applicable to these large corporations may well not apply to smaller corporations. For example, diversification requires significant financial and management resources to implement, and many small or medium corporations that attempt a diversification strategy are likely to fail or underperform their peers.

2. Does not attempt to analyze why some corporations are successful and others are not. The research only focuses on corporations that are already deemed to be highly successful, and then looks at creating a business fitness landscape model
that will assist in checking if increased diversification may assist in keeping those successful corporations above a pre-defined benchmark.

3. Does not attempt to look in detail at the multitude of other reasons that large, highly successful corporations may fail.

4. Does not complete a demographic study of the Fortune 100 using the new tools.

1.4 **Significance of the research**

For shareholders, boards of directors, and executives, the problems of maintaining corporate leadership and corporate survival, in today’s gales of change (Davis and Meyer, 1998; Schumpeter, 1939; Sombart, 1929), is becoming an ever increasing challenge. This research will show that the lifespan of corporations varies enormously and at least one corporation, General Electric, has managed to hold on to its leadership position for over 100 years. If survival time as a leading corporation is a measure of fitness, then clearly some corporations are significantly “fitter” than others.

The need for business to continue to survive and thrive in a competitive business landscape cannot be overstated. No doubt, the core issues facing a business typically change radically over any extended business life cycle (Drazin and Kazanjian, 1990; Shay and Rothaermel, 1999; Tushman and Anderson, 1986). The issues facing a start-up usually revolve around innovation, seed capital and the need to cross the “chasm” (Moore, 1991). A mid term company may be focused on its Initial Public Offering, or may be successful enough to play a key role in fueling the “tornado” (Moore, 1995) of hyper-growth. For a company that has become the “gorilla” (Moore et al., 1999) of its market space, that is, it is at the pinnacle of success, it is probably safe to say that no issue raises greater concern than how to maintain that success.

For many players, however, the fall from the pinnacle does not come from direct competitive attack, but from a total shift in the business environment. That is, the gorilla is often not replaced on the pinnacle, the pinnacle more often collapses under the gorilla! In these examples, the major driving force is not the direct attack from a better run business, but the attack of a changing business environment that leaves the once advantaged business, high
and dry. It is not being suggested that environmental change is always the driving force for unseating the dominant company or the fittest species, it is to clarify the need to understand that the fittest company not only has to be the best at what it does, it must also be the best at withstanding and leveraging change.

It is this perspective of withstanding and leveraging change which forms the foundation of this research. And so it is from this foundation, that the concepts of the business fitness landscape and the business fitness index are introduced.

1.5 Some key definitions

The title of this thesis is “The Decay of Corporations and an Analysis of Their Business Fitness Landscapes”. At this early stage in the documentation of the research, it is worthwhile to carefully parse this title and to clearly define the intended definition of the words from which it is composed. Many of the terms and metaphors referred to in this research, have, and are used, with varying meanings in both the general and scholarly media. It is therefore important to define the intended meanings of the key terms.

1.5.1 Business or corporation?

The terms “business” and “corporation” are commonly applied, however, it should be noted that their usage is not totally random, and not always used in an interchangeable manner. In general usage, corporations are usually considered to be a subset of the set of businesses. Similarly, in this research the term “corporation” will be used as a subset of all businesses, specifically, to refer to large and established businesses. By “large businesses” I refer to businesses typically in the Fortune 500 rankings, and in this case, usually in the Fortune 100 ranking. By “established businesses” I am referring to businesses that are typically well known brands, incorporated, usually public companies, leaders in the industries in which they participate, and are certainly past the start-up business stage. The term “business” refers to these “corporations”, plus the rest of the large and small businesses found in a typical free-market economy. Using this rather artificial but important distinction between “business” and “corporation”, those parts of the research that targets the large
established businesses, will use the term “corporation”. Meanwhile, the parts of the research that includes applicability to smaller businesses will use the term “business”.

Applying this distinction, the sections referring to Fortune 100 analysis, the application of the tools to selected organizations, and the analysis of the decay of large established organizations, the term “corporation” is used. The sections of the research that have a more generic application, such as the fitness index and the landscape modeling, will use the term “business”.

This subtle distinction between corporation and business is not unique to this research, but is commonly seen in the scholarly research and in the media. For example:

1. Fortune 500: annual ranking of America’s largest corporations (CNN, 2008a).
2. Entrepreneurship in the large corporation: a longitudinal study of how established firms create breakthrough inventions (Ahuja and Lampert, 2001).
3. The best science and engineering graduates of Japanese universities traditionally aspire to long-term positions with large, well-known corporations… Small business on the other hand (Scherer, 1991, p.27).

1.5.2 Decay of corporations

The focus of this research is the development and application of modeling tools that can assist in the analysis of the decay phase of the life cycle of large corporations. In other words, with reference to Figure 1-1, this research is focused on Phase 4, that is, that phase of the corporate life cycle in which the corporation is in significant decay. Decay may be measured by loss of market share, reduced profits, declining revenue, or all of these. In summary, the corporation’s ranking, relative to a defined industry benchmark, has experienced relative deterioration or decay. It is this relative decline in position that is referenced when the research refers to “corporation decay”, or “the decay of corporations”. Furthermore, it is this corporate decay, or corporate decline, which defines the limit on the lifespan of a corporation or business.
1.5.3 Business lifespan

Before moving into a detailed discussion on the main body of the research, it is important to clarify the definition of the term “lifespan”, in the context of the phrase “the lifespan of a business”. Clarification of this definition is also important with respect to an understanding of what is meant by the “half-life”, and the “mean-life”, of a business.

At first glance, the lifespan of a business could be considered as the time period between the birth and the death of the business. This definition runs into problems, however, due to the common difficulty in identifying exactly what event defines either the birth of a business, or the death of a business. For example, is the birth of a business, the date of incorporation, or the date the brand name is first used, or the date the founder recruits the first employee? All these events may or may not be deemed defining events with respect to the birth of the business. Considering these criteria, for example, it would be very difficult to find agreement on the year Xerox was founded.

A similar problem soon emerges when defining the death or extinction of a business. Is the business extinct when the brand disappears, or when it is legally dissolved, or when it becomes bankrupt, or when it no longer controls any significant assets? Did Enron, for example, become extinct in 2001? Most business analysts would probably say “yes” to that question. However it should be noted that in 2007, the Enron Recovery Corporation, which was doing business as Enron, had revenues of close to three billion dollars (Hoover’s, 2008a).

One of the objectives of the research was to develop tools that would assist in getting a handle on the trends associated with the lifespan of a large corporation. One of the first tasks that needs to be completed therefore, is to obtain agreement as to what are the boundary points that define a corporation’s lifespan. Not until these boundary points are defined, is it possible for the research to move on to define and compare the lifespan, mean-life, and half-life, of different corporations.

The approach taken in this research to define the lifespan of a corporation is summarized in Figure 1-1. In this figure, a highly simplified diagram of the life cycle of a stereotypical corporation is presented. Based on the work of a number of researchers (James,
1974; Miller and Friesen, 1984; Moore, 1995; Quinn and Cameron, 1983) a typical corporation’s life cycle can be broken down into a number of phases. In this research, these phases have been simplified into four basic phases, generically referred to as: Birth, Growth, Maturity and Decay, and having the respective active characteristics of: developing, growing, maturing and decaying.

The four business life cycle phases used in this research are a simplification of the five phase topology described by Miller and Friesen (1984). They suggested the five stages of Birth, Growth, Maturity, Revival and Decay. The Revival phase was excluded from this research for a number of reasons. Firstly, not every corporation will experience a revival phase. Secondly, revival is simply new growth after some decay. It was soon concluded that a new phase description is not justified to describe this stage. Thirdly, if you include a Revival phase, why not include a Rebirth phase. Finally, it was concluded, that given enough time, the life cycle of every industry leading, large corporation, could be described in terms of the selected phases; Birth, Growth, Maturity and Decay.

For a corporation that has become an industry leader, it has, most likely, grown to become a member of the Russell 3000, then the S&P 500, and possibly even the Fortune 100. Furthermore, there are many other rankings and indexes, to which the corporation could possibly end up belonging. A customized ranking or index could also be used in place of one of these better known groups. The important point is that one of these rankings or indexes could be used to set the clearly defined boundary conditions which define the lifespan of the corporation. The question, therefore, which enquires about the lifespan of a corporation, becomes a question enquiring about the lifespan of the corporation relative to a given benchmark, as defined by a given ranking or index. Once this approach is in place, the life spans, the mean-lives, and the half-lives, of comparable corporations can be statistically analyzed. A detailed analysis of the theory and application of these parameters is covered in Chapters 4 and 5.
Figure 1-1. A stereotypical life cycle of an industry leading corporation.

Derived from the work of a number of researchers (James, 1974; Miller and Friesen, 1984; Moore, 1995; Quinn and Cameron, 1983), a typical corporation’s life cycle can be broken down into four fundamental phases. These phases can be described as: developing, growing, maturing and decaying. For a corporation that has become an industry leader, it could probably grow to become a member of the Russell 3000, then the S&P 500, and possibly even the Fortune 100. Furthermore, there are many other rankings and indexes, to which the corporation could possibly end up belonging. Note that the vertical axis is simply labeled “$”, in reality it may refer to revenue, market capitalization, or a weighted index, depending on the reference ranking or index.

1.5.4 Business fitness landscapes

Having defined “business”, “corporation”, and “corporation decay”, with respect to the context of this research, it is important to provide clarity to the phrase “fitness landscape”. To begin this discussion, it is worthwhile to look at these two terms separately.
“Fitness” in this context refers to the usual definition of fitness with respect to a measure of being “fit”. That is, in this research, “fit” refers to the typical dictionary definition of being adapted to an end or design, suitable by nature or by art, to be adapted to an environment so as to be capable of surviving (Merriam-Webster, 2008). Similarly, “landscape”, in the context of this research, is defined as an extensive single set of information, or broad expanse of information, which can be seen from a single viewpoint. The phrase “business fitness landscape”, therefore, refers to a broad expanse of information, which can be seen from a single viewpoint, relating to a business’ level of adaptation to the environment in which it needs to survive. Note that further background detail and contextual justifications for these definitions are examined in more detail in Chapter 2.

1.6 Overview of the research methods

A number of research methods were used in completing this research. Research methods used were constructive research, mathematical modeling, quantitative analysis, and empirical research methods.

Constructive research refers to the creation or construction of a model which was then evaluated against the associated data. Mathematical modeling refers to the creation of a mathematical algorithm which was evaluated against associated data. Quantitative analysis refers to the measurement and analysis of quantities. Empirical research refers to the research findings that were based directly on observations from the applicable data.

All of the research relied on secondary data. The research method used and the applicable secondary data sources are detailed in the following subsections.

1.6.1 Development of a new business landscape model

The research method used, and the applicable secondary data sources, associated with the development of a new business landscape model, were:

1. Research Method(s): constructive research, mathematical modeling, and quantitative analysis.
2. Data Sources:
   - Bureau of Economic Analysis, U.S. Department of Commerce
   - EconStats Global Economic Data
   - U.S. Census Bureau

1.6.2 Development of a new definition of business fitness

The research method used, and the applicable secondary data sources, associated with the development of a new definition of business fitness, were:

1. Research Method(s): constructive research and empirical research.

2. Data Sources:
   - Bureau of Economic Analysis, U.S. Department of Commerce
   - Hoover’s Business Reports
   - U.S. Census Bureau

1.6.3 Development of new modeling tools

The research method used, and the applicable secondary data sources, associated with the development of the new modeling tools, were:

1. Research Method(s): constructive research and mathematical modeling

2. Data Sources:
   - Bureau of Economic Analysis, U.S. Department of Commerce
   - EconStats Global Economic Data
   - Fortune 500 Company Archives
   - Hoover’s Business Reports
   - Securities and Exchange Commission’s EDGAR database
   - U.S. Census Bureau
1.6.4 Development of a new business fitness index

The research method used, and the applicable secondary data sources, associated with the development of a new business fitness index, were:

1. Research Method(s): constructive research, mathematical modeling, and quantitative analysis

2. Data Sources:
   - Bureau of Economic Analysis, U.S. Department of Commerce
   - EconStats Global Economic Data
   - Fortune 500 Company Archives
   - Hoover’s Business Reports
   - U.S. Census Bureau

1.6.5 Macro analysis of Fortune 100

The research method used, and the applicable secondary data sources, associated with the macro analysis of the Fortune 100, were:

1. Research Method(s): quantitative analysis and empirical research

2. Data Sources:
   - Fortune 500 Company Archives
   - Hoover’s Business Reports

1.6.6 Micro analysis of select, Fortune 100, corporations

The research method used, and the applicable secondary data sources, associated with the micro analysis of select Fortune 100 corporations were:

1. Research Method(s): quantitative analysis and empirical research

2. Data Sources:
   - Fortune 500 Company Archives
• Hoover’s Business Reports
• Securities and Exchange Commission’s EDGAR database

1.7 Structure of the dissertation

The overall structure of the dissertation is summarized in Figure 1-2. As shown in this figure the main body of the dissertation of nine chapters is divided into three sections. These three sections are the Foundation, the Development and the Synthesis.
Figure 1-2. A summary of the overall structure of the dissertation.
The Foundation section covers the first three chapters. The first chapter is an introduction which summarizes the research objectives and the research methods. The second chapter is a literature review which introduces the conceptual foundations of fitness landscapes. The third chapter is also a literature review, however it examines the literature associated with the existing major business indexes, landscapes, and key technical risk parameters, specifically as they relate to the decay of corporations.

Section 2, the Development section, covers the next four chapters and forms the body of the research. The first chapter of this section, Chapter 4, introduces two new business risk parameters that are designed to assist the business analyst to quantify the life spans of corporations. Chapter 5 examines the total history of the Fortune 100 landscape and analyses the associated data in detail. Chapter 6 describes the creation of the new business fitness landscape model. Chapter 7 introduces a new Business Diversity Fitness Index that is designed to be a significant indicator of which corporations should be the best equipped to resist the corporate decay that results from business environmental change.

Section 3 is the Synthesis section and contains the final two chapters, Chapters 8 and 9. This section is followed by the References and Appendices. Chapter 8 examines the application of the tools and models to a selection of Fortune 100 corporations. Chapter 9 provides a summary of the key findings, conclusions and recommendations that arise from the research. In the appendices, the reader will find detailed information that is deemed to be important and relevant, and that was created as a direct result of the research, and so cannot be easily accessed, independently of that research.

1.8 Key parameters of the research

The research was focused on the 100 largest U.S. corporations during the period of 1955 to 2009. The following are the key parameters that should be noted in association with this selection:

1. Limiting the study to the period between the years 1955 and 2009, is a practical and reasonable boundary condition that makes best use of the available data. It is also an attempt to leverage sufficient data to potentially identify significant trends,
and is an attempt to avoid extreme “black swan” (Taleb, 2007) events such as the Great Depression and the Second World War.

2. The selection of the Fortune 100 is an attempt to remain focused on mature, well established corporations. This selection allows the research to focus on the transition phase of corporations in which they move from the Maturity Phase to the Decay Phase, without getting mired in the myriad of issues that impact corporations during the birth and growth phases.

3. The restriction of the study to U.S. corporations reflects the location in which the necessary data existed, the significance of that data, and the location in which the bulk of the research was completed.

4. The focus of the research is a generalized study associated with the decay of large corporations in the U.S. It is expected, however, that most of the research should be applicable to other well developed markets in which a significant number of industry leading, large corporations exist, although no attempt has been made to verify or falsify this assumption.

5. One of the aims of the research was to develop tools and conclusions that had general applicability, at least with respect to large industry leading corporations, thus no significant attempt was made to focus on any particular market event, business, or individual, except in an attempt to provide an example, or to verify or falsify a general thesis.

The above summarizes many of the overarching key parameters of the research. Note that there will also be a detailed explanation and justification for the selection of all the significant parameters, as and when their application is introduced in the research.

1.9 Closing comments on the chapter

The aim of this chapter was to set the stage by providing an introduction to the research. This introduction presented: an overview of the problems, the context in which those problems exist, the research objectives, the significance of the research, clarified the definition of key terms, provided an overview of the research methods, provided an overview
of the structure of the dissertation, and introduced the key parameters of the research. Having established the objectives and the context, the research now moves on to review the existing literature.
2 LITERATURE REVIEW PART ONE - CONCEPTUAL FOUNDATIONS

This chapter, “Literature Review - Conceptual Foundations”, and the following chapter, “Literature Review - Business Landscapes” summarize the findings of a detailed literature review that was completed as part of the research. This first literature review chapter reviews the literature that underlines many of the key conceptual foundations of the research, especially with respect to the development of new business fitness landscape model and the new business diversity fitness index. It should be noted that this chapter builds on the literature review surrounding the definition of corporation decay that was introduced in Chapter 1. This chapter also provides an important precursor to the next chapter, which covers the literature review associated with the development of the new business risk parameters and the other modeling tools and analysis work that extends the business fitness landscape analysis.

The review of the literature surrounding the conceptual foundations has been structured as follows:

1. Overview of literature sources
2. An introduction to the conceptual foundations
3. The power of metaphor
4. An analysis of the “fitness” metaphor
5. An analysis of the “landscape” metaphor
6. The history and development of the leading landscape models
7. The fitness landscape
8. The adaptive seascape

9. Survival of the fittest

10. Survival of the most diverse

This initial analysis, of the conceptual underpinnings of the research, will be followed by an overview of the literature behind the existing business landscapes, models and indexes. These two chapters combined are designed to provide the necessary background material to allow the reader to examine the strengths, limitations, and opportunities of the new business fitness landscape modeling, as presented in this research. Note that the abbreviations used in this list are part of the connection file names as documented by EndNote, and so are not shown in their expanded format. For reference purposes, the embedded abbreviations are documented in the List of Abbreviations.

2.1 Literature research sources

The sources for this literature research were various, but the main sources included:

1. Bureau of Economic Analysis, U.S. Department of Commerce

2. California State University San Marcos, Kellogg Library

3. EconStats Global Economic Data

4. Fortune 500 Company Archives

5. Hoover’s Business Reports


7. National Library of Australia, Canberra

8. San Diego State University, Love Library

9. Securities and Exchange Commission’s Electronic Data Gathering And Retrieval (EDGAR) database
10. Southern Cross University Library

11. U.S. Census Bureau

12. University of California San Diego, Geisel Library

13. University of California Santa Barbara, Davidson Library

The search for references via online databases included the use of the following EndNote Connection Files (Thomson Reuters, 2009). Note that the abbreviations used in this list are part of the connection file names as documented by EndNote, and so are not shown in their expanded format. For reference purposes, the embedded abbreviations are documented in the List of Abbreviations.

1. Acad Search Prem (EBSCO).enz

2. Aust Grad School of Mgt.enz

3. Bus Source Prem (EBSCO).enz

4. Cal St U-San Diego.enz

5. Cal St U-San Marcos.enz

6. ERIC (EBSCO).enz

7. ERIC (OVID).enz

8. Libraries Australia.enz

9. Library of Congress.enz

10. Natl Lib of Australia.enz

11. San Diego State U.enz

12. Southern Cross U.enz

13. U California.enz
2.2 Conceptual foundations of the “Business Fitness Landscape”

One of the key conceptual foundations for the concept of the Business Fitness Landscape arises from the work of Sewall Wright in which he introduces the idea of the adaptive landscape (1932). This concept of the adaptive landscape was created by Wright as a useful metaphor associated with the study of the evolution of species. A number of writers (Fleming and Sorenson, 2001; Frenken, 2006; Kauffman and Johnsen, 1991; Koza, 1992; McCarthy, 2004; McCarthy and Tan, 2000; Vassilev et al., 1999) have extended Wright’s concept of the “adaptive landscape” and the role of competitive adaptation, to develop a more generalized concept of the “fitness landscape”.

The expression “fitness landscape” is now applied to a variety of applications that are unrelated to species evolution (Alander et al., 2002; Bedau et al., 2003; Fleming and Sorenson, 2001; Hoshino et al., 1998; Mattfeld et al., 1999; McCarthy, 2004; Stutzle and Hoos, 2000; Vassilev et al., 1999; Yang et al., 2004). These applications have included computer programming, electronics, antennae design, combat systems, chaos theory, robotics, and factory processes. As far as the author is aware, however, this research provides the first detailed application of the concept of a “fitness landscape” to the generalized but explicit concept of the “Business Fitness Landscape”. As of January 6\textsuperscript{th}, 2008, for example, a Google Scholar search of “fitness landscape” generated 7,110 results, while a Google Scholar search of “business fitness landscape” generated zero results.

Before examining the business fitness landscape concept and model in detail, and to appreciate the power and limitations of the underlying metaphors, models and analysis, it is important to examine why the fitness landscape concept has become such a powerful and common tool in art, science and business. To that end, it is advantageous to examine the evolution of the metaphors: “fitness”, “landscape” and “fitness landscape” in an historical perspective so as to assist in establishing a key hypothesis of this research. That hypothesis is that in the same way that the hybrid landscape model, that combines uniformitarianism with catastrophism, provides the most accurate description of the fitness landscape for species survival, it also provides the most accurate landscape model to explain and predict the survival and extinction of established businesses.
2.2.1 The role of metaphor

The fitness landscape concept is a beautiful example of an iterative process of metaphor driving thought, and thought driving metaphor. This powerful linkage between metaphor and thought is examined in detail in the book, “Metaphors We Live By” (Lakoff and Johnson, 1980) which analyzes the understanding of metaphor and its role in language and thought. According to Lakoff, metaphor is a fundamental tool that allows us to use what we know about our world to get a better understanding of what we are struggling to get to know. Further, according to Lakoff there are some concepts that structure our most basic understandings of our experience, and they often become the "metaphors we live by". These are the metaphors that can shape our perceptions and actions without us ever fully noticing them.

Within the phrase “business fitness landscape” there are two significant, perception changing metaphors: “fitness” and “landscape”. The following sections examine these metaphors in detail.

2.2.2 The “fitness” metaphor

As stated in the Introduction to this Research, “fitness”, as it is used in this research, refers to the usual definition of fitness, namely as a measure of being “fit”. In this thesis, therefore, “fit” refers to the common dictionary definition:

“adapted to an end or design: suitable by nature or by art, adapted to the environment so as to be capable of surviving.” (Merriam-Webster, 2008)

It should be noted that this generally accepted definition of fitness is possibly broader than the definition of fitness typically referred to in genetic studies. In genetics, the definition of fitness is focused, by definition, on the gene, and so is meant to refer to the ability of a species to continue to survive and transmit its genotype to reproductive offspring so that it maximizes the long-term preservation of that genotype. Any non-gene related, nurture based, or experiential attributes of a species are clearly outside the purview of the genetic fitness landscape. In this research, however, it will be shown that non-genetic based research areas such as business development, can benefit from the metaphors, methodologies and concepts
of the geneticist, and that possibly genetics may benefit from a better understanding of the importance of adaptability, specifically in environments of rapid discontinuous change.

2.2.3 The “landscape” metaphor

The word “landscape” is commonly used as a noun, verb and as an adjective. According to the Oxford English Dictionary, the first documented usage of the word “landscape” goes back to 1592 (2002) when the word is used as a noun to describe a picture that represents natural inland scenery, as distinguished from a portrait or religious art.

In a table donne by Cæsar Sestius where hee had painted Landskipes. (1598 R. HAYDOCKE tr. Lomazzo III. i. 94) (OED, 2002)

“Landscape”, however, has come to have a wide range of other meanings and usage. The range of usage includes; landscape gardening, political landscape, landscape page orientation, cultural landscapes and anthropic landscape. The definition that appears to have the breadth and reach that the landscape metaphor deserves in this context is:

Landscape (n), a section or expanse of rural scenery, usually extensive, that can be seen from a single viewpoint. (Miller, 2006)

In the context of this research, I propose a broader and more conceptual definition for the noun “landscape”. Namely:

Landscape (n), an extensive single set of information, or broad expanse of information, which can be seen from a single viewpoint. For example, political landscape, fitness landscape, or business landscape.

This broader, more conceptual definition of “landscape” provides the basis for extending the already powerful “landscape” metaphor. By metaphor, I am referring to the common usage of the word “metaphor”, such as:

A comparison which imaginatively identifies one thing with another dissimilar thing, and transfers or ascribes to the first thing (the tenor or idea) some of the qualities of the second (the vehicle or image). (About.com, 2007)
When considering “landscape” as a metaphor, and in the context of a Lakoff (Lakoff and Johnson, 1980) iterative flow, the power and limitations of the concept are soon to be seen. One’s concept, or worldview, feeds on the understanding of the metaphor and the understanding of the metaphor then feeds on that worldview. It is indeed an iterative loop of metaphor driving thought, and thought driving metaphor. That is, one in which the current worldview of the observer drives the metaphor, the metaphor then drives the thought, and the thought then drives the understanding in the context of the metaphor, which is now in the context of the new worldview.

The role of the “current worldview” is a profound part of understanding the journey that follows. A journey that takes the reader from the prevailing steady state worldview, to an acceptance of change, evolution, Darwinian evolution, Newtonian predictability, uniformitarianism, catastrophism, the adaptive landscape, survival of the fittest, the fitness landscape, the competitive market, and on to the concept of the business fitness landscape.

While living in a world of change and bombarded by comparative historic information, it may be difficult to appreciate a worldview founded in a previous epoch. An epoch in which the prevailing worldview was a concept of the “steady state”.

To describe or conceptualize any object, be it a farm, a species, a geological feature, a business entity, a financial instrument, or an astronomical phenomena, one must do so with respect to the surroundings or environment in which the observer exists and interacts (Parks, 2005). For humans one of the most obvious and dominant environments which shapes our worldview is the land or urban environment which surrounds where we live. It is not surprising, therefore, that our perception of this land, or landscape, and the forces which shape that land, and the timeframes in which those forces act, provides one of the most powerful frameworks for the way in which we understand and describe our whole worldview.

The concept of “landscape” has become a powerful and evocative metaphor for describing all sorts of events and the associated environment surrounding those events (Bryngelson et al., 1995; Forman and Godron, 1986; Krackhardt, 1990; Palmer and Neuenschwander, 2000; Pulliam and Danielson, 1991; Yang et al., 2004). It is proposed, therefore, that in the same way that we have changed our understanding of how much and at
what rate our physical landscape changes, humans have changed the very basic conceptual foundations of their worldview. This changing world landscape view has played a key role in driving our understanding of all areas of research, including evolution, geology, geography, climatology and cosmology. It is now time to apply this changing world landscape view to an analysis of business development.

### 2.2.4 The evolution of the landscape model

The proposed concept of the business fitness landscape is new, but it is also built on solid historical and conceptual foundations that go back over 3,000 years. In reviewing the conceptual foundations of the business fitness landscape model, the literature associated with the following landscape models will be examined:

1. The steady state landscape
2. The changing landscape of uniformitarianism
3. The changing landscape of catastrophism
4. The hybrid landscape of catastrophism and uniformitarianism
5. The adaptive landscape
6. The fitness landscape
7. The modern business landscape

#### 2.2.4.1 The steady state landscape

In today’s world of rapid societal and technological change, immersed in a gale of 24 by 7 in-depth video news coverage of earthquakes, tsunamis, volcanoes, global economic competition, major scientific discoveries, civil unrest, mass migrations, species extinction, climate change, continental drift, asteroids and the threat of nuclear annihilation, it is becoming difficult to even appreciate, let alone understand, a more traditional, steady state, worldview. It appears, however, that a general appreciation of change is really a relatively recent phenomena. Certainly for the bulk of the recorded history of Western civilization, the
prevailing documented worldview was that of minimal change. It was a steady state landscape.

Figure 2-1 illustrates speciation versus time in a non-changing, non-evolutionary, Genesis-event, steady state landscape. The great mono-theist religions of the world were all built on, and struggled to maintain, the relatively same steady state worldview. As writers have pointed out (Lindberg and Numbers, 1986; Van Till, 1996), a literal reading of Genesis 1 leads almost inevitably to the understanding that God created a fully functioning ecological system in a very short space of time. It should therefore be of little surprise to see this view reflected in the earliest commentaries on Genesis.

![Figure 2-1. Speciation versus time in a non-changing, non-evolutionary, Genesis event, steady state landscape.](image)

An appreciation of change is really a relatively recent phenomena. Certainly for the bulk of the recorded history of Western civilization, the prevailing worldview was that of minimal change. It was a steady state landscape.

The fundamental worldview of Genesis is similar in the Jewish, Christian and Islamic faiths. The Qur'an, the final revelation, contains the essence of all previous revelations, including the Torah. Certainly for the bulk of the recorded history of Western civilization, the
prevailing worldview was that of minimal change. It was a steady state landscape. The fact is, however, that the steady state landscape was soon to be placed under serious doubt.

The difficulty in accepting a non-steady state worldview is multi-faceted. Change implies a beginning and an end, imperfection to perfection, perfection to imperfection, continuous creation, continuous destruction, possible unseen forces, and poses a major threat to the current leaders of the status quo. A steady state world also had the simplistic appeal that many people sought and that many leaders were happy to provide. Importantly, the reality was that in the context of the location and period of Western civilization, at least up until the industrial revolution, long term macro change was relatively transparent.

2.2.4.2 Steady state landscape with the appearance of change

The concept of the steady state landscape had, and has, significant social, political, religious and economic foundations and so modification of the concept was always going to take priority over any quick rejection of the concept. One adaptation of the concept, aimed at handling potential falsifying observations was the introduction of the concept of the steady state landscape with the appearance of change.

Basil of Caesarea, for example, believed that the world was created in less than an instant, writing that:

God did not command the earth immediately to give forth seed and fruit, but to produce germs, to grow green, and to arrive at maturity in the seed; so that this first command teaches nature what she has to do in the course of ages (Lindberg and Numbers, 1986; Van Till, 1996, p.28).

Philip Henry Gosse (1857) extended the steady state landscape with the appearance of change even further by taking on conflicting evidence directly. He wrote that just as Adam had been created with a navel, so all of creation had been formed with the illusion of a previous existence. This previous existence was to include the fact that trees would be created with growth rings, coral polyps would reside on ancient coral reefs, and that some rocks were created with fossils already inside them, all for the purpose of revealing God’s truly creative powers.
By the early to mid nineteenth century, the prevailing Western view of a steady state world was well and truly under attack. The landscape of change had arrived. The seeds of this discontent, however, reach back to antiquity.

2.2.4.3 The landscape of change

The first insight into the concepts of evolution, or evolutionary change, goes back at least to the ancient Greeks. Aristotle, born in 381 BCE, the son of the court physician to the King of Macedon, went on to work at Plato’s Academy for twenty years until Plato’s death. Aristotle then went on to found a school of his own, called the Lyceum, where he established a reputation as a great organizer of knowledge. During this time he came close to developing a one-man encyclopedia of knowledge in which he classified more than five hundred animal species. His analysis showed an understanding of the interrelatedness of species (Avery, 2003), and his writings revealed an understanding that at least introduces the concept of evolutionary change. Aristotle wrote:

Nature proceeds little by little from lifeless things to animal life, so that it is impossible to determine either the exact line of demarcation, or on which side of the line an intermediate form should lie. Thus, next after lifeless things in the upward scale comes the plant. Of plants, one will differ from another as to its apparent amount of vitality. In a word, the whole plant kingdom, whilst devoid of life as compared with the animal, is yet endowed with life as compared with other corporeal entities. Indeed, there is observed in plants a continuous scale of ascent towards the animal (Aristotle, 1955, p113).

In addition to touching on the concept of evolutionary change, Aristotle’s writings directly addressed the concept of competitive adaptation within a broader context or landscape. Aristotle went on to write:

…all parts of one whole happened as if they were made for something, these were preserved, having been appropriately constituted by an internal spontaneity; and wheresoever things are not so constituted, they perish, and still perish (Aristotle, 1955, p36).

Aristotle’s writings with respect to evolutionary change and competitive adaptation were revived in the Middle Ages by the Islamic philosopher Averroes (1126 – 1198).
Averroes shocked many Muslim and Christian leaders by his comments (Najjar, 2004) on the work of Aristotle, especially where it suggested that the world around us was not created at a particular point in time, but that it had evolved over a long period of time, and is still evolving.

The concept of a changeable landscape, within an evolutionary context, achieved additional impetus through the writings of Leonardo da Vinci (Avery, 2003). Leonardo was aware of the existence of fossil shells in the rocks of the high mountain ranges of Lombardy. Leonardo wrote that he believed the shells of now extinct living organisms were part of an earlier landscape, that they had been buried in the strata and then uplifted to the top of the mountains by massive geological upheavals. Leonardo wrote:

…the shells in Lombardy are at four levels, and thus it is everywhere, having been made at various times… The stratified stones of the mountains are all layers of clay, deposited one above the other by various floods of the rivers (Avery, 2003, p3).

Leonardo’s interpretation of fossils in the context of an earlier landscape was independently rediscovered by the Danish scientist and anatomist, Niels Stensen (1638 – 1686). Stensen, recognizing the similarity of some curiously shaped stones to living organisms, hypothesized that these stones, or fossils, were the changed composition of unchanged earlier forms. Stensen also established a law of strata, which states that with respect to the disposition of sediment layers, the oldest layers are typically at the bottom.

The increasing information and analysis of thousands of species of plants and animals, during the 17th and 18th centuries, was to provide additional impetus for the concept of evolution and the metaphor of the adaptive landscape. The Swedish naturalist, Carl von Linné (1707 – 1778), usually referred to by his Latin name, Carolus Linnaeus, published his famous book, “Systema Naturae” (1767), in which he introduced a method of classification for all living things in which he arranged closely related species into genera, genera into classes and classes into orders (Stearn, 1959).

Although Linnaeus laid the data out in a form that would inevitably lead to the theory of evolution, he himself believed that species were immutable. However, Linnaeus’ work did
not go unnoticed by Erasmus Darwin (1731 – 1802). In 1794, Erasmus Darwin, published a book called “Zoonomia” (1794) in which he proposed a theory of evolution which laid an important foundation for the theory that his grandson, Charles Darwin, would later make famous (1859).

Linnaeus’ belief in immutable species was to parallel beliefs and scientific enquiry relating to the magnitude and rate of change in the geological landscape. Although many of these beliefs were no doubt influenced as much by prevailing religious beliefs, as by scientific enquiry, the way in which the physical landscape changed was to play a crucial role in the debate about the forces which shaped the biological landscape. It is not surprising, therefore, that James Hutton (1726 – 1797) considered the father of modern geology (Bailey, 1967), was to play a key role in influencing Charles Darwin’s theory of evolution. Hutton is noted for championing the concept of uniformitarianism and the Plutonist School of thought (Bleeker, 2003). These concepts were to play a key role in how scientists viewed the natural landscape.

The reality was that as far as the concept of natural change was concerned, the prevailing worldview in the eighteenth century had not been significantly modified for the previous 600 years. In some ways, the clocklike precision and predictability of the Newtonian world tended to reinforce the Linnaeus belief in immutability. Any idea that the natural world landscape was not invariant was to generate much the same shock and debate as that confronting Averroes, in the Middle Ages, when he revived Aristotle’s concept of evolutionary change.

2.2.4.4 The changing landscape of uniformitarianism

Uniformitarianism, the observation that fundamentally the same geological processes that operate today also operated in the distant past, is one of the most basic principles of modern geology (Porter, 1976). Uniformitarianism exists in contrast with catastrophism, which states that the Earth’s surface features originated suddenly in the past, by geological processes radically different to those currently occurring. Note, however, that many "catastrophic" events are perfectly compatible with uniformitarianism. For example Lyell thought that ordinary geological processes would cause Niagara Falls to move upstream to...
The Decay Of Corporations

Lake Erie within 10,000 years (1830), leading to catastrophic flooding of a large part of North America.

Uniformitarianism is a generalization of the principle of actualism, which states that present day processes, including astronomical, geological and paleontological, can be used to interpret past patterns. The principle of actualism is the cornerstone of paleoecology.

Hutton’s ideas concerning Uniformitarianism were later popularized by Charles Lyell and Lyell’s writings were to greatly influence Charles Darwin (Darwin and Carroll, 2003). Lyell's first book, “Principles of Geology” (1837) was also his most famous, most influential, and most important. First published in three volumes in 1830-33, it established Lyell's credentials as an important geological theorist and introduced the doctrine of uniformitarianism. The central argument in Principles was that the present is the key to the past. That is, geological remains from the distant past can, and should, be explained by reference to geological processes now in operation and thus directly observable. Lyell's interpretation of geologic change as the steady accumulation of minute changes over enormously long spans of time was also a central theme in the Principles, and a powerful influence on the young Charles Darwin, who was given Volume 1 of the first edition by Robert FitzRoy, captain of HMS Beagle, just before they set out on the voyage of the Beagle (Keynes, 1997).

People’s worldview and the landscape metaphor were now different. Change was now a fact of life, but it was still limited to a world of gradual and constant change. This new view of landscape played a key role in providing a basis for the acceptance of Darwinian evolution and its call for continuous change and adaptation. But the slow pace and uniformity of change encouraged the acceptance of a belief that the fittest species would survive and this concept was soon applied to the business world, especially with the growth and recognition of the competitive market economy. Note that constant change has exponential, not linear consequences, thus the exponential curve rather than a linear line, as shown in Figure 2-2.
Figure 2-2. Speciation versus time is a world of constant change.

People’s worldview and the landscape metaphor were now different. Change was now a fact of life, but it was still limited to a world of gradual, but constant change. This new view of landscape played a key role in providing a basis for the acceptance of Darwinian evolution and its call for continuous change and adaptation. But the slow pace and uniformity of change encouraged the acceptance of a belief that the fittest species would survive and this concept was soon applied to the business world, especially with the emergence of the competitive market economy. Note that constant change has exponential, not linear consequences, thus the exponential curve rather than a linear line.

2.2.4.5 The rapidly changing landscape of catastrophism

During the late eighteenth and early nineteenth century the idea that the earth, plants and animals, may be subject to occasional catastrophic change gained serious scientific consideration. The French paleontologist Georges Cuvier, for example, proposed that the patterns of extinction that he observed in the fossil records may have been the result of violent change, and that this change was from natural causes (Mayr, 1972). The idea that sudden catastrophic change has played a key role in shaping the world around us, was to become known as the theory of Catastrophism.
During the twentieth century, the theory of Catastrophism gained increasing acceptance as more evidence of earth’s catastrophic past was found. The source of the violent change has covered the full gamut, from volcanism, asteroids, comets, sudden climate change, and massive earthquakes. Napier and Clube (1979), for example, suggested the role of the impacts from planetesimals as the sun periodically passes through the spiral arms of the galaxy:

Impacts of the sort (planetesimals) at ~50 Myr intervals therefore produce an abundance of deleterious effects, the consequence of which are catastrophic extinctions (Napier and Clube, 1979, V.282, p.458).

The debate between catastrophism and uniformitarianism was to last nearly 200 years, and the role of one versus the other is still hotly debated. The evidence for long periods of relative uniform gradual change is extensive, and has played a key role in the successful research into paleoecology and geology. The evidence, however, that catastrophic events had also played a key role in shaping the world around us, was also increasing. It was time to consider a new world landscape view, the worldview of the hybrid landscape.

2.2.4.6 The hybrid landscape of catastrophism and uniformitarianism

A seminal paper in establishing the hybrid landscape of catastrophism and uniformitarianism was the paper of Raup (1982). This paper describes the results of a study of marine speciation extinction rates over the last 550 million years. The research shows significant, on-going, background extinction events, with an occasional large extinction event in which 30% or more of the marine species become extinct. The classical "Big Five" mass extinctions identified by Raup are: the End Ordovician, Late Devonian, End Permian, End Triassic, and End Cretaceous. These extinction events, and their associated peak extinction intensities, are shown in Figure 2-3.
The Decay Of Corporations

Figure 2-3. Peak extinction intensities for five major extinction events during the last 550 million years.

This figure is a simplification of the work of Raup (1982). This research shows significant, on-going, background extinction events, with an occasional large extinction event in which 30% or more of the marine species become extinct. The classical "Big Five" mass extinctions identified by Raup are: the End Ordovician, Late Devonian, End Permian, End Triassic, and End Cretaceous.

The work of scientists like Napier, Clube, Raup and Sepkoski supports a world landscape view that is a hybrid landscape of catastrophism and uniformitarianism. Such a hybrid landscape is represented in the simplified landscape model shown in Figure 2-4. It is a key hypothesis of this research that in the same way that the hybrid model, that combines uniformitarianism with catastrophism, provides the most accurate description of the fitness landscape for species survival, it also provides the most accurate landscape model to describe the prevailing environment for businesses, in which businesses emerge, thrive, contract, and eventually disappear.
The adequacy of simply being the “fittest”, as a basis for survival in a rapidly changing, discontinuous world was becoming distorted. This distortion was not being fully appreciated. An interesting hypothesis arises from the research that for both species and businesses, being the fittest is neither sufficient nor necessary to survive in a landscape of rapid, discontinuous change.

Figure 2-4. Speciation versus time in a hybrid evolutionary landscape, combining uniformitarianism with catastrophism.

During the late eighteenth and early nineteenth century the idea that the earth, plants and animals, may be subject to occasional catastrophic change, gained serious scientific consideration. It is a key hypothesis of this research, that in the same way that the hybrid model, that combines uniformitarianism with catastrophism, provides the most accurate description of the fitness landscape for species survival, it also provides the most accurate landscape model to describe the prevailing environment for businesses. That is, businesses emerge, thrive, contract, and eventually disappear, in an environment of non-linear change.

It is a further aim of this research to show that the hybrid evolutionary landscape, combining uniformitarianism with catastrophism, is not only limited to a study of species survival, but that it is also applicable to a study of the business environment in which businesses survive, decay, or become extinct. Further, it is a key objective of the research to
show the importance, in such a hybrid environment of rapid change, interspersed with periods of relative stability, that established businesses, like species, don’t survive just by being the fittest, they survive by being located, by luck or design, near an emergent new optima. It is this positioning that places the business in the best position to capture the commanding heights in a new business fitness landscape that has suddenly emerged after a catastrophic change. A business is deemed to be in an optimum position, during such a period of change, if in the new landscape it has the shortest fitness path length to travel, to reach one of the new fitness peaks that has emerged in the new landscape. It therefore follows that in a very dynamic, changeable fitness landscape, the business which has multiple, viable, but not necessarily fittest positions, in a given fitness landscape, will have the highest probability of surviving in a new landscape after a significant, sudden, or catastrophic change.

In summary, diversity of positions is an important attribute for any business that wants to maximize its capability to both survive and thrive in a rapidly changing business fitness landscape. For a business, diversity of positions in any given fitness landscape increases the chance of the business having a short path length to a new fitness peak, a fitness peak which has emerged in the new fitness landscape created by a sudden catastrophic change.

To examine the thesis of the importance of being well positioned relative to new emerging fitness peaks, it is now appropriate to look at the history and application of the fitness landscape concept.

**2.2.4.7 The fitness landscape**

When Wright (1932) introduced the idea of the fitness landscape, as a useful model associated with the study of the evolution of species, he created a topographic landscape model like the one shown in Figure 2-5. In this figure of a typical fitness landscape, the arrows indicate the direction of improved adaptation or fitness, and the points A, B, and C are points of optimal fitness and points D and E are points of minimal fitness. The arrows indicate the direction of improved fitness. The topographic-like map at the bottom joins points of iso-adaptation or iso-fitness. In this example, the brown species is well positioned.
on the three fitness peaks F1 to F3, and the spotted species is positioned in multiple sub-optimal positions in the fitness landscape.

Figure 2-5. Sketch of a typical fitness landscape.

The arrows indicate the direction of improved adaptation or fitness, and the points A, B, and C are points of optimal fitness and points D and E are points of minimal fitness. The arrows indicate the direction of improved fitness. The topographic-like map at the bottom joins points of iso-adaptation or iso-fitness. In this example, the brown species is well positioned on the three fitness peaks F1 to F3, and the spotted species is positioned in multiple sub-optimal positions in the fitness landscape. Derived from concept of the adaptive landscape introduced by Wright (1932)

Over the last 76 years, the concept of the fitness landscape has played an important role in assisting evolutionary biologists to conceptualize and communicate the relationships between genotypes, the associated phenotype, and their long term survival as measured by a species’ reproductive success. This replication capability for a given environment is referred
to as “fitness” and this fitness is displayed by height on a three dimensional topographic-like map in which similar genotypes are assumed to be “close” to each other and dissimilar genotypes are shown as being “far apart”. The collection of all species in a given environment, their fitness height and their genotype separation, can then be used to create a “fitness landscape”.

In this research the first use of the concept of the fitness path length, with respect to business environment modeling, will be introduced. The fitness path length is the shortest distance, on a three dimensional fitness landscape, that a business is required to move from its current position on the fitness landscape, to at least a minimum position on a new fitness peak. In Figure 2-5 for example, the fitness path length “EC” is shorter than the fitness path length “EB”.

2.2.4.8 The adaptive seascape

Wright’s adaptive landscape and its corollary, the fitness landscape, has become one of the most powerful heuristic models ever created in genetics. Avery, in his book “The Adaptive Seascape” (2003) criticized the metaphor, however, on the grounds that a landscape carries the implication of being fixed and unchanging, and so hides the fact that fitness is relative and dynamic. That is, fitness is relative to an environment that is in a continual state of flux.

The adaptive surface, rather than being static and fixed, is dynamic and fluid. Organisms on an adaptive peak at one time may, as conditions change, find themselves in an adaptive trough. Although a fixed fitness for each genotype is easier to deal with conceptually and mathematically, such an oversimplification is remote from reality. As the physical and biological environment changes, the fitness of organisms vary accordingly. Therefore, the adaptive surface is best visualized as an adaptive seascape, rather than an adaptive landscape, with the fitness of individuals rising and falling on the restless surface of the ocean as conditions change (Avery, 2003, p137).

Although Avery’s work emphasizes the importance of the dynamics of the adaptive surface, if the only comparison is with the steady state landscape, or even the landscape of uniformitarianism, then the adaptive seascape is probably a better metaphor as it conveys the sense of dynamic movement. However, with respect to the hybrid landscape of
uniformitarianism and catastrophism, with its relative stability interspersed with periods of rapid change, the fitness landscape is a probably a more useful metaphor for describing the long term survival environment for both species and businesses. In this thesis, as in most related research, the fitness landscape, and not the adaptive seascape, is the metaphor and model of choice for studying the dynamics of the business landscape.

### 2.2.5 Survival of the fittest

The economist Herbert Spencer, and not Charles Darwin, is credited with first introducing the phrase "survival of the fittest". Spencer used the phrase after reading Darwin's *Origin of Species* (1859), writing:

"This survival of the fittest, which I have here sought to express in mechanical terms, is that which Mr. Darwin has called 'natural selection', or the preservation of favored races in the struggle for life” (Spencer, 1864 p.444).

Spencer also used this phrase, in the competitive business context, in his work; *The Man Versus The State* (1884). Spencer wrote that companies which offer better goods and services will survive better in the marketplace and will tend to accumulate an ever growing market share, while poorly adapted companies will be forced out by the better adapted companies.

Today, however, the phrase “survival of the fittest” is used in such a wide range of contexts that the majority of evolutionary biologists prefer to use the term “natural selection”. That notwithstanding, it has been the driving force behind the development of the “fitness landscape” and that concept has been applied to a wide range of serious scientific, engineering and business applications.

### 2.2.6 Survival of the most diverse

It is a key hypothesis of this research that highly adapted species may survive and thrive in a given environment, but in an environment of rapid, discontinuous change, it is the species or business that is most able to adapt to that change that have the highest likelihood of
surviving. This statement does not necessarily mean that a business needs to be the most adaptable. In other words the species or business does not necessarily need to have the ability to quickly change, it may be sufficient for it to simply increase the probability to survive by increasing the probability of it being at or near a fitness peak after any given, sudden and violent, environmental change. Figure 2-6 illustrates this situation.
In a fitness landscape undergoing rapid environmental change, a species (or business) that was previously less adapted to a previous environment could find the fitness path length to an emerging new optima, significantly shorter. A shorter path length implies that the once less adapted species may be best placed to reach the newly emerged optimization peak. In an environment of rapid change, it may be very fortuitous to be in the right place at the right time. A business (or species) may increase its ability to survive by positioning itself in multiple sub-optimal fitness locations. This would be a disadvantage, however, in an environment of minimal change. In this example, a rapid change in the fitness landscape has positioned the spotted species to be in an ideal position to reach the newly emerged fitness peak F1. In other words, in this new landscape, the spotted species is, or soon will be, on the fitness peak, and the brown species is now in the sub-optimal positions.

From a species perspective, this analogy may have applied to the changing fortunes of dinosaurs and mammals, it may also be an effective analogy to explain the changed fortunes of IBM and Xerox, and may apply to the future destiny of Microsoft and Google.

This research suggests that in a changing business environment, discontinuous environmental business change leads both to corporate decay for previously well established corporations, and possibly to corporate growth for previously immature corporations. Furthermore, it suggests that diversity of positioning, or diversity of industry participation, may significantly increase the chances of opportunistic growth.

Adaptability may enable a species to possibly reach a new fitness peak, but diversity of fitness is also a viable, and certainly a more proactive approach, to surviving change. A
species or a business that has a diversity of fitness traits exists in multiple locations in the fitness landscape, and as such is able to increase its likelihood of being in the right place at the right time.

It is one of the aims of this research to show that established businesses, like species in an environment of rapid change, don’t survive just by being the fittest, they survive by being located in the optimum position in a new fitness landscape. By optimum position, it is meant that the business which has the shortest path length to a new fitness peak, in a new fitness landscape, will have the best chance of surviving. It therefore follows that in a very dynamic changeable fitness landscape, the business which has multiple, viable, but not necessarily the fittest positions in the fitness landscape, will have the highest probability of surviving, and a higher probability of thriving.

In summary, the business with the shortest path lengths to the most number of highest peaks, in any given fitness landscape, will have the highest probability to both survive and thrive in a rapidly changing business fitness landscape. Decades of strategic management research (Ansoff, 1957; Chandler, 1962; Gort, 1962; Porter, 1980b; Ramanujam and Varadarajan, 1989; Rumelt, 1982), however, has also shown that corporations that attempt to become more diversified, often put their short term vitality and survival at risk.

2.3 Strategic management and the risks of diversification

One of the most common and most significant topics for strategic management research revolves around the advantages and disadvantages of corporate diversification (Markides and Williamson, 1996; Ramanujam and Varadarajan, 1989). When done successfully corporate diversification can provide multiple engines of growth and the rewards can be tremendous. For successful corporate diversification involving large corporations consider the success seen by Apple, General Electric, Berkshire Hathaway, and 3M. When done unsuccessfully, the consequences of attempted diversification can be extremely damaging to the parent corporation. For unsuccessful diversification consider AOL and Time Warner, HP and Compaq, and Mattel and the Learning Company.
The risk reward ratio associated with corporate diversification is significant. The fact that the risk is high comes from the multifaceted challenges associated with any attempt to diversify. These challenges are numerous and have been heavily researched and documented (Bettis, 1981; Leontiades and Tezel, 1981; Markides, 1999; Markides and Williamson, 1994; Markides and Williamson, 1996; Montgomery and Singh, 1984; Ramanujam and Varadarajan, 1989; Rumelt, 1974; Rumelt, 1982; Salter and Weinhold, 1979). In summary the risks of diversification include:

1. Management organization: does the parent corporation have the organizational structure that is capable of absorbing and integrating the new organization(s).

2. Management depth and capability: is there the management skills, expertise and bandwidth required to run the newly expanded organization and understand the business issues associated with the new or expanded industry presence.

3. Cost of expansion: is the financial cost of diversification such that it has stretched financial reserves of the parent company simply to far. For example, is the corporation still capable of withstanding potential economic shocks and capable of mitigating the inevitable risks associated with the diversification.

4. Failure to realize benefits: are the potential cost savings and increased revenues of the acquisition over-stated so that the real cost of the acquisition is significantly higher than planned.

5. Impact on strategic assets: is there a significant impact on strategic assets such as brand, management, management processes, factories, customer satisfaction, and skilled resources.

6. Cultural: are the management styles, customer management relationship processes, employees and customers sufficiently compatible or symbiotic to ensure success.

7. Relative financial performance: the costs of acquisitions and the impact of increased span of control often leads firms that have higher diversifications to under-perform their peers financially.
The risks of diversification are clearly significant, however the benefits of diversification are also significant.

2.4 Strategic management and the benefits of diversification

The strategic management research surrounding the benefits of diversifications is similar in scale to the research surrounding the disadvantages of diversification. For example, Song studied how acquiring firms seek diversification to compensate for weaknesses in profitability and growth. Lecraw (1984) concluded that firms’ financial performance was disadvantaged if they did not follow a diversification strategy. Jacquemin and Berry (1979) found that diversification is positively related to the asset growth of the firm. Backaitis et al. (1984) correlated diversification with market power. Weston and Mansinghka (1971) found that diversification allowed firms to improve profitability from inferior to average levels relative to their peers. Galbraith et al. (1986) concluded that diversification to unrelated industries was an effective hedging strategy against technological change. While Michel and Shaked (1984) concluded that diversification into unrelated firms allowed the acquiring firm to generate statistically significant improved performance compared to firms that diversified into related firms.

In summary the benefits of diversification, and the need for investment in diversification, are argued to be multifaceted. The benefits or justification for diversification have been argued to include:

1. Necessary restructuring in response to technological or regulatory change.
2. To provide a hedge against possible or future technological or regulatory change.
3. To provide increased protection from reduced barriers of entry due to loss of intellectual property protection, tariff changes, and changing market access regimes.
4. Market diversification as a hedge against foreign exchange rate or inflation rate risk.
5. Market diversification as a hedge against local or regional business cycle risk.

6. To find new engines of growth as a corporation or business unit moves into the decay phase of their business lifecycle.

7. Establish improved business strongholds designed to protect established markets from increased competition.

8. For increased size as a protection against being acquired.

9. Agency objectives in which management or key investors seek to satisfy personal objectives.

10. To acquire key processes, skills, or intellectual property for increased competitive advantage, or to establish improved barriers to entry.

11. To put excess financial reserves to work so as to improve return on investment capital.

12. To achieve improved access to financial markets for the corporation and or its customers.

13. To secure vital supply chain objectives.

14. To secure increased market dominance and therefore enhance the ability to set market prices, demand better pricing from suppliers, and to be able to better serve customer needs.

2.5 The relative cost-reward of diversification

The research evaluating the costs and benefits of diversification is extensive but inconclusive. One possibly significant issue identified by Ramanujam and Varadarajan (1989) is that most of the studies on diversification made insufficient or no allowance for the relative business cycle effects during the periods of their studies. For example Rumelt’s (1982) study covered 1949 to 1969, which was a relatively stable low inflation period. Michel and Shaked’s (1984) study covered 1975 to 1981 which was a period of relative instability,
post the oil shocks of the early 1970s. Maybe that is a factor in explaining why the two studies had such different findings with respects to the relative advantages of diversification.

The other possible interpretation associated with the conflicting findings of Rumelt’s study and Michel and Shaked’s study is that the risks of diversification are indeed high, but so are the possible rewards. Furthermore, during a period of relative economic equilibrium the studies may indicate that the rewards of diversification are not worth the risk. However during periods of disequilibrium, as in periods of rapid, non-uniform change, which possibly describes the period of the last ten years, the rewards of diversification may well outweigh the disadvantages.

For a Fortune 100 corporation the minimum reward of diversification, or for that matter non-diversification, is to at least survive as a member of that select group. If the corporation is extremely successful maybe it can continue to grow or mature to a higher level in the Fortune 100. The worse possible result is for the corporation to decay and fall below its current benchmark, be it the Russell 1000, the S&P 500 or the Fortune 100. It is safe to assume that no corporation will survive in the Fortune 100 for long if it doesn’t have a successful and competitive diversification strategy. During periods of relative equilibrium it will need, at a minimum, a related-diversification strategy to avoid being overtaken by faster growing firms. This research also suggests that during periods of disequilibrium, to avoid decay resulting from non-linear growth or contraction from a particular industry segment, the corporation will also need an effective unrelated-diversification strategy. Any study of the decay of corporations therefore needs to consider the major strategic management analysis models that have dominated the literature of the last 50 years, and that have had significant acceptance as effective tools for describing the growth and decay of corporations.

2.6 Five models related to the decay of corporations and the role of diversification

Five leading competitive strategy conceptual frameworks that have had significant acceptance in describing the decay of corporations include:

2. Ohmae’s Four Basic Routes To Strategic Advantage (Ohmae, 1991),

3. Hamel and Prahalad’s Core Competency Agenda Matrix (Prahalad and Hamel, 1994),

4. D’Aveni’s Hypercompetition Model (D’Aveni et al., 1995), and


Each one of these five models will be examined separately.

### 2.6.1 BCG’s Growth Share Matrix

BCG’s Growth Share Matrix (Aaker, 2008; Hedley, 1977; Shay and Rothaermel, 1999; Wernerfelt, 1984), takes a two dimensional portfolio planning matrix approach to strategic analysis of a large corporations related and unrelated business units. The two dimensions are, 1. Growth of the market associated with a particular business unit, and 2. The business unit’s relative market share, relative to its next largest competitor.

The matrix provides insight into the corporation’s product portfolio relative to its competitor organizations. Products are then placed in an effective 2 x 2 matrix consisting of question marks, rising stars, cash cows, and dogs. This model assists the business analyst to identify how certain products can be used to fund new growth ventures.

Referring back to the corporation lifecycle model introduced in the introduction. Four stages in the corporation lifecycle were described, namely; birth, growth, maturity and decay. In the BCG Growth Share Matrix, birth would equate to question marks, growth would equate to rising stars, maturity would equate to cash cows, and decay would equate to dogs. The recommendation would be to diversify by divesting the dogs and reallocate resources from the associated divestment, as well as resources from the cash cows, to new diversified
ventures. Divestitures which follow this process will typically change the diversity status of the corporation.

2.6.2 Ohmae’s Four Basic Routes To Strategic Advantage

Ohmae’s Four Basic Routes To Strategic Advantage (Ohmae, 1991; Shay and Rothaermel, 1999) focuses not on performance in absolute terms but on relative performance to the corporations competitors. The path to this relative performance advantage is via four basic routes (Shay and Rothaermel, 1999). These routes are:

1. Strategic degrees of freedom
2. Key success factors
3. Aggressive initiatives, and
4. Relative superiority

Referring back to the research’s corporation lifecycle model, birth would equate to strategic degrees of freedom in which products are targeted to markets that are relatively untouched by competition. Growth equates to key success factors in which investments are made to products or business units so as to strengthen existing competitive advantages. Maturity equates to aggressive initiatives in which unconventional tactics are employed that challenge the existing playing field. Finally decay equates to relative superiority where existing products or business units are challenged by competitors. In this last stage, investment in diversification is often utilized to compensate for declining relative superiority.

2.6.3 Hamel and Prahalad’s Core Competency Agenda Matrix

The Core Competency Agenda Matrix (Prahalad and Hamel, 1994; Shay and Rothaermel, 1999) model emphasizes the role collective learning within the firm is often a key differentiating asset of the firm. This learning or knowledge base includes knowledge of managing vital production processes and associated technological intellectual property. It is this knowledge base which effectively differentiates the firm and plays a key role in ensuring that the corporation stays out of the decay phase for the longest possible period.
Like the Growth Share model, the Core Competency Agenda Matrix also uses a 2x2 two-dimensional matrix. The two axes in this case being existing / new competencies and existing / new markets. This matrix establishes a heuristic model which defines four alternative groupings for the corporation’s business units. These four alternatives are labeled:

1. Mega Opportunities
2. White Spaces
3. Premier Plus Ten
4. Fill In The Blanks

Mega Opportunities dominates the Birth phase of the corporation and is often associated with significant investment in diversification in an attempt to acquire core competencies for the future. White Spaces dominates the Growth phase of the corporation and may include some investment in diversification as the corporation attempts to apply and extend existing competencies into new products and services. Premier Plus Ten dominates the Maturity phase of the corporation and is associated with minimal investment in diversification. In this phase the focus is on enhancing market position for the corporation’s best established products and services. Finally the Fill In The Blanks stage is dominant during the Decay phase of the corporation. In this Decay phase the model sees the Corporation focused on finding new applications for increasingly under-utilized competencies. A significant investment in diversification may well be appropriate in this Fill In The Blanks stage.

2.6.4 D’Aveni’s Hypercompetition Model

The D’Aveni’s Hypercompetition Model (D'Aveni et al., 1995; Markides, 1999; Shay and Rothaermel, 1999) is an interesting competitive strategy conceptual framework for this research, in that it was developed as a response to the non-equilibrium, hypercompetitive, business environment that many strategic management analysts see as prevailing in the business environment since the mid 1980s. An environment is which deregulation, reregulation, technological change, and major changes to once existing economic barriers, are rapidly changing once established competitive advantage and barriers to entry.
The D’Aveni’s Hypercompetition Model can be used to group a corporation’s business units, subsidiaries, or products and services into four areas. This four areas are:

1. Cost And Quality
2. Timing And Know-how
3. Strongholds
4. Deep Pockets

The Cost And Quality stage is seen to dominate during the Birth phase of a corporation. In this stage the level of competition is seen to be rapidly increasing and a corporation may need to invest in diversification to ensure it has access to the features, quality and price demanded by its customers. The second stage, Timing And Know-how, relates to the Growth phase of the corporation. Here new opportunities are being identified by the competition and the corporation must move fast to keep or capture first-mover advantage. A timely investment in diversification may be what is required to fast-track the corporation’s position in such a growth market. The third stage, Strongholds, aligns with the Maturity phase of the corporation. In this stage strong positions must be maintained and defended as barriers to entry may begin to fail, rivalry dominates, and branding is key. A related diversification investment may assist in strengthening existing strongholds. The fourth and final stage, Deep Pockets, is aligned with the decay phase of the corporation. In this stage deep pockets and well established market strongholds characterize the few remaining competitors. An investment in related diversification may be required to compensate for slowing growth and to leverage opportunities presented by weakened competitors. It is also a critical stage to consider an investment in unrelated diversification to ensure that a new engine of growth is captured before the decay phase gains dangerous momentum to the downside.

2.6.5 The Austrian school and strategic management

There are two significant conceptual foundations for strategic thinking and research in the field of strategic management. They are the Industrial Organization approach (Buzzell and Gale, 1987; Jacobson, 1992; Porter, 1980a; Porter, 1998) and the so called Austrian
The Austrian School approach focuses on the market process and entrepreneurial discovery. Its strength, and some would also argue its weakness, is that it emphasizes research topics, that although considered important, have received relatively less attention in the research literature (Jacobson, 1992). The research topics that the Austrian School emphasizes include:

1. Profitability from entrepreneurial discovery
2. Business environment disequilibrium
3. Modeling market heterogeneity
4. The importance of unobservable influences on business performance

Meanwhile the Industrial Organization approach emphasizes:

1. Profitability by restricting competitive forces
2. Business environment equilibrium
3. Modeling market regularity
4. The importance of observed and measurable strategic factors

The Austrian School argues that advocates for the Industrial Organization approach (often referred to as non-Austrians) fail to adequately describe the motive for the continued search for new products and processes (Jacobson, 1992), and therefore fail to fully appreciate the drive and justification for the risk-taking associated with unrelated diversification. Furthermore that the non-Austrians fail to give sufficient attention to the dynamics of the business environment brought about by technological change (Nelson and Winter, 1982).

The non-Austrians argue that because of the importance the Austrians place on unobservable factors as having a significant influence on business decisions, the Austrians
are unable to say anything significant about the observable factors (Kirzner, 1976). The Austrians argue however that their methods provide significant new insight precisely because they take into account the importance of the unobservables.

It is believed that the economic approach underlying the business strategy research covered by this dissertation is more closely aligned with the Austrian School (Hayek, 2001; Jacobson, 1992; Nelson and Winter, 1982; Schumpeter, 1939; Schumpeter, 1943) approach of Menger, Mises, Hayek, Kirzner and Schumpeter, versus the Industrial Organization (Buzzell and Gale, 1987; Jacobson, 1992; Porter, 1980a; Porter, 1998) approach of Caves, Porter, Buzzell, Gale, and Aaker. In particular, as reviewed in the previous section, it should be noted that the research focuses on the disequilibrium, heterogeneity, and entrepreneurial discovery that characterizes the Austrian School versus the equilibrium, empirical regularities, and planned strategy execution that dominates, for example the PIMS (Buzzell and Gale, 1987) Industrial Organization approach.

### 2.7 A demographic approach

It should noted that the bulk of this research in strategic management takes a demographic approach in that it focuses on whole populations and communities of corporations, versus focusing on individual corporations and case studies. This approach has had wide application in strategic management as relating to the decay of corporations, the lifecycle of the corporation, business environment, business ecology, business evolution, business diversification, and organizational ecology (Bettis, 1981; Bettis and Hitt, 1995; Burgelman, 1991; Carroll and Hannan, 2004; Freeman and Hannan, 1983; Hannan, 1998; Hannan and Freeman, 1977; Hannan and Freeman, 1993; Jovanovic, 2001; Lovas and Ghoshal, 2000; Nelson and Winter, 1982; Singh and Lumsden, 1990).

For analogy, a similar demographic study of the members of a community versus say the corporate membership of say the S&P 500, might ask similar research questions to many of the research questions that were examined in this research. For example, these equivalent demographic based questions could include:

1. What is the half life of a defined community?
2. How many years does it take for half the members to leave the community?

3. Is there a change in the half-life over time?

4. Is there a identifiable trend in that change in the half-life over time?

5. What is the best fit in that trend analysis?

6. Members leave the community for all sorts of reasons – death, relocation, expulsion, sickness, new opportunities, environmental change, technological change, competitive pressure from other members, etc. It appears some members have multiple positions of strength within the community (high diversification), while others have few or only one position of strength (low diversification) in the community. What tools exists to document and examines this relative diversity?

7. Can new tools to model diversity be created that have significant benefits over and above the existing tools?

8. Do the tools reveal any relationship between relative diversity of position and the members ability to extend their relative survival time or membership time in the community?

2.8 Closing comments on the chapter

The aim of this chapter was to review the literature associated with the introduction of the key conceptual foundations underlying the research. The key concept to be explored here was the concept of the fitness landscape. This exploration began with a review of the power of metaphor and its role in the business fitness landscape model. The discussion then reviewed the evolution of the landscape metaphor over the last 3,000 years. This review led to a discussion of the literature surrounding the development of the adaptive landscape and the subsequent development of the fitness landscape. The review then moved on to introduce the concept of reducing the fitness path length as a possible key parameter in predicting the potential decay of a corporation.

The role of the fitness path length was explained with respect to a business that may be sub-optimal in one business environment, may, by diversity of industry participation, have
a higher probability of reaching a new, emerging optima, that may appear in a period of rapid, discontinuous change in the business environment. This led to the conclusion that the literature surrounding the benefits and disadvantages of diversification needed to be examined.

The literature appears to suggest that the arguments for and against diversification are inconclusive. From this position, five models related to the decay of corporations and the role of diversification were examined and the conclusion was reached that the research covered by this dissertation, focuses more on the disequilibrium, heterogeneity, and entrepreneurial discovery that characterizes the Austrian School, versus the equilibrium, empirical regularities, and planned strategy execution that dominates, for example the PIMS Industrial Organization approach. Furthermore, it was concluded that this research in strategic management takes a demographic approach in that it focuses on whole populations and communities of corporations, versus focusing on individual corporations and case studies.

In the next chapter, being part two of the literature review, the focus will be to look at the literature associated with existing business landscapes, models and indexes. This review of existing business indexes, landscapes, and key technical risk parameters will include a short analysis of their history and their application, as well as their strengths and weaknesses.
3 LITERATURE REVIEW PART TWO – EXISTING BUSINESS LANDSCAPE MODELS

In the previous chapter, the literature surrounding the broader conceptual foundations underlying the study of fitness landscapes, and their applicability to a new analysis of the decay of corporations, was examined. In this chapter, the focus will be on the literature associated with existing business indexes, landscapes, and key technical risk parameters. This review will include a short analysis of their history and their application, as well as their strengths and weaknesses. It is this review which attempts to identify and highlight many of the preexisting ideas that provide the background context for the new ideas of this research.

Before an introduction and analysis of any new business fitness landscape methodology, it is important to examine the associated literature that exists with respect to business landscapes in general and business fitness landscapes in particular. To this end, answers will be sought for the following three questions:

1. What relevant business indexes, landscapes and parameters exist?
2. What are the strengths and weaknesses of the existing business indexes, landscapes and parameters?
3. In what ways might a new set of business landscape tools, including a new business index, a new business landscape model, and a new business risk parameter, build on the strengths and address some of the limitations of the existing business landscape tools?

The response to these questions has been structured under the following seven headings, and these headings will form the structure for the balance of this chapter:

1. A review of the major U.S. business indexes
2. A review of the major U.S. business ranking landscapes

3. A review of the major U.S. industrial classification landscapes

4. U.S. Census Bureau business data

5. Hoover’s, Inc. business data

6. Securities and Exchange Commission business data

7. Selected approach to extending the existing business indexes, landscapes and risk parameters

### 3.1 A review of the major U.S. business indexes

Four major U.S. business indexes have been identified as important and relevant to this research. Their importance and relevance was determined on the basis of the number of times they are referenced in the business analysis literature, and their coverage of the focus area of this research, namely the largest corporations in the U.S. during the last 54 years.

The four major U.S. business indexes that were identified are; Dow Jones Industrial Average (Pierce and Jones, 1991), Standard and Poor’s 500 (S&P, 2007), NASDAQ Composite (Ingebretsen, 2002), and the Russell 3000 Index (Russell, 2008). Table 3-1 summarizes the analysis of these four business indexes.
# The Decay Of Corporations

## Literature Review – Existing Business Landscape Models

### Business Index

<table>
<thead>
<tr>
<th>Overview</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dow Jones Industrial Average (DJIA)</strong></td>
<td>• Very widely tracked.</td>
<td>• Components of the index are selected at the discretion of a committee.</td>
</tr>
<tr>
<td>• The DJIA is a price-weighted index of 30 of the largest public corporations in the USA.</td>
<td>• The longest history of any of the major indexes.</td>
<td>• May fail to keep pace with structural changes in the economy.</td>
</tr>
<tr>
<td>• The index covers all major areas of the U.S. economy except transportation and utilities.</td>
<td></td>
<td>• Component selection may distort the historical data.</td>
</tr>
<tr>
<td>• First established in 1896.</td>
<td></td>
<td>• Biased towards large corporations.</td>
</tr>
<tr>
<td><strong>Standard and Poor's 500 (S&amp;P 500)</strong></td>
<td>• Widely tracked.</td>
<td>• Low selection transparency. Components selected at the discretion of a committee.</td>
</tr>
<tr>
<td>• A market weighted index of 500 U.S. large cap stocks chosen for market size, liquidity and industry grouping.</td>
<td>• Significant historical data.</td>
<td>• May fail to keep pace with structural changes in the economy.</td>
</tr>
<tr>
<td>• Index stocks are selected by a committee at Standard &amp; Poor’s.</td>
<td>• Very representative of the U.S. large cap stock market.</td>
<td>• Component selection may distort the historical data.</td>
</tr>
<tr>
<td>• First established in 1957.</td>
<td></td>
<td>• Biased towards large U.S. corporations.</td>
</tr>
<tr>
<td><strong>NASDAQ Composite</strong></td>
<td>• A broad, well tracked index.</td>
<td>• Limited to stocks listed on the NASDAQ exchange and so is biased towards U.S. technology and high growth stocks.</td>
</tr>
<tr>
<td>• A market weighted index of all of the common stocks and similar securities listed on the NASDAQ exchange.</td>
<td></td>
<td>• Limited history.</td>
</tr>
<tr>
<td>• First established in 1971 with an index of 100.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Russell 3000 Index</strong></td>
<td>• Covers both large cap and small cap stocks.</td>
<td>• Limited history.</td>
</tr>
<tr>
<td>• A broad index of the U.S. stock market.</td>
<td>• Very transparent, rules based weighting system.</td>
<td>• Limited to U.S. stocks.</td>
</tr>
<tr>
<td>• Tracks 3,000 of the largest public companies in the USA.</td>
<td>• A major benchmark for both large cap and small cap U.S. stocks.</td>
<td>• Not as well quoted as the other major indexes.</td>
</tr>
<tr>
<td>• Totally reconstructed every year.</td>
<td></td>
<td>• Annual restructuring of data makes any historical analysis difficult.</td>
</tr>
<tr>
<td>• Established in 1984.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3-1. Summary of the analysis of the four major U.S. business indexes (Ingebretsen, 2002; Pierce and Jones, 1991; Russell, 2007; S&P, 2007).
3.2  A review of the major U.S. business ranking landscapes

The following list of major U.S. business ranking landscapes has been identified as being important and relevant to this research. A business ranking landscape is a broad expanse of business related information that tracks businesses according to their relative ranking associated with their revenue, profit, growth, number of employees or other factors. These ranking landscapes are important, in the sense that they are widely used to view, monitor and track key business environments, and they are relevant, in that they do provide a broad expanse of related and informative business activity information that can be readily seen from a single viewpoint. As such, they meet the definition established in this research of being a major U.S. business landscape of comparative interest.

Three U.S. business rankings landscapes were identified for analysis. They are: Fortune 500 (CNN, 2008c), Fortune Global 500 (CNN, 2008d) and the Forbes 500 (Forbes, 2008). Table 3-2 summarizes the analysis of these major U.S. business rankings landscapes.
<table>
<thead>
<tr>
<th>Business Rankings Landscape</th>
<th>Overview</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
</table>
| Fortune 500                 | • A ranked list of the 500 largest U.S. corporations as measured by gross revenue.  
• Fortune magazine compiles and publishes the list annually.  
• The Fortune 500 ranking was first published in 1955.                                                                                                                                                                                                                                                                                                                                                      | • Simple, transparent, objective and consistent.  
• Significant historic data.                                                                                                                                                                                                                                                                                                                                                                                                  | • Limited to the largest U.S. corporations.  
• Companies may leave the list due to a name change associated with a merger or acquisition.  
• May fail to correctly rank non-public companies.                                                                                                                                                                                                                                                                                                                                                                           |
| Fortune Global 500          | • A ranked list of the 500 largest corporations in the world as measured by gross revenue.  
• Fortune magazine compiles and publishes the list annually.  
• The Fortune Global 500 ranking was first published in 1990.                                                                                                                                                                                                                                                                                                                                                | • Simple, transparent, objective and consistent.  
• Global coverage.                                                                                                                                                                                                                                                                                                                                                                                                                                                             | • Companies may leave the list due to a name change associated with a merger or acquisition.  
• Limited historic data.  
• May fail to correctly rank non-public companies.  
• Data distorted by changes in exchange rates.                                                                                                                                                                                                                                                                                                                                                                           |
| Forbes Global 2000          | • A ranked list of the world’s 2,000 largest public corporations as measured by combining sales, profits, assets, market value and number of employees.  
• Forbes magazine compiles and publishes the list annually.  
• The Forbes Global 2000 ranking was first published in 2003.                                                                                                                                                                                                                                                                                                          | • Transparent, objective and consistent.  
• Global coverage.                                                                                                                                                                                                                                                                                                                                                                                                                                                             | • Limited to the world’s largest corporations.  
• Companies may leave the list due to a name change associated with a merger or acquisition.  
• May fail to correctly rank non-public companies.  
• Very limited historic data.                                                                                                                                                                                                                                                                                                                                                                           |

Table 3-2. Summary of the analysis of the major U.S. business rankings landscapes (CNN, 2008b; CNN, 2008c; CNN, 2008d; Forbes, 2008).

These business rankings were deemed to be important, in the sense that they are widely used to view, monitor and track key business environments, and they are relevant, in that they provide a broad expanse of related and informative business activity information that can be readily seen from a single viewpoint. As such they meet this research’s definition of being a major U.S. business landscape of comparative interest.
3.3 A review of the major U.S. industrial classification landscapes

The following list of major U.S. industrial classification landscapes have been identified as being important and relevant to this research. They are important, in the sense that they are widely used to view, monitor and track key business environments. They are relevant, in that they provide a broad expanse of related and informative business activity information that can be readily seen from a single viewpoint. As such they meet the definition of being a major U.S. industrial classification landscape of comparative interest.

Five industrial classification landscapes were identified for analysis. They are: the Standardized Industrial Classification (SIC) (U.S. Office of Management and Budget., 1987), the North American Industry Classification System (NAICS) (U.S. Census Bureau., 2007), the Global Industry Classifications Standard (GICS) (S&P, 2008), the International Standard Industrial Classification (ISIC) (United Nations, 1999), and the Fama and French industry classification algorithm (FF) (Fama and French, 1997).

Of the five industrial classification landscapes, two of the five were eliminated from further detailed analysis due to their limited use or applicability to the U.S. industrial landscape. The two eliminated landscapes are the United Nations’ standard, ISIC, and the Fama and French industry classification algorithm, FF. Due to lack of U.S. Government support, ISIC has had very limited application in the U.S. compared to the well established and supported standards such as SIC and NAICS. The Fama and French algorithm, on the other hand, is relatively new and has failed to obtain significant application by the broader business analyst community (Bhojraj et al., 2003). Table 3-3 summarizes the analysis of the three remaining major U.S. industrial classification landscapes: SIC, NAICS, and GICS.
## Tabular Summary of U.S. Industry Classification Systems

<table>
<thead>
<tr>
<th>Industrial Classification Landscape</th>
<th>Overview</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Industrial Classification (SIC)</td>
<td>• A four digit industrial coding system introduced by the U.S. government in 1939.</td>
<td>• Still in widespread use by corporations and by the U.S. Securities and Exchange Commission.</td>
<td>• Is being replaced by the six-digit NAICS or North American Industry Classification System.</td>
</tr>
<tr>
<td></td>
<td>• Companies are grouped on a supply-based production orientation.</td>
<td>• Significant historic data.</td>
<td>• Has failed to keep up with the restructuring of the U.S. economy, e.g. as economy has moved away from primary towards tertiary industries.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Accessible, open data.</td>
<td>• U.S. focused.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• No longer evolving.</td>
</tr>
<tr>
<td>North American Industry Classification System (NAICS)</td>
<td>• A six digit industrial coding system introduced by the U.S. government in 1997.</td>
<td>• More accurately reflects structural changes in the U.S. economy.</td>
<td>• Limited historic data.</td>
</tr>
<tr>
<td></td>
<td>• Jointly developed by the U.S., Canada and Mexico.</td>
<td>• Improved data detail.</td>
<td>• North America focused.</td>
</tr>
<tr>
<td></td>
<td>• Companies are grouped on a supply-based production orientation.</td>
<td>• Significant recent data.</td>
<td>• Classification is production oriented rather than business model oriented.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The new standard for tracking the U.S. economy.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Closely linked with the international standard classification systems like the U.N.’s ISIC system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Widely available data.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• An evolving standard.</td>
<td></td>
</tr>
<tr>
<td>Global Industry Classifications Standard (GICS)®</td>
<td>• Jointly developed by Standard and Poor’s and Morgan Stanley Capital International Barra (MSCI Barra).</td>
<td>• Leverages key financial indexes such as S&amp;P 500.</td>
<td>• Limited historic data.</td>
</tr>
<tr>
<td></td>
<td>• Introduced in 1999.</td>
<td>• Its ability to better track correlated stock returns makes it popular with financial analysts.</td>
<td>• Not as widely used as the alternative classification systems.</td>
</tr>
<tr>
<td></td>
<td>• Companies are grouped on the basis of their principal business activity.</td>
<td>• Strong consistency of data from year to year.</td>
<td>• Data is less accessible.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Global coverage.</td>
<td>• Focused on the needs of the financial analyst market.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Flexible and evolving.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Designed by and for financial analysts.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Restricted, proprietary.</td>
<td></td>
</tr>
</tbody>
</table>

3.4 A review of the key technical risk parameters from Modern Portfolio Theory

Markowitz (1952) established the foundations of Modern Portfolio Theory (MPT). Its aim was to create a mathematical framework for decision making relating to investment risk and investment return. MPT creates a rational and objective approach to asset selection and portfolio management and assists in pricing volatile, risky assets. Sharpe (1964) extended the work of Markowitz with the development of the Capital Asset Pricing Model (CAPM) by taking into consideration an asset's sensitivity to market risk.

Based on MPT and CAPM there are five key technical risk parameters that are commonly applied to the analysis of a business’ market valuation or market capitalization as part of Modern Portfolio Theory. The five key technical risk parameters are: alpha, beta, r-squared, standard deviation, and the Sharpe ratio. These five technical parameters assist in evaluating investment risk and are all major components of modern portfolio theory. This theory provides a standardized financial model used for assessing business valuation risk by comparing those valuations to well established market benchmarks. Table 3-4 summarizes the major attributes of these five risk parameters. These five technical parameters assist in evaluating investment risk. As such, the strengths and weaknesses of these risk parameters are an important reference point in the development of any new risk parameter associated with monitoring and predicting the decay of corporations.
<table>
<thead>
<tr>
<th>Risk Parameter</th>
<th>Overview</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
</table>
| **Alpha**     | • Alpha is a measure of a security's relative return, on a risk-adjusted basis, to a benchmark index.  
• An alpha greater than zero indicates that the security will have a higher return relative to the benchmark index.  
• An alpha less than zero indicates that the security will have a lower return relative to the benchmark index. | • Widely used and quoted.  
• A useful measure of performance. | • Need to factor in the statistical correlation to the benchmark index. |
| **Beta**      | • Beta is a measure of the volatility of a security in comparison to a benchmark index.  
• A beta of greater than 1.0 indicates that the security is more volatile than the benchmark.  
• A beta of less than 1.0 indicates the investment will be less volatile than the benchmark. | • Widely used and quoted.  
• A useful measure of risk. | • Need to factor in the statistical correlation to the benchmark index. |
| **R-squared** | • R-Squared is a measure of the proportion of a security’s price movement that can be explained by movements in the underlying benchmark such as the S&P 500 index.  
• Securities which have an R-squared value greater than 85 are usually considered to be closely correlated to the benchmark index.  
• Securities which have an R-squared value less than 70 are usually considered to be uncorrelated to the benchmark index. | • Widely used and quoted.  
• A useful measure of performance. | • Need to factor in the statistical correlation to the benchmark index. |
| **Standard Deviation** | • The standard deviation of a security is a measure of the price volatility of the security.  
• A high standard deviation is a measure of high price volatility in a security. | • Widely used and quoted.  
• A useful measure of risk and performance. | • Need to factor in the statistical correlation to the benchmark index. |
| **Sharpe ratio** | • The Sharpe ratio is a measure of a security’s risk-adjusted performance.  
• A security with a high Sharpe ratio should have higher risk-adjusted performance. | • Widely used and quoted.  
• A useful measure of risk and performance. | • Need to factor in the statistical correlation to the benchmark index. |

Table 3-4. Summary of the Modern Portfolio Theory risk parameters.  
(Black et al., 1972; Elton and Gruber, 1981; Markowitz, 1952; Mehrling, 2005; Rubinstein, 2006; Sharpe, 1964).

These five technical parameters assist in evaluating investment risk. As such, the strengths and weaknesses of these risk parameters are an important reference point in the development of any new risk parameter associated with monitoring and predicting the decay of corporations.
3.5 A review of the key technical risk parameters from post-modern portfolio theory

Modern Portfolio Theory, and its mean-variance optimization calculations, assumes a world of Gaussian distributed returns. This theoretical framework has been criticized as being overly unrealistic. The following quote is a recent example of this criticism:

Robert Merton, Jr., and Myron Scholes were founding partners in the large speculative trading firm called Long-Term Capital Management … Then during the summer of 1998, a combination of large events, triggered by a Russian financial crisis, took place that lay outside their models. It was a Black Swan. LTCM went bust and almost took down the entire financial system with it, as the exposures were massive. Since their models ruled out the possibility of large deviations, they allowed themselves to take a monstrous amount of risk. The ideas of Merton and Scholes, as well as those of Modern Portfolio Theory, were starting to go bust. (Taleb, 2007, p.281)

The power, relative simplicity, and the relative ease of calculating the MPT risk parameters means that MPT and CAPM will remain an important, although flawed, basis for estimating portfolio risk. In the late 1980s, the Pension Research Institute at San Francisco State University developed a series of mathematical algorithms that started the process of including non-Gaussian considerations to create a more accurate and more realistic portfolio theory. This new theory has become known as Post-Modern Portfolio Theory or PMPT (Rom and Ferguson, 1994).

PMPT is a refinement to Modern Portfolio Theory. Whereas Modern Portfolio Theory assumes that investment returns are normally distributed and uses a Mean-Varience Optimization (MVO) model for asset allocation, Post-Modern Portfolio Theory assumes a method of asset allocation that optimizes a portfolio based on returns versus downside risk. This Downside Risk Optimization (DRO) model does not assume that returns are normally distributed, but assumes that returns follow a non-mesokurtic or non-Gaussian skewed distribution that reflects an investor’s natural bias away from risk.

With today’s access to powerful computing power, and the recent advances in financial and portfolio theories, PMPT has created a usable, more accurate measure for the
risk and return of a portfolio, and MPT is now seen as simply a special, symmetrical, outcome of PMPT.

Four key technical risk parameters have emerged from PMPT. These are: Downside Risk, Sortino Ratio, Volatility Skewness, and Excess Return. The relationship of these PMPT risk parameters to the risk parameters found in PMT, are summarized in Table 3-5.

<table>
<thead>
<tr>
<th>MPT vs. PMPT Risk Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>Measure of risk</td>
</tr>
<tr>
<td>Outperformance vs. benchmark</td>
</tr>
<tr>
<td>Risk vs. benchmark risk</td>
</tr>
<tr>
<td>Excess return per unit of risk</td>
</tr>
</tbody>
</table>

*Table 3-5. The relationship of the key risk parameters of Modern Portfolio Theory to the risk parameters of Post-Modern Portfolio Theory.*

PMPT is a refinement to Modern Portfolio Theory. Whereas Modern Portfolio Theory assumes that investment returns are normally distributed and uses a Mean-Variance Optimization (MVO) model for asset allocation, Post-Modern Portfolio Theory assumes a method of asset allocation that optimizes a portfolio based on returns versus downside risk. This Downside Risk Optimization (DRO) model does not assume that returns are normally distributed, but assumes that returns follow a non-mesokurtic or non-Gaussian skewed distribution that reflects an investor’s natural bias away from risk.

Table 3-6, summarizes the PMPT risk parameters and the strengths and weaknesses of these parameters.
<table>
<thead>
<tr>
<th>Risk Parameter</th>
<th>Overview</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Downside risk</strong></td>
<td>• A measure of the likelihood that a security will decline in value.</td>
<td>• A key parameter in downside risk optimization analysis.</td>
<td>• Like any statistical measure, it may underestimate the impact of extreme but rare events.</td>
</tr>
<tr>
<td></td>
<td>• Annualized standard deviations of returns below a benchmark.</td>
<td>• An important, real world parameter for the majority of investors.</td>
<td></td>
</tr>
<tr>
<td><strong>Sortino ratio</strong></td>
<td>• Measures returns adjusted for the target and downside risk.</td>
<td>• Compensates for non-normal distributions.</td>
<td>• Limited by the accuracy of key parameters such as the downside risk parameter.</td>
</tr>
<tr>
<td></td>
<td>• Sortino ratio equals ((r-t)/d) where, (r) = the annualized rate of return, (t) = the target return, and (d) = downside risk</td>
<td>• May result in better accuracy than the Sharpe ratio.</td>
<td></td>
</tr>
<tr>
<td><strong>Volatility skewness</strong></td>
<td>• Ratio of a distribution's percentage of total variance from returns above the mean, to the percentage of the distribution's total returns from returns below the mean.</td>
<td>• Factors in significantly more of the true information contained in the returns under consideration.</td>
<td>• Still excludes rare and extreme events.</td>
</tr>
<tr>
<td></td>
<td>• A measure of how “non-normal” is a distribution of returns, and so is a measure of the applicability of standard MPT calculations.</td>
<td>• Does not assume a normal distribution for returns.</td>
<td></td>
</tr>
<tr>
<td><strong>Excess return</strong></td>
<td>• Returns in excess of the risk-free rate, or in excess of a market measure such as the S&amp;P 500 index.</td>
<td>• A useful measure of performance.</td>
<td>• Need to factor in the statistical correlation to the benchmark index.</td>
</tr>
</tbody>
</table>

**Table 3-6. Summary of the key Post-Modern Portfolio risk parameters.**
(Kaplan and Siegel, 1994; Rom and Ferguson, 1994; Sharpe, 1964; Sortino and van der Meer, 1991).

These four additional technical parameters to MPT further assist in evaluating investment risk. As such, the strengths and weaknesses of these risk parameters are also an important reference point in the development of any new risk parameter associated with monitoring and predicting the decay of corporations.
3.6 **U.S. Census Bureau**

The United States Census Bureau (US Census Bureau, 2008) conducts an economic census every five years. This census is begun in years ending in a “2” or a “7”. In 2007, for example, more than 4 million businesses were sent an economic census questionnaire, which they were obligated to return by the 12\textsuperscript{th} of February, 2007. From this extensive data, the U.S. Census Bureau collects the following, economy wide, multi-sector, economic data:

1. Annual Capital Expenditures Survey
2. Business and Professional Classification Survey
3. Business Expenditures Survey (formerly the Assets and Expenditure Survey)
4. Business Register
5. Census of Governments
6. Company Organization Survey
7. County Business Patterns
8. Economic Census
9. Economic Census of Island Areas
10. Information and Communication Technology Survey
11. Investment Plans Survey
12. Medical Expenditure Panel Survey
13. National Employer Survey
14. Non-employer Statistics
15. Quarterly Financial Report
16. Retail and Services Area Survey
17. Statistics of U.S. Businesses

18. Survey of Business Owners (including minority- and women-owned businesses)

19. Survey of Industrial Research and Development

20. Survey of Pollution Abatement Costs and Expenditures

As part of this research, this extensive data was mined to obtain much of the secondary data used in developing the landscape models that will be described in detail in Chapters 6 and 7. Table 3-7 provides a sample of the kind of data obtained from the U.S. Census Bureau:

<table>
<thead>
<tr>
<th>NAICS CODE</th>
<th>NAICS DESCRIPTION</th>
<th>DATA TYPE</th>
<th>0-99</th>
<th>100-999</th>
<th>1,000-4,999</th>
<th>5,000-9,999</th>
<th>10,000+</th>
</tr>
</thead>
<tbody>
<tr>
<td>31313</td>
<td>Colleges, Universities, and Professional Schools</td>
<td>Full-time</td>
<td>5843</td>
<td>579</td>
<td>517</td>
<td>769</td>
<td>988</td>
</tr>
<tr>
<td>31319</td>
<td>Colleges, Universities, and Professional Schools</td>
<td>Part-time</td>
<td>902</td>
<td>366</td>
<td>544</td>
<td>1,932</td>
<td>1,550</td>
</tr>
<tr>
<td>31311</td>
<td>Colleges, Universities, and Professional Schools</td>
<td>Employment</td>
<td>4,285</td>
<td>16,385</td>
<td>133,385</td>
<td>148,327</td>
<td>1,340,172</td>
</tr>
<tr>
<td>31313</td>
<td>Colleges, Universities, and Professional Schools</td>
<td>Annual Payroll ($1,000)</td>
<td>742,274</td>
<td>404,000</td>
<td>3,272,400</td>
<td>3,300,120</td>
<td>48,375,930</td>
</tr>
<tr>
<td>3141</td>
<td>Business Schools and Computer and Management Training</td>
<td>Full-time</td>
<td>6,306</td>
<td>647</td>
<td>119</td>
<td>6,971</td>
<td>70</td>
</tr>
<tr>
<td>3141</td>
<td>Business Schools and Computer and Management Training</td>
<td>Part-time</td>
<td>8,343</td>
<td>600</td>
<td>300</td>
<td>7,385</td>
<td>202</td>
</tr>
<tr>
<td>3141</td>
<td>Business Schools and Computer and Management Training</td>
<td>Employment</td>
<td>20,410</td>
<td>10,087</td>
<td>15,925</td>
<td>58,102</td>
<td>11,238</td>
</tr>
<tr>
<td>3141</td>
<td>Business Schools and Computer and Management Training</td>
<td>Annual Payroll ($1,000)</td>
<td>819,624</td>
<td>644,451</td>
<td>903,885</td>
<td>2,364,560</td>
<td>485,367</td>
</tr>
<tr>
<td>3141</td>
<td>Business Schools and Computer and Management Training</td>
<td>Full-time</td>
<td>70</td>
<td>62</td>
<td>24</td>
<td>307</td>
<td>0</td>
</tr>
<tr>
<td>3141</td>
<td>Business Schools and Computer and Management Training</td>
<td>Part-time</td>
<td>753</td>
<td>115</td>
<td>88</td>
<td>436</td>
<td>48</td>
</tr>
<tr>
<td>3141</td>
<td>Business Schools and Computer and Management Training</td>
<td>Employment</td>
<td>1,207</td>
<td>3,261</td>
<td>3719</td>
<td>6,277</td>
<td>1,569</td>
</tr>
<tr>
<td>3141</td>
<td>Business Schools and Computer and Management Training</td>
<td>Annual Payroll ($1,000)</td>
<td>36,718</td>
<td>89,153</td>
<td>30,153</td>
<td>308,153</td>
<td>53,948</td>
</tr>
</tbody>
</table>

Table 3-7. A sample of the detailed data available from the U.S. Census Bureau.

This extensive data was mined to obtain much of the secondary data used in developing the landscape models that will be described in detail in the later sections of this thesis.

3.7 Hoover’s, Inc.

Hoover’s, Inc. (Hoover’s, 2008e) is a private company that specializes in providing data and analysis of private and public companies. This data is selected from their database of over 20 million companies. In addition, they provide in-depth coverage of over 40,000 business enterprises from around the world. Table 3-8 provides a sample of the type of data available from the Hoover’s database:
Of special interest to this research, is the fact that Hoover’s offer their premier subscribers the option to download what they refer to as a “competitive landscape”. This competitive landscape provides detailed, comparative financial data on the companies they have identified as the major competitors of the subject company being researched.

The Hoover’s database, and its associated website, provides tools and subscriptions to obtain customizable, in-depth, company information, including names of the corporate decision makers, financials, growth data and competitors. Of special interest to this research, is the fact that Hoover’s offer their premier subscribers the option to download what they refer to as a “competitive landscape”. This competitive landscape provides detailed, comparative financial data on the companies they have identified as the major competitors of the subject company being researched.
3.8 Securities and Exchange Commission filings and forms

Electronic Data Gathering And Retrieval (EDGAR, 2008) is usually referred to as EDGAR and is a trademark of the U.S. Securities and Exchange Commission (SEC). EDGAR is the system by which the SEC gathers electronic data, performs analysis, data validation, indexing, acceptance, and forwarding of submissions by companies and others who are required by law to file forms with the SEC. Note that not all documents filed with the Commission by public companies will be available on EDGAR. Companies were phased into the EDGAR electronic filing system over a three-year period, ending May 6, 1996. Also, smaller companies, that is those with less than $10 million in assets, do not have to file reports with the SEC.

The information available on EDGAR is extensive, and includes registration statements, prospectuses, and periodic reports such as 10-Ks, 10-Qs and 8-Ks. These reports provide a valuable database of information that has been a useful source of secondary data for this research. The EDGAR databases include:

1. A general description of a registrant’s business
2. Company subsidiaries
3. Applicable industrial classifications
4. Predecessor companies up to a five year period
5. The year the company was organized
6. The company’s form of organization
7. Principal products produced
8. Principal markets for the products
9. Methods of distribution
10. Number of employees
11. Anticipated material changes in the number of employees in various departments

12. Competitive conditions

13. Research and development expenditure

14. A listing of the company’s officers and directors

3.9 Final selection of the existing business indexes, landscapes and risk parameters, targeted for additional research and development

Having reviewed the existing, major business indexes, landscapes and risk parameters, and having summarized some of their strengths and weaknesses, the information was examined to determine how the data could be used to support a new model of the business fitness landscape, especially as it applies to business fitness landscapes in business environments which are undergoing rapid discontinuous change.

Based on the analysis summarized in sections 3.1 to 3.8, and the availability of extensive independent historical data, the following parametric secondary data was selected as the basis for further research. This research includes new business landscape analysis, the creation of a new business landscape model, and the development of a new business risk parameter. The selected parametric secondary data for this new research will be:

1. Fortune 100 analysis from 1955 to 2009

2. North American Industry Classification System (NAICS)

3. U.S. Census Bureau gross domestic product statistics by NAICS code

4. U.S. Census Bureau level of concentration by NAICS code

5. U.S. Census Bureau annual industry growth statistics by NAICS code

6. Hoover’s competitive landscape analysis by business name
7. SEC filings and forms (EDGAR) for specific businesses, to assist in identifying specific competitive industry codes.

3.10 Closing comments on the chapter

This chapter completes the review of the literature and introduces the existing secondary data that will form the foundation for the research. In the next chapter, the first step in extending the existing business indexes, landscapes and risk parameters will begin. The first step in this process, and the basis for the next chapter, will be the creation of two new risk parameters, to enable the monitoring and analysis of corporate decay.
4 TWO NEW BUSINESS RISK PARAMETERS

The previous chapter reviewed the literature associated with the key technical risk parameters that are commonly applied to the analysis of a business within a portfolio. The review introduced the business risk parameters that make up MPT and PMPT. This chapter discusses the development of two new risk parameters that are related to measuring the lifespan of a business, and that provide an important extension to the risk parameters currently in use.

The two new risk parameter are:

1. **Theta or half-life**: defined as a measure of the average time it takes for half of the businesses in a portfolio or group, to decay. Decay, defined in Chapter 1, is the stage at which a specified business is removed from the underlying benchmark, group or set, to which the nominated business is deemed to belong.

2. **Tau or mean-life**: defined as the mean time it takes for the businesses in a portfolio or group, to decay.

In this chapter a theoretical model for these two new risk parameters is established and it is shown how this theoretical model can assist in calculating and monitoring business decay rates by industry. In the next chapter these two new risk parameters are then applied to the observed business decay rate data.

To appreciate the context of these two new risk parameters, the five technical risk parameters from Modern Portfolio Theory, that were first introduced in Chapter 3, will be reviewed. These five risk parameters are:

1. **Alpha**: a measure of a security's relative return, on a risk-adjusted basis.
2. **Beta**: a measure of the volatility of a security in comparison to a benchmark index.

3. **R-squared**: a measure of the proportion of a security’s price movement that can be explained by movements in the underlying benchmark.

4. **Standard deviation**: a measure of the price volatility of a security.

5. **Sharpe ratio**: a security’s risk-adjusted performance.

The five portfolio risk parameters of Modern Portfolio Theory were developed assuming mean-variance optimization calculations in a world of Gaussian distributed returns. Over the last 15 years, Post Modern Portfolio Theory has added four additional portfolio risk parameters that applies a method of asset allocation that optimizes a portfolio based on returns, versus downside risk. This Downside Risk Optimization (DRO) model does not assume that returns are normally distributed, but assumes that returns follow a non-mesokurtic or non-Gaussian skewed distribution that reflects an investor’s natural bias away from risk. These four additional risk parameters are:

1. **Downside Risk**: a measure of the likelihood that a security will decline in value.

2. **Sortino Ratio**: a measure of returns adjusted for the target and downside risk.

3. **Volatility Skewness**: the ratio of a distribution's percentage of total variance from returns above the mean, to the percentage of the distribution's total returns from returns below the mean.

4. **Excess Return**: a measure of returns in excess of a market measure benchmark.

With the advent and accessibility to low cost computing power, PMPT has provided tools for the business analyst that addresses some of the shortcomings of MPT. These enhanced parameters, however, are still criticized for ignoring important market characteristics such as black swan events (Mandelbrot and Hudson, 2004; Taleb, 2007). It is further proposed, however, that neither the risk parameters from MPT, nor the risk parameters from PMPT, adequately factor in the risk applicable to securities, based on the applicable, underlying, industry attrition rates. It is proposed, therefore, that a new risk
parameter, Theta, and a new risk parameter, Tau, are important new risk parameters that will assist the business analyst to factor in critical business half-life and mean-life time periods.

In defining Theta and Tau, it is important to have an agreed definition of when a business is deemed to have become “decayed” and apply that same definition to all the members of the group. As far as the new business risk parameters are concerned, there does not need to be an understanding of what caused the business to decay. The focus here is the development of two new, statistically based, business risk factors, with as broad of an application as possible, that provide an indirect measure of the lifespan of large corporations.

The definition of the threshold or benchmark that defines when business decay has occurred, is certainly worthy of further discussion and research, but where the bar is set, assuming it is applied equally across all businesses in a defined set, will not impact the application or usefulness of the new risk parameters. As far as all the businesses in the defined set are concerned, these new risk parameters have equal statistical applicability to all the members that currently reside above the agreed benchmark. This benchmark approach is the same approach that is commonly applied in both MPT and PMPT.

4.1 The problem and its significance

For much of our everyday decision making we need a clear understanding of the mean-life of the products we are dealing with. Furthermore, the more perishable, or subject to decay the product is, the more critical information is on the product’s lifespan. To understand the scope of this problem imagine running a life insurance business and trying to price a life insurance policy in a situation where you have no idea what the expected mean-life is applicable to your customers. Imagine purchasing a large amount of seed and having no idea of the rate at which it might decay. Consider the consequences of making a long-term investment in a diversified, but fixed portfolio of businesses for your child’s college fund, but having no idea as to how often you should update the portfolio to compensate for the decay of the constituent investments. Or imagine the perils of buying a carton of milk without the aid of “use-by” dates!
The reality is that, as we probably all know, businesses are very perishable, and large corporations are subject to the same significant forces of decay. It is critical, therefore, that we understand these forces of decay and have the metrics necessary to quickly evaluate and compare the expected life-span of businesses. Theta and Tau are designed to help satisfy this requirement.

4.2 A statistical approach

In discussions and presentations, a question has often been raised concerning the issue of trying to attempt to predict the lifespan of businesses. The question is usually posed along the lines: “Surely, isn’t every business unique, and don’t they decay quickly or slowly for all sorts of reasons, not least of which include good or bad management, luck, misfortune, and timing”. All these factors are significant, but the same kinds of issues are applicable to say the life-spans of individuals, yet we factor in the relative age of an individual with respect to the standard human life-cycle on an almost continuous basis.

The reality is, most events, if not all, occur in a probabilistic universe in which a statistical approach is usually the correct, if not the only approach, to quantifying macro effects. The fundamental strength of the statistical approach to Theta and Tau is no different to the probability of say getting a steady tire pressure reading using a pressure gauge. Air pressure results from the random impacts of different molecules on a surface. The fundamental analysis for such a basic phenomena is a statistical analysis. The same fundamental statistical approach is the same for Theta and Tau. The bottom line is that the results, and the validity of the results, are statistical answers to statistical questions that are dependent on the size of the population and the individual attributes of the constituent members of the population. Taking this probability argument to its extreme, even with respect to the very structure of space and time, any modern quantum physicist would probably say to Einstein: “Sorry Albert, but God does play dice with the universe!” (Durt, 1996)
4.3 The role of the exponential

For a portfolio of corporations, studied over a given time period, statistically valid hypotheses have been and can be established (Barron et al., 1994; Forster and Ellis, 2009; Forster, 2007; Foster and Kaplan, 2001; Hannan and Freeman, 1977; Jovanovic, 2001). The analysis of these statistics will be detailed in Chapter 5. In this section however, the focus is justifying the role of the exponential, and the derivation of a corporation’s half-life \( \Theta \), and the corporation’s mean-life \( \tau \), as derived directly from this exponential relationship.

The exponential plays a special role in population studies due to the fact that its has the special property of being non-transformed during differentiation. That is, its differential, or rate of change, is the same as the original function. This arises from the fact that it describes any population growth or decay in which the population has the property of changing proportionately to its population size. This special compounding change of growth or decay is commonplace, because it describes the situation applicable to any population that is undergoing a given rate of decay or growth per given time period. In other words, if one assumes, that a population of corporations has an attrition rate “\( A \)”, then the size of the population will be described by an exponential relationship.

To justify this statement from first principles, consider the situation just described in terms of differential calculus. Consider the population of corporations or businesses “\( B \)”, experiencing an attrition rate “\( A \)”, then the following general relationship holds:

\[
\frac{dB}{dt} = -AB
\]  

\( (4.1) \)

Furthermore, as a function of time, the function describing the number of businesses is given by the differential equation:

\[
\frac{dB(t)}{dt} = -AB(t)
\]  

\( (4.2) \)
Rearranging, we get:

\[ \frac{dB(t)}{B(t)} = -Adt \]  \hspace{1cm} (4.3)

Integrating we get:

\[ \ln B(t) = -At + c \]  \hspace{1cm} (4.4)

Where “c” is the constant of integration, and by exponentiation:

\[ B(t) = e^{-At}e^c \]  \hspace{1cm} (4.5)

And by solving for “c” when “t” = 0, we get:

\[ B_0 = e^{-0}e^c = e^c \]  \hspace{1cm} (4.6)

Therefore equation 1.5 becomes the generalized exponential equation describing the population of businesses experiencing a decay rate of “A”. Namely:

\[ B(t) = B_0e^{-At} \]  \hspace{1cm} (4.7)

### 4.4 Defining Theta: the half-life of a business

Theta will be defined as the half-life of a business, industry or a security. The Greek character \( \theta \) (Theta) has been selected due to the fact that the character well symbolizes halving, but also because in classical Greece, Theta was used as an abbreviation for thanatos, which referred to death or attrition, and was written in Greek as \( \theta \alpha \nu \alpha \tau o \zeta \).

For an initial set of businesses \( B_0 \) in which the business attrition rate is \( A \), it will be proven that the Theta, or half-life \( t_h \) of the business set, is given by the relationship:

\[ \theta = t_h = \frac{\ln(2)}{A} \]  \hspace{1cm} (4.8)
The attrition rate $A$ will vary by industry, region, time, and a combination of many other variables. As the focus of this paper is the econometrics of two new risk parameters, which have broad applicability, no attempt will be made, to restrict the application of the new risk parameters by restricting the rate to any particular industry, region, time or other parametric variable.

To establish this relationship we need to consider the relationship between the number of surviving businesses $b$ with respect to time $t$. If the per unit time period attrition rate is $A$, and the initial number of businesses in the set at time zero is $B_0$ then they are related by the exponentially decreasing function:

$$b = B(t) = B_0e^{-At}$$  \hspace{1cm} (4.9)

Now at the half-life time $t_h$ the number of surviving businesses, is by definition, half the original number of businesses, and so:

$$b = \frac{B_0}{2}$$  \hspace{1cm} (4.10)

That is, combining equations 4.2 and 4.3 we get:

$$\frac{B_0}{2} = B_0e^{-At_h}$$  \hspace{1cm} (4.11)

$$\frac{1}{2} = e^{-At_h}$$  \hspace{1cm} (4.12)

$$-\ln(2) = -At_h$$  \hspace{1cm} (4.13)

$$\theta = t_h = \frac{\ln(2)}{A}$$  \hspace{1cm} (4.14)
This relationship between the attrition rate and time, means that if 10% of businesses in a set of businesses $B$, are becoming extinct each year then the half-life $\theta$, of a business belonging to that business set is:

$$\theta = \frac{0.693}{0.1} = 6.93 \text{ years}$$  \hspace{1cm} (4.15)

4.5 Defining Tau: the mean-life of a business

The second new risk parameter to be defined relating to business attrition rates, is “Tau”. Tau will be defined as the mean life of a business, industry or a security. The Greek character $\tau$ (Tau) has been selected as it is often used to symbolize the mean life of a set which is governed by a first-order rate law.

It has been established that the mean lifetime of the set is equal to the arithmetic mean of the individual lifetimes of the set’s members. From this fact a useful relationship can be established between the mean lifetime and the decay constant. Assuming a collection of businesses belong to an industry or economic set, and that a first-order rate law of attrition applies, then we can establish a relationship between the attrition rate and the mean lifetime for the business set.

To establish this relationship, we need to consider the relationship between the number of surviving businesses $b$, with respect to time $t$. If the per unit time period attrition rate is $A$, and the initial number of businesses in the set at time zero is $B_0$, then they are related by the exponentially decreasing function:

$$b = B_0 e^{-At}$$  \hspace{1cm} (4.16)

Then there exists a normalizing factor $c$ which creates a total probability space which equals 1. That is:
By definition we have made \( \tau \) to be the arithmetic mean over this probability space and so we have:

\[
\int_0^\infty t c_B e^{-At} dt = 1 \tag{4.20}
\]

\[
\int_0^\infty tA e^{-At} dt = \tau \tag{4.21}
\]

That is:

\[
\tau = \int_0^\infty tA e^{-At} dt = \lim_{b\to\infty} \int_0^b tA e^{-At} dt \tag{4.22}
\]

\[
= A \lim_{b\to\infty} \int_0^b t e^{-At} dt \tag{4.23}
\]

The integral can be determined using integration by parts, that is, there exists a function \( u \) and a function \( v \), where the following relationship holds:

\[
\int_a^b u dv = (uv)|_a^b - \int_a^b v du \tag{4.24}
\]

Applying this to \( \tau \) we therefore let:

\[
u = t \tag{4.25}
\]

\[
dv = e^{-At} dt \tag{4.26}
\]
Therefore:

$$du = dt$$  \hspace{1cm} (4.27)$$

and

$$v = -\frac{1}{A}e^{-At}$$  \hspace{1cm} (4.28)$$

And so:

$$\tau = A\lim_{b \to \infty} \left[ \left( -\frac{1}{A}te^{-At} \right|_0^b - \int_0^b \frac{1}{A}e^{-At}dt \right]$$  \hspace{1cm} (4.29)$$

$$= A\lim_{b \to \infty} \left[ \left( -\frac{t}{A}e^{-At} \right|_0^b + \frac{1}{A} \int_0^b e^{-At}dt \right]$$  \hspace{1cm} (4.30)$$

$$= A\lim_{b \to \infty} \left[ \left( -\frac{b}{A}e^{-Ab} - 0 \right) + \frac{1}{A} \left( -\frac{1}{A}e^{-Ab} \right|_0^b \right]$$  \hspace{1cm} (4.31)$$

$$= A\lim_{b \to \infty} \left[ \left( -\frac{b}{A}e^{-Ab} - 0 \right) + \frac{1}{A} \left( -\frac{1}{A}e^{-Ab} - \frac{1}{A}e^{-A.0} \right) \right]$$  \hspace{1cm} (4.32)$$

$$= A \left[ (0-0) + \frac{1}{A} \left( 0 + \frac{1}{A} \right) \right]$$  \hspace{1cm} (4.33)$$

$$= \frac{A}{A^2}$$  \hspace{1cm} (4.34)$$

$$\tau = \frac{1}{A}$$  \hspace{1cm} (4.35)$$
That is, the mean lifetime $\tau$ is the reciprocal of the attrition rate $A$. Applying this relationship to the example used in the previous section, where the average attrition rate $A$ is 10% per year, results in a mean lifetime of 10 years:

$$\tau = \frac{1}{0.1} = 10 \text{ years} \quad (4.36)$$

Further, it should also be noted that when time $\tau$, which equals $\frac{1}{A}$ is entered into equation 1.2 we can see that:

$$b = B_0 e^{-\lambda\tau} \quad (4.37)$$

$$b = B_0 e^{-\lambda \times \frac{1}{A}} \quad (4.38)$$

$$b = \frac{B_0}{e} \quad (4.39)$$

That is, the mean lifetime of a business in a business set of $B_0$ components is the time at which the number of remaining businesses has declined by a factor of $e$, or a factor of approximately 2.718. In other words, at time $\tau$, approximately 36.8% of the businesses will be remaining. This analysis is summarized in Figure 4-1.
The Decay Of Corporations

Two New Business Risk Parameters

4.6 Overview of Theta and Tau

Based on the analysis, the measure of corporate decay over time is summarized in Figure 4-1. This figure shows a graph of the relationship between the number of surviving businesses $b$, over time $t$, given an attrition rate $A$. If $B_0$ is the number of businesses at time 0, then the number of surviving businesses at time $t$ is defined by the relationship $b = B_0 e^{-At}$.

If $B_0$ is the number of businesses at time 0, then the number of surviving businesses at time $t$ is defined by the relationship $b = B_0 e^{-At}$. Given this relationship, the research shows that the business half life $\theta$, which is the time at which half the businesses have become extinct, is inversely proportional to the attrition rate, and is equal to $\ln(2) / A$. Furthermore, the research establishes that the business mean life $\tau$, namely the mean life of a business in the portfolio, is $1 / A$. The research also shows, that at this mean life time $\tau$, the number of surviving businesses will be $B_0 / e$.
\[ b = B_0 e^{-At} \]. Given this relationship, the business half life \( \theta \), which is the time at which half the businesses have become extinct, is inversely proportional to the attrition rate, and is equal to \( \ln(2) / A \). Furthermore, the research establishes that the business mean life \( \tau \), namely the mean life of a business in the portfolio, is \( 1 / A \). The research also shows, that at this mean life time \( \tau \), the number of surviving businesses will be \( B_0 / e \).

### 4.7 Closing comments on the chapter

Theta and Tau, provide important new econometric tools that aid in the analysis and forecasting of the corporate life cycle. Furthermore, with these parameters, the business analyst can monitor the rate of decay associated with a set of large corporations. As such, these handles, or indirect values of corporate decay, can play a key role in describing, comparing and predicting the likely future earnings of a business.

It should be noted that Theta and Tau are derived from idealized mathematical first principles and form the basis for a new theoretical framework for demographically measuring, describing and monitoring the lifespan of corporations. The real-life application of the data associated with Theta and Tau may need to factor in real-world disturbances as is the case in applying all theoretical models. As an analogy consider the statement that the mean life Tau for Colonial Americans was 25 years (Smith, 1978) and that the Tau for Americans in 2008 is 78 years (Huguet et al., 2008). This is important and relevant demographic reference information that establishes important generalizations about Americans. This demographic information is important even though for particular individuals their lifespan may well vary widely from these means due to individual traits and experiences as well as more generalized events such as war and plague.

The next chapter will document the analysis of a significant population of corporations, so as to identify and analyze trends in corporation attrition rates. In so doing, this analysis will also determine the effective trends in the Theta and Tau risk parameters.
5 A NEW APPROACH TO ANALYZING THE DECAY OF CORPORATIONS

Corporate decay, as measured by overall business decay rates, whether the business decay results from mergers, acquisitions, privatization, bankruptcy or technological obsolescence, appears to be alive and well in today’s highly dynamic and competitive business environment. The confirmation, extension, or falsification of such trends is of critical importance to business analysts, portfolio managers, investors and shareholders. This chapter details a new approach to analyzing the decay of corporations and applies this new approach to the analysis of a significant population of corporations. From this analysis, the research will identify and analyze trends in corporation attrition rates, as well as the trends in the Theta and Tau risk parameters.

5.1 The problems

This chapter focuses on finding answers for some critical questions associated with the lifespan of corporations. These critical questions include:

1. What is an effective, objective definition of corporate decay?

2. What is the difference between corporate extinction and corporate decay?

3. What does a comprehensive model of the life cycle of a corporation look like?

4. What are the distinct phases in that life cycle?

5. What are the thresholds, and the benchmarks that define those thresholds, that define when one phase of the life cycle ends, and another phase begins?

6. What kind of macro analysis can be completed that can apply and analyze this life cycle model in the context of solid historical data?
7. How many years of corporation attrition rates samples are required to obtain, statistically meaningful, historical trend results?

8. What are the key findings of that historical analysis? In particular, what is the mean life \( \tau \), and the half life \( \Theta \), of the modern large corporation?

9. Are these life spans changing over time?

10. Does an historical analysis of the attrition rate of corporations reveal any cyclical patterns?

11. How much variability in the lifespan can be expected from year to year?

12. Do large corporations experience extinction events, similar to the extinction events observed in species, struggling to survive in a Darwinian fitness landscape?

5.2 The significance of the problem

For shareholders, boards of directors, and executives, the problems of maintaining corporate leadership and corporate survival, in today’s rapidly changing business environment, are becoming an ever increasing challenge. The lifespan of corporations, however, varies enormously, and at least one corporation, General Electric, has managed to hold on to a leadership position for over 100 years. If survival time as a leading corporation is a measure of fitness, then clearly some corporations are significantly “fitter” than others.

For investors, trying to value a stock based on forecast future earnings, a key focus is trying to understand business positioning relative to the typical life cycle of that type of business. The business decay rate, and the trends associated with those decay rates, are a key factor in determining key business risk factors such as the mean life \( \Theta \), and the half-life \( \tau \) (Forster and Ellis, 2008), of the business in a given industry. Furthermore, it is probably safe to assume that no medium to long term corporate investment strategy could possibly be deemed to be well thought-out if it doesn’t take into consideration the lifespan of its core component corporations. This begs the question, of how can a market capitalization and its associated security valuation, which, we assume is valuing future potential earnings, be complete, without an attempt to understand the lifespan of the security?
5.3 The methodology

In determining the most suitable methodology for a new analysis of the decay of corporations, the following factors were taken into consideration:

1. The selection and determination of clear definitions for key terms and boundary conditions. This includes a key definition for “corporation decay”, and a clear understanding of the threshold at which time “decay” is deemed to have occurred.

2. The need for objective data that covers a sufficient set of corporations from which statistically meaningful results can be extracted across the larger economy.

3. Access to data that covers a sufficient time period that enables the observation of time dependent trends.

4. Exclusion of data associated with extreme “one-off” events. That is, attempting to exclude events that would normally be considered to occur less than once every x years, where x is equal or greater than the period of the study. The removal of this “fat tail” (Mandelbrot and Hudson, 2004, p.168) is an attempt to remove significant, nonparametric distortions associated with economic, geographic, geopolitical, or extreme “black swan” (Taleb, 2007) events. It should be noted that the attempted avoidance of the obvious extreme events, such as the Great Depression, is not an attempt to ignore their importance, but to allow Gaussian based statistical approaches to examine important trends that are applicable in the “normal”, or linear, business-as-usual periods. It is well understood, that the extension of the conclusions beyond any period greater than an equivalent period of the study, is a dangerous extrapolation that may ignore significant nonlinearities in the model.

5. The use of readily accessible data to ensure ease of replication and verification or falsification of results by other researchers.

6. The use, wherever possible, of readily accessible tools in the analysis process, to ensure that further research is readily accessible.
5.4 A definition of corporate decay

In any analysis of business or corporation decay rates, one of the more controversial issues is the selection of key boundary conditions, such as defining corporate decay. One of the first questions that emerged at this stage was to determine when the line has been crossed and decay has occurred. Clearly, businesses, unlike species, often don’t simply disappear, but tend to fade away via mergers, acquisitions, rebranding, receivership, privatization, nationalization, malfeasance, or simple decay (Chandler, 2000). Occasionally a business disappears below the horizon, only to reappear much later, stronger than ever. Apple Computer, Inc is a case in point, although in its current incantation it has dropped the word “Computer” from its brand name (Collins and Porras, 1994; Kim and Mauborgne, 2005).

A good example of a company that was once strong, then disappeared, and whose brand at least, has re-emerged, is Polaroid. Polaroid Corporation was founded in 1937 by Edwin Land and became famous for its instant film cameras in the 1970s. Its significant, but unsuccessful investments into consumer movie systems and digital cameras, forced Polaroid into bankruptcy in October 2001, at which time all its assets, including its brand name were sold to Bank One (New York Times, 2002). Since 2002, the Polaroid name has reappeared on Polaroid branded digital cameras, LCD screens and DVD players. In summary, the old corporation may be extinct, but the brand is still alive.

There is usually a certain vagueness to the answer that often follows simple questions such as: “Has that company failed? Has it gone?” Such a question demands the need to draw a line in the sand, and consider that when a company crosses that line, then its status has clearly changed. That new status may be extinction, but more likely, that new status is a state of relative decay. This conclusion, which was first introduced in Chapter 1, has led the research to consider the landscapes that are based around business rankings, in which companies are ranked by well defined, verifiable benchmarks, such as total revenue, as providing the best criteria for establishing a new approach to analyzing the decay of corporations.

The definition of the threshold that defines corporate decay is certainly worthy of further discussion, but where the bar is set, assuming it is applied equally across all
businesses in a defined set, may well be a subjective decision. The important issue is to set
the bar of decay at a consistent, meaningful level, in the most objective manner possible, sufficient to allow an historical trend analysis.

It is true that companies that fall out of the Fortune 100 list don’t usually become immediately “extinct”, even Enron (McLean and Elkind, 2003) which was removed from the Fortune 100 list in 2003 is still operating as a 40 person shell company in 2008 (Enron, 2008b). Other companies are involved in mergers, acquisitions, bankruptcy, nationalization, brand name change, privatization, or some simply just fade away. Occasionally companies will fall below some arbitrary level, for example, the largest 100 corporations with respect to revenue, only to reemerge the following year, or a number of years later. The key objective, is to apply an objective definition consistently across a sufficient time period, so one can determine if a significant trend can be observed.

At this stage of the study, a review Figure 5-1 reveals a generalized sample life cycle of an industry leading corporation. Note that this figure is a modified version of Figure 1.1. In this new version, some additional complexity has been added to the corporation life cycle. Unlike the previous version, the life cycle in this figure includes the possibility of a corporation going through multiple periods of growth and decay. It should be noted, that this research recognizes that this re-entrant behavior exists in the data, and as such, these events will increase the measured attrition rate and decrease the measured lifespan of corporations. It was determined, however, that keeping these artifacts in the data is more accurate then ignoring them. The reality is, that in some cases, corporate decay is not, always forever (Martin and Meehan, 2005).

Figure 5-2 shows how the theoretical model of Figure 5-1 relates to part the actual life cycle of a real corporation. This example, tracking the Fortune 100 life cycle of the Xerox Corporation during Xerox’s Maturity phase, shows how the corporation’s growth or decay is not monotonic, but is expected to fluctuate over time. In this study, the research assumes that as long as the corporation remains in the Fortune 100, then it is deemed not to have decayed, nor become extinct. The important point is that the benchmark or threshold at which the corporation is deemed to have become decayed, is flexible.
Figure 5-1. A less simplified diagram, compared to Figure 1.1, of the life cycle of a stereotypical corporation.

Derived from the work of a number of researchers (James, 1974; Miller and Friesen, 1984; Moore, 1995; Quinn and Cameron, 1983), a typical corporation’s life cycle can be broken down into four fundamental phases. These phases can be described as; developing or Birth (B), growing or Growth (G), maturing or Maturity (M), and decaying or Decay (D). As shown in this figure, a corporation typically lives its life moving in and out of these phases, between it initial birth and its final decay.
5.5 Selecting the data

Having selected clear definitions for the key terms and boundary conditions, the next step in the research methodology revolves around the need to select the most appropriate data, and to select the processes and tools that will be used to analyze that data. To best address the methodological challenges, that were summarized in Section 5.3, it was
determined that the most suitable research method would be empirical research into publicly available secondary data. Empirical research was chosen due to the real world empirical nature of the study, and a reliance on secondary data was selected as a result of the need to examine and describe real world trends over the longest possible time period. In other words, the long term historical nature of this research, effectively eliminates the possibility of relying on primary data.

To minimize nonparametric distortions associated with multiple geographic locations it was decided to restrict the study to one region. The region selected was the USA due to its size and the availability of relatively consistent, long term, business data collection methodologies.

The minimum time period selected for the study was that period which would provide a statistically meaningful trend analysis. In this context, a statistically meaningful trend analysis was selected to be one which generated data which had a 95% confidence level of having an error of less than 1%, while assuming the data had a standard deviation of less than 3.5%. Using the National Institute of Standards and Technology (NIST) sampling size recommendation (NIST, 2006), based on the relationship:

$$N \geq \left(\frac{1.96}{\delta}\right)^2 \sigma^2$$

in which $\delta$ is the maximum error, and $\sigma$ is the standard deviation, the number of samples required is determined to be 47. Assuming one new decay rate sample per year, the required time period for the study is therefore greater than or equal to 47 years. Furthermore, the time period of most interest was selected to be post World War 2, in an attempt to exclude potentially one-off major distortions of the data associated with the Great Depression and the war. In addition, the focus is on the most recent data, in an attempt to maximize the correlation to trends to be found in the most current business environment.

Based on the above criteria and determinations, the following list of major business landscapes were identified as being relevant:
1. Fortune 500 (CNN, 2008c)

2. Fortune Global 500 (CNN, 2008d)

3. Forbes 500 (Forbes, 2008)

Of these three, the Fortune Global 500 was excluded due to its limited historical data, and also because of the distortion of the data by changing exchange rates over time. The Forbes 500 was excluded due to the fact that changes in the way the ranking is performed has distorted the accuracy of data for historical analysis purposes. These criticisms do not apply to the Fortune 500, as the data goes back to 1955, and the ranking uses simple, consistent criteria. It was therefore decided to use the Fortune 500 as the preferred business ranking landscape for analysis. Furthermore, as the focus of the study is to look at the largest, most successful corporations in the USA, so as to exclude the usual decay and failure that is normally considered when talking about up and coming corporations, it was decided to analyze the top 100 corporations in the Fortune 500, namely the Fortune 100.

Based on an analysis of the data selection options which were summarized in Section 5.5, it was decided that the Fortune 500 database would provide the best data for a new analysis of business decay rates. It was also determined that a detailed analysis, based on this data, of the 100 largest American corporations during the period 1955 to 2008 would provide a practical but reasonable boundary condition that makes best use of the available data and leverages sufficient data to potentially identify significant trends. Furthermore, this database was readily accessible to all researchers via the Fortune CNN website (CNN, 2008b). The database of choice had therefore been narrowed down to the Fortune 100, from 1955 to 2008, inclusive.

5.6 The analysis

Having selected the core data, the next step was to select the key tools that would be used in the analysis, and to design the overall analysis methodology. As one of the key methodology parameters was to use tools that would be readily accessible, so that other researchers could easily duplicate and extend the research, it was decided to use the data handling capabilities of Microsoft Excel. The power and tools associated with the readily
accessible Microsoft Excel 2003 SP3 with the Microsoft Data Analysis Toolpak (Microsoft, 2006) were deemed to be adequate for manipulating the approximately 30,000 data points required to complete the analysis process.

The methodology for analyzing the Fortune 100 from 1955 to 2008 was a multistep process in which the first step was to download the raw Fortune 500 data from the CNN Fortune 500 archives (CNN, 2008c). The archived data was then imported into an Excel spreadsheet, and then processed via seven input and output data arrays, a total of approximately 30,000 array elements. The processing was set up to be fully automated, using standard Excel functions and processes. This processing included, automated conditional formatting, macros, and Microsoft’s Visual Basic for Applications programming language (Jackson and Staunton, 2001).

The Excel processing, as used in this research, effectively automated the process of examining each business in the previous year and recording which ones had moved up, sideways, downwards, or completely off the list in the following year. Using automated, conditional formatting, the outcome for each business was flagged, recorded and tabulated. The conditionally formatted output was then used to automate the creation of a Fortune 100 trend analysis report. This automated approach simplified, for example, the updating of the report when the 2008 data became available, and will simplify the extension of the study to include data which covers future Fortune 100 annual rankings.

As for any significant historical analysis, which spans a period of over 50 years and examines the movements of 100 corporations at a time, the amount of data to be analyzed soon becomes significant. To handle the process efficiently, it was imperative to create a highly scalable and automated process. The following subsections describes the inputs, data structures, algorithms, processes and outputs in detail.

### 5.6.1 The Fortune 100 analysis input data

The Fortune 100 archives, going back to 1955, are available on the Web at money.cnn.com (CNN, 2008b). The first step in analyzing the Fortune 500 data was to copy and paste the ranked company names into a spreadsheet. This spreadsheet was to form the
main input data for the Fortune 100 analysis and became the first input array used in the analysis. Later, this input array would have conditional formatting applied, so it also became one of the key output arrays for the analysis.

### 5.6.2 The Fortune 100 analysis data structures

To load, track and analyze 100 businesses over a 54 year period, seven data arrays with a total of approximately 30,000 array elements were created on a single Excel worksheet. Six additional worksheets were used to capture the graphical output data. All the worksheets were part of a single workbook. Table 5-1 summarizes the data structures used in the analysis.
Table 5-1. Summary of the data arrays used in analyzing the Fortune 100 data covering the period 1955 to 2008.

Note that MICA is used as part of the selected businesses micro analysis that is described in detail in Chapter 8. MACA is used to hold the summary output data used in the macro analysis of the Fortune 100 decay rates. RDIOA holds the Fortune 100 ranking inputs, and also holds the resulting conditional formatting used to indicate whether a business is surviving, staying in the same place, moving up, or moving down in the following year. EOA holds flags that indicates if a business has become extinct. DOA holds flags that indicate the direction a business has moved in the following year. SDIA and ADOA are the initial and final input and output data arrays.

5.6.3 The MICA and MACA data arrays

The MICro analysis input output Array (MICA) is the array used to specify and report on corporations that require automated detailed tracking through the Fortune 100 data. The results of this detailed analysis research, or micro analysis, will be examined in detail in Chapter 8.

The MACro analysis output Array (MACA) is the array used to collect the results of the large scale or macro decay trends detected in the Fortune 100 data. MACA collects and reports on the automated data analysis output arrays.

5.6.4 The ranked data input output array

The Ranked Data Input Output Array (RDIOA) receives the Fortune 100 archive data. This archive data is then automatically scanned to create the Extinction Output Array (EOA)
and the Direction Output Array (DOA). The DOA cell formulas work with the EOA and the RDIOA to create the DOA output data. The DOA output data is then examined by the conditional formatting formulas shown in Figure 5-3 so as to create the Fortune 100 Detailed Analysis Data Report.

![Figure 5-3. A screen-grab of the Excel conditional formatting formulas.](image)

These conditional formatting formulas were used in conjunction with the Direction Output Array to create the Fortune 100 Detailed Analysis Data Report shown in Appendix B.

### 5.6.5 The Extinction Output Array (EOA)

The EOA is automatically created by Excel from the Fortune 100 input data by using the Excel formula:

\[
=IF((COUNTIF(C$17:C$116,B17))>0,1,0)
\]

This formula looks at each business name and checks or counts to see if that same business name exists anywhere in the following year in the Fortune 100 list. If it doesn’t exist a flag of “1” is set indicating that an extinction or a decay event has been detected. These decay events are then used to automatically calculate the number of decay events in that year.
5.6.6 The Direction Output Array (DOA)

The DOA is also automatically created by Excel from the Fortune 100 input data by using the Excel formula:

=-(IF(B128>0,(MATCH(B17,C$17:C$116,0)),9999))-(MATCH(B17,B$17:B$116,0))

This formula looks at each business name and checks the location or rank of the business name against the location or rank of the same business name in the following year. The resulting data is then used by the conditional formatting formulas described earlier, to determine the correct formatting to show increasing, or declining rank, for each business name.

The detailed output, created during the Fortune 100 detailed analysis, can be found in a twenty two page report titled “Fortune 100 Detailed Data Analysis Report” (Forster, 2008). A small sample extract of the data in this report is shown in Table 5-3 and the full report is included in Appendix A. With reference to Table 5-3, it can be seen, for example, that the corporation Enron is ranked 7 in the year 2001 and that it is formatted bold, indicating that the following year it has a higher or same ranking as it does in the year 2001. Looking in the 2002 column you do indeed see that Enron has climbed to a ranking of 5, however you will also see that although it has climbed to a rank of 5, its name is now no longer in a bold font, and that its name also has a shaded background. The shaded background behind the corporate name signifies that in the following year, the “Enron” corporation was not listed in the Fortune 100 list. That is, Enron, as signified by the “Enron” corporation, is now in a state of decay.
The Fortune 100 Detailed Data Analysis Report is detailed in Appendix B. Across the top is the Fortune 100 year under consideration. Below that is the micro analysis area which is described in detail in Chapter 7. Under that area are the calculated mean lifetime in years, the percent of businesses surviving in that year, and the percent of businesses that were removed in that year. Under these is the list of ranked businesses that make up the Fortune 100 for the applicable year.
Table 5-3. A sample extract from the Fortune 100 Detailed Data Analysis Report.

This report details the analysis of the Fortune 100 data from 1955 to 2008 and forms the output from the approximately 30,000 element data arrays that captures the details of the new business decay analysis. Across the top of each page of the report is the Fortune 100 year under consideration. Below that is the calculated mean lifetime in years, the percent of businesses surviving in that year, and the percent of businesses that were removed in that year. Under these is the list of ranked businesses that make up the Fortune 100 for the applicable year. Each business name in this list has had conditional formatting applied, to indicate, if the business in question has moved up, down, or become “decayed” in the following year. Businesses that have moved up (or remained in the same position) are bold. Businesses that have moved down are formatted in italics. Businesses that have become decayed in the following year, that is, are not in the Fortune 100 in the following year, are shown in italics, and are also displayed using a shaded background.
Table 5-4 summarizes, for each year of the Fortune 100; the actual decay rates, the associated exponential trend line decay rate, the mean life, and the half life, of the corporations in the Fortune 100 rankings. Table 5-5, meanwhile, shows the statistical analysis summary for the actual decay rates shown in Table 5-4.

Table 5-4 reveals that the decay of corporations has increased from 3.9% per annum in 1955 to 9.5% per annum in 2008, and that the mean life of a corporation has decreased from 26.4 years to 10.5 years over this same period. This decrease, reveals a trend, in which the mean life of corporations has decreased by a compound rate of 1.72% per annum over the last 54 years.

Note that the formula for the trend line was calculated, using a least squares error method (Albright, 2003), and found to have the relationship:

$$r_e = 0.0379e^{0.0174(y-1955)}$$

where $r_e$ is the rate of decay in % per annum and $y$ is the Fortune 100 year.
Table 5-4. Rates of decay of the Fortune 100 from 1955 to 2008.

“Actual” lists the actual percentage of corporations that moved into the Decay Phase. “eTrend” is the rate of decay as specified by the associated exponential trend line. “Mean Life: Tau” is the mean life in years. “Half Life: Theta” is the half life of a corporation for the specified year.

5.6.7 Statistical significance of the decay rate data

Table 5-5 summarizes the key statistics of the decay rate data. This analysis shows that the standard error of the data ranges from 0.5% to 1.0%, and the standard deviation...
ranges from 0.3% to 0.7% depending whether the extreme 1995 event data is excluded or included in the analysis.

Table removed due to copyright restrictions

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Table 5-5. Statistical analysis of the Fortune 100 decay rate analysis, through the period 1956 to 2008.

The analysis shows a mean decay rate of 7.5% when you include the extreme year 1995, and a mean decay rate of 6.6% when you exclude the 1995 extreme data. Note that the 1955 data was excluded as no actual decay rate for 1955 could be determined without the existence of reference data from 1954. This 1954 data was not available as the Fortune 100 data collection was not begun until 1955. A detailed analysis of the extreme data from 1995 is described in Section 5.7.

The results shown in the histogram Figure 5-4, summarizing the new analysis of business decay rates covering the period from 1955 to 2008, appears to have confirmed that there has been a significant decrease in the lifespan of the leading business corporations.
The Decay Of Corporations

A New Approach To Analyzing The Decay Of Corporations

Figure 5-4. Fortune 100 business decay rates histogram.

This Fortune 100 business decay rates histogram also displays the superimposed exponential trend line. The trend line reveals that in 1956, 3.9% of Fortune 100 businesses would become extinct in a given year. This translates to a mean life of 26.0 years and a half life of 18.0 years. Further, the study shows that by 2008, the business decay rate trend had increased significantly to 9.5% per annum, resulting in a mean life of only 10.5 years and a half life of only 7.3 years.

Table removed due to copyright restrictions
The Fortune 100 business decay rate scatter diagram has a 4 year moving average trend line superimposed. The moving average trend line indicates a possible 10 to 15 year periodic peak in decay rates. Additional data is required to confirm this important periodic trend.

After further study it was observed that R-squared analysis of the exponential trend line revealed an R-squared goodness of fit of only 0.187. That is only 18.7% of the variance was explained by the exponential trend line. Although this level of fit is significant, it suggests that the exponential trend line provides low confidence in predicting year on year decay rates. As a result additional R-squared analysis was carried out to see if alternative
models might provide a better goodness-of-fit. In total, five models were examined: linear, power, log\(_{10}\), natural log, and exponential. The results of this analysis is summarized in Table 5-6. The models studied revealed that the exponential and log\(_{10}\) models both had the best level of fit, however as it was observed that the log\(_{10}\) model exhibited rapid change in the earlier time periods and less rapid change in the later time periods, whereas the actual data tended to the opposite trend, it was decided that the exponential trend line was indeed the best of the five models in describing a trend line for the actual data.

<table>
<thead>
<tr>
<th>Selected Model</th>
<th>R-squared goodness-of-fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>0.110</td>
</tr>
<tr>
<td>Power</td>
<td>0.065</td>
</tr>
<tr>
<td>Log(_{10})</td>
<td>0.187</td>
</tr>
<tr>
<td>Ln</td>
<td>0.053</td>
</tr>
<tr>
<td>Exponential</td>
<td>0.187</td>
</tr>
</tbody>
</table>

Table 5-6. R-squared goodness-of-fit for five models selected for the decay rate trend line.

In total, five models were examined: linear, power, log\(_{10}\), natural log, and exponential. The models studied revealed that the exponential and log\(_{10}\) models both had the best level of fit, however as it was observed that the log\(_{10}\) model exhibited rapid change in the earlier time periods and less rapid change in the later time periods, whereas the actual data tended to the opposite trend, it was decided that the exponential trend line was indeed the best of the five models in describing a trend line for the actual data.

5.6.8 Is the decay rate of corporations increasing?

Given the relatively poor R-squared goodness-of-fit of the data to the exponential trend line, the answer to the question: “Is the decay rate of corporations increasing?” does not have an clear answer. As a result it was decided to attempt to introduce one sided t-test hypothesis testing as an alternative, verifying approach to help justify the statement that the rate of decay of corporation has indeed increased during the period of the analysis.
The approach taken was to test the hypothesis that for the first 10 years of the study the decay rate was below a given rate of decay, and to then confirm that an equivalent statistically significant observation could be made that the decay rate was above a significantly higher value for the last 10 years of the study.

**Analysis 1956 to 1965 data**

Test of the hypothesis that the average p.a. extinction rate between 1956 and 1965 is less than or equal to 5% p.a.

\[
H_0 \leq 5\%
\]

\[
H_a > 5\%
\]

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count (N)</td>
<td>10</td>
</tr>
<tr>
<td>mean</td>
<td>0.0520</td>
</tr>
<tr>
<td>sample variance</td>
<td>0.0005</td>
</tr>
<tr>
<td>sample standard deviation</td>
<td>0.0215</td>
</tr>
<tr>
<td>skewness</td>
<td>0.4327</td>
</tr>
<tr>
<td>absolute kurtosis</td>
<td>0.2201</td>
</tr>
<tr>
<td>coefficient of variation (CV)</td>
<td>41.34%</td>
</tr>
</tbody>
</table>

Since the skewness of 0.4327 is less than \(2\sqrt{6/N}\) and also the absolute kurtosis which is 0.2201 which is also less than \(2\sqrt{24/N}\), we can approximate that the data for these years is sufficiently normal for the t-test (Tabachnick and Fidell, 1996).
The Decay Of Corporations

A New Approach To Analyzing The Decay Of Corporations

<table>
<thead>
<tr>
<th>t-Test: Mean vs. Hypothesized Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05000</td>
</tr>
<tr>
<td>0.05200</td>
</tr>
<tr>
<td>0.02150</td>
</tr>
<tr>
<td>0.00680</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>0.29</td>
</tr>
<tr>
<td>.3876</td>
</tr>
</tbody>
</table>

From the above table, it is evident that, at 95% confidence level we do not have enough evidence to reject the null Hypothesis and therefore conclude that the average extinction rate for the years 1956 to 1965 is less than or equal to 5% per annum.

**Analysis of 1999 to 2008 data**

Test of the hypothesis that the average p.a. extinction rate between 1999 and 2008 is greater than or equal to 10 % p.a.

\[ H_0 \geq 10\% \]

\[ H_a < 10\% \]

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count (N)</td>
<td>10</td>
</tr>
<tr>
<td>mean</td>
<td>0.1080</td>
</tr>
<tr>
<td>sample variance</td>
<td>0.0009</td>
</tr>
<tr>
<td>sample standard deviation</td>
<td>0.0305</td>
</tr>
<tr>
<td>absolute skewness</td>
<td>0.2932</td>
</tr>
<tr>
<td>absolute kurtosis</td>
<td>0.6795</td>
</tr>
<tr>
<td>coefficient of variation (CV)</td>
<td>28.22%</td>
</tr>
</tbody>
</table>
Since the absolute skewness is 0.2932 is less than 2*sqrt(6/N) and the kurtosis is 0.6795 which is less than 2*sqrt(24/N), we can assume a normal distribution for the data through the years 1999 to 2008 (Tabachnick and Fidell, 1996).

<table>
<thead>
<tr>
<th>t-Test: Mean vs. Hypothesized Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>hypothesized value</td>
</tr>
<tr>
<td>mean data</td>
</tr>
<tr>
<td>std. dev.</td>
</tr>
<tr>
<td>std. error</td>
</tr>
<tr>
<td>n</td>
</tr>
<tr>
<td>df</td>
</tr>
<tr>
<td>t</td>
</tr>
<tr>
<td>p-value (one-tailed, upper)</td>
</tr>
</tbody>
</table>

From the above table we see that at the 95% confidence level we do not have enough evidence to reject the null hypothesis, and hence we can conclude that for the years 1998 to 2008, the average extinction rate is greater than or equal to 10% per annum.

So in conclusion we can state with 95% confidence that the decay rate per annum during the period 1998 to 2008 was twice the decay rate observed between 1956 and 1965. Furthermore, the trend in the rate of change between these two periods may well be the exponential trend line described in the model earlier, however the goodness-of fit of that trend line was only 18.7%. This is significant, but further data is needed to be able to confidently use this trend line to predict actual decay rates for a given year.

It should be noted however that the introduction of the exponential trend line to explain the change in the rate of decay, that is the acceleration or deceleration of the decay rate, means that the research leverages two exponential models. The first model defining the half-life of a corporation is well founded from mathematical first principles as described in Chapter 4. The second exponential model, introduced in this Chapter, defining the trend in decay rates, has a low r-square value and is therefore statistically less well founded, but is not
necessarily incorrect. It should also be noted that the significance of the first exponential model does not depend on the accuracy or even existence of the second exponential model. The derivation of Theta and Tau, as described in Chapter 4, arise directly from the well founded first exponential model, and have no dependence on the values, or even the existence of the second exponential model.

5.7 A review of the 1995 Fortune 100 mass business decay event

From 1955 to 2008, excluding 1995, the mean decay rate from the Fortune 100 list was 6.6% per annum, that is, on average, during this period, approximately 7 corporations that were in the Fortune 100 list in a given year, were not in the Fortune 100 list the following year. In 1995, however, the Fortune 100 decay rate peaked at 53%. For the period of the study, the 1995 decay rate was indeed an extreme, “black swan” event. It should be noted, however, that the Fortune 100 decay rates lag the actual economy by one year. That is, the Fortune 100 rankings are actually reporting on corporation rankings for the year before. This is necessitated by the fact that quarterly revenues are reported with a typical one to two month delay. The Fortune 100 list for 1995, for example, was published in May 1995 and is actually reporting on 1994 annual revenues.

A detailed analysis of the corporations that were removed from the Fortune 100 in 1995 reveals that the majority were not removed by mergers, acquisitions or bankruptcy, but were associated with a significant change in relative total revenue performance of the USA’s largest corporations. The basis of this significant change in relative revenue performance is not obvious, in the sense that 1994 was not a year of significant economic recession or economic growth for the whole economy. It did, however, represent a significant inflection point, or non-linearity, in economic growth.

After the Savings and Loans crisis of the late 1980s and early 1990’s in which over 1,000 banks disappeared, the end of the Cold War in 1991, and the impact of the 1991 Gulf War, George H. Bush, the 41st President of the United States (“Bush 41”), released a comprehensive plan to bail out and re-regulate the U.S. banking industry. Bush 41 also felt he had to respond to Reagan’s economic legacy, in which by 1990 the federal deficit had increased to $220 billion, or three times the budget deficit of 1980. In addition the U.S.
federal debt had increased by the same ratio to approximately $3.2 trillion. Bush 41’s attempt to bring the U.S. economy under control by regulation, interest rate rises, tax increases and spending cuts would lead to a mild recession in late 1990 and would play a key role in his election defeat to Clinton in 1993.

By 1995, the stress points within the U.S. economy were under control and the economy had been brought to a “soft landing”. As a result of strong economic management and the signing of the North American Free Trade Agreement (NAFTA) in 1993, the U.S. economy was now well positioned for the economic growth years that would characterize the Clinton presidency (Stiglitz, 2002). This situation is well summarized in the following quotation by Hoenig in the Federal Reserve Bank’s review of the economy in 1995:

… positive factor for the U.S. economy in 1995 is the renewed strength in U.S. bank lending. During the early stages of the current expansion, credit flows were very weak. Consumers and businesses reduced their credit needs to lower their debt burdens and repair their balance sheets. At the same time, banks were reluctant to extend new credit. Indeed, bank business loans declined for three consecutive years - in 1991, 1992, and 1993; a period that was referred to, not so affectionately, as "the credit crunch." ….business lending at banks rebounded sharply in 1994. (Hoenig, 1995)

Following the “credit crunch” (Hall, 1993) of the early 1990s, the Dow Jones Industrial Average, an excellent barometer for monitoring the economic outlook of the large cap U.S. corporations, reveals that 1995 was the year in which many large corporations in the U.S. went into hyper-growth. Referring to Figure 5-6 it can be seen that 1995 was the year in which the DOW started its strong climb from 4,000 to 11,000 over a period of just 4 years. 1995 was the “hockey stick” year in which the DOW increased by 35%. In this economic environment of rapid change, corporations that were well positioned for growth, would ride the wave of expansion and bask in the Fortune 100 rankings, while 53, flat-footed Fortune 100 placeholders, would be pushed below the bar.
Figure 5-6. A plot of the daily close of the Dow Jones Industrial Average (DJIA) index between January 3, 1955 and February 24, 2006.

The plot shows that 1995 was a “hockey stick” year, which would see the start of the Dow’s strong climb from 4,000 to 11,000 points in only 4 years. The 35% hyper-growth of the large cap Fortune 100 companies in 1995 would also see 53, of the Fortune 100 companies of 1994, pushed out of the Fortune 100, creating a significant “black swan” Fortune 100 decay event.

5.8 Closing comments on the chapter

A new approach to the analysis of business decay rates has been introduced, detailed, and applied to the U.S. Fortune 100 rankings, covering the period from 1955 to 2008. Using the new approach to the analysis of business decay rates, there is strong evidence confirming
that rates of corporate decay are surprisingly high, even for the most established businesses in the economy.

The focus on the U.S. Fortune 100, during the period 1955 to 2008, showed those organizations that are at the pinnacle of fitness in the overall business fitness landscape, during a period that excludes obvious, one in fifty year event, economic disruptions. This focus on the most successful, during a period of relative continuous growth, minimizes the impact of nonparametric events that often dominate the life cycle of smaller, high-growth companies. Furthermore, by redefining business decay with the application of a clean line in the sand, that is, the business is, or is not, still in the Fortune 100, it is possible to define business decay more objectively, in which extensible analysis can assist in the detection and analysis of business decay rate trends.

The study extends the findings of previous researchers (Carayannis and Ziemnowicz, 2006; Foster and Kaplan, 2001; Hannan and Freeman, 1977) by covering a longer period. It also provides a more detailed analysis, the use of clearly defined boundary conditions, and the use of data and analysis tools which strongly support extensible research, in which current findings can be easily updated to include future data as and when it becomes available.

The findings of this new approach to the analysis of business decay rates are significant. The findings show that the business decay rate trend is one in which the decay rate is increasing significantly, even for the most successful businesses. The study reveals that in 1955, the decay rate trend line indicates that 3.8% of Fortune 100 businesses would become extinct in a given year. This translates to a mean life or Tau (Forster and Ellis, 2008) of 26.4 years and a half life or Theta of 18.3 years. Further, the study shows that by 2008, the business decay rate had increased significantly to 9.5% per annum, resulting in a mean life Tau, of 10.5 years and a business half life Theta, of 7.3 years. These results reveal a significant trend in which the mean lifetime for the largest corporations, has decreased by 15.9 years during the period 1955 to 2008, that is, over the last 54 years, the mean lifetime of the largest, most successful corporations has declined by a compound rate of 1.72% per annum.
Using a least squares error methodology, the decay rate exponential trend line, determining the relationship between the rate of decay $r_e$, and the Fortune 100 year $y$, over the period of the study, was determined to be given by the relationship:

$$r_E = 0.0379e^{0.0174(y-1955)} \quad (4.1)$$

This trend line reveals a small, but significant, exponentially increasing decay rate, versus a linear mean decay rate of 7.48%, with a standard error of 1.00% and a median of 6.00%. The study also revealed that a significant Fortune 100, mass business peak decay event, occurred in 1995. In 1995 an extreme “black swan” event occurred in which the decay rate jumped from the mean rate of 7.16% to a rate of 53.00%. The significance of this event is such that the results for 1995 alone increases the kurtosis of the 54 years of sample data from 4.62% to 32.19%.

A detailed analysis of the businesses that were removed from the Fortune 100 in 1995 shows that the majority were not removed as a result of mergers, acquisitions, bankruptcy or brand name changes, neither were they removed by macro economic contraction or expansion, but the event does appear to coincide with the end of the credit crunch of 1993 and the start of a rapid growth in the DJIA which occurred between 1995 and 1999. The findings suggest an important relationship. That is, when a rapid change occurs in the economic environment, even when part of that change is positive, then the associated economic inflection point may well be associated with a spike in business decay rates.

The next chapter reports on a change of focus in the research in which the research moves from a macro analysis of the decay of corporations, to the development of a business fitness landscape model. This model will provide the foundations for the upcoming micro analysis, which will attempt to examine some of the reasons why some corporations appear to have longer life spans compared to other corporations.
6 A FOUR DIMENSIONAL BUSINESS FITNESS LANDSCAPE MODEL

This chapter describes the development of a general purpose, four dimensional, business fitness landscape model. This model builds on and extends many of the ideas described in the first five chapters and is used to establish the foundations of the Business Diversity Fitness Index (BDFI) that will be examined in detail in the next chapter.

6.1 The problem

The first phase of the research focused on exploring the data, and tools to examine that data, associated with a macro analysis of the trends relating to the lifespan of corporations. In this chapter, and the next chapter, the focus moves to describing the development of new tools that will assist in the micro analysis of individual businesses, in an attempt to better explain why some corporations enjoy a longer lifespan compared to other corporations.

6.2 Significance of the problem

As reviewed in Chapter 1, understanding the expected lifespan of a corporation is of critical importance to investors, managers and business owners. In the previous chapter, some key metrics were established relating to the expected lifespan of a “typical” Fortune 100 corporation. Clearly, any tool that can assist management or investors to understand the likely lifespan of a particular business is of special significance. In this chapter, it is proposed that in the same way that the Wright’s (1932) adaptive landscape assists the biologist to better understand the survival prospects of a species in the context of its competitive fitness landscape, this new four dimensional business fitness landscape will assist the business analyst to better understand the forces and prospects applicable to a given business.
6.3 The fitness landscape

When Wright introduced the idea of the adaptive landscape, as a useful model associated with the study of the evolution of species, he created a two dimensional topographic landscape model like the one shown in Figure 6-1. In this section of the research documentation, a four dimensional (4D) business fitness landscape will be created, that builds on the original concepts and metaphors introduced by Wright. The development and application of this model, as an effective landscape for viewing a business in the context of its surrounding economic environment, will be examined in detail.

Figure 6-1. Sketch of a typical two dimensional (2D) fitness landscape.

Derived from concept of the adaptive landscape introduced by Wright (1932) and introduced into this research in Chapter 2. In Wright’s original model of a two dimensional (2D) adaptive landscape, peaks and troughs were used in an attempt to show the relative level of adaptation of different species to a given environment. Species which were assigned a peak position were assumed to be better adapted to the given environment, compared to species assigned to a trough position. Arrows could then be used to indicate the direction of improved adaptation and a topographic-like map showing lines of iso-adaptation could also be included.

In Wright’s original model of a two dimensional (2D) adaptive landscape, peaks and troughs were used in an attempt to show the relative level of adaptation of different species to
a given environment. Species which were assigned a peak position were assumed to be better
adapted to the given environment, compared to species assigned to a trough position. Arrows
could then be used to indicate the direction of improved adaptation and a topographic-like
map showing lines of iso-adaptation could also be included. The challenge of this research, is
to apply this adaptive landscape model to the business world, and to extend the model from
two dimensions to four dimensions.

### 6.4 Key assumptions

The research into creating a new business landscape model made use of the following
key understandings. Note that some of these key assumptions were explored in a more
general context in the early stages of the research and are referenced in Chapters 1 to 3.
These key assumptions were:

1. The concepts of “fitness” and “level of adaptation” are considered to be
equivalent and so are used interchangeably, as in “survival of the fittest” and
“survival of the most adapted”. To this end an adaptation landscape is the same as
a fitness landscape.

2. For the purposes of the model, business fitness is assumed to be simply a measure
of how much a business dominates its particular industry. This will be measured
in terms of its share of the total addressable market for a given gross product.

3. A business may have a single establishment or multiple establishments, and it may
be used as a group noun in which it refers to multiple businesses in multiple
industries with multiple establishments.

4. No effective distinction is made between private enterprise businesses,
individuals, corporations, conglomerates, non-profit organizations and
Government entities. For this research, “business” refers to entities that are
contributors to the total gross product of a region. A region may be a town, state,
country, geographic area or other.
5. In genetics, fitness or adaptation to a given environment, usually refers to the ability of a species to reproduce, and in so doing, produce viable offspring that will continue to survive and reproduce. In other words, genetic fitness is a measure of the ability of a given genotype to survive for the longest period possible. In this research, however, business fitness is defined to be simply a measure of a business’ ability to control as much of the total gross product as possible and to maintain that control for the longest period possible.

6. With this definition of business fitness, being a measure of possession of the maximum possible gross product. The position of a business in a map of the gross product, also defines the business fitness landscape model.

7. In the same way that Wright’s adaptation landscape, in itself, cannot communicate the ability of a species to survive environmental change (it only measures the relative fitness for a given environment), the business fitness landscape model to be introduced in this section of the research, also fails to directly communicate the ability of a business to survive business environmental change. This challenge of how to measure business fitness with respect to handling changes in the business environment, is an extension of this area of the research, and will be explored in detail in Chapter 7.

Having reiterated the key understandings and assumptions of the research associated with the new business fitness landscape model, the next step is to clearly understand the key research objectives.

### 6.5 Key objectives

The objectives of the research, as described in this section, revolve around the creation of a new business fitness landscape model. Those objectives were:

1. Create a new business landscape model that builds on the original work of Wright, to create an alternative and informative, multi-dimensional, landscape display that leverages the available business data and displays that data in a new, and informative manner.
2. Build a business landscape model that is easy to apply to new industry data, as that data becomes available.

3. Create a model that fully utilizes the landscape metaphor, as reviewed in Chapter 3 of the research.

4. While being compatible with the other objectives, the landscape model should portray a reality which is as informative and as accurate as possible.

5. Define the model mathematically, in as much detail as possible, to aid future analysis and extension of the model.

6. Develop a model that provides the basis for developing a comprehensive business fitness index that will assist in directly comparing the fitness of one business to another in the context of the business landscape.

7. Create a model that is as automated as possible, in that the model requires the minimal intervention and work by the business analyst in taking new business data and using that data to create a new business landscape.

As part of detailing this area of the research, the details of the mathematical model, the input data, the tools and the output data arrays are examined in detail. In addition, the tools and techniques will be applied the whole U.S. economy, based on U.S. Bureau of Commerce data. Furthermore, the tools are applied to the available data from multiple years in attempt to show how the tools can be used to reflect changes over time, and so reveal a four dimensional (4D) business fitness landscape, in which changes to the 3D landscape are seen over time.

6.6 The steps involved in creating the model

The documentation of the research involved in creating the new 4D business fitness landscape model is presented in the sequence by which the major building blocks of the model were developed. The steps in that sequence were:

1. Research the objectives associated with creating the 4D business fitness landscape
2. Select and define the four dimensions of the model

3. Create the basic two dimensional Gaussian building block

4. Transform the two dimensional basic building block into a three dimensional basic building block

5. Map the key input data to the 4D landscape

6. Develop an equation which describes the overall 4D landscape

7. Analyze the landscape’s input parameters

8. Review the landscape’s output data structures

9. Provide an example of a simple landscape

10. Provide an example of a complex landscape

11. Extend the business fitness landscape metaphor with the application of color, shading, noise and fractal structures

12. Develop the fractal structures

13. Review the final complex landscape with fractal structures

14. Add the fourth dimension

15. Provide an example of a complex landscape, undergoing rapid discontinuous change, over time

16. Describe how this new landscape model will be applied to the next stage of the research
6.7 Key design parameters of the Business Fitness Landscape (BFL) model

The selection and definition of the BFL model was driven by the key objectives of the research that were first introduced in Chapter 1. The applicable key objectives for this stage of the research and objectives that played a key role in the design of the model were:

1. Since the 1930s, multi-dimensional adaptive landscape models, and fitness landscape models, have been used in the study of the rise and fall of species. Are there modeling techniques helpful in studies of the life spans of well established corporations?

2. Some corporations appear to be better equipped to have a longer survival time compared to other corporations. Corporations survive or decay for many reasons. In an environment in which the business fitness landscape in undergoing rapid discontinuous change, that is a business environment that is in a state of disequilibrium, is unrelated-diversification a significant attribute of these longer surviving corporations?

3. Can an effective business fitness landscape model be created that helps to view, describe, and better understand the overall business environment in which corporations survive or collapse due to unrelated-diversification?

4. What new information can the corporation’s business fitness landscape tell us about the likely lifespan of the corporation?

5. What are the benefits of the new BFL model versus the existing alternative models?

6.7.1 Selection of the BFL dimensions

As reviewed in Section 6.4, a key driver for the design and selection of the data underlying the model’s dimensions was a desire to leverage the heuristic power of the adaptive fitness landscape model first introduced by Wright (1932). That is, the desire was to leverage and go beyond the topographic model of Wright, and move to a new four dimensional BFL model.
It should be noted that availability of data also played a key role in the selection and design of the model’s dimensions, however although data availability is a necessary prerequisite in the model’s design, availability of data was never considered a sufficient prerequisite.

In creating a landscape model that would have special applicability for studying unrelated-diversification, a key dimension was the selection of a suitable industry code so that the relative market independence of the corporation’s business units could be clearly identified. For the purposes of this model, five industrial classification landscapes were identified for analysis. They are: the Standardized Industrial Classification (SIC) (U.S. Office of Management and Budget., 1987), the North American Industry Classification System (NAICS) (U.S. Census Bureau., 2007), the Global Industry Classifications Standard (GICS) (S&P, 2008) the International Standard Industrial Classification (ISIC) (United Nations, 1999), and the Fama and French industry classification algorithm (FF) (Fama and French, 1997). As described in detail in Chapter 3, the industrial classification system selected was the NAICS. Thus the NAICS code would form one of the key dimensions of the model.

To study industry market significance, the total value of an industry on sub-industry, as a relative share of gross domestic product, was selected as the obvious candidate for the second dimension.

For the third dimension, two data parameters were considered. The first parameter being relative monopoly power or industry concentration, and the second parameter being relative industry growth. Industry concentration was considered as a key measure of pricing power and as a measure of effective barriers to entry. Relative industry growth was considered as a major dimension; however, it was discounted due the fact that relative industry growth is often simply a measure of industry maturity versus having any inherent protection as a hedge against technology, geopolitical or regulatory change. For that reason, industry concentration, measured by comparing the relative number of larger corporations to the number of smaller corporations for a given industry, was seen as a more important parameter compared to industry growth for the purposes of evaluating the hedging power of unrelated diversification. Furthermore, industry growth would not be completely ignored but would be reflected in the model by displaying growth as a rate of change as reflected in the
kurtosis of the industry peak. This approach was designed to give the analyst a quantified and qualified view of the industry’s significance from a growth perspective.

Furthermore, to study rates of decay and relative survival time, clearly time would also be one of the dimensions. Other aspects of the model would also be used to show data applicable to the model. For example texture would be used to indicate errors in the data, and color in the model would be used to provide an intuitive guide to the relative market size of industries.

In summary, the four dimensions of the model would leverage data based on industry:

1. NAICS code, as a measure of an industry’s diversification distance.
2. Industry size with respect to GDP as a measure of opportunity.
3. Industry concentration as a measure of pricing power and barriers to entry.
4. Time, to enable the display of relative change.
Figure 6-2. Summarizes the definition of the major axes that make up the three dimensional version of the business fitness landscape model.

The horizontal xy plane is defined by the industry NAICS codes and the industry concentration (measure of monopoly power) index. The vertical dimension is defined by the industry size as measured as a share of gross domestic product.

The next figure, Figure 6-3 illustrates how the fourth dimension, time, will be added to transform the three dimensional landscape to the full, four dimensional landscape.
The fourth dimension, time, is added by the creation of time slices or time frames to the 3D model shown in Figure 6-2.

6.7.2 The business strategy suggested by the BFL model

The BFL model was designed to provide a new heuristic model that builds on and complements the work of Michel and Shaked (1986), Galbraith et al. (1986), and Dubofsky and Varadarajan (1987), which used market based measures of risk and return to show that unrelated diversifiers earned higher returns then related diversifiers.

The new BFL model was designed to provide a business analyst with new insight into the level of unrelated diversification that a large Fortune 100 or Fortune 500 corporation might possess. The proposition is that a corporation that has high unrelated diversification is better able to withstand sudden discontinuous change that impacts one or a few industries. This kind of change is often related to technological, geopolitical, or regulatory changes that appears to becoming more common, and is arguably related to the increasing rate of decay being observed in the Fortune 100 data of the last 50 years.
6.7.3 **Strengths and weaknesses of the BFL model versus key existing alternatives**

As detailed in Section 2.6, five leading competitive strategy conceptual frameworks were identified and examined as having significant acceptance in describing the decay of corporations. These five included:

1. **Boston Consulting Group’s (BCG’s) Growth Share Matrix** (Aaker, 2008; Hedley, 1977; Wernerfelt, 1984),

2. **Ohmae’s Four Basic Routes To Strategic Advantage** (Ohmae, 1991),

3. **Hamel and Prahalad’s Core Competency Agenda Matrix** (Prahalad and Hamel, 1994),

4. **D’Aveni’s Hypercompetition Model** (D’Aveni et al., 1995), and


In comparison to the BFL model, the BCG Growth Share Matrix is not focused on unrelated diversification between diversified corporations but is focused on the product and business unit portfolio within a large corporation. As such it is more applicable to an analysis of the results of related diversification rather than unrelated diversification. As such, it could be argued that the model has little relevance to a study of unrelated diversification, but has a lot of relevance to studying the impact of acquisitions and divestitures and the resulting change in the related diversification of the corporation (Ramanujam and Varadarajan, 1989).

Ohmae’s Four Basic Routes To Strategic Advantage is designed to compare competitors, not unrelated diversified corporations or conglomerates. In a study focused on unrelated diversification, factors such as relative superiority have little relevance or meaning (Shay and Rothaermel, 1999).

Hamel and Prahalad’s Core Competency Agenda Matrix and its focus on the relative knowledge base and core competencies within comparative firms, also has little relevance to
measuring and tracking the relative corporate life-cycle associated with unrelated diversification (Prahalad and Hamel, 1994).

In D’Aveni’s Hypercompetition Model, the fourth and final stage, Deep Pockets, an investment in related diversification may be required to compensate for slowing growth and to leverage opportunities presented by weakened competitors. It is also a critical stage to consider an investment in unrelated diversification to ensure that a new engine of growth is captured before the decay phase gains dangerous momentum to the downside. As such the Hypercompetition Model has significant relevance to a study of unrelated diversification, however, unlike BFL it does not provide a heuristic model which allows the business analyst to view and examine the relative unrelated diversification of competitive corporations (D'Aveni et al., 1995).

The Austrian school and strategic management (Hayek, 2001; Jacobson, 1992; Nelson and Winter, 1982; Schumpeter, 1939; Schumpeter, 1943) is less of a business model and more of a conceptual framework. This framework however provides a core foundation for this research in that the business strategy research covered by this dissertation is believed to be more closely aligned with the Austrian School (Hayek, 2001; Jacobson, 1992; Nelson and Winter, 1982; Schumpeter, 1939; Schumpeter, 1943) approach of Menger, Mises, Hayek, Kirzner and Schumpeter, versus the Industrial Organization (Buzzell and Gale, 1987; Jacobson, 1992; Porter, 1980a; Porter, 1998) approach of Caves, Porter, Buzzell, Gale, and Aaker. This observation follows from the fact that the research focuses on the disequilibrium, heterogeneity, and entrepreneurial discovery that characterizes the Austrian School versus the equilibrium, empirical regularities, and planned strategy execution that dominates, for example the PIMS (Buzzell and Gale, 1987) Industrial Organization approach.

6.7.4 A summary of the BFL model’s advantages

In summary the strengths and advantages of the BFL model over existing models include:
1. The model leverage of a powerful heuristic model that has had proven success in describing adaptive landscapes in previous, non-business, applications.

2. Provide an alternative perspective of new market opportunities, which is suited to analyzing a corporation’s relative unrelated diversification.

3. Optimized to reveal threats posed by rapid discontinuous change, the kind of change that is the focus of the disequilibrium studies of the Austrian School versus the gradual refinement that is the focus of the Industrial Organization models of the 1980s.

4. A model better suited to measure and describe the increasing role extrinsic destruction plays in explaining the reduced lives of market leading corporations. This Extrinsic destruction refers to corporate destruction that arises from outside the existing industry participants.

5. The ability to easily leverage standard analysis tools.


7. Provides the basis for an objective measure of unrelated diversification, namely the development of the Business Diversity Fitness Index which will be introduced in the next Chapter.

8. Replicatable and testable.

6.8 Selection of a basic, two dimensional, landscape building block

Having defined the four dimensions of the landscape, the next step was to determine the basic building block for the landscape. To determine this basic building block, the focus of the research moved to an examination of what structures would best suit a simple two dimensional landscape as described by Wright.

Two structures were identified as being worth further consideration. They were firstly, a simple step function in which a business or industry totally exists, or totally does not exist, as a function of position. The second approach was to use some form of distribution
function, in which the existence or non-existence of a business or industry is a probability function which diminishes as you move further away from the mean expected position of existence.

The advantages of the binary definition of the basic structure are threefold: simplicity, the ability to explicitly position the business or industry under consideration, and lastly, the opportunity to use a structure that would minimize blocking or hiding of structures that may exist behind the binary structure on the 4D landscape. The disadvantages of the binary structure, however, are also threefold. Firstly, a simple binary structure is fairly unnatural. Even a basic atomic particle appears to exist as a probability function which is distributed through space-time. Secondly, a sharp binary positioning implies a level of accuracy that is overly artificial. The positioning of a business in terms of industry, size, time and level of concentration has many degrees of freedom and many sources of error. A landscape which converts this to a hard yes or no existence is inherently misleading. Thirdly, such a binary step function will generate a landscape that is not like the smooth continuous two dimensional landscape of Wright, and so this breaches one of the objectives of the model, which was to build on, not replace, the Wright adaptive landscape. For these reasons, it was determined that the best basic building block for the landscape model would be a continuous probability distribution function. It was decided, however, that the simplicity and clarity provided by the binary structure could play a role in the research associated with creation of the Business Diversity Fitness Index. This area of the research will be described in detail in Chapter 7 of the dissertation.

6.9 The two dimensional Gaussian building block

Once it was determined to use a probability distribution as the basis for the two dimensional landscape model, it was a short step to consider the use of the normal distribution as the distribution function of choice. The normal distribution, which maximizes entropy among all distributions when given a specified mean and variance level, is the most widely used distribution function, and has numerous applications in psychology, physics and economics. The normal distribution, as applied by Laplace (Huck, 1974) is ideally suited to the analysis of errors arising from experiments, and similarly, to those errors that would be
expected to be found in the data that will be used as the basis for building the landscape model.

The normal distribution is also known as the Gaussian distribution and is named after Carl Friedrich Gauss (Patel and Read, 1996) who defined the equation describing the probability distribution function of the normal distribution. In the family of Gaussian distributions, each member of the distribution family is defined by two parameters, the mean \( \mu \), and the variance which corresponds to the standard deviation squared, namely \( \sigma^2 \). In the landscape model, the mean will be used to specify the position on the horizontal plane, and the standard deviation will be used to specify the industry growth. Industry size, meanwhile, will be reflected in the overall weight applied to the distribution function.

With respect to two dimensions, the basic building block will be defined by the two dimensional Gaussian distribution function:

\[
z = \left( \frac{1}{\sigma \sqrt{2\pi}} \right) e^{-\frac{(d-\mu)^2}{2\sigma^2}}
\] (6.1)

Where:

- \( z \) is the probability at location \( d \)
- \( d \) is the sample distance from the mean
- \( \sigma \) is the standard deviation
- \( \mu \) is the mean

The two dimensional plot of this function is shown in Figure 6-4.
The Decay Of Corporations

A Four Dimensional Business Fitness Landscape Model

6.10 The three dimensional Gaussian building block

For modeling the business fitness landscape in three dimensions, the standard two dimensional Gaussian Probability Distribution Function (PDF) is transformed into three dimensions by applying the well established Pythagorean relationship:

\[ d = \sqrt{x^2 + y^2} \]  \hspace{1cm} (6.2)
In addition, a weighting factor $w$ was applied to allow for the creation of a weighted 3D Gaussian landscape building block. Combining this weighting factor $w$ and equations 6.1 and 6.2 results in the formula for the basic 3D business fitness landscape building block:

$$
Z = w \left( \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{(\sqrt{x^2+y^2}-\mu)^2}{2\sigma^2}} \right)
$$

(6.3)

Figure 6-5 shows the appearance of the Gaussian probability distribution function when mapped to these three nominal dimensions “x”, “y” and “z”. In summary, the 2D Gaussian function has been basically rotated 360 degrees around the z axis, during the conversion from the 2D plane to the 3D space.
Figure 6-5. Plot of the three dimensional (3D) basic modeling element as used in the business fitness landscape research model.

Note that the two dimensional model has been effectively rotated 360 degrees around the z axis.

Furthermore, Figure 6-6 shows the aerial or topographic view of the 3D modeling element when viewed perpendicular to the “xy” plane. This topographic view reveals the symmetry of the 3D modeling element around the mean position of both the applicable NAICS parameter and the level of concentration index.
3D Basic Modeling Element - Topographic View

Figure 6-6. Topographic view of the three dimensional basic modeling element revealing the symmetry around the mean on the xy plane.

6.11 Converting the 3D elements to create the 3D landscape

The Gaussian building block elements can now be combined to create the 3D fitness landscape by summing the individual building block elements over the entire 3D space. Assuming $q$ unique fitness peaks, each with a unique weighting parameter $w_p$, mean location $\mu_p$, and standard deviation, $\sigma_p$, then the sum of these peaks over the entire space results in a 3D fitness landscape that is described by the equation 6.4:
Creating the 4D business fitness landscape mathematical model

To create the mathematical model for the 4D business fitness landscape, equation 6.4 can be translated for use in the four dimensional business fitness landscapes, by applying the axes or dimensions that were defined in Section 6.7.

Table 6-1 summarizes the mapping of these parameters. Furthermore, in Section 6.13 the application of these parameters is analyzed in detail. Before moving to this analysis, however, the equations describing both the 3D landscape and the 4D landscape are developed. The development of this mathematical model is documented in the following sections.
### Mapping of the Gaussian Probability Distribution Function (PDF) Parameters to the Corresponding 3D and 4D Fitness Landscape Parameters

<table>
<thead>
<tr>
<th>Business Fitness Parameter</th>
<th>Basic Gaussian PDF</th>
<th>3D Fitness Landscape</th>
<th>4D Fitness Landscape</th>
</tr>
</thead>
<tbody>
<tr>
<td>The industry peak index</td>
<td>( p )</td>
<td>( p )</td>
<td>( p )</td>
</tr>
<tr>
<td>Total number of industry peaks in a given landscape at a given timeframe</td>
<td>( q )</td>
<td>( q )</td>
<td>( q_t )</td>
</tr>
<tr>
<td>The weighting applied to industry peak ( n )</td>
<td>( w_n )</td>
<td>( i_{sp} )</td>
<td>( i_{sp_t} )</td>
</tr>
<tr>
<td>The NAICS code of an industry peak ( n )</td>
<td>( x )</td>
<td>( i_{np} )</td>
<td>( i_{np_t} )</td>
</tr>
<tr>
<td>The level of concentration of an industry peak ( n )</td>
<td>( y )</td>
<td>( i_{cp} )</td>
<td>( i_{cp_t} )</td>
</tr>
<tr>
<td>The weighted market size of an industry peak ( n )</td>
<td>( z )</td>
<td>( l_{3D} )</td>
<td>( l_{4D} )</td>
</tr>
<tr>
<td>The total market size of a business landscape</td>
<td>( Z )</td>
<td>( L_{3D} )</td>
<td>( L_{4D} )</td>
</tr>
<tr>
<td>The mean of industry peak ( n )</td>
<td>( \mu )</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>The time frame index in a given 4D landscape</td>
<td>-</td>
<td>-</td>
<td>( t )</td>
</tr>
<tr>
<td>Total number of time frames in a given 4D landscape</td>
<td>-</td>
<td>-</td>
<td>( f )</td>
</tr>
<tr>
<td>The standard deviation of industry peak ( n )</td>
<td>( \sigma )</td>
<td>( \sigma_p )</td>
<td>( \sigma_{p_t} )</td>
</tr>
</tbody>
</table>

Table 6-1. Summary of the mapping of the Gaussian probability distribution functions parameters to the corresponding three dimensional and four dimensional, business fitness landscape models.

Applying the business fitness parameters and the corresponding business fitness landscape symbols, as described in
Table 6-1, with Equation 6.4 results in the following generalized equation for a 3D business fitness landscape peak:

$$z_p = w_p \left(1 \frac{1}{\sigma_p \sqrt{2\pi}} e^{-\frac{\left(\sqrt{i_{n_p}^2 + i_{c_p}^2} - \mu_p\right)^2}{2\sigma_p^2}}\right)$$  \hspace{1cm} (6.5)$$

These individual fitness peaks can then be summed over the entire business fitness landscape space to create the equation which describes the entire business fitness landscape in three dimensions. Namely:

$$L_{3D} = \sum_{p=1}^{p=q} w_p \left(1 \frac{1}{\sigma_p \sqrt{2\pi}} e^{-\frac{\left(\sqrt{i_{n_p}^2 + i_{c_p}^2} - \mu_p\right)^2}{2\sigma_p^2}}\right)$$  \hspace{1cm} (6.6)$$

By definition, the mean $\mu$ will be set to 0. That is, the mean of each fitness peak will be at the center of the Gaussian probability distribution function, and the center of the peak will be offset within the output data array, and the variables; $q$, $i_s$, $i_{n_p}$, and $i_{c_p}$ will be allowed to change at each time frame $t$. With these changes, equation 6.6, describing the 3D business fitness landscape, at a given time frame $t$, becomes:

$$L_{3D} = \sum_{p=1}^{p=q} w_p \left(1 \frac{1}{\sigma_p \sqrt{2\pi}} e^{-\frac{\left(\sqrt{i_{n_p}^2 + i_{c_p}^2} - \mu_p\right)^2}{2\sigma_p^2}}\right)$$  \hspace{1cm} (6.7)$$
6.12.1 Defining the standard deviation parameter in terms of industry growth

As stated in Section 6.9, one of the objectives of the model was to represent industry growth via the use of the standard deviation parameter, $\sigma_p$. In the Gaussian probability distribution function, the standard deviation defines the kurtosis or flatness of the industry peak. An industry peak with a low standard deviation will have high kurtosis, while an industry peak of high standard deviation will have lower kurtosis. The relationship between the standard deviation $\sigma$, and kurtosis $\beta_2$, is given by the relationship (Huck, 1974):

$$\beta_2 = \frac{\mu_4}{\sigma^4}$$ (6.8)

where $\mu_4$ is defined as the fourth statistical moment about the mean.

Relative to the standard normal distribution, the kurtosis of a set of $N$ scores of the real-valued random variable $X$, is given by the relationship (Huck, 1974):

$$\beta_2 = \frac{\sum (X - \mu)^4}{(N - 1)\sigma^4} - 3$$ (6.9)

It is of interest to note that the application of kurtosis, as a measure of how spread out empirical data is relative to the normal distribution, can also be an important measure of portfolio risk. Mandelbrot, for example, has written extensively (2004) on how an over-reliance on the normal distribution and an underestimation of the effect of kurtosis, is, in his opinion, a major flaw of many business models and that a fractal view of risk, ruin and reward was a more effective tool for studying the misbehavior of markets compared to the more popular Gaussian approach.

The generalized business fitness landscape has been normalized to a minimum standard deviation of one. That is, the industry with the highest growth in a given landscape, is represented by a Gaussian building block which has a standard deviation of one. It is this standard deviation parameter that was used to reflect relative industry growth. Growth was
modeled as being inversely proportional to the standard deviation of the basic Gaussian building block. Furthermore, an industry undergoing the minimum growth in a given landscape was displayed by a Gaussian building block which has a standard deviation of four.

Assuming this linear relationship, the generalized relationship between industry growth $i_g$, and standard deviation $\sigma$, was therefore defined by the two points (0, 4) and (1, 1), resulting in the linear equation:

$$\sigma = \left(\frac{1-4}{1-0}\right) i_g + 4$$  \hspace{1cm} (6.10)

$$\sigma = 4 - 3i_g$$  \hspace{1cm} (6.11)

### 6.12.2 Defining the industry peak weighting in terms of industry size and industry growth

Having defined the standard deviation for the industry model in terms of the industry growth parameter, the next challenge was to devise an appropriate formula for calculating the industry peak weighting factor $w_n$.

The industry peak weighting factor clearly had a key influence on the height of the industry peak in the business landscape, and so this factor should be related to the industry size $i_n$ for peak $n$. This relationship between industry peak height and the industry size was defined as a design requirement of the business model in Section 6.9.

Furthermore, the industry peak weighting factor should also compensate for a decrease in the peak height as the standard deviation of the Gaussian distribution function changes. In Section 6.12.1 it was shown that the standard deviation of the business model changes in proportion to the industry growth. The impact of changing the standard deviation on peak height can be determined from the equation for the peak $p$, namely:
\[ z_p = w_p \left( \frac{1}{\sigma_p \sqrt{2\pi}} e^{-\frac{\left(\sqrt{i_{p}^2 + \xi_{p}^2} - \mu_p\right)^2}{2\sigma_p^2}} \right) \]  

(6.12)

Now the maximum peak height will occur at the mean position, that is, when:

\[ \sqrt{i_{np}^2 + i_{\xi_p}^2} = \mu_p \]  

(6.13)

When this occurs, and normalizing this peak height to 1, gives:

\[ 1 = w_p \frac{1}{\sigma_p \sqrt{2\pi}} \]  

(6.14)

\[ w_p = \sigma_p \sqrt{2\pi} \]  

(6.15)

That is, we need to multiply the standard deviation, \( \sigma_p \), by \( \sqrt{2\pi} \), to maintain a peak height of 1. The actual peak height required, however, is defined to be proportional to the industry size for peak \( p \), or in other words, as specified by the input parameter, \( i_{sp} \). The weighting factor, for industry peak \( p \), namely \( w_p \) is therefore:

\[ w_p = i_{sp} \sigma_p \sqrt{2\pi} \]  

(6.16)

However, we know from Section 6.12.1, that:

\[ \sigma = 4 - 3i_g \]  

(6.17)

And so combining these equations gives:
That is, $w_p$ is the weighting that needs to be applied to the Gaussian probability distribution function to generate the industry peak, so that it is proportional to the industry size $i_{sp}$ and has been adjusted for the change in the standard deviation which has been used to display the industry growth $i_{gp}$.

### 6.12.3 The addition of the time dimension to the mathematical model

Equation 6.7, also becomes the building block of the sequence that describes the 4D business fitness landscape. This sequence, covering $T$ time frames, now describes the total business fitness landscape in four dimensions. These four dimensions being: industry NAICS, industry concentration, industry size, and time.

$$L_{4D} = \sum_{p=q_1}^{p=q_4} w_{p1} \left( \frac{1}{\sigma_{p1} \sqrt{2\pi}} e^{-\left(\frac{i_{p1}^2+2i_{p2}^2}{2\sigma_{p1}^2}\right)} \right)_{t=0}, \quad (6.19)$$

$$\sum_{p=1}^{p=q_1} w_{p1} \left( \frac{1}{\sigma_{p1} \sqrt{2\pi}} e^{-\left(\frac{i_{p1}^2+2i_{p2}^2}{2\sigma_{p1}^2}\right)} \right)_{t=1}, \quad (6.20)$$

$$\sum_{p=1}^{p=q_1} w_{p1} \left( \frac{1}{\sigma_{p1} \sqrt{2\pi}} e^{-\left(\frac{i_{p1}^2+2i_{p2}^2}{2\sigma_{p1}^2}\right)} \right)_{t=2}, \quad (6.21)$$
6.13 An analysis of the business fitness landscape parameters

In this section, the theory, data structure, and application of each of the business fitness landscape parameters, is examined in detail. The data parameters that will be examined are:

1. Industry size
2. Industry concentration
3. Industry growth
4. Industry NAICS code

Furthermore, the raw industry data of the U.S. economy, over the ten year period from 1998 to 2007, is presented. This information will then be normalized, in preparation for the creation and display of a four dimensional landscape.

6.13.1 The industry size input parameter

The industry size, \( i_s \), is a key input parameter and plays the dominant role in defining the height of an industry peak. The industry size is a measure of the share of gross domestic product applicable to a particular industry.

The U.S. data for the industry size is available from the U.S. Department of Commerce, Bureau of Economic Analysis (BEA, 2008) and is normally expressed in billions.
of dollars. In building the business landscape model, this industry size is expressed as a percentage of the total size of all the industries under consideration. This percentage is then normalized to a parameter that ranges from 0.1 to 1.0, with the smallest industry size having a value of 0.1 and the largest having a value of 1.0. All other industries are then interpolated to lie between within this range. Table 6-2 and Table 6-3 summarize this industry sizing data for the U.S. economy over the period 1998 to 2007.
### Industry Size ($I_s$) of the U.S. Economy by Major Industry, in USD$ Billions, From 1998 to 2007

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry, fishing, hunt</td>
<td>78.5</td>
<td>73.6</td>
<td>70.1</td>
<td>69.3</td>
<td>65.9</td>
<td>80.7</td>
<td>95.7</td>
<td>87.0</td>
<td>112.0</td>
<td></td>
</tr>
<tr>
<td>Mining</td>
<td>72.6</td>
<td>69.3</td>
<td>93.8</td>
<td>101.0</td>
<td>81.4</td>
<td>104.0</td>
<td>124.1</td>
<td>158.8</td>
<td>199.2</td>
<td></td>
</tr>
<tr>
<td>Utilities</td>
<td>138.6</td>
<td>142.6</td>
<td>144.3</td>
<td>149.2</td>
<td>148.8</td>
<td>161.6</td>
<td>178.2</td>
<td>193.7</td>
<td>210.5</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>366.6</td>
<td>408.7</td>
<td>440.6</td>
<td>463.3</td>
<td>478.3</td>
<td>523.6</td>
<td>601.4</td>
<td>621.3</td>
<td>540.2</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1,112.1</td>
<td>1,193.3</td>
<td>1,226.5</td>
<td>1,094.1</td>
<td>1,123.0</td>
<td>1,148.0</td>
<td>1,214.2</td>
<td>1,351.2</td>
<td>1,421.6</td>
<td></td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>505.4</td>
<td>537.1</td>
<td>563.8</td>
<td>557.7</td>
<td>554.7</td>
<td>576.0</td>
<td>619.0</td>
<td>682.2</td>
<td>716.2</td>
<td></td>
</tr>
<tr>
<td>Retail trade</td>
<td>59.1</td>
<td>62.8</td>
<td>66.5</td>
<td>68.9</td>
<td>71.0</td>
<td>73.7</td>
<td>76.4</td>
<td>82.8</td>
<td>86.9</td>
<td></td>
</tr>
<tr>
<td>Transportation and warehousing</td>
<td>235.3</td>
<td>247.4</td>
<td>261.2</td>
<td>251.9</td>
<td>250.3</td>
<td>258.8</td>
<td>290.7</td>
<td>318.3</td>
<td>348.2</td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td>273.7</td>
<td>302.8</td>
<td>308.3</td>
<td>305.6</td>
<td>307.3</td>
<td>313.7</td>
<td>361.8</td>
<td>411.5</td>
<td>432.6</td>
<td></td>
</tr>
<tr>
<td>Finance, insurance, real estate</td>
<td>1,388.6</td>
<td>1,426.6</td>
<td>1,443.8</td>
<td>1,492.5</td>
<td>1,438.2</td>
<td>1,488.0</td>
<td>1,616.0</td>
<td>1,724.0</td>
<td>1,863.0</td>
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</tr>
<tr>
<td>Professional and business</td>
<td>975.1</td>
<td>1,072.2</td>
<td>1,146.6</td>
<td>1,211.2</td>
<td>1,253.4</td>
<td>1,338.4</td>
<td>1,467.0</td>
<td>1,630.3</td>
<td>1,766.9</td>
<td></td>
</tr>
<tr>
<td>Educational services, health</td>
<td>582.7</td>
<td>615.8</td>
<td>644.6</td>
<td>719.2</td>
<td>777.0</td>
<td>823.8</td>
<td>880.1</td>
<td>930.8</td>
<td>994.5</td>
<td></td>
</tr>
<tr>
<td>Arts, entertainment, recreation</td>
<td>267.9</td>
<td>289.1</td>
<td>310.5</td>
<td>306.3</td>
<td>303.7</td>
<td>313.7</td>
<td>361.8</td>
<td>411.5</td>
<td>432.6</td>
<td></td>
</tr>
<tr>
<td>Other services, except government</td>
<td>196.6</td>
<td>202.9</td>
<td>215.8</td>
<td>226.2</td>
<td>237.1</td>
<td>247.1</td>
<td>256.8</td>
<td>270.7</td>
<td>283.8</td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td>915.5</td>
<td>954.3</td>
<td>1,005.7</td>
<td>1,052.8</td>
<td>1,128.2</td>
<td>1,200.2</td>
<td>1,261.5</td>
<td>1,316.3</td>
<td>1,381.6</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>7,640.2</td>
<td>8,089.2</td>
<td>8,648.4</td>
<td>8,811.1</td>
<td>8,983.1</td>
<td>9,368.6</td>
<td>10,052.5</td>
<td>10,929.5</td>
<td>11,733.7</td>
<td></td>
</tr>
</tbody>
</table>

**Table 6-2.** The size of the major industries in the U.S. economy, expressed in constant dollars, over the period 1998 to 2007.

### Industry Relative Size ($I_{rs}$) of the U.S. Economy by Major Industry, Normalized From 0.1 to 1.0, From 1998 to 2007

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry, fishing, hunt</td>
<td>0.105</td>
<td>0.103</td>
<td>0.102</td>
<td>0.101</td>
<td>0.100</td>
<td>0.106</td>
<td>0.112</td>
<td>0.108</td>
<td>0.109</td>
<td>0.119</td>
</tr>
<tr>
<td>Mining</td>
<td>0.103</td>
<td>0.101</td>
<td>0.112</td>
<td>0.115</td>
<td>0.106</td>
<td>0.116</td>
<td>0.124</td>
<td>0.139</td>
<td>0.156</td>
<td>0.156</td>
</tr>
<tr>
<td>Utilities</td>
<td>0.130</td>
<td>0.132</td>
<td>0.133</td>
<td>0.135</td>
<td>0.133</td>
<td>0.135</td>
<td>0.140</td>
<td>0.147</td>
<td>0.153</td>
<td>0.161</td>
</tr>
<tr>
<td>Construction</td>
<td>0.226</td>
<td>0.243</td>
<td>0.257</td>
<td>0.266</td>
<td>0.269</td>
<td>0.273</td>
<td>0.292</td>
<td>0.324</td>
<td>0.332</td>
<td>0.298</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.353</td>
<td>0.554</td>
<td>0.587</td>
<td>0.530</td>
<td>0.521</td>
<td>0.538</td>
<td>0.581</td>
<td>0.638</td>
<td>0.667</td>
<td>0.689</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>0.284</td>
<td>0.297</td>
<td>0.308</td>
<td>0.306</td>
<td>0.304</td>
<td>0.313</td>
<td>0.337</td>
<td>0.358</td>
<td>0.374</td>
<td>0.390</td>
</tr>
<tr>
<td>Retail trade</td>
<td>0.320</td>
<td>0.335</td>
<td>0.351</td>
<td>0.361</td>
<td>0.370</td>
<td>0.381</td>
<td>0.392</td>
<td>0.417</td>
<td>0.434</td>
<td>0.452</td>
</tr>
<tr>
<td>Transportation and warehousing</td>
<td>0.171</td>
<td>0.176</td>
<td>0.182</td>
<td>0.178</td>
<td>0.177</td>
<td>0.181</td>
<td>0.184</td>
<td>0.206</td>
<td>0.218</td>
<td>0.227</td>
</tr>
<tr>
<td>Information</td>
<td>0.187</td>
<td>0.199</td>
<td>0.201</td>
<td>0.200</td>
<td>0.201</td>
<td>0.204</td>
<td>0.224</td>
<td>0.245</td>
<td>0.253</td>
<td>0.265</td>
</tr>
<tr>
<td>Finance, insurance, real estate</td>
<td>0.628</td>
<td>0.657</td>
<td>0.712</td>
<td>0.760</td>
<td>0.761</td>
<td>0.780</td>
<td>0.818</td>
<td>0.864</td>
<td>0.963</td>
<td>1.000</td>
</tr>
<tr>
<td>Professional and business</td>
<td>0.481</td>
<td>0.521</td>
<td>0.552</td>
<td>0.563</td>
<td>0.579</td>
<td>0.597</td>
<td>0.632</td>
<td>0.686</td>
<td>0.755</td>
<td>0.812</td>
</tr>
<tr>
<td>Educational services, health</td>
<td>0.316</td>
<td>0.330</td>
<td>0.351</td>
<td>0.373</td>
<td>0.398</td>
<td>0.417</td>
<td>0.441</td>
<td>0.462</td>
<td>0.489</td>
<td>0.516</td>
</tr>
<tr>
<td>Arts, entertainment, recreation</td>
<td>0.185</td>
<td>0.193</td>
<td>0.202</td>
<td>0.205</td>
<td>0.211</td>
<td>0.216</td>
<td>0.227</td>
<td>0.238</td>
<td>0.251</td>
<td>0.260</td>
</tr>
<tr>
<td>Other services, except government</td>
<td>0.155</td>
<td>0.167</td>
<td>0.163</td>
<td>0.167</td>
<td>0.172</td>
<td>0.176</td>
<td>0.180</td>
<td>0.186</td>
<td>0.191</td>
<td>0.197</td>
</tr>
<tr>
<td>Government</td>
<td>0.456</td>
<td>0.472</td>
<td>0.493</td>
<td>0.513</td>
<td>0.545</td>
<td>0.575</td>
<td>0.600</td>
<td>0.623</td>
<td>0.651</td>
<td>0.680</td>
</tr>
</tbody>
</table>

**Table 6-3.** Relative U.S. industry size, during the period 1998 to 2007, after data normalization.

All industry size data derived from the data in Table 6-2. Data normalization consisted of taking the lowest industry size during the ten year period and assigning it the value of 0.1, and then taking the highest industry size during this period and assigning it the value 1. All other industry sizes then underwent relative interpolation between 0.1 and 1.

### 6.13.2 The industry level of concentration input parameter
The decay of corporations, \( i_c \), is another key input variable and defines the position of the peak along the y axis. The industry level of concentration is a measure of the percentage of large establishments relative to the total number of establishments in a particular industry. Industries, such as Government, which have a level of concentration close to one, are deemed to be the industries controlling the commanding heights of the economy (Chase, 1998; Yergin and Stanislaw, 2002), and are placed at the rear of the landscape (high y-axis value), while highly competitive industries, such as farming, which are highly fragmented and competitive, are positioned at the front of the landscape (low y-axis value).

The secondary research data used for determining the industry level of concentration is based on the data from the U.S. Department of Commerce, Bureau of Economic Analysis (BEA, 2008). Table 6-4 is an extract of the detail available from this data source. As can be seen from this extract, for each NAICS industry code, the number of firms, and the number of establishments in each employment size category are provided. To provide a simple, but realistic measure of concentration, the total number of establishments with 500+ employment size was divided by the total number of establishments. This data was then normalized between 0.1 and 1.0, in the same way that the industry size parameter was normalized. Note that the BEA considers an establishment to be a localized business operation. As such, it should be noted that an establishment is in general a subset of a business in the same way that a business is often a subset of a corporation, although in many cases they may be one in the same.

Table 6-7 shows the normalized industry concentration data for all the major U.S. industries at the time of the last Economic Census in 2004. Normalization consisted of taking the lowest industry concentration and assigning it the value of 0.1, and then taking the highest industry concentration during this period and assigning it the value 1. All other industry concentrations then underwent relative interpolation between 0.1 and 1. Note that industry concentration data was not calculated for the other years in the 1998 to 2007 study period, due to limitations of the available data. It should be noted that the U.S. Economic Census, on which this parameter is based, is only run every five years.
Number of Firms, Number of Establishments, Employment, and Annual Payroll by Employment Size of the Enterprise for the United States. All Industries, 2004.

SOURCE: 2004 County Business Patterns. For information on confidentiality protection, sampling error, nonsampling error, and definitions, see http://www.census.gov/epcd/susb/introusb.htm and http://www.census.gov/csd/susb/defterm.html.

Table 6-4. An extract from the U.S. Department of Commerce, Bureau of Economic Analysis (BEA, 2008), U.S. Economic Accounts, showing the breakdown of firms and establishments by size of employment and NAICS code.

This data was used as the basis for determining the relative level of concentration by industry.

<table>
<thead>
<tr>
<th>NAICS Code</th>
<th>NAICS 6 Digit Equivalent Codes</th>
<th>NAICS Description</th>
<th>Estabs &lt;500 employees</th>
<th>Estabs &gt;=500 employees</th>
<th>% of Estabs &gt;=500 employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>611</td>
<td>611000</td>
<td>Educational Services</td>
<td>74029</td>
<td>4731</td>
<td>6.01%</td>
</tr>
<tr>
<td>6111</td>
<td>611100</td>
<td>Elementary and Secondary Schools</td>
<td>19631</td>
<td>841</td>
<td>4.11%</td>
</tr>
<tr>
<td>6112</td>
<td>611200</td>
<td>Junior Colleges</td>
<td>614</td>
<td>319</td>
<td>51.19%</td>
</tr>
<tr>
<td>6113</td>
<td>611300</td>
<td>Colleges, Universities, and Professional Schools</td>
<td>1832</td>
<td>1550</td>
<td>41.83%</td>
</tr>
<tr>
<td>6114</td>
<td>611400</td>
<td>Business Schools and Computer and Management Training</td>
<td>7395</td>
<td>202</td>
<td>2.66%</td>
</tr>
<tr>
<td>61141</td>
<td>611410</td>
<td>Business and Secretarial Schools</td>
<td>436</td>
<td>46</td>
<td>9.54%</td>
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<tr>
<td>61142</td>
<td>611420</td>
<td>Computer Training</td>
<td>2561</td>
<td>90</td>
<td>3.39%</td>
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<tr>
<td>61143</td>
<td>611430</td>
<td>Professional and Management Development Training</td>
<td>4398</td>
<td>66</td>
<td>1.48%</td>
</tr>
<tr>
<td>6115</td>
<td>611500</td>
<td>Technical and Trade Schools</td>
<td>7165</td>
<td>429</td>
<td>5.65%</td>
</tr>
<tr>
<td>611511</td>
<td>611511</td>
<td>Cosmetology and Barber Schools</td>
<td>1624</td>
<td>7</td>
<td>0.43%</td>
</tr>
<tr>
<td>611512</td>
<td>611512</td>
<td>Flight Training</td>
<td>887</td>
<td>149</td>
<td>14.38%</td>
</tr>
<tr>
<td>611513</td>
<td>611513</td>
<td>Apprenticeship Training</td>
<td>1319</td>
<td>14</td>
<td>1.05%</td>
</tr>
<tr>
<td>611519</td>
<td>611519</td>
<td>Other Technical and Trade Schools</td>
<td>3335</td>
<td>259</td>
<td>7.21%</td>
</tr>
<tr>
<td>6116</td>
<td>611600</td>
<td>Other Schools and Instruction</td>
<td>31805</td>
<td>1025</td>
<td>3.12%</td>
</tr>
<tr>
<td>61161</td>
<td>611610</td>
<td>Fine Arts Schools</td>
<td>10180</td>
<td>4</td>
<td>0.04%</td>
</tr>
<tr>
<td>61162</td>
<td>611620</td>
<td>Sports and Recreation Instruction</td>
<td>10426</td>
<td>13</td>
<td>0.12%</td>
</tr>
</tbody>
</table>

Table 6-5. An extract from the spreadsheet showing how the data in Table 6-4 was used to calculate the industry concentration parameter $i_c$. 

A Four Dimensional Business Fitness Landscape Model
### Industry Level of Concentration ($I_c$) of the U.S. Economy by Major Industry, For 2004

<table>
<thead>
<tr>
<th>NAICS</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.130</td>
</tr>
<tr>
<td>21</td>
<td>0.603</td>
</tr>
<tr>
<td>22</td>
<td>0.869</td>
</tr>
<tr>
<td>23</td>
<td>0.000</td>
</tr>
<tr>
<td>31</td>
<td>0.516</td>
</tr>
<tr>
<td>42</td>
<td>0.559</td>
</tr>
<tr>
<td>45</td>
<td>0.692</td>
</tr>
<tr>
<td>48</td>
<td>0.601</td>
</tr>
<tr>
<td>51</td>
<td>0.811</td>
</tr>
<tr>
<td>52</td>
<td>0.781</td>
</tr>
<tr>
<td>54</td>
<td>0.387</td>
</tr>
<tr>
<td>61</td>
<td>0.389</td>
</tr>
<tr>
<td>71</td>
<td>0.332</td>
</tr>
<tr>
<td>81</td>
<td>0.351</td>
</tr>
<tr>
<td>82</td>
<td>1.000</td>
</tr>
</tbody>
</table>

**Table 6-6.** The level of concentration of the major industries in the U.S. economy, expressed as a percentage of large establishments to total establishments.

This data is based on the economic census of 2004 and the reference data is derived from US Department of Commerce, Bureau of Economic Analysis (BEA, 2008).
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A Four Dimensional Business Fitness Landscape Model

<table>
<thead>
<tr>
<th>Industry Relative Level of Concentration</th>
<th>NAICS</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry, fishing, hunting</td>
<td>11</td>
<td>0.217</td>
</tr>
<tr>
<td>Mining</td>
<td>21</td>
<td>0.643</td>
</tr>
<tr>
<td>Utilities</td>
<td>22</td>
<td>0.883</td>
</tr>
<tr>
<td>Construction</td>
<td>23</td>
<td>0.100</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>31</td>
<td>0.564</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>42</td>
<td>0.603</td>
</tr>
<tr>
<td>Retail trade</td>
<td>45</td>
<td>0.723</td>
</tr>
<tr>
<td>Transportation and warehousing</td>
<td>48</td>
<td>0.641</td>
</tr>
<tr>
<td>Information</td>
<td>51</td>
<td>0.830</td>
</tr>
<tr>
<td>Finance, insurance, real estate,</td>
<td>52</td>
<td>0.803</td>
</tr>
<tr>
<td>Professional and business</td>
<td>54</td>
<td>0.448</td>
</tr>
<tr>
<td>Educational services, health</td>
<td>61</td>
<td>0.450</td>
</tr>
<tr>
<td>Arts, entertainment, recreation, accom</td>
<td>71</td>
<td>0.399</td>
</tr>
<tr>
<td>Other services, except government</td>
<td>81</td>
<td>0.416</td>
</tr>
<tr>
<td>Government</td>
<td>82</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Table 6-7. Relative industry concentration, during the period 1998 to 2007, after data normalization.

All levels of concentration data are derived from the data in Table 6-6. Data normalization consisted of taking the lowest industry concentration and assigning it the value of 0.1, and then taking the highest industry concentration during this period and assigning it the value 1. All other industry concentrations then underwent relative interpolation between 0.1 and 1.

6.13.3 The industry growth input parameter

The industry growth input parameter $i_{g}$, is a key input parameter and plays the dominant role in defining the flatness or kurtosis of an industry peak. The industry growth parameter defines the standard deviation that is applicable to the industry peak being studied. The way in which the industry growth parameter is applied to the Gaussian probability distribution function that describes the industry peak, is detailed in Section 6.12.1

The industry growth is a measure of the percentage change in the industry size, relative to the industry size in the previous period. This data is therefore calculated from the
industry size data obtained from the U.S. Department of Commerce, Bureau of Economic Analysis (BEA, 2008). The percentage change is then normalized to a parameter that ranges from 0.1 to 1.0, with the industry having the lowest growth being assigned a value of 0.1 and the industry having the highest growth being assigned a factor of 1.0. All other industries are then proportioned to lie between within this range. This is the same approach that was used to calculate the relative industry size Table 6-3.

Table 6-8 and Table 6-9 summarize the industry growth sizing data, for the major industry groupings in the U.S. economy, over the period 1999 to 2007. Note that the data for 1998 was excluded due to the lack of NAICS based data for 1997. Without this data, the 1998 year on year growth data could not be calculated.
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A Four Dimensional Business Fitness Landscape Model

### Year to Year % Growth ($I_g$) of the U.S. Economy by Major Industry, From 1999 to 2007

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry, fishing, hur</td>
<td>-6.24%</td>
<td>-4.76%</td>
<td>-1.14%</td>
<td>-4.91%</td>
<td>22.46%</td>
<td>18.59%</td>
<td>-10.45%</td>
<td>1.52%</td>
<td>28.74%</td>
</tr>
<tr>
<td>Mining</td>
<td>-4.59%</td>
<td>35.35%</td>
<td>7.68%</td>
<td>-19.41%</td>
<td>27.76%</td>
<td>19.33%</td>
<td>27.96%</td>
<td>25.44%</td>
<td>0.80%</td>
</tr>
<tr>
<td>Utilities</td>
<td>2.89%</td>
<td>1.19%</td>
<td>3.40%</td>
<td>-3.62%</td>
<td>3.48%</td>
<td>8.60%</td>
<td>10.27%</td>
<td>8.70%</td>
<td>8.67%</td>
</tr>
<tr>
<td>Construction</td>
<td>11.48%</td>
<td>7.81%</td>
<td>5.15%</td>
<td>1.62%</td>
<td>1.59%</td>
<td>9.70%</td>
<td>7.96%</td>
<td>5.78%</td>
<td>5.07%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>5.10%</td>
<td>1.82%</td>
<td>-0.88%</td>
<td>0.56%</td>
<td>2.08%</td>
<td>15.33%</td>
<td>13.74%</td>
<td>5.13%</td>
<td>6.39%</td>
</tr>
<tr>
<td>Finance, insurance, real estate, Professional and business</td>
<td>9.96%</td>
<td>6.94%</td>
<td>2.15%</td>
<td>3.41%</td>
<td>3.48%</td>
<td>6.62%</td>
<td>9.77%</td>
<td>11.13%</td>
<td>8.38%</td>
</tr>
<tr>
<td>Educational services, health</td>
<td>5.68%</td>
<td>7.92%</td>
<td>8.22%</td>
<td>8.04%</td>
<td>6.02%</td>
<td>6.83%</td>
<td>5.76%</td>
<td>6.84%</td>
<td>6.68%</td>
</tr>
<tr>
<td>Arts, entertainment, recreation,</td>
<td>7.91%</td>
<td>7.40%</td>
<td>2.03%</td>
<td>4.26%</td>
<td>3.97%</td>
<td>7.57%</td>
<td>7.01%</td>
<td>7.72%</td>
<td>5.45%</td>
</tr>
<tr>
<td>Other services, except govern</td>
<td>3.20%</td>
<td>6.36%</td>
<td>4.82%</td>
<td>4.82%</td>
<td>3.93%</td>
<td>5.41%</td>
<td>4.84%</td>
<td>5.18%</td>
<td>5.18%</td>
</tr>
<tr>
<td>Government</td>
<td>4.24%</td>
<td>5.39%</td>
<td>4.68%</td>
<td>7.16%</td>
<td>6.38%</td>
<td>5.11%</td>
<td>4.34%</td>
<td>4.96%</td>
<td>5.10%</td>
</tr>
</tbody>
</table>

Table 6-8. The year to year growth in the size of the major industries in the U.S. economy, over the period 1999 to 2007.

Reference data derived from US Department of Commerce, Bureau of Economic Analysis (BEA, 2008).

### Year to Year % Relative Growth ($I_{rg}$) of the U.S. Economy by Major Industry, Normalized From 0.1 to 1.0, From 1999 to 2007

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry, fishing, hur</td>
<td>0.316</td>
<td>0.341</td>
<td>0.400</td>
<td>0.338</td>
<td>0.788</td>
<td>0.724</td>
<td>0.247</td>
<td>0.444</td>
<td>0.891</td>
</tr>
<tr>
<td>Mining</td>
<td>0.344</td>
<td>1.000</td>
<td>0.545</td>
<td>0.100</td>
<td>0.875</td>
<td>0.737</td>
<td>0.879</td>
<td>0.837</td>
<td>0.432</td>
</tr>
<tr>
<td>Utilities</td>
<td>0.466</td>
<td>0.439</td>
<td>0.475</td>
<td>0.395</td>
<td>0.476</td>
<td>0.580</td>
<td>0.588</td>
<td>0.562</td>
<td>0.561</td>
</tr>
<tr>
<td>Construction</td>
<td>0.608</td>
<td>0.547</td>
<td>0.504</td>
<td>0.446</td>
<td>0.445</td>
<td>0.575</td>
<td>0.663</td>
<td>0.473</td>
<td>0.204</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.475</td>
<td>0.531</td>
<td>0.239</td>
<td>0.385</td>
<td>0.481</td>
<td>0.570</td>
<td>0.604</td>
<td>0.505</td>
<td>0.478</td>
</tr>
<tr>
<td>Wholesale trade</td>
<td>0.522</td>
<td>0.501</td>
<td>0.401</td>
<td>0.406</td>
<td>0.486</td>
<td>0.578</td>
<td>0.550</td>
<td>0.514</td>
<td>0.502</td>
</tr>
<tr>
<td>Retail trade</td>
<td>0.518</td>
<td>0.520</td>
<td>0.477</td>
<td>0.469</td>
<td>0.482</td>
<td>0.479</td>
<td>0.545</td>
<td>0.503</td>
<td>0.497</td>
</tr>
<tr>
<td>Transportation and warehousing</td>
<td>0.503</td>
<td>0.511</td>
<td>0.360</td>
<td>0.409</td>
<td>0.475</td>
<td>0.622</td>
<td>0.575</td>
<td>0.573</td>
<td>0.514</td>
</tr>
<tr>
<td>Information</td>
<td>0.594</td>
<td>0.449</td>
<td>0.405</td>
<td>0.428</td>
<td>0.453</td>
<td>0.671</td>
<td>0.645</td>
<td>0.503</td>
<td>0.524</td>
</tr>
<tr>
<td>Finance, insurance, real estate, Professional and business</td>
<td>0.503</td>
<td>0.575</td>
<td>0.542</td>
<td>0.420</td>
<td>0.465</td>
<td>0.506</td>
<td>0.566</td>
<td>0.579</td>
<td>0.488</td>
</tr>
<tr>
<td>Educational services, health</td>
<td>0.512</td>
<td>0.549</td>
<td>0.554</td>
<td>0.551</td>
<td>0.518</td>
<td>0.531</td>
<td>0.514</td>
<td>0.531</td>
<td>0.529</td>
</tr>
<tr>
<td>Arts, entertainment, recreation, Other services, except govern</td>
<td>0.549</td>
<td>0.541</td>
<td>0.452</td>
<td>0.489</td>
<td>0.484</td>
<td>0.543</td>
<td>0.534</td>
<td>0.546</td>
<td>0.508</td>
</tr>
<tr>
<td>Government</td>
<td>0.489</td>
<td>0.507</td>
<td>0.496</td>
<td>0.537</td>
<td>0.524</td>
<td>0.503</td>
<td>0.490</td>
<td>0.500</td>
<td>0.503</td>
</tr>
</tbody>
</table>

Table 6-9. Relative U.S. industry growth size, during the period 1999 to 2007, after data normalization.

All industry growth data derived from the data in Table 6-8. Data normalization consisted of taking the lowest industry growth size during the nine year period and assigning it the value of 0.1, and then taking the highest industry size during this period and assigning it the value 1. All other industry growth numbers then underwent relative interpolation between 0.1 and 1.
6.13.4 The industry NAICS input parameter

The industry NAICS parameter, \( i_n \), is a key input variable and defines the position of the industry peak along the x axis. The NAICS, or North American Industrial Classification System, as first described in Literature Review Part, is a two to six digit code that ranges from 11 to 999999. A representative sample of typical NAICS codes is shown in Table 6-10.

Industry separation, as shown in Table 6-10, is proportional to the most significant digits of the NAICS code, and not to the absolute value of the code. For this reason, for most of the research, the NAICS codes were normalized to a six digit code which preserved the significance of the left most digits in each code. This process, which is described in detail in the next chapter of the research, is not of significance in this part of the research, as the industry landscapes described in this section were all limited to the highly significant two digit NAICS codes that categorize the major U.S. industries. The NAICS codes used in the examples displayed in this Chapter can be seen in Table 6-11.

It should also be noted that in the process of optimizing the display area of the business landscape, the minimum and maximum NAICS codes of the input data were calculated to ensure that the relevant industry peaks were displayed with the maximum separation.
Sample of NAICS Data Structure

<table>
<thead>
<tr>
<th>Code</th>
<th>Industry Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Mining</td>
</tr>
<tr>
<td>211</td>
<td>Oil and Gas Extraction</td>
</tr>
<tr>
<td>2111</td>
<td>Oil and Gas Extraction</td>
</tr>
<tr>
<td>21111</td>
<td>Oil and Gas Extraction</td>
</tr>
<tr>
<td>211111</td>
<td>Crude Petroleum and Natural Gas Extraction</td>
</tr>
<tr>
<td>211112</td>
<td>Natural Gas Liquid Extraction</td>
</tr>
<tr>
<td>212</td>
<td>Mining (except Oil and Gas)</td>
</tr>
<tr>
<td>2121</td>
<td>Coal Mining</td>
</tr>
<tr>
<td>21211</td>
<td>Coal Mining</td>
</tr>
<tr>
<td>212111</td>
<td>Bituminous Coal and Lignite Surface Mining</td>
</tr>
<tr>
<td>212112</td>
<td>Bituminous Coal Underground Mining</td>
</tr>
<tr>
<td>212113</td>
<td>Anthracite Mining</td>
</tr>
<tr>
<td>2122</td>
<td>Metal Ore Mining</td>
</tr>
<tr>
<td>21221</td>
<td>Iron Ore Mining</td>
</tr>
<tr>
<td>212210</td>
<td>Iron Ore Mining</td>
</tr>
<tr>
<td>21222</td>
<td>Gold Ore and Silver Ore Mining</td>
</tr>
<tr>
<td>212221</td>
<td>Gold Ore Mining</td>
</tr>
<tr>
<td>212222</td>
<td>Silver Ore Mining</td>
</tr>
<tr>
<td>21223</td>
<td>Copper, Nickel, Lead, and Zinc Mining</td>
</tr>
<tr>
<td>212231</td>
<td>Lead Ore and Zinc Ore Mining</td>
</tr>
<tr>
<td>212234</td>
<td>Copper Ore and Nickel Ore Mining</td>
</tr>
<tr>
<td>21229</td>
<td>Other Metal Ore Mining</td>
</tr>
<tr>
<td>212291</td>
<td>Uranium-Radium-Vanadium Ore Mining</td>
</tr>
<tr>
<td>212299</td>
<td>All Other Metal Ore Mining</td>
</tr>
<tr>
<td>2123</td>
<td>Nonmetallic Mineral Mining and Quarrying</td>
</tr>
<tr>
<td>21231</td>
<td>Stone Mining and Quarrying</td>
</tr>
<tr>
<td>212311</td>
<td>Dimension Stone Mining and Quarrying</td>
</tr>
<tr>
<td>212312</td>
<td>Crushed and Broken Limestone Mining and Quarrying</td>
</tr>
<tr>
<td>212313</td>
<td>Crushed and Broken Granite Mining and Quarrying</td>
</tr>
<tr>
<td>212319</td>
<td>Other Crushed and Broken Stone Mining and Quarrying</td>
</tr>
</tbody>
</table>

Table 6-10. A sample extract of typical NAICS industry codes.

In this example all the industries are related to the mining industry 21. For this reason, all the industries have 21 as the two most significant digits in their NAICS code. Note that NAICS codes are used to position an industry peak along the x axis in the business fitness landscape.

6.14 The fitness landscape data structures

Having described the objectives of the business fitness landscape model, the theory behind the model, and the details of the input data for the model, it is now possible to analyze how the data has been structured to create the actual business fitness landscapes. This
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analysis begins with a description of how the input data was entered to create a landscape, and then followed by a description of how that same input data was used to create the industry peaks, and eventually the total landscape.

6.14.1 The landscape input data structures

To create a business fitness landscape model, a minimum of four pieces of data was required for each industry peak in the landscape. These four pieces of data are: NAICS code, industry size, industry growth, and industry concentration.

Table 6-11 shows a typical input data form for defining a business fitness landscape model. Note that the current format supports up to 16 industry peaks per landscape. The “Select” column allows the analyst to control the display of individual industry peaks. The “Business Position” column allows the business analyst to study the positioning of a corporation in a given business landscape. This particular feature is described in detail in the research as presented in Chapter 7.

At the bottom of the input form are fields for controlling the time dimension, fractal display, and other options. A detailed explanation of each of these fields is as follows:

1. **Time Period.** Used to control the fourth dimension of the landscape model, namely time. Assuming the available industry data is required and available, the analyst can enter the appropriate time period in this field and this then triggers the automatic transfer of the appropriate industry peak data for the given time period into the input data form. Once this transfer has been completed, the software automatically builds the landscape for the given time period.

2. **Show Non-Gaussian Peaks.** Allows the analyst to turn off the Gaussian peak display and display the industry peaks as a fine step function. This display can assist in viewing and analyzing the Business Diversity Fitness Index which will be described in detail in Chapter 7.

3. **Border.** Controls the border around the landscape that the analyst wants to reserve so as to fine tune the display of the industry peaks. A 10% border around the XY
plane is the default. This allows room to display the Gaussian probability
distribution function for those peaks that are on, or close to, the 0% or 100%
extremes.

4. **Normalize Max Height To 1.** For display optimization, the analyst can use this
field to force the landscape model to display the largest peak at the full height of
1. Note that all other peaks in the given landscape will be proportionately
amplified.

5. **Fractals On.** This field allows the analyst to turn the display of inherent errors on
or off. A pseudo-random fractal layer is used to represent these errors. Turning the
fractal layer on also enhances the display of a more real-life landscape display.

6. **Fractal Significance.** Controls the level of errors to be displayed via the use of
fractals in the overall landscape.

7. **Show Peak Bp Only.** This field allows the analyst to turn off the industry peaks
and just display the peak business positions. The application of this field is
explained in more detail in Chapter 7.

8. **Rotate Landscape.** This allows the analyst to control the Visual Basic for
Applications (VBA) program which enables the rotation of the whole business
fitness landscape. This rotation capability allows the analyst to view an industry
peak that may be hidden behind another peak. Each click on the “Rotate” button
rotates the landscape 90 degrees.
### Table 6-11. A typical input data form for defining a business fitness landscape model.

Note that the current format supports up to 16 industry peaks per landscape. The “Select” column allows the researcher to control the display of individual industry peaks. The “Business Position” column allows the business analyst to study the positioning of a corporation in a given business landscape. This particular feature is described in detail in Chapter 7 of the research. At the bottom of the input form are fields for controlling the time dimension, fractal display, and other options.

#### 6.14.2 The output data structures of a typical business fitness landscape

The current research model for a typical business fitness landscape consists of a landscape with up to 16 industry peaks, plus additional input and output layers for display of fractals, noise, and other information.
Each industry peak is defined by a 61 x 61 array. Each landscape has up to 16 industry peaks plus additional fractal and output layers to create each landscape. The end result is that a three dimensional landscape is defined by an approximately 70,000 cell array, whereas a four dimensional landscape, with multiple time frames, requires approximately one million data cells for its definition. Table 6-12 shows an extract of one of these typical industry peak output arrays.
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6.14.3 The hardware and software requirements required to generate the business fitness landscape models.

Using a fairly standard personal computer, configured for professional business and research applications, with two gigabytes of memory, running Windows XP on a dual core 1.8 GHz Intel x86 processor, a typical industry landscape, which may be composed of 500,000 to 1,000,000 Gaussian probability distribution function calculations, can typically be created in less than five seconds.

<table>
<thead>
<tr>
<th>Industry NAICS Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 11 12 13 14 15 16 17 18 19 20 21 22 23</td>
</tr>
<tr>
<td>18 000 000 000 000 000 000 000 000 000 000 000 000 000 000</td>
</tr>
<tr>
<td>19 000 000 000 000 000 000 000 000 000 000 000 000 000 000</td>
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<tr>
<td>42 000 000 000 000 000 000 000 000 000 000 000 000 000 000</td>
</tr>
<tr>
<td>43 000 000 000 000 000 000 000 000 000 000 000 000 000 000</td>
</tr>
</tbody>
</table>

Table 6-12. An example of an extract from a typical industry peak output array.

Each industry peak is defined by a 61 x 61 array. Each landscape has up to 16 industry peaks plus additional fractal and output layers to create each landscape. The end result is that a three dimensional landscape is defined by an approximately 70,000 cell array, whereas a four dimensional landscape, with multiple time frames, requires approximately 1,000,000 data cells for its definition.
All the analysis on the landscape modeling tools was carried out using Microsoft Excel 2003, with Service Pack 3, Statistical Analysis Pack, and Visual Basic for Applications.

### 6.15 An example of a 3D business landscape

Figure 6-7 shows an example of a three dimensional business fitness landscape with three industry peaks, namely construction, finance and government. Note that the three industry peaks are shown with their associated 3D Gaussian probability distributions. The construction industry is shown at the front as it has a low level of industry concentration. Government is shown at the rear as it has a high level of concentration. The finance industry has the highest peak as it is has the largest industry size and also has the sharpest peak as it had the highest year to year industry growth.

The peaks in Figure 6-7 are smooth, showing a classical Gaussian distribution. The peaks in this example have no fractal structure layer and so any inherent error in the output data has not been displayed.
Three industry peaks are shown with their associated Gaussian probability distribution. Construction is shown at the front as it has a low level of industry concentration. Government is shown at the rear as it has a high level of concentration. Finance is the highest peak as it is has the largest industry size and has the sharpest peak as it has the highest year to year industry growth.

6.16 A fitness landscape of the whole U.S. economy

Figure 6-8 shows a three dimensional landscape of the whole U.S. domestic economy as of 2007. Table 6-11 shows the input data that was used to create this landscape. Note that many of the peaks are close enough to each other on the landscape to partially overlap and coalesce. The landscape rotate function here is a useful tool to assist in viewing industry
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peaks that may be hidden by larger peaks located in the foreground. It is of interest to see how the finance and real estate industry has come to be, literally, part of the commanding heights of the U.S. economy (Chase, 1998; Yergin and Stanislaw, 2002).

![A 3D Landscape of the Whole USA Domestic Economy of 2007](image)

Figure 6-8. Shows a three dimensional landscape of the whole U.S. domestic economy as of 2007.

Table 6-11 shows the input data form that was used to create this landscape. Note that many of the peaks are close enough to each other on the landscape to partially overlap and coalesce. The landscape rotate function here is a useful tool to assist in viewing industry peaks that may be hidden by larger peaks located in the foreground. It is of interest to see how, in 2007, the finance and real estate industry has grown to become the commanding heights (Chase, 1998; Yergin and Stanislaw, 2002) of the U.S. economy.
6.17 Using texture to extend the landscape metaphor while displaying important additional information

At this stage it is worthwhile to refer back to two of the original objectives of the landscape model that were first stated in Section 6.5. Namely:

1. Create a model that fully utilizes the landscape metaphor.

2. While being compatible with the other objectives, the landscape model should portray a reality which is as informative and as accurate as possible.

It is reasonable to assume that when most people use a landscape metaphor, they are referencing a three dimensional world image of a familiar, picturesque landscape. In some cases, this landscape may approach a vision similar to the landscape of the Grand Teton mountain range, as shown in Figure 6-9.
It is assumed that when most people use a landscape metaphor, they are referencing a three dimensional world image of a familiar, picturesque landscape. In some cases, this landscape may approach a vision similar to the landscape of the Grand Teton mountain range.

People who have witnessed dramatic and sudden volcanic landscape change in say Hawaii or Iceland, the fall colors of New England, or the first snow of winter, these people may add a fourth dimension, a dimension of time, in which the landscape not only changes in space, but also changes with respect to time. Similarly, in this research an attempt was made to capture four dimensions of change, not as it relates to the earth’s surface, but as it relates to the business environment, as experienced by a diverse, multi-industry, corporation. Furthermore, in the same way that the two dimensional fitness landscape of Wright, leveraged the power of the landscape metaphor, the new business fitness landscape established in this research, will add color, shape, texture and dimensions, to efficiently communicate key features of the modern, complex, business fitness landscape. This section
reports on how noise and fractals can be used to display inherent errors in the model, while at the same time adding a certain realism to the model.

The accuracy of the fitness landscape model developed during this research was limited to the accuracy of the empirical secondary data from which was built, combined with the sampling resolution used in building the model. The following errors in the model have been taken into consideration:

1. Industry size: an indeterminate error of 2.0%.
2. Industry NAICS code: no indeterminate error. A determinate sampling error of 1.6%
3. Industry growth: an indeterminate error of 1%.
4. Industry concentration: an indeterminate error of 2.0% and a sampling determinate error of 1.6%.

These errors combined total to a peak error of 8.2% in the model, with an average root mean square error of 5.8%. The model has therefore been designed to assume a baseline root mean square noise level in the display of the landscape data of 5.8%.

Three approaches were considered during the research as to how best to display this inherent error noise in the model. Understandably, the three approaches selected were all associated with the application of random, or pseudo-random, noise to the landscape. These were:

1. Apply a purely random noise layer.
2. Apply a purely pseudo random fractal noise layer.
3. Apply a combined random noise and pseudo random noise layer.

Figure 6-10 shows a typical random noise layer generated from the use of Excel’s random number generator. In this case a zero to peak noise level of 0.05 or 5% has been
generated. For display purposes a bias of 0.05 has been applied to ensure all sample points remain positive. The use of pure random noise results in a very artificially high entropy level.

![Random Noise](image)

**Figure 6-10. A typical random noise layer generated by using Excel’s random number generator.**

In this case a zero to peak noise level of 0.05 or 5% has been generated. For display purposes a bias of 0.05 has been applied to ensure all sample points remain positive. The use of pure random noise results in a very artificially high entropy level.

Figure 6-11 shows a pseudo-random fractal noise layer generated by using a fractal generation technique developed during the research. In this case a zero to peak fractal noise level of 0.05 or 5% has been generated. Once again, for display purposes, a bias of 0.05 has been applied to ensure all sample points remain positive. The use of a pure fractal noise layer results in a more realistic, but very artificially low entropy level.
Figure 6-11. A pseudo-random fractal noise layer generated by using a fractal generation technique developed during the research.

In this case a zero to peak fractal noise level of 0.05 or 5% has been generated. For display purposes a bias of 0.05 has been applied to ensure all sample points remain positive. The use of pure fractal noise layer results in a more realistic, but still overly artificial entropy level.

Before describing the technique used to generate the three dimensional fractal layer it is worthwhile to review what fractals are and their role in the definition and rendering of landscape models.

6.17.1 The role fractals play in displaying errors in the Business Fitness Landscape

Fractals is a term first introduced by Mandelbrot (1967) to describe structures which have self-similarity over a range of scales and are found to have fractional dimensions, as opposed to integer dimensions, of length, area and volume. Fractals have found a wide use in a variety of applications, including financial analysis and computerized terrain rendering. Their application to three dimensional terrain rendering resides in the fact that natural landscapes show significant self-similarity which is independent of the scale of observation.
Similar to the effective use of color and scale, the ability to maintain a realistic landscape texture, independent of zooming in and out of the landscape by an analyst, is a valuable attribute of using fractals to display inherent errors in the model. This is a significant observation in that it maximizes the leverage obtained by capturing the heuristics of the landscape metaphor. The use of fractals to display noise, errors, entropy and scaling artifacts in a model has been discussed by a number of researchers, including Mendelbrot (1982), Montroll and Shlesinger (1983), Procaccia and Schuster (1983), Pawelzik and Schuster (1987), and Sugihara et al. (1990).

Noise variables, including noise variables in accounting, finance and strategic management models, are typically a function of the errors inherent in the measurements (Easton and Monahan, 2005). Noise is usually characterized as a mean square fluctuation versus frequency. That is, the rate at which there is random or pseudo random change as a function of time. The resulting power spectra is found to be proportional to $1/f^{\beta}$ where $\beta$ is greater than or equal to zero (Mandelbrot, 2002). In the case where $\beta$ is zero the noise is described as white noise, and when $\beta$ is 2 it is described as Brownian noise. Furthermore it is found that $\beta$ is related to the fractal dimension $D$ by the relationship $D = (5 - \beta) / 2$, and that noise is therefore well described by use of the fractal dimension (Lowen and Teich, 1993).

The pseudo-random fractal layer used in this research was created using a modification of a technique known as the midpoint-displacement algorithm (Musgrave et al., 1989). The application of the midpoint-displacement algorithm, in this research, consisted of a process which involved the placement of pseudo-random, range-bound numbers in the corners of an array or grid. Within this grid, a finer grid was overlaid, in which fractionally more constrained, pseudo-random range bound numbers were inserted. This process of smaller, pseudo-random fractional displacements was continued as required. Any gaps in the array were then filled in using linear interpolation, to produce a landscape of randomly undulating planes, as shown in Figure 6-11.

At this stage of the research it became clear that maybe a third approach, to the process of adding an appropriate and realistic noise layer to the landscape, was required. This third approach was considered so as to avoid the artificially high entropy level of pure
random noise and the artificially low entropy level of pure fractal noise. So this third approach was to consider the use of a combined layer. That is, a layer which combined a layer of random noise, with a layer of pseudo-random fractals. Figure 6-12 shows a representative sample of one of these combined layers. This combined layer was selected as the best approach to both represent the determinate and indeterminate errors in the model, as well as being the best approach for presenting the most realistic landscape metaphor.

![Figure 6-12. This final combined layer consists of a layer of random noise, combined with a layer of pseudo-random fractals.](image)

This combined layer was selected as the best approach to both represent the determinate and indeterminate errors in the model, as well as being the best approach for presenting the most realistic landscape.

### 6.18 The application of color to the landscape

In addition to position, shape, size and texture, information has been added to the landscape model with the use of an intuitive color scheme. Continuing on with the landscape metaphor, and leveraging a landscape vision similar to that shown in the idealistic landscape represented by Figure 6-9, the color legend shown in Table 6-13 was applied to the landscape surface plots. The color legend has been used to communicate industry peak positioning.
relative to the vertical axis or landscape altitude. Landscape altitude being directly related to industry size. An attempt was made to select intuitive landscape colors in which a landscape altitude of 0 is colored blue, low levels above 0 are dark green, and the colors are then gradated to light green, grey, and eventually white.

<table>
<thead>
<tr>
<th>Color Legend</th>
<th>Grayscale Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>□ 1.200-1.400</td>
</tr>
<tr>
<td>White</td>
<td>□ 1.000-1.200</td>
</tr>
<tr>
<td>White</td>
<td>□ .800-1.000</td>
</tr>
<tr>
<td>White</td>
<td>□ .600-.800</td>
</tr>
<tr>
<td>White / Gray</td>
<td>□ .400-.600</td>
</tr>
<tr>
<td>Gray / Light Green</td>
<td>□ .200-.400</td>
</tr>
<tr>
<td>Light Green / Dark Green</td>
<td>□ .000-.200</td>
</tr>
<tr>
<td>Light Blue</td>
<td>□ -.200-.000</td>
</tr>
</tbody>
</table>
Table 6-13. The color and grayscale legend used to communicate industry size.

An attempt was made to select intuitive landscape colors in which a landscape altitude of .000 or less is colored blue, low levels above 0 are dark green, and the colors are then gradated to light green, gray, and eventually white. Note, in attempt to improve transitioning from one color or grayscale to another, color blending and grayscale blending has been used for all positive landscape altitudes.

6.19 Bringing it all together, an example of a complex landscape model

Figure 6-13 shows an example of a complex business fitness landscape model, showing most of the properties of the model developed during the research study. This example, based on the input data form shown in Table 6-11, is a model of the whole U.S. domestic economy, as it was in 2007. This example illustrates the application of the model’s capabilities with respect to handling multiple industry peaks, and the use of position, size, shape, texture and color. In Section 6.20 the capability of the model to show the fourth dimension, or change over time, will be illustrated. Also note that in Chapter 7, an additional feature of the model, namely the capability of showing individual business positioning in the landscape model, and the use of this feature in determining the Business Diversity Fitness Index, will be examined in detail.
Figure 6-13. An example of a complex business fitness landscape model.

This sample landscape model shows most of the properties of the model developed during the research study. This example, based on the input data form shown in Table 6-11, is a model of the whole U.S. domestic economy, as it was in 2007. This example illustrates the application of the model’s capabilities with respect to handling multiple industry peaks, and the use of position, size, shape, texture and color. In Section 6.20 the capability of the model to show the fourth dimension, namely change over time, will be illustrated. Also note that in Chapter 7, an additional feature of the model, namely the capability of showing individual business positioning in the landscape model, and the use of this feature in determining the Business Diversity Fitness Index, will be examined in detail.

The landscape model shown in Figure 6-13 is fairly typical of a relatively complex landscape. This particular model was created from the summing of 21 layers or arrays, 15 of which are individual industry peaks. Each layer or array has 65 x 65 data cells. In total, the model consists of approximately 90,000 data cells and includes 60,000 Gaussian probability distribution function calculations per time frame. These calculations are typically completed in approximately two to five seconds. The total model is saved as a single, 7 megabyte Excel workbook, containing approximately 25 spreadsheets.
6.20 Visualization of the changing U.S. economy, from 1998 to 2007, as an example of a four dimensional landscape model

Figures 6-14 to 6-17 provide a visualization of the changing U.S. economy over the period 1998 to 2007. These figures, showing the business landscape over a total of 10 time frames, illustrates how the model can be used to capture and display a business fitness landscape in four dimensions. The four dimensions being; industry NAICS code, industry size, industry concentration, and time. As described in this chapter, other information can be displayed via the model’s use of shape (industry growth), texture (error), and color (relative industry size).

Although it was not one of the objectives of the research study to use the models and tools created in the research, to study changes in the macro U.S. economy, it is of interest to see, however, how a new visualization tool, such as the landscape model, can be used to obtain an alternative perspective on the business landscape. For example, the following three observations are worth noting:

1. Comparing the business landscape over time it can be seen that the government sector’s share of the economic landscape has not changed significantly, in that as the economy has grown, the government sector has grown in proportion to the growth in the economy.

2. From the model, it can be seen that, at least for the U.S. economy in 2007, the Government sector is not part of the commanding heights, but may be better described, as a backstop.

3. It is also interesting to see the impact on the landscape of the decline in manufacturing in the U.S. This is especially evident between 2001 and 2003.
Figure 6-14. Timeframes 1 to 3 of the U.S. 4D business landscape between 1998 and 2000.
Figure 6-15. Timeframes 4 to 6 of the U.S. 4D business landscape between 2001 and 2003. Note the decline in manufacturing and the rise of the finance sector.
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Figure 6-16. Timeframes 7 to 9 of the U.S. 4D business landscape between 2004 and 2006.

2004
U.S. Business Landscape
GDP: $10.1T

2005
U.S. Business Landscape
GDP: $10.9T

2006
U.S. Business Landscape
GDP: $11.7T
Figure 6-17. Timeframe 10 of the U.S. 4D business landscape in 2007.

Note the total dominance by the finance sector, the decline in the manufacturing sector, and the constant relative size in the Government sector.

6.21 Summary of the business fitness landscape model

In reviewing the business fitness landscape model, it is informative to review the original objectives and comment on how well these objectives have been met. The objectives of this section of the research were:

1. Create a new business landscape model that builds on the original work of Wright: The model created does extend Wright’s original model from two dimensions to four dimensions and leverages the powerful landscape metaphor to create a tool with the potential to view the dynamics of a complex business landscape in a new and informative perspective.

2. Leverage the available business data, and display that data in a new and informative manner: This approach to viewing the dynamics of the business environment is new, and certainly informative. The model attempts to use dimensions, space, size, shape, texture and color to show as much as possible of the dynamics of the complex business environment using the most intuitive and informative metaphors available.
3. **Build a business landscape model that is easy to apply**: Significant effort went into the design of the model that would leverage and display existing data in an informative way, while ensuring that the model could be built using easily accessible tools, and was sufficiently adaptable and extensible to support additional data and industries.

4. **Create a model that fully utilizes the landscape metaphor, as reviewed in Chapter 3 of the research**: The new business landscape model unmistakably leverages the landscape metaphor.

5. **The new landscape model should portray a reality which is as informative and as accurate as possible, while being compatible with the other objectives**: The selection of dimensions, shape, color and texture, were all designed to portray the available information as accurately as possible.

6. **Define the model mathematically, and in sufficient detail, to support future analysis and extension of the model**: A full mathematical description of the model was developed as part of the research.

7. **Develop a model that provides the basis for developing a comprehensive business fitness index that will assist in directly comparing the fitness of one business to another in the context of the business landscape**: The foundations for doing this were laid down by the model described in Chapter 6. The way in which these model foundations can be leveraged to enable the comparison of one business to another are described in detail in Chapter 7 and Chapter 8.

8. **Create a model that is as automated as possible, so that the model requires the minimal intervention and work by the business analyst, to take new business data, and use that data to create a new business landscape**: Significant research effort went into designing an automated modeling process. It is believed that this objective has been met in that, if desired, the landscape model input data form is the only input data required to generate a totally new business fitness landscape.
6.22  Closing comments on the chapter

This chapter introduced and explored in detail a new business fitness landscape model that builds on the original work of Wright. The next step was to build on this model to develop a methodology for creating a comprehensive business fitness index that will assist in directly comparing the fitness of one business to another in the context of the business landscape and the thesis surrounding the criteria for business fitness as described in this research. This objective, the creation of a Business Diversity Fitness Index, was the next challenge of the research, and is explored in detail in the next Chapter.
Building on and extending the four dimensional business fitness landscape model that was detailed in Chapter 6, this chapter details the development and application of a new index, the Business Diversity Fitness Index (BDFI), that provides a simple, straightforward means to directly compare the “fitness” of one business to another business. The BDFI is a measure of how well placed a corporation is, within the context of the business environment in which it exists, to withstand rapid discontinuous change to its surrounding business environment. The BDFI builds on the conceptual foundations that were first introduced in Chapter 2, namely, that a business with the strongest, most diverse, multi-industry business positioning is going to have an increased probability of resisting the decline that may arise from sudden discontinuous change. Furthermore, that same business is also going to have an increased probability of being in the best place to leverage any emerging new opportunities for renewed growth.

7.1 The problem

The business fitness landscape model that was described in the previous chapter provides one method of reviewing a business in the context of the business landscape in which it operates. This business landscape viewpoint provides an important broad expanse of information, which allows the business analyst to view the business in the context of the wider business landscape. It would be useful, however, to have a simple index by which this broad expanse of information relating to the business’ overall diversity fitness could be summarized and quantified. With such an index one business’ diversity fitness could be directly compared with another business’ diversity fitness. It is the aim of this chapter to detail the design and application of such an index.
7.2 The significance of the problem

The significance of the problem addressed in this chapter is a subset of the significance of the problem addressed by the overall research. The previous chapters have reviewed in detail as to why there is a need to get a better handle on the lifespan of corporations, and have introduced new tools and metrics to achieve that end goal. The outcome of this chapter is the importance of diversity and the development of a new index which will allow the business analyst, business owner, or investor, to compare one business’ diversity to another.

An understanding of the significance of this approach may be better appreciated by considering how many people, for example, compare mutual funds. A person could review the component investments, the management, the fees, the track record, and so forth, and do the same for all the mutual funds under consideration. Actually, every person considering those funds, could, and probably should, do the same. This approach would be effective, but possibly inefficient. Morningstar Inc. (2009), for example, has established a significant business by doing that kind of independent analysis, and charging its clients a fee to access the results. Furthermore, it has come up with a five star rating to allow funds to be quickly compared. The BDFI, introduced here, is attempting to be the basis of a similar rating system, however, in this case the index is monitoring business fitness as it relates to the diversity of the business’ operations.

7.3 The objectives

In creating this new business fitness index, the following seven objectives were sought:

1. To develop a simple index that would allow the fitness of one business to be directly compared to the fitness of another business.

2. To maximize the correlation between the index and the business’ real fitness, given the available data, tools and time.

3. To reflect the accuracy or inaccuracy of the underlying calculations.
4. To directly relate the index to the corresponding business fitness landscape.

5. To leverage wherever possible the same data that is used to create the fitness landscape to calculate the fitness index.

6. To minimize the use of additional business data, beyond that data used to create the fitness landscape, in creating the fitness index.

7. To maximize speed of calculation, as well as ease of use, the steps required to create the fitness index should be as automated as possible.

### 7.4 How the BDFI depends on and builds on the BLM

The BDFI depends on and arises out of the Business Fitness Landscape (BFL) model that was introduced in the last Chapter, in at least five ways:

1. The BDFI leverages the same data as that used to create the BFL model.

2. The index calculated for a given large corporation is directly related that corporation’s BFL.

3. The BDFI provides a quantitative value to the subjective view of a corporation’s unrelated diversification, as viewed in the BFL.

4. The same tools that are used in creating the BFL are used to calculate the BDFI.

5. The same heuristics that are used in creating the BFL are leveraged in calculating the BDFI.

Furthermore, the BDFI builds and extends the BFL by:

1. Revealing and quantifying information that can be subjectively seen in the BFL.

2. Providing additional quantifiable information that allows key aspects of one corporation’s BFL to be directly compared to another corporation’s BFL.

3. Presents information that is buried in the BFL so that the information is clearly revealed in a way that aids analysis and testability.
In summary, the BDFI, both depends and builds on the BFL in a number of aspects. It is true to say, however, that the BDFI could be calculated without using the four dimensional landscape model, and could be displayed as a direct outcome of a two dimensional spreadsheet calculation. This alternative approach however, would lack the power of the heuristic model afforded by the landscape metaphor, and would potentially bypass the value provided to the business analyst associated with the visualization of the corporation’s relative unrelated diversification. It is this visualization, backed-up by quantifiable analysis that leverages the true value of the landscape model. Furthermore, a similar challenge questioning why the visual landscape is required when a spreadsheet analysis could lead to the same results, could be applied to the 2x2 matrix of the BCG Growth Share Matrix or alternative models that leverage portfolio matrices. Many of the findings of the BCG model could indeed be explained without the 2x2 matrix, but it is this simple 2x2 matrix that provides a powerful heuristic model that forces the business analyst to classify business units in a new and enriching manner. A similar comment applies to Wright’s adaptation landscape model. And the same comment applies to the BFL. It is the BFL that gives significance to the diversity model. The diversity model is seen as one insight that is made clearer by the BFL. That is the power of the metaphor model as explored in Chapter 2 of the dissertation.

7.5 Some terminology

For consistency and clarity it is important to document some of the high level key terminology that is used in this section of the research. In general a “business landscape” is assumed to be a set of “industries” that are relevant to the business analysis. Each industry has a unique NAICS code, and each industry is made up of a number of “businesses”, and each business may have multiple points of presence. These points of presence are referred to by the Bureau of Commerce, and in this research, as “establishments”. The term “corporation” has been extended from its normal usage, to refer to an entity which has the possibility of multiple businesses in multiple industries. The number of independent businesses in multiple industries is the measure of diversity that is referred to in this research.
7.6 The methodology

This section describes in detail the methodology for creating the business fitness index. As is typical for applied mathematics, the methodology is driven by logically extending the key objectives, the available input data, and the desired outcome. The key objectives have already been established. The next step is to look at the input variables, the key weights and thresholds, the intermediate output data, and then finally to look at the business fitness index as the key output variable.

7.6.1 Input variables for the business fitness index

One of the objectives for the business fitness index is to be able to leverage, wherever possible, the same data that is used to create the associated business fitness landscape. To that end, the following input data that was also used in developing the business fitness landscape model will be used:

- \( i_{hm} \): The industry NAICS code for industry \( m \)
- \( i_{sm} \): The industry market size for industry \( m \)
- \( i_{gm} \): The industry annual growth for industry \( m \)
- \( i_{cm} \): The industry concentration for industry \( m \)
- \( b_{pm} \): The business position in industry \( m \)

Given the above list of input variables, it should be noted that it was possible to use the same input data that was used to create the overall business landscape as was used to create the business fitness index. Furthermore, a fairly standard approach in creating an index is the process of normalizing the key input data so that it falls between 0 and 1 (Desai, 1991). In the methodology used to create the business fitness index introduced by this research, this
process is used extensively. To this end, all the input data is effectively normalized to a percentage using the relationship:

\[ x_i = \frac{100(x - \min(x))}{(\max(x) - \min(x))} \]  

(7.1)

where \( x_i \) is the index, in this case expressed as a percentage, \( \min(x) \) is the minimum value obtainable by the value \( x \) and \( \max(x) \) is the maximum value obtainable by value \( x \).

It should also be noted, that the one input variable which has been used up until this stage of the research was the business positioning variable \( b_{p_m} \). This variable is the normalized input variable describing the position of the business in the industry \( m \). Position refers to the normalized market position which is based on the business’ percentage share of the total market revenue associated with a given industry.

7.6.2 The input constants for the business fitness index

The development of the business fitness index revealed the need for a number of constants for setting weights and thresholds. These constants were created during the development to ensure that the contribution of each input variable is appropriate to ensure the best possible correlation between the index and empirical results, and to ensure that the combination of the input variables would map appropriately to a simple five star index rating. These constants are independent of any landscape, industry, or business position. The following input constants were allocated for use in calculating the index:

\( W_p \): Weighting for business positioning

\( W_s \): Weighting for industry size

\( W_g \): Weighting for industry growth
$W_s$: Weighting for industry concentration

$T_s$: Threshold for industry NAICS separation

$T_f$: Threshold for minimum fitness

$F_l$: Limit or maximum applied to the fitness count

### 7.6.3 The intermediate output variables for the business fitness index

Due to the relative complexity of calculating the business fitness index, a number of intermediate or interim output variables were introduced. These output variables were used to capture intermediate data calculations. The following output variables, therefore, were created as an aid in structuring the calculation of the business fitness index. Note that all these output variables are directly calculated from the input data and the associated weights and thresholds:

$N$: The number of industries in which the corporation has a business position

$m$: The industry index number. The corporation is assumed to have $N$ related industries and that each of these industries will be indexed from $m$ equal to one to $m = N$

$b_{sm}$: Business separation in industry $m$ from the primary business

$i_{np}$: The primary NAICS code of the landscape

$s_{nm}$: The secondary NAICS code for industry $m$

$r_m$: Relevance of industry $m$

$p_m$: Positioning of business in industry $m$
introducing the main output variable, the BDFI

the input data, the applicable weights and thresholds, and the intermediate output variables, are all components of the journey to reach the main output variable, the BDFI. Furthermore, it was decided to present the BDFI as a ranking of zero to five stars, similar to the way in which Morningstar ranks mutual funds (Sharpe, 1998). This presentation of the BDFI ranking is designed to be simple, clear, and to reflect the underlying relative accuracy and inaccuracy of the calculation.

the BDFI, is a measure of how well a large, well established corporation, with substantial multiple businesses, in multiple industries, can withstand rapid, discontinuous, business landscape, or business environment, change. The thesis here, is that a large corporation which has the strongest, most diverse, multi-industry, business positioning, is going to have the highest business fitness index. The BDFI, therefore, is really a measure of a corporation’s business diversity.

It is of interest to note that for geneticists, the definition of “diversity” is a term used to describe the relative uniqueness of each individual in a population (Patil and Taillie, 1982). High diversity is considered to be an advantage as the greater the diversity than the greater the variety of genes available to the genetic algorithm and so the greater the probability of finding a viable phenotype which is well suited to a new environment, when the need arises. Diversity in this context is the ultimate measure of fitness to withstand rapid, discontinuous change.

The BDFI was directly derived from the associated business fitness landscape. To that end, the development of the BDFI took into consideration each of the industry peaks in which the corporation has a business presence. The BDFI calculation therefore needs to factor in

\[ n_m \]: Actual NAICS separation distance between parent NAICS and child NAICS for
industry \( m \)

\[ n'_m \]: Relative NAICS separation distance between parent NAICS and child NAICS for
industry \( m \)

7.6.4 Introducing the main output variable, the BDFI

The input data, the applicable weights and thresholds, and the intermediate output variables, are all components of the journey to reach the main output variable, the BDFI. Furthermore, it was decided to present the BDFI as a ranking of zero to five stars, similar to the way in which Morningstar ranks mutual funds (Sharpe, 1998). This presentation of the BDFI ranking is designed to be simple, clear, and to reflect the underlying relative accuracy and inaccuracy of the calculation.

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The BDFI was directly derived from the associated business fitness landscape. To that end, the development of the BDFI took into consideration each of the industry peaks in which the corporation has a business presence. The BDFI calculation therefore needs to factor in
three main features of each industry peak. Namely the relevance $r$ of the industry peak, the positioning $p$ of the business in that industry peak, and lastly the NAICS separation $s$, or path length of the secondary, or related industry peak relative to the primary or main industry peak. Therefore the business diversity fitness index has the generalized high level relationship:

$$BDFI = \sum_{m=1}^{N} (r_m p_m s_m) > T_f$$  \hspace{1cm} (7.2)$$

where $N$ is the total number of industries in which the corporation in question has a business position, $m$ is the index number of the applicable industry, and $T_f$ is a pre-determined, minimum fitness threshold.

### 7.6.5 A calculation for the relevance of an industry peak

The peaks in the business fitness landscape were created by the formation of a three dimensional Gaussian distribution which is defined by four variables. These variables being: an industry's NAICS code, concentration index, market size, and relative industry growth. The relevance of the industry peak is therefore some weighted relationship of each of these four parameters. The NAICS code is considered later in the BDFI calculation, namely as the $i_{nm}$ parameter. At this stage the focus of our attention will be on the three remaining parameters, namely industry size, industry growth and industry concentration, and the definition of the relevance of the industry peak as a weighted combination of these three variables. Therefore the relevance of the industry peak, for industry $m$, with weights $W$, is of the form:

$$r_m = \frac{W_s i_{sm} + W_g i_{gm} + W_c i_{cm}}{W_s + W_g + W_c}$$ \hspace{1cm} (7.3)$$
### 7.6.6 Business positioning

Positioning, $b_{p_m}$, is defined to be the business position, or market share of the business, in a given industry $m$. This parameter, therefore, is simply a measure of the business’ market share or dominance in a particular industry. For future flexibility, a weighting factor $W_p$ has been introduced for the business positioning parameter. Note, however, that initially $W_p$ was given a default value of 1 and so is effectively not being used at this stage. Therefore, for the purposes of calculating the Business Diversity Fitness Index, the business positioning factor, for industry $m$, has the relationship:

$$ p_m = W_p b_{p_m} $$

### 7.6.7 Determining business independence

Analysis of the NAICS codes during the research has shown that the NAICS separation, $s_m$, introduced above, provides an excellent measure of industry independence. This result is not surprising considering that the NAICS codes have been defined to reflect the uniqueness of industrial activity. If a corporation has two businesses which reside in industries with very close NAICS codes, then those two businesses operate in more related industries and so have less industry independence compared to two businesses which operate in industries which have widely separated NAICS codes. For example, referring to Table 7-1, which shows an extract of NAICS codes, the most significant digits, that is the digits furthest to the left of each code, relate to the similarity of each industry. Industry 2211, “Electric Power Generation, Transmission and Distribution”, is less related to industry 2361, “Residential Construction”, than say industry 2211 compared to industry 221113, “Nuclear Electric Power Generation”. In other words, industry separation is not proportional to the code, but is proportional to the most significant digits of the code.
<table>
<thead>
<tr>
<th>Raw NAICS</th>
<th>Normalized NAICS</th>
<th>Industry Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>212393</td>
<td>212393</td>
<td>Other Chemical and Fertilizer Mineral Mining</td>
</tr>
<tr>
<td>212399</td>
<td>212399</td>
<td>All Other Nonmetallic Mineral Mining</td>
</tr>
<tr>
<td>213</td>
<td>213000</td>
<td>Support Activities for Mining</td>
</tr>
<tr>
<td>2131</td>
<td>213100</td>
<td>Support Activities for Mining</td>
</tr>
<tr>
<td>21311</td>
<td>213110</td>
<td>Support Activities for Mining</td>
</tr>
<tr>
<td>213111</td>
<td>213111</td>
<td>Drilling Oil and Gas Wells</td>
</tr>
<tr>
<td>213112</td>
<td>213112</td>
<td>Support Activities for Oil and Gas Operations</td>
</tr>
<tr>
<td>213113</td>
<td>213113</td>
<td>Support Activities for Coal Mining</td>
</tr>
<tr>
<td>213114</td>
<td>213114</td>
<td>Support Activities for Metal Mining</td>
</tr>
<tr>
<td>213115</td>
<td>213115</td>
<td>Support Activities for Nonmetallic Minerals (except Fuels)</td>
</tr>
<tr>
<td>22</td>
<td>220000</td>
<td>Utilities</td>
</tr>
<tr>
<td>221</td>
<td>221000</td>
<td>Utilities</td>
</tr>
<tr>
<td>2211</td>
<td>221100</td>
<td>Electric Power Generation, Transmission and Distribution</td>
</tr>
<tr>
<td>22111</td>
<td>221110</td>
<td>Electric Power Generation</td>
</tr>
<tr>
<td>221111</td>
<td>221111</td>
<td>Hydroelectric Power Generation</td>
</tr>
<tr>
<td>221112</td>
<td>221112</td>
<td>Fossil Fuel Electric Power Generation</td>
</tr>
<tr>
<td>221113</td>
<td>221113</td>
<td>Nuclear Electric Power Generation</td>
</tr>
<tr>
<td>221119</td>
<td>221119</td>
<td>Other Electric Power Generation</td>
</tr>
<tr>
<td>22112</td>
<td>221120</td>
<td>Electric Power Transmission, Control, and Distribution</td>
</tr>
<tr>
<td>221121</td>
<td>221121</td>
<td>Electric Bulk Power Transmission and Control</td>
</tr>
<tr>
<td>221122</td>
<td>221122</td>
<td>Electric Power Distribution</td>
</tr>
<tr>
<td>2212</td>
<td>221200</td>
<td>Natural Gas Distribution</td>
</tr>
<tr>
<td>22121</td>
<td>221210</td>
<td>Natural Gas Distribution</td>
</tr>
<tr>
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<td>221210</td>
<td>Natural Gas Distribution</td>
</tr>
<tr>
<td>2213</td>
<td>221300</td>
<td>Water, Sewage and Other Systems</td>
</tr>
<tr>
<td>22131</td>
<td>221310</td>
<td>Water Supply and Irrigation Systems</td>
</tr>
<tr>
<td>221310</td>
<td>221310</td>
<td>Water Supply and Irrigation Systems</td>
</tr>
<tr>
<td>22132</td>
<td>221320</td>
<td>Sewage Treatment Facilities</td>
</tr>
<tr>
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<td>221320</td>
<td>Sewage Treatment Facilities</td>
</tr>
<tr>
<td>22133</td>
<td>221330</td>
<td>Steam and Air-Conditioning Supply</td>
</tr>
<tr>
<td>221330</td>
<td>221330</td>
<td>Steam and Air-Conditioning Supply</td>
</tr>
<tr>
<td>23</td>
<td>230000</td>
<td>Construction</td>
</tr>
<tr>
<td>236</td>
<td>236000</td>
<td>Construction of Buildings</td>
</tr>
<tr>
<td>2361</td>
<td>236100</td>
<td>Residential Building Construction</td>
</tr>
<tr>
<td>23611</td>
<td>236110</td>
<td>Residential Building Construction</td>
</tr>
<tr>
<td>236115</td>
<td>236115</td>
<td>New Single-Family Housing Construction</td>
</tr>
</tbody>
</table>

Table 7-1. An extract from a table of North American Industrial Coding System codes.

The raw NAICS data was extracted from the 2007 U.S. Census Bureau data (U.S. Census Bureau, 2007). Note the way in which the most significant digits refer to the industry area and the least significant digits refer to sub-industries. The middle column shows a sample of normalized NAICS codes created as part of this research. During this normalization process the codes have been converted to a standard six digit integer and the significance of the digits has been preserved.
The actual NAICS code for each industry where a corporation has a business presence, can be used to determine the industry path length or industry independence factor. A corporation which has multiple independent businesses, in very closely related industries, should have a lower diversity fitness rating compared with a corporation which has the same number of independent businesses in more unrelated industries.

It needs to be noted that calculating business independence, by comparing NAICS codes, requires the analyst to first normalize the NAICS codes and to clearly identify the primary and secondary industries that are applicable for a multi-business corporation operating in the larger business landscape. The steps in this process are:

1. Normalize the NAICS code.
2. Identify the NAICS code of the primary industry.
3. Identify the NAICS codes of the secondary industries.
4. Calculate the NAICS distance, or separation, of each secondary industry from the primary industry.
5. Calculate the relative, weighted, separation of each secondary industry.

In the following sections, each of these processes is examined.

### 7.6.8 Normalizing the NAICS codes

The fact that industry separation is proportional to the most significant digits of the NAICS code, and not to the absolute value of the code, introduced a complication to calculating and comparing NAICS separation, or the industry independence path length. The highest level NAICS code, for example, is typically two digits, while the lowest level NAICS code is typically six digits. This structure can be seen in Table 7-1. For ease of automated, mathematical manipulation, the NAICS codes needed to be normalized to a standard six digit integer. To simplify the NAICS separation calculation, the following Excel functions were used to normalize all the NAICS codes to 6 digits, while preserving the weighting to the most significant digits.
The NAICS normalization process firstly multiplies the raw NAICS (rNAICS) code by 10,000 to create a minimum six digit integer (note that the minimum raw NAICS code used in this research is 11, and the maximum NAICS code is 999999). The new integer, resulting from this multiplication was then converted to a text string. From this text string, the six, left-most characters were extracted. This new, six-character string was then converted back to a number, creating the normalized six digit NAICS code (nNAICS). The Excel formula used to perform this transformation was:

\[ \text{nNAICS} = \text{VALUE(LEFT(TEXT(rNAICS*10000,0),6))} \] (7.5)

### 7.6.9 Identifying the primary industry

Every industry, in which the corporation has a business presence, was defined to be either a primary industry, or a secondary industry, of the corporation. By definition there will only be one primary industry and all the other industries will be considered secondary industries. The primary industry was set by definition to be the industry which has the highest combination of business positioning, as described to in Section 7.6.6, and business relevance, as described in Section 7.6.5. The product of business relevance, \( r_m \), and business positioning, \( p_m \), is defined to be the business dominance factor \( b_{dm} \), for industry \( m \), (DFM). That is:

\[ b_{dm} = r_m p_m \] (7.6)

To ensure there was only one reference parent, in the event that two industries had the same maximum business dominance factor, then the industry which had the first, calculated, maximum business dominance factor, was selected by default as the primary industry (Primary). The final Excel formula used to select the parent NAICS was:

\[ \text{Primary} = \text{IF(DFM=MAX(DFMrange),"P",IF(DFM>0,"C",""))} \] (7.7)
7.6.10 Calculating the secondary industry’s independence

Once the primary NAICS and the secondary NAICSs had been identified, it was a relatively simple process to calculate the relative NAICS independence \( n_r \) (or \( N_r \)) of each child NAICS from its parent NAICS.

The first step was to calculate the absolute difference between the parent and child NAICS. This absolute difference was then checked against the preset NAICS threshold for separation \( T_s \). If the difference was less than the threshold value, then the relative position was set as the measure of the relative NAICS. If the absolute difference is equal or greater than the threshold then the relative NAICS was set to 1. The Excel formula used to calculate the relative NAICS was:

\[
N_r = \frac{\text{IF}(|\text{ABS}(p\text{NAICS}-s\text{NAICS}) < T_s, \text{ABS}(p\text{NAICS}-s\text{NAICS}), T_s))}{T_s} \quad (7.8)
\]

Note that the labels for variables and constants, such as “\( T_s \)”, in the above formula, refer to variables and constants that were defined during the research for use in Excel formulas as range names. These range names are a plain text, text string, and as such do not make use of subscripts and superscripts.

In summary, if a secondary industry NAICS was sufficiently removed from its primary industry NAICS, then it was determined to be fully independent of its primary or parent and so its \( N_r \) is set to 1. If, however, the child NAICS was close to its parent, then it was determined to be still partially dependent on its parent and so its industry positioning was proportionately discounted. The NAICS separation as a measure of business independence is therefore summarized in the following mathematical relationship:

\[
s_m = \frac{|i_{np} - i_{nm}|}{T_s} \quad (7.9)
\]

That is, the relative separation of industry \( m \) is basically the absolute difference between the NAICS code for the primary industry and the NAICS code for industry \( m \), divided by the fixed minimum separation threshold \( T_s \).
The Decay Of Corporations

7.6.11 Calculating the secondary business’ vitality

The vitality of a secondary business, \( b_v \), in industry \( m \), was simply defined as the product of the secondary business’ separation independence, \( s_m \), and the secondary business’ dominance, \( b_{dm} \). That is:

\[
b_{vm} = s_m b_{dm}
\]

(7.10)

Now as described in Section 7.6.9:

\[
b_{dm} = r_m p_m
\]

(7.11)

Therefore business vitality is literally the product of business independence, business relevance and business positioning. That is:

\[
b_{vm} = r_m p_m s_m
\]

(7.12)

7.6.12 Determining if the secondary business is fit

The question, “Is the secondary business “fit”?, is really a question which demands a logical “yes” or “no” answer. In other words, is the secondary business in the “fit” state or not as defined in this context of independence and dominance? To that end, the second last step in calculating the Business Diversity Fitness Index was to check the vitality of each secondary business against a preset threshold and assign a binary result of “0” or “1”. The fitness threshold parameter was defined as \( T_f \) and given the Excel label Tf. The applicable Excel formula was therefore:

\[
Bf=IF(Bv>Tf,1,0)
\]

(7.13)

7.6.13 The final steps in calculating the BDFI

The last step in calculating the Business Diversity Fitness Index was simply a matter of summing the binary business fitness levels for each secondary business in the landscape.
For clarity, simplicity and the need to have an index which reflected the reality of the accuracy of the process, a simple zero to five star rating was chosen for reporting BDFI. The following Excel formulae, describes the process of converting the binary fitness levels to a zero to five start fitness rating:

\[ Q20: =\text{SUM}(Q5:Q19) \quad (7.14) \]
\[ Q24: =\text{IF}(Q20>\text{FL},\text{FL},Q20) \quad (7.15) \]
\[ Q25: =\text{REPT}("*",Q24) \quad (7.16) \]

In the above formulae, the Excel label “FL” refers to the fitness level threshold \( F_i \) that was introduced in Section 7.6.2. The default setting for \( F_i \) is 5, so as to match the Morningstar format discussed in Section 7.2.

7.7 The formula for BDFI

Having reviewed all the steps required to calculating the Business Diversity Fitness Index, the overall formula for the index was now at hand. In summary the index was given by the high level relationship as discussed in Section 7.6.4, where industry relevance was combined with business positioning and business separation, to define the index as:

\[
BDFI = \sum_{m=1}^{N} (r_m p_m s_m) > T_f
\]

(7.17)

As discussed in Section 7.6.5, the industry relevance \( r_m \) was calculated by combining the weighted industry size, industry growth, and industry concentration, using the following relationship:

\[
r_m = \frac{W_s i_m + W_g i_m + W_c i_m}{W_s + W_g + W_c}
\]

(7.18)
Also, as discussed in Section 7.6.6, the business positioning \( p_m \) was simply the weighted market position, or revenue share, of the business in the industry being considered. That is:

\[
p_m = W_p b_{p_m}
\]  

(7.19)

Lastly, the measure of business independence, \( s_m \), for the business in industry \( m \) is shown in Section 7.6.7 to be given by:

\[
s_m = \frac{|i_{n_p} - i_{n_m}|}{T_s}
\]  

(7.20)

And so, by combining these relationships into the definition for the Business Diversity Fitness Index (BDFI):

\[
BDFI = \frac{\sum_{m=1}^{N} W_p b_{p_m} (W_i i_{s_m} + W_g i_{s_m} + W_c i_{c_m})(|i_{n_p} - i_{n_m}|)}{T_s (W_i + W_g + W_c)} > T_f
\]  

(7.21)

That is, the BDFI is the sum of all the businesses, from all the industries in the business landscape, that meet a minimum requirement relating to: industry relevance, business positioning in the industry, and lastly, business independence or separation from other related businesses in the business landscape.

### 7.8 An introduction to the BDFI Calculation Spreadsheet

A key objective of the research was to not only develop the theory for defining a new business fitness index, but to also develop the tools for applying the theory to real corporations. To that end, the mathematics discussed earlier, for calculating the BDFI were implemented in Excel so that once the minimum input data was loaded into the input fields of the BDFI Calculation Spreadsheet, all the calculations would be performed automatically, and the resulting BDFI would be shown.
Table 7-2 shows a blank BDFI Calculation Spreadsheet. Note that the cells with the grey background are all locations for comments, constants, or places for interim or final output data. The cells with the white background are the available locations for entering the necessary industry and business data. The basic input data required is:

1. Landscape name
2. Business name
3. Industry descriptions
4. Industry raw NAICS codes
5. Industry sizes
6. Industry growths
7. Industry concentrations
8. Business positioning in each industry
### Business Diversity Fitness Index (BDFI) Calculation Example

#### Landscape:
- **Industry**
  - #
  - Industry
  - rNAICS
- **Size**
  - In
  - Icm
- **Growth**
  - Igm
- **Concentration**
  - Icm
- **Business Positioning**
  - Business Rel
  - Business Dom
  - Business Pri

#### Business:
- **Rel**
  - Pri
  - Sec
  - NAICS
  - Inp
  - Sep
  - Vitality
  - Fit

#### Weights:
- **Ws**
- **Wg**
- **Wc**
- **Wp**
- **Ts**
- **Tf**

#### Output Calculations:
- **BDFI**

<table>
<thead>
<tr>
<th>#</th>
<th>Industry</th>
<th>rNAICS</th>
<th>Size</th>
<th>Growth</th>
<th>Concent</th>
<th>Business</th>
<th>Position</th>
<th>Rel</th>
<th>Dom</th>
<th>Pri</th>
<th>Sec</th>
<th>NAICS</th>
<th>Inp</th>
<th>Sep</th>
<th>Vitality</th>
<th>Fit</th>
</tr>
</thead>
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</tbody>
</table>

Weights: 2.00 Ws 4.00 Wg 1.50 Wc 1.00 Wp 10000 Ts 0.0200 Tf

#### Table 7.2: An extract from a blank BDFI Calculation Spreadsheet that was developed as part of the research.

Note that the input data currently supported includes the landscape name, the business name, and up to 16 industries in the one business landscape. Each industry requires an industry name, the raw NIACS code, and normalized industry size, growth and concentration. For each industry there is also a data cell for entering the business positioning, assuming it exists, for each industry in the business landscape. All the shaded area are intermediate output data locations. The final BDFI value, will appear, after the data is entered, in the lightly shaded boxes at the bottom of the table.

### 7.9 An example of a BDFI calculation input data set

Table 7-3 is an example of a BDFI Calculation Spreadsheet with sample input data loaded, but before the output calculations are completed.
Business Diversity Fitness Index (BDFI) Calculation Example

Landscape: USA GDP 2007

<table>
<thead>
<tr>
<th></th>
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<td>21.7%</td>
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<td>Mining</td>
<td>21</td>
<td>15.6%</td>
<td>43.5%</td>
<td>64.3%</td>
<td>30%</td>
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<td></td>
</tr>
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<td>Utilities</td>
<td>22</td>
<td>18.1%</td>
<td>56.1%</td>
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</tr>
<tr>
<td>4</td>
<td>Construction</td>
<td>23</td>
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<td></td>
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<td>Transportation</td>
<td>48</td>
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<td>51.4%</td>
<td>64.1%</td>
<td>20%</td>
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<tr>
<td>9</td>
<td>Information</td>
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<td>52.4%</td>
<td>83.0%</td>
<td>0%</td>
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<tr>
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<td>Finance</td>
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<td>20%</td>
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<tr>
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<tr>
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<td>Education</td>
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<td>52.9%</td>
<td>45.0%</td>
<td>0%</td>
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<td></td>
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<tr>
<td>13</td>
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<td>50.8%</td>
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<td>40%</td>
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<td>50.4%</td>
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<td>68.0%</td>
<td>50.3%</td>
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</tr>
</tbody>
</table>

Weights: 2.00 4.00 1.50 1.00 7.5000 0 10000 0.5200

BDFI: [ ]

Table 7-3. An extract from a BDFI Calculation Spreadsheet, showing only sample input data.

Note that normally the intermediate output data and the calculated BDFI will automatically be calculated within a couple of seconds of entering the input data.

The BDFI Calculation Spreadsheet was initially designed to support up to 16 industries or businesses associated with the one business landscape. The rows can be easily copied to extend this support for much larger landscapes, up to the limits supported by the Microsoft Excel program. Similarly, the weighting factors are clearly labeled so that it is a simple matter to adjust the index by placing different weightings on the input and output parameters.

### 7.10 An example of the completed BDFI calculation

Table 7-4 shows a completed BDFI Calculation Spreadsheet. As the input data set for the BDFI calculation is entered into this spreadsheet, the BDFI can be calculated and continually updated as more industry and business data is entered. In the shaded area is the intermediate output data, including the industry relevance, the business dominance, the identification of the primary and secondary industries, the normalized NAICS codes, the normalized business separation indexes, and the final calculations of business vitality which lead to the business fitness binary values for each industry that has a business position. At the
The Decay Of Corporations

Business Diversity Fitness Index (BDFI) Calculation Example

<table>
<thead>
<tr>
<th>Industry</th>
<th># Industry</th>
<th>NAICS Prim</th>
<th>NAICS Sec</th>
<th>Prim Weight</th>
<th>Sec Weight</th>
<th>Position</th>
<th>Rel</th>
<th>Dom</th>
<th>Sep</th>
<th>Pri</th>
<th>Sec</th>
<th>Vitality</th>
<th>Fit</th>
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</thead>
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<tr>
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<td>0</td>
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<tr>
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<td>10.0%</td>
<td>0%</td>
<td>-</td>
<td>0</td>
<td>0</td>
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<td>55.7%</td>
<td>44.8%</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>0.0000</td>
<td>0</td>
</tr>
<tr>
<td>Education</td>
<td>12</td>
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<td>51.6%</td>
<td>52.9%</td>
<td>45.0%</td>
<td>0%</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0.0000</td>
<td>0</td>
</tr>
<tr>
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<td>13</td>
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<td>1</td>
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</tr>
<tr>
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<td>19.7%</td>
<td>50.4%</td>
<td>41.6%</td>
<td>0%</td>
<td>-</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0.0000</td>
<td>0</td>
</tr>
<tr>
<td>Government</td>
<td>15</td>
<td>82</td>
<td>68.0%</td>
<td>50.3%</td>
<td>100.0%</td>
<td>0%</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0000</td>
<td>0</td>
</tr>
</tbody>
</table>

Weights:
- Position: 7.00
- Rel: 4.00
- Dom: 4.00
- Sep: 1.50
- Pri: 1.00
- Sec: 7.5000

BDFI: 4.00

****

Viewing business positioning in the business landscape

In the shaded area you see all the intermediate output data, including the industry relevance, the business dominance, the identification of the primary and secondary industries, the normalized NAICS codes, the normalized business separation indexes, and the final calculations of business vitality which lead to the business fitness binary values for each industry that has a business position. At the bottom of the BDFI Calculation Spreadsheet you see the BDFI ranking between 0 and 5, and the equivalent number of stars.
and the landscape shading have been enabled. This three dimensional Gaussian landscape view, although informative with respect to industry size, separation, and concentration, potentially hides some information. To address this issue, the theory and tools were extended to allow the removal of industry peaks in which there is no significant business positioning, and if required, command the three dimensional landscape view to change from the Gaussian landscape to a step function peak view. This peak view can also be limited to just the peaks which have a significant business positioning. In this way, the researcher can concentrate on the business dominance and separation, while evaluating the business diversity via the business diversity fitness index calculation. The application of these landscape viewing options is shown in the following examples.
Figure 7-1. The three dimensional Gaussian business landscape of the same industry data that was used in the BDFI calculation example that was shown in Table 7-3.

In this example, the fractal landscape detail has also been enabled. In addition, all industry data has been displayed. This all industry, 3D view, may hide or de-emphasize those industries in which the corporation has a significant business position. For this reason, the research was extended to provide the theory and tools for better viewing those industries in which the corporation has a business presence.

The extension of the tools to better show business positioning in the landscape, was the development of the code that allows the business analyst to remove industry peaks in which the corporation does not have a business position. Continuing with the same data used in the BDFI Calculation Spreadsheet example, Figure 7-2 shows the landscape created from the input data that was referred to in Table 7-3. In this figure, all the industry peaks that had zero business positioning have been removed.
Figure 7-2. Shows the 3D Gaussian business landscape created from the input data that was referred to in Table 7-3.

In this figure, however, in an attempt to get a better view of the business diversity, all the industry peaks that had zero business positioning have been removed.

The other options available to the business analyst include the option to turn off the fractal landscape detail and to transform the industry peaks from a 3D Gaussian distribution function to a 3D step function. The advantage of using the step function is that it is less likely to hide business positioning peaks, removes peak overlap, and clearly shows the individual contributions of each business position. Figure 7-3 shows the business landscape of the BDFI example, with non-Gaussian peaks, no fractals, and no industry peaks that have a zero business positioning.
In an attempt to get a clearer view of the business diversity landscape, the 3D Gaussian landscape has been replaced with a simple 3D step function landscape. In addition, all the industry peaks that had zero business positioning, and all the fractal structures have been removed.

7.12 Closing comments on the chapter

Building on the development of the business fitness landscape that was described in the previous chapter, this chapter described the development and application of a new business fitness index, the BDFI. The BDFI was designed to provide a straight forward method to directly compare the “fitness” of one business with another business, with respect to the business’ diversity of industry participation. The next chapter documents how the theory and tools developed for calculating the BDFI, as well as the other tools developed and discussed earlier in this study, were applied to a selection of corporations. This is followed in the final chapter by a discussion of the application, usefulness, and accuracy of the index.
8 APPLICATION OF THE MODELING TOOLS TO SELECTED BUSINESSES

Having created, introduced and developed the business fitness landscape modeling tools, and examined those tools in a broader perspective, the last stage of the research was to focus on the application of those tools to a selection of Fortune 100 businesses. This chapter documents the process of how the research on tool development and the macro analysis of corporation decay leads to a detailed, applied, micro analysis of corporation decay.

This chapter does not stand on its own. It complements and builds on the first seven chapters. Those seven chapters provided the detailed descriptions and analyses that were required to put the modeling tools in perspective. This chapter, on the application of the tools, provides only a cursory introduction to the conclusions and recommendations that arise out of their application. The detailed discussion on the conclusions and recommendations, as well as the contributions associated with the other chapters, will be covered in Chapter 9.

8.1 Objectives

The six aims of this micro analysis were:

1. Analyze the life spans and life cycles of specific businesses, and compare these specific examples to the generalized macro results already described.

2. Examine the possible extinction events and survival traits associated with selected Fortune 100 businesses.

3. Present examples on how the business fitness landscape tools can be applied.

4. Study the findings associated with the detailed three dimensional and four dimensional business fitness landscapes of one of the selected businesses.
5. Assess if the tools reveal significant new information with respect to specific businesses.

6. Investigate if the application of the business fitness landscape tools reveal significant new information with respect to businesses in general.

### 8.2 Methodology

The methodology used in completing this micro analysis was multifaceted, and as such the following five points should be noted while reviewing the analysis:

1. The analysis relied on independent, well accepted, quality secondary data, which is readily accessible to other researchers for independent verification and extensible research. The sources for the secondary data included: Hoover’s (2008e), the U.S. Census Bureau (2008), the Bureau of Economic Analysis (BEA, 2006), the Fortune 500 archives (CNN, 2008b), Barron’s Online (2008), the SEC’s EDGAR database (SEC, 2008), and the various corporate websites of the businesses selected for analysis.

2. The micro analysis included empirical research, in as much as it included direct observations derived from the secondary data, per the hypothetico-deductive method (Popper, 1972). Furthermore, a number of testable theses are presented, that are derived directly from these empirical observations.

3. The micro analysis was focused on verifying or falsifying the applicability of the business fitness landscape modeling tools to a “real-world” selection of businesses. The fact that these modeling tools make significant use of mathematical models, is a direct result of a significant reliance on the use of the mathematical modeling methodology in this analysis.

4. The application of the tools to selected businesses required significant quantitative analysis, including the collection, sorting, measurement and analysis of large data arrays. Some of these data arrays, such as the business fitness landscape model had over 70,000 data elements per time slice, as described in detail in Chapter 6.
5. Finally, significant constructive research was applied. The modeling tools provide a construct in which mathematical models were applied in an attempt to identify trends that link a business’ positioning in its industry participation landscape, to its life expectancy in the Fortune 100.

In applying the above methodology, the first step was to select the businesses that would be the candidates for micro analysis. The second step was to group the businesses and to determine which types of analysis would be applied to each of the selected business groupings.

### 8.3 The selection process

When choosing the businesses to be included in the micro analysis, the following criteria were identified as being important, with respect to being representative, rigorous, and efficient:

1. Selecting businesses that were well known, or in other words had significant brand presence, so as to leverage the reviewer’s existing interest or knowledge of the business.

2. The need for representative businesses from multiple industries.

3. The need for businesses that represented both the survivors and non-survivors.

4. The need to select not only businesses that were the leaders in the Fortune 100, but also businesses that were in the mid Fortune 100 rankings.

5. Choosing a selection that would include at least two businesses from at least three industries to enable both intra-industry and inter-industry comparisons. This criterion led to the conclusion that at least 6 businesses should be included in the micro analysis.

6. And finally, a selection which included representative businesses from both the old established order of pre 1955, as well as the relatively new businesses, that is those businesses that entered the Fortune 100 rankings after 1970.
8.4 The selection

With the objectives, as specified in the selection process, in place, the Fortune 100 rankings from 1955 to 2008 were reviewed and the following businesses were chosen as suitable candidates for the micro-analysis:

1. General Motors (GM), a leader and long term survivor in the Fortune 100 during the whole period under study, namely 1955 to 2008 (Sloan, 1990). Note that GM describes its primary industry as automobile manufacturing (Hoover’s, 2008d).

2. General Electric (GE), a leader and long term survivor in the Fortune 100 during the whole period under study. GE is a major business participant in multiple industries and so is often described as a conglomerate (Collins et al., 2001; Slater, 1999). For this analysis, GE was viewed as a manufacturer, and GE certainly has a significant and ongoing, heritage as a major U.S. manufacturer, but it should be noted that in 2008, GE’s primary industry is now considered to be mainly financial, and specifically described as “All Other Nondepository Credit Intermediation”.

3. International Business Machines (IBM), a leading long term survivor (Gerstner, 2002; Watson Jr and Petre, 1990) in the Fortune 100 during the whole period under study and whose primary industry participation is now “Computer Systems Design Services”.

4. Xerox, a mid-tier Fortune 100 player that entered the Fortune 100 in 1970, and survived in the ranking until 2001 (Hiltzik, 1999; Smith and Alexander, 1988). Xerox’s primary industry of participation is “Printing Machinery and Equipment Manufacturing”.

5. Exxon Mobil (Weston, 2002), a leader and long term survivor in the Fortune 100 during the whole period under study, and whose primary industry participation is “Petroleum Refineries”.

Application Of The Modeling Tools To Selected Businesses
6. Enron, a short-lived, Fortune 100 energy trading and energy transportation business, that shot into the Fortune 100 in 1997 only to fall-out of the rankings, even faster than it entered, in 2002 (Eichenwald and Lang, 2005; Swartz et al.). Note that the Enron that was tracked in the Fortune 100 is now closed-down, however, the industry participation of the 2008, Enron Creditors Recovery Corporation, is “Electric Power Generation”. Also, it should be noted that Enron Creditors Recovery Corporation, is still doing business as “Enron”.

Having selected the businesses to be studied, the next step was to group the selected businesses as an aid in comparative analysis, and to allow selected analysis techniques to be more easily applied to individual businesses or business groupings. With this approach in mind, and based on the selection process described in Section 8.3, it was decided to group the businesses into the three industry areas. These three industry groups and their constituents are:

2. Computer manufacturing and services: IBM and Xerox.
3. Petrochemical and energy utilities: Exxon Mobil and Enron.

### 8.5 The analysis process

Having selected and grouped the businesses, and after reviewing the objectives of the analysis, it is time to move on to the micro analysis process itself. The following analysis process was implemented:

1. Fortune 100 analysis of each business.
2. Industry participation analysis of each business.
3. Three dimensional and four dimensional business fitness landscape analysis for two of the businesses. One of the two having a highly diverse industry participation profile and the other one being significantly less diverse.
4. Business Diversity Fitness Index (BDFI) analysis of the two businesses that were selected for business fitness landscape analysis.

5. Theta and Tau risk parameter analysis of the two businesses selected for BDFI analysis.

The first step in this process, namely the analysis of each of the selected businesses, is documented in the following subsections.

8.6 Fortune 100 analysis

The Fortune 100 analysis applied the tools and methodologies that were described in detail in Chapter 5. This analysis involved extracting the rankings of each business, for each year, in the Fortune 100 database that was created as part of the research. This database, of approximately 30,000 data points, is summarized in Appendix B. As shown in this appendix, the Fortune 100 database was designed from the beginning to track and plot up to 8 specified businesses in parallel. However, so as to minimize clutter in the Fortune 100 graphs, each graph was limited to display the Fortune 100 life of only two businesses at a time. These groupings of two will be by the three industry areas described in Section 8.4.

8.6.1 Fortune 100 analysis of General Motors and General Electric

The micro analysis of the Fortune 100 lives of selected businesses begins with two representatives that are major players in both manufacturing and finance, while at the same time being two of the great leaders of business in the USA over the last 60 years. Namely General Motors and General Electric.

Figure 8-1 shows plots of the Fortune 100 lives of these two companies between 1955 and 2008. Both these companies have been in the top 10 rankings of the Fortune 100 for most of this period. The Fortune 100 analysis of General Motors shows that it has held the number one ranking, based on gross revenue, for most of the period of the analysis. It faltered for a while in the mid 70s due to the oil crisis and in the 80s due to competition from the Japanese. However, by the late 80s, with renewed general economic growth, lower oil prices, and
demand for large utility vehicles, General Motors was once again number one. The economic contraction of 2001, overseas competition and increasing oil prices, and the corresponding fall in General Motors Fortune 100 rankings, revealed that General Motors appeared to be exposed to the overall economic environment and has significant sensitivity to oil prices. These weaknesses of General Motors were once again exposed in 2008 when the general business environment suffered a major discontinuity brought on by higher oil prices, a growing concern of the environmental impact of large vehicles, the financial crisis, and the impact of the overall 2007 to 2009 economic recession. It should be noted that the Fortune 100 rankings for 2009, which are based on the full 2008 revenue numbers, were not available at the time of documenting this research.

Like General Motors, General Electric has been one of the leading U.S. corporations during the whole period of the study. The highest Fortune 100 ranking General Electric achieved between 1955 and 2008 was fourth. Like many large industrials, General Electric faltered somewhat in the mid 70s and the mid 80s. Under the stewardship of Jack Welch (Welch and Byrne, 2001) they managed to recapture their fourth ranking, and compared to many of their peers, have managed to minimize the impact of the 2008 recession on their overall ranking.
Figure 8-1. A plot of the Fortune 100 lives of General Motors and General Electric between 1955 and 2008.

The graph was created by extracting the rankings of General Motors and General Electric from the Fortune 100 database created during this research. This database of approximately 30,000 data points is summarized in Appendix B and was described in detail in Chapter 5. Note that in 2008, when the general business environment suffered a major discontinuity brought on by higher oil prices, the growing concern of the environmental impact of large vehicles, the financial crisis, and the impact of an overall economic recession, General Motors finds itself struggling to avoid bankruptcy. General Electric, however, compared to many of their peers in the Fortune 100, have managed to minimize the impact of the 2008 recession on their overall ranking.
8.6.2 Fortune 100 analysis of IBM and Xerox

Having introduced two manufacturing and financial businesses, the next two businesses in the micro analysis of the Fortune 100 lives of selected businesses, will be two technology businesses. Both these businesses are household names, but one, IBM, was in the Fortune 100 in 1955 and was still in the Fortune 100 rankings in 2008. The other, Xerox, entered the Fortune 100 in 1970 and exited the rankings in 2001. Their lives in the Fortune 100 are captured in Figure 8-2.

With reference to Figure 8-2, IBM was ranked at position 61 in the year 1955 and then managed to quickly move up to the ranking position 9 by 1965. IBM managed to stay in the top 10 until 2007. Although IBM declined to position 15 in 2008, it has managed to withstand the recession of 2008 comparatively well.

Xerox’s path through the Fortune 100, between the years 1955 to 2008, shows some major similarities and some major differences compared with IBM. Xerox’s entry to the Fortune 100 starts in 1970 and by 1973 it has quickly risen to ranking position 40. It will stay at this level for approximately 16 years before jumping up to position 20 in 1990. However, this lofty ranking will be short-lived, and by 2001, Xerox leaves the Fortune 100 rankings altogether.
The Decay Of Corporations

Application Of The Modeling Tools To Selected Businesses

Figure 8-2. A graph of the Fortune 100 lives of IBM and Xerox over the period 1955 to 2008.

Both these businesses are household names, but one, IBM was in the Fortune 100 in 1955 and was still in the Fortune 100 rankings in 2008. The other, Xerox, entered the Fortune 100 in 1970 and exited the rankings in 2001. With reference to the figure IBM is seen to be ranked at position 61 in the year 1955 and quickly moves up to the ranking position 9 by 1965. IBM then stays in the top 10 until 2007. Although IBM declines to position 15 in 2007, it manages to withstand the recession of 2008 comparatively well. Xerox’s path through the Fortune 100, shows some major similarities and some major differences compared to IBM. Xerox’s entry to the Fortune 100 starts in 1970 and by 1973 it has quickly risen to ranking position 40. It stayed at this level for approximately 16 years before jumping up to position 20 in 1990. However, this lofty ranking was short-lived, and by 2001, Xerox leaves the Fortune 100 rankings altogether.
8.6.3 Fortune 100 analysis of Exxon Mobil and Enron

The last two businesses examined with respect to the micro analysis of the Fortune 100 lives of selected businesses, will be two energy related businesses. Both these businesses are also household names, one, Exxon Mobil, is a household name as a result of its dominance of the petroleum industry for over 60 years, and the other, Enron, is a household name as a result of its spectacular rise, and just as spectacular collapse, in a cloud of corporate malfeasance. Their lives in the Fortune 100 are captured in Figure 8-3.

With reference to Figure 8-3, Exxon Mobil is seen to be ranked in the top 4 of the Fortune 100 through the period of the study. Furthermore, in defiance or possibly as a result of “peak oil” (Deffeyes and Silverman, 2003), Exxon Mobil still has the high ranking of 2 in 2008.

Enron’s path through the Fortune 100, between the years 1955 to 2008, is a picture of contrast to the stability of Exxon Mobil’s ranking. Enron’s entry to the Fortune 100 starts in 1997, and in only 4 years it had risen to the lofty ranking of 5. However, in late 2001, Enron collapses into bankruptcy at the end of a long term strategy of accounting fraud (Agrawal and Chadha, 2005).
Table removed due to copyright restrictions

Figure 8-3. A plot of the Fortune 100 lives of Exxon Mobil and Enron between 1955 and 2008.

Both these businesses are household names, one, Exxon Mobil, is a household name as a result of its dominance of petroleum industry for over 60 years, and the other, Enron, is a household name as a result of its spectacular rise, and just as spectacular collapse, in a cloud of corporate malfeasance. Exxon Mobil is seen to be ranked in the top 4 of the Fortune 100 through the period of the study, namely 1955 to 2008. Furthermore, in defiance, or possibly as a result of “peak oil” (Deffeyes and Silverman, 2003), Exxon Mobil still has the high ranking of 2 in 2008. Enron’s path through the Fortune 100, is a picture of contrast to the stability of Exxon Mobil’s ranking. Enron’s entry to the Fortune 100 starts in 1997, and in only 5 years it has risen to the lofty ranking of 5. However, one year later, in 2003, Enron collapses into bankruptcy.
8.7 Industry analysis

The second area of micro-analysis involved an analysis of the industries in which each of the selected businesses participates. These industry participation classifications are listed by NAICS code. Each of the selected corporations reports its revenue to the Bureau of Commerce by NAICS codes and a summary of this analysis can be found by reference to the SEC EDGAR database and via third party business analysis sites such as Hoover’s.

This industry analysis uses the same businesses and business groupings as were used in the Fortune 100 analysis. For each business, a two column table was created, listing each industry in which the business claims it receives a significant part of its revenue. These industry lists include both the U.S. Bureau of Commerce NAICS classification description, and the associated 2 to 6 digit NAICS code. The classification, in which the business claims to receive its largest revenue source, is deemed to be the business’ primary industry. This primary classification is added to the industry description, and the text in that row has been displayed in a bold font.

8.7.1 Industry analysis of General Motors and General Electric

The first two businesses that were examined from an industry participation analysis perspective were General Motors and General Electric. General Motors’ Industry Participation table is shown in Table 8-1, and General Electric’s Industry Participation table is shown in Table 8-2 and Table 8-3. It is interesting to compare the General Electric industry table to the industry table of General Motors. This comparison highlights the multi-faceted, conglomerate nature of General Electric’s operations, versus the relatively focused operations of General Motors. In spite of this, both these corporations had very similar Fortune 100 lives between 1955 and 2008.

It should also be noted that both General Motors and General Electric have significant business operations in both manufacturing and financial services. Their financial services operations both cover areas such as consumer financing. It is also worth noting that whereas General Motors, unlike General Electric, has been significantly impacted by the decline in automotive sales in 2008, both have been directly impacted by the extreme turmoil that has
impacted the financial services industries in 2008. For General Electric especially, the current size of their financial operations is such that it has suffered a major decline in its profitability and share price as a direct result of its significant financial services exposures. This situation is well captured by Bary in his quote in Barron’s Online:

A key problem for GE is that GE Capital is an enormous borrower with some $540 billion of debt outstanding at the end of the second quarter (2008). With GE Capital credit-default swaps trading at about 3 percentage points today, double recent levels, the company's financing costs may soon rise, squeezing profit margins. There also have been some investor fears about GE Capital's commercial and residential mortgage exposure as well as the adequacy of its loan-loss reserves. (Bary, 2008)

It is worth noting, especially with respect to a study focused on the rates of corporate decay, that in 1896 General Electric was one of the original 12 companies listed on the newly-formed Dow Jones Industrial Average, and that 112 years later, it is the only one of the original companies remaining in the Dow. In 2008, however, GE is facing formidable new challenges.

From an unrelated diversification perspective, General Electric’s industry participation reveals significant strength compared to the relative fragility of General Motors’ industry participation. General Electric has over three times the unrelated diversification compared to General Motors. This diversification fragility refers to the thesis that corporations with low unrelated diversification will be less able to protect themselves in the event of a significant business environment change. General Motors ability to consistently track at the top of the Fortune 100 between 1955 and 2008 appears present a falsifying observation to this thesis, however the results of the last 18 months suggest otherwise. General Electric has survived without significant government assistance in the recession of 2008 while General Motors was forced into bankruptcy in June 2009.
Table 8-1. General Motors industry participation in 2008, listed by NAICS code (Hoover's, 2008d).

For each business, a two column table has been created, listing each industry in which the business claims it receives a significant part of its revenue. These industry lists include both the U.S. Bureau of Commerce NAICS classification description, and the associated 2 to 6 digit NAICS code. The classification in which the business claims to receives its largest revenue source, is deemed to be the business’ primary industry. This primary classification is added to the industry description, and the text in that row has been displayed in a bold font.

Table removed due to copyright restrictions

Table 8-2. Part 1 of 2 of General Electric’s industry participation in 2008, listed by NAICS code (Hoover's, 2008c).

Note that due to the diversity in General Electric’s industry participation, it was not possible to fit this table on one page. Refer to Table 8-3 for Part 2 of 2 of General Electric’s industry participation.
Table 8-3. Part 2 of 2 of General Electric’s industry participation in 2008, listed by NAICS code (Hoover's, 2008c).

Note that due to the diversity in General Electric’s industry participation, it was not possible to fit this table on one page. Refer to Table 8-2 for Part 1 of 2 of General Electric’s industry participation.
8.7.2 Industry analysis of IBM and Xerox

The second two businesses that were examined from an industry participation analysis perspective were IBM and Xerox. IBM’s industry participation table is shown in Table 8-4, and Xerox’s industry participation table is shown in Table 8-5. These two have been grouped together in this section for review as they are both considered technology stocks and, as their industry participation tables show, they both have significant operations in the 333 and 334 NAICS categories. These categories relate to office equipment manufacturing and computer equipment manufacturing, respectively.

Table removed due to copyright restrictions

Table 8-4. IBM’s industry participation in 2008, listed by NAICS code (Hoover’s, 2008f).

When comparing IBM’s and Xerox’s Fortune 100 lives to their respective industry participation tables, it is clear that IBM has greater diversity in operations compared to Xerox, but it is also worth noting that IBM’s diversity is still significantly less than the diversity of General Electric.
When comparing IBM’s and Xerox’s Fortune 100 lives to their respective industry participation tables, it is clear that IBM has greater diversity in operations compared to Xerox, but it is also worth noting that IBM’s diversity is significantly less than the diversity of General Electric. Comparing IBM to Xerox, IBM has significant operations in computer software and computer services which are lacking in the Xerox operations. Both of these areas have been significant “life-savers” for the IBM corporation (Paulson, 2006), especially with respect to the last 10 years of operations. This timeframe also corresponds to the end of the Xerox lifespan (Markides, 1999) with respect to their existence in the Fortune 100.

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**Table 8-5. Xerox’s industry participation in 2008, listed by NAICS code (Hoover’s 2008e).**

When comparing IBM’s and Xerox’s Fortune 100 lives to their respective industry participation tables, it is clear that IBM has greater diversity in operations compared to Xerox, but it is also worth noting that IBM’s diversity is nowhere close to the diversity of General Electric. During this comparison you should also note the fact that IBM has significant operations in computer software and computer services which are lacking in the Xerox operations. It is also worth noting that both of these areas have been significant “life-savers” for the IBM corporation (Paulson, 2006), especially with respect to the last 10 years of operations. This timeframe also corresponds to the end of the Xerox lifespan (Markides, 1999) with respect to their existence in the Fortune 100.
8.7.3 Industry analysis of Exxon Mobil and Enron

The last two businesses that were examined, from an industry participation analysis perspective, were Exxon Mobil and Enron. Exxon Mobil’s industry participation table is shown in Table 8-6 and Table 8-7, while Enron’s industry participation table is shown in Table 8-8. Although this is admittedly a comparison of extremes, these two businesses were grouped together for review as they are both considered energy stocks, and as their industry participation tables show, they both have significant operations in the 221 and 486 NAICS categories. These categories relate to energy generation and pipeline operations.

When comparing Exxon Mobil’s and Enron’s industry participation tables, it is clear that Exxon Mobil has a very impressive diversity of operations, especially with respect to energy and petro-chemicals. This depth of diversity reflects Exxon Mobil’s vertical and horizontal industry integration and may well support its consistently high ranking in the Fortune 100 for the whole period since 1955, including the massive economic environment discontinuity that prevailed in 2008.

Any comparison of Exxon Mobil with Enron is going to be a comparison of extremes, especially considering that Enron went into bankruptcy in late 2001. The review with respect to Enron in 2008 is the Enron Recovery Corporation which is focused on recovering the remaining Enron assets, for distribution back to the remaining Enron creditors. A number of interesting observations should be noted about this situation. The first one, is that in spite of being in receivership for over 4 years, Enron’s revenue in 2007 was over $2.7 billion. Furthermore, it underlines the difficulty of defining the end of life of a corporation, or the extinction of a corporation, and therefore underlines the difficulty of defining the lifespan of a corporation. The Enron that existed in 2000 is definitely extinct, but some significant assets, and some not-insignificant operations, are still in existence as late as 2008.
Table 8-6. Part 1 of 2 of Exxon Mobil’s industry participation in 2008, listed by NAICS code (Hoover’s, 2008b).

Note that due to the diversity in Exxon Mobil’s industry participation, it was not possible to fit this table on one page. Refer to Table 8-7 for Part 2 of 2 for the balance of Exxon Mobil’s industry participation.
Table removed due to copyright restrictions

Table 8-7. Part 2 of 2 of Exxon Mobil’s industry participation in 2008, listed by NAICS code (Hoover’s, 2008b).

Exxon Mobil has a very impressive diversity of operations, especially with respect to energy, utilities, and petro-chemicals. This depth of diversity reflects Exxon Mobil’s vertical and horizontal industry integration and surely goes hand-in-hand with its consistently high ranking in the Fortune 100 for the whole period of the study, including the massive economic environment discontinuity that prevailed in 2008. Refer to Table 8-6 for Part 1 of 2 for the balance of Exxon Mobil’s industry participation.
Any comparison of Exxon Mobil with Enron is going to be a comparison of extremes, especially considering that Enron went into bankruptcy in late 2001. What we are really reviewing with respect to Enron in 2008 is the Enron Creditors Recovery Corporation which is focused on recovering the remaining Enron assets for distribution back to the Enron creditors. A number of interesting observations should be noted about this situation. The first one is that in spite of being in receivership for over 5 years, Enron’s revenue in 2007 was over $2.7 billion (Enron, 2008a). Furthermore, it once again underlines the difficulty of defining the extinction, and therefore the lifespan of a corporation. Most business analysts would probably conclude that the Enron that existed in 2000 is definitely extinct, however, some of its assets are clearly still in existence as late as 2008.

### 8.8 Business fitness landscape analysis

The third area of micro-analysis involved the creation and analysis of a three dimensional (3D) business fitness landscape model of Xerox and a four dimensional (4D) landscape of General Electric. The process that was developed for creating and analyzing 3D and 4D business fitness landscapes was described in detail in Chapter 6. This area of micro-analysis used the data captured in the business’ industry participation table that was described in detail in Section 8.7.

#### 8.8.1 The 3D business fitness landscape of Xerox

Figure 8-4 shows the 3D business fitness landscape of Xerox. This landscape was built using the Xerox industry participation analysis that was described in Section 8.7.2 and
made use of industry growth and industry sizing data collected from the U.S. Bureau of Economic Analysis (BEA, 2008). Table 8-9 summarizes the data that was used to build this 3D landscape. Notice that there are only two peaks in the Xerox landscape, revealing a lack of diversity relative to the General Electric conglomerate model as revealed in the General Electric industry participation Table 8-2 and Table 8-3, and as shown in the General Electric business fitness landscape of Figure 8-6.
Table 8-9. Shows the 3D business fitness landscape input data form for Xerox as of 2008.

A detailed description of the design of this form and the parameters used in the form were described in detail in Chapter 6. Note that the NAICS codes used in this form are the same as the codes referred to in Table 8-5, however in this form the codes have been divided by 10,000 for normalization purposes and to emphasize the three most significant digits of the NAICS code. Also note that only industries which have a difference in the three most significant digits are identified in this form and in the subsequent landscape. The fitness landscape created from this input data is shown in Figure 8-4.
8.8.2 The 4D business fitness landscape of General Electric

Together, Figure 8-5 and Figure 8-6 show the four dimensional business fitness landscape of General Electric. The additional dimension, over the 3D model, is the dimension of time. A series of 3D landscapes, associated with different timeframes are used to create the 4D landscape. These landscapes were built from the General Electric industry analysis that was described in Section 8.7.1 and made use of industry growth and industry sizing data collected from the U.S. Bureau of Economic Analysis (BEA, 2008). Table 8-10 summarizes the data that was used to build this four dimensional landscape.
Table 8-10. The 4D business fitness landscape input data form for General Electric in 2004.

A detailed description of the design of this form and the parameters used in the form were described in detail in Chapter 6. Note that the NAICS codes used in this form are the same as the codes referred to in Table 8-2 and Table 8-3, however in this form the codes have been divided by 10,000 for normalization purposes and to emphasize the three most significant digits of the NAICS code. Also note, that only industries which have a difference in the three most significant digits are identified in this form and in the subsequent landscape. The fitness landscape created from this input data is shown in Figure 8-5.
Figure 8-5. The 4D business fitness landscape of General Electric in 2004.

The dimensions shown are \( i_n = \) industry NAICS code, \( i_c = \) industry concentration, \( i_s = \) industry size, and \( i_t = \) industry landscape timeframe. Together, Figure 8-5 and Figure 8-6 show the four dimensional business fitness landscape of General Electric. The additional dimension, over the 3D model, is the dimension of time. A series of 3D landscapes, associated with different timeframes are used to create the 4D landscape.

The creation of these business fitness landscapes was described in detail in Chapter 6. Note the five diverse peaks in the landscape, suggesting a high business diversity fitness index (BDFI) for General Electric. An analysis of the General Electric BDFI will be examined in detail in Section 8.9. Refer to Figure 8-6 to see the year 2007 timeframe of General Electric’s 4D business fitness landscape.
The dimensions shown are $i_n =$ industry NAICS code, $i_c =$ industry concentration, $i_s =$ industry size, and $i_t =$ industry landscape timeframe. Together, Figure 8-5 and Figure 8-6 show the four dimensional business fitness landscape of General Electric. The additional dimension, over the 3D model, is the dimension of time. A sequence of 3D landscapes, associated with different timeframes, are used to create the 4D landscape.

The creation of these business fitness landscapes was described in detail in Chapter 6. Note the five diverse peaks in the landscape, suggesting a high business diversity fitness index (BDFI) for General Electric. An analysis of the General Electric BDFI will be examined in detail in Section 8.9. Refer to Figure 8-6 to see the year 2004 timeframe of General Electric’s 4D business fitness landscape.

Note the significantly higher peak in the rear of the landscape. This peak relates to General Electric’s increasing dependence on the finance industry.

### 8.9 Business diversity fitness index analysis

The fourth area of micro-analysis is focused on determining the business diversity fitness index (BDFI) of the two businesses whose landscapes were created in Section 8.8, that is, Xerox and General Electric. The creation of the BDFI, and its application was described in
In review, the BDFI is a direct measure of the diversity of industries in which a business has significant revenue-earning operations. The BDFI is directly related to a business’ corresponding fitness landscape in that it is created from the same data that is used to create the fitness landscape. In general descriptive terms, the BDFI is a measure of the number of significant peaks, and the relative separation of those peaks. As such, it can be argued that it is an effective measure of a business’ ability to withstand changes to its business landscape, or business environment.

The choice of Xerox and General Electric was designed to underline the application of the BDFI as a measure of business diversity. This emphasis was achieved by comparing a relatively non-diversified corporation such as Xerox, to the relatively highly diversified corporation, General Electric.

8.9.1 The business diversity fitness index of Xerox

Table 8-11 shows the completed BDFI Calculation Form for Xerox. All the industry data for Xerox, including the NAICS codes, industry size and industry concentration, is the same information that was used in calculating Xerox’s business fitness landscape as shown in Figure 8-4. As this data was entered into the cells on the form, that is, those cells with the white background, the BDFI was automatically calculated and displayed in summary form, as one to five stars, at the bottom of the form.

As described in detail in Chapter 7, each industry participation area of the business being studied was automatically flagged with a “1” or “0” flag. These flags can be seen in the column labeled “Business Fit” on the BDFI Calculation Form. A “1” flag indicates that the industry participation was relatively both significant and independent, or the fact that it was the business’ primary industry. A “0” flag was generated if the industry participation was either, relatively not significant, or not independent. The total number of “1” flags was used to calculate the final BDFI, and this index was displayed as a one to five star rating at the
bottom of the BDFI Calculation Form. In the case for Xerox, the diversity index was
determined to be a low diversity rating of only one star.

Note that for Xerox, it received one flag of “1” for its primary industry “Photocopy
Equipment”, and a flag of “0” for its secondary industry area, “Computer Equipment
Manufacture”. This flag “0” was due to two issues associated with this secondary industry of
Xerox; namely, that Xerox’s “Computer Equipment” participation had low separation from
its primary industry, and also because it had a low business position rating in that industry.
These two issues can be seen in the two columns labeled, “Business Sep” and “Business
Vitality”, respectively.
**Business Diversity Fitness Index (BDFI) Calculation Example**

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<th>Business: Xerox</th>
</tr>
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</table>

<table>
<thead>
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<th>competitor</th>
<th>Sep</th>
<th>Vitality</th>
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<td>6.9%</td>
<td>30%</td>
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<td>20%</td>
<td>0.0123</td>
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<td>10.0%</td>
<td>43.2%</td>
<td>30%</td>
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</tbody>
</table>

**Weights:**

- Ws: 2.00
- Wg: 4.00
- Wc: 1.50
- Wp: 1.00

**BDFI:** 1.00

Table 8-11. An example of the Xerox BDFI Calculation Form that was first introduced and described in detail in Chapter 7.

In this example, the BDFI Calculation form has been loaded with the same data that was used to calculate the business fitness landscape for Xerox. In this application, however, that same data creates a BDFI rating for Xerox that will range from one to five stars. One star is the lowest possible rating and describes a business that has a minimal business diversity. Five stars refers to a business that has an excellent business diversity. In this case, Xerox shows that it has very low business diversity.

**8.9.2 The business diversity fitness index of General Electric**

In the case of General Electric, the BDFI revealed a very high business diversity fitness index of five stars. As shown in Table 8-12, General Electric received one flag of “1” for its primary industry “Credit Intermediation”, and seven other flag “1”s for its multiple secondary industry areas. All these secondary industry areas show significant separation from General Electric’s primary industry, and reveal General Electric’s strong business positioning and business vitality in each of its secondary industries. The end result is that General Electric received the highest possible BDFI rating of five stars.
### Business Diversity Fitness Index (BDFI) Calculation Example

#### Landscape: USA GDP 2007

#### Business: GE

<table>
<thead>
<tr>
<th>#</th>
<th>Industry</th>
<th>NAICS</th>
<th>Industry Size</th>
<th>Industry Growth</th>
<th>Industry Concent</th>
<th>Industry Rel</th>
<th>Industry Dom</th>
<th>Business Posit</th>
<th>Business Bype</th>
<th>Pri Sec</th>
<th>Sec NAICS</th>
<th>Pri NAICS</th>
<th>Business Sep</th>
<th>Business Vitality</th>
<th>Business Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Machinery Mfg</td>
<td>33.3</td>
<td>49.3%</td>
<td>11.2%</td>
<td>6.9%</td>
<td>30%</td>
<td>S</td>
<td>333000</td>
<td></td>
<td>100%</td>
<td>0.0615</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Electrical Equip.</td>
<td>33.5</td>
<td>20.2%</td>
<td>10.0%</td>
<td>43.2%</td>
<td>30%</td>
<td>S</td>
<td>335000</td>
<td></td>
<td>100%</td>
<td>0.0581</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Transportation Eq.</td>
<td>33.6</td>
<td>79.9%</td>
<td>27.4%</td>
<td>34.1%</td>
<td>30%</td>
<td>S</td>
<td>336000</td>
<td></td>
<td>100%</td>
<td>0.1275</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Credit Intermediation</td>
<td>52.2</td>
<td>98.5%</td>
<td>47.6%</td>
<td>50.9%</td>
<td>50%</td>
<td>P</td>
<td>522000</td>
<td></td>
<td>100%</td>
<td>0.3051</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Rental and Leasing</td>
<td>53.2</td>
<td>17.2%</td>
<td>41.5%</td>
<td>43.8%</td>
<td>30%</td>
<td>S</td>
<td>532000</td>
<td></td>
<td>100%</td>
<td>0.1065</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Professional, scie.</td>
<td>54.0</td>
<td>89.2%</td>
<td>62.8%</td>
<td>22.5%</td>
<td>30%</td>
<td>S</td>
<td>540000</td>
<td></td>
<td>100%</td>
<td>0.1854</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Information</td>
<td>51.0</td>
<td>90.3%</td>
<td>61.1%</td>
<td>40.0%</td>
<td>30%</td>
<td>S</td>
<td>510000</td>
<td></td>
<td>100%</td>
<td>0.1941</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>Health Care and S.</td>
<td>62.0</td>
<td>100.0%</td>
<td>53.9%</td>
<td>10.0%</td>
<td>30%</td>
<td>S</td>
<td>620000</td>
<td></td>
<td>100%</td>
<td>0.1722</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Weights:
- Ws: 2.00
- Wg: 4.00
- We: 1.50
- Wp: 1.00
- Ts: 10000
- Tf: 0.0200

**BDFI:** 5.00  

#### Table 8-12. General Electric’s BDFI Calculation Form.

In this table, General Electric receives one flag of “1” for its primary industry “Credit Intermediation”, and seven other flag “1”’s for its multiple secondary industry areas. All these secondary industry areas show significant separation from General Electric’s primary industry, and reveal General Electric’s strong business positioning and business vitality in each of its secondary industries. The end result is that General Electric receives the highest possible BDFI rating of five stars.

### 8.9.3 The vulnerability of Xerox, compared to General Electric, to discontinuous business environment change based on BDFI analysis

Based on the previous BDFI analysis, it is observed that Xerox has a significant participation in two relatively separate industries. This is in contrast to General Electric which has a significant participation in 8 separate industries. This information alone, while excluding the industry separation, industry strength, and corporate positioning within the industries, al factors taken into consideration in the BDFI, suggests that Xerox is up to 4 times more likely to be impacted by a discontinuous business environment change when compared to General Electric. This environmental impact could be a change in government regulation, geopolitical, technology change, or any other change that is significant enough and sudden enough to create an environmental impact that forces the corporation into the decay phase of the corporation lifecycle before the corporation has time to adjust to the change.
8.10 Theta and Tau analysis

The fifth and last area of micro-analysis was focused on the calculation and application of the Theta and Tau risk parameters to the two businesses whose BDFI was just calculated. That is, the focus of this section is to calculate and review the Theta and Tau of Xerox and General Electric. The creation of Theta and Tau, and their applicability, were described in detail in Chapter 5.

As described in Chapter 5, Theta is a new risk parameter and is a probability measure of a business’ half-life, relative to a set of businesses, of which it is a member. Tau, meanwhile, is also a new risk parameter, and is a probability measure of a business’ mean-life. As shown in Chapter 5, for a group of businesses experiencing a constant attrition rate “A”, then they will have a half-life Theta (θ), and a mean-life Tau (τ), which relates to the attrition rate A, according to the following two relationships:

\[ \theta = \frac{\ln(2)}{A} \] (8.1)

\[ \tau = \frac{1}{A} \] (8.2)

8.10.1 The Theta and Tau of Xerox

As reviewed in Section 8.6.2, Xerox was a member of the Fortune 100 between 1970 and 2000. In 1970, and as detailed in Chapter 5, the Fortune 100 had an exponentially trending Theta of 13.8 years and an exponentially trending Tau of 19.9 years. By 2000, however, the Theta and Tau of the Fortune 100 had decreased to 8.1 years and 11.7 years, respectively. These numbers, therefore, are the applicable Theta and Tau of Xerox, assuming you consider Xerox to be a typical member of the Fortune 100 set during this period.

This perspective on the Theta and Tau of Xerox as a member of the Fortune 100 is informative, but it can also be misleading. It does provide approximate boundaries as to the probable life of Xerox. But “probable” is the limit of certainty that can be applied. In 1970,
for example, based on the analysis, and assuming the Fortune 100 half-lives are normally distributed, one could have stated that the expected half-life of Xerox in the Fortune 100 is 13.8 years, with a standard deviation in the reference attrition rate of 1.0%. Factoring in this standard deviation, one can also say that there is a 95% probability (that is, within two standard deviations) that Xerox’s half-life will be between 9.9 and 33.3 years.

It is to be expected that Fortune 100 attrition rates will vary depending on the industry groupings of its members. This analysis can be taken further, therefore, by analyzing the Theta and Tau of Xerox with respect to members in the Fortune 100 who have similar industry participations to Xerox. Table 8-13 shows the major industry areas that were used in this study of industry participation by major industry area. The major industries in this analysis were considered to be defined by the two most significant digits in the six digit NAICS codes. This approach may be successful in saying more about the typical lifespan of Fortune 100 corporations that are in manufacturing. The problem, however, is that based on the relatively small number of Fortune 100 manufacturing businesses in the research database, any conclusion will have significant potential for error.
### Table 8-13. Breakdown of the major industries used in the Fortune 100 Theta and Tau analysis.

The Theta and Tau analysis was completed using the whole Fortune 100 and also by analyzing the Theta and Tau of the selected businesses with respect to members in the Fortune 100 who have similar major industry participation to the major industry participation of the selected business. This Table shows the major industry areas that were used in this study. A major industry in this analysis is defined by the two most significant digits in the six digit NAICS code.

<table>
<thead>
<tr>
<th>Industry</th>
<th>NAICS</th>
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<tbody>
<tr>
<td>Agriculture</td>
<td>11</td>
</tr>
<tr>
<td>Mining</td>
<td>21</td>
</tr>
<tr>
<td>Utilities</td>
<td>22</td>
</tr>
<tr>
<td>Construction</td>
<td>23</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>31</td>
</tr>
<tr>
<td>Wholesale Trade</td>
<td>42</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>45</td>
</tr>
<tr>
<td>Transport</td>
<td>48</td>
</tr>
<tr>
<td>Information</td>
<td>51</td>
</tr>
<tr>
<td>Finance</td>
<td>52</td>
</tr>
<tr>
<td>Professional Services</td>
<td>54</td>
</tr>
<tr>
<td>Education</td>
<td>61</td>
</tr>
<tr>
<td>Entertainment</td>
<td>71</td>
</tr>
<tr>
<td>Other Services</td>
<td>81</td>
</tr>
<tr>
<td>Government</td>
<td>82</td>
</tr>
</tbody>
</table>

#### 8.10.2 The Theta and Tau of General Electric

Having looked at the Theta and Tau of a relatively non-diversified corporation such as Xerox, it was of interest to look at the Theta and Tau of a highly diversified corporation such as General Electric. As reviewed in Section 8.6.1, General Electric was a member of the Fortune 100 during the whole period of the Fortune 100 analysis, namely 1955 to 2008. In 1955 for example, and as detailed in Chapter 5, the Fortune 100 had an exponentially trending Theta of 18.0 years and an exponentially trending Tau of 26.0 years. By 2008, however, the Theta and Tau of the Fortune 100 had decreased to 7.1 years and 10.2 years, respectively. These numbers, therefore, are the applicable Theta and Tau of General Electric, relative to the total Fortune 100.
8.10.3 Analysis of General Electric’s and Xerox’s BFL, BDFI, Theta, Tau, and actual life in the Fortune 100

Table 8-14 summarizes the analysis of General Electric’s and Xerox’s BFL, BDFI, Theta, Tau and actual life span in the Fortune 100. In reference to this table it should be noted that the second column summarizes the number of significant peaks that make up the corporation’s Business Fitness Landscape. The third column summarizes the corporation’s Business Diversity Fitness Index rating. The fourth and fifth columns summarize the corporation’s half life or Theta for the first and last year in which the corporation has been tracked in the Fortune 100. The sixth and seventh columns summarize the mean life or Tau for the first and last year in which the corporation has been tracked in the Fortune 100. The eighth or last column details the actual lifespan of the corporation in the Fortune 100.

Figure removed due to copyright restrictions

Table 8-14 Analysis of General Electric’s and Xerox’s BFL, BDFI, Theta, Tau, and actual life in the Fortune 100

The second column summarizes the number of significant peaks that make up the corporation’s Business Fitness Landscape. The third column summarizes the corporation’s Business Diversity Fitness Index rating. The fourth and fifth columns summarize the corporation’s half life or Theta for the first and last year in which the corporation has been tracked in the Fortune 100. The sixth and seventh columns summarize the mean life or Tau for the first and last year in which the corporation has been tracked in the Fortune 100. The eighth or last column details the actual lifespan of the corporation in the Fortune 100.

As was detailed in Section 2.4, this research is focused on proposing and developing new demographic tools (Bettis, 1981; Bettis and Hitt, 1995; Burgelman, 1991; Carroll and Hannan, 2004; Freeman and Hannan, 1983; Hannan, 1998; Hannan and Freeman, 1977; Hannan and Freeman, 1993; Jovanovic, 2001; Lovas and Ghoshal, 2000; Nelson and Winter, 1982; Singh and Lumsden, 1990) that focus on whole populations and communities of
corporations, versus focusing on individual corporations. The six case studies detailed in this Chapter demonstrate how these tools can be applied, but a detailed demographic analysis using these tools is outside the scope of this research.

8.11 Closing comments on the chapter

The Theta and Tau analysis of General Electric closed the application of the business fitness landscape tools to the six selected businesses. The micro analysis documented in this Chapter describes the movement of the focus of the research from theory to application. In clarifying the strengths and weaknesses of the tools and how they can be used to obtain a better understanding of the metrics and forces applicable to an analysis of the lifespan of specific corporations and their associated business fitness landscapes, this analysis has been an important precursor to the next step. Namely, a detailed look at the conclusions and recommendations arising from the research.
9 FINDINGS, CONTRIBUTIONS, CONCLUSIONS, AND RECOMMENDATIONS

In this final chapter, the findings, contributions, conclusions and recommendations of the research are presented. The presentation of this information has been divided into four sections. The first section leverages the whole of the research as it presents a macro perspective on all the issues that were the focus of the research. The second section summarizes each chapter by their key contributions to the scholarly research. The third section presents the overarching conclusions that arose from the research. The fourth, and final section, presents the overall implications and recommendations for future research.

9.1 A new perspective on the research issues

The focus issue of the research was to extend the body of knowledge surrounding the analysis of the decay of large corporations. In addressing this issue, the research focused on both reviewing and extending the existing research, models and metrics that are available to discuss, monitor and analyze the decay of modern large corporations. The approach taken to extend this body of knowledge was multi-disciplinary, in that not only were traditional business analysis tools applied and extended, but also an attempt was made to apply tools that have been effective in evolutionary biology, chemistry, physics, and engineering. Extensive mathematical modeling was also applied, including both Gaussian and fractal statistical analysis.

The importance of the corporation decay issue was explained by noting that the rate of corporate decay has increased significantly over the last 50 years. The observation that a significant number of established corporations disappear in any one year, was an important observation that had been noted by a number of researchers (Ferguson, 2008; Foster and Kaplan, 2001; Hannan and Freeman, 1977). The recent financial turbulence of 2008 and early 2009 has significantly increased the relevance of further research into the lifespan of corporations. During the late 1990’s, a period of high growth, bull markets, and plentiful
initial public offerings, the focus of much business analysis was on entrepreneurship and the analysis of the Birth Phase of the corporate life cycle. Today, with the collapse of financial markets and the disappearance of major brand name corporations, it was argued that it was timely to move the focus to the other end of the corporate life cycle. Namely the Decay Phase, in which mature, well established corporations decline into a state of decay.

It was decided early on in the research, to focus on an analysis of the decay of large corporations, versus any attempt to analyze the collapse of all types of corporations. This focus on the largest, most successful corporations, was to restrict the research to just the decay phase of the corporation lifecycle. By focusing the research on the largest corporations the focus could remain on the decay phase of the business cycle, versus any concern surrounding the impact of the multiple factors that are associated with the birth, growth, or maturation phases of a business. In summary, when you are at the top of the mountain, every path takes you down the mountain! Camus captures the inexorable force of decay in this quote from The Myth of Sisyphus:

The gods had condemned Sisyphus to ceaselessly rolling a rock to the top of a mountain, whence the stone would fall back of its own weight. They had thought, with some reason, that there is no more dreadful punishment than futile and hopeless labor (Camus et al., 1975, p.1).

The significance of the research into the decay of corporations had little to do with the confirmation that all businesses eventually decay, but had a lot to do with the fact that people and organizations need to make significant long-term investments in businesses for all sorts of reasons, not least of which include: reward, risk management, and pooling of resources. For many of these investments, all, or a significant portion of those investments, may be invested directly or indirectly in corporate stocks. In the current, 2008 environment of falling stock prices, should these investments be moved from stocks, to cash, or some other investment? Some financial advisors (Horowitz, 2008) are recommending that late 2008 is not the time to pull out of equities as you are in danger of locking in the recent losses. Furthermore, the alternative options have potentially poorer returns, and there is a danger of missing out on any imminent and significant rally in stock prices. In general, they do recommend, that the equity investments should be in large, well capitalized corporations, which have the best prospect of surviving the current financial turmoil. In other words,
equities remain a significant investment area in most well structured portfolios, but as of early 2009, it is probably not advisable to be long-term investor in Citicorp, Saks, Xerox, Eastman Kodak, AIG or General Motors, as these companies could soon disappear. You may even want to ask the same question about General Electric, Ford, and even Bank of America.

These companies, and many like them, especially in a period of rapid, discontinuous business environmental change, may not go extinct, but at least with respect to being viable, independent, high growth corporations, they may well disappear. In this situation, the importance of understanding the decay of large corporations was of special importance. It soon became clear that the best run corporations do appear to decay over time. That being the case, the research focused on what models and metrics could be used to discuss, monitor and analyze the lifespan of a modern large corporation? This was a non-trivial question, and so in response, the research broke the question into specific focus areas. These focus areas, included:

1. What is an effective definition for the decay of a corporation?
2. What is the average life of a modern large corporation?
3. Is the rate of decay of corporations changing?
4. If the rate of decay of corporations is changing, what may be some of the key factors to explain this change?
5. Given a portfolio of corporations, can we predict a half-life or equivalent, in which a given portion of the portfolio will have disappeared or decayed?
6. Some corporations appear to be better equipped to have a longer survival time compared to other corporations. What are some of the attributes of these longer surviving corporations?
7. Since the 1930s, multi-dimensional adaptive landscape models, and fitness landscape models, have been used in the study of the rise and fall of species. Are these modeling techniques helpful in studies of the life spans of well established corporations?
8. Can an effective business fitness landscape model be created that helps to describe and better understand the overall business environment in which corporations collapse?

9. What can the corporation’s business fitness landscape tell us about the likely lifespan of the corporation?

10. How can these tools be applied to analyze a selected business?

11. What does the application of these tools tell us about selected businesses?

9.2 Key findings and contributions

This section documents the key findings and contributions that were a direct result of the research. A finding was determined to be a contribution if it had significant original content and was also deemed to have significant importance to the overall research. It should be noted that these findings and contributions are grouped by chapter, not in an attempt to summarize the applicable chapter, but to simply highlight the important observations, findings and conclusions that were considered to be significant, and to present that information in the same sequence by which they were first introduced in the documentation of the research.

9.2.1 Key findings and contributions presented in the Introduction

The first chapter provided a broad introduction to the research. As such this chapter included background notes to the research, the research objectives, the significance of the research, introduced definitions for the key terms, and described the research methodologies. As the role of this chapter was to provide a broad introduction, it would not be expected to easily lend itself to establishing significant new findings or contributions, however, the following findings and contributions are noted:

1. Contribution: Introduced new, more objective, and more quantifiable definitions for the “lifespan”, “mean-life”, and “half-life” of a business.

2. Finding: Proposed a new, simpler definition for the phases in a typical business life cycle by extending the concepts introduced by a number of researchers
(James, 1974; Miller and Friesen, 1984; Moore, 1995; Quinn and Cameron, 1983). This new life cycle consisted of a complex sequence of multiple phases, of which four basic phase types were identified. These four basic phases were generically referred to as: Birth, Growth, Maturity and Decay

3. Contribution: Introduced how an independent benchmark, such as the Fortune 100 rankings, could be used to define the duration of a business lifespan, and could also be used to set the boundary conditions which define the points where a business moves from one life cycle phase to another.

9.2.2 Key findings and contributions presented in the Literature Review Part One - Conceptual Foundations

The literature review was covered in two parts. The first part of the literature review covered the literature underlying the major conceptual foundations underlying the research. The second part of the literature review covered the literature associated with the existing business indexes, landscapes and technical risk parameters, which were deemed to be relevant to the research into the decay of large corporations, and their associated business fitness landscape. The findings and contributions from the first part of the literature review were:

1. Finding: The general role of metaphor in business analysis modeling, and the particular significance and power of the landscape metaphor.

2. Finding: How the landscape model for describing all sorts of change has evolved over the last 3,000 years.

3. Contribution: Introduction of a key hypothesis, that in the same way that the hybrid model that combines uniformitarianism with catastrophism, provides the most accurate description of the fitness landscape for species survival, it also provides the most accurate landscape model to describe the prevailing environment for businesses in which businesses emerge, thrive, contract, and eventually disappear.
4. Finding: Introduction of the role that rapid, discontinuous change can play in dramatically changing the fortunes of a species or business that was previously less adapted in a previous environment.

5. Contribution: The first use of the concept of the fitness path length with respect to business environment modeling.

6. Contribution: Presentation of a new thesis, namely that established businesses, like species, in an environment of rapid change, don’t survive just by being the fittest; they survive by being located in the optimum position in a new fitness landscape. By optimum position, it is meant that the business which has the shortest path length to a new fitness peak, in a new fitness landscape, will have the best chance of surviving. It therefore follows, that in a very dynamic, changeable fitness landscape, the business which has multiple, viable, but not necessarily, the fittest positions in the fitness landscape, may have a higher probability of not only surviving, but have a high probability of thriving.

9.2.3 Key finding and contributions presented in the Literature Review Part Two - Existing Business Indexes, Landscapes and Key Technical Risk Parameters

The second part of the literature review covered the literature associated with the existing business indexes, landscapes and technical risk parameters. It was important in establishing the key foundations on which the research was to be built. The number of original key contributions in this chapter was significantly less compared to the previous chapter. This reflected the fact that this chapter was focused on studying the existing business indexes, landscapes and technical risk parameters, whereas the previous chapter focused on the more significant, conceptual foundations. A number of significant focus areas for the future research were established in this chapter. These focus areas included: the selection of the Fortune 100 database, the decision to use the NAICS codes, and the decision to extend the risk parameters of modern portfolio theory. The summary, the key findings and contributions presented in this chapter were:

1. Contribution: The value of the Fortune 100 rankings as a benchmark for an analysis of the decay of corporations in the post-war period.
2. Finding: The strength of NAICS as an excellent industry classification system for use in the development of a comprehensive business fitness landscape.

3. Finding: The power and limitations of the key technical risk parameters from MPT and PMPT as key reference points for the development of the new risk parameters required to measure and monitor the rate of decay of corporations.

4. Finding: Identification of the valuable secondary data that resides at the U.S. Census Bureau, Hoover’s, and the SEC’s EDGAR database.

9.2.4 Key findings and contributions presented in the chapter on two new business risk parameters

In the chapter on new business risk parameters the conclusion was reached that neither the risk parameters from MPT, nor the risk parameters from PMPT, adequately factor in the risk applicable to securities, based on the applicable, underlying, business rates of decay. In response, two new risk parameters, Theta and Tau, were introduced, and it was shown how they describe important key relationships relating to the number of surviving businesses over time. The key findings and contributions presented in this chapter were:

1. Contribution: The relationship between the number of surviving businesses \( b \), over time \( t \), given an extinction rate \( A \), was established. It was shown that if \( B_0 \) is the number of businesses at time 0, then the number of surviving businesses at time \( t \) is defined by the relationship \( b = B_0 e^{-At} \).

2. Contribution: A new risk parameter Theta, the half life of a business was developed from mathematical first principles. It was shown that the business half life \( \theta \) is the time it takes for half the businesses in a portfolio to become extinct, and that this time period is equal to \( \ln(2) / A \).

3. Contribution: A new risk parameter Tau, the mean life of a business was developed from mathematical first principles. It was shown that the business mean life \( \tau \), is the mean time it takes for the businesses in a portfolio to become extinct, and that this time period is equal to \( 1/A \).
4. Contribution: That at this mean life time $\tau$, the number of surviving businesses will be $B_0 / e$.

5. Finding: The fact that with the introduction of the two new risk parameters, $\tau$ and $\theta$, the business analyst has effective new metrics for describing and documenting the rate of decay associated with a set of businesses.

9.2.5 Key findings and contributions presented in the chapter on a new analysis on the decay of large corporations

In the chapter on a new analysis on the decay of large corporations, a new approach to the analysis of corporation decay was presented. The key findings and contributions of this section of the research were:

1. Contribution: Introduction of a new approach to the macro analysis of 100 of the largest American corporations, which covered 54 years over the inclusive period of 1955 to 2008. The Fortune 100 ranking was used as an effective, objective benchmark for defining the threshold at which corporations were deemed to have transitioned from the Maturity Phase to the Decay Phase.

2. Contribution: Using a least squared error method an exponential trend line was proposed that shows that the rate of decay of the Fortune 100 corporations over the period 1955 to 2008 is $r_E = 0.037862e^{0.0174(y-1955)}$, where $r_E$ stands for the rate of extinction or decay and $y$ is the calendar year, on or after 1955. It should be noted that this trend line was shown to be the best of five alternative models studied, however, it also showed a significant but low R-squared goodness-of-fit value of only 0.187. As such, using the trend line to predict the expected extinction rate for a given year must be done with care. The extinction rate data was shown to have a standard deviation of 3.3% after excluding the extreme extinction event of 1995.

3. Contribution: After checking to see if the data was sufficiently normal using Tabachnick and Fidell’s (1996) methodology, one sided t-test hypothesis testing was carried out to test the hypothesis that the extinction rate of corporations is
increasing. The finding that the extinction rates for Fortune 100 corporations is increasing was suggested by the inability to reject the two hypotheses that; 1. Between 1956 and 1965 inclusive, being the first ten years of the study, the extinction rate of Fortune 100 corporations was less than 5% per annum, and, 2. Between 1999 and 2008 inclusive, being the last ten years of the study, the extinction rate of Fortune 100 corporations was greater than 10% per annum.

4. Contribution: Introduction of a methodology that uses easily accessible tools, to produce a highly automated process that simplifies the analysis of the rate of decay of corporations over a multi-year timeframe.

5. Contribution: Established that over the last 54 years, the actual annual rate of decay of Fortune 100 corporations has ranged from 2% to 53%.

6. Contribution: Using a detailed analysis of the 53% peak extinction rate of 1995, confirmed that a mild economic contraction, followed by significant economic expansion, can result in a significant decay event.

7. Contribution: Showed that between 1955 and 2008 the exponential trend line, relating to the decay of corporations, suggests that the rate of decay has increased from 3.8% per annum in 1955 to 9.5% per annum in 2008, with a standard deviation of 3.3%.

8. Contribution: Showed how the exponential trend describing the acceleration of the decay rate between 1955 and 2008, suggests that the mean-life trend of Fortune 100 corporations appears to have decreased from 26.4 years to 10.5 years. That is, that the mean-life of Fortune 100 corporations is decreasing by a compound rate of 1.72% per annum. Note that the low R-squared value of 0.187 for this trend line needs to be considered when applying these findings.

9. Contribution: Showed that between 1955 and 2008, the half-life trend of Fortune 100 corporations appears to have decreased from 18.3 years to 7.3 years. Note that the low R-squared value of 0.187 for the associated trend line needs to be considered when applying these findings.

9.2.6 Key findings and contributions presented in the chapter detailing the development of a new four dimensional business fitness landscape model

In the chapter on a four dimensional business fitness landscape model, the work of Wright (1932) on adaptive landscapes was extended and applied to describe the business environment. In this chapter, a 4D business fitness landscape was created and this new business model was applied to the U.S. economy covering a period of ten years. In summary, the key findings and contributions of the research that was documented in this chapter, included:

1. Contribution: Showed how Wright’s original model of the adaptive landscape could be extended to create a new business model. The new model extended Wright’s original two dimensional adaptive landscape model, to a new four dimensional business fitness landscape model. Furthermore, the new four dimensional model leveraged the powerful landscape metaphor to create a tool with the potential to view the dynamics of a complex business landscape in a new and informative perspective.

2. Finding: Illustrated how publicly available secondary business data could be viewed in a context that fully leverages the power of the landscape metaphor.

3. Contribution: Developed a new multi-dimensional business landscape model, that uses not only additional dimensions, but also space, size, shape, texture and color, to show how it could be effective in revealing the multi-faceted dynamics of today’s complex business environment.

4. Contribution: Demonstrated how easily accessible tools such as Microsoft Excel could be used to build an information rich business landscape model, that is extensible and relatively easy to apply.
5. Contribution: Mathematically defined the new business landscape model so as to aid future analysis and to enable the extension of the model. Using the 3D Gaussian as the elemental building block, the 4D business fitness landscape was shown to be described by the sequence:

\[ L_{4D} = \sum_{p=1}^{q_1} \sum_{t=0}^{r_1} \sum_{p=1}^{q_2} \sum_{t=0}^{r_2} \left( \frac{1}{\sigma_{x_1} \sqrt{2\pi}} e^{-\frac{(x_{x_1} - \mu_{x_1})^2}{2\sigma_{x_1}^2}} \right) \]

Please refer to Chapter 6 and the Glossary Of Mathematical Symbols for a detailed description of the terms used in this sequence.

7. Contribution: Created a model that was as automated as possible. That is, the model requires the minimal intervention and work by the business analyst in taking new business data and using that data to create a new business landscape.

9.2.7 Key findings and contributions presented in the chapter on a business diversity fitness index

The objective of the research as presented in the chapter on a business diversity fitness index was to simplify and extend the landscape model that was developed in the previous chapter, by exploring the creation of a simple index by which one business could be quantifiably compared directly with another business. The BDFI described in this chapter is the new business fitness index that was introduced to satisfy that objective. The key findings and contributions of the research that were presented in this chapter were:

1. Contribution: Developed an index that allows the diversity of industry participation fitness of one business to be directly compared to the fitness of another business.

2. Finding: Demonstrated that the BDFI successfully leverages the same data that is used to create the fitness landscape.
3. Finding: Showed how the new index was designed to be extensible and easy to apply, while making use of easily accessible tools.

4. Contribution: Defined the index mathematically, in as much detail as possible, as an aid to future analysis, and to assist in the extension of the index by future researchers. Leveraging much of the same data that is used to create the associated business fitness landscape, the BDFI was shown to be described by the following inequality:

\[
BDFI = \sum_{m=1}^{N} \frac{W_p b_m (W_s j_{s_m} + W_g i_{g_m} + W_c i_{c_m}) (|l_{i_{p_m}} - i_{m}|)}{T_s (W_s + W_g + W_c)} > T_f
\]

Please refer to Chapter 7 and the Glossary Of Mathematical Symbols for a detailed description of the terms used in this inequality.

9.2.8 Key findings and contributions from the chapter on the application of the modeling tools to selected large corporations

While the earlier chapters introduced and developed the business fitness landscape modeling tools, the aim of this chapter was to examine those tools in a more empirical perspective. In this chapter the tools that were developed during the research were applied to a selection of Fortune 100 corporations. This chapter moved the discussion from tool development and macro analysis, to a detailed, applied, micro analysis, associated with a small set of selected corporations. The key findings and contributions associated with the application of the modeling tools to selected large corporations were:

1. Contribution: Verification that at least for the small sample of selected corporations, there was a correlation between their observed Fortune 100 lifecycles, their Theta and Tau, their business fitness landscape, their BDFI, and the diversity of their industry participation tables.

2. Finding: Evidence that revealed the surprising diversity of long-term Fortune 100 leaders such as GE and Exxon Mobil.
3. Finding: Evidence of the potential fragility, from a business diversity perspective, of General Motors.

4. Finding: Verification of Xerox’s short Fortune 100 life span and an associated lack of industry diversity. In juxtaposition to the Xerox study, the research into IBM revealed IBM’s relatively long life span being associated with a high level of industry diversity.

5. Finding: Showed how the 3D business fitness landscape of Xerox reveals its inherent vulnerability to discontinuous business environment change, compared to GE’s relatively robust positioning.

9.3 Conclusions

This discussion of the overarching conclusions has been grouped into seven main areas. These main areas are:

1. Business lifecycle
2. Lifecycle trends
3. Landscape modeling
4. Risk parameters
5. Importance of diversity
6. Fitness index
7. Application of the theory

The following discussion will examine each of these areas in detail.

9.3.1 Business lifecycle

The lifecycle of any corporation can be well described by combinations of four simple lifecycle phases. These lifecycle phases are Birth, Growth, Maturity and Decay. It was noted that in a given corporation lifecycle not all these phases may be present and that there may
occur multiple instances of a given phase. In addition, the thresholds or the boundary conditions that define the start and end of the Maturity Phase, may be set by the use of a predefined and well know benchmark, such as the Fortune 100 rankings. Such a benchmark therefore, makes an effective, quantifiable, and objective measure, for both the life span of a corporation and for determining the attrition rate for a set of corporations. Furthermore, once the attrition rate for a set of corporations can be defined, then the research showed how that attrition rate can be used to determine both the mean life and the half life for the set of corporations.

9.3.2 Lifecycle trends

Having defined the means and the metrics, it was shown how it is now possible to document the historical trend in the mean life and the half life of corporations. Using these techniques, as well as by developing a new approach to the analysis of the decay of large corporations, it was shown that since 1955 the mean life of Fortune 100 corporations has been declining by a compound rate of 1.72% per annum.

9.3.3 Landscape modeling

The changes observed in the expected mean life spans and half lives, although important, fail to identify or explain why some corporations clearly have longer life spans compared to other corporations. This basic observation motivated the investigation of the use of the adaptive landscape model to see if there was a possible business environment factor that might explain why some corporations were better able to withstand the gales of change compared to other corporations. The motivation to develop an information rich business landscape, led to the development of a new four dimensional, business fitness landscape model.

The research looked at a number of possible models that may have applicability to business environments in general. In that process, the power of the landscape metaphor was introduced and the use of that landscape model over the last 3,000 years was examined in detail. This review led to a discussion on Wright’s (1932) introduction of the adaptive landscape and this adaptive landscape and its applicability to the evolution of species was
extended to the fitness landscape of business. This extension of Wright’s model led to the understanding that it has potential to assist in identifying which businesses may be best suited to survive rapid, discontinuous change in the general business environment.

### 9.3.4 Risk parameters

Business survival in a business landscape of near continuous change was identified as a topic of significant importance. As such the research focused on the metrics of corporate decay over time. The significance of the rate of decay of large corporations is such that any long term investment portfolio which is significantly exposed to the fortunes of these large corporations need to take into consideration the lifespan of the corporations. As such, it was suggested that the risk parameters of MPT and PMPT need to be extended to include risk factors that monitor the lifespan of corporations. As a consequence, the risk parameters Theta and Tau were developed to provide the investor with an important statistical handle on the expected mean life and the expected half life of corporations.

### 9.3.5 Importance of unrelated diversification

The research into the landscape metaphor and the various landscape models for broad, environmental change, led to probably the most significant thesis that arose out of the research. That thesis was that established businesses, like species in an environment of rapid change, don’t necessarily survive just by being the fittest, or most adapted to a given environment, but may significantly increase their chance of surviving by maximizing their diversity. That is, by being located in multiple positions, some of which have a certain probability of being close to an optimum position in a new fitness landscape. Survival success may have more to do with diversity, and that selection of the “fittest” may have more to do with fortuitous selection that often arises out of the nonlinearities that characterizes the point of rapid, discontinuous change. The power of this nonlinearity was seen in 1994 to 1995 and will most likely be seen in the economic nonlinearity that characterizes 2008 to 2009. In an environment of rapid change having multiple paths to a multiple new fitness peaks may have significant advantages.
9.3.6 Fitness index

It was shown how there existed the possibility that corporations that had extremely rugged and diverse industry participation landscape, should have a stronger ability to withstand a business environment impact which significantly damaged any one fitness peak. It was also suggested that for those corporations which had the most diversity, or the highest diversity path length, may well be best placed to leverage the success that might follow from participation in an emerging, new, fast growing, industry fitness peak.

The importance of the concept of the diversity path length is such that the research went on to establish a practical model for calculating the diversity path length. The BDFI which emerges out of this research was described in detail and the methodology for applying it to a typical, large, Fortune 500 corporation was explained by example. The BDFI allows for the first time a means to directly compare the fitness of a corporation, as measured by its diversity of operations.

9.3.7 Application of the theory

Having developed the theory and the tools, the research then moved to apply the research to a selection of Fortune 100 corporations. This application of the modeling tools to selected large corporations not only showed how the tools and models can be applied to corporations, it suggested important new explanations as to why some types of corporations experience significantly longer life spans than other corporations. The application of the theory suggests that whereas diversity of operation may threaten the survival of a start-up due to the danger of spreading limited resources too thinly, for a mature large corporation this maybe exactly what is required to survive the discontinuous change that characterizes today’s dynamic business environments.

9.3.8 A review of the exponential trends observed in the research

When reviewing the research it should be noted that more than one exponential trend has been described and documented. These exponential trends have different applications, have different levels of accuracy, and are effectively independent of each other. In conclusion therefore it is worthwhile to review these exponentials.
9.3.8.1  **Exponential 1 (always seen in a sufficiently large population, given a rate of decay)**

The research introduces two new portfolio risk parameters. Namely:

1. **Theta or Half-life**: defined as a measure of the average time it takes for half of the businesses in a portfolio or group to decay. Decay is defined as the stage at which a specified business is removed from the underlying benchmark, group or set, to which the nominated business was deemed to belong.

2. **Tau or Mean-life**: defined as the mean time it takes for the businesses in a portfolio or group, to decay.

Assuming that a rate of decay does exists, then these two new portfolio risk parameters are shown, using mathematical first principles, to result in an exponential decay over time in the population of surviving corporations. Furthermore if the rate of decay per annum is \( A \) then the half life of a corporation is shown to be \( \ln(2)/A \) and the mean life is shown to be \( 1/A \). Note that this relationship depends on nothing more than the existence of a rate of decay. If a rate of decay exists, than the population will decline exponentially. Just like radioactive decay. The generalized exponential equation describing the population of businesses \( B \) experiencing a decay rate of “\( A \)” is found to be \( B(t) = B_0 e^{-At} \). This relationship, referred to as exponential 1, is well founded from mathematical first principles. The derivation of this exponential relationship is explained in detail in Section 4.3.

9.3.8.2  **Exponential 2 (sometimes seen in the trend associated with a change in the rate of decay)**

While applying the theoretical model of Theta and Tau, the research also detected another exponential trend. That was a trend in the change in the rate of decay per annum over time. That is, some acceleration or deceleration in decay was detected in the period covered by the research. Namely 1956 to 2008.
When a detailed statistical analysis, including one-sided hypothesis t-testing was completed, an important and significant trend was detected. The research showed that there was a 95% confidence that the decay rate in the first decade (1956 to 1965) was less than 5% per annum, while the decay rate in the last decade (1999 to 2008) was greater than 10% per annum. Furthermore, the trend describing the acceleration between these two periods could have been a straight line, a sine wave, an exponential, another function, or some noisy convergence of more than one of these. As it so happened, the research showed that this acceleration is relatively noisy (not surprising given the fact that there are only 100 corporations in the Fortune 100 in any one year), however the function with the best goodness-of-fit was also an exponential. This fit however, was significant but small, being 0.187 or 18.7%. It should be noted that the fact that this acceleration was also, approximately, an exponential, is totally unrelated to exponential 1 that defines the formula for Theta and Tau. Theta and Tau do not depend on Exponential 2. If the decay acceleration was zero, that is a straight horizontal line, then Theta and Tau would still be defined as described above. In other words, the low goodness-of-fit to exponential 2 does not discount the theoretical basis for Theta or Tau.

9.3.8.3 Exponential 3 (sometimes seen or not seen in the rate of decay of individual corporations)

As was detailed in the thesis, the research takes a demographic approach to the study of how portfolios of corporations decay over time. This is not the first time that this approach has been taken. This approach has had wide application in strategic management as relating to the decay of corporations, the lifecycle of the corporation, business environment, business ecology, business evolution, business diversification, and organizational ecology (Bettis, 1981; Bettis and Hitt, 1995; Burgelman, 1991; Carroll and Hannan, 2004; Freeman and Hannan, 1983; Hannan, 1998; Hannan and Freeman, 1977; Hannan and Freeman, 1993; Jovanovic, 2001; Lovas and Ghoshal, 2000; Nelson and Winter, 1982; Singh and Lumsden, 1990).

As a result of this demographic approach there is a danger of losing sight of the forest for the trees. A corporation or population element may well decay slowly, suddenly, exponentially, or via some other timeline. Given an attrition rate, over sufficient time, over a
sufficiently large population, the population will still decline exponentially, independently of the trend-line associated with any individual corporation. In other words, a business analyst should not expect to see exponential decay in any given corporation case study.

9.4 Recommendations and implications for further research

Often when research answers questions, those answers may also generate new questions. Similarly in this research, the findings have generated recommendations and have implications for further research. These recommendations and implications include:

1. Complete a full demographic study of the Fortune 100 using the new tools and methodologies.

2. Exploration of other benchmarks, besides the Fortune 100, as a suitable benchmark for defining when a business move in and out of the different business lifecycle phases. Especially, the investigation of independent benchmarks that are appropriate for smaller corporations compared to the Fortune 100 corporations that were the focus of this research.

3. The application of Theta and Tau as standard new portfolio risk parameters.

4. The construction and analysis of additional 4D business fitness landscapes of a wider range of corporations, in a wider range of industries, in an attempt to identify unique business landscape characteristics.

5. The application of the concepts underlying the BDFI to evolutionary biology and other disciplines.

6. The calculation, publication and application of a five star BDFI rating for all publicly listed corporations.

7. Currently the responsiveness of the user interface that comes with the current version of the model is limited. An analyst can rotate the model up or down, as well as clockwise and anti-clockwise, however the rotations are not smooth due to the large number of calculations required to recreate each view of the model.
Displaying the model using multiple images that have been cached, or the use of a high speed graphical processor in conjunction with a new version of the application, would allow an analyst to explore the landscape in a much more investigative manner. It would also be useful if the model could be extended so that the position of the corporation could be more clearly displayed within each industry peak, and if the NAICS code was automatically added to each peak during the model building process.

8. The extension of the technology underlying the 4D landscape model so that a business analyst can fly over, through, and around the landscape as an aid to exploring and understanding the business environment. The extension of the model in this way may be better understood in terms of imagining the business analyst as an Avatar (Au, 2008; Second Life, 2009), flying over a 3D digital world, exploring a rugged, volcanic terrain, searching for hidden, new business opportunities, and continually on the lookout for violent change. Violent change that may not only destroy once successful businesses, but may also present new opportunities for a well placed, opportunistic business.

9. The BFL model has potential application to financial accounting. A significant amount of research (Bettis, 1981; Fowler and Schmidt, 1989; Hill et al., 1992; Michel and Shaked, 1984; Robins and Wiersema, 1995; Rumelt, 1986) has been undertaken to compare the relative financial performance of related and unrelated diversified firms to relatively undiversified firms. Diversification, as mentioned in this research, poses both significant challenges and opportunities for corporations. Related diversification is often associated with synergistic financial opportunities, however firms appear to have trouble realizing those opportunities (Hill and Hoskisson, 2002). Further research into the financial performance of firms that diversify vertically for financial benefits, rather than for supply chain benefits, is needed. This relative financial performance research, including relative return on assets, return on equity, and return on capital invested, could be mapped directly to a firm’s BDFI. Furthermore, a study linking a firm’s financial performance to its BDFI and to its operational span of control capabilities would be of particular interest to business analysts.
10. Significant research has been carried out on the relative performance of diversified corporation versus less diversified corporations. However many of these studies have covered a relatively short time period and as such the results of the studies may have been influenced by whether or not the economy had been in a state of growth or contraction. The financial performance of these corporations needs to be studied over a longer period, plus any analysis needs to factor-in related diversification versus unrelated diversification.

11. In reviewing the existing research on diversification it was not surprising to find that the bulk of the research focused on the more easily measured and tracked financial performance of corporations with respect to diversification versus non-diversification. However, as pointed out in the research the harder to measure contributions of diversifications, that is those aspects more emphasized by the Austrian School of Economics, appear to require significant additional research. In particular, the costs and benefits of diversification in the areas of:

- Necessary restructuring in response to technological or regulatory change.
- To provide a hedge against possible or future technological or regulatory change.
- To provide increased protection from reduced barriers of entry due to loss of intellectual property protection, tariff changes, and changing market access regimes.
- Market diversification as a hedge against foreign exchange rate or inflation rate risk.
- Market diversification as a hedge against local or regional business cycle risk.
- To find new engines of growth as a corporation or business unit moves into the decay phase of their business lifecycle.
- For increased size as a protection against being acquired.
- Agency objectives in which management or key investors seek to satisfy personal objectives.
- To acquire key processes, skills, or intellectual property for increased competitive advantage, or to establish improved barriers to entry.
- To secure vital supply chain objectives.
9.5 Closing comments on the research

In closing, it is worthwhile revisiting some of Ballmer’s observations which were first presented at the introduction to the research:

The most important decision you make in the technology industry is whether to participate in the hot markets of the future or stay wedded to the hot markets of the past. Very few, I might argue no big technology company has ever really been able to be multicore, until we did. I’d argue that even the great companies generally wind up having a single core, and that core either dies, or gets humdrum, and somebody [else] does the new thing (Ballmer, 2006b).

With Ballmer’s comments in mind, it is worth noting that since the work of Wright in the 1930s it has been well recognized that diversity is critical for a species to survive environmental change. In today’s extremely dynamic business environment, management and shareholders may need not only new tools, but also a new perspective, as well as a new understanding of the role diversity plays in extending the life span of corporations. For if there is one explanation for the incessant increase in the decay of corporations it is the ever increasing market competition that’s today’s leading corporation are exposed. Competition, not just from reduced barriers to entry in a flat world (Friedman, 2007), but also from the incessant rate of technological change. In such an environment, especially for the largest most successful corporations, diversity in industry participation is critical. Hopefully the analysis and tools presented in this research will assist some corporations to resist and slow down the ever increasing rate of corporation decay.

The reader may also be interested to note that as at the 3rd April, 2009, the relatively diversified petroleum corporation Exxon Mobil appears as strong as ever. GM faces imminent restructuring as its CEO is sacked at the request of its most significant investor, the U.S. Government. GE’s share price is starting to recover. IBM is poised to grow stronger with talk of possible new acquisitions. Meanwhile Microsoft experiences a typical day, peering out over its business landscape from its lofty peak, it observes its share price stagnating and watches as Google’s share price continues to rise (BarChart, 2009). Meanwhile both Sisyphus and Ballmer remain as busy as ever.
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APPENDIX A: Fortune 100 Detailed Data Analysis Report

This appendix summarizes the Fortune 100 detailed data analysis that was completed as part of the research. The report analyzes the Fortune 100 rankings from 1955 to 2008. For details on how this report was created, and how the analysis was completed, please refer to Chapter 5.

Report removed due to copyright restrictions
APPENDIX B: The Business Fitness Landscape Modeling Workbench

Figure Appendix B.1 shows a screen-grab of the typical output from the development environment that was used during the creation of the 4D business fitness landscape modeling system. The complete system, including input data forms, data analysis, macros, graphics display, and graphics control, were developed as part of the research, using standard Microsoft Excel 2003 with Service Pack 3, the Statistical Analysis Pack, the MegaStat add-on for Excel, and Visual Basic for Applications.
Figure Appendix B.1. A screen-grab showing the typical output from the development environment that was used during the creation of the 4D business fitness landscape modeling system. The complete system, including input data forms, data analysis, macros, graphics display, and graphics control, were developed as part of the research, using standard Microsoft Excel 2003, with Service Pack 3, the Statistical Analysis Pack, the MegaStat add-on for Excel, and Visual Basic for Applications.