Assessment of Technology-Based Ventures:

Complexity and Viability

Toward early-stage, technology-based venture
screening and assessment decision aids.

by

Douglas Ian Sparkes

A thesis
presented to the University of Waterloo
in fulfilment of the
thesis requirement for the degree of
Doctor of Philosophy
in
Management Sciences

Waterloo, Ontario, Canada, 2000

0-612-60568-X

The University of Waterloo requires the signatures of all persons using or photocopying this thesis. Please sign below, and give address and date.

Abstract

The assessment of early-stage, technology-based ventures is a high-risk endeavor, complicated by the fact that typically there is very little information on which to base analysis. The complexity of this evaluation problem is further compounded by a lack of decision tools specifically intended for this evolutionary stage.

The objective of this research is the development of decision aids for screening and assessment of very-early stage ventures. Specifically, for ventures entering the product development stage, not having yet reached initial market introduction, and having at most an initial prototype. To achieve this end, two paths are explored, presented as three separate but related studies.

The first two studies consider the decision behaviour of venture assessment experts, and have implications for tool development through increased understanding of the concepts utilized and their application. The third, and perhaps the most significant study of the three, considers the assessment problem from a different perspective.

Rather than considering the decision process of experts, this study poses a basic question. What parameters influence the potential of an early-stage venture to successfully evolve through to the market introduction phase? The final study considers ventures as complex systems evolving under uncertainty and the application of concepts from viability theory. An assessment framework is proposed, and an initial examination of validity and reliability is undertaken.

Implicit in this approach is the understanding that investment opportunity assessment is an ongoing activity. At any instant in time, the issue facing the investor is whether to exercise an option to support the venture further. Thus, the prospective assessment tool must not only be applicable for screening and assessment, but also for tracking venture development. The proposed assessment framework is shown to have potential not only in this monitoring role, but also as a means to facilitate expert assessment panels.

Acknowledgements

I would like to take this opportunity to thank all those who participated in this research. In particular I would like to thank my supervisor, Dr. Paul Guild, for his guidance and patience, as well as my Ph.D. committee, Dr. Don Cowan, Dr. David Fuller, Dr. Ji-Ye Mao, and my external examiner, Dr. Joseph Paradi. Through their questions and comments, this has become a stronger dissertation.

In addition, I would like to thank Mr. Ken Robson for his cooperation and valuable insights.

Finally, I would like to thank May Tajima and my family, Sigrid, Christopher, Lindsey and Sarah for their invaluable support and understanding.

Dedication

To my parents

My father, for the drive to succeed.

My mother, for teaching us never to quit.

Table of Contents

List of Tables

List of Illustrations

Chapter 1
Introduction

It is generally accepted that small and medium-sized enterprises (SMEs) are important contributors to Canadian economic growth. However, as discussed by Rothwell and Zegveld (1982), simply measuring their share of economic output and employment does not reflect their true economic significance. They appear to be an important part of the overall economic infrastructure, and play a key role in economic evolution.

In terms of economic infrastructure, these ventures tend to operate in market segments where economies of scale are not especially important, capital intensity is low, skill intensity is high and demand is highly specific and variable (Rothwell and Zegveld, 1982). Typically, established firms in mature markets tend to adopt small, incremental product improvements. Entry of new, small firms into these markets have a significant impact on market dynamics, often becoming the catalyst for evolutionary or revolutionary change (Rothwell and Zegveld, 1982; Benson et al., 1993).

Studies have suggested that small, technology-based, high growth companies are more innovative and often more effective at the creation of jobs and wealth than are larger ventures (Capon et al., 1992; Kassicieh et al., 1997). This appears to be the case in the United States and Canada, and indeed for most capitalist economies. As discussed by Kassicieh et al. (1997), in the United States, approximately 60% to 80% of job creation and sales growth can be accounted for by 30% of the firms, primarily small to medium sized, in the economy. Further, as the primary driver of these high-growth ventures is new technology, it may be argued that technology-based ventures are a significant factor for economic growth.

This SME role is becoming increasingly important as Canada moves towards a so-called 'knowledge-based economy'. But what is meant by a knowledge-based economy and how did it evolve to have a role in the current economy?

1.1 Macroeconomic View Pre-1970s

In the nineteenth and into the twentieth centuries it was customary for economists to classify the firm's factors of production in terms of either land, capital or labour. Within this framework, technology and knowledge was assumed to be an economic constant, only changing in the 'long-run' (e.g.: Dornbush and Fischer, 1978; Mansfield, 1979; Rabino and Wright, 1993). Further, technology and knowledge were assumed to be generally available to all participants within a market and as such were not perceived to be a major source of competitive advantage.

Macro-economic growth models prevalent prior to the 1970s postulated that growth in the economy was the result of either an increase in the availability of factors of production or through improvements in their productivity (Dornbusch and Fischer, 1978). In terms of factor growth, the key factor was considered to be labour. Specifically, over time the labour force grows and the average output of labour changes. Within this framework, increased labour productivity could occur through two mechanisms. First, labour has more capital in terms of machines and factory space applied to it. Alternatively, there is technological progress resulting in higher skilled labour and more sophisticated machines. However, if the economy is at full-employment there are only two ways of obtaining growth, increase the contribution of other factors of production and/or use those factors more effectively. Increasing factor effectiveness may come about either from more efficient resource allocation or because of more effective technology.

This view of economic growth can be formalized mathematically by expressing economic output as a function of capital and labour. A key assumption is constant returns to scale. In other words, economic output increases in direct proportion to the quantity of factors applied. This also implies that the output per unit of labour, labour productivity, depends on the amount of capital per worker. As a result, the greater the amount of capital applied to a unit of labour, the higher its productivity. Another underlying assumption is diminishing returns to capital intensity. As the capital per worker increases, the worker becomes more productive and economic growth rises, but at a diminishing rate. The result of this framework is the notion that the more 'capital-intensive' the economy, the higher the economic output.

1.2 Recognition of the Role of Technology and Knowledge

As discussed by Dornbush and Fischer (1978), it can be seen when examining production functions that there is a constant term defining the ratio at which combining labour and capital creates economic growth. One source of growth is to simply increase the factors of production. The other source of long-term growth is through a change in the production constant. Such changes are considered to occur in the 'long-run', and reflect the impact of technological progress on factor productivity. While technological progress is considered to be a long-run effect, in 'short term' it is considered to be an economic constant.

This view of technological progress implies only that more output can be produced with the same inputs (Dornbusch and Fischer, 1978). That is, the marginal productivity of all factors are increased by the same ratio. Other forms of technological progress, however, impact the relative productivity of each factor of production. A 1970 study by Robert Solow found that over 80% of US economic growth in the period from 1909 to 1949 was due to technological progress (Dornbusch and Fisher, 1978). Critical reviews of this work at the time contended that the large contribution of technology could be explained through omitted factors and poor measurement of economic inputs.

Later work tended to support Solow's findings regarding the significance of technological progress on growth. Further research indicated that the contribution of labour to economic growth was greater than what would be expected simply from labour force growth (Dornbusch and Fischer, 1978). Examination of the factors contributing to increased labour productivity found advances in knowledge to account for a significant portion of the technological progress contribution to economic growth.

1.3 The Impact of Technology on Competitive Advantage

So far, the discussion has been on the macro-economic impact of technological change. As discussed by Roberts and Mayer (1991), during the 1970s technologies were considered to be a peripheral issue when developing a firm's product strategy or making strategic investment decisions. Technology issues were usually considered to be a business unit characteristic and were often not considered when restructuring occurred. As a result, companies often had to deal in an environment complicated by unstable engineering capabilities, ineffective product development and difficulty developing areas of competence (Roberts and Mayer, 1991; Prahalad and Hamel, 1992).

For a micro-economic perspective of the impact of technology and technological change, consider the work of Porter (1991). In his discussion of technology and its role providing the firm with competitive advantage, Porter (1991) describes technological changes as one of the most important drivers of competition. According to Porter, the relationship between technology and competition is often misunderstood. Technological change in itself is not critical. Rather, it is the way in which technological change affects industry structures and relationships at a macro-economic level and firm competitive advantage at the micro-economic level that is important. In terms of the firm's competitive advantages, it is technology's role in differentiation and reducing costs to the firm that are important.

To understand the role of technology as a source of competitive potential, one must begin by examining the five forces of competition and the value chain of the firm (Porter, 1991). In his discussion of strategy, Porter describes the five fundamental economic forces as the threat of new entrants, the relative strength of buyers and sellers, substitution and the structure of the industry in which the firm competes. All of these forces can be significantly impacted by technological change.

In terms of industry structure, technological change can have a wide range of impacts, such as changing economies of scale or making new interrelationships possible. Further, even if a technology does not provide competitive advantage to any one firm, it may affect the profit potential of all firms in the industry. It is here that the distinction between base and distinctive technologies must be made. When considering barriers to entry for new competition, technological change can act to either increase or decrease barriers. This may result through such mechanisms as lowering the cost of product designs, increasing or decreasing the capitalization required to enter an industry or through its influence on switching costs (Porter, 1991).

The influence of technological change on switching costs has a major impact on buyer and supplier relationships. Another important factor of buyer and supplier bargaining power is technology substitution. This is the most common effect of technology change, and is a function of the relative value to the price of competing products and switching costs (Porter, 1991).

In the value chain model, the firm is viewed as a collection of activities that may be classified as primary value activities and support activities. Porter describes five generic primary activities that contribute to the creation of value. These are inbound logistics, operations, outbound logistics, marketing and sales and service. Support activities associated with the firm are classified as infrastructure, product development, human resources and procurement.

Technologies will be associated with all aspects of the value chain, not simply the technologies that are embodied in the venture's product or service. Further, any technology associated with a value activity has the potential to have an impact on firm competitive advantage. In general terms, technology affects competitive advantage through its impact on relative cost and the firm's ability to differentiate itself from its competition. Technology affects cost or differentiation if it influences the drivers of cost or uniqueness associated with each of the firm's value activities.

1.4 An Assessment Challenge

Technology cannot be treated as a fixed quantity. Rather, technologies must be considered as dynamic entities that are an important source of competitive advantage (Porter, 1991; Rabino and Wright, 1993). Further, as discussed by Kassicieh et al. (1997), the primary basis for high growth ventures are new technologies and their associated knowledge and skills.

The traditional physical assets of the firm have become less central, with the critical element for the firm becoming the knowledge base associated with the creation and application of its technologies (Drucker, 1986; Ford, 1988; Benson et al., 1993; Alvesson, 1995). As the economy evolves towards one in which technology and its application are the major source of competitive advantage, the associated knowledge and skills become important factors of production. This leads to an economic structure that is less capital-based and increasingly knowledge-based.

A trend associated with the evolution towards an increasingly knowledge-based economy is the emergence of small, young enterprises that tend to introduce novel products based on new or unproven technologies. Often their products or services are based on non-standard production containing a significant problem-solving component (Benson et al., 1993). As a result, there is significant difficulty assessing either the firm or its potential market because of high uncertainty in both the associated customer needs and the competitive environment. While uncertainty and risk are inherent in all business ventures, technology-based ventures often face higher risk from unsolved scientific and technical challenges (Sonneborne and Wilemon, 1990). Further, when the venture is significantly knowledge-based, there is often little or no physical assets or inventory that may be used to evaluate the venture in terms of capital and collateral (e.g.: Stewart, 1991; Stewart, 1994; Alvesson, 1995).

The focus of this research is the assessment of new, small, knowledge-intensive, technology-based ventures at an early stage in their development. Typically, these ventures have been in existence for not more than three years and are at the pre-market introduction, prototype-development stage. Further, technology-based ventures are considered to be a subset of knowledge-based enterprises. This is based on the assertion that knowledge is a key element of the technology-based enterprise, both in the development and application of technology. In this research these new, small, knowledge-intensive, technology-based ventures will generally be referred interchangeably as technology-based or knowledge-based ventures.

Given the considerable investment of resources these firms require, and the failure rate, the challenge faced by lending and investment organizations is how to assess 'technology-based' and/or 'knowledge-intensive' ventures (e.g.: Stewart, 1991; Cooper, 1993; Stewart, 1994; Alvesson, 1995; Liberatone and Styliarou, 1995). The risk these institutions face is immense. As discussed by Hofer and Sandberg (1987) and Slatter (1992) estimates of start-up venture failure vary from 65% in the first five years to 80% within the first three years. Further, Balachandra and Friar (1997), found that of the approximately 16,000 new products introduced in the United States in 1991, almost 90% failed to meet their business objectives and could be classified as failures.

Many researchers (e.g.: Johne and Snelson, 1988; Rabino and Wright, 1993; Stewart, 1994) have discussed the shortcomings of traditional venture screening and accounting practices when considering knowledge-based firms. A central difficulty is the measurement of the venture's intellectual capital, especially as this becomes an increasing component of the cost of production. As discussed by Johne and Snelson (1988), traditional new venture screening models do not adequately handle non-financial aspects such as human and organizational behavior.

When dealing with knowledge-based enterprises, the venture's intangible assets may be more important in assessing the associated investment risk than hard assets (Stewart, 1994). As a result, measures of the non-financial qualities of the venture, the intangibles, are increasingly of interest. The banking industry, for example, has recognized a deficiency in their operations when providing services to these ventures, and have responded by the creation of specialist groups within their organizations. These groups, sometimes referred to as 'knowledge-based banking', are comprised of experienced individuals whose focus is on the provision of banking services to this segment of the market.

1.5 Research Overview

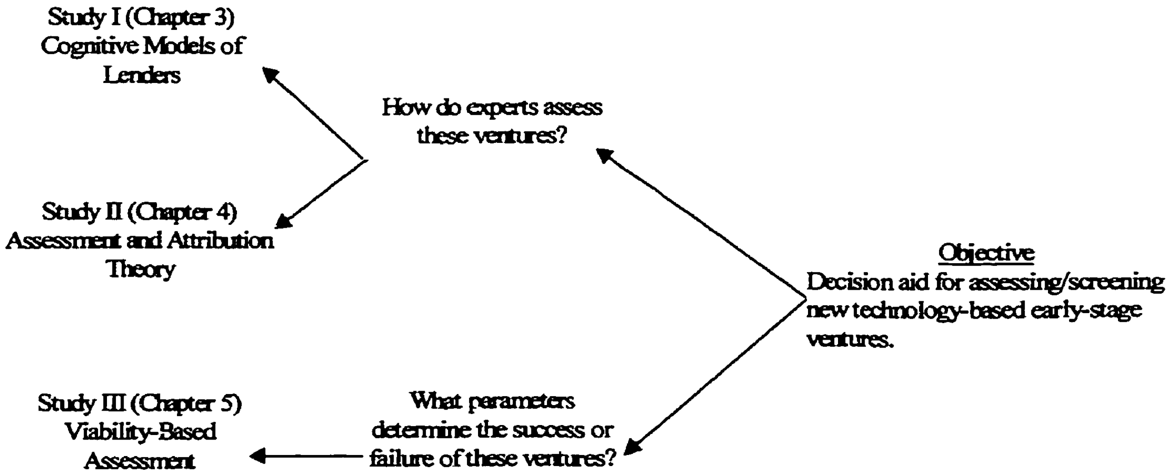
The principle objective of this research is to improve the understanding of early-stage, technology-based venture assessment and to provide a framework for improving this process. The focus is theory- and model-development, the goal of which is not to provide a single, all encompassing tool, but rather to lay the foundation for development of a 'toolbox' of intelligent decision aids. This stems from a philosophical belief that such toolboxes provide the necessary flexibility to a decision-maker that a single tool, must by its nature restrict. As these tools will generally focus on intangibles, the assessments will be linguistic in nature and hence the application of fuzzy techniques will be the principal approach explored.

This research is not intended as a large-scale empirical study of venture assessment. Two reasons for this: first, it is impractical to obtain large samples of experts for in-depth interviews[1]. Secondly, the points of interest are the concepts used during the assessment process and the unique ways these may be combined during the assessment process. This information is not readily available in large studies using aggregated data.

[1] This is highlighted by an attempt to obtain data using a general questionnaire outlined in Appendix F.

As illustrated in Figure 1.1, this objective may be thought of as having two major issues associated with it. First is the question, how do experts assess these ventures? Here, the goal is to better understand the decision process of assessment experts. The second issue seeks to better understand many key aspects of venture assessment, and hence, the development of decision aids through the question: What parameters define the success or failure of these ventures?

Figure 1.1
Research Issue Diagram



This research has been conducted, and is presented, in three related studies as shown in Figure 1.1. In the first study, a group of lending experts is examined and their assessment process explored through identification of the concepts used and their relationships. As discussed, it is impractical to obtain large samples of experts for in-depth interviews. Indeed it is often impractical to obtain truly in-depth interviews because of their own time constraints - these are busy people. This can be mitigated to some extent through the application of fuzzy cognitive maps, which as discussed by MacNeill et al. (1994) and Kosko (1997) permit the aggregation of knowledge from a variety of potentially incomplete sources that leads to a consensus map. This approach is used to create a simple, fuzzy cognitive map and an experiment devised to demonstrate the potential of this approach to devise a decision aid.

The first study also raises an interesting question. When the concepts used by lenders are considered in the overall context of the investment and venture assessment literature, it becomes apparent that they do not use any unique set of assessment concepts. In view of this, what is the underlying assessment model? The second study considers this question through the application of a model based on attribution theory. The goal is to provide insight into what leads a venture to be accepted or rejected, as well as what may differentiate investor groups. Specifically, if it is assumed that an assessor is initially neutral to a venture, what 'drives' it to become accepted or rejected? In terms of tool creation, this has implications for understanding how assessment information is being interpreted as it is acquired, and hence, how to structure potential decision aids.

While the first two studies strive to understand the decision process of experts, the third study returns to the initial objective and explores the second issue posed in Figure 1.1. What parameters determine the success or failure of early-stage, technology-based ventures? Although the prior studies provide useful information, two issues remain. First, why can different experts use different assessment criteria sets and be equally successful? Second, how can the decision process be improved?

In study three, rather than simply searching for more success factors, a model-based framework is explored. This is a departure from an approach based on empirically derived, aggregated success criteria. Instead, it attempts to understand very early-stage ventures as complex emergent systems and what constraints are in play as it evolves. Consideration of what makes such a system 'viable' leads to an assessment framework with potential as a future decision aid.

As study three is specifically concerned with model- and theory-development, an important issue is internal validity. Thus, initial model validation is undertaken through a series of experiments. The first two experiments seek to find support for model concepts among assessors. The next three examine the predictive validity and inter-expert reliability through the assessment of several cases. Again, the number of participants is selected to reflect a typical assessment team. This is an important consideration since application of these tools is not undertaken by a population permitting larger empirical studies. Thus the important issues of how the framework is used and agreement among members are not lost.

Chapter 2
Literature Review

Increasingly, banks and other financial institutions are faced with the problem of assessing ventures having a high level of intangible assets. Traditionally the focus when assessing a new venture has been on its financial attributes, typically examination of the proposed balance sheet and predicted cash flows. The various ratios that may be employed in this analysis focus on the venture's assets and overall financial situation. In the case of new knowledge-based ventures, however, these financial indicators have a very high level of ambiguity and uncertainty, and as such the assessment is often little more than a guess.

2.1 Venture Assessment Techniques -- Current Practices

Venture assessment may be viewed as a multiple criteria decision problem in which an opportunity is evaluated against a set of criteria. There are a wide range of methods and techniques that may be employed in the evaluation and selection of investments. As discussed by Schilling and Hill (1998), these techniques range from informal, based largely on the analyst's experience, to highly quantitative.

Methods such as net present value (NPV) provide a concrete financial estimate of the potential investment that can facilitate planning and trade-off decisions. A difficulty with this type of approach when utilized as an investment-planning tool is that it tends to favour platform or derivative products (Schilling and Hill, 1998). As a result, there can be a bias against advanced research and development or breakthrough technology projects. This tends to preclude investment in future products or ventures that have high potential payback.

Some research suggests (e.g.: Schilling and Hill, 1998) that investment decisions based on a call option approach may be more suitable for high uncertainty project or venture investment decisions. Using a stock market analogy, the investor is essentially buying a right to exploit a technology in the future if it becomes valuable. As pointed out by Schilling and Hill (1998), while it may provide a useful framework for evaluating investment alternatives, it has shortcomings. It is based on the assumption that the investor can acquire and retain the option at a relatively low cost. Therefore, for an incremental investment the uncertainty can be lowered sufficiently to determine the eventual viability and market potential of the technology or venture. In the case of a venture, however, this may not be possible and may require a large investment to determine the technological viability. Hence, if the venture technology is found not to be viable then the investment is lost.

A further difficulty is the assumption that the option can be exercised (Schilling and Hill, 1998). This may be especially problematic in emerging technologies where there is significant uncertainty and new technological trajectories may still be emerging. The potential risk is that by the time the venture technology has been developed to the point that it is commercially viable it can be locked out of its target market, resulting in the loss of the investment. This barrier may result from the switching cost associated with competing technologies that have established themselves (Porter, 1991; Schilling and Hill, 1998).

Typically, the venture assessment process occurs in stages that can be defined by their time-scales. Initially a venture proposal will be screened in a matter of minutes. This assessment is performed at a relatively high level and generally results in a yes/no accept/reject type of decision. Venture proposals that are accepted for further assessment may next be assessed in a period of hours. In this case the venture is examined in more detail before acceptance or rejection. The final stage of assessment takes place in a period of days and weeks. This stage often includes a significant level of research and 'due diligence'.

A key consideration when evaluating a venture's investment potential is its risk (Souder, 1983; McNamara and Bromiley, 1993). Determining the risk associated with a venture is a complex topic, with the major issue often being the identification of sources of relevant risk. Often confused with the concept of uncertainty, risk is the state in which likelihoods of known alternative outcomes can be specified. Uncertainty, on the other hand, is the state in which neither the outcomes nor the likelihoods of their occurance are known. In terms of venture assessment, risk is often taken to be the venture's probability of failure, and is often reflected in measures such as the anticipated lifetime profits versus the probability of achievment.

As discussed by Souder (1983), distinguishing between a good and bad investment or lending opportunity depends on the availability of valid and reliable data concerning the potential of the proposed ideas. Given that data are available to the decision-maker, several statistical approaches have been put forward to aid in the decision process, such as regression and discriminant analysis, cluster analysis (e.g.: Seaver and Kostas, 1992) and data envelopment analysis (e.g.: Camm and Downs, 1992; Retzlaff-Roberts, 1992; Talluri and Sarkis, 1997). Of these approaches, discriminant and regression approaches are the most prevalent and are examined further.

2.1.1 Discriminant and Regression Models

Perhaps the most common statistical approach for the analysis of lending and investment data with the goal of providing assessment tools is through the application of regression analysis and discriminant models.

Discriminant analysis may be either a statistical or a non-parametric linear programming technique and has the objective of classifying an observation into one of several possible groups (e.g.: Affifi and Clark, 1990; Retzlaff-Roberts, 1992; Zikmund, 1994). In the case of loan evaluation, the objective may be to classify a potential loan into different risk classes or into acceptance or rejection groups. The goal of discriminant analysis is to identify a set of factor weights that will minimize the amount of misclassification given a data set for which the membership in the classification groups is known. The resulting factor weights can then be used to predict to which classification group a new entity will belong (Retzlaff-Roberts, 1992).

Much research has been conducted on new venture evaluation models, especially in the areas of credit and loan risk (e.g.: Wilkinson, 1992; McNamara and Bromiley, 1993). The vast majority of these models focus on determining if the venture is a good credit risk, or if it has a high likelihood of bankruptcy. In addition, as discussed by McNamara and Bromiley several models have been developed which attempt to identify when a small business loan may be deteriorating, rather than determining possible bankruptcy.

Development of these models requires access to a large database of historical records concerning the characteristics of the business and the state of the venture at the time the model was developed. In essence these models attempt to predict the likelihood of a future outcome based on past experiences (Wilkinson, 1992). In discriminant and regression models, the state of the firm is most often described in terms of a success or failure, based on some predetermined set of criteria. For example, failure of a small business loan could be defined in terms of the number of loan payment periods that the borrower is delinquent.

An example of this type of assessment tool is the Small and Medium-sized Enterprise Assessment Model developed by McNamara and Bromiley (1993). It consists of six financial metrics: profitability, cash flow, liquidity, leverage, collateral margin, and size. Of particular interest when viewed from the perspective of assessing knowledge-intensive enterprises is the operational definition of these metrics. Each requires measurement of the venture's total assets, which is problematic in these ventures.

A complication in the development of these models is that they are prone to selection effects (McNamara and Bromiley, 1993). Contributing to this is the lack of data from ventures which were initially rejected or who have ended their relationship with the financial institution before the end of the model development period. Additional difficulties may arise from concepts such as the definitions of 'good' and 'bad' risks, differences within the set of ventures, and small shifts in the characteristics population over time (Wilkinson, 1992). As can be easily seen, the statistical approach may encounter difficulties when dealing with new knowledge enterprises, because of the rapidly changing economic environment and relatively small database.

2.1.2 Intelligent Systems

Another potential source of venture assessment tools is through the application of intelligent systems. These include expert systems (e.g.: Bouwman, 1983; Firebaugh, 1989; Gonzalez and Dankel, 1993; Liberatone and Styliarou, 1995), fuzzy systems (e.g.: Hruschka, 1988; Chen and Hwang, 1992; Kosko, 1992; Dutta, 1993; Cox, 1994) and neural networks (e.g.: Nelson and Illingworth, 1991; Kosko, 1992; Lin and Lee, 1996; Li et al., 1997). As discussed by Khurgin and Polyakov (1985), expert methods are often used when dealing with complex decision problems with high levels of uncertainty. Several expert system tools have been proposed for application in venture assessment.

Liang (1992) describes an example of the application of intelligent systems for bankruptcy prediction. In his work, he compared the relative performance of an expert system implementation based on a data set to the performance of a discriminant model and a neural network using backward propagation. In this case it was found that the expert system implementation performed marginally better than the other approaches, correctly identifying the bankruptcy cases approximately 80% of the time.

2.2 Technology Evolution

As discussed by Henderson (1991), the evolutionary theory of ventures has similarities to population evolution models in mathematical biology. These models have their origins in the work of Gause during the 1930s (Henderson, 1991), and demonstrated that in a constrained resource environment, organisms of the same species would eventually become extinct. Further, when organisms compete for resources, one will eventually displace the other. If, however, the species were complementary then they would both survive. In an environment in which one species has a local competitive advantage over another competing for the same resources, the organism having the advantage should prevail. It is easy to see the parallels to the business environment.

This work on evolution leads to the concept of variety (Beer, 1985; Henderson, 1991). In essence the richer the environment, the greater the number of potential outcomes or states and the greater the areas of differentiation and hence competitive advantage. This leads to the concept of business strategy, without which the development of ventures would follow the path of Darwinian evolution (Henderson, 1991). In this view of a firm's evolution, natural selection operates as poorly aligned firms will be eliminated and the fittest firms will be the best performers (Lefebvre et al., 1996). As further discussed by Lefebvre et al. (1996), firms operate in dynamic and turbulent external environments and must continuously adapt to these circumstances if they are to remain viable. An implication arising from the evolutionary theory of the firm is that the ability to adapt and survive in its environment is a function of past experience.

Ventures tend to be more successful when they enter markets that are in the early high growth stages of evolution (Hofer and Sandberg, 1987). Possible reasons for this including less intense competition and the ability to recover from strategy experimentation. One factor that has the potential to greatly influence the stability of these evolving markets is new technologies and the pace of technological development (Robert and Mayer, 1991; Norton and Bass, 1993). Technology-based ventures faced with rapid advancement of their product technologies, and hence very high rates of new product introduction, must commit significant resources to research and product development to remain viable (Roberts and Mayer, 1991).

There are two major components of technological evolution that are acting on the venture and its markets: technological diffusion and substitution. Technological diffusion may be defined as how a technology is adopted over time while substitution is how it displaces the current technologies (Norton and Bass, 1993). In their research into technological evolution and the impacts of displacement and substitution in high-tech markets, Norton and Bass (1993) examine how new technologies take over the demand from earlier generations. In their model, the new generation will eventually drive the sales of the earlier technology generation below its level of sustainability. However, at the time of introduction, the earlier technology will continue to experience growth for some period as diffusion occurs and then it will begin being displaced.

Technological Decomposition Theory examines the evolution of a product or technology from the 'inside-out' through examination of the constituent technologies. In his discussion of technological decomposition theory, Hilbrink (1990) identifies three characteristics of technological change. These are initial effects, manufacturing constituents and the concavity of technological change. The initial effect of technological change is to create a short period in which the rate of change is high. This is followed by a comparatively long period in which the rate of change slows to a more or less constant rate. The third characteristic discussed by Hilbrink (1990) is the 'concavity' of technological change. This relates to the rate of change of technological change, which slows over time.

As described by Hilbrink (1990), research has found that there are periods during which fields of technology develop rapidly, often including discontinuities where one technological trajectory has been abandoned in favour of another.

Examination of these periods of rapid technological change indicates that they occur when technology constituents improve simultaneously.

2.2.1 Venture Evolution

Bell (1991) describes the evolution of new ventures as having five fundamental stages: concept, seed, product development, market development, and finally steady state. Further, these evolutionary stages of ventures may be grouped into three phases: formulation, development and deployment. During the formulation phase the venture attempts to match the perceived opportunities from a technology with perceived market needs. Having defined a product concept, the venture must make the transition from a concept into a viable product for market deployment.

At this phase, the product concept must be defined sufficiently so that development can begin. This implies that the objectives and requirements of the product must be clearly specified. If there is significant uncertainty and ambiguity in these requirements, a high potential for development failure may be expected. This is also the stage where many startup ventures seek investor financing, and at which significant levels of resources begin to be allocated. As the venture moves into the deployment stage, another transition occurs. Now the dominant focus becomes the venture's ability to successfully manufacture and support the new product in its target market.

2.3 New Venture Success

While many tools are employed in the assessment process, the issue of what factors are important to new venture success must be considered. Several researchers have examined the criteria leading to new venture success (e.g.: Hofer and Sandberg, 1987; Ayal, 1990; Sonneborn and Wilemon, 1990; Roberts and Mayer, 1991; Meldrum and Millman, 1991; Slatter, 1992; Bell and McNamara, 1993; Hall and Hofer, 1993; Baldwin, 1995; Shepherd, 1999).

Meldrum and Millman (1991) examined the problems and risks associated with marketing new 'high-tech' products, while Slatter (1992) examined factors contributing to the high failure rate among 'high-tech' startups. Bell and McNamara (1993) identified several key dimensions that should be considered when assessing the viability these types of startups. Hall and Hofer (1993) examined the various criteria that venture capitalist consider when making investment decisions concerning these ventures, while Baldwin (1995) discussed the role of innovation in the success of small ventures.

As discussed by Sonneborn and Wilemon (1990), it is common for high-tech ventures to direct a significant fraction of their resources towards developing internal expertise and building a strong technical foundation. According to Roberts and Meyer (1991), the best opportunity for venture growth comes through the development of a critical mass of engineering talent related to a core technology. This may result in the development of a distinctive area of competence that may evolve to provide the venture with a sustainable competitive advantage and become the basis of future product development. The foundation for competitive advantage in technology-based ventures often occurs very early in their development (Slatter, 1992). It is the focus on a single technology or a group of closely related technologies that results in the development of areas of excellence, competencies, and an understanding of its markets, the basis for the creation of core competencies (Prahalad and Hamel, 1992).

2.3.1 Entrepreneurs

When examining the creation and success of new small ventures, the role of the entrepreneur must be considered. Some consider the characteristics of the entrepreneur to be among the most important factors to be considered when assessing the potential for success of a new venture (e.g.: Hofer and Sandberg, 1989). As discussed by Kassicieh et al. (1997), there are three major schools of thought concerning entrepreneurs: traits, environmental and behavioral.

The first of these schools, the traits approach, attempts to identify potential entrepreneurs through the personality traits of the individual. The attributes that are considered include locus of control, ambiguity tolerance, risk attitudes, and the need for achievement. This approach has generally been unproductive, however some of its proponents argue that it has relevance when applied to specific subsets of entrepreneurs (Hofer and Sandberg, 1987; Kassicieh et al., 1997).

The second school, the environmental approach, includes issues such as the entrepreneur's family background, experience and educational characteristics. Here the propensity to become an entrepreneur is considered to be a function of the individual's environment. In other words, situational effects have an impact on entrepreneurship.

The third school of thought, behavioral, is derived from social psychology research into the relationship between attitudes and behavior of individuals. Issues that are examined from this perspective include initiative, self-confidence and persistence. One area where this approach has had success is in the examination of technical versus non-technical entrepreneurs (Kassicieh et al., 1997).

As discussed by Hofer and Sandberg (1987), environmental and psychological factors focus on trying to predict who will become an entrepreneur, while behavioural factors attempt to explain the success of entrepreneurs. Further, some research has found that many demographic or environmental factors were poor predictors of venture success even though they were indicators of who may attempt a venture. The primary link to new venture success appears to be related to behavior (Hofer and Sandberg, 1987). Specifically, the ability to recognize needs of a changing environment, the motivation to act, ability to take effective action based on perceptions and the ability to motivate others are critical attributes of a successful entrepreneur.

2.4 New Product Success

The product is possibly the most important factor contributing to the success of a new high-tech venture (Bell and McNamara, 1993). Therefore, the factors that lead to new product success may be viewed as synonymous with new venture success. Simply stated, without a viable product there cannot be a viable venture. Roberts and Mayer (1991) point out that new ventures that focus their new products as an extension of a single core technology are more likely to be successful than more diverse ventures. In the case of very small technology-based ventures, this focus becomes even more important (Sonneborn and Wilemon, 1990). A vulnerability that can arise due to this level of focus is "technological myopia", where the individuals in the venture fail to recognize emerging opportunities or threats. To counter this, it is important that the venture has an ability to maintain an external view and technological "intelligence". This leads to the concepts of boundary spanning and absorptive capacity (Cohen and Levinthal, 1990).

Cooper (1988, 1993) has written extensively on the new product development process and the factors that are important for new product success. Many other researchers have investigated the factors which lead to successful new products (e.g.: Cooper and Kleinschmidt, 1987; Cooper and Kleinschmidt, 1988; Johne and Snelson, 1988; Wind and Mahajan, 1988; Ayal and Raban, 1990; Shilling and Hill, 1998; Sobek et al., 1998; Ozer, 1999). Further, as the ventures of interest in this research are dependent on the success of their product or service for survival, financial success may be assumed to be the dominant success metric (Bell and McNamara, 1991, Astebro and Bernhardt, 1995).

A wide range of factors effecting the success of new products and new ventures have been discussed in the literature (e.g.: White, 1978; Johne and Snelson, 1988; Cooper, 1988; Wind and Mahagan, 1988; Roberts, 1991; Benson et al., 1993; Schilling and Hill, 1998; Calantone et al., 1999). As discussed by di Benedetto (1994) in his review of the NEWPROD research program (Cooper, 1986; Cooper and Kleinschmidt, 1987; Cooper, 1993), prominent among the critical success factors in new product development are the technological and marketing synergy between the proposed product and the firm.

In his discussion of new product evaluation, White (1978) looked at the concept of technological potential. White began by posing a set of questions concerning the nature of the technological limitations that the innovation had removed or lessened. Next, the analysis focuses on the technology required to utilize the innovation effectively and efficiently. Finally, issues related to the innovation's profit potential, market dynamics and impact on the consumer are examined.

As discussed by Schilling and Hill (1998), the creation of a viable product requires the venture to assemble a set of assets which includes direct technical knowledge, complementary technical knowledge, market knowledge, manufacturing knowledge and financial ability.

2.5 Project Success Factors

In addition to the research into the factors that lead to the success of new ventures and products, another aspect of these ventures must be considered. Not only are the factors that may influence the future success of the venture's product important, so too are the steps comprising the execution of the product development project. Several authors (e.g.: Slevin and Pinto, 1988; Pinto and Mantel, 1990, Cooper, K.G. 1993; Kumar et al., 1996; Balachandra and Friar, 1997) have discussed the factors that can result in project success or failure.

A review of project / product success studies undertaken by Balachandra and Friar (1997) found that they tend to be non-uniform in their findings and in some cases are contradictory. For example, some studies found that an innovative product had a greater chance of success while other studies indicated that this had a greater chance of failure. They argue that this difference is due to missing context variables associated with the innovation, market and technology information related to many of the success factors in these studies.

2.6 The Role of Synergy and Core Competence

From this discussion, a major problem when assessing venture potential becomes apparent. Successful deployment of an emerging technology, and hence venture success, is dependent on the venture's ability to manage and support that technology successfully. In the case where the technology is either largely knowledge itself, or utilizing technologies requiring specialized knowledge, the issue becomes one of management of knowledge assets within the venture. This is complicated by the difficulties inherent in the measurement of a venture's knowledge assets and developing strategies for its successful management.

A key assessment area then is that of synergy, the extent to which the organization has the requisite skills to develop and provide its products and or services successfully. Effective new product development seeks to capitalize on synergies, or goodness-of-fit, among the skills and technologies possessed by the firm (Wind and Maharjan, 1988). As observed by Cooper and Kleinschmidt (1987), synergy is critical for achieving financial success in new product development, and therefore may be considered to be a critical success factor for a new startup venture.

Since synergy is related to the extent to which an organization has the skills, talents and resident knowledge required for successful development and marketing of its product, it can be thought of as describing the competencies of the venture. As ventures become more knowledge-intensive, the influence of these synergies, especially those related to the technological competence of the enterprise, become more important further accenting the shortfall of traditional assessment metrics. This leads us to consider the concept of core competence described by Prahalad and Hamel (1990).

For a venture to remain viable in the long-term, it must be continually adapting and evolving its products. A venture that fails to do this is the proverbial 'one-trick pony' and has no long-term viability. As discussed by Prahalad and Hamel (1990), it is the core competence of the firm that facilitates this adaptation and generation of a continuing stream of new products. Further, as the venture's areas of core competence strengthen, so does its ability to estimate along the market-product dimension.

2.7 Intellectual Capital and Absorptive Capacity

When considering the assessment of technology-based ventures that are knowledge-intensive, the measurement of knowledge assets has been identified as a major problem area. This leads to the issue of intellectual capital.

Two general categories of intellectual capital can be identified in a firm: human and structural (Stewart, 1994). Human intellectual capital provides the source of innovation and renewal for the firm, while structural intellectual capital turns know-how into a property of the organization. The basis of human capital is the knowledge and skills possessed by the firm, and how they are used (Stewart, 1991). This knowledge may take many forms, including; patents, processes, management skills, technologies, information about customers and supplies, and experience. Structural intellectual capital, on the other hand, may include information systems, knowledge of market channels, and management focus. Structural capital is important in the long term, as it amplifies the value of the human capital by providing a framework for the firm to put ideas to work and can be used repeatedly to create value (Stewart, 1994).

Absorptive capacity is the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends. Thus it is critical to its innovative capabilities (Cohen and Levinthal, 1990). This ability is largely a function of the firm's level of prior related knowledge, and is a critical component of the venture's innovative capabilities. Prior knowledge includes basic skills, knowledge of the most recent scientific or technological developments in a given field or even a shared language. As a result, prior related knowledge provides an ability to recognize the value of new information, assimilate it, and apply it. This is essential if the venture is to be able to understand and evaluate technological advances that will impact its viability. Further, it provides a basis for predicting the potential trajectories of these advances.

Research into the cognitive structures and memory development of individuals suggests that accumulated prior knowledge increases both the ability to put new knowledge into memory, knowledge acquisition, and it enhances the ability to recall and use information (Cohen and Levinthal, 1990; Steers, 1991). Further, memory development is self-reinforcing in that the more objects and patterns stored the more readily new information about these concepts is acquired. As a result, the breadth of categories into which prior knowledge is organized, the differentiation of those categories and the linkages across them permit individuals to make sense of and in turn acquire new knowledge. Further, prior knowledge and skill is an important component of creativity, permitting associations and linkages that may not have been considered before.

At the organizational level, absorptive capacity depends on the capacities of the individual members, and tends to develop cumulatively. However, a firm's absorptive capacity is not simply the sum of the absorptive capacities of its employees. Absorptive capacity also depends on the environment-organization and internal communications structures. To fully understand absorptive capacity at the organizational level, the character and distribution of expertise within the organization must be understood (Cohen and Levinthal, 1990).

Communications cannot be disentangled from the distribution of expertise in the organization, as shared knowledge and expertise are essential for communications (Cohen and Levinthal, 1990). However, there may be a trade-off in the efficiency of internal communication with respect to the ability to assimilate and exploit information. While sharing a specialized common language facilitates effective communications within the venture, it may result in the inability to tap into diverse external knowledge sources. This may result when an internal language, coding scheme, or particular body of expertise becomes sufficiently overlapping and specialized that it impedes the incorporation of external knowledge. A common manifestation of this is the so-called "Not-Invented-Here" Syndrome. Therefore, while some overlap in knowledge is necessary for communications, there are benefits in diversity of knowledge structures, especially regarding the organization's capacity for innovation.

As discussed, absorptive capacity is not resident in any single individual, but depends on the linkages across the capabilities of the individuals within the firm. The ideal knowledge structure for an organizational sub-unit should reflect only partial overlapping knowledge complemented by non-overlapping diverse knowledge (Cohen and Levinthal, 1990). Therefore there is a trade-off between knowledge diversity and commonality across individuals. At the extreme, very-high knowledge commonality and reduced diversity, may have a negative impact on communications, both within and external to the organization, as well as the organization's capacity to be innovative. Further, some amount of redundancy in expertise may be desirable in order to create cross-functional absorptive capacities.

From this discussion of the importance of intellectual capital, competencies and absorptive capacity, it becomes apparent that when assessing ventures, expert decision making, and dealing with the high degree of intangible assets, will be key components.

2.8 Expert Decision Making

Many researchers have examined decision-making in terms of individuals (e.g.: Fischoff, 1990; Kahneman and Tversky, 1990a; Kahneman and Tversky, 1990b; Kahneman and Tversky, 1990c; Camerer and Johnson, 1991; Dorner and Scholkopf, 1991; Mayer, 1992) and as groups (e.g.: Radford, 1977; Nutt and Backoff, 1986; Levine and Moreland, 1990; Prasad and Rubenstien, 1992). For example, Dorner and Scholkopf (1991), examined decisions associated with controlling complex systems, and discussed the role of cognitive model development when determining a course of action. When coping with complex systems, the expert's ability to manage the information processing becomes important (e.g.: Beer, 1985; Dorner and Scholkopf, 1991) and may result in the phenomenon of "blocking out" information to reduce complexity.

In their discussion of information processing, Sears et al. (1988) define three stages; gathering information, deciding on the information's relevance, and integration of the information into a judgement. Each of these stages has the potential for bias, such as prior expectations. The net result of these biases is that the decision process may appear haphazard and irrational.

Another phenomenon often observed in decision-making is 'anchoring' (e.g.: Kahneman and Tversky, 1990b; Cohen and Levinthal, 1990). Kahneman and Tversky (1990b) discuss the tendency for decision-makers to overlook distributional information and focus on case data instead. They then describe the use 'matching rules', and suggest that intuitive predictions are generated as a result of matching a case's standing in a distribution of outcomes with its standing in a distribution of impressions. In other words, the anticipated outcome of an action will be based on how it relates to the decision-maker's prior experiences. This leads to the concept of attribution and attribution theory.

2.9 Assessment and Attribution

Ultimately, the process of assessing a new venture results in a decision to invest or lend. While, as discussed, many tools and methods are available to aid in this decision process, in the end a practitioner must make a decision that may be very subjective. In essence this decision reflects an evaluation of the potential for success or failure of the venture.

Attribution theory examines how people explain the causes of their own and other's behavior (e.g.: Gleitman, 1992). Simply stated, attributions are the explanation individuals generate to explain events such as success and failure. These attributions are based on the internal cognitive model of the person assigning the attribution. As these models are unique for each individual, two people faced with the same information may act differently because they may attribute the potential outcome to different factors. It can be seen that this has possible consequences for examining venture assessment. Specifically, two individuals, when provided information describing a venture will interpret this information and assign a unique expectancy of success or failure to that venture.

Many approaches have been put forward to explain an individual's behaviour (e.g.: Gleitman, 1992; Greenberg et al., 1996). For example, one view maintains that a person's actions are the result of the present situation's similarity to past experiences. From this perspective, actions are determined externally, that is, they are reactions to external forces present in the individual's environment. In the case of decisions associated with new venture assessment, the decision may be strongly influenced by its similarity to past scenarios and primarily influenced by factors external to the venture.

A related view of behaviour is social learning theory (e.g.: Gleitman, 1992). As discussed by Gleitman, this maintains that an individual's actions are a function of both personality traits and situational factors. As a result, the factors influencing the decision-maker's actions include competencies, encoding strategies, and expectancies. In this framework, competencies are the abilities possessed by the decision-maker (Gleitman, 1992). They are the 'kinds of things a person can do and understand'.

Encoding strategies are how an individual interprets a situation and are a function of the individual's prior knowledge and experiences (e.g.: Gleitman, 1992). Expectancies are the causal relationships perceived by the decision-maker. In terms of venture assessment, they are the perceived causal relationships between various concepts and the venture's potential success or failure. As with the encoding strategies, these causal relationships are also a function of the decision-maker's prior knowledge and experiences. Related to this is the assignment of values to the concepts or factors believed to be causal to success or failure. Often, these values are not easily expressed as numerical values. Rather, they can only be expressed by the decision-maker linguistically and are subjective in nature (e.g.: Hruschka, 1988; Kacprzyk and Fedrizzi, 1988; Gleitman, 1992; Dutta, 1993; Zedah, 1993).

Another important aspect of social learning theory is the perceived control an individual has over the situation (e.g.: Greenberg et al., 1996). This leads to the concepts of internal and external control. External control relates to the influence factors that are not under the individual's control have on an outcome. Internal control on the other hand relates to the degree of perceived influence the individual has on the outcome. In terms of attributing success or failure, a high level of perceived external control would imply that the outcome was the result of factors outside the individual's influence. A high level of perceived internal control indicates that the individual perceived the outcome to be a result of the person's actions and abilities. Therefore, a key issue is whether to attribute the cause of a given behavior to internal states or external conditions.

A related issue is whether the cause of a given behaviour is stable or unstable (e.g.: Gleitman, 1992). Stability describes whether the factor is temporary or permanent. In other words, is the cause stable or changing over time? If an outcome is perceived to be the result of a stable cause then the outcome will be expected to reoccur.

When considering the attribution process, several sources of error and bias must be considered. Among these, and perhaps most relevant when considering the assessment of new ventures, is the tendency to rate internal factors higher than external factors. This is the so-called fundamental attribution error, and leads to a tendency to under estimate the potential impact of situational factors (Gleitman, 1992; Greenberg et al., 1996). Further, as discussed by Gleitman, this tendency to under estimate the importance of situational factors only occurs when trying to understand the behaviour of others.

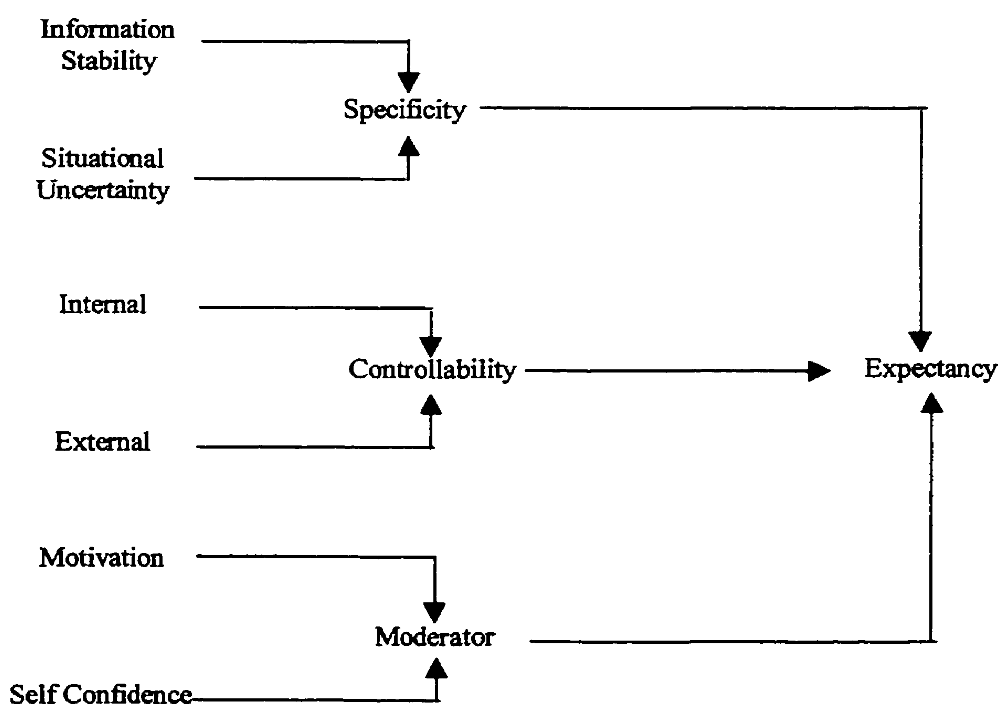
Abraham et al. (1988) proposed a simple, illustrative model of attribution dynamics to examine an individual's behaviour, for example mood, consisting of a state space defining the individual's 'decision' state. Abraham (1988) defines attribution as behavioural motivation that is dependent upon the expectancy of success or failure. While this model was conceived to describe an individual's behaviour, it provides the inspiration for a similar view of venture assessment. Extended to venture assessor decisions, investment or lending behaviour may be viewed as the result of the decision-maker's expectancy of venture success or failure. This expectancy is based on the subjective values assigned to concepts, represented as decision criteria, to which the decision-maker perceives a causal relationship with future success.

Abraham's proposed attribution model consists of two underlying state variables, internalization and specificity. Internalization considers the degree to which the factors acting on the individual are perceived as internally or externally controlled. The specificity state variable has two constituent factors, situational specificity and information temporal stability. The first of these, situational specificity concerns the specific-global aspects of attribution. The issue here is whether the attribution factor is considered by the decision-maker to be applicable in a global sense to all cases, or whether there are a high degree of situation specific attributes. Therefore, the greater the perceived global applicability of a concept to the decision problem, the higher the perceived situational specificity.

In the case of information temporal stability, the concern is whether the factors to which success or failure is being attributed will change over time. Therefore, a factor that is considered to be stable is expected to continue to impact the potential success or failure of the venture. An unstable factor however, may be expected to change over time and as such increases decision uncertainty. Further, stability influences both internal and external attribution factors (Abraham, 1988).

These proposed variables, Figure 2.1, define the decision-maker state-space. As such, the decision-maker's state at any moment is described by the perceived quantity of each state-variable. As previously discussed, it is unreasonable to expect that any two decision-makers will react in the same way to a set of information inputs. To account for this, Abraham (1988) introduces a control or moderator variable in addition to the state variables. Abraham identifies several potential moderator variables that may be introduced, such as individual and cultural bias, self confidence and risk aversion.

Figure 2.1
Abraham (1988) Attribution Model



When assessing ventures at the end of the concept stage or early in the development stage, a key objective is to estimate its potential to successfully reach the market introduction stage. Further, it is at this point in a venture's evolution that the development of its areas of future core competence begins (Slatter, 1992). While it may have access to the technology and knowledge that will eventually become the foundation of these competencies, they have not yet been integrated in such a way as to be truly a competency.

In a macro sense, the objective of a venture is to convert inputs into a desired set of outputs or products. The continued effectiveness and efficiency of this conversion process is closely related to the ability of the venture to develop competencies in key aspects of the conversion process and to evolve and adapt these areas of competency as its environment changes. When viewed from this perspective, the issue when assessing the potential of a new technology-based venture becomes one of determining if the venture system is viable.

2.10 Complexity Theory

The traditional approach to understanding complex systems has been to understand individual system components and then to try understanding how they work as a group (e.g.: Jenkins and Bella, 1993). When dealing with very complex systems, this approach has often had poor results (Jenkins and Bella, 1993; Roetzheim, 1994). For example, no matter how much effort is expended in understanding the individual behaviour of an investor, the overall performance of the stock market is still extremely difficult to model. A recent approach to dealing with very complex systems is complexity theory (e.g.: Jenkins and Bella, 1993; Roetzheim, 1994), which deals with groups of interacting entities and has its roots in chaos and dynamic systems theory.

As discussed by Roetzheim (1994), complexity theory may be defined as the study of emergent behaviour exhibited by interacting components operating at the threshold of stability and chaos. In other words, there is a region in which system behaviour can be modelled and predicted with a reasonable degree of accuracy. This system behaviour is typically referred to as stable, while at the other extreme are systems whose behaviour is completely chaotic and unpredictable. Complex systems may exhibit complicated behaviour that is often surprising or unpredictable, referred to as emergent behaviour.

A system that exhibits stable behaviour within a certain range of parameters and chaotic behaviour is said to have phases. The system transition from stable to chaotic is often where emergent behaviour is exhibited, and can be described as complex (Roetzheim, 1994). Once reached, this emergent behaviour can be quite predictable. As discussed by Roetzheim, complex systems often do not exist in this state by 'choice'. Rather, the system exists in this state between stability and chaos due to the complex interaction of internal and environmental factors.

Further, an overall understanding of the structure of a complex system is not necessary to understand emergent behaviour of a system. Rather it may be understood and modelled based on a relatively small number of rules describing the interaction of system components (Roetzheim, 1994). This has important implications for the understanding of venture evolution and assessment. Rather than modelling all of the intricacies of the venture and how it interacts with its environment, a simpler rule-based approach, as used by assessment experts, has great potential.

2.11 Viability Theory and Venture Assessment

As discussed by Jenkins and Bella (1993), socio-technical systems generally cannot be effectively modelled as linear systems. In the case of venture evolution there is a complex system of internal and external interactions. Activities associated with the venture must be viewed as occurring within a dynamic web of information and resource transfer that exhibits the characteristics of self-organization and chaos (Jenkins and Bella, 1993). As such, ventures are inherently unstable, and further, when taking a complexity theory view of venture development it can be seen that if the venture truly reaches a stable state, that is no changes are occurring within the system, then the venture may be considered to be non-functional, i.e. dead. On the other hand, if the venture system is operating completely randomly, with no identifiable behaviour pattern then it is completely chaotic and is invariably headed for destruction.

From this perspective, venture assessment criteria are attempting to judge whether a venture is likely to move into one of these regions, either death, chaos or profitability. The question of interest is whether the venture system will move into a region of viable behaviour and stay there. Therefore, the problem of new venture assessment may be viewed as identification of the viability constraints and then determining if the venture as constituted is within a viable region.

To examine this question of system viability further, Viability Theory[1] (Aubin, 1991) is considered. As described by Aubin (1991), viability theory is a mathematical theory that considers the evolution of macro-systems such as those arising in biology, economics and non-linear control theory under uncertainty. Obviously, not every potential evolutionary trajectory for a system is possible. This is referred to as viability and as discussed by Aubin (1991) implies that the state of a system must obey constraints called viability constraints. Therefore, to understand the evolution of a system and its potential for further evolution, these constraints must be understood. Viability theory provides a framework for understanding the connections between system dynamics and constraints in the selection of viable evolutions. Further, its theorems provide the basis for understanding the regulation processes or feedback that maintain viability or improve the state according to some preference relationships (Aubin, 1991).

---

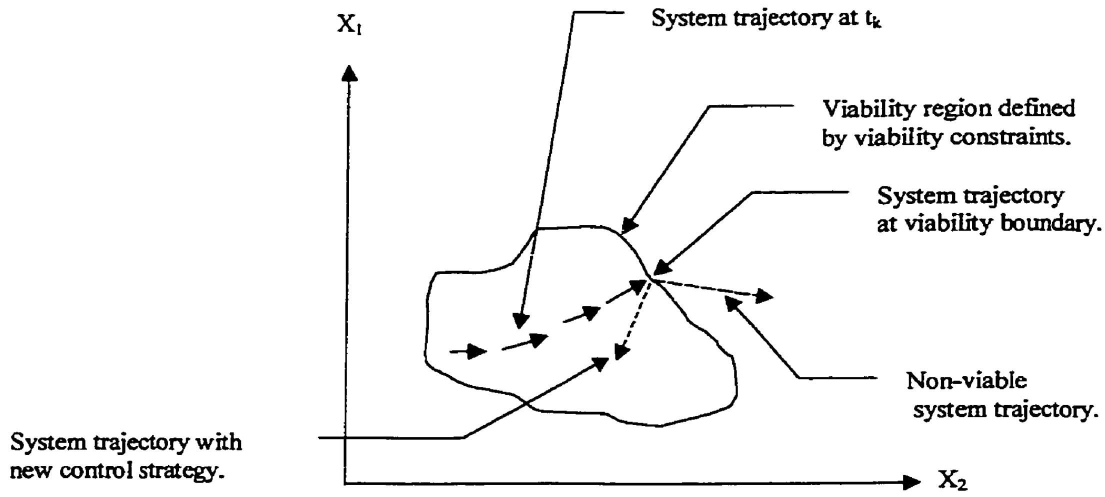
[1] For a more detailed discussion of viability theory the reader is referred to Appendix G.

The systems typically considered within the viability theory framework have three basic characteristics (Aubin, 1991). The first characteristic is a non-deterministic engine of change providing several possible evolutionary trajectories. This means that at any instant there are several feasible evolutionary paths that depend on the state and possibly the previous history of the system up to that time. As such, the concept of evolution in which future states can be predicted is no longer sufficient to model system behaviour. Further, even if there are deterministic mechanisms existing within the system, they are often inherently unstable.

The second viability characteristic is that there are constraints that the system must obey at each instant under a 'death penalty'. In other words, if the system violates the constraints it will cease to exist. In the venture context, this may be manifested as bankruptcy.

The third characteristic is referred to as the inertia principle. System control governed by the inertia principle results in changes to the system control only when system viability is threatened. Unlike optimal control theory (e.g.: Bajpai et al., 1980), viability theory does not require a decision-maker to guide the system by an optimality criterion. In the optimal control paradigm, the choice of controls is not static, but can be changed at each instant to take into account possible changes in the system's environment. The inertia principle of viability theory states that the system controls are kept constant as long as viability of the system is not at stake. As long as the system state lies in the interior of the 'viability set', defined as the states satisfying the viability constraints, any control strategy will work. As a result, the system can maintain the control inherited from the past. As the state of a system may evolve while the control remains constant, it may reach the boundary of the viability region with an outward velocity (Aubin, 1991). This event corresponds to a period of crisis during which the system must find a new control strategy such that the trajectory is forced back into the viability set. If this is not possible, the system 'dies'.

Figure 2.2
System Viability



It is quickly apparent that this describes the internal controls of most ventures, which place a set of operating controls and periodically updated strategies in place. These processes and procedures are often only modified when it becomes apparent that the continued survival of the venture is at stake. Further, it is not uncommon for ventures to experience periods of 'crisis' as they evolve. Often at these points in time, the venture must make major changes to its management and control structure to survive and continue to grow.

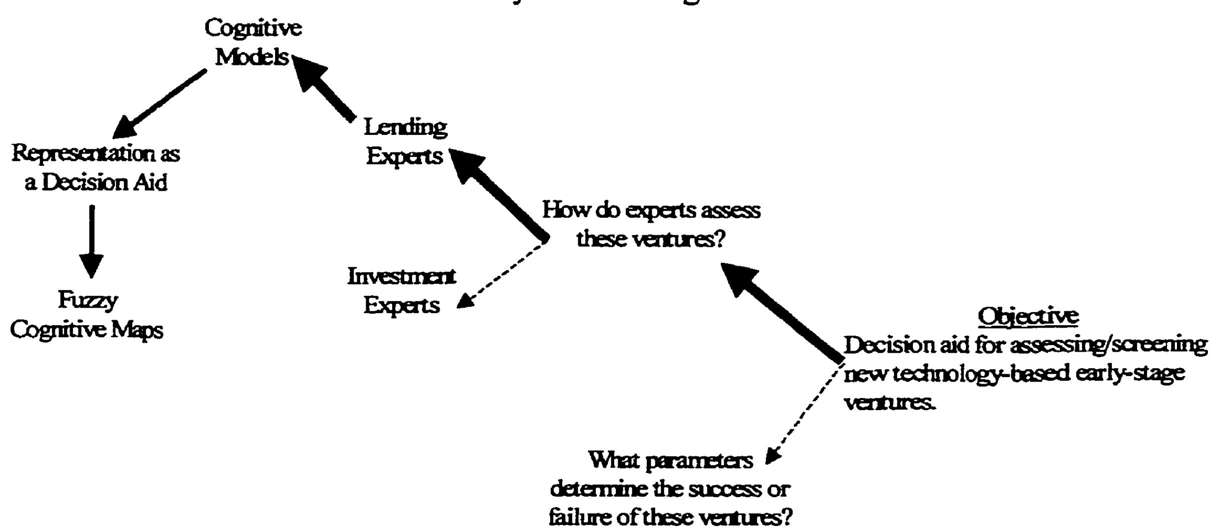
As pointed out by Aubin (1991), as long as the system remains within the viability region and therefore satisfies its viability constraints, any control strategy will work. This has interesting implications for understanding the assessment of new ventures. Perhaps most interestingly, the question of how different assessment practitioners can use different sub-sets of criteria, drawn from the set of assessment criteria, when assessing a venture and still have a 'correct' or 'satisfactory' outcome. In other words, this may answer the question: Why is there no optimal set of criteria that all experienced assessors use?

Chapter 3

Study I: Cognitive Models of Lenders

As discussed in the introductory chapter, this research consists of three studies having the overall goal of advancing our understanding during the assessment of early-stage, technology-based ventures. In the first of these studies, the assessment behaviour of a group of lending experts is considered. Several researchers have examined the criteria (e.g.: Hall and Hofer, 1993; Bachher et al., 1999) and the assessment process (e.g.: Hall and Hofer, 1993) of investors. The goal of this study is to explore the assessment process when considering lenders. To this end, as illustrated in Figure 3.1, the cognitive models of a group of lending experts are examined. In terms of decision aid development, these cognitive models will then become the basis for the creation of fuzzy cognitive maps (e.g.: Kosko, 1992).

Figure 3.1
Study I Issue Diagram



3.1 Methodology

As the goal is to examine the cognitive models of a small group of lending experts, open interviews with seed questions and content analysis were utilized (e.g.: Ericsson and Simon, 1984)[1]. Each interview began with a general discussion of venture characteristics and lending decisions, and concluded with the expert being asked to recall a specific lending decision that was funded and one which was rejected. When discussing cases which were accepted or rejected, no specific information identifying the venture was requested, and the questioning sought to identify those characteristics and attributes which the expert considered most important in their decision.

The experts were senior lending officers, identified from Canadian bank Internet sites as being involved in lending to knowledge-based ventures. They were subsequently contacted by email and then contacted by telephone to arrange a suitable interview time. In the case where more than one expert was located at a site, only one was selected. This was done to ensure that there was no bias introduced due to contact between experts.

Each interview began with a statement of the broad research objectives, an overview of the planned interview format and an initial questionnaire to obtain demographic information. In three cases the interview was tape-recorded with the permission of the expert; tapes were subsequently transcribed. The other two are based on notes, and in one case the majority of the interview was conducted via email and fax. This was required due to the availability and geographic location of the expert. During the interviews, questions (Appendix C) were posed to the experts to begin discussion. As the interview proceeded and topics developed, further questions were posed in response to statements by the expert to delve deeper into topics. Details of the initial questionnaire and interview seed questions may be found in Appendix C.

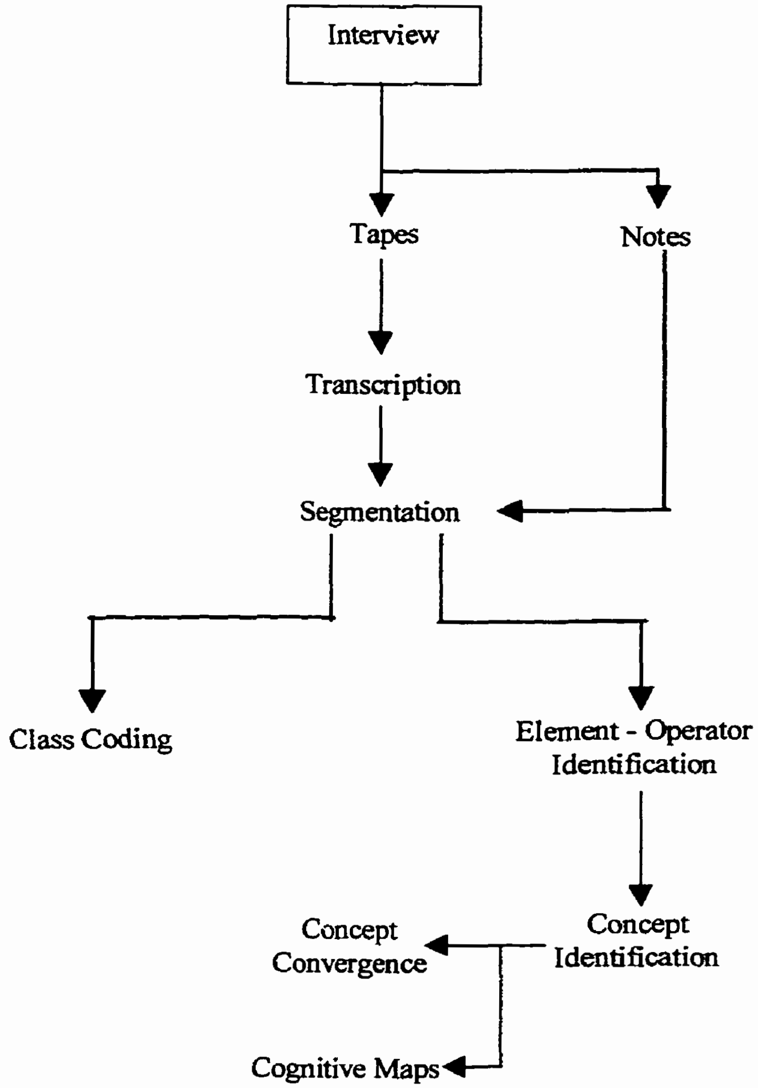
The interview transcripts and notes were then analyzed, as indicated in Figure 3.2. Typically, the analysis begins with a transcript of a set of verbal utterances that have been

---

[1] Approval was obtained from the University of Waterloo Office of Human Research.

obtained through interview sessions (e.g.: Bouwman, 1983; Waterman and Newell, 1971; Ericsson and Simon, 1984; Olson and Biolsi, 1991). Through analysis of these transcripts, objects are identified and encoded thus providing the basis for further analysis.

Figure 3.2
Methodology Overview



3.1.1 Sample Size

A question that arises when conducting interview-based research is: when is enough? Unlike conventional statistics, this issue is often difficult to determine. There are several issues that contribute to this decision, specifically information contribution from adding additional experts and the 'economics' of collecting and analyzing the information.

Several researchers (e.g.: Dutta, 1993; Gonzalez and Dankel, 1993; Sandri et al., 1995) have considered this problem when interviewing during knowledge elicitation for expert system development. In terms of the lending decision, a single assessor, or at most a small team typically undertakes this. As such, the unit of analysis at the outset is the individual expert. Further, the expertise of interest pertains to the assessment of very early-stage, pre-market introduction, technology-based ventures, limiting the number of experts available. It is therefore impractical to undertake studies requiring large samples. An additional constraint is the interview time available, further restricting the data collection method.

The overall goal of the knowledge acquisition process is to identify the concepts being utilized by the lending experts and the apparent relationships between them. An approach that addresses some of the problems resulting from the data collection constraints is the use of fuzzy cognitive maps (e.g.: Kosko, 1992; MacNeill et al., 1994; Kosko, 1997).

A common problem when using tree structures to represent expert knowledge is that generally they cannot be combined. This problem increases with the number of trees to be combined and as pointed out by Kosko (1992) creates the paradoxical situation in which larger sample sizes produce less reliable knowledge structures. An important attribute of fuzzy cognitive maps is that they may be aggregated (Kosko, 1992; Kosko, 1997), thereby permitting the development of a consensus map using several potentially incomplete sources. As a result, two or more cognitive maps can be combined to produce a new aggregate[2] map.

In this research, the 'stopping-rule' employed is based on the concept of marginal return. In other words, as each interview is analyzed, the number of new assessment concepts, and hence new information, is monitored. This is expected to decrease (e.g.: Nielsen, 1994) and is considered sufficient when the number of new concepts identified is less than two. This is related to the economics of data collection and the scarcity of experts. Each interview takes a minimum of one hour of the expert's time, followed by several days of analysis time to transcribe, segment and code. Thus, as the number of new concepts drop, the return on effort is also reduced. Based on the work of Nielsen (1994) the number of lending experts is expected to be five[3].

The second issue to consider is the impact of the number of experts on the aggregate fuzzy cognitive map. If it is assumed that the experts have equal and complete credibility, credibility index (C.I.) of 1, then the impact of adding one more sample to an aggregate map may be assessed[4].

3.1.2 Expert Characteristics

An important issue that must be addressed is the suitability, or 'credibility', of the interview experts (e.g.: Sandri et al., 1995). Determination of credibility is of interest

---

[2] Several aggregation methods may be considered, such as for example, mean or 'min plus mean' or optimistic (max) aggregation.

[3] A recent article by Nielsen (2000) further supports this number of experts.

[4] This is based on a simple simulation in which a set of 10 relationships, each with a frequency of occurrence from 0.1 to 1.0, was run through 10 interviews. This was repeated 15 times with different elicitation patterns and the impact on weights and the map assessed (Appendix E). Several scenarios were considered based on the expected frequency of occurrence of the relationships, and the results indicate that after five experts the impact on the aggregate map is expected to be less than 10%. Further, at this sample size, concepts that occur more than 50% of the time have the greatest influence on the map, with the impact on their weights expected to be less than 15%.

because it provides a method to weight the opinion of experts. As discussed, prior to each interview a brief questionnaire was administered, Appendix C, to gather background information on each expert. This information is then used to develop a credibility index for each expert.

The underlying premise is that credibility is a function of experience. The initial questionnaire has two main areas: technology-based venture experience and general demographic information. Experience is defined as having four measurement variables: reported years of technology-based venture evaluation, number of ventures evaluated, reported size of typical venture evaluated, and the value of the typical loan or investment.

The reported number of years provides a direct measure of the experience level of the expert, while the number of ventures evaluated provides an indication of the 'richness' of this experience base. The typical size of the firms being evaluated provides a check that the ventures the expert is familiar with fall into the category of interest, specifically, small ventures that are in the very early stages of their evolution. If the typical size of the ventures is relatively large, then it may be that the experience is focused on later stage ventures.

The final issue to be considered with regard to experience is the value of loans or investments that are made in these ventures. This measurement variable is an indirect indication of the size of the ventures being considered, as well as their development stage. It is expected that early stage ventures will typically require smaller loans, less than $500K, during their seed and start-up stages. Therefore, subjects who are typically dealing with large loans may be dealing with larger more established ventures. This also provides an indication of the level of risk associated with that expert's decisions. The characteristics of the interviewed experts, based on the pre-interview questionnaire data[5], are provided in Table 3.1.

---

[5] The pre-interview questionnaire elicited background information from the experts by providing classification categories, arranged along a 6-point scale.

Based on the pre-interview questionnaire information, an expert credibility index is then developed. The issue then becomes one of defining an ideal expert and defining the measurement variables to reflect this. Each of the measurement variables was assigned a value based on the criteria provided in Table 3.2.

Table 3.1
Lending Expert Characteristics

Criteria	Median	Interpretation
Years with Bank	6	Greater than 20 years
Education Level	2	Honours Degree
Years Since Finished Education	6	Greater than 15 Years
Typical Venture Size (Employees)	3	11 - 20 Employees
Typical Venture Size (Sales)	5	Greater than $500K
Period Involved with Small Ventures	3	Greater than 3 Years
Number Assessed per Year	4	Greater than 50 Ventures
Size of Investment/Loan	3.5	Greater than $500K

Assignment of credibility scores is based on the following guidelines. Characteristics that are considered to be indicative of an ideal candidate are given a value of 1. Thus in the case of "years with the bank", those that are category four or higher are awarded a 1. The next step is to determine the penalty for the 'worst case'. Again using "years with the bank", subjects with very little experience were heavily penalized, resulting in a value of 0.25 for those in category one. The general guideline used for assigning the remaining score was to split the difference. This was modified slightly to adjust numbers up or down. For example, using "years with the bank", the remaining score would be 0.625, but was adjusted to 0.65. Similarly, in the case of "education level", the intermediate score would be 0.875, but was adjusted to 0.85.

Table 3.2
Credibility Index Variable Assignment

Measurement Variable		Credibility Score	Measurement Variable Value
Years with Bank	X_Y	$X_1 = 1.0$	$X_Y > 4$
		$X_1 = 0.65$	$2 \leq X_Y \leq 4$
		$X_1 = 0.25$	$X_Y < 2$
Education Level	X_E	$X_2 = 1.0$	$X_E > 4$
		$X_2 = 0.85$	$2 \leq X_E \leq 4$
		$X_2 = 0.75$	$X_E < 2$
Years Since Finished Education	X_F	$X_3 = 1.0$	$X_F > 4$
		$X_3 = 0.75$	$2 \leq X_F \leq 4$
		$X_3 = 0.5$	$X_F < 2$
Typical Venture Size (Employees)	X_{VE}	$X_4 = 1.0$	$2 \leq X_{VE} \leq 4$
		$X_4 = 0.85$	$X_{VE} < 2$
		$X_4 = 0.75$	$X_{VE} > 4$
Typical Venture Size (Sales)	X_{VS}	$X_5 = 1.0$	$2 \leq X_{VS} \leq 4$
		$X_5 = 0.85$	$X_{VS} < 2$
		$X_5 = 0.75$	$X_{VS} > 4$
Period Involved with Small Ventures	X_X	$X_6 = 1.0$	$X_X > 3$
		$X_6 = 0.75$	$1 < X_X \leq 3$
		$X_6 = 0.5$	$X_X \leq 1$
Number Assessed per Year	X_N	$X_7 = 1.0$	$X_N > 4$
		$X_7 = 0.75$	$2 \leq X_N \leq 4$
		$X_7 = 0.5$	$X_N < 2$
Size of Investment	X_M	$X_8 = 1.0$	$2 \leq X_M \leq 5$
		$X_8 = 0.85$	$X_M < 2$
		$X_8 = 0.75$	$X_M > 5$

The credibility index is a normalized, weighted sum of the individual measurement variables. The criteria weights, Table 3.3, have been chosen to reflect the relative weighting desired in the experience and general demographic information. The overall weighting assigned to experience is 75%, which is then evenly divided among the measurement variables. The remaining 25% are then divided equally among the remaining measures. The resulting credibility indices are shown in Table 3.4.

Table 3.3
Credibility Criteria Weights

	Credibility Factor Weight	Measurement Variable	Criteria Weight (k_I)
Demographic Information	k_1	Years with Bank	0.083
	k_2	Education Level	0.083
	k_3	Years Since Finished Education	0.083
Relevant Experience	k_4	Typical Venture Size (Employees)	0.15
	k_5	Typical Venture Size (Sales)	0.15
	k_6	Period Involved with Small Ventures	0.15
	k_7	Number Assessed per Year	0.15
	k_8	Size of Investment	0.15

Table 3.4
Expert Credibility Indices

Expert	Index
S1	0.93
S2	0.87
S3	0.85
S4	0.95
S5	0.84

3.2 Interview Coding

Once the interview recordings have been transcribed, or interview notes collected, they are segmented (e.g.: Ericsson and Simon, 1984), which is the basis of further analysis. The first step in the analysis is to examine the types of utterances that occur during the interview. This leads to segment classification and provides a qualitative assessment of the interviews. The results of this response classification are provided in Table 3.5.

Table 3.5
Response Classifications

	Frequencies (Percent)				
	S1	S2	S3	S4	S5
χ^2	195	136	386	449	191
Lending Decision Characteristics	23.4%	20.7%	20.1%	26.4%	29%
Market Attribute	11.8%	17.1%	11.2%	17.4%	3%
Product Attribute	7.7%	6.3%	4%	1.6%	6%
Venture Attribute	38.6%	45.9%	52.9%	37.6%	45%
Financing Considerations	18.5%	9%	11.2%	5.3%	15%
Other Risk	0%	1%	0%	1.6%	2%

The chi-square statistic is a simple qualitative check and in all cases indicated that the distribution of concepts is not random. The most frequently occurring classification is utterances concerning characteristics of the venture, such as its size and characteristics of the management team. The next most common group are segments regarding lending decision characteristics and considers information such as the size of the loan requested and various aspects of bank policy.

3.3 Assessment Concept Identification

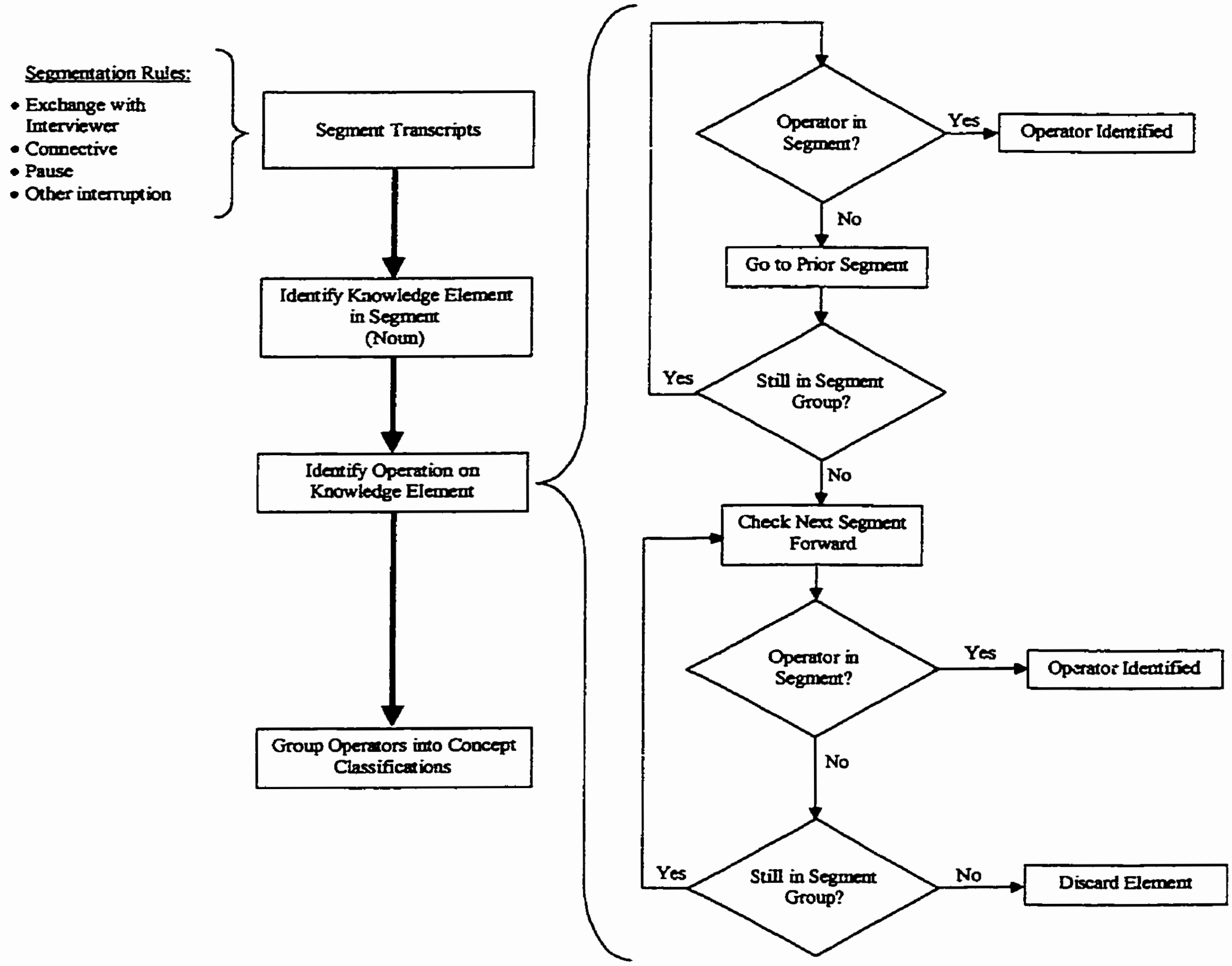
The next stage in the analysis is to identify the assessment concepts used by the banking experts. The overall approach to this problem is illustrated in Figure 3.3, and is similar to the analysis approach described by Bouwman (1983), and to means-end analysis discussed by Firebaugh (1989). In both cases, the fundamental idea is to identify the operators that convert an initial element into an output element.

In this analysis, each segment corresponds to a statement, with encoding of each retaining the most semantic content. While it is desirable to encode the information contained in the segment itself, in some cases it may be necessary to examine the preceding and following segments to determine context and remove ambiguity. As discussed by Ericsson and Simon (1984), the information reported consists primarily of knowledge elements required as inputs to a set of operators. These operators acting on the knowledge elements produce new knowledge. Therefore, the first step in the analysis is to identify the knowledge elements present in an interview segment. The segment is then examined to identify the operator being applied to the element.

The next analysis step is to standardize the results such that synonyms are corrected where it is considered desirable. For example, one set of analysis may have coded an operator as "financing risk" while another has been coded as "financial risk". These would be re-coded across all analyses as "financial risk". While it is permissible to simplify the coding, this must be weighed against the possibility of loss of semantic content (Ericsson and Simon, 1984). As such, each case is considered to determine the potential impact of the re-coding.

Simply considering the concepts that are used by the experts does not provide a complete picture of the decision process. In this research, these operators are the assessment concepts employed by the experts when assessing a new venture. Based on these operators, the final analysis step is to examine how the concepts that have been identified are related. This is done through the application of fuzzy cognitive maps (e.g.: Kosko, 1992; MacNeill et al., 1994; Taber, 1994; Kosko, 1997; Liu and Satur, 1999; Satur and Liu, 1999). Due to the complexity of these maps, the various relationships between the concepts may be represented through the creation of connection matrices (e.g.: Kosko, 1992; Taber, 1994).

Figure 3.3
Element-Operator Analysis



As described by Kosko (1992), fuzzy cognitive maps are signed, directed graphs with feedback that model the world as a collection of classes and causal relationships between the classes. The directed edges relate the various concepts and provide a measure of the causality between the concepts. While simple cognitive maps are restricted to edge values in {-1,0,1}, edge values in fuzzy cognitive maps may take on values in the interval [-1,1]. Here a value of zero indicates no causal relationship. The sign of the connection indicated increasing or decreasing causal relationships. Therefore, once the concepts have been identified, a simple cognitive matrix indicating the presence of relationships and the direction of the relationship may be developed.

3.4 Elements and Operators

The following tables, Table 3.6 through Table 3.10, list the elements and operators (e.g.: Waterman and Newell, 1971; Bouwman, 1983) identified for each of the experts who participated in this study. Definitions of these concepts may be found in Appendix E. For this analysis, a common set of element codes was defined as well as operators. As the analysis proceeded, the list was augmented as required (Ericsson and Simon, 1984). Included with the operators are lists of identified qualifiers for the input element. For example, the operator Maturity {venture} was found to have the qualifiers [established, new]. The output elements resulting from the application of these operators are examined in the next section.

3.5 Fuzzy Cognitive Map Development

The initial stage in the development of the fuzzy cognitive maps, Figure 3.4, is to develop simple trivalent {-1, 0, 1} maps (Kosko, 1992). Hence, if a causal relationship is present, it occurs to maximal positive or negative degrees. The use of a trivalent set is valid as experts tend to provide information in this form, and reflects relationships more accurately than when requested to provide weighted evaluations (Kosko, 1992). Further, during analysis of the interview transcripts the presence and sign of a relationship are more easily determined than its magnitude. When combined and normalized, these trivalent relationship maps are in the interval [-1,1] and approximate the underlying unknown population opinion of the relationship between concepts (Kosko, 1992). The connections between concepts in the expert's map are then represented as a causal connection matrix, for example Table 3.13. This is a convenient format, as the complexity of the maps tends to make them awkward to represent graphically once there is a significant number of concepts.

Table 3.6
Knowledge Element - Operator Analysis
Expert S1

Knowledge Element	Operator
Venture	Financability {venture} Maturity {venture} [established, new] Credibility {venture} Financial Strength {venture} Development Risk {venture} Attractiveness {venture} [high, low, acceptable] Cash-flow Potential{venture}
Technology	Potential {technology}
Product	Revenue Potential {product} Exist {product} Maturity {product} [exist, beta-testing, partially completed, completed] Market Potential {product} Development Requirement {product}
Market Forecast	Credibility {forecast}
Market	Velocity {market} Growth Potential {market} Focus {market} Familiarity {market} Exist {market} Competition {market} Access {market}
Management	Quality {management} Experience {management} Expectations {management} [financing] Credibility {management} Cooperation {management} Completeness {management}
Industry	Type {industry} [software, entertainment, film, technology-based, service] Growth Potential {industry}
Financing	Type {financing} [debt, sub-debt, equity, personal, commercial] Required {financing}
Development Team	Credibility {development team}
Development Requirement	Financing {development requirements} [not loan, cash-flow, equity] Available Resources {development requirement}
Cash-flow	Credibility {cash-flow}
Business Plan	Quality {business plan} Exist {business plan} Credibility {business plan} Completeness {business plan}
Board of Directors	Exist {BOD}

Table 3.7
Knowledge Element - Operator Analysis
Expert S2

Knowledge Element	Operator
Venture	Vulnerability {venture} Type {venture} [knowledge-based, technology-based] Maturity {venture} [R&D stage] Growth Potential {venture} Financial Strength {venture} Credibility {venture} Cash-flow Potential {venture} Attractiveness {venture}
Technology	Proprietary {technology}
Product	Potential {product} Maturity {product} [market presence, product launch] Life-cycle {product} Exist {product} Development Requirements {product} Development Financing {product}
Market Forecast	Credibility {forecast}
Market	Velocity {market} growth potential {market} Focus {market} [niche] Exist {market}
Management	Credibility {management} Cooperation {management} Completeness {management} Quality {management} Experience {management} Expectations {management} [realistic] Communications {management} Commitment {management} Cohesive {management}
Financing	Risk {financing}
Industry	Type {industry} [insurance]
Development Team	Credibility {development team}
Cash-flow	Required {cash-flow}
Business Plan	Quality {business plan} Exist {business plan} Credibility {business plan}

Table 3.8
Knowledge Element - Operator Analysis
Expert S3

Knowledge Element	Operator
Venture	Type {venture} Revenue Potential {venture} Maturity {venture} [commercialization] Cash-flow Potential {venture}
Technology	Proprietary {technology} Potential {technology} Credibility {technology}
Product	Potential {product} Maturity {product} Life-cycle {product} Development Requirement {product} Development Focus {product}
Market	Velocity {market} Potential {market} Focus {market} [niche] Familiarity {market} [investor]
Management	Quality {management} Credibility {management} Cohesive {management} Experience {management} Completeness {management} Communications {management}
Industry	Type {industry} [biotech, IT, service, software, health care, pharmaceutical]
Financing	Required {financing} Risk {financing} Resources {financing}
Development Team	Quality {development team} Capability {development team}
Business Plan	Quality {business plan} Completeness {business plan}

Table 3.9
Knowledge Element - Operator Analysis
Expert S4

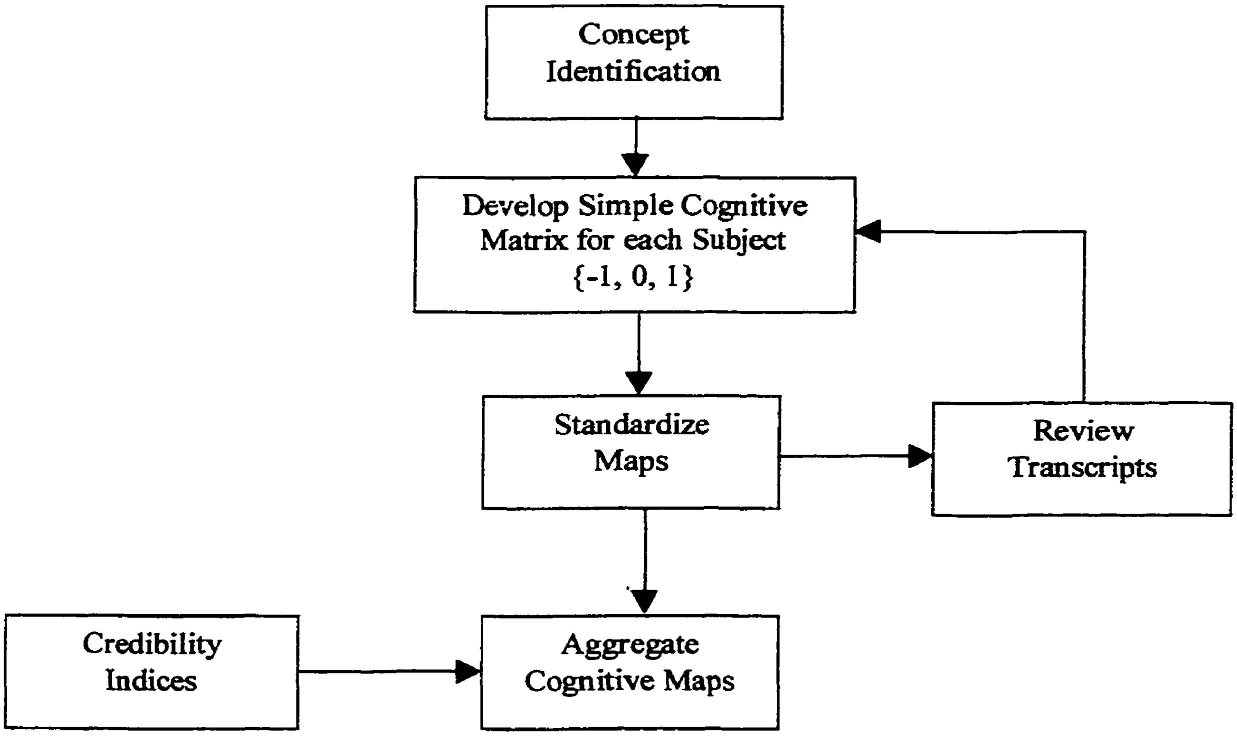
Knowledge Element	Operator
Industry	Type {Industry} Market Velocity {industry} [rapid, fast, slow] Market Maturity {industry}[emerging, mature] Required Capitalization {industry} [high, low] Investment Cycle {industry}[long, short]
Market	Familiarity {target market} [high, low] Venture Understanding {target market} [high, low]
Venture	Market growth potential {venture} Leadership potential {venture} Attractiveness {venture} Maturity {venture}
Product	Innovativeness {product} Exist {product} Uniqueness {product} Potential {product}
Management	Experience {venture management} Receptiveness {venture management} Commitment {venture management} Cohesiveness {venture management} Credibility {venture management} Completeness {venture management} Quality {venture management}
Board Of Directors	Quality {BOD} [Strong, Weak, Unknown, Absent] Exist {BOD} [Defined, Undefined, Absent] Complete {BOD} Requirement {BOD}
Business Plan	Exist{business plan} [Exists, Undefined, Absent]
Development Team	Vulnerability {development team} Experience {development team} Quality {development team} Credibility { development team} Management {development team} Capabilities {development team} [knowledge]
Technology	Potential {technology} Control {technology}

Table 3.10
Knowledge Element - Operator Analysis
Expert S5

Element	Operator
Venture	Type {venture} [stand-alone] Maturity {venture} Credibility {venture} Attractiveness {venture} Cash-flow Potential {venture}
Product	Potential {product}
Market	Potential {market} Focus {market} Familiarity {market} [investor]
Management	Quality {management} Completeness {management} Communications {management} Commitment {management}
Industry	Type {industry} [computer games]
Financial	Resources {financial} Required {financial} Risk {financial} Type {financial} Availability {financial} Investment Cycle {financial} [long, short]
Development Team	Quality {development team} Capabilities {development team}

Each expert has different sets of concepts they consider relevant to the decision process. Standardization, or conformation, of the connection matrices simply involved including the concepts that had not been identified in each map and assigning them zero connections. Once standardized, each map can be combined additively (Kosko, 1992). Further, as each expert has a different credibility relative to the others, this can be incorporated through the application of a weighted average.

Figure 3.4
Fuzzy Cognitive Map Development



Based on the analysis of the interview transcripts, a list of assessment concepts can be generated, Table 3.11. In this table, each of the concepts is assigned an identifier, i.e.: C_1, for simplified expression of the connection matrices. Table 3.12 provides an example of a trivalent connection matrix for expert S1. Each row in the matrix indicates the influence that a concept has on the others. The matrices for the remaining experts, as well as the overall connection matrix may be found in Appendix E.

Table 3.11
All Experts Concept List

Concept		Concept	
C_1	Venture Vulnerability	C_{34}	Management Credibility
C_2	Venture Type	C_{35}	Management Cooperation
C_3	Venture Protection	C_{36}	Management Completeness
C_4	Venture Maturity	C_{37}	Management Communications
C_5	Venture Market Understanding	C_{38}	Management Commitment
C_6	Venture Growth Potential	C_{39}	Management Cohesiveness
C_7	Venture Financability	C_{40}	Investment Cycle
C_8	Venture Credibility	C_{41}	Industry Growth Potential
C_9	Venture Attractiveness	C_{42}	Financing Type
C_{10}	Technology Potential	C_{43}	Financial Resources
C_{11}	Technology Credibility	C_{44}	Financing Risk
C_{12}	Technology Control	C_{45}	Financing Availability
C_{13}	Revenue Potential	C_{46}	Development Team Vulnerability
C_{14}	Required Financing	C_{47}	Development Team Quality
C_{15}	Required Cash-flow	C_{48}	Development Team Management
C_{16}	Required Capitalization	C_{49}	Development Team Experience
C_{17}	Proprietary Technology	C_{50}	Development Team Credibility
C_{18}	Product Potential	C_{51}	Development Team Capabilities
C_{19}	Product Maturity	C_{52}	Development Risk
C_{20}	Product Life-cycle	C_{53}	Development Requirements
C_{21}	Product Existence	C_{54}	Development Focus
C_{22}	Market Velocity	C_{55}	Development Financing
C_{23}	Market Growth Potential	C_{56}	Cash-flow Potential Credibility
C_{24}	Market Maturity	C_{57}	Cash-flow Potential
C_{25}	Market Forecast Credibility	C_{58}	Business Plan Quality
C_{26}	Market Leadership Potential	C_{59}	Business Plan Existence
C_{27}	Market Focus	C_{60}	Business Plan Credibility
C_{28}	Market Familiarity	C_{61}	Business Plan Completeness
C_{29}	Market Existence	C_{62}	BOD Requirement
C_{30}	Market Access	C_{63}	BOD Quality
C_{31}	Management Quality	C_{64}	BOD Existence
C_{32}	Management Experience	C_{65}	BOD Completeness
C_{33}	Management Lender Expectations		

Table 3.12
Concept Trivalent Connection Matrix - Expert S1

	C4	C7	C8	C9	C10	C13	C19	C21	C22	C23	C25	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C41	C43	C44	C45	C52	C51	C53	C55	C56	C57	C58	C59	C60	C61	C64
C4				1		1	1											-1		1																
C7																																				
C8																															1			1		
C9																								-1												
C10				1						1														-1												
C13																															1					
C19				1		1																									1					
C21																																				
C22																													1							
C23				1		1																		-1							1					
C25																			1																	
C27																								-1												
C28																																				
C29						1			1																											
C30																																				
C31				1								1												-1												
C32											1					1		-1	1	1																
C33																				-1																
C34																1								-1												
C35				1																																
C36																1																				
C41				1		1				1																					1					
C43				1																				-1							1					
C44				-1																																
C45																								-1		-1										
C52				-1																																
C51																										-1										
C53																										1			1							
C55				1																											-1					
C56																																				
C57				1																				-1					1							
C58																																		1		
C59				1																																
C60				1																																
C61																																1				
C64				1															1																	

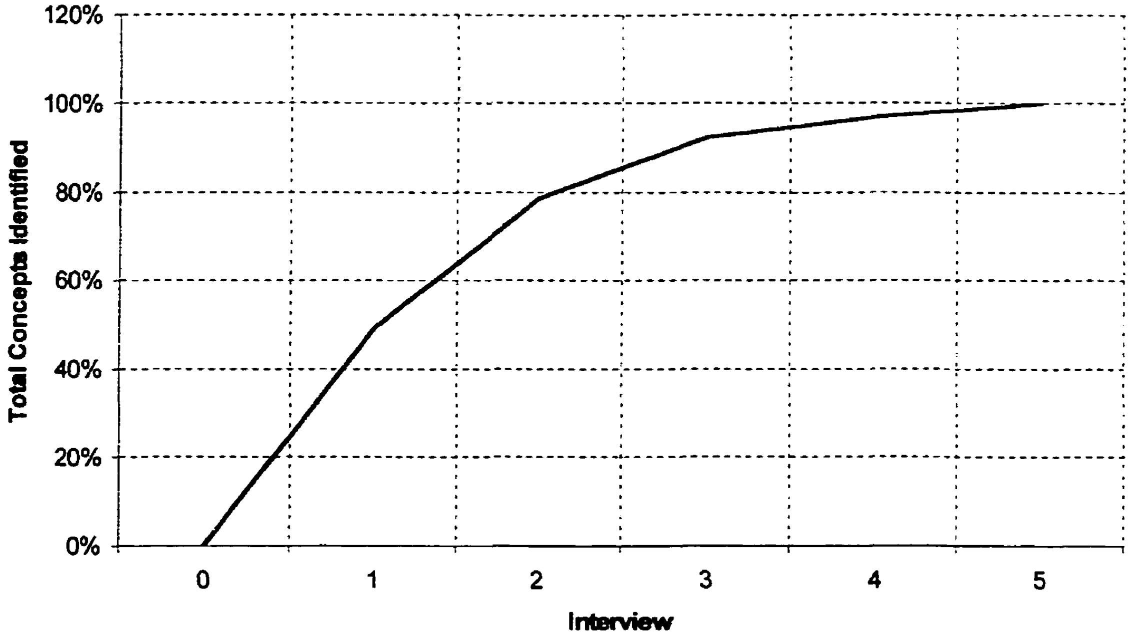
3.6 Discussion

The objective of this study has been to examine concepts and relationships used by lending experts when assessing a new venture. To examine this, fuzzy cognitive maps (Kosko, 1992) have been employed as a tool for describing the cognitive models of a group of lending experts. In total, 65 concepts were identified from the interview analysis, and as illustrated in Figure 3.7, the number of additional concepts diminished with each interview as expected. This result provides support for the interview sample size in that it is expected that additional experts will add few new concepts. Examination of the concepts also indicates that there are a core group, consisting of approximately 45% of the concepts, which occur frequently, i.e. 60% or more of the cases.

When compared to the concepts identified in the literature (e.g.: Hofer and Sandberg, 1987; Roberts, 1991; Bell, 1991; Meldrum and Millman, 1991; Slatter, 1992; Cooper, 1993; Hall and Hofer, 1993; Kassicieh et al., 1997) it can be seen that there are no unique concepts emerging. Rather, the lender concept set is a subset of the various concepts and criteria put forward in the literature. With respect to the cognitive maps of the experts, a core group of relationships is apparent, related to the core concepts. It is expected that additional experts will reinforce the core relationships while slowly reducing any 'spurious' relationships.

An interesting finding from the interview sessions was the perception of the difference between knowledge-based and technology-based ventures. In all cases the experts interviewed responded that they would not assess these ventures differently. Further questioning revealed that the perceived difference between these venture types is related to the rate of change of evolution, referred to in the coding as velocity. In all cases, the experts indicated that the higher the knowledge content of the venture, the greater the associated perceived rate of change.

Figure 3.7
Assessment Concept Elicitation



In terms of development of decision aids, the examination of the core concepts indicates that they are generally related to management issues. As such this may provide the basis of a toolbox component for evaluating a venture's overall management quality.

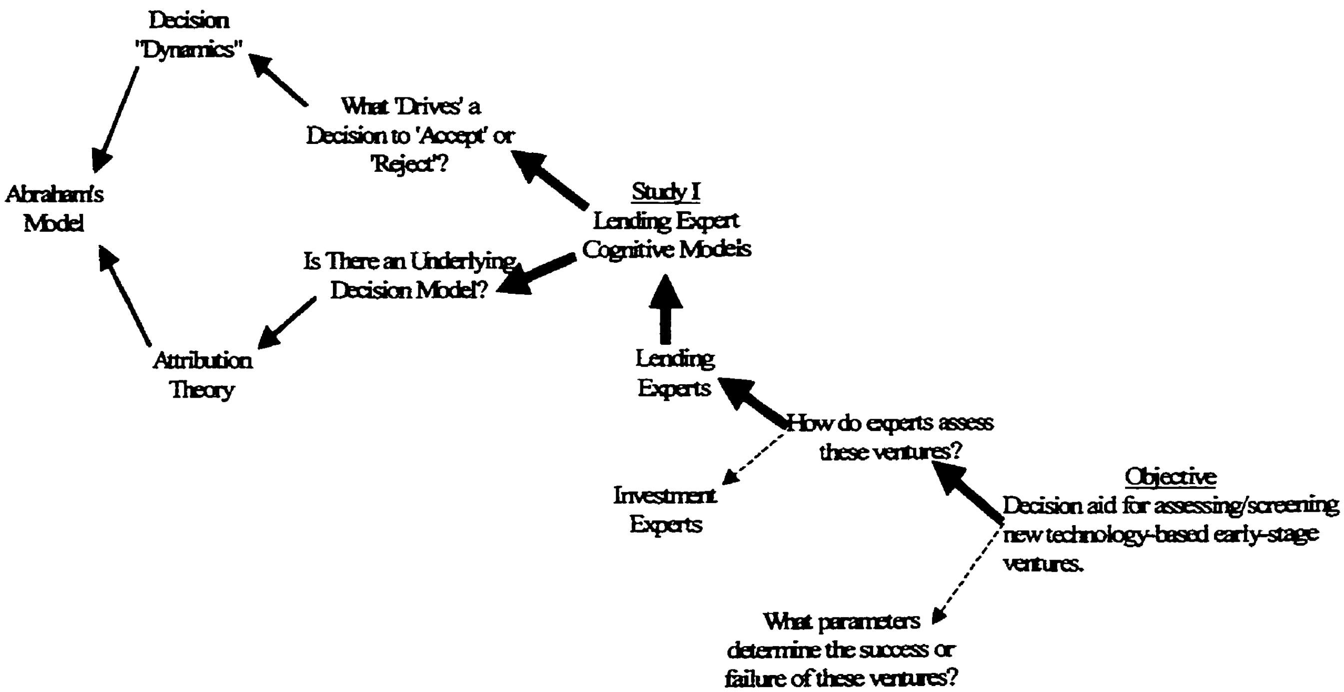
The observation that the elicited lender concepts are not unique, and may be viewed as a subset of concepts and assessment criteria found in the literature sets the stage for the next study. This observation combined with the apparent similarity with Public Venture Capital Funds leads to an interesting question. If the criteria are all derived from the same macro-set of criteria, what underlying process is occurring? This question provides the starting point for the next study, which examines the role of attribution in the assessment process.

Chapter 4

Study II: Assessment and Attribution Theory

In the previous study of lender cognitive models, it became apparent that the criteria used by the lending experts are strikingly similar to what has been found for investor groups. This raises a simple but fundamental question. If investor and lender groups are using the same basic set of criteria, how do they differ? This study explores the question with the aid of a model based on attribution theory (e.g.: Abraham, 1988; Gleitman, 1992; Greenberg et al., 1996). The objective of this study is to investigate the model's effectiveness in differentiating investor groups.

Figure 4.1
Study II Issue Diagram



Regarding the development of decision aids, understanding the underlying decision process is an important first step in tool creation. Support for this model not only provides insight into how information is being processed during venture assessment. It provides a basis for grouping decision criteria and system architecture.

To examine these questions, a data set identifying the importance attached to different investment criteria is utilized (Bachher, 1994). In this data set[1], the subjects were in three groups of investors, defined as 'business angels', private venture capitalists, and public venture capital funds, were investigated. The approach used when collecting these data was to provide the participants with a questionnaire that was completed during an interview session. This data set is of interest because it provides information along several dimensions.

During the administration of the questionnaire, the subjects were asked to consider a technology-based venture in which they had recently invested. They were then provided with the criteria set and asked to rank the importance of each of the criterion on a 7-point scale anchored on 'not very important' to 'very important'. Further, they were asked to rank their perception of each criterion for an accepted venture on a scale, ranging from very negative - neutral - very positive. This process was repeated for a venture that had been recently considered for investment but rejected. Additional information collected for each of the investment scenarios included the venture stage, defined as seed stage, start-up or first stage.

4.1 An Attribution Theory Model of Investor Behaviour

To examine the question whether or not the application of attribution theory can explain the differences between different investor groups, a model is developed that is an extension of the attribution dynamics model discussed by Abraham et al. (1988). Abraham describes the expectancy of success or failure as derived from factors associated with control and specificity.

---

[1] Refer to Appendix A for more information on regarding this data set.

The Abraham model is of interest for several reasons. First, its simplicity, the model consists of a minimum set of decision inputs. Second, the original model was proposed as a basis for a discussion of what leads to phenomena such as mood changes and depression. While this may seem like a leap to investment decisions, its simplicity makes it easy to generalize. Further, in examining decision dynamics, it provides a basis for understanding how 'migration' between accepts or rejects decisions occur as well as such phenomena as indecision[2]. Finally, if this model can provide insight into the path to accept and reject decision, it should provide understanding of how ventures are differentiated.

The first issue to be considered when developing an attribution theory model of investor behaviour is what Abraham (1988) describes as 'internalization'. In this model it will be referred to as the locus of causation, as it encompasses perceived control issues of the venture and the assessor. Factors that are perceived to be under the control of the venture are considered to be internal factors. Those not under the control of the venture, such as market forces and competitor reaction, are considered to be external factors. A further perspective that must be considered is the perceived internal control of the individual performing the assessment.

From this perspective, uniqueness in the business proposal may be viewed as tending to increase the perception that a venture is insulated from external, market related factors such as competition. As such, the greater the degree to which the venture has unique market attributes the less the impact of competitors, hence higher control. On the other hand, if the venture product or service is perceived as common place, then the venture will have a loss of external control due to increased vulnerability from competitors.

The next issue to be considered is the stability state variable and its two components, 'situational specificity' and 'information temporal stability'. In this model, situational specificity is the degree to which the venture characteristics are defined and

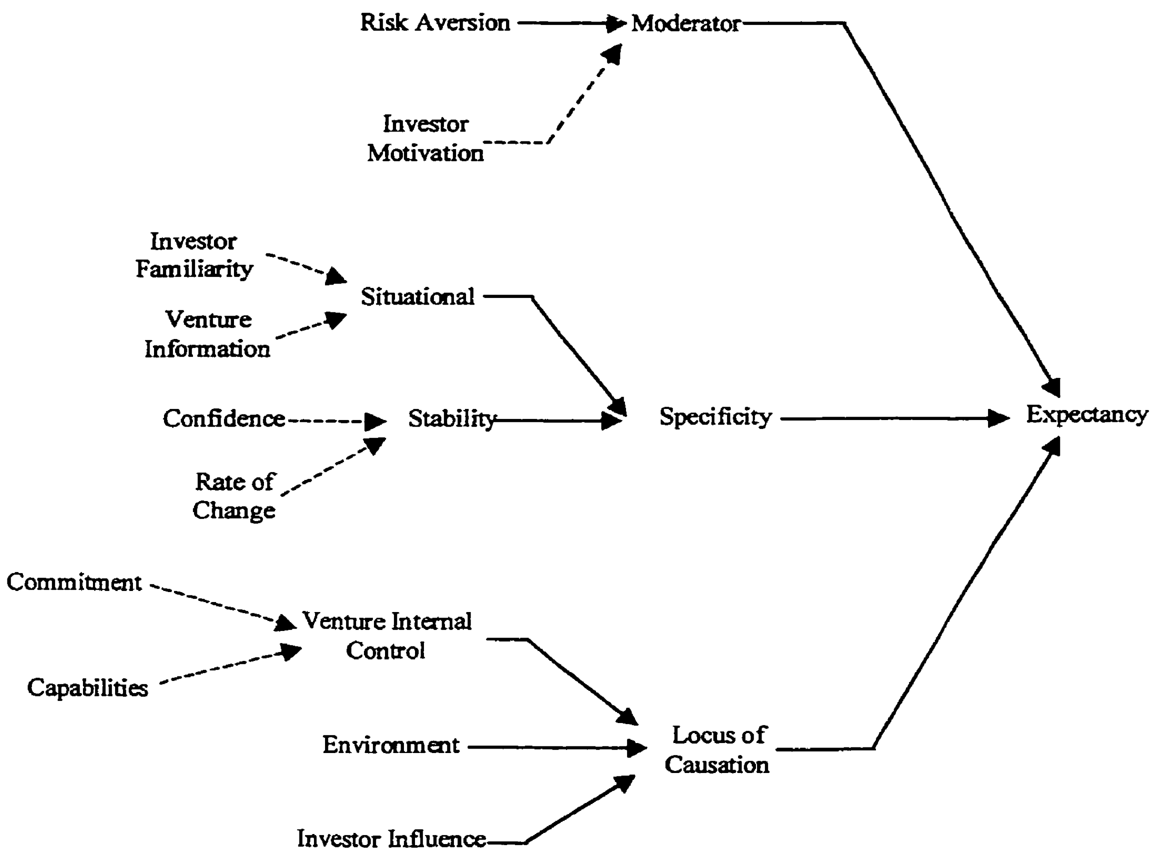
---

[2] Abraham's model is based on a the idea of explaining behaviour using a set of differential equations, and phenomena such as mood change as trajectories between attractors. In a similar fashion, indecision may be viewed as movement between an accepts and rejects attractor.

includes the investor's familiarity with relevant market and technology issues. Stability is defined as the perceived temporal stability of factors perceived as important to venture success.

Within the model, the moderator is considered to be the level of assessor risk aversion. There are several other possibilities, such as level of motivation and ambiguity intolerance. However, risk aversion will be the only moderator considered due to the evidence, both anecdotally and in the literature, that it is a significant differentiating characteristic.

Figure 4.2
Proposed Attribution Model



4.2 An Attribution Model of Venture Assessment

Based on the proposed attribution model, Figure 4.2, a fuzzy model is developed, consisting of membership functions defining the input and output variables. This approach was used to remove the necessity of defining the model's differential equations[3]. Each of the input membership functions[4] was defined with five levels, corresponding to a set of five linguistic qualifiers for each variable. Further, at this stage in the model development the relative size and location of the memberships were assigned arbitrarily.

The next task is to define the fuzzy rule base. As five levels of membership have been chosen for each input variable, a fuzzy associative memory (FAM) having 5^3 cells is required. Each cell provides an expected outcome, as defined in the output membership function, based on the inputs. In this model the output is also defined with five levels, corresponding to the expectancy qualifiers, reject, tend-to-reject, neutral, tend-to-accept, and accept.

The result of this attribution model implementation is the decision surface shown in Figure 4.3. This corresponds to the decisions generated by each possible combination of input variables. Although the decision surface is very general, it does provide some indication of how accept and reject decisions would be expected to cluster and provides an opportunity to examine expected behaviours.

As discussed, a control or moderator variable in this model is the risk aversion of the decision maker. It is assumed that the level of risk aversion is relatively constant within an investor group and therefore should cause them to cluster. As indicated in Figure 4.3, it is expected that there will be an accept region in the upper right corner of the plane. The

---

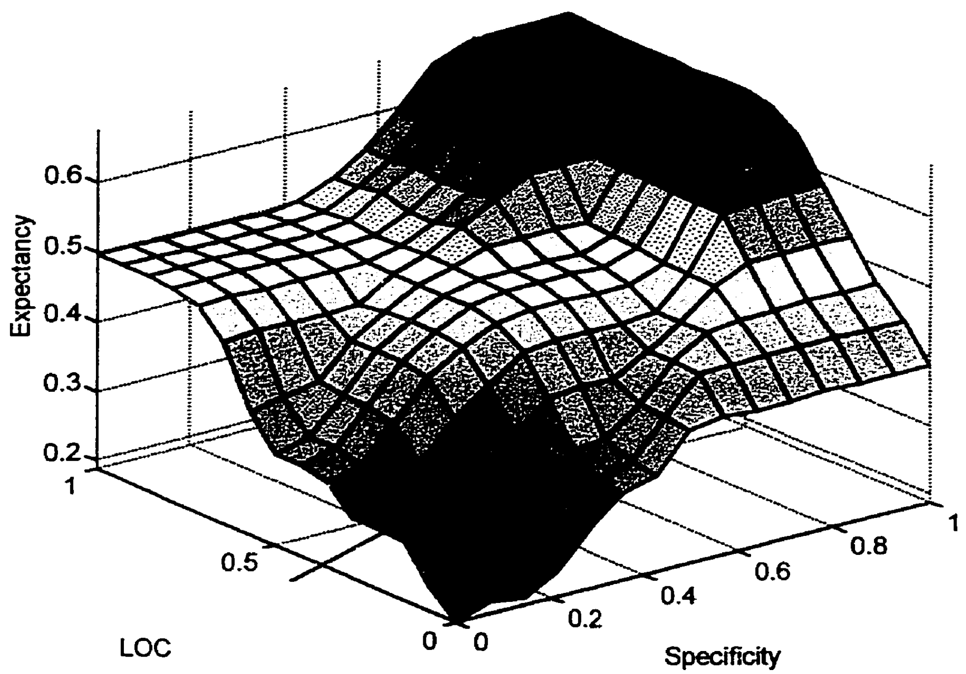
[3] The model as proposed by Abraham would require the researcher to develop a set of differential equations defining the system. This approach takes advantage of the idea of FAMs as 'universal approximators' (e.g.: Kosko, 1994; Kosko, 1997). As an experiment, a model based on this FAM was created in MATLAB and the trajectories resulting from different information acquisition profiles was examined.

[4] Modified Gaussian membership functions were chosen; however, triangular or trapezoidal membership functions would also be valid and are the functional forms typically chosen for system implementation.

reject region will be found in the lower left and there is expected to be a region of neutral attribution.

Given the assumption that the level of risk aversion is relatively constant within an investor group, it is also expected that the centroid of the accept region will tend to move further to the right as the risk aversion increases. Similarly, the boundary for the reject region is expected to migrate to the right, indicating that the decision maker is more likely to reject a venture proposal. In terms of the proposed model, this movement to the right of the plane is expected due to the increased threshold for an acceptable level of specificity and locus of causation.

Figure 4.3
General Attribution Model Decision Surface



4.2.1 Hypothesis Summary

1. The importance attributed to criteria for accepted ventures will be equal to the importance attributed to criteria for rejected ventures.

2. Based on the decision surface of the proposed model, the accept decision region for each of the investor groups will be found in the upper right corner.

3. Based on the decision surface of the proposed model, the reject decision region for each of the investor groups will be found in the lower left corner.

4. Investor groups are expected to exhibit different centroids for their accept and reject regions.

5. Investor group centroids are expected to migrate to the upper right corner of the surface as the inherent level of risk aversion increases.

6. The 'Business Angel' group is expected to be the least risk averse and will have their acccept region located furthest to the left.

7. Private venture capitalists are expected to be more risk averse than the business angel group and less risk averse than the public venture capital fund group.

8. Public venture capital fund investors are expected to be the most risk averse and will tend to have their accept region located furthest to the upper right of the surface.

4.3 Analysis Methodology

This study considers the criteria importance and impact data elicited from three sets of investors[5] (Bachher, 1994). The importance assigned to each of the criteria provides an indication of its attribution to the future success (accept cases) or failure (reject cases) by the subject. Therefore, it is postulated that this data provides insight into the individual's attribution model. The impact data indicates how this model was made operational during

---

[5] Data collected in accordance with the University of Waterloo Office of Human Research.

the accept-reject decision. The question becomes: what underlying structure exists for these reported criteria importance? Figure 4.4 provides an overview of the methodology, which is based on principal components analysis.

Analysis begins with an assessment of the quality of the importance and impact data using t-tests and general descriptive statistics. The objective is to identify any problems within the data set. Following this initial assessment, principal components analysis was undertaken to examine the underlying structure of the importance data. The outcome is a set of orthogonal factors that explain a relatively high proportion of the variance. These are linear combinations of the original data, with only a portion of the factor loadings being significant. Each was reviewed, and non-significant loadings, based on a minimum statistical power (Kraemer and Thiemann, 1987), are disgarded. This process provides a minimum number of factors that explain a significant proportion of the variance, as well as reducing the number of criteria that must be considered.

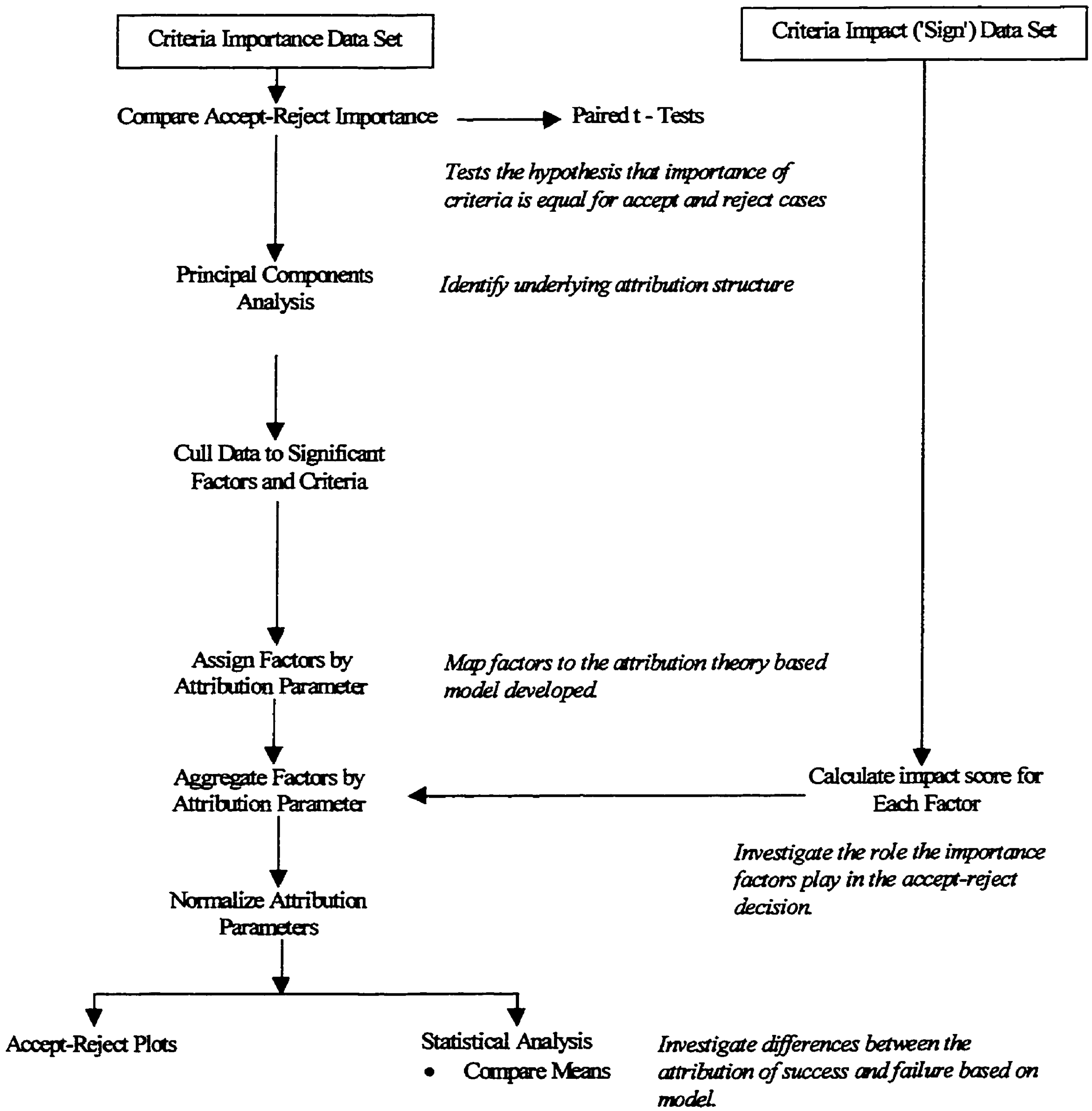
Having identified the factors, their impact on the accept-reject decision must be determined. This was done by constructing impact scores for each factor on a case by case basis, using mean aggregation. This resulted in the creation 60 accept and 60 reject impact sets. Once derived, the factors were mapped to the proposed attribution model variables, and examined to test the hypotheses.

4.3.1 Assessment of Data Quality and Importance Means

Prior to the analysis, several steps were taken to examine data quality. The data consist of 60 accept cases and 60 reject cases, obtained from three investor groups, 20 subjects in each group. General descriptive statistics were examined and in several cases 'bad' data, i.e. values out of range, were identified and eliminated from further analysis.

The first stage was to perform t-tests (e.g.: Keller at al., 1994) on the criteria importance data to determine if there were differences in the importance assigned to a criterion when considering an accepted venture as opposed to those rejected. This tests the study's first hypothesis: there will be no differences between the perceived importance of the accept and reject case criteria.

Figure 4.4
Analysis Methodology



This analysis required the testing that the difference in the means for each criterion was zero, and resulted in 95 t-statistics for each of the three investor groups. A critical t-value of 2.724 (α = 0.005, d.f=35) was used, and in all cases the null hypothesis, no difference, could not be rejected (Appendix B).

4.4 Principal Components Analysis of Criteria Importance

As the importance data t-tests indicated that there is no difference beween the accept and reject data, only the accept data were considered at this stage. This was considered to be a more conservative treatment of the data and removed 'double counting' of the responses. For the principal components analysis a minimum eigenvalue[6] of 1.0 and varimax rotation to obtain maximum orthogonality between the factors (as per Afifi and Clark, 1990) was used. Of the remaining post-rotation factors, only those which accounted for at least 5% of the variance explained were retained (as per Afifi and Clark, 1990), which tended to remove those consisting of a single criterion. To further process the data, only significant factor loadings were considered. As the factor loadings are the correlation of the criteria onto a factor (Affifi and Clark, 1990), the approach outlined by Kraemer and Thiemann (1987) for determining the statistical power as a function of sample size and correlation coefficent was employed. Therefore, for a sample size of N=60, a minimum factor load of 0.50 (H_o: $\rho = \rho_o$: ρ_o= 0) was selected. This provides a statistical power[7] of 95% for a one-tailed test at the 1% confidence level.

The result of this processing was the identification of four factors (Appendix B) based on a post-rotation variance explained of at least 5%. Further, of the original 95 criteria found in the data set, only 36 (38%) remained. The total variance explained by

---

[6] Eigenvalues provide a measure of the variance explained by each of the components and are subject to variation based on sample size. A minimum eigenvalue of 1 is used in this analysis to eliminate components that account for a variance of less than 1/N*100%. As this sample size is approximately 60, this discards components accounting for less than 1% of the variance.

[7] The higher the statistical power, the lower the likelihood of type II error, i.e.: wrongly accepting or rejecting a null hypothesis.

these for factors is approximately 30%. Conceptually, the objective of this step in the analysis was to identify the underlying attribution structure when investors assess a new venture. The next task was to examine how these factors are applied in their assessment decisison-making. To achieve this, factor impact scores were constructed using the information regarding how strong a positive or negative influence each criterion was considered to be when making the accept or reject decision.

4.5 Importance Factors and Decision Impact

As discussed, to examine the role that each of the importance factors played in the accept-reject decision, impact scores were constructed. Mean aggregation[8] was employed to derive these scores, which is simply the arithmetic average of the criteria impacts associated with a factor. The implication of this form of aggregation in terms of a decision-maker is that the various criteria impacts are assessed and integrated together with equal weighting. The mean, variance and sample size for the impact scores are provided in Table 4.1 for accept decisions and Table 4.2 for reject decisions.

Table 4.1
Impact Scores for Criteria Importance Factors
Mean Aggregation Method --Accepted Ventures

Factor	Mean	Variance	N_{ACCEPT}
1	5.35	0.72	59
3	4.73	0.96	59
4	4.64	1.15	59
5	5.48	0.52	59

As shown, the mean values for the impact scores differ for accept and reject decisions. Recall that no significant difference was found between the importance attributed to the decision criteria in the accept or reject cases, and that the factors are

[8] The issue of aggregation is of interest from a system design perspective, therefore the impact of different aggregation approaches was also examined.

assumed to be indicators of an underlying attribution structure. The mean impact values for accept and reject decisions imply that these factors are being applied differently, and thus provide a better basis for discrimination than the criteria.

Table 4.2
Impact Scores for Criteria Importance Factors
Mean Aggregation Method
Rejected Ventures

Factor	Mean	Variance	N_{REJECT}
1	4.33	0.84	57
3	3.90	1.0	55
4	4.17	0.93	56
5	4.14	1.1	57

Table 4.3
Importance Factor Impact Scores
Difference in Means F-Test

Investor Group	Criteria Impact Discriminant Analysis	Factor Impact Scores (Mean Aggregation)
All	11.1***	16.5***
Business Angel	0.57	4.5**
Private Venture Capitalist	0.49	5.52**
Public Venture Capital Fund	0.49	6.75***

*** $p < 0.001$
** $p < 0.005$

To examine the performance of this approach, a discriminant analysis (e.g.: Affifi and Clark, 1990) was performed first with the overall criteria impact data and then using the factor impact scores. As indicated in Table 4.3, the performance as measured using an F-test (null hypothesis that the group means are different) is better with the factor impact scores. While the discriminant analysis performance was comparable when all groups were considered together, it has poor discrimination power when the accept-reject decisions within an investor group are considered. This is an indication that the underlying assumption regarding the analytic approach is sound. Specifically, the importance factors provide insight into how the criteria are attributed to success or failure while the impact scores indicate how the investors apply these attribution factors in their decisions.

4.6 Investor Decisions and the Attribution Model

While the previous analysis found that the factors and impact scores were able to differentiate the accept-reject decisions, how effective is the proposed attribution model in explaining the behaviour of the different investor groups? To explore this question, the first step is to map these factors to the attribution model. This was achieved by examining[9] each

---

[9] As a check on the classification of the factors, two independent judges were asked to classify these criteria. These judges were graduate students in the department of management sciences familiar with many of the concepts described by the individual criteria. However, they were not familiar with the attribution model or its associated theory. Each judge was given a set of coding definitions, with the objective of determining if they would code the criteria, and hence tend to define the factors, in a similar manner. There are two levels of coding to be considered. First, whether they code a criterion as belonging to locus of causation (LOC) or specificity, and then the coding within those dimensions. Of these two levels, the first would have the greatest impact on further analysis. Fairly good agreement with the coding at the first level was found. The combined agreement is 78%, with and average individual agreement of 72%. The implication is that the definition of factors does not appear unreasonable when considered by external judges. At the next level in the coding, there is, not surprisingly, less agreement. This is largely due to the differences in opinion as to whether a criterion represents either a situational or stability issue in the case of specificity.

		Agreement	t-statistic (p-value)
Level 1	Experimenter - Judge 1	67%	4.30 (p = 0.0000)
P(random)=0.3	Experimenter - Judge 2	78%	5.71 (p = 0.0000)
	Experimenter - Judge 1&2	78%	5.71 (p = 0.0000)
	Judge 1 - Judge 2	83%	6.42 (p = 0.0000)
Level 2	Experimenter - Judge 1	50%	4.50 (p = 0.0000)
P(random)=0.2	Experimenter - Judge 2	64%	6.58 (p = 0.0000)
	Experimenter - Judge 1&2	67%	7.00 (p = 0.0000)
	Judge 1 - Judge 2	69%	7.42 (p = 0.0000)

of a factor's criteria and determining which model parameters best describe it. The results of this process are presented in Table 4.4.

Based on the mapping, the mean value for specificity and locus of causation (LOC) were calculated, with LOC being the mean of the impact scores of factors one and three. Similarly specificity was taken to be the mean of factors four and five. As shown in Table 4.5, difference in means F-tests indicate that the attribution model provides good accept-reject decision separation for the different investor groups. The next question is how does the separation within accept and reject decisions compare. In Table 4.5, the hypothesis tested was if the means between accept and reject decisions within different groups was significant. In terms of a decision surface, the issue is if the centers of the regions containing accept and reject regions are different.

At first glance it would seem that all is required is to measure the differences in the means for each accept and reject group and determine if the means are significantly different. This however assumes that the regions are normally distributed, and therefore this assumption must be tested, as shown in Table 4.6. Each of the distributions was examined to determine its kurtosis and skewness. This provides an indication of the distribution's shape and specifically the presence of long tails that would lead to misleading evaluations of the centers if the mean were used.

As indicated in Table 4.6 and Figure 4.5, the accept-reject regions tend to be located as expected, with accept in the upper quadrant. Also apparent is overlap areas between accept and reject. These overlaps will be examined further in terms of the moderator's role in the model. As a result, simply measuring the distances between means may be misleading, and several transformations[10] were considered in an attempt to reduce the impact of the distributions. To determine the mean distance between within the reject and accept decision groups in the attribution model, all Euclidean distances were calculated and then averaged. The results of this approach are provided in Table 4.7.

---

[10] log (x), exp(x), reciprocal and power transformations were considered.

Table 4.4
Factor to Attribution Model Mapping (By Author)

Factor	Criteria	Locus of Causation		Specificity		
		Venture Internal	Environmental	Stability	Investor Familiarity	Situational
	Environmental External Control					
1	The entrepreneurs' familiarity with customer requirements		1			
	Quality of competitor analysis			1		
	The entrepreneurs' familiarity with business drivers		1			
	Track record of co-investors in the deal			1		
	Proposed venture will create a new market or niche		1			
	Quality of product analysis					1
	There are other co-investors present in the investment			1		
	A functioning prototype has already been developed			1		
	The entrepreneurs' familiarity with product and market		1			
	Ease to evaluate proposal by investor(s)					1
	Venture Internal Control					
3	Clarity of communication in proposal					1
	Overall quality of proposal					1
	Completeness of venture proposal					1
	Effectiveness of graphics, tables and figures in the proposal					1
	Financial skills of the entrepreneur(s)	1				
	Marketing research skills of the entrepreneur(s)	1				
	Clear emphasis on key points					1
	Production skills of the entrepreneur(s)	1				
	Quality of financial analysis			1		
	Quality of market analysis			1		
	Sales force and/or distribution skills of the entrepreneur(s)	1				
	Advertising and promotion skills of the entrepreneur(s)	1				
	The entrepreneurs' demonstrated leadership ability in the past			1		

Table 4.4 Continued
Factor to Attribution Model Mapping (By Author)

		Locus of Causation		Specificity		
Factor	Criteria	Venture Internal	Environmental	Stability	Investor Familiarity	Situational
	Investor Familiarity					
4	Investor's familiarity with the technology of the venture				1	
	Investor's familiarity with the industry of the venture				1	
	Investor's familiarity with the market targeted by the venture				1	
	Investor's familiarity with the offering (product or service) of the venture				1	
	Ability to attract a viable investor group			1		
	The venture's stage of development (e.g. seed, start-up, first-stage, second stage			1		
	Venture Situational Specificity					
5	The entrepreneurs' familiarity with technology enablers			1		
	The entrepreneurs' ability to react to changing risk			1		
	Proposed venture is satisfying an existing market need					1
	The entrepreneurs' ability to anticipate need for change			1		
	Venture can demonstrate a defendable competitive position			1		
	The entrepreneurs' management commitment to success					1
	Expected market risk to the investor(s)					1

Table 4.5
Investor Group Attribution
Difference in Means F-Test for Accept and Reject
By Investor Group

All Groups	22.4***
Business Angels	6.0#
Private Venture Capitalists	5.6#
Public Venture Capital Funds	11.7***

*** $p \leq 0.001$
** $p \leq 0.005$
# $p \leq 0.008$

4.7 Attribution Model and Lenders

So far the discussion has centered on the behaviour of investors. However, what can be said about lenders? To briefly consider this, the concepts elicited from the lender subjects in the first study are revisited. As these may be thought of as the attributions assigned to the venture lending decision, how do they fit with the model? To explore this, the concepts are first mapped to the attribution model[11], as shown in Appendix B.

[11] As a check on the concept classification, two independent judges were asked to classify these criteria. These judges were graduate students in the department of management sciences. Two levels of coding are considered. First, whether they code a criterion as belonging to locus of causation (LOC) or specificity, and then the coding within those dimensions.

		Agreement	t-statistic (p-value)
Level 1	Experimenter - Judge 1	60%	6.32 (p = 0.0000)
P(random)=0.3	Experimenter - Judge 2	70%	7.91 (p = 0.0000)
	Experimenter - Judge 1&2	73%	8.30 (p = 0.0000)
	Judge 1 - Judge 2	83%	9.88 (p = 0.0000)
Level 2	Experimenter - Judge 1	48%	4.35 (p = 0.0000)
P(random)=0.2	Experimenter - Judge 2	55%	5.53 (p = 0.0000)
	Experimenter - Judge 1&2	60%	6.32 (p = 0.0000)
	Judge 1 - Judge 2	78%	9.09 (p = 0.0000)

Figure 4.5
Attribution by Investor Group

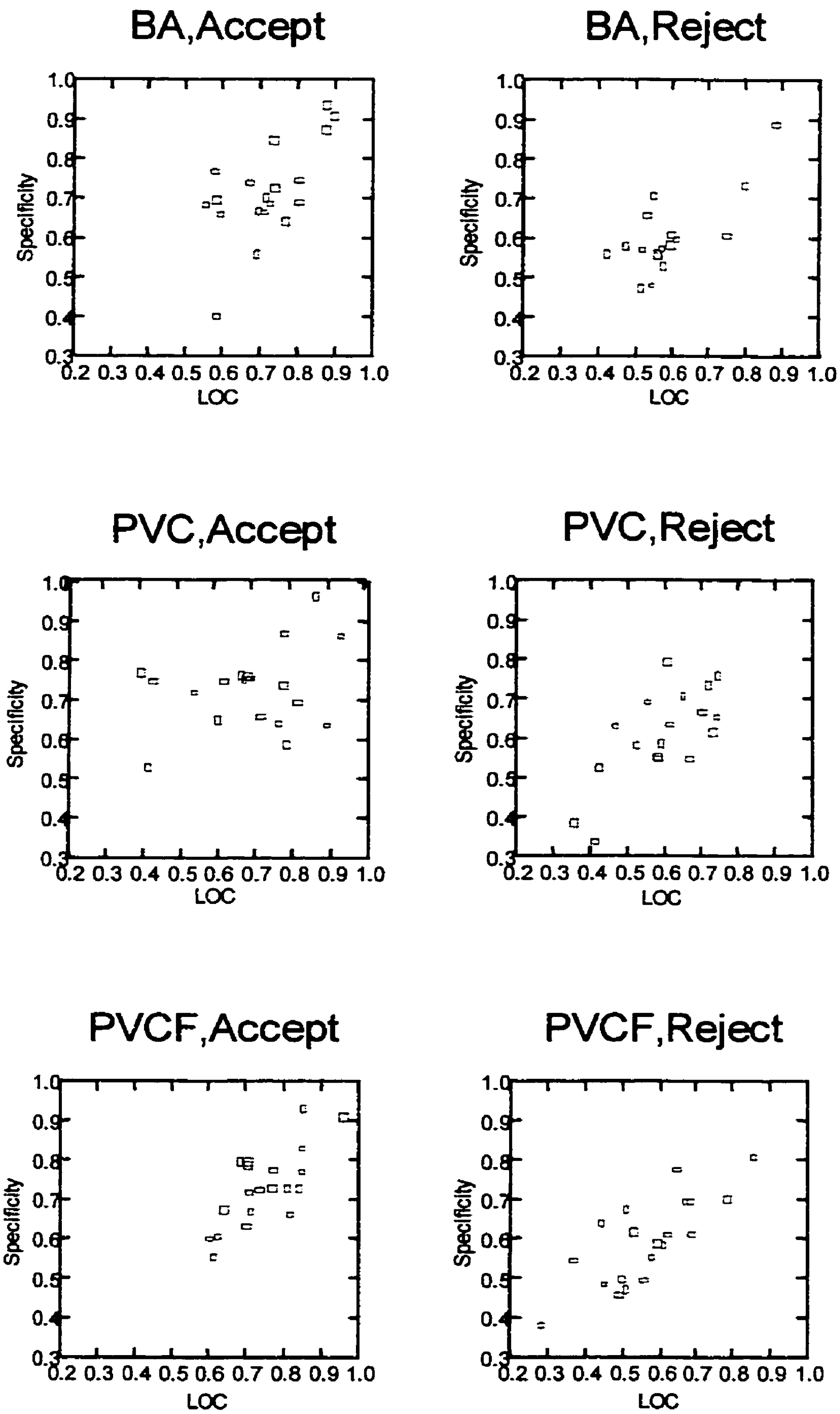


Table 4.6
Assessment of Accept-Reject Regions
By Investor Group

Investor Group		Specificity	Locus of Causation	Qualitative Assessment of Distribution
Business Angel (Reject)	Mean	0.59	0.60	
	Skewness	1.35	1.55	Tails to right.
	Kurtosis	1.6	3.3	LOC has long tail.
Business Angel (Accept)	Mean	0.72	0.71	
	Skewness	0.10	-0.35	LOC Tail to left.
	Kurtosis	-0.84	1.5	LOC has long tail.
Private Venture Capitalist (Reject)	Mean	0.59	0.60	
	Skewness	-0.48	-0.73	Tails to left.
	Kurtosis	-0.66	0.699	Spec. distribution is flat. LOC has tail.
Private Venture Capitalist (Accept)	Mean	0.69	0.72	
	Skewness	-0.51	0.30	Spec. tail to left.
	Kurtosis	-0.28	0.85	
Public Venture Capital Fund (Reject)	Mean	0.57	0.59	
	Skewness	0.07	0.06	
	Kurtosis	0.39	-0.46	
Public Venture Capital Fund (Accept)	Mean	0.75	0.73	
	Skewness	0.30	0.25	Spec. and LOC tail right.
	Kurtosis	-0.45	-0.07	

With this mapping as a new protocol, the interview data were reviewed and coded in terms of the attribution model. The results of this revised coding are presented in Appendix B. As shown, the dominant considerations among the lenders are stability and situational specificity. Of secondary importance are control issues. As expected due to the nature of lending, investor influence on the venture is not a major consideration. However, both external and venture internal control occur with a relatively high frequency.

Overall, these results are consistent with what is expected from the attribution model. From this analysis, combined with the comparison to public venture capital funds (PVCF) in the first study, it can be expected that the lender group will be located in the upper right. While they are likely to be near PVCF, it can be speculated that lenders will have a high mean specificity coordinate and a mean LOC coordinate slightly less than PVCFs due to the low investor influence role.

Table 4.7
Between Group Distances (Euclidean)

Group Comparison	Mean Euclidean Distance	Variance
Business Angel Accept vs Private Venture Capitalists Accept	0.204***	0.014
Business Angel Accept vs Public Venture Capital Funds Accept	0.179***	0.011
Private Venture Capitalist Accept vs Public Venture Capital Funds Accept	0.197***	0.013
Business Angel Reject vs Private Venture Capitalists Reject	0.185***	0.012
Business Angel Reject vs Public Venture Capital Funds Reject	0.191***	0.019
Private Venture Capitalist Reject vs Public Venture Capital Funds Reject	0.206***	0.015

*** $p < 0.001$

Table 4.8
Lending Expert Attribution Coding

	S1	S2	S3	S4	S5
Situational Specificity	34%	19%	36%	32%	40%
Stability	38%	40%	23%	21%	7%
Environment Control	11%	13%	10%	20%	13%
Investor Influence	5%	9%	2%	3%	3%
Venture Internal Control	12%	19%	29%	25%	37%
	100%	100%	100%	100%	100%

4.8 Discussion

Several hypotheses have been proposed concerning the expected investor behaviour. First, it was expected that the accept decision region for each of the investor groups will be found in the upper right corner. The reject decision region for each of the investor groups is expected to be in the lower left quadrant. Further, different investor groups are expected to exhibit different centroids for their accept and reject regions. These centers should migrate to the upper right quadrant of the surface as the inherent level of risk aversion increases. Finally, it has been hypothesized that 'Business Angels' should be the least risk averse while the Public Venture Capital Funds will be the most risk averse.

The analysis supports the hypothesis that the accept decision region tends to be found in the upper right quadrant. This is seen through visual examination of the S-L planes, Figure 4.5, and the coordinates of the group centers, Table 4.6. Similarly, the reject region tends to be the lower left quadrant. The hypothesis that investor groups are expected to exhibit different accept and reject centroids is also supported. Examination of the F-tests and the mean distances, Table 4.7, between clusters support distinct investor group regions.

It has also been hypothesized that the investor group centers should migrate to the upper right corner of the phase plane as the inherent level of risk aversion increases. This is based on the assumption that risk aversion will be the dominant moderating variable between these investor groups. From the analysis, it appears that Business Angels and Private Venture Capitalists are the most similar. The Public Venture Capital Funds are found to be located furthest to the upper right, as expected, indicating that relatively high levels for specificity and control are required for an accept decision.

When the lender experts are considered, it can be seen that their primary consideration is specificity. This is seen in the high frequency of occurence of concepts related to situational specificity and stability. Locus of control appears to be less of an issue, with investor influence being of less concern. This result is not surprising given the nature of lending, which does not place the assessor in a position of asserting a significant level of control over the venture. Considering an often heard statement from lenders "...we want to be more like venture capitalists...", this would require steps to reduce systemic risk aversion, and possibly a re-orientation towards locus of causation (LOC) issues.

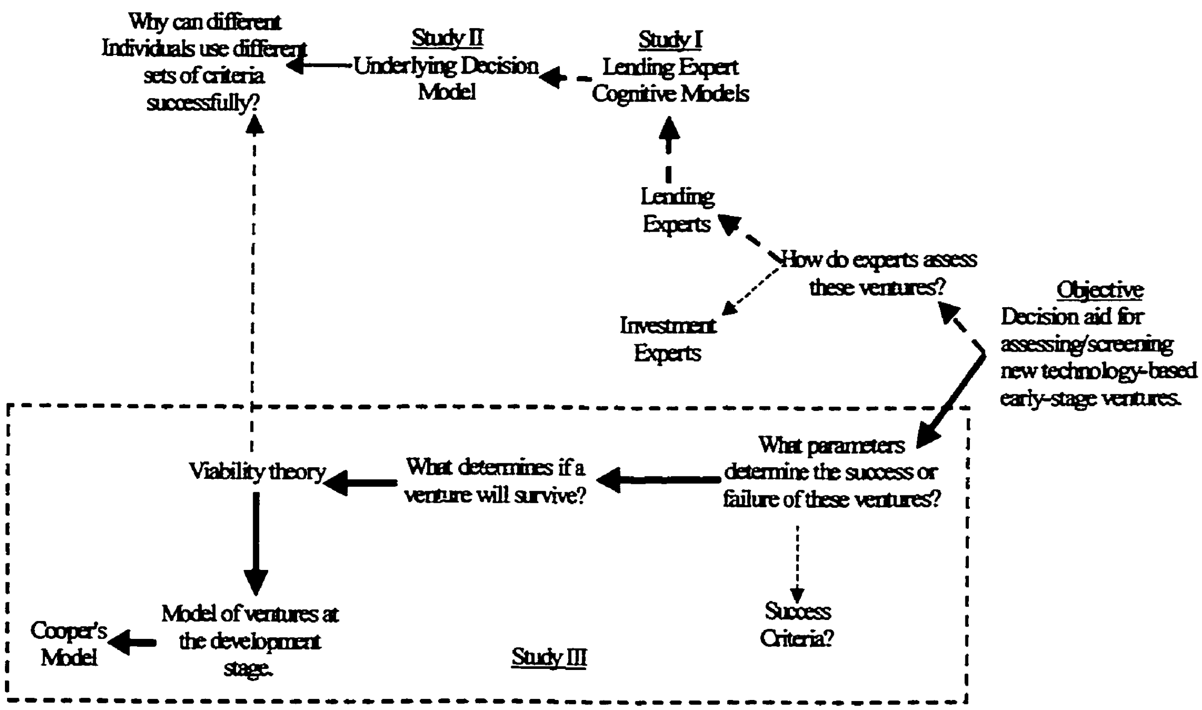
In this study, the question of interest was: if investor and lender groups are using the same basic set of criteria, how do they differ? To explore this, a model based on attribution theory was considered, specifically its effectiveness in differentiating investor groups. Overall, the proposed model appears able to differentiate between investor groups and provide some insight into accept-reject decisions, as well as how information is processed. Specifically, the apparent role of risk aversion, both systemic and individual suggests a need to 'calibrate' decision aids to the user type. The apparent tendency for different investor types to place different emphasis on specificity and LOC may also have implication on how tools may be configured.

Chapter 5

Study III: Viability-Based Assessment

In the initial study, the question being considered was what do lending experts consider when evaluating early-stage, technology-based ventures? The second study considered the question: 'If different assessor groups are using the same underlying set of assessment criteria, what, if anything, makes them different?' In terms of the overall objective, a decision aid, these questions are of interest because they improve the understanding of the criteria and process that underlies the venture assessment process.

Figure 5.1
Study III Overview



This study proposes and explores a model to explain part of the assessment of early stage ventures, specifically the assessment of perceived technological viability. As illustrated in Figure 5.1, the original objective is the creation of a decision aid for screening and assessing early-stage technology-based ventures. Rather than considering "how these ventures are assessed?", this study examines the issue of "what should be assessed?". Several researchers (e.g.: Cooper, 1986; Slevin and Pinto, 1988; Bell and McNamara, 1993; Balachandra and Friar; 1997), have considered success factors from various perspectives. In this study, an empirical study of venture success factors is not the focus. Rather, a theoretical understanding of what determines if a system will evolve and survive is the issue of interest.

The idea that a new venture evolves and is constantly threatened with failure (death), coupled with the realization that these organizations are evolving under conditions of high uncertainty leads to the consideration of viability theory (Aubin, 1991). To explore this further, a venture-system model is proposed and parameters identified that may serve as the basis for a screening and assessment aid.

5.1 Early-Stage Venture Viability

While there are several contributors to venture system viability, for example market and finanicial as well as technological, the focus will be on technological viability. This is not to imply that these other viability components are weak or unimportant at this stage in the venture's evolution. Rather, for early stage ventures it becomes an important determinant of the venture's likelihood to evolve further. As discussed by Slatter (1992), a fundamental issue that must be addressed early in the development phase is the technological foundation of the venture.

To consider the idea of system viability further, a model describing the dynamics of a new venture-system during its development phase is required. What characteristics should this model possess? Not only must this model capture the dynamics, but also it must be general enough to represent a wide range of technology-based ventures. Further, it should reflect the nonlinear nature of a venture-system, especially at the early-stages of venture development. Finally, it should permit the examination of the venture-system in terms of stability.

When a venture begins the development phase, its goal is typically to create a single, or at most a very limited number, of products. This is due to the limited resources of the venture, which restrict the range of development activities it may undertake. As such, the venture may be viewed as a project and the simple model proposed by K.G. Cooper (1993), illustrated in Figure 5.2, provides a starting point.

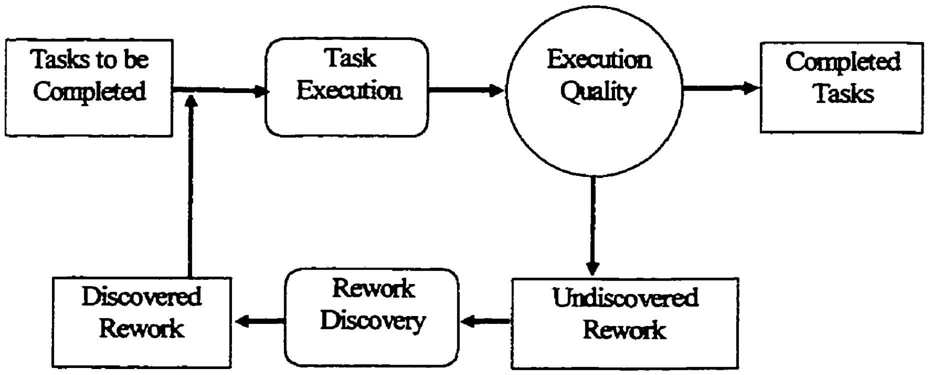
The objective of Cooper's model was to examine problems such as project delay, 'cycling' and the impact of rework, which conventional views of projects have difficulty addressing. These issues are particularly relevant when projects have a significant design component or high uncertainty, as commonly found in product development.

Two important features of Cooper's model are the quality of task execution and rework discovery time. Intuitively, the rate at which tasks are executed will be related to their complexity and the capabilities of the venture. Further, the lower the task execution quality, the greater the degree of rework that can be expected. Quality can be impacted by a number of factors, including capabilities, effectiveness of communications, and various motivational factors. Further, the faster a task deficiency can be identified, the less overall impact it will have. This is a function of the experience of the development team and the quality of the project planning.

5.2 Extending the Model

Beginning with the project execution model (K.G. Cooper, 1993), extensions may be made that provide insight into new venture viability assessment. To begin, consider the re-statement of the model illustrated in Figure 5.2. For simplicity, it is assumed that the product or service definition at the end of the formulation phase is stable enough that the amount of effort can be identified. With this model as a basis, several concepts may be identified that will have a significant development phase impact. Specifically, technological capability, technological complexity and 'quality potential', defined as the venture's potential to execute a 'high quality' development phase.

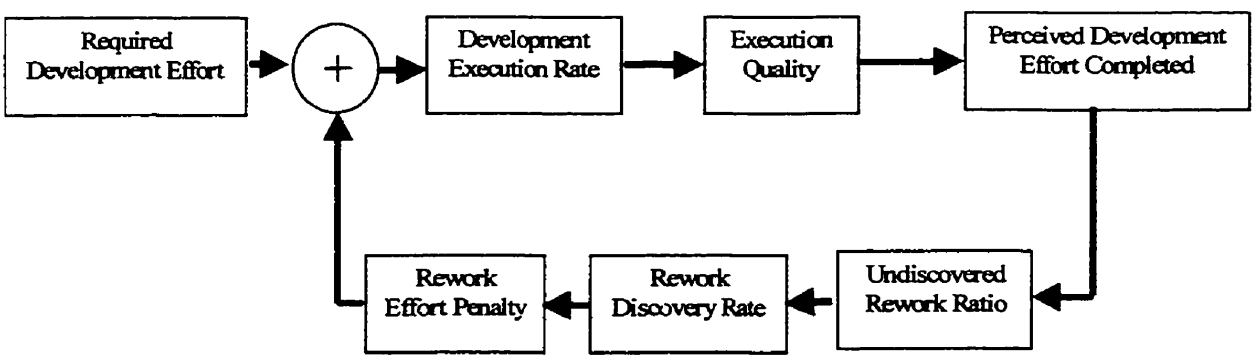
Figure 5.2
The Cooper Project Execution Model



Adapted from K.G. Cooper (1993).

Cooper's model, Figure 5.2, implies that as rework is discovered in the system it is simply fed back for re-execution. This appears to overlook the tendency for increased task interdependence as technological complexity increases, and hence, the potential for the rework to have a 'ripple' effect through the development process. In the proposed model, Figure 5.3 this is represented by a rework effort penalty, which accounts for the additional effort as the discovery of rework is delayed.

Figure 5.3
Development Phase Execution Model



Based on the issues identified in Figure 5.3, the following relationships[1] may be identified in the development phase model. In terms of systems and viability theory, these components may be considered to define sets of state variables and associated constraints that must be estimated when determining system technological viability.

Required Effort $\rightarrow f$(complexity)

Execution Rate $\rightarrow f$(complexity, capabilities)

Execution Quality $\rightarrow f$(complexity, capabilities, quality potential)

Rework Ratio $\rightarrow f$(complexity, capabilities, quality potential)

Rework Discovery Rate $\rightarrow f$(complexity, capabilities, quality potential)

Rework Effort Penalty $\rightarrow f$(complexity)

5.2.1 Technological Capability

The first of these components is technological capability, a complex concept that may be decomposed into three interrelated issues; technological synergy, absorptive capacity, and technological vulnerability. In terms of viability, a venture can only evolve along trajectories viable within its technological capabilities, and cannot follow paths that require technological capabilities that it does not possess or cannot sustain.

Technological Capability $\rightarrow g$ (technological synergy, absorptive capacity, technological vulnerability)

A central issue when considering a venture's technological capability is the synergy between what is required to realize the venture's product and what it has

---

[1] A problem that is apparent when considering this model is the subjective nature of the key variables. That is, they are easily expressed linguistically but are difficult to quantify. To facilitate this investigation, a fuzzy simulation model was developed (Appendix G). The objective of this model is to examine the behaviour of the system as well as to consider potential viability constraints.

available (e.g.: Sonneborne and Wilemon, 1990; Shilling and Hill, 1998). This includes not only the venture's physical technology assets, but also determination if the requisite knowledge and skills exist. As discussed by Lefebvre et al. (1996), the technical capabilities of a venture are shaped by the past technical experiences of the individuals comprising it. However, as technology is not static, the venture must posses an ability to identify, understand and assimilate relevant technological change, hence absorptive capacity (Cohen and Levinthal, 1990). Further, as these intangible assets are not easily copied or transferable, they become a key component of the venture's competitive potential.

The final component, technological vulnerability is concerned with the control of technologies critical to the venture. This is particularly important in the case of proprietary technologies as they, by definition, provide the venture with a key aspect of its competitive potential. Thus a critical technology that is controlled to a significant extent external to the venture decreases its technological capability.

5.2.2 Technological Complexity

The next issue to be addressed is the technological complexity of the venture's product. Complexity may be defined as the number of possible states that may exist in a given system (Beer, 1985). Starting with this description, technological complexity may be defined as a function of technological variety and maturity. Technological maturity contributes to complexity through its influence on uncertainty, and is manifested as four types of risk: breakthrough, obsolescence, integration and infrastructure[2].

---

[2] Infrastructure risk pertains principally to younger technologies, and arises from the availability of complementary technologies. Specifically, do the technologies exist that are necessary for successful deployment of the product (Weiss and Birnbaum, 1989)? While important to consider early in the development of a product, in this study it is considered as a key component of market viability and is not developed further.

Technological Complexity $\rightarrow g$(technological variety, technological maturity)

Technological variety may be simply stated as the number of required technologies. As the number increases, so does the associated variety. For example, if each component of the required technology and knowledge base is considered to have two states, present or absent, then, as the number of components, N, increases the number of possible system states, and hence complexity, would increase at 2^N. Obviously, if the number of states were expanded to include various degrees of availability, then the complexity would further increase.

Established technologies have relatively little uncertainty associated with them in terms of their future technological trajectories (Dosi, 1982). A dominant design has evolved (Weiss and Birnbaum, 1989), and as such present and future performance and availability are relatively predictable. In other words, the possible future states of a mature technology or knowledge area are fewer. Therefore, as maturity increases, the system complexity will tend to decrease.

At the other extreme, emerging or very young technologies have significant uncertainty associated with them. Often a dominant design is yet to emerge and various possible technological trajectories may exist. Associated with this, new breakthroughs may occur, or may need to occur (Bell and McNamara, 1991), which can change the viability of an immature technology[3]. At the other end of the maturity curve however, technologies become increasingly vulnerable to discontinuities and/or major shifts in technological paradigms that may render them obsolete, obsolescence risk. Thus, the assessment problem becomes one of determining the stability of the venture's technologies.

---

[3] These breakthroughs, or discontinuities, may be either enhancing, such as development of complementary technologies, or destructive, such as development of competing technologies leading to displacement.

The final component of technological complexity to be considered is integration risk, and concerns the potential difficulties that may occur when attempting to integrate different technologies and/or products together for the first time. Thus, while breakthrough risk is research and development oriented and focuses on the discovery or invention aspects of innovation, the focus of integration risk is at the system level.

Returning to the concept of viability, a venture can only remain viable as long as the technologies upon which it is based remain viable. As system complexity increases, and hence, system uncertainty, the number of potential technological trajectories also increases, with the potential to move the venture outside its viability region.

5.2.3 Quality Potential

Quality potential is defined in this study as the ability of the venture to develop a product with minimal energy, and hence, is a function of the organization's effectiveness and efficiency in resource allocation and usage. Therefore, it is defined as having two dimensions, management quality and organizational effectiveness. Concepts such as 'product quality' and 'rapid development' are the outcome of this potential. In terms of viability, a venture can remain viable only if it has the capability to control the allocation of resources and effort during the development process such that total effort, hence energy, is minimized.

Quality Potential $\rightarrow g$ (organizational effectiveness, management quality)

As discussed by Shilling and Hill (1998) and Sobek et al. (1998), it is important that the organization be suitable for the type of project being undertaken. Further, poor coordination and communications within the organization are a major contributor to development delays, especially for high technological complexity situations (e.g.: Moenaert and Souder, 1990; Wheelwright and Clark, 1992; Shilling and Hill, 1998; Sobek et al., 1998). A related resource allocation issue is that of development project concurrence and over-extension, and is a common cause of product development delay (Shilling and Hill, 1998). Realistically, this is almost certain to occur, the issue becoming how great is the over-extension.

5.3 Summary of Viability Postulates

In summary, four basic postulates have been put forward that serve as the basis for developing a viability assessment framework.

1. A venture can only evolve along trajectories that are viable within its technological capabilities. In other words, a venture cannot follow paths that require technological capabilities that it does not possess or cannot sustain.

2. A venture can only remain viable as long as the technologies upon which it is based remain viable.

3. As system complexity increases, and hence system uncertainty, the number of potential technological trajectories also increases, with the possibility of a venture's movement outside its viability region.

4. A venture can remain viable only if it has the capability to control the allocation of resources and effort such that total energy is minimized. In other words, this is a function of the efficiency and effectiveness of the venture in terms of its development process.

5.4 Model Validation Issues

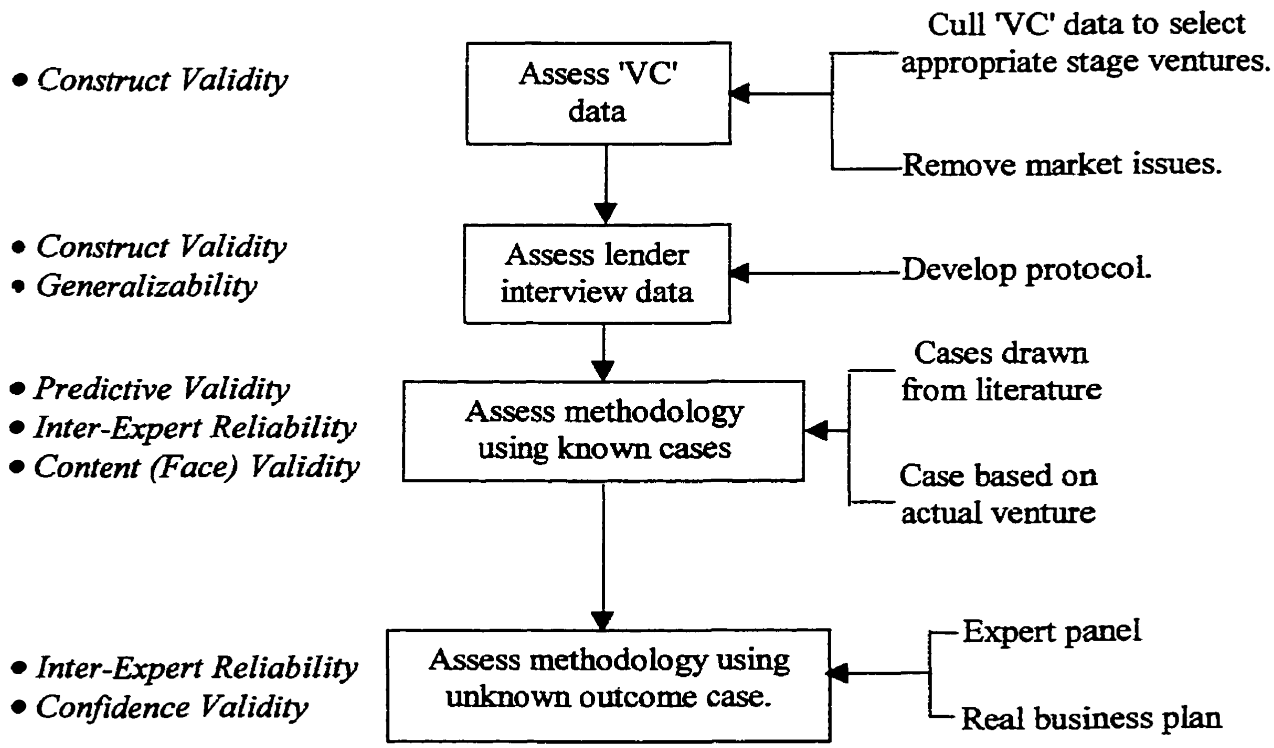
Based on the early-stage venture model, a set of constructs has been proposed that indicate if a venture will survive or not. This model must now be validated. At this research stage, validation has a 'theory development' perspective. Hence, as discussed by Cook and Campbell (1979), the important validity considerations[4] are

---

[4] As discussed by Cook and Campbell (1979), the importance of validity considerations depends on the type of research being undertaken. Thus for theory development and testing it is most important to show that constructs are present and that there are causal relationships. Hence construct and internal

internal and construct. Therefore, construct validity of the causes (internal validity) will be the focus.

Figure 5.4
Methodology Validation Plan



Internal validity considers the question: are the constructs in the proposed model present in actual assessment? The objective therefore is to determine if the elements of the model are appropriate and to confirm that there is a relationship between the model concepts and venture viability. To this end, the validation plan, outlined in Figure 5.4, was undertaken.

As indicated in Figure 5.4, the planned validation process has four major components. First, the venture capitalist data (Bachher, 1994) will be revisited to

---

validity are the most important issues. In the case of applied research, where the interest is often in the impact of a specific treatment, Cook and Campbell argue that the priorities change. Specifically, the validity importance becomes internal validity, external validity, construct validity of effect, statistical conclusion validity, construct validity of the cause.

determine if the concepts proposed for viability assessment are indeed present. For this step in the process, only those cases that are identified as early stage ventures entering the product development stage of their evolution are considered. In addition, the criteria[5] set presented to the subjects was very broad and included several criteria that are directed to market and other post product development stage issues. These criteria were removed for this analysis.

A further internal validation issue to be considered is whether the model concepts can be generalized to lenders as well as investors. This leads to the second and third steps in the validation process, in which lender data is assessed to determine if there is support for the proposed viability model. This analysis will be based on questionnaire data, as well as by re-examination of the lender interviews to determine the frequency of occurrence of these concepts. The analysis of the lender interview data also required the development of a coding protocol based on the proposed model.

The final part of the validation process consists of providing a group of subjects with a set of early-stage venture cases which will be considered using the proposed assessment model. Several of the cases will be drawn from the literature, specifically from cases discussed by Bell (1991). In these cases, the subjects know the case outcome. An additional case will be provided, for which the subjects do not know the outcome. This case is based on an actual venture that is entering the product development phase. The objective of this validation step is to examine the predictive validity of the model.

---

[5] A meta-analysis of criteria used for the assessment of R&D projects and new product innovation undertaken by Balachandra and Friar (1997), identified 144 potential assessment criteria, classified into 72 groups, from the literature. The 95 criteria used by Bachher (1994) may be viewed as a subset of this.

5.5 Validation of the Proposed Model

It has been postulated that technological viability of a venture system at its early stage will be the dominant consideration. This viability is defined by a set of constraining factors that define the viability region of a venture at this stage of its evolution. In this section, the question of whether early stage venture assessment practitioners are indeed attempting to estimate venture viability is considered. To examine this, a structural model[6] (e.g.: Asher, 1976; Fox, 1984) for technological viability, Figure 5.5, is proposed, as well as a set of hypotheses, Table 5.1, regarding the expected relationships.

Table 5.1 indicates the hypothesized causal direction of the relationship (row → column) as well as the correlation sign. Further, the expected correlation is based on the assessor's perceived requirements. Therefore, for example, a positive correlation between perceived technological complexity and 'required' technological capability is indicated. In essence the model defines a set of state variables within the venture system to be estimated when considering a venture's technological viability. To examine the assessment behaviour of practitioners in terms of this model the methodology summarized in Figure 5.6 has been undertaken.

To begin the analysis, the investor group data set (Bachher, 1994) is again considered[7]. In this study, the data set is examined to isolate only those accept-reject decisions that pertained to an early stage venture, that is, only those identified as being at the concept or start-up stage.

---

[6] This model is block-recursive (Fox, 1984) since causal loops are present within the model which can be isolated by defining concept blocks within the model. For clarity, disturbance terms have been omitted from the proposed model.

[7] As discussed previously, this data consisted of the importance attributed to a set of criteria when making an investment decision. The investor groups involved in the study were then asked to identify the impact each criterion had on an investment opportunity recently accepted and one recently rejected. The subjects also identified which stage the venture was at, seed, start-up, or initial market introduction.

Figure 5.5
Viability Model Relationships

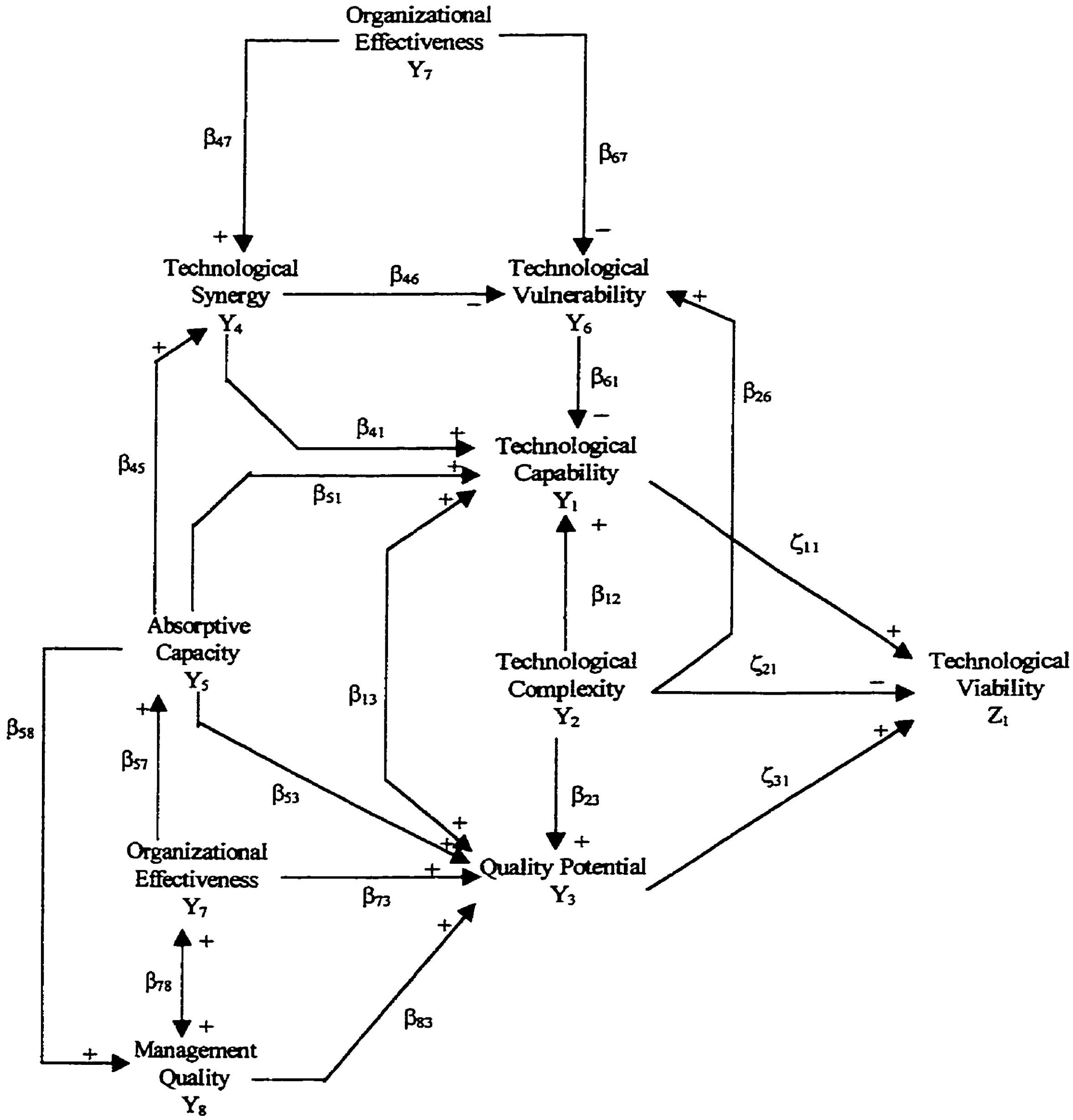


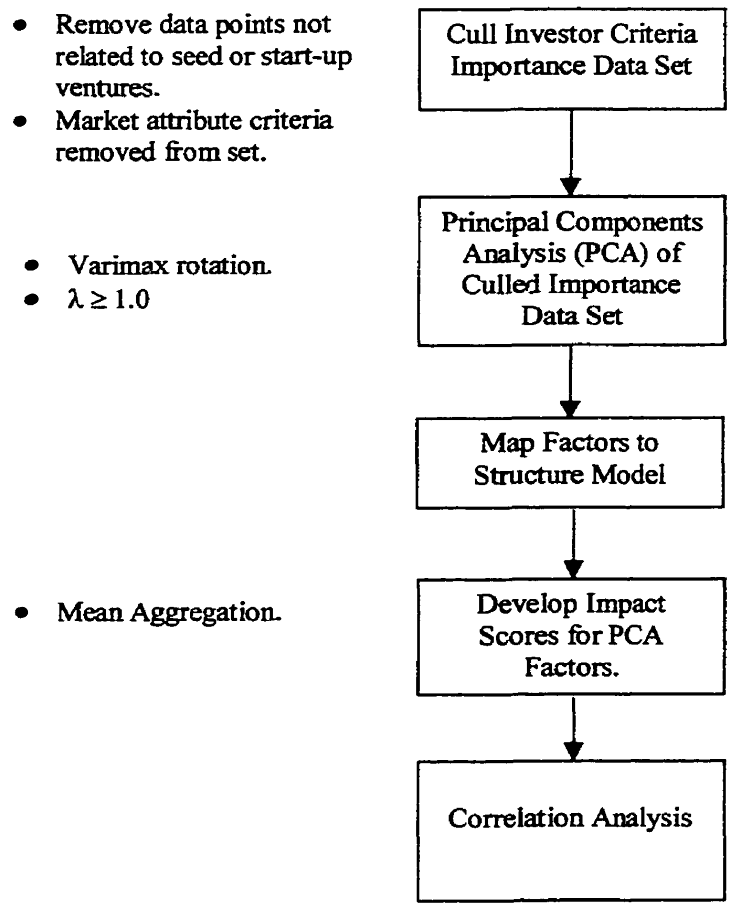
Table 5.1
Viability Model Hypotheses

Causal Direction →	Technological Capabilities	Technological Complexity	Quality Potential	Technological Synergy	Absorptive Capacity	Technological Vulnerability	Organizational Effectiveness	Management Quality	Technological Viability
Technological Capabilities	--		$\beta > 0$						$\beta > 0$
Technological Complexity	$\beta > 0$	--	$\beta > 0$			$\beta > 0$			$\beta < 0$
Quality Potential	$\beta > 0$		--						$\beta > 0$
Technological Synergy	$\beta > 0$			--					
Absorptive Capacity	$\beta > 0$		$\beta > 0$	$\beta > 0$	--			$\beta > 0$	
Technological Vulnerability	$\beta > 0$			$\beta > 0$		--	$\beta > 0$		
Organizational Effectiveness			$\beta > 0$	$\beta > 0$	$\beta > 0$	$\beta < 0$	--	$\beta > 0$	
Management Quality			$\beta > 0$				$\beta > 0$	--	

As indicated in Figure 5.6, the first step in the analysis is to discard data identified as not being associated with concept or start-up ventures. Principal components analysis (e.g.: Affifi and Clark, 1990) of the remaining data indicated that the factors are dominated by market considerations. This outcome is not surprising as examination of the criteria set shows a significant proportion, approximately 70%, of the criteria are market-oriented. Thus, the next analysis step was to refine the data by removing market-characteristics criteria and analyzing the remaining data using principal component analysis. The factors identified were then mapped to the structural model variables, Table 5.1.

Figure 5.6

Analysis Methodology



The assumption in this analysis is that the identified factors describe the underlying investor attribution of technological viability. Next, their impact in the accept-reject decision is considered. This assumes the decision is based on perceived viability, such that a reject decision indicates a perception that the venture is not viable from a viability theory perspective. Impact scores were derived by mean aggregation of the individual criterion impacts for each accept and reject case. Correlation analysis (e.g.: Affifi and Clark, 1990), was then performed to examine the relationships between the proposed structural variables.

5.6 Investors and Viability

As discussed, once the factors in the reduced data set were identified, they were mapped to the model variables as shown in Table 5.2. This lists the factors identified in the investor data from highest to lowest eigenvalue[8]. These factors were then defined in terms of the model variables $\{Y_1$ to $Y_8\}$. However, no direct mapping was found for model variable Y_3. As a result, an estimate using a linear combination of absorptive capacity (Y_5), organizational effectiveness (Y_7) and management quality (Y_8) was used for further analysis.

The results of the investor group correlation analysis are provided in Table 5.3, and illustrated in Figure 5.7. In this figure, the solid lines indicate identification of significant correlation, while the dashed lines symbolize hypothesized relationships that were not found. The heavy dashed line, β_{13}, represents a correlation between the estimated quality potential and technological capability. If this estimated variable is not included in the model, then correlation is found between management quality and technological capability.

5.7 Analysis of Lender Interviews

The goal of the previous analysis was to seek evidence that the proposed model's constructs are present when investors assess new ventures. The objective of this analysis is to strengthen the model's construct validity as well as illustrate that it may be generalized to lenders[9] as well as investors. To this end, the lending expert data (Study I) is coded using a protocol (e.g.: Olson and Biolsi, 1991) based on the proposed model, Table 5.4, and associated assessment concepts.

---

[8] The minimum eigenvalue for the analysis is 1.0.

[9] A large-scale questionnaire was also attempted. The return rate was low and as such has weak statistical power. A discussion of this work can be found is Appendix F.

Table 5.2
Investor Importance Factor to Viability Model Map (As Defined by Author)

	Criteria	Technological Capabilities (Y1)	Technological Complexity (Y2)	Technological Synergy (Y4)	Absorptive Capacity (Y5)	Technological Vulnerability (Y6)	Organizational Effectiveness (Y7)	Management Quality (Y8)
1	The entrepreneurs' ability to react to changing risk	1						
	The entrepreneurs' ability to anticipate need for change	1						
	The entrepreneurs' familiarity with product and market	1						
	The entrepreneurs' familiarity with technology enablers	1						
	A functioning prototype has already been developed	1						
2	Technology factors are changing rapidly		1					
	Market factors are changing rapidly		1					
	Customer need factors are changing rapidly		1					
3	Research and development skills of the entrepreneur(s)				1			
	Financial skills of the entrepreneur(s)				1			
	Engineering skills of the entrepreneur(s)				1			
	Production skills of the entrepreneur(s)				1			
4	Venture offering is proprietary					1		
	Venture offering can be protected by a patent					1		
5	Venture offering is highly innovative			1				
	Ventures' technical aspects are very clear			1				
6	The entrepreneurs' ability to put a balanced management team in place						1	
7	The entrepreneurs' demonstrated leadership ability in the past							1
	The entrepreneurs' track record relevant to the venture							1

Table 5.3
Correlation Analysis
Investor Group Data
Start-up Phase Criteria (Market and Investment Characteristics Removed)

	Decision	Technological Capabilities (Y1)	Technological Complexity (Y2)	Technological Synergy (Y4)	Absorptive Capacity (Y5)	Technological Vulnerability (Y6)	Organizational Effectiveness (Y7)	Management Quality (Y8)
Decision	1.00							
Technological Capabilities (Y1)	0.41*	1.00						
Technological Complexity (Y2)	0.16	0.37	1.00					
Technological Synergy (Y4)	0.41**	0.73****	0.26	1.00				
Absorptive Capacity (Y5)	0.29	0.57****	0.24	0.50****	1.00			
Technological Vul. (Y6)	0.28	0.20	0.20	0.37	0.11	1.00		
Organizational Eff. (Y7)	0.31	0.40*	0.13	0.23	0.46***	0.21	1.00	
Management Quality (Y8)	0.40*	0.60****	0.23	0.45**	0.50****	0.12	0.61****	1.00
Quality Potential (Y3)	0.40	0.62****	0.24	0.46**	0.24	0.17	0.86****	0.86****

Bartlett[10] $\chi^2 = 147^{****}$
* $p \leq 0.1$
** $p \leq 0.05$
*** $p \leq 0.01$
**** $p \leq 0.005$

[10] Bartlett Chi-square tests the hypothesis that the correlations are zero.

Figure 5.7
Identified Viability Relationships
Investor Groups

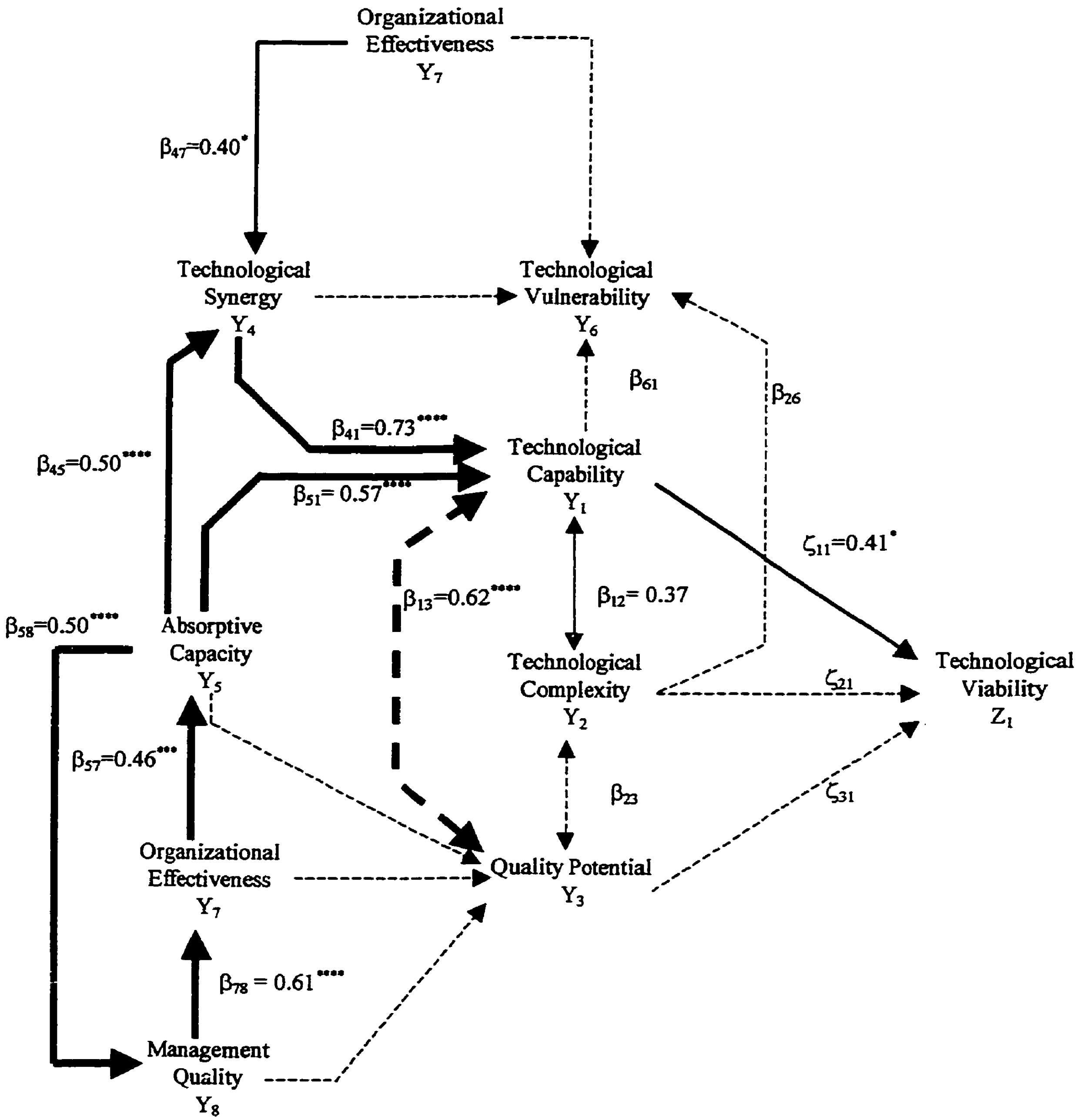


Table 5.4
Assessment Model Coding Protocol

		Coding
Technological Capability	Technological Synergy	Technological Synergy Required Technologies Available Technologies.
	Absorptive Capacity	Required Knowledge Available Knowledge. Knowledge Distribution.
	Technological Vulnerability	Technology Control. Knowledge Control. Proprietary Technology Control.
Technological Complexity		Technology Complexity. Technology Maturity. Novelty of Application. Technology Development Requirement. Alternative Technologies
Quality Potential	Management Quality	Management Quality. Planning Quality. Scheduling Quality. Design Process Control.
	Organizational Effectiveness	Development Project Concurrence. Organizational Structure.
Later Stage Issues		Manufacturing Capability Market Attributes
Comment		Comment

5.7.1 Lender Interview Results

The results of coding the interview data are provided in Table 5.5 and Table 5.6. In both tables, the results are based on the frequency of occurrence[11] of the model concepts.

[11] Through the course of the coding, some segments were classified as 'comments', in other words, they did not relate to any of the coding concept. The frequency of occurrence data has been corrected to remove comments from the total number of coded segments.

Table 5.5
Interview Coding Results
Ranked by Mean Frequency of Occurrence

	Rank	S1	S2	S3	S4	S5
Management Quality	1	38.2%	36.5%	36.8%	45.3%	28.4%
Market Attributes	2	19.7%	26.1%	34.2%	9.4%	14.9%
Available Knowledge	3	11.2%	7.8%	2.6%	7.5%	25.4%
Technology Development Requirement	4	3.9%	5.2%	14.5%	15.1%	11.9%
Technology Maturity	5	2.6%	7.0%	3.9%	5.7%	3.0%
Novelty of Application	6	3.9%	--	--	1.9%	10.4%
Proprietary Technology Protection	7	7.9%	--	--	7.5%	--
Required Technologies	8	2.6%	6.1%	2.6%	3.8%	--
Technological Complexity	9	1.3%	4.3%	5.3%	1.9%	1.5%
Organizational Effectiveness	10	2.6%	4.3%	--	--	1.5%
Technological Vulnerability	11	3.3%	2.6%	--	1.9%	--
Required Knowledge	12	2.6%	--	--	--	3.0%

Table 5.5 provides a summary of the most frequently occurring assessment concepts, ranked according to their mean frequency of occurrence. As indicated in Table 5.5, the lending expert assessment process is dominated by management quality, followed by market characteristics of the venture. The remaining concepts have a wide range of variance, reflecting the earlier findings that there are differences in the assessment concepts used by each expert.

When these assessment concepts are grouped into the model variables, their frequencies of occurrence can be examined. As shown in Table 5.6, the model is dominated by quality potential. This is not surprising given the high frequency of occurrence of management quality related issues. Care must be taken in interpreting these results however, as there may be a tendency among the lending experts to consider general management quality rather than those characteristics specifically related to the management of design and development teams. While not easily differentiated in this data, future research may consider this further.

Among the non-'other issues' concepts, technological complexity is the next most frequently considered model variable. This is strongly influenced by risk considerations such as development requirements. Finally, issues associated with technological capabilities of the venture appear the least often. This is not surprising considering that this is the assessment area most problematic for lenders. As indicated by several of the interviewees, there is a high reliance on external expertise in this part of the decision process.

Table 5.6
Model Coding Results

		S1	S2	S3	S4	S5
χ^2 (DF: 6)		89****	55****	81****	94****	51****
Technological Capability	Technological Synergy	3%	4%	6%	3%	0%
	Absorptive Capacity	3%	8%	8%	15%	27%
	Technological Vulnerability	0%	10%	3%	11%	0%
Technological Complexity		23%	25%	16%	12%	26%
Quality Potential	Management Quality	37%	45%	37%	38%	28%
	Organizational Effectiveness	0%	0%	4%	3%	1%
Other Issues		34%	9%	26%	20%	15%

**** $p \leq 0.0005$

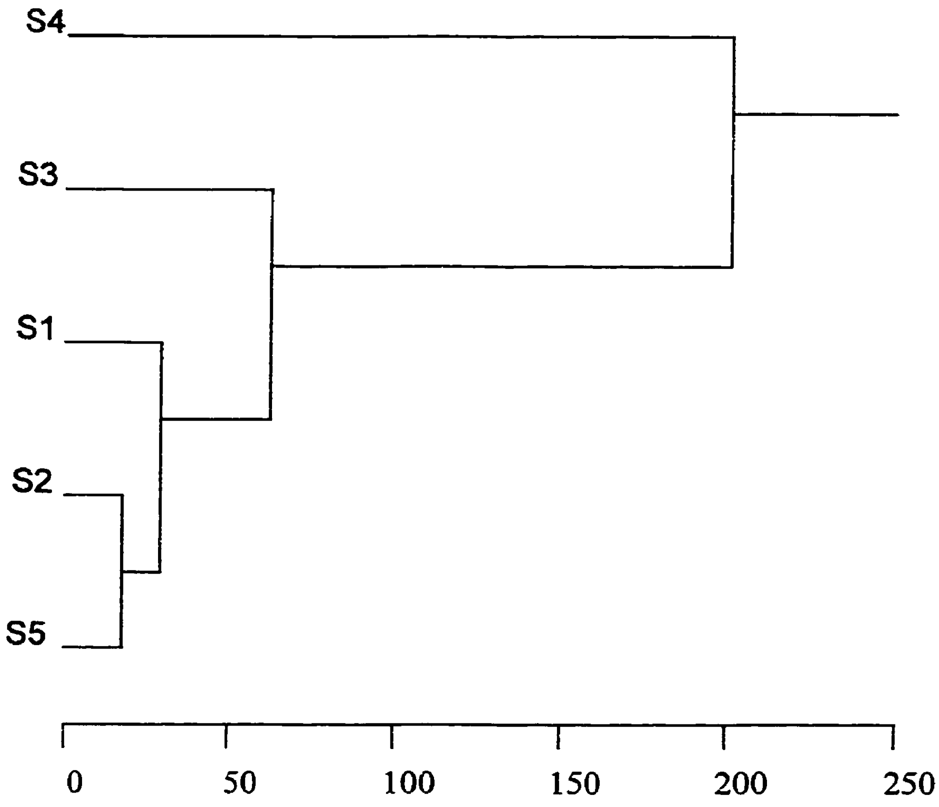
Table 5.7
Interview High-Level Coding Chi-Square Comparison

	S1	S2	S3	S4	S5
Expert S1	--				
Expert S2	30****	--			
Expert S3	62****	162****	--		
Expert S4	384****	291****	36****	--	
Expert S5	52****	11*	30****	59****	--

**** $p \leq 0.0005$
*** $p \leq 0.001$
** $p \leq 0.005$
* $p \leq 0.01$

Table 5.7 examines the hypothesis that the frequency of occurrence of model concepts is similar between lending experts in the study. As indicated, the most similar pair is S2-S5, while the least similar is S1-S4. Although there are similarities in terms of the most frequent concept, i.e. management quality, this reinforces the difference between the experts. To explore this further, the chi-squares were compared to the credibility indices developed in study I. No correlation was found between credibility index, or difference in credibility index, and the chi-square. As a final check, cluster analysis, Figure 5.8, was used to examine potential bias due to analysis of taped interviews compared to notes only. While the lowest difference is found between the two subject interviews (S2, S5) that relied on notes, they do tend to be clustered with other interviewees whose interviews are taped. Thus, while some bias may have been introduced due to note taking during the interviews, its impact can be considered acceptable.

Figure 5.8
Hierarchical Cluster Analysis Based on Chi-Squares



5.8 Model 'Predictive' Validity

Another aspect of model validation is its ability to describe or predict a venture outcome (e.g.: Zikmund, 1994). Based on the proposed model, a prototype screening and assessment aid[12] was created (Appendix H) for use in three experiments. The first experiment considered six short cases having a known outcome, drawn from Bell (1991).

The next experiment, consisted of having a group of subjects assess an early-stage venture case using the prototype decision aid. This case was based on an actual technology-based start-up, modified to prevent identification of the venture or

[12] Refer to Appendix G for more information regarding the creation of this tool.

individuals, and was presented to assessors in two parts. For this case, the assessors were not provided with the outcome of the venture, which is known to the researcher. Initially, the participants reviewed a business plan and were asked to screen the venture using the decision aid. In addition to the business plan, an envelope was provided containing information relevant at the time the business plan was produced, and one year later. The participants were again asked to provide an assessment of the venture with this additional information. The objective of this validation stage is to provide further insight into the predictive validity of the tool.

The third validation experiment again makes use of an early-stage venture business plan based on a biotechnology venture. An expert panel was created to assist in the assessment of an actual proposal, consisting of a chemist and two microbiologist from the University of Waterloo as well as an accountant. In addition to screening the venture using the proposed decision aid, the venture was also assessed using the Bell-Mason Diagnostic (Bell, 1991). This provides a comparison to another methodology described in the venture assessment literature. Unlike the first two experiments, the outcome of this venture is not known. The venture assessment in this case was compared to the Bell-Mason Diagnostic result and to a self-assessment by the venture.

5.9 Model Comparison to 'Bell' Cases

In this experiment a set of six short cases[13], two each of viable, 'marginally viable', and not viable, were presented to a group of assessors. For this experiment, venture cases were defined as marginally viable if they experienced difficulty during their start-up that could have led to the failure of the venture. The result summary for each case is provided in Table 5.8 through Table 5.13. Each table provides a t-statistic for the hypothesis that the means of the judges is equal to the score provided

---

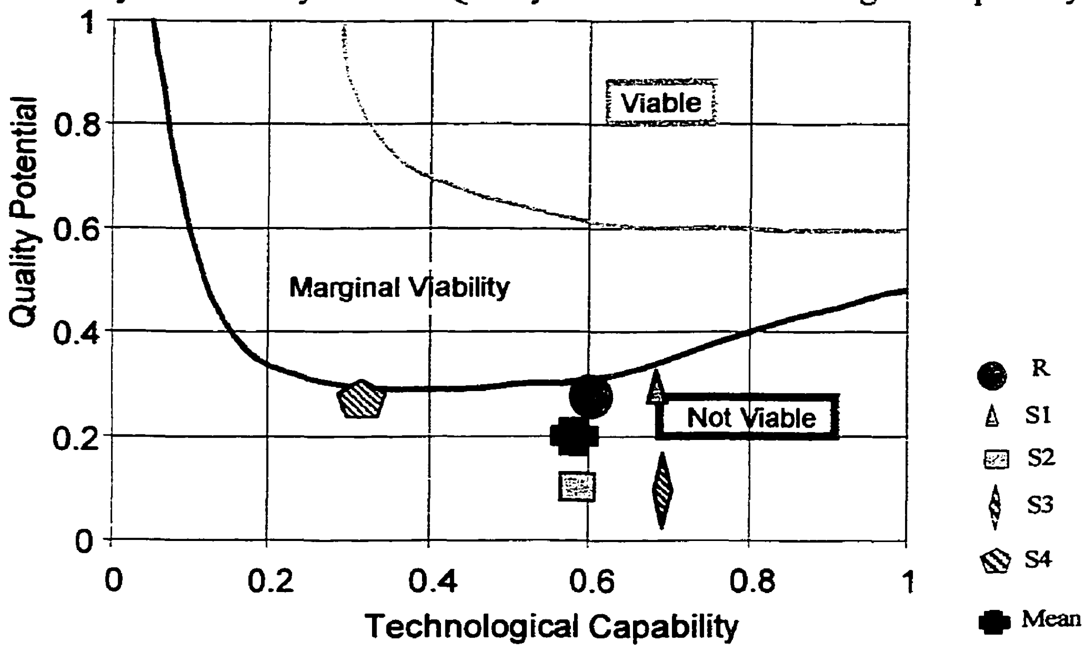
[13] These cases are found in "High-Tech Ventures" by Bell, pages 276 - 310, and consist of "Analytica", "Ovation", "Cirrus Logic", "Gateway", "Gensym" and "Maspar".

by the researcher. Graphical results[14] are provided in Figure 5.9 through Figure 5.11 for the 'Analytica' case. The remaining charts may be found in Appendix I. The subjects in this experiment consisted of three graduate students in the department of management sciences and a technology company executive.

Table 5.8
Case: Analytica (Not Viable)

	R	S1	S2	S3	S4	Mean	t-statistic (H_0: S = R)	$P(T_c \geq t)$
Technological Capability	0.61	0.71	0.57	0.71	0.28	0.58	-0.39	0.72
Technological Complexity	0.76	0.71	0.85	0.85	0.85	0.81	1.67	0.19
Quality Potential	0.28	0.28	0.14	0.14	0.28	0.23	-1.54	0.22
Index[15]	0.00	0.07	0.00	0.002	0.00	0.00		

Figure 5.9
'Analytica' Viability Chart -- Quality Potential vs. Technological Capability



[14] The charts are based on simulations of the model discussed in Appendix G and Appendix J.
[15] A discussion of the index may be found in Appendix G.

Figure 5.10
'Analytica' Viability Chart -- Technological Complexity vs. Technological Capability

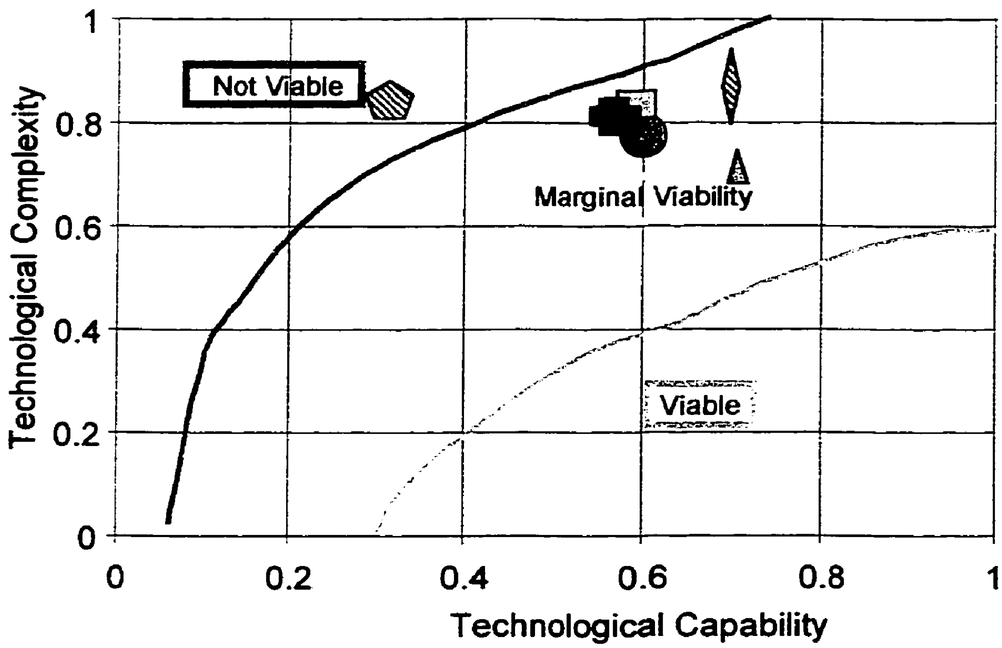


Figure 5.11
'Analytica' Viability Chart --Technological Complexity vs. Quality Potential

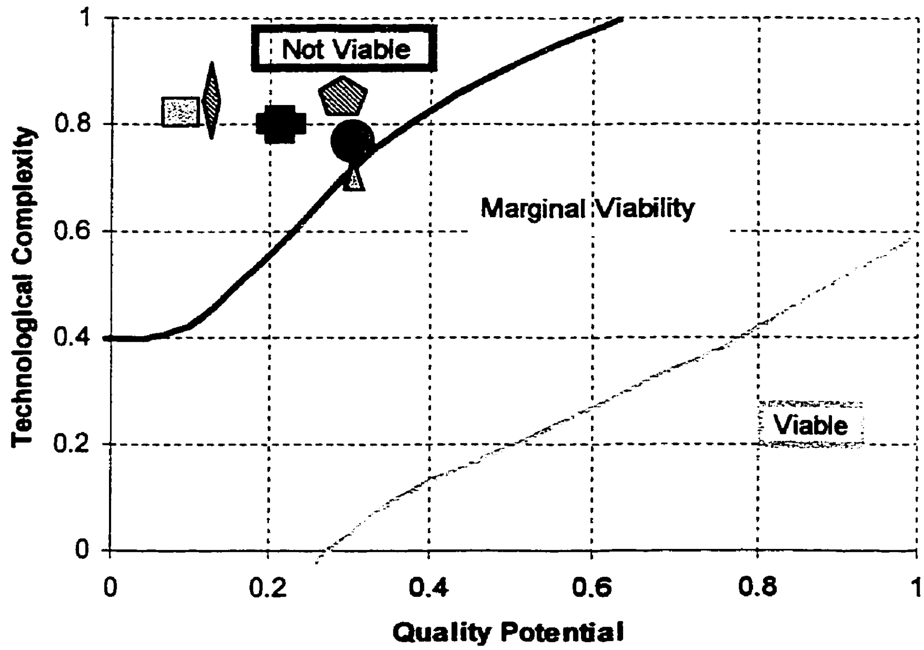


Table 5.9
Case: Gensym (Marginal)

	R	S1	S2	S3	S4	Mean	t-statistic (H_o: S = R)	$P(T_c \geq t)$
Technological Capability	0.71	0.85	0.71	0.85	0.85	0.79	3.0	0.06
Technological Complexity	0.71	0.57	0.85	0.85	0.71	0.74	0.53	0.63
Quality Potential	0.42	0.43	0.71	0.57	0.85	0.60	2.4	0.09
Index	0.2	0.55	0.61	0.52	0.84	0.64		

Table 5.10
Case: Gateway (Viable)

	R	S1	S2	S3	S4	Mean	t-statistic (H_o: S = R)	$P(T_c \geq t)$
Technological Capability	0.85	0.85	1.0	0.85	0.85	0.88	1.0	0.39
Technological Complexity	0.47	0.71	0.71	0.57	0.43	0.58	1.99	0.14
Quality Potential	0.78	0.57	0.85	1.0	0.85	0.81	0.43	0.69
Index	0.85	0.53	0.86	0.92	0.85	0.88		

Table 5.11
Case: Cirrus Logic (Viable)

	R	S1	S2	S3	S4	Mean	t-statistic (H_o: S = R)	$P(T_c \geq t)$
Technological Capability	0.85	1.0	0.71	0.85	0.71	0.82	-0.45	0.68
Technological Complexity	0.47	0.71	0.85	0.42	0.57	0.61	1.82	0.17
Quality Potential	0.78	0.86	0.85	1.0	0.71	0.84	1.29	0.29
Index	0.85	0.87	0.67	0.91	0.79	0.86		

Table 5.12
Case: Ovation (Not Viable)

	R	S1	S2	S3	S4	Mean	t-statistic (H_o: S = R)	$P(T_c \geq t)$
Technological Capability	0.15	0.28	0.28	0.14	0.43	0.26	2.26	0.11
Technological Complexity	0.67	0.71	0.85	0.85	0.85	0.79	4.3	0.02
Quality Potential	0.21	0.43	0.14	0.28	0.28	0.27	1.25	0.30
Index	0.00	0.00	0.00	0.00	0.00	0.00		

Table 5.13
Case: MASPAR (Marginal)

	R	S1	S2	S3	S4	Mean	t-statistic (H_o: S = R)	$P(T_c \geq t)$
Technological Capability	0.71	0.57	0.71	0.85	0.85	0.74	0.53	0.63
Technological Complexity	0.85	0.71	0.85	0.71	0.71	0.77	-2.99	0.06
Quality Potential	0.71	0.57	0.85	1.0	0.85	0.80	1.206	0.31
Index	0.62	0.00	0.67	0.89	0.84	0.84		

Table 5.14
F-Test of Difference in Means for Cases

Not Viable (0) Case: Analytica Case: Ovation	0		
Marginal Viability (0.5) Case: Gensym Case: Maspar	23.7	0	
Viable (1.0) Case: Gateway Case: Cirrus Logic	64.5	9.97	0

Approximate F: 32.7
DF: 2,27
p = 0.000 (Bonferroni)

To examine the model's capacity to discriminate between the three groups F-tests were performed[16]. The null hypothesis is that there is no difference in means between the groups. In all cases, Table 5.14, the F-test indicates that there is a significant difference between the groups. The correlation of the index with venture viability was considered next, as shown in Table 5.15. The strong correlation in this analysis indicates that the viability index may be a useful assessment metric.

Table 5.15
Viability Vs Index (Dependent Variable: Viability)

	SSE	D.F.	MSE	
Index	4.65	17	0.27	F: 9.46****
Error	0.35	12	0.03	
Correlation:	0.87****			
Bartlett χ^2	38.69****			

**** $p \leq 0.0005$ (Bonferroni)

5.10 Model Comparison to Venture I

In the previous experiment, there is a potential bias due to the fact that the judges know the outcome of the case, hence influencing their responses. In this experiment, a case[17], the outcome of which is not known, is provided to a group of assessors. This case is of interest because it was funded by a group consisting of a venture capitalists and a venture capital fund. The case was assessed individually

---

[16] F-tests were performed using the discriminant function in SYSTAT.

[17] The case is based on an actual venture entering the product development phase. It has been reviewed in accordance with the office of research to remove any information that may permit identification of the venture or individuals involved. In addition, financial information and projects were removed from the case so that this information cannot be used to identify the venture. Case sections where information was removed was identified to the participants. For example, tables indicating expected expenditures were included with the numerical information removed.

rather than as an expert panel, by a group consisting of a lending expert from study I, an accountant, an entrepreneur familiar with technology startups, and two Ph.D. students at the University of Waterloo. One of these graduate students has an extensive engineering background (18+ years).

The experiment was conducted in three stages. Stage one was to review the venture business plan. Stage two was to provide the participants with additional information in two parts. Part one consisted of information which would have been available to the assessor had they gone to the venture as part of a due diligence process. The second part of the additional information consisted of information available if they had re-visited the venture approximately one year later.

There are two issues of interest in this experiment: How is the venture assessed at each time period? How well do the respondents agree? Not only does this provide an indication of the tool's predictive validity, it provides an indication of the methods inter-expert reliability and its usefulness as a monitoring tool. The results of each assessment period may be seen in Table 5.16 through Table 5.18.

Table 5.16
Initial Venture Business Plan

	S1	S2	S3	S4	S5	Mean
Technological Capability	0.85	0.85	0.67	0.85	0.71	0.79
Technological Complexity	0.33	0.85	0.61	0.71	0.71	0.64
Quality Potential	0.85	0.57	0.35	0.71	0.71	0.64
Index	0.85	0.52	0.05	0.82	0.78	0.77

As indicated in Table 5.16, four of the five assessors considered the venture to be viable after reviewing the business plan only. Of these four, one considered the venture to be marginal (S2), while in one case the venture was considered definitely not viable (S3), based on the viability index and location on the charts (Appendix I). This result is consistent with the fact that in the real case the venture was funded.

Table 5.17
Additional Venture Information - Part I

	S1	S2	S3	S4	S5	Mean
Technological Capability	0.67	0.57	0.67	0.57	0.57	0.61
Technological Complexity	0.85	0.85	0.61	0.85	0.85	0.80
Quality Potential	0.67	0.42	0.35	0.42	0.42	0.49
Index	0.004	0.001	0.05	0.001	0.001	0.08

Table 5.18
Additional Venture Information - Part II

	S1	S2	S3	S4	S5	Mean
Technological Capability	0.33	0.57	0.62	0.57	0.57	0.53
Technological Complexity	0.85	0.85	0.71	0.85	0.86	0.82
Quality Potential	0.33	0.28	0.28	0.28	0.57	0.35
Index	0.00	0.00	0.00	0.00	0.001	0.00

When additional information, based on what would have been observed had the subjects visited the venture as part of their due diligence process was provided, the assessment changes as indicated in Table 5.17. Based on the viability index, all subjects considered the venture to be 'not viable' after reviewing the additional information. The implication of this is that the venture would not be considered for further investment at this point, which eventually would be the correct decision. Further additional information, Table 5.18 reinforces this finding. A graphical example of the assessment process is provided in Figure 5.12 to 5.14, with more detailed charts available in Appendix I.

Table 5.19
Venture Assessment versus Time
Group t-statistics, Ho: No Difference between Periods, Pooled Variance, D.F: 8

	Time 0 - 1	Time 1 - 2	Time 0 - 2
Technological Capability	3.77*	1.37	3.91*
Technological Complexity	-1.61	-0.36	-1.97
Quality Potential	1.80	2.24	3.60*
Index	3.93*	1.16	4.02*

* $p \leq 0.05$ (Bonferroni)

To examine this assessment process further, group t-statistics were examined as shown in Table 5.19. This tests the null hypothesis that there is no difference between the groups. In other words, the additional information was not changing the assessor's perception of the venture viability.

Table 5.20
Model - Time Correlation

	Time	Technological Capability	Technological Complexity	Quality Potential	Index
Time	1.00				
Technological Capability	-0.78**	1.00			
Technological Complexity	0.51	-0.54	1.00		
Quality Potential	-0.73*	0.72*	-0.47	1.000	
Index	-0.74*	0.77**	-0.56	0.84****	1.000

Bartlett χ^2: 42.9****
**** $p \leq 0.001$(Bonferroni)
*** $p \leq 0.005$
** $p \leq 0.01$
* $p \leq 0.05$

As can be seen, the most significant difference encountered between the initial information (business plan only) and the first supplement is in the perceived technological capability. When the correlation between the model variables over the three time periods is considered, Table 5.20, perceived technological capability decreased as more information was provided. The perceived technological complexity did not appear to change significantly with additional information. However, examination of the difference between the initial information and the two supplements indicates that the perceived quality potential was also decreasing.

To illustrate this further, the progress of assessment process for subject S1 shown in Figure 5.12 through Figure 5.14. As can be seen in this case, the initial venture assessment places it in the viable region. However, as information is added, the venture tends to move into the marginal region, and in the case of Figure 5.12 and 5.13, moves near the 'not viable' boundary. The final information supplement places the venture completely in the 'not viable' region.

Figure 5.12
Quality Potential vs. Technological Capability for Each Time Step
Subject S1 and Mean (cross)

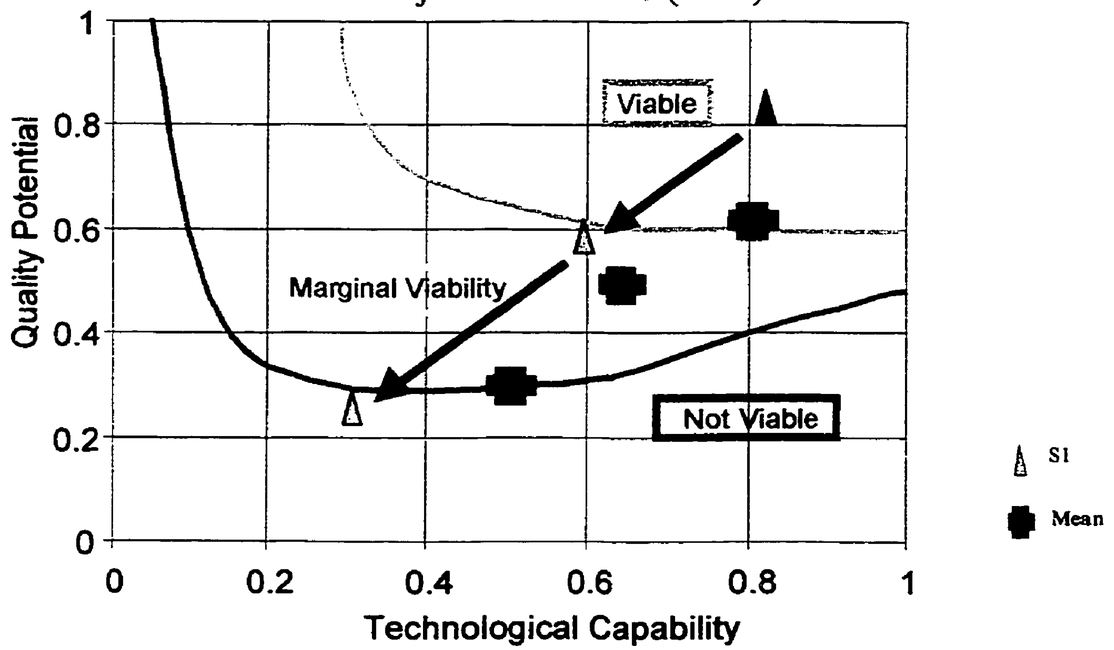


Figure 5.13
Technological Complexity vs. Technological Capability for Each Time Step
Subject S1 and Mean (cross)

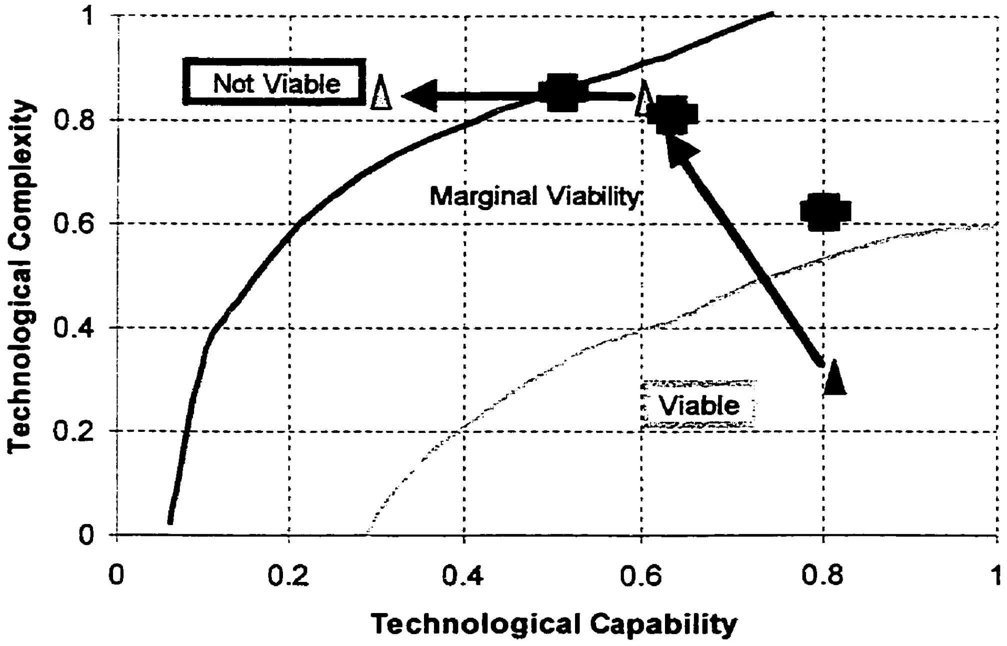
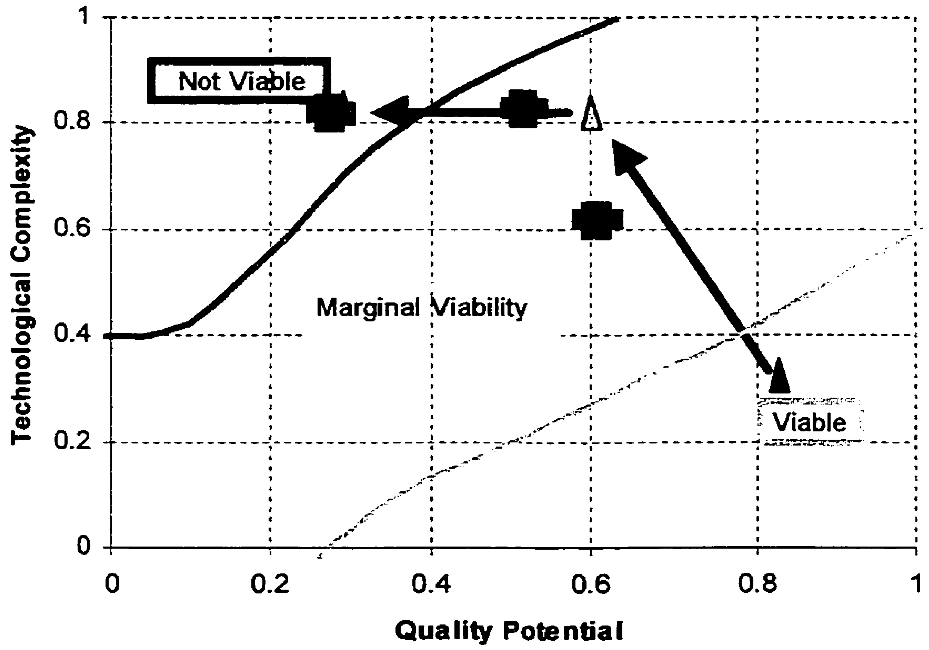


Figure 5.14
Technological Complexity vs. Quality Potential for Each Time Step
Subject S1 and Mean (cross)



5.11 Model Comparison to Venture II

Unlike the first two experiments, the outcome of the venture in this case is not known. The objective is to examine the usefulness of the methodology when dealing with an expert panel, hence inter-expert reliability, and to compare it with another venture assessment method from the literature, specifically the Bell-Mason Diagnostic (Bell, 1991). Comparison with another tool addresses confidence validity by examining assessment agreement and provides a basis for evaluating relative strengths and weaknesses.

5.11.1 Expert Panel Assessment

This case considers an early stage (concept stage) biotechnology - pharmaceuticals venture[18] that is being proposed for venture capital funding. To assess this case, an expert panel was created, consisting of the researcher, two microbiologists (One Ph.D.) and a chemist (Ph.D.) on staff at the University of Waterloo and a Management Sciences graduate student with extensive accounting background. Each of the members of the panel was given a copy of the business plan as well as a copy of the assessment tool. The definitions and usage of the tool was reviewed with each prior to beginning the venture assessment. While the panel members completed their assessments individually, Table 5.21, they were free to discuss their opinions with other participants.

Table 5.21 provides a summary of the panel assessment using the viability method (Appendix H). The t-statistic is provided as a measure of the agreement between the researcher and the other judges, testing the null hypothesis that there is no difference in the judgements.

As an additional indicator of the agreement between the judges, an approximate chi-square statistic was calculated by taking the ratio of the maximum to minimum variance. Based on this, using eight degrees of freedom (df: 8), the venture

---

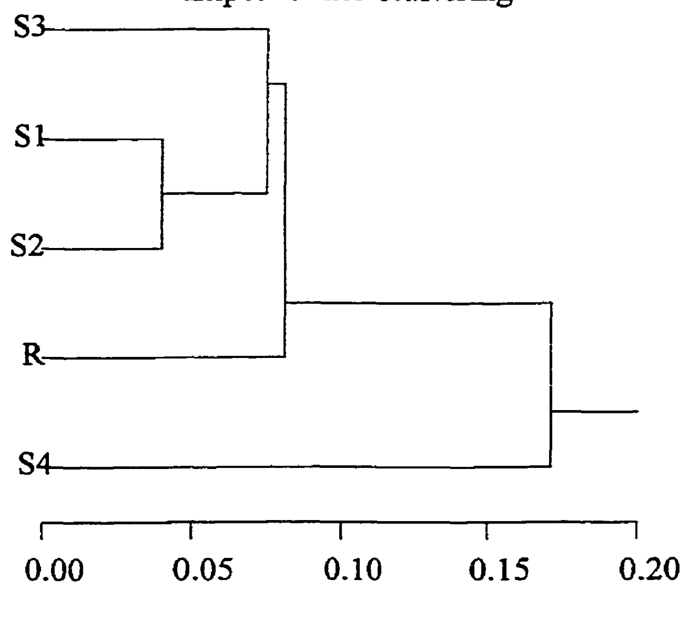
[18] Permission for assessment of this case was obtained from the venture under nondisclosure.

assessment scores do not appear to be significantly different. This agreement among the judges is also apparent when examining the viability plots, Figure 5.16 through Figure 5.18.

Table 5.21
Expert Panel Assessment Results

	R	S1	S2	S3	S4	Mean	t-statistic (H_o: S = R)	$P(T_c \geq t)$
Technological Capability	0.28	0.29	0.28	0.42	0.14	0.28	0.04	0.97
Technological Complexity	0.85	0.71	0.71	0.71	0.85	0.77	-3.0	0.10
Quality Potential	0.42	0.43	0.36	0.43	0.14	0.36	-1.16	0.36
Variance	0.088	0.045	0.052	0.027	0.168			
Index	0.0	0.0	0.0	0.008	0.0	0.0		
Approximate χ^2	6.2							

Figure 5.15
Expert Panel Clustering



The assessments by the various judges were also examined using cluster analysis. As shown in Figure 5.15, the closest clustering is among the scientific members of the panel {S1, S2, S3}, while the greatest difference is associates with the judge with an accounting background. This is of interest in terms of inter-expert reliability in that although they tended to look at different aspects of the venture, and had different perspectives as indicated by the cluster analysis, their assessment outcomes were in agreement.

As indicated by the graphs, Figure 5.16 to Figure 5.18, there is good agreement among the judges. In Figure 5.16, the judges considered the venture to be in or on the boundary of the 'not viable' region, indicating that if the venture were to proceed, it has little chance of successfully reaching market introduction as currently configured. Also, Figure 5.16 indicates that there was consensus that the venture has low technological capability and quality potential.

Figure 5.16
Quality Potential vs. Technological Capability: Case B Expert Panel

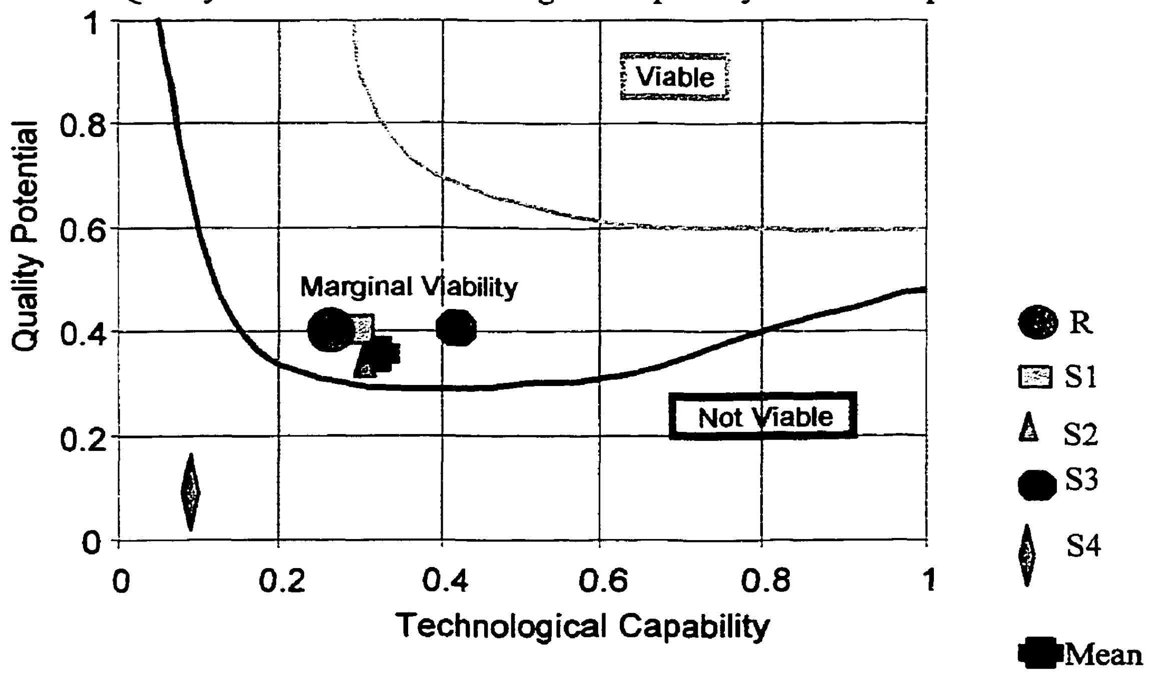


Figure 5.17
Technological Complexity vs. Technological Capability: Case B Expert Panel

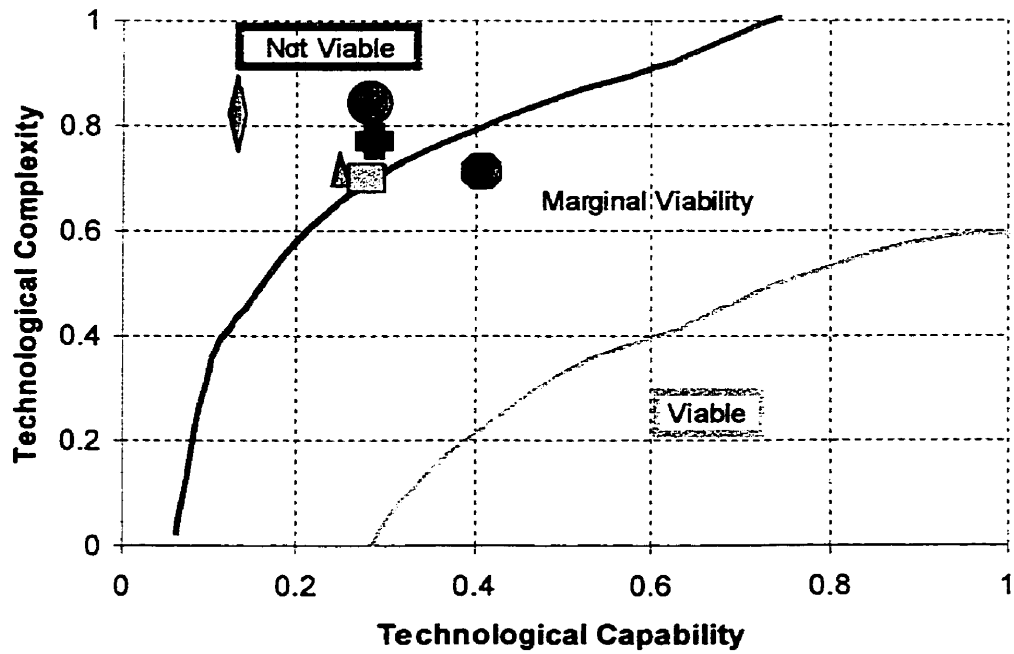
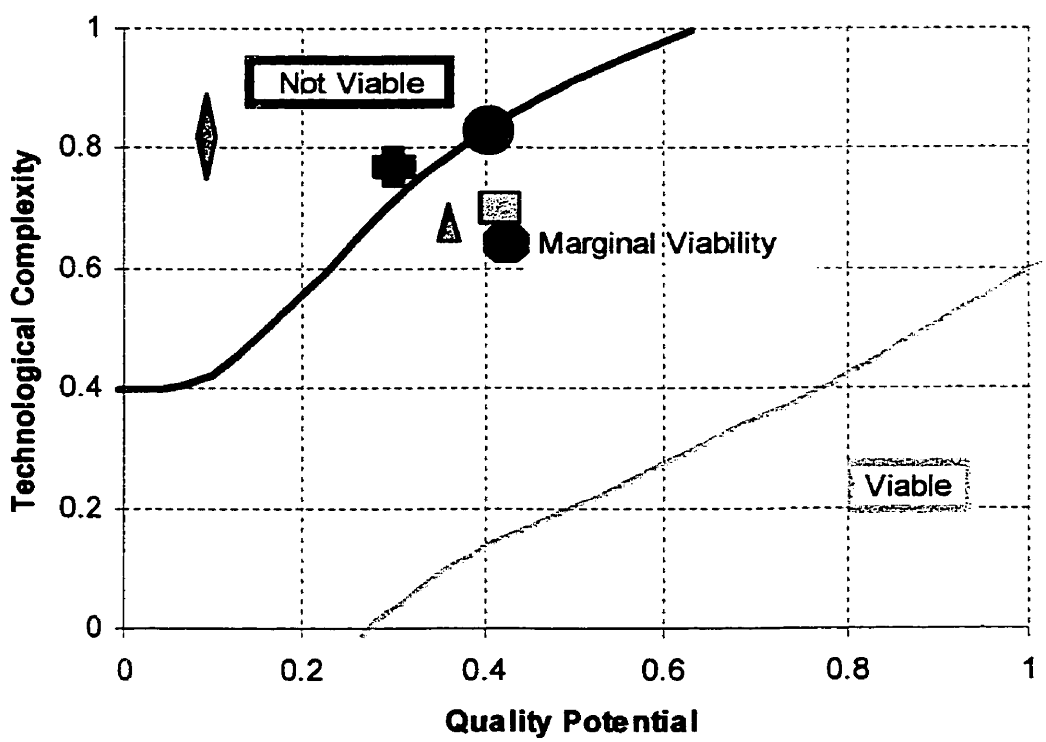


Figure 5.18
Technological Complexity vs. Quality Potential: Case B Expert Panel



Examination of the remaining graphs, Figure 5.17 and Figure 5.18, indicates that there is consensus that the proposed venture was 'not viable'. Note that this simply reflects the opinion of the panel that the venture, as configured at the point in time when assessed was weak and not likely to successfully reach the market introduction stage. This is not to say that the concept is 'bad', rather that the venture needs to undertake steps to improve both its technological capability and quality potential before proceeding.

5.11.2 Comparison with Bell-Mason Diagnostic

The next objective is to provide an assessment of confidence validity by comparing the viability assessment with the assessment using another tool. A problem encountered when assessing early-stage, technology-based ventures is that there are very few tools specifically designed for this stage. As such, the 'Bell-Mason Diagnostic' (Bell, 1991), while not specifically intended for very early stage ventures, is one of the few and was chosen for this experiment based on its availability in the literature and its appropriateness for assessing early stage ventures.

The Bell-Mason Diagnostic consists of a set of venture success criteria, determined empirically from case research, organized along several dimensions. Each of these criteria is presented as a question requiring a yes/no answer. The scores for each dimension[19], provided in Table 5.22, simply reflect the proportion of 'yes' responses for each. To determine an overall rating, the majority opinion was used, providing a score based on whether each question associated with a dimension received a majority of 'yes' or 'no' responses. A tie was considered to be a 'yes' response[20].

---

[19] Refer to Appendix I for more details on the expert panel responses. Note that only four of the five members of the panel were available for this stage of the experiment.

[20] This leads to an optimistic aggregation of the votes, which is a moderately less risk-averse approach.

Table 5.22
Bell-Mason Diagnostic Scores for Case II

	R	S1	S3	S4	Majority
Technology/Engineering	0.37	0.21	0.16	0.05	0.21
Operations	0.10	0.20	0.30	0.40	0.20
Finance and Cash Flow	0.00	0.00	0.00	0.25	0.00
Board of Directors	0.00	0.00	0.00	0.00	0.00
Management Team	0.50	0.50	0.50	0.25	0.50
CEO	0.14	0.00	0.00	0.00	0.00
Sales	0.00	0.00	0.00	0.00	0.00
Marketing	0.60	0.60	0.60	0.40	0.50
Business Plan	0.63	0.50	0.63	0.88	0.75

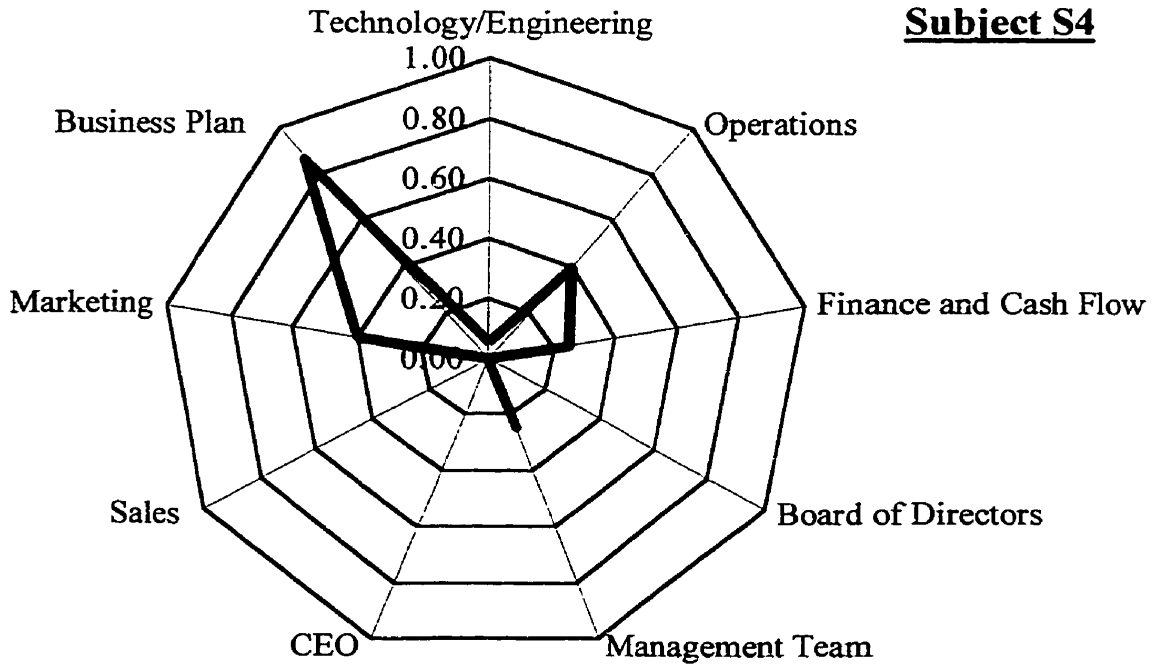
χ^2: 58.3****

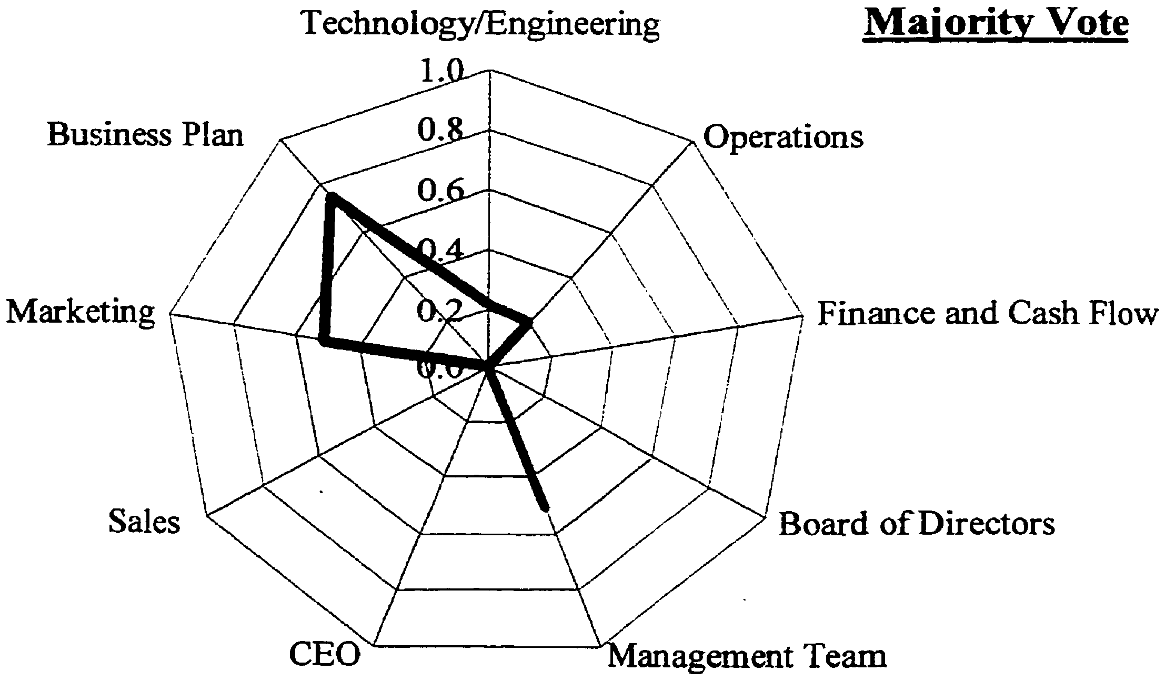
**** $p \leq 0.0005$

Figure 5.19 graphically illustrates the scores given by expert panel member 'S4', as well as the majority assessment. Examination of the 'Subject S4' plot indicates that the venture was given relatively a high score for its business plan, and weaker for several other dimensions such as marketing. Similarly, the 'Majority' plot illustrates that the proposed venture scored moderately well in terms of its business and marketing plans and management team, while having a lower score for technology/engineering.

Overall, the diagnostic indicates that the proposed venture has weaknesses in the technology-engineering dimension. This is consistent with the assessment using the viability approach. In terms of the management team, the diagnostic indicates that the venture has some strength in that dimension, although the CEO and Board of Directors dimension scored very poorly. This is not surprising for a venture at this stage as it has yet to form a Board and the CEO is one of the concept team.

Figure 5.19
Bell-Mason Diagnostic Results





When compared to the viability approach the quality potential dimension scores relatively low. This difference is principally due to the focus on engineering and planning management rather than general management skills. Finally, the Bell-Mason Diagnostic does not reflect the complexity of the proposed venture and as such makes impact of the strengths and weaknesses less apparent.

5.12 Discussion

An objective of this study is to seek validation for a viability theoretic view of venture assessment. The most important consideration at this stage of theory development is construct validity. This leads to two questions: Is there support for the existence of the hypothesized model constructs? Are the expected relationships are present?

Regarding the existence of the hypothesized constructs, analysis of the investor data appears to support their presence in the assessment process. This is further supported by the examination of the lending experts. Using a coding protocol based on the proposed model, evidence was found that these concepts are present in their assessment process. This analysis is based on the assumption that expert investors and lenders tend to use concepts and criteria that are reflected in the proposed model. Analysis also indicates that the expected model relationships are present, with several of the hypothesized relationships are apparent in the investor data.

Based on the proposed model, a prototype assessment aid was developed. This leads to the next validity issue, predictive validity. Two experiments were devised to investigate this, with evidence was found to support the predictive validity. Further, the second of these experiments illustrates the framework's potential as a monitoring tool. It was shown that venture progress can be tracked over time, and hence provides a basis for an 'early warning' system. As discussed previously, at this stage of a venture's evolution the concept may have merit, but the issue of the venture's capacity to successfully reach market development must be addressed.

In terms of inter-expert reliability, the last three experiments indicate that although the participants considered different aspects of the cases, their assessments tend to converge when using the framework. The number of subjects chosen for each of the case assessments was intended to reflect a typical assessment team. This was also apparent when the decision aid was used with an expert panel. Although they came from different backgrounds and perspectives, their assessments were similar.

The final validity issue to be considered was confidence validity. To explore this, the expert panel also assessed the venture using an additional tool, the Bell-Mason Diagnostic (Bell, 1991). This tool provides a wider view of the venture and addresses issues such as marketing and sales that were considered outside the scope of the present research. Further, it is intended for use at all stages of venture evolution, although is considered appropriate for early-stage ventures.

Overall, the diagnostic and viability frameworks identified similar weaknesses. The majority score indicates serious deficiencies, and hence may be a poor investment candidate. As with the viability framework, it does not indicate whether the venture concept is 'good' or 'bad', only the state of the venture. A major difference between the viability framework and the Bell-Mason Diagnostic is the framework's ability to provide an indication of the severity of the venture weakness, a feature that many of the participants noted[21].

---

[21] A short post-test questionnaire (Appendix I) was administered to the participants to assess perceived tool usefulness and clarity. The participants indicated fairly strong agreement with the assessment outcome (median: 6 on 7-point scale).

	Median (N=7)
Tool Appropriateness	6
Clarity of Instructions	6
Perceived Usefulness	6

Chapter 6

Conclusions and Future Research

At a fundamental level, what motivates this type of research? From the perspective of a lender, it is to reduce the risk that their loan will default. For investors, it is to make money - to identify those ventures that have a high potential return on their investment. In the case of entrepreneurs and venture management, it is to understand how to create a successful venture, typically in terms of financial success. For the academic, it is the need to understand what mechanisms are at work in the evolution of successful ventures.

The common thread running through these points-of-view is the need to understand the mechanisms that lead to successful ventures. To this end, much of the prior research has focussed on the criteria used by experts when assessing ventures in an effort to identify those characteristics that are predictors of success. Closely related to this has been the development of increasingly sophisticated statistical models for use by lenders and investors as decision aids.

A potential shortcoming of statistical models of venture performance is that while well suited for understanding the past, they have weakness when attempting to forecast future behaviour and events. Although these models will often outperform forecasting by experts (e.g. Dawes, 1982), they degenerate to speculation when forecasting significantly into the future. A possible explanation for this may be seen when viability is considered. As long as the system under consideration is stable, the forecasts may have some validity. Further, if it is evolving slowly relative to model updates, short-term forecasts will remain relatively accurate. However, when the system is changing rapidly relative to the model or is subject to discontinuities, then forecasting will have difficulties and may even be irrelevant.

The overall goal of this research has been to increase understanding of venture assessment, which has led to three studies. The first examined the assessment behaviour of lenders, while the second considered investors through the development of model based on attribution theory. The third study considered the venture as an evolving system and examined an assessment framework based on viability.

The initial study of lender behaviour found that; when viewed in terms of the criteria, lenders and investors act in similar ways. Thus, if there are differences among these groups, as anecdotally reported, they may be at a deeper level. The implication is that there is little value added by simply examining their criteria, rather it is the relationships between them that are of potential interest. To this end, fuzzy cognitive maps were developed to explore the interactions of the assessment criteria. While this increases the understanding of how criteria may be related, the question of what differentiates groups of lenders and investors remains.

This search for underlying structure led to the second study, which considered the assessment decision process within a framework based on attribution theory. Using this approach, apparent differences were identified between investor groups along three dimensions, control, specificity, and a moderator variable. While the moderator will be multidimensional, including more than risk aversion, it was assumed to be the dominant influence. Examining groups of investors within this framework indicated that their differences are a function of required levels of perceived control and specificity, dominated by stability.

The attribution model also implied a decision surface, with reject and accept regions. Examination of this surface illustrated the role of risk aversion in expanding or contracting these regions. Further, risk aversion was seen to have two components, systemic risk aversion that accounted for the clustering of different investor groups on this surface, and individual risk aversion that accounted for the variation within the group. This also provided a potential explanation of why some individual criteria sets are larger than others. The increased information tends to reinforce the perceived levels of control and specificity, thereby reducing uncertainty to acceptable levels in terms of risk and ambiguity tolerance.

The attribution framework provided insights into the assessment process, however it did not adequately address several questions: Why can different assessors operate with different subsets of criteria and still be successful? Why don't all successful practitioners use a specific criteria set? Further, a major shortcoming with a criteria based approach is that it provides no indication of what action should be taken in the case of missing information. This is a particularly important issue for very early stage ventures as they may be missing many of the characteristics that are being considered by a criteria-based view.

The third study was exploratory, focussing on model-development and examined the assessment of early stage, technology based ventures from the point of view of viability. This takes a system view of ventures, specifically that of complex systems evolving under uncertainty like those found in evolutionary biology (Aubin, 1991). When considering the viability of a venture-system, there are many interacting components, such as market and financial viability. While these viability components are always of concern, technological viability is arguably the dominant consideration for these early stage ventures.

Within this framework, the structure of technological viability can be explored which has implications not only for understanding the process, but also for improving it. Further, it provides a starting point for considering several of the questions posed. Consider the questions: Why can individuals operate with different subsets of criteria and still be successful? Why don't all successful practitioners use a specific criteria subset?

Lenders and investors appear to be drawing from the same general set of assessment criteria, with no unique content differences between the groups. However, within these groups, individuals appear to have unique sets of criteria and perceived relationships. So, why don't all successful venture assessors evolve to use the same criteria set? From a systems-theory point of view, an assessment practitioner may be thought of as building an estimation model that is attempting to define venture-system states. Thus, criteria sets may be viewed as being based on the assessment practitioner's attribution of the success of these indicators when estimating venture viability. When viewed from a viability theory perspective, the estimation is not unique, hence there is no unique set of criteria.

While there are theoretical arguments that make this view of a venture's evolution compelling, is there evidence that this is what occurs in practice? To investigate this further, a model was proposed and validation sought. The objective was to evaluate the potential of this approach as the basis of an assessment aid. Based on the results of study three, there are indications that the components of technological viability are present. Further, this also suggests potential areas for improving early stage venture assessment and management, such as assessment of a venture's 'quality potential'.

Perhaps the main contribution of this research is the movement away from a criteria based view of assessment to a system view. As for the examination of criteria, there is no 'magic bullet' set of criteria, rather it is the estimation of viability that is important. As for assessment of ventures, the goal of predicting the next Microsoft when it is a start-up is a fool's errand. It is not more attainable than predicting the weather ten years into the future. At best, the current venture viability can be estimated and monitored over its evolution, as illustrated in the third study.

6.1 Potential Shortcomings

The studies undertaken in this research are not without their shortcomings and areas for potential improvement. In the first study, validation of the cognitive maps is problematic. Ideally, comparing the model output to that of an actual expert for an accepted and rejected venture would be undertaken. However, in the case of the lending experts, two problems arise. First is the difficulty of obtaining access to realistic venture information due to privacy considerations. A possible approach would be to develop a case that can be used by the experts as an assessment example. The difficulty is in developing a case that has sufficient richness to be a realistic test. A related problem is the difficulty in obtaining reject information, as the lending organizations do not track or retain information on ventures that are not accepted. Again, cases could be used, but it would be difficult to create a realistic reject case.

Another approach that was investigated is to create a questionnaire to confirm the relationships identified in the cognitive maps. The difficulty encountered with this approach is that it requires confirmation of the concepts and relationships, resulting in 2500 questions. This is undoubtedly an infeasible approach. Even when customized to each expert, there are 700 potential questions.

Another potential shortcoming with the first study is inter-coder reliability. In this study a single investigator performed the operator-element analysis and subsequent coding. A possible improvement to the study would be to train several independent analysts in the methodology and compare the results. The approach used in this study is not simply a case of applying a defined protocol to transcribed utterances, but requires the analyst to consider the context of each. This requires familiarity with the topic area, the methodology and the interview information. As a result, the use of multiple analysts was not considered feasible in this case.

In the second study, a potential weakness is bias in the mapping of the criteria factors to the attribution model. To minimize this, the mapping was compared to that of a set of independent judges. These judges were selected from graduate students in the department of management sciences who were familiar with many of the concepts embodied in the criteria. However, these judges did not have significant familiarity with attribution theory or the proposed model. Given this, the level of agreement between the experimenter and the judges is quite good. A potential area of improvement in this study may be to provide a seminar to a set of judges to increase their familiarity and then compare their opinions of criteria classification.

The third study has several potential problems related to the data suitability. Future studies are required to develop a data set that is focused more clearly on early stage technology-based ventures. The best approach would be to identify several ventures at the seed stage and follow them in a long-term longitudinal study. However, a difficulty when undertaking any research on this stage of venture evolution is the small available sample. Identification requires close cooperation with organizations and individuals that will be approached early by these ventures. This approach is complicated by a tendency for many investors to avoid ventures that are at the very early stages of product development.

6.2 Future Research

In this research several studies have been undertaken and discussed. Through the development of models and prototype tools, the potential of different research avenues has been considered, with the overall objective of understanding and improving early stage venture assessment. These paths suggest several potential areas of future research.

6.2.1 Assessment Practices

In terms of venture assessment practices, and the problems encountered by lenders when assessing new high technology, knowledge-intensive ventures, perhaps the problem is not one of assessing the ventures at all. Rather, it is an issue of boundary spanning and technology forecasting. As such, this may be an area of research that has potential 'value added' for lending decision-making. To this end, it is proposed that current practice among lenders and investors with respect to technology forecasting and boundary spanning are examined.

6.2.2 Attribution Theory

A premise of this research is that risk aversion, systemic and individual, is a dominant factor for the moderator in the proposed attribution model. Further examination of the impact of other factors, such as ambiguity intolerance, on the decision process need to be undertaken. This research would require measures of risk aversion, ambiguity intolerance and other personality characteristics to be measured along with control and specificity parameters during the decision process.

In the second study, the 'end' points of the decision have been considered. However, the dynamics of the decision process as the assessor acquires information and reduces uncertainty would be of interest. Future research to examine these dynamics would require think-aloud sessions to be conducted with investors as they are in the process of evaluating a venture. As this is a long-term process, occurring over the time span of hours to weeks, such a study would involve many interview sessions and therefore would be logistically difficult.

6.2.3 Viability Based Assessment

The third study in this research explored a viability-theoretic framework for venture assessment. While this study demonstrated the application of the model, work is required to refine the model and it's component FAMs (see Appendix G). Further, an assumption in the current model is that the product is completely defined at the start of the development phase. Future iterations of the model will remove this assumption.

The logical next stage is to extend the models to include other aspects of viability as well as to strengthen its empirical foundation and test propositions that have been generated. This research is envisaged as a relatively long-term longitudinal study of several ventures as they evolve through the concept and start-up stages. As with most research in this area the principal difficulty will be identifying ventures early enough to be of value. While studies of ventures that have evolved beyond this stage can provide useful data, a common difficulty is selection bias. In other words, these ventures have survived and may be considered to have been viable while those that did not survive may be of most interest.

A possible approach to data analysis for such a longitudinal study is data envelopment analysis (DEA). The idea of viability regions seems conceptually similar to the concept of an efficient frontier in DEA. This relationship is in itself a potential area of future research.

In terms of venture management, this framework provides an approach for monitoring and control. This may be achieved through identification of development milestones as the venture evolves, and the application of 'backcasting'. Periodic monitoring then provides a tool for tracking the venture's development and determining if it has remained on a viable trajectory.

6.2.4 Development of Decision Support Aids

As discussed in the introductory chapter, the goal is to develop a toolbox of assessment aids. Each of the studies has implication for the development of toolbox components. There are several toolboxes available for financial analysis associated with packages such as MATLAB and EXCEL. The objective would be to create add-ons that provide intelligent tools for coping with many of the intangibles associated with these early stage ventures.

In the first study, the application of fuzzy cognitive maps in aggregating expert opinions was illustrated. When the aggregate map is examined, the focus is on management quality issues. This may provide the basis for a decision tool to help assess this aspect of the venture.

The second study illustrates the potential impact of issues such as risk aversion in the decision process and the need to 'calibrate' tools to user groups. Further, it may be of interest to explore decision tools which attempt to assess the stability of information being acquired during the decision process.

The third study, viability-based assessment, suggests a set of constraints to be evaluated and monitored. This may have the greatest potential for a new decision support tool. A possible approach based on this approach is to develop a knowledge-based system to evaluate the venture viability coupled with a database for backcasting. In addition, evaluation of the model also suggests several tools for assessing capability and complexity. For example, the application of knowledge-mapping (e.g.: Sparkes and Guild, 1999) for assessing synergy and absorptive capacity may be useful additions to the toolbox.

List of Appendices

Appendix A -- Abstract of Bachher, 1994

One of the main difficulties that early stage technology-based companies in Canada face is obtaining equity capital to aid their growth. This study provides an understanding of the decision-making criteria currently used by Canadian equity investors to evaluate technology-based companies seeking early stages of financing (seed, start-up or first stages). Three different types of investors were studied: Business Angels (BAs), Private Venture Capitalists (PVCs) and Public Venture Capital Funds (PVCFs). The group differences in their decision-making criteria between evaluating an early stage technology based and non-technology-based company were determined. Data were collected using survey questionnaires administered through personal interviews.

The key and important decision making criteria used by these investors were grouped into five categories: characteristics of the entrepreneur(s), characteristics of the market targeted by the venture, characteristics of the venture offering (product or service), investor(s) requirements and characteristics of the investment proposal from the venture to the investor(s). Results from the study showed that there are significant differences between the criteria used by these types of investors when evaluating early stage technology and non-technology based companies. For example, all investor types consider characteristics of the venture offering (product or service) with a significantly higher degree of importance when evaluating an early stage technology based company as compared to an early stage non technology based company. Results also showed that PVCFs appear to make a greater number of investments in early stage technology based companies than PVCs in Canada at this time. Lastly, both PVCFs and BAs showed similar investment patterns (in terms of number of investments) at the early stages of a company.

In conclusion, we expect that entrepreneurs will have increased chances of success if they know what Canadian equity investors are looking for as they decide where to lend their support among our technology based enterprises.

Appendix B -- Analysis of Investor Data

B.1 Business Angel Criteria t-Tests

	Accept			Reject						
Criterion	Mean	SD	N	Mean	SD	N	Difference	Pooled SD	t	p-value
1	6.200	0.768	20	6.263	0.806	19	-0.063	0.618	-0.251	0.599
2	6.500	0.607	20	6.526	0.612	19	-0.026	0.371	-0.135	0.554
3	6.050	0.945	20	6.105	0.937	19	-0.055	0.885	-0.183	0.573
4	6.100	1.252	20	5.895	1.560	19	0.205	1.989	0.454	0.675
5	5.400	1.314	20	5.421	1.170	19	-0.021	1.552	-0.053	0.521
6	5.526	1.219	19	5.500	1.543	18	0.026	1.921	0.058	0.523
7	5.800	1.056	20	5.842	1.068	19	-0.042	1.128	-0.124	0.549
8	6.650	0.745	20	6.316	1.293	19	0.334	1.099	0.995	0.840
9	5.700	1.129	20	5.684	1.057	19	0.016	1.197	0.045	0.518
10	6.200	0.768	20	6.105	0.809	19	0.095	0.621	0.375	0.646
11	6.600	0.681	20	6.526	0.964	19	0.074	0.690	0.277	0.609
12	4.850	1.531	20	5.000	1.528	19	-0.150	2.339	-0.306	0.620
13	5.250	1.517	20	5.368	1.422	19	-0.118	2.167	-0.251	0.599
14	6.300	0.979	20	6.053	1.129	19	0.247	1.112	0.732	0.768
15	5.389	1.290	18	5.389	1.145	18	0.000	1.487	0.000	0.500
16	4.471	1.586	17	4.688	1.580	16	-0.217	2.506	-0.393	0.653
17	6.000	0.918	20	6.000	0.882	19	0.000	0.811	0.000	0.500
18	6.222	1.060	18	6.118	1.219	17	0.105	1.299	0.271	0.607
19	5.350	1.182	20	5.368	1.257	19	-0.018	1.486	-0.047	0.519
20	4.313	2.213	16	4.533	1.959	15	-0.221	4.385	-0.293	0.615
21	5.800	1.240	20	5.526	1.467	19	0.274	1.836	0.630	0.736
22	4.250	1.209	20	4.421	1.346	19	-0.171	1.632	-0.418	0.662
23	5.500	1.277	20	5.368	1.535	19	0.132	1.984	0.292	0.615
24	4.800	1.361	20	4.684	1.250	19	0.116	1.711	0.276	0.609
25	4.842	1.302	19	5.056	1.349	18	-0.213	1.756	-0.490	0.688
26	5.000	1.522	20	5.053	1.268	19	-0.053	1.972	-0.117	0.547
27	4.400	1.429	20	4.789	1.357	19	-0.389	1.945	-0.872	0.808
28	5.600	1.603	20	5.789	1.398	19	-0.189	2.269	-0.393	0.653
29	6.150	1.424	20	6.263	1.368	19	-0.113	1.952	-0.253	0.600
30	5.650	1.089	20	5.895	1.100	19	-0.245	1.198	-0.698	0.757
31	5.450	1.468	20	5.474	1.504	19	-0.024	2.208	-0.050	0.520
32	5.579	1.677	19	5.667	1.414	18	-0.088	2.418	-0.172	0.568
33	4.850	1.599	20	4.789	1.584	19	0.061	2.533	0.119	0.547
34	4.684	1.204	19	4.778	1.215	18	-0.094	1.463	-0.235	0.593
35	4.200	1.105	20	4.316	1.204	19	-0.116	1.333	-0.313	0.623
36	4.778	1.263	18	4.778	1.353	18	0.000	1.712	0.000	0.500
37	4.316	2.056	19	4.474	1.926	19	-0.158	3.968	-0.244	0.597
38	4.889	1.875	18	4.889	1.875	18	0.000	3.516	0.000	0.500
39	5.000	2.028	19	5.053	1.985	19	-0.053	4.026	-0.081	0.532
40	5.300	1.218	20	5.053	1.615	19	0.247	2.031	0.542	0.706
41	5.263	1.147	19	5.111	1.278	18	0.152	1.470	0.381	0.648
42	5.000	1.522	20	5.158	1.537	19	-0.158	2.339	-0.322	0.626
43	4.737	1.327	19	4.947	1.508	19	-0.211	2.018	-0.457	0.676
44	5.550	1.276	20	5.053	1.615	19	0.497	2.105	1.070	0.858

Criterion	Accept Mean	Accept SD	Accept N	Reject Mean	Reject SD	Reject N	Difference	Pooled SD	t	p-value
45	4.950	1.849	20	4.526	2.091	19	0.424	3.883	0.671	0.749
46	6.350	0.587	20	6.105	0.937	19	0.245	0.604	0.983	0.837
47	5.684	1.701	19	5.737	1.284	19	-0.053	2.272	-0.108	0.543
48	5.850	0.875	20	5.895	1.049	19	-0.045	0.928	-0.145	0.558
49	6.000	0.816	19	5.944	1.110	18	0.056	0.941	0.174	0.569
50	6.263	0.933	19	6.111	1.568	18	0.152	1.642	0.361	0.641
51	5.700	1.418	20	5.526	1.467	19	0.174	2.079	0.376	0.647
52	5.450	1.432	20	5.474	1.429	19	-0.024	2.046	-0.052	0.521
53	5.316	1.416	19	5.167	1.543	18	0.149	2.189	0.306	0.620
54	4.700	2.003	20	4.579	2.009	19	0.121	4.022	0.188	0.575
55	5.500	1.504	20	5.632	1.571	19	-0.132	2.363	-0.267	0.605
56	5.150	1.268	20	5.211	1.357	19	-0.061	1.722	-0.144	0.557
57	5.800	1.152	20	5.474	1.645	19	0.326	1.998	0.721	0.764
58	5.850	1.348	20	5.737	1.558	19	0.113	2.114	0.243	0.596
59	5.105	1.370	19	5.176	1.551	17	-0.071	2.125	-0.146	0.558
60	5.650	1.309	20	5.579	1.387	19	0.071	1.816	0.165	0.565
61	5.350	1.725	20	5.474	1.712	19	-0.124	2.954	-0.225	0.589
62	5.150	1.785	20	5.263	1.881	19	-0.113	3.358	-0.193	0.576
63	4.579	2.090	19	4.647	2.029	17	-0.068	4.250	-0.099	0.539
64	5.111	1.491	18	5.278	1.602	18	-0.167	2.394	-0.323	0.627
65	5.250	1.372	20	5.316	1.455	19	-0.066	1.996	-0.145	0.558
66	4.150	1.424	20	4.211	1.512	19	-0.061	2.154	-0.129	0.551
67	3.950	1.317	20	4.000	1.333	19	-0.050	1.755	-0.118	0.547
68	4.400	1.353	20	4.474	1.467	19	-0.074	1.987	-0.163	0.565
69	4.550	1.234	20	4.579	1.305	19	-0.029	1.610	-0.071	0.528
70	5.050	1.356	20	5.111	1.491	18	-0.061	2.020	-0.132	0.553
71	5.500	1.670	20	5.222	1.865	18	0.278	3.114	0.484	0.686
72	5.500	1.051	20	5.316	1.293	19	0.184	1.381	0.489	0.688
73	5.158	1.642	19	4.889	1.811	18	0.269	2.980	0.474	0.682
74	4.412	1.770	17	4.500	1.751	16	-0.088	3.101	-0.144	0.557
75	4.588	1.417	17	4.941	1.345	17	-0.353	1.908	-0.745	0.772
76	5.706	1.160	17	5.533	1.187	15	0.173	1.375	0.415	0.661
77	6.000	1.257	20	5.842	1.259	19	0.158	1.582	0.392	0.652
78	5.474	1.307	19	5.316	1.455	19	0.158	1.912	0.352	0.638
79	4.950	1.638	20	5.000	1.700	19	-0.050	2.782	-0.094	0.537
80	5.400	1.392	20	5.316	1.416	19	0.084	1.970	0.187	0.574
81	5.350	1.461	20	5.474	1.541	19	-0.124	2.251	-0.257	0.602
82	4.900	1.447	20	4.947	1.353	19	-0.047	1.966	-0.105	0.542
83	3.600	1.729	20	3.789	1.686	19	-0.189	2.918	-0.346	0.635
84	5.300	1.129	20	5.158	1.068	19	0.142	1.209	0.403	0.657
85	5.150	0.875	20	5.053	0.911	19	0.097	0.797	0.340	0.633
86	5.650	0.745	20	5.421	1.121	19	0.229	0.897	0.755	0.775
87	5.500	1.235	20	5.421	1.387	19	0.079	1.720	0.188	0.575
88	4.650	1.348	20	4.895	1.286	19	-0.245	1.739	-0.579	0.719
89	4.950	1.504	20	4.632	1.571	19	0.318	2.361	0.647	0.741
90	6.650	0.745	20	6.368	1.300	19	0.282	1.107	0.835	0.798
91	4.950	1.356	20	5.368	1.257	19	-0.418	1.713	-0.998	0.841
92	5.100	1.410	20	5.053	1.471	19	0.047	2.074	0.103	0.541
93	4.000	1.795	19	4.111	1.641	18	-0.111	2.965	-0.196	0.578

Criterion	Accept Mean	Accept SD	Accept N	Reject Mean	Reject SD	Reject N	Difference	Pooled SD	t	p-value
94	4.900	1.683	20	5.053	1.545	19	-0.153	2.615	-0.295	0.616
95	3.944	1.259	18	4.000	1.458	17	-0.056	1.847	-0.121	0.548

B.2 Private Venture Capitalist Criteria t-Tests

Criterion	Accept Mean	Accept SD	Accept N	Reject Mean	Reject SD	Reject N	Difference	Pooled SD	t	p-value
1	5.842	1.167	19	5.333	1.414	18	0.509	1.672	1.196	0.884
2	5.947	1.129	19	5.500	1.425	18	0.447	1.641	1.062	0.856
3	6.053	1.026	19	5.667	1.372	18	0.386	1.456	0.973	0.835
4	6.158	1.068	19	5.389	1.650	18	0.769	1.909	1.692	0.955
5	5.474	1.073	19	5.222	1.263	18	0.251	1.367	0.654	0.743
6	5.263	1.447	19	4.944	1.589	18	0.319	2.304	0.638	0.738
7	5.895	1.100	19	5.333	1.715	18	0.561	2.051	1.192	0.883
8	6.105	1.150	19	6	1.138	18	0.105	1.308	0.280	0.610
9	5.263	1.558	19	5.111	1.530	18	0.152	2.385	0.299	0.618
10	6	1.202	19	5.611	1.290	18	0.389	1.551	0.949	0.829
11	6.053	1.311	19	6	1.328	18	0.053	1.741	0.121	0.548
12	5.842	1.068	19	5.167	1.249	18	0.675	1.344	1.772	0.962
13	5.579	1.170	19	5.389	1.378	18	0.190	1.626	0.453	0.675
14	6.211	1.273	19	5.667	1.782	18	0.544	2.376	1.073	0.858
15	5.421	1.305	19	5.667	1.237	18	-0.246	1.618	-0.587	0.279
16	4.824	1.131	17	4.824	1.074	17	0	1.217	0	0.500
17	6.158	1.214	19	5.667	1.782	18	0.491	2.301	0.985	0.838
18	4.941	1.819	17	4.412	1.734	17	0.529	3.158	0.869	0.807
19	5.444	1.381	18	5.222	1.629	18	0.222	2.281	0.441	0.671
20	4.063	1.652	16	4.059	1.519	17	0.004	2.512	0.007	0.503
21	5.368	1.640	19	5.278	1.526	18	0.091	2.515	0.174	0.569
22	4.316	1.250	19	4.167	1.295	18	0.149	1.617	0.357	0.639
23	5.316	1.455	19	5	1.541	17	0.316	2.238	0.632	0.736
24	4.526	1.429	19	4.500	1.724	18	0.026	2.492	0.051	0.520
25	4.947	0.970	19	4.588	0.939	17	0.359	0.914	1.125	0.870
26	4.526	1.577	19	4.294	1.896	17	0.232	3.008	0.401	0.656
27	3.842	1.463	19	3.824	1.551	17	0.019	2.265	0.037	0.515
28	6.111	0.900	18	5.944	1.305	18	0.167	1.257	0.446	0.672
29	6.421	0.692	19	6.222	1.263	18	0.199	1.021	0.598	0.725
30	5.778	1.353	18	5.278	1.320	18	0.500	1.786	1.122	0.869
31	5.389	1.650	18	5.167	1.425	18	0.222	2.376	0.433	0.667
32	5.526	1.307	19	4.833	1.618	18	0.693	2.150	1.437	0.925
33	5.389	1.290	18	5.667	1.138	18	-0.278	1.479	-0.685	0.247
34	4.889	1.079	18	4.938	1.436	16	-0.049	1.585	-0.112	0.455
35	4.765	1.147	17	5	1.155	16	-0.235	1.324	-0.587	0.279
36	4.842	1.259	19	4.688	1.401	16	0.155	1.756	0.344	0.635
37	5.063	1.526	16	5.563	1.153	16	-0.500	1.829	-1.046	0.148
38	5.375	1.310	16	5.438	1.263	16	-0.063	1.656	-0.137	0.445
39	5.588	1.176	17	5.412	1.064	17	0.176	1.257	0.459	0.677
40	5.842	0.958	19	5.444	1.097	18	0.398	1.056	1.176	0.880

Criterion	Accept Mean	Accept SD	Accept N	Reject Mean	Reject SD	Reject N	Difference	Pooled SD	t	p-value
41	5.895	0.994	19	5.500	1.150	18	0.395	1.151	1.119	0.868
42	6.105	1.150	19	5.444	1.247	18	0.661	1.435	1.677	0.953
43	5.176	1.425	17	4.889	1.451	18	0.288	2.068	0.591	0.723
44	5.706	1.263	17	5.444	1.294	18	0.261	1.636	0.604	0.727
45	5.353	1.656	17	4.833	1.790	18	0.520	2.981	0.890	0.813
46	5.842	1.214	19	5.333	1.455	18	0.509	1.786	1.157	0.876
47	4.882	1.654	17	4.765	1.522	17	0.118	2.526	0.216	0.585
48	5.842	1.068	19	5.333	1.085	18	0.509	1.158	1.437	0.925
49	6.211	1.032	19	5.833	1.505	18	0.377	1.647	0.893	0.814
50	5.235	1.640	17	5.111	1.605	18	0.124	2.631	0.226	0.590
51	5.526	1.307	19	5.278	1.406	18	0.249	1.839	0.557	0.711
52	5.368	1.257	19	5	1.138	18	0.368	1.441	0.933	0.825
53	5.722	0.958	18	5.176	1.185	17	0.546	1.154	1.502	0.933
54	5.167	1.200	18	4.313	1.302	16	0.854	1.561	1.990	0.977
55	6.053	0.780	19	6	1.085	18	0.053	0.884	0.170	0.568
56	5.842	0.958	19	5.500	1.098	18	0.342	1.058	1.011	0.844
57	6.263	0.872	19	6.444	0.856	18	-0.181	0.747	-0.638	0.262
58	5.053	1.224	19	4.889	1.641	18	0.164	2.078	0.345	0.635
59	3.316	1.157	19	3.444	1.247	18	-0.129	1.444	-0.325	0.372
60	5.947	0.911	19	5.588	1.176	17	0.359	1.090	1.030	0.849
61	5.579	1.017	19	5.333	1.283	18	0.246	1.332	0.647	0.741
62	5.789	0.918	19	5.500	1.249	18	0.289	1.190	0.807	0.790
63	3.765	1.348	17	3.400	0.986	15	0.365	1.422	0.863	0.806
64	4.111	1.367	18	4.188	1.276	16	-0.076	1.757	-0.168	0.433
65	4.632	1.606	19	4.889	1.568	18	-0.257	2.520	-0.493	0.311
66	5	0.943	19	4.833	1.295	18	0.167	1.271	0.449	0.673
67	4.737	1.046	19	4.444	1.199	18	0.292	1.261	0.792	0.786
68	4.842	1.167	19	4.500	1.249	18	0.342	1.458	0.861	0.805
69	5.158	1.068	19	4.944	1.349	18	0.213	1.471	0.535	0.704
70	4.684	1.416	19	4.278	1.406	18	0.406	1.992	0.876	0.809
71	3.750	1.807	16	2.941	1.519	17	0.809	2.772	1.395	0.918
72	5.118	1.764	17	4.938	1.569	16	0.180	2.797	0.309	0.621
73	4.438	2.065	16	4.188	1.940	16	0.250	4.013	0.353	0.638
74	5	1.922	14	4.462	1.854	13	0.538	3.569	0.740	0.770
75	3.647	1.693	17	3.778	1.665	18	-0.131	2.818	-0.230	0.409
76	5.176	1.131	17	5.333	1.231	12	-0.157	1.375	-0.355	0.361
77	6.158	1.167	19	6.111	1.132	18	0.047	1.323	0.124	0.549
78	5.556	1.504	18	5.353	1.766	17	0.203	2.677	0.366	0.643
79	4.632	1.640	19	4.722	1.320	18	-0.091	2.229	-0.185	0.427
80	5.053	1.508	19	4.944	1.259	18	0.108	1.940	0.236	0.593
81	5.526	1.389	19	5.056	1.349	18	0.471	1.877	1.045	0.852
82	4.895	1.696	19	4.778	1.517	18	0.117	2.597	0.221	0.587
83	3.211	1.584	19	3.412	1.543	17	-0.201	2.449	-0.385	0.350
84	5.632	0.955	19	5.111	1.605	18	0.520	1.720	1.207	0.886
85	5.737	0.733	19	5.222	1.437	18	0.515	1.280	1.383	0.917
86	5.526	1.349	19	4.833	1.383	18	0.693	1.864	1.543	0.939
87	5.632	1.342	19	4.889	1.779	18	0.743	2.463	1.439	0.925
88	4.158	1.608	19	4	1.572	18	0.158	2.529	0.302	0.619
89	4.526	1.867	19	4.222	1.865	18	0.304	3.481	0.496	0.690

Criterion	Accept Mean	Accept SD	Accept N	Reject Mean	Reject SD	Reject N	Difference	Pooled SD	t	p-value
90	6	1.764	19	5.333	1.970	18	0.667	3.486	1.086	0.861
91	5.053	1.177	19	4.778	1.166	18	0.275	1.373	0.713	0.762
92	4.895	1.629	19	4.833	1.618	18	0.061	2.637	0.115	0.546
93	4.316	1.529	19	4.444	1.247	18	-0.129	1.959	-0.279	0.390
94	4.579	1.677	19	4.588	1.543	17	-0.009	2.610	-0.017	0.493
95	3.706	1.359	17	3.938	1.063	16	-0.232	1.499	-0.543	0.294

B.3 Public Venture Capital Fund Criteria t-Tests

Criterion	Accept Mean	Accept SD	Accept N	Reject Mean	Reject SD	Reject N	Difference	Pooled SD	t	p-value
1	5.800	1.196	20	5.700	1.218	20	0.100	1.458	0.262	0.603
2	6.050	1.191	20	5.800	1.152	20	0.250	1.372	0.675	0.750
3	6.150	0.933	20	5.850	1.137	20	0.300	1.082	0.912	0.819
4	6.150	0.813	20	6	0.795	20	0.150	0.646	0.590	0.722
5	5.250	1.020	20	5.250	0.967	20	0	0.987	0	0.500
6	5.550	0.999	20	5.550	0.887	20	0	0.892	0	0.500
7	5.800	0.834	20	5.700	0.865	20	0.100	0.721	0.372	0.645
8	6.200	0.834	20	6.250	0.851	20	-0.050	0.709	-0.188	0.426
9	5.950	0.945	20	5.950	0.826	20	0	0.787	0	0.500
10	5.900	1.119	20	6	0.918	20	-0.100	1.047	-0.309	0.379
11	6.500	0.688	20	6.450	0.686	20	0.050	0.472	0.230	0.591
12	5.789	0.918	19	5.684	0.885	19	0.105	0.813	0.360	0.641
13	6.100	0.641	20	5.950	0.605	20	0.150	0.388	0.761	0.777
14	6.500	0.688	20	6.200	1.005	20	0.300	0.742	1.101	0.865
15	5.550	1.191	20	5.250	1.020	20	0.300	1.229	0.856	0.804
16	4.947	1.079	19	4.789	1.084	19	0.158	1.170	0.450	0.674
17	6.050	0.945	20	5.900	1.021	20	0.150	0.967	0.482	0.685
18	5	1.026	20	4.500	1.395	20	0.500	1.500	1.291	0.902
19	5.750	1.372	20	5.850	1.387	20	-0.100	1.903	-0.229	0.409
20	4.474	1.429	19	4.316	1.003	19	0.158	1.523	0.394	0.653
21	5.450	0.887	20	5.450	0.826	20	0	0.734	0	0.500
22	5.100	1.071	20	5.350	0.875	20	-0.250	0.957	-0.808	0.209
23	5.400	1.046	20	5.600	0.883	20	-0.200	0.937	-0.653	0.257
24	5.500	1	20	5.650	0.933	20	-0.150	0.936	-0.490	0.312
25	5.150	1.089	20	5.300	0.923	20	-0.150	1.020	-0.470	0.319
26	5.750	0.910	20	5.600	0.995	20	0.150	0.909	0.497	0.691
27	5.050	1.191	20	4.900	1.210	20	0.150	1.441	0.395	0.654
28	5.900	0.852	20	6	0.795	20	-0.100	0.679	-0.384	0.351
29	6.450	0.605	20	6.200	0.616	20	0.250	0.372	1.296	0.902
30	5.250	1.682	20	5.450	1.050	20	-0.200	1.966	-0.451	0.326
31	5.250	1.209	20	5.750	0.851	20	-0.500	1.092	-1.513	0.065
32	6	0.858	20	5.950	0.759	20	0.050	0.657	0.195	0.577
33	5.750	0.910	20	5.700	0.979	20	0.050	0.893	0.167	0.566
34	5.400	1.231	20	5.100	1.210	20	0.300	1.489	0.777	0.782
35	4.850	1.348	20	4.750	1.070	20	0.100	1.482	0.260	0.602

Criterion	Accept Mean	Accept SD	Accept N	Reject Mean	Reject SD	Reject N	Difference	Pooled SD	t	p-value
36	5.150	1.182	20	4.950	1.234	20	0.200	1.461	0.523	0.700
37	5	1.451	20	5.400	1.353	20	-0.400	1.968	-0.902	0.184
38	5.350	1.387	20	5.200	1.399	20	0.150	1.941	0.340	0.633
39	5.500	1.504	20	5.650	1.309	20	-0.150	1.988	-0.336	0.368
40	5.650	1.040	20	5.450	1.504	20	0.200	1.671	0.489	0.688
41	5.750	0.851	20	5.550	1.191	20	0.200	1.071	0.611	0.729
42	5.750	0.786	20	5.600	0.940	20	0.150	0.751	0.547	0.708
43	5.050	1.050	20	5	1.026	20	0.050	1.078	0.152	0.561
44	6.263	0.991	19	6.22	0.730	18	0.043	0.764	0.303	0.619
45	5.526	1.073	19	5.421	1.071	19	0.105	1.149	0.303	0.619
46	6.450	0.510	20	6.400	0.503	20	0.050	0.257	0.312	0.623
47	4.684	2.056	19	5.353	1.656	17	-0.669	3.529	-1.079	0.140
48	5.900	0.788	20	6	0.858	20	-0.100	0.679	-0.384	0.351
49	5.950	1.191	20	5.900	1.210	20	0.050	1.441	0.132	0.552
50	6.150	1.268	20	6.200	1.508	20	-0.050	1.941	-0.113	0.455
51	6	0.918	20	6.050	0.887	20	-0.050	0.814	-0.175	0.430
52	5.600	1.046	20	5.750	1.020	20	-0.150	1.067	-0.459	0.323
53	5.500	1.051	20	5.600	1.046	20	-0.100	1.100	-0.302	0.382
54	4.750	1.070	20	4.800	1.152	20	-0.050	1.236	-0.142	0.443
55	5.550	1.276	20	5.650	1.348	20	-0.100	1.724	-0.241	0.405
56	5.950	0.945	20	5.850	1.268	20	0.100	1.250	0.283	0.611
57	5.800	0.834	20	5.850	0.813	20	-0.050	0.678	-0.192	0.424
58	5.158	0.898	19	4.950	1.276	20	0.208	1.229	0.591	0.723
59	3.700	1.720	20	4.211	1.653	19	-0.511	2.848	-0.945	0.172
60	5.450	1.050	20	5.400	1.142	20	0.050	1.204	0.144	0.557
61	5.200	1.105	20	4.800	1.281	20	0.400	1.432	1.057	0.855
62	5.421	0.838	19	5.350	0.875	20	0.071	0.735	0.259	0.602
63	2.750	1.293	20	2.850	1.268	20	-0.100	1.639	-0.247	0.402
64	4.850	1.755	20	4.500	1.792	20	0.350	3.146	0.624	0.734
65	5.350	1.387	20	5.316	1.376	19	0.034	1.910	0.077	0.531
66	4.750	1.118	20	4.700	1.081	20	0.050	1.209	0.144	0.557
67	4.650	1.182	20	4.500	1.235	20	0.150	1.462	0.392	0.653
68	4.700	1.081	20	4.700	1.129	20	0	1.221	0	0.500
69	4.900	1.165	20	5.150	1.089	20	-0.250	1.272	-0.701	0.242
70	4.350	1.785	20	4.200	1.673	20	0.150	2.993	0.274	0.608
71	4.250	1.118	20	4.150	1.226	20	0.100	1.376	0.270	0.606
72	5.350	1.182	20	5.450	1.146	20	-0.100	1.355	-0.272	0.393
73	5.200	1.240	20	5.556	0.984	18	-0.356	1.268	-0.984	0.163
74	5.211	0.918	19	5.333	1.029	18	-0.123	0.947	-0.382	0.351
75	3.850	1.461	20	3.895	1.696	19	-0.045	2.496	-0.088	0.465
76	5.158	1.675	19	5.167	1.383	18	-0.009	2.372	-0.017	0.493
77	6.050	0.759	20	6.100	0.718	20	-0.050	0.546	-0.214	0.415
78	5.650	1.040	20	5.700	1.081	20	-0.050	1.125	-0.149	0.441
79	5.150	0.988	20	5.500	0.827	20	-0.350	0.830	-1.215	0.112
80	5.700	0.657	20	5.650	0.813	20	0.050	0.546	0.214	0.585
81	5.800	0.768	20	5.750	0.716	20	0.050	0.551	0.213	0.584
82	5.700	0.801	20	5.650	0.745	20	0.050	0.599	0.204	0.581
83	3.900	1.373	20	3.947	1.471	19	-0.047	2.020	-0.104	0.459
84	6.050	0.826	20	6.100	0.912	20	-0.050	0.757	-0.182	0.428

Criterion	Accept Mean	Accept SD	Accept N	Reject Mean	Reject SD	Reject N	Difference	Pooled SD	t	p-value
85	5.800	0.894	20	5.900	1.021	20	-0.100	0.921	-0.330	0.371
86	6.100	0.718	20	6	0.858	20	0.100	0.626	0.400	0.655
87	6.200	0.768	20	5.950	1.050	20	0.250	0.846	0.859	0.805
88	5.300	1.081	20	5.500	1.100	20	-0.200	1.189	-0.580	0.281
89	5	1.124	20	4.850	1.040	20	0.150	1.172	0.438	0.669
90	6.650	0.587	20	6.350	0.875	20	0.300	0.555	1.273	0.899
91	5.750	0.716	20	5.750	0.786	20	0	0.566	0	0.500
92	5.400	1.046	20	5.500	0.946	20	-0.100	0.995	-0.317	0.376
93	5.050	1.099	20	4.950	1.146	20	0.100	1.261	0.282	0.611
94	5.150	1.309	20	5.250	1.020	20	-0.100	1.376	-0.270	0.394
95	4.450	1.234	20	4.450	1.191	20	0	1.471	0	0.500

B.4 Criteria Importance Principal Components Analysis

Table B.1a
Factor Analysis of Criteria Importance, All Investor Groups
($L_i \geq 0.50$)

Factor	Post Rotation Variance	Criteria Number	Criteria	Factor Load
1	8.3	11	The entrepreneurs' familiarity with customer requirements	0.870
		87	Quality of competitor analysis	0.761
		9	The entrepreneurs' familiarity with business drivers	0.741
		74	Track record of co-investors in the deal	0.715
		32	Proposed venture will create a new market or niche	0.707
		86	Quality of product analysis	0.690
		73	There are other co-investors present in the investment	0.642
		50	A functioning prototype has already been developed	0.589
		8	The entrepreneurs' familiarity with product and market	0.572
		92	Ease to evaluate proposal by investor(s)	0.505

Table B.1b
Factor Analysis of Criteria Importance, All Investor Groups
($L_i \geq 0.50$)

Factor	Post Rotation Variance	Criteria Number	Criteria	Factor Load
3	9.4	80	Clarity of communication in proposal	0.803
		82	Overall quality of proposal	0.789
		79	Completeness of venture proposal	0.784
		95	Effectiveness of graphics, tables and figures in the proposal	0.744
		22	Financial skills of the entrepreneur(s)	0.737
		24	Marketing research skills of the entrepreneur(s)	0.690
		81	Clear emphasis on key points	0.684
		25	Production skills of the entrepreneur(s)	0.632
		88	Quality of financial analysis	0.614
		84	Quality of market analysis	0.599
		26	Sales force and/or distribution skills of the entrepreneur(s)	0.592
		27	Advertising and promotion skills of the entrepreneur(s)	0.538
		12	The entrepreneurs' demonstrated leadership ability in the past	0.532
4	5.5	67	Investor's familiarity with the technology of the venture	0.914
		66	Investor's familiarity with the industry of the venture	0.913
		69	Investor's familiarity with the market targeted by the venture	0.903
		68	Investor's familiarity with the offering (product or service) of the venture	0.806
		72	Ability to attract a viable investor group	0.572
		65	The venture's stage of development (e.g. seed, start-up, first-stage, second stage	0.527

Table B.1c
Factor Analysis of Criteria Importance, All Investor Groups
($L_i \geq 0.50$)

Factor	Post Rotation Variance	Criteria Number	Criteria	Factor Load
5	6.6	10	The entrepreneurs' familiarity with technology enablers	0.855
		1	The entrepreneurs' ability to react to changing risk	0.803
		30	Proposed venture is satisfying an existing market need	0.700
		2	The entrepreneurs' ability to anticipate need for change	0.698
		49	Venture can demonstrate a defendable competitive position	0.657
		14	The entrepreneurs' management commitment to success	0.633
		55	Expected market risk to the investor(s)	0.577

B.5 Lender Concept to Attribution Model Coding

Table B.2
Assessment Concept to Attribution Classification Mapping

Attribution Model Classification	Lender Assessment Concept
Environmental Influence / Control	Venture Market Understanding Required Capitalization Proprietary Technology Product Potential Market Leadership Potential Market Focus Market Access Market Growth Potential Investment Cycle Industry Growth Potential

Table B.2
Assessment Concept to Attribution Classification Mapping

Attribution Model Classification	Lender Assessment Concept
Venture Internal Control	Venture Protection Technology Control Management Quality Management Experience Management Completeness Management Credibility Development Team Vulnerability Development Team Quality Development Team Capabilities Development Team Management Development Team Experience
Investor Control / Influence	Management Cooperation Management Expectations BOD Quality BOD Existence
Stability	Venture Maturity Venture Credibility Venture Vulnerability Technology Credibility Revenue Potential Product Maturity Market Velocity Market Maturity Market Forecast Credibility Product Existence Management Commitment Management Cohesiveness Financing Availability Development Team Credibility Development Requirements Development Focus Development Financing Cash-flow Potential Credibility Cash-flow Potential Business Plan Credibility BOD Requirement BOD Completeness

Table B.2
Assessment Concept to Attribution Classification Mapping

Investor Familiarity	Market Familiarity
Situational Specificity	Venture Type Venture Financability Venture Attractiveness Venture Growth Potential Technology Potential Required Financing Required Cash-flow Product Life-cycle Market Existence Management Communications Financing Type Financial Resources Financing Risk Development Risk Business Plan Existence Business Plan Completeness Business Plan Quality

Appendix C -- Interview Documents

The University of Waterloo

Faculty of Engineering
Department of Management Science
Waterloo, Ontario, Canada
N2L 3G1
Tel. and Fax: (519) 888-4802

Date

Dear Sir/Madam;

The University of Waterloo's Institute for Innovation Research is currently undertaking research into the assessment of new, knowledge-intensive, technology-based enterprises. These ventures present unique assessment difficulties and the institute's objective is to provide techniques and tools to aid in this endeavor.

As part of this research program, we are undertaking to model the decision process of "assessment practitioners" when evaluating this class of ventures at the early stages of their development. The objective is two fold, enhanced understanding of this process and to set the stage for the development of an intelligent decision support system.

To further this research, we are requesting your participation through access to those in your organization who are actively involved in the assessment of new knowledge-based ventures, either for the granting of loans or taking of equity positions. Involvement will involve the completion of an initial questionnaire, a set of not more than four recorded interviews of approximately 1 hour and follow-up questionnaires, spaced over several months. In all cases, the identity of participants will be treated as confidential.

Upon completion of this study, the results will be made available to you and the participants. While this stage of the research focuses on modeling of the decisions, it is our intention to develop this model into an intelligent decision aid. If you are interested in participation in the verification and validation of this tool, it will be made available to your organization.

Sincerely,

Douglas Sparkes   Dr .Paul Guild

Thank you for participating in this phase of our small business investment decision making study. Your responses will remain confidential and any reported results will contain aggregated results only. Before beginning, please tell us a little about yourself.

1.0 How long have you been associated with this organization?

- ☐ Less than 1 Year
- ☐ 6 to 10 Years
- ☐ 16 to 20 Years
- ☐ 1 to 5 Years
- ☐ 11 to 15 Years
- ☐ More than 20 Years

2.0 What is your highest level of education?

- ☐ College Diploma
- ☐ Masters
- ☐ Ph.D.
- ☐ Honours Degree
- ☐ MBA

2.1 How long has it been since you finished formal education?

- ☐ Less than 1 Year
- ☐ 3 to 5 Years
- ☐ 10 to 15 Years
- ☐ 1 to 3 Years
- ☐ 5 to 10 Years
- ☐ more than 15 Years

2.2 Which group best describes your educational background?

- ☐ Arts
- ☐ Business
- ☐ Mathematics
- ☐ Science
- ☐ Engineering
- ☐ Other ___________

3.0 In terms of employees, what is the typical size of a small company you deal with?

- ☐ 1-5 people
- ☐ 11 - 20 people
- ☐ 51 - 75 people
- ☐ 6-10 people
- ☐ 21 - 50 people
- ☐ more than 75 people

3.1 In terms of annual sales, what is the typical size of a small company you deal with?

- ☐ Less than $50k
- ☐ $101k - $250k
- ☐ $501k - $1,000k
- ☐ $51k - $100k
- ☐ $251k - $500k
- ☐ more than $1,000k

3.2 How long have you been involved in the evaluation of small ventures?

- ☐ Less than 1 Year
- ☐ 3 to 5 Years
- ☐ 10 to 15 Years
- ☐ 1 to 3 Years
- ☐ 5 to 10 Years
- ☐ more than 15 Years

3.3 How many small ventures do you assess in a year?

- ☐ 1 - 10
- ☐ 26 - 50
- ☐ 76 - 100
- ☐ 11 - 25
- ☐ 51 - 75
- ☐ more than 100

3.4 How large is the typical 'investment' in one of these ventures?

- ☐ Less than $100,000
- ☐ $250,000 to $500,000
- ☐ $750,000 to $1,000,000
- ☐ $100,000 to $250,000
- ■ $500,000 to $750,000
- ☐ more than $1,000,000

The University of Waterloo

Faculty of Engineering
Department of Management Science
Waterloo, Ontario, Canada
N2L 3G1
Tel. and Fax: (519) 888-4567

Research Consent

I agree to participate in the research being undertaken by Douglas Sparkes of the Department of Management Sciences under the supervision of Dr. Paul Guild. I have made this decision based on the information provided in the information letter provided to me, and have had the opportunity to receive any additional details I wanted regarding this research. As a participant in this study I realize that I am being asked to complete an initial questionnaire which will take 5 to 10 minutes, a set of not more than 4 interviews of approximately 1 hour duration, and a set of not more than 3 follow-up questionnaires of approximately 15 minutes duration. I understand that I may decline to answer any of the questions, if I so choose. I also understand that I may withdrawal this consent at any time. All information I provide will be held in confidence, and I will not be identified in the thesis or other related research publications. I also understand that this project has been reviewed and received ethics clearance through the Office of Research Ethics at the University of Waterloo. Any questions or concerns about the study or your participation can be directed to that office at 519-888-4567, Ext. 6005.

Participant's Name:

Participant's Signature:

Date:

Initial Interview Discussion Questions

1. How would you define a technology-based venture?

2. Do you believe that these ventures have special decision attributes?

3. What characteristics do you believe differentiate a knowledge-intensive venture from technology-based venture?

4. Do you believe that knowledge-intensive ventures have special decision attributes?

5. When assessing a early stage knowledge-intensive venture are you considering this as an 'investment' decision or as a 'lending' decision.

6. What characteristics do you believe differentiate these two types of decisions?

7. When assessing a knowledge-intensive venture, what are your specific objectives?

8. What issues do you consider to be most relevant?

9. Are there any specific sources of information that you tend to use during the assessment process?

10. Describe for me a recent example of a very early stage knowledge-intensive venture that you have assessed and decided to make an investment in?

11. Were there any characteristics of this venture that made it unique?

12. What features lead to the decision to invest?

13. Are there any aspects of this venture that you considered to be marginal and could have easily changed your mind on investing?

14. Describe for me a recent example of an early stage knowledge-intensive venture that you have assessed and decided <u>not</u> to make an investment in?

    14.1. What stage was the venture at?

15. Are there any characteristics of this venture that made it unique?

16. What features lead to the decision <u>NOT</u> to invest?

17. Are there any aspects of this venture that you considered marginal and could have easily changed your mind?

Appendix D: Interview Transcripts and Notes

D.1 Interview Discussion Notes -- Expert S1

- Subject does not deal with equity investing, only with debt lending. As a result the subject feel that he looks at ventures differently than would be the case for someone who is going to make equity investing.
- The dominant difference is that as a debt lender the level of risk that he is willing to take is much lower than that for a equity investor.
- Does occasionally team up with the equity lending parts of the bank when examining a small venture
- Since doing more conventional lending tends to see ventures that are more mature than pre-market introduction ventures, but does occasionally deal with them.
- Unlike lending for personal loans, credit scoring does not play a significant role in the decision process. Each case is considered on its own merits and the variables are too wide ranging to be adequately handles by a simple credit scoring model.

1. How would you define a technology-based venture?
2. Do you believe that these ventures have special decision attributes?

- Considers that there is no major difference between knowledge-based ventures and technology based ventures in terms of the lending decisions.
- Typically when asked to give an example of knowledge based venture software or the entertainment industry come to mind.

3. What characteristics do you believe differentiate a knowledge-intensive venture from technology-based venture?
4. Do you believe that knowledge-intensive ventures have special decision attributes?
5. When assessing a early stage knowledge-intensive venture are you considering this as an 'investment' decision or as a 'lending' decision.

- Looking at the venture from a lending perspective.

6. What characteristics do you believe differentiate these two types of decisions?
7. When assessing a knowledge-intensive venture, what are your specific objectives?

- There are four major areas that are considered: product, market, financing and the management team

- Of these the projected cash-flow requirements of the venture are the main concern.

- Typically providing operating funds that are related to the expected accounts receivable. Use various standard financial ratios to monitor the venture.

- Does not see the life-cycle of the venture products as a major concern other than how it will impact the cash-flow of the venture. The link is through the required R&D spending rate of the venture.

- Realistic market projects are important since that has a major impact on the cash-flow projections of the venture.

- Don't like to lend to a venture that only has a single product. Need to see that the venture has a plan to develop spin off products or future generations of products so that the venture cash-flow has long term potential.

- Does not think that R&D should be funded through bank loans, rather this funding should be through internally generated funds that have been generated through product sales.

- Market projections beyond a year or two are considered to be unreliable.

- Since looking for cash-flow potential of the venture it is important that there be at least one customer for the product. If not the product should be in beta testing with expressions of interest from a credible customer.

- Often dealing with small ventures supplying larger companies.

- The management team must cover the major functional areas of the venture. If they do not then want to see some indication that these people will be acquired in the near future. Also find that having a technology person in charge is not always the best situation.

- The technical people in the venture are not a major consideration. Want to have some indication that these people are in place, but no other significant consideration is made.

- Securing of the loan is based on the projected stability of the venture cash-flow.

- Not trying to identify and secure specific assets. Knowledge assets are not specifically examined

8. What issues do you consider to be most relevant?

9. Are there any specific sources of information that you tend to use during the assessment process?

- Primarily look at the business plan.
- No business plan and the venture will not even be considered.
- Look for a realistic business plan that has a realistic assessment of the potential size of the markets the venture will be going into. Want to see who are the customers, who is the competition and how these customers will be reached. All these issues will have an impact on the venture's cash-flow potential.
- Look at the CVs of the management team. Less interested in the CVs of the technical staff. Looking to see is the management team has the ability to manage the venture from a financial and growth point of view.
- Do not spend much time regarding the management team dynamics.
- Look to see if there is a strong board of directors for the venture. A strong board provides advice and mentoring to the venture especially in the early years.
- Look to see if the market and cash-flow projections can be substantiated. Sometimes this will involve interviews with major customers or other independent sources.
- Like to see third party verification of projections. Often market and sales projections are over-optimistic.
- Look for a good clear executive summary that gives a clear picture of what the venture is and what it is trying to do.

10. Describe for me a recent example of a very early stage knowledge-intensive venture that you have assessed and decided to make an investment in?

- Lately has been dealing with turnaround situations where the original management team has made some mistakes that have lead the company into trouble and a new management team is trying to turn the company around.
- Common management mistakes:
    - No second or follow-on products.
    - Try to grow through acquisitions and end up in financial trouble. This often results in the venture moving away from its core business.
    - Grow too fast and outgrow the management team's ability to control the venture.

    - Often if the founder is a technical person the venture becomes a R&D shop with the focus being on developing technology and not on selling products to get cash flowing in the venture.

- Use financial ratios to track the venture progress.

- If the venture is too early stage then there is no revenue stream to support debt financing.

- Main risk areas

    - Balance strength risk - what is the risk that the venture will not be able to maintain a viable cash-flow

    - R&D risk. This is not only the technological risks that the venture might face when trying to develop its products, but also the financial risk that it will not have the cash-flow required to sustain its research and development.

    - Revenue stream risk. This is related to the sales

    - Cost risks. Can the venture keep its costs under control

    - Infrastructure risk - this is related to cost risk in that the company may try to grow too fast to accommodate sales projections which are not realistic.

11. Were there any characteristics of this venture that made it unique?

12. What features lead to the decision to invest?

13. Are there any aspects of this venture that you considered to be marginal and could have easily changed your mind on investing?

- Inadequate revenue stream

14. Describe for me a recent example of an early stage knowledge-intensive venture that you have assessed and decided <u>not</u> to make an investment in?

    14.1. What stage was the venture at?

15. Are there any characteristics of this venture that made it unique?

16. What features lead to the decision <u>NOT</u> to invest?

17. Are there any aspects of this venture that you considered marginal and could have easily changed your mind?

D.2 Interview Transcript -- Expert S1

	Question		Response
1.0	So to start off with, in terms of dealing with knowledge-based companies versus technology-based companies, do you see any real distinction between those two?	1.1	No, no.
		1.2	Other than I think knowledge based company is probably a wider definition.
		1.3	It includes technology
2.0	Okay, so for the companies that uh...I guess what would be your typical example of a knowledge based company then?	2.1	Uh, well the majority of the ones we would see would be in computer software.
3.0	And in terms of examining companies that are very sort of knowledge intensive versus your standard technology company, is there any specific characteristic that you see in those companies that really separate them apart?	3.1	A. Well, my definition of knowledge-based also includes um companies that are in areas such as entertainment,
		3.1.1	so um the film industry and so on.
		3.2	So the technology side of it isn't a big issue there
		3.2.1	uh but the majority I'd say its the technology because really you're talking about a specific product and its applications.
		3.3	So, uh the emphasis would be on technology.
4.0	Okay. Um, so then in terms of your decisions whether to invest or... I guess what I'm specifically interested in is investment issues versus debt financing . When you're looking at a company for the first time, what kind of attributes are you looking	4.1	I guess to be clear, um, I'm solely concentrating on debt financing.

	for in that company?		
		4.2	We do have another arm of the Bank of Montreal that looks at equity or sub debt type financing.
		4.3	I think there are different criteria in the sense of risk tolerance and return.
5.0	Okay.	5.1	Uh, I think the fundamentals are the same
		5.1.1	but the amount of risk that I'm willing to take as a provider of debt is going to be lower than someone who's making an equity play.
6.0	Okay, then would you say that in your decision making process, do you use a lot of credit scoring models and that type of thing?	6.1	Uh no.
		6.2	There wouldn't be any formalized, tick the box to get the right answer.
		6.3	No its not that uh formalized whereas I think that's pretty common in something like personal debt financing.
		6.4	I think in the area of commercial, in general commercial financing, you don't really have that.
		6.5	I mean in each of these companies there's so many variables
		6.5.1	and issues that you couldn't easily compartmentalize it to come up with some decision.
7.0	Okay, when you're looking at...if I came in right now with a business plan, what kind of things would be your first quick scan, what would you be looking for?	7.1	Well, there's really um four areas that we would have to review.
		7.2	Um your going to be looking at the product itself,
		7.2.1	uh the market,
		7.2.2	the financing required,
		7.2.3	and perhaps most importantly, the management.
8.0	All right, so in terms of the product, again looking at knowledge intensive companies where the product might not be all that tangible, what kind of issues are you looking for there?	8.1	Um, that relates from a debt financing perspective to the stage in the company's life cycle.

		8.2	When you're talking about a very early stage that either doesn't even have a completed product
		8.2.1	or um may have one in the beta testing stage.
		8.3	Um it is very difficult for us to get a comfort level that that product will actually generate revenue.
9.0	Right.	9.1	Our real goal is to uh be able to assess and rely on _(future?)_ cash flows.
		9.2	Without that verification which really comes from third parties,
		9.2.1	from the users of the product,
		9.2.2	uh its very difficult for anyone to make a pitch to us that their product is going to make them money.
		9.3	There's just no way that the return I'm basing my loans at, that I could take that sort of risk.
10.0	So then, basically you're looking to see, does this product have customers already?	10.1	That's right.
11.0	Okay, or potential customers. What I'm thinking of more now is that company that has their prototype where it's in beta and uh they might not officially have a customer yet but they're working more for people that are signed on to...	11.1	Well no not necessarily um but there may be a deal that can be structured.
		11.2	But what I want to be comfortable with is let's say they have a product that's uh in beta or um partially completed,
		11.2.1	or 100% complete,
		11.2.2	I want to be able to get uh, a comfort level that the company has the financial resources to get it to the stage where it's going to be commercialized.
		11.3	Because I'm not going to come into the picture with loan advances until they are at that stage because what I'll be financing is uh cash flow that they're going to be generating from the sales in terms of receivables
		11.3.1	or contract financing or whatever.
12.0	Okay.	12.1	Um, I wouldn't likely put my money in and then hope that they've got enough to finish the product.
13.0	Right.	13.1	Which is where the equity side has got to be there so that I know that those resources are there.

14.0	In terms of Bank of Montreal equity side, do you often partner with them in looking at a company?	14.1	Yeah we do.
		14.2	We work pretty closely with them.
		14.3	Uh, and they have various levels of um involvement.
		14.4	Normally from a sub-debt side they too are looking for companies that already have established cash flows,
		14.4.1	that may be looking to ramp up or acquire another company.
		14.5	Because there, although its sub-debt, and they're getting you know, various equity or quasi-equity type returns, uh, they too are relying on the cash flow to pay them back.
		14.6	And of course, they're standing, they're even behind the bank from a security point of view so their position is that much more precarious.
		14.7	Um then there is a portion that is looking at true equity plays
		14.7.1	and then they'll take, you know if they like the deal
		14.7.2	or the technology
		14.7.3	or whatever, will take the, uh, the true equity risk there.
15.0	Okay.	15.1	Hoping for the true equity return.
16.0	Yeah. Because that's going to be a big hit.	16.1	That's right.
17.0	In terms of the product life cycle, does that, how does that enter into your lending decisions?	17.1	Well, you know, we don't really want to be financing, and certainly in technology, a one trick pony. .
		17.2	Um we want to get an understanding that okay, they may be coming out with a certain product but then where is that going to be leading in the future?
		17.3	Are there enhancements that can come, other product spin offs that can come?
		17.4	Its very rare you can find a company that can sustain a cash flow on one product
18.0	Sure. Okay. In terms of um sort of call it a technology intensive company versus a knowledge intensive company, if that makes sense, do you see any specific differences in their life cycles, their product life cycles?	18.1	Um probably no.

		18.2	Um, if you're looking at pure knowledge based.
		18.3	In other words um almost providing a service to create something,
		18.3.1	uh, its not so much the provisional product that has to keep evolving,
		18.3.2	or more products coming on line,
		18.3.3	but you do have to address the issue on what industry are they in
		18.3.4	and is that industry going to grow
		18.3.5	and what possible evolutions could occur there,
		18.3.6	would this person's expertise there be of value five years down the road.
19.0	Okay so you're looking at the potential future value of that knowledge asset in the company. Is that a fair statement?	19.1	Yeah. Yeah.
		19.2	Not from a... you can't quantify a, like a, give it a specific evaluation, but you're trying to assess whether it can still generate cash flow.
20.0	Sure. Okay. In terms of like for instance a software company, their product life cycle may be very fast. You know, they might have to be turning out a new product every six months to stay in the game.	20.1	Right.
21.0	Does that enter into your lending decision at all?	21.1	Yes, because we are looking at R&D requirements,
		21.1.1	whether they are R&D expenditures and how does the company intend to finance that.
		21.2	And that shouldn't be financed out of bank lines.
		21.3	It should be financed out of internally generated uh cash flow or equity indications.
22.0	Okay. So in terms of uh a security loan then, a company's traditional lending point of view, what assets, like let's say you're dealing for instance with a software company and all they've got is four computers and a couple printers. What are you looking at in terms of um security and loan?	22.1	Primarily accounts receivable.

23.0	So, you're basing at sort of an operating type loan where you say you'll lend them up to 50% of accounts receivable or something like that.	23.1	Whatever, yeah.
24.0	Okay. Um okay in terms of the market, what are the key issues you're looking for there?	24.1	Um, I see a lot of plans where it simply says, you know, the world market is ten billion dollars and if we get two percent of it we're millionaires.
		24.2	Um, we try to get an understanding of who actually they're focusing their product towards,
		24.2.1	who their real potential customer base is.
		24.3	Um and is it realistic.
		24.4	Um and also who's their competition.
25.0	Okay.	25.1	And then we're looking at, you know, do they have things like strategic alliances for distribution,
		25.1.1	um track record if any.
26.0	So, basically you're looking at uh attributes that are going to directly impact accounts receivable? Is that uh...	26.1	Yeah because that's what generating the cash flow.
27.0	Okay. In terms of um, maybe this is more of an equity criteria than lending but in terms of uh if its a new product hitting the market and maybe they have one customer, do you explicitly look at the likelihood that that product's going to be adopted widely in that market or are you relying on what they are projecting?	27.1	A. Well, I think we have to (pause), we um would want to have access or try and do third party investigation.
		27.2	Or if there's any literature that's available,
		27.2.1	any associations,
		27.2.2	uh maybe talk to their existing customers,
		27.2.3	uh try and get an understanding if their product has applications uh on a wider basis within --
		27.2.4	say they sell to the financial industry -- well then, who would want to buy this.
		27.3	The financial industry.
		27.4	And also, can it be adapted to other industries.

28.0	All right. And then, in terms of the management team, again take the scenario of someone coming in for the first time with a business plan, what are you looking for in the management team?	28.1	Well, you're looking to see if the management team, um, is covering off the key success areas for any company.
		28.2	Uh, normally with these technology companies, the, the founder, the inventor has a strong technology background,
		28.2.1	but that in itself is probably you know, only the bottom rung of what it needs to be successful.
		28.3	You're going to look at the other key elements.
		28.4	You know, marketing, financial, administration, production, uh and who's in those roles.
		28.5	Uh and if they don't have individuals there, how are they going to address those?
		28.6	You're also going to look at uh, who they've got on their board of directors
		28.6.1	and what sort of outside advice, expertise, mentoring that they're taking.
29.0	Okay, in terms of sort of um management team dynamics, is there anything that you look for specifically in that? Um how well they work together...	29.1	Well, I mean to a degree I want to see what the backgrounds are.
		29.2	I don't know how normally you can really assess that other than you pick up certain vibes
		29.2.1	but I guess if they were all relatives, you'd wonder how'd that happen, you know, um and that may cause an eyebrow to be raised.
		29.3	Um I can't recall any instance where that has come up per se.
30.0	Okay. So, in terms of staging your assessment of the company. Okay, when the guy walks in the first time with their business plan, what happens after that?	30.1	Um, normal procedure is we um, I mean we get many requests, come on out and see us, you know, hear my story, let me come in and tell you my story.
		30.2	Um if I did that in the normal course for everyone that wanted to walk in, I mean that's all I'd be doing.
31.0	Sure.	31.1	Um normal procedure is, uh, you would ask them if they have a business plan.
		31.2	If they don't that's not a good sign.

		31.3	Uh if they do, you'll ask them to send you that to prepare you for any subsequent conversations.
		31.4	Uh, usually, just by reading the business plan you'll likely be able to tell which ones are not good
		31.4.1	and uh probably give them know that there's nothing there that you can do.
		31.5	And you know, verify that with the prospect in further conversations.
32.0	Mhmm.	32.1	Um, if there's something in the business plan that does um come across as very positive
		32.1.1	and you wish to explore it, then you will meet with the prospect and try and structure it from there.
		32.2	Now, I find that with many of these, especially smaller companies, its an issue of managing expectations
		32.2.1	and clarifying really what their needs are because I find many of them are coming to banks really looking for equity money.
		32.3	And you have to explain what you really do and who should be doing probably their deal, or that it should be a mix.
33.0	Okay.	33.1	Uh, because naturally if they can get equity money at bank rates uh, with not having to give anything up, they'll take it.
34.0	Sure.	34.1	But there's not too many people that will do that. So, that's often the challenge when you're dealing with less sophisticated companies.
		34.2	When you're dealing with those that have already, you know, that have passed the early stage
		34.2.1	and have a management team in place, uh,
		34.2.2	and usually the management team for even a relatively small, ongoing, high-tech company has a caliber of people that you wouldn't normally find in a comparable company of another industry.
35.0	Okay.	35.1	Because they're bringing in uh, people to uh, help them in their growth.
36.0	Mhmm.	36.1	It may only be a one million dollar sale company today
		36.1.1	but the type of people they have in it are those that could handle it when its a twenty million dollar company.
37.0	Okay.	37.1	And so the expectations or the knowledge of really how the system works is at a better level.
		37.2	You can talk more as peers.
		37.3	Whereas if you're dealing with uh maybe an earlier stage,

		37.3.1	especially if the person you're dealing with is purely the technology person, they don't really understand the financing side of it.
38.0	Okay.	38.1	So, there's a lot of, there's some mentoring and guidance, within limits, there's only so much that we can do, or should do.
		38.2	But, uh, you know we'll try and guide them or refer them to somewhere that may be more appropriate.
39.0	Okay. So in terms of what you're doing, if they don't have a plan in place, its a non-starter?	39.1	Yeah.
		39.2	They have to get a plan.
		39.3	I just need to hear a story.
40.0	In terms of what you would call a bad plan, or a not good plan, what kinds of things do you look for. Like, uh I guess the first question is, how long do you typically spend on a business plan do you think?	40.1	There are some you can, you know frankly, some of them ten minutes and you know.
41.0	You just know.	41.1	You know its not going anywhere.
		41.2	Um you don't really um.
		41.3	I mean you're doing essentially what equity uh providers do you know.
		41.4	First quick scan can often tell you whether there's anything there to pursue.
		41.5	Um and sometimes you might only spend ten minutes on it, or you get the flavour very quickly.
42.0	Mhmm.	42.1	Um, certainly you don't have the time to do hours and hours of analysis on every business plan that comes in.
		42.2	It's just not feasible.
		42.3	Um some of the key things that you're trying to um get out very quickly is, is there a very succinct story at the beginning.
		42.4	Uh, that's usually what's going to make you want to read on.
43.0	Okay.	43.1	The executive summary.
		43.2	Um, you're looking at projections and seeing how they are substantiated.
44.0	Okay.	44.1	Um, you want to see what third party verifications they're providing

		44.1.1	or can provide even if its not part of your initial plan on on their assumptions of the market or the product.
		44.2	Um, you know, if they have clients who their clients are right now.
		44.3	Um, and I guess some brief biographies on the key management people.
		44.4	And also, a well thought our summary of what their request is.
45.0	Okay, so if they know exactly what they're asking for, rather than sort of, we need money...	45.1	Yeah.
		45.2	That again just sort of gives you an indication that they have a level of sophistication that understand what they may or may not get.
46.0	In terms of um, the uh again, a technology-based company that might be fairly knowledge intensive, um you look at the bios of the key management people. Do you look at all at the um, sort of the key technical people?	46.1	Um, I guess it depends on the level of risk that you're taking.
		46.2	Certainly yes, we do look at that.
		46.3	Um, you may not get into the same level of due diligence as an equity player.
		46.4	If there is an equity player coming in at the same time you're coming in, you hope that you can trade some information.
		46.5	Um and you're normally not doing that same, you know quite that same level to get that feeling but you may be relying on them.
		46.6	Um, I guess you're, if there is historical performance you can rely, you know, take some reliance on that too.
47.0	Mhmm.	47.1	Uh, but part of your due diligence could be conversations with uh key technical people to help you understand.
		47.2	Especially when you're looking at uh, R&D requirements and so on.
48.0	Okay. In terms of their R&D requirements, what are you looking for when you're talking to key technical people. Are you looking for uh indications	48.1	Well, I think its both.

	of what risks they're facing or are you looking more for indications of do they have the infrastructure and materials to do the job or..		
		48.2	I mean if future cash flows are dependent on successful R&D,
		48.2.1	uh you want to try and get some understanding of what are the challenges they're facing and/or problems that they've faced to date.
		48.3	Uh and do they have the resources in place now to deal with that
		48.3.1	or what's it going to cost to get them.
49.0	Okay, what I'd like to do now is sort of recall what you would consider knowledge-intensive technology based company, say a software company or an IT company that you've dealt with recently. And what kind of things uh, sort of the process you went through and what kind of things struck you as important to leading you to invest, or providing money to that company uh other than the financials. Was there specific issues that come to mind that you considered important to that particular company?	49.1	Well, I'm not sure how to answer this.
		49.2	Well, um certainly the four key elements that I mentioned before, are the starting point.
		49.3	Um there are a number of companies that we looked at recently that are in the turn around phase.
50.0	Oh. Okay.	50.1	Where uh, the company has been around a few years, um, has made mistakes, primarily due to management decisions. (pause)
51.0	Okay.	51.1	We're looking at situations where there has to be an equity infusion to take place to basically cover those mistakes and move forward.
		51.2	And, what we're interested in is that sufficient financing is going in to put the company back on a sound financial footing because they were before the

			mistakes.
		51.3	And then more importantly that um, those mistakes aren't going to happen again which relates a good part to existing management which is usually different than the ones that made the mistakes.
		51.4	Um and also that the revenue streams that they're now predicting, are verifiable.
		51.5	Like they have an order book that demonstrates that um, at least the percentage of what they're predicting is already in the bag.
52.0	Sure. Okay turn to the mistakes. What would you say is the most common mistake that you see uh a company that's early start up and they're, you know, they've got their first customer and they're chugging along. What would you say is the most common sort of fatal thing that you see happening?	52.1	At the early stage (pause), um, its probably not being able to get the second customer.
53.0	Okay. So they sort of way overestimated the potential based on one key guy that wants to buy their product.	53.1	Yeah.
		53.2	Or that uh, their initial product worked in I guess a relatively small applications
		53.2.1	and they've never been able to uh, further develop that into something that has either wider acceptance
		53.2.2	or larger applications.
		53.3	Um, when you get past that stage the most common mistake say would be companies that went on an acquisition trail.
54.0	Okay.	54.1	In order to grow.
		54.2	And those acquisitions either they were in, they got out of their core business.
55.0	Okay.	55.1	Uh, they grew too fast
		55.1.1	and didn't have the managerial expertise to deal with that
		55.1.2	and basically had to right off that investment.
		55.2	And also, because of problems that arose there, they took their eye off the ball on the core business.
56.0	Okay. So then in terms	56.1	Oh, I guess the third one would be when the

	of ...		visionary, the founder,
		56.1.1	who being perhaps too technically oriented, has turned his company into an R&D shop --
		56.2	concentrated on that and forgotten that you still have to sell something at the end of the day.
57.0	Sure. Actually I can think of a perfect example of that, who, I used to work for.	57.1	Yeah, there's lots like that.
58.0	Okay, um I guess my next question is kind of thinking again of companies that you've dealt with recently. Can you think of one that you decided not to give any money to and what was the key factor that lead to that outside of that they just had bad financial projections.	58.1	I'd say that the majority of those would be those that are just at too early a stage for the bank to be in because they don't even have a revenue stream, or its so nominal, or its pure contract -
		58.2	you know they've got two guys in the basement
		58.2.1	and they've got a contract for a hundred thousand dollars and they need fifty thousand to get it done.
		58.3	Um, its really too much risk.
		58.4	Uh because you're so dependent on two people with no track record
		58.4.1	being able to um correctly estimate costs and profitability
		58.4.2	and then have the where with all to develop that.
59.0	Okay, when you're talking about risk, what specifically are the different aspects of risk that you're... In the general term, there's the risk that the thing's going to default.	59.1	Yes.
60.0	How would you sub-divide the risk is I guess.	60.1	Okay as it all falls together, so trying to break it up...
		60.2	um, we're certainly looking at um we'll call it, these are my own definitions..
61.0	Sure. That's what I'm looking for.	61.1	I'm just winging it here after you raised the question.
		61.2	Um we're looking at, call it balance sheet risk.
		61.3	We're looking at uh the financial structure of the company
		61.3.1	and does it have uh strength to withstand setbacks -

		61.4	everyone has setbacks.
62.0	Okay.	62.1	And, then we're looking at the R&D risk.
		62.2	Do they have the financial resources to sustain necessary R&D for product expansion
		62.2.1	and enhancement.
		62.3	You know, and this is all within the context of the four key risks which is really what it all boils down to (pause).
		62.4	Um, you're looking at, certainly you're looking at the revenue stream which we've discussed in detail
		62.4.1	and is that valid
		62.4.2	and sustainable.
		62.5	You're also looking at the cost side of it.
		62.6	Um, in a number of cases,
		62.6.1	another problem that these companies had is they try and build up too much infrastructure
		62.6.2	too quickly in order to handle this huge sales volume that they're going to get that doesn't show up.
		62.7	And very quickly the costs and revenues start to flip over and then it starts going into the red.
		62.8	Um, as I'm looking you know, how we try and structure the deal so that we're covering those issues is primarily through, through a margin so that we're financing current assets.
		62.9	There may be some uh financing of long term assets but again that's, you know, higher risk level in the sense that you're putting out money that you want to get paid back in three years, five years based on fixed assets.
		62.10	Its pretty hard to project that far out on an earlier growth company.
		62.11	Although you may ask for, you may get projections five years down the road.
		62.12	How accurate is something that you're getting for the year 2005?
63.0	Yeah.	63.1	You're lucky if you can take comfort in the '99 ones, maybe the 2000.
		63.2	But once you get past two years, I don't really think we could put any reliance on projections.
		63.3	So, looking, you're looking at that issue.
		63.4	So what you're really trying to do for a three year margin is keep a pretty tight rein on borrowings
		63.4.1	and knowing you know where the trouble spots arise.
		63.5	And then the other way you're trying to control that is through financial covenants of the company so that you have certain triggers based on certain financial ratios --

		63.6	primarily working capital ratios or debt tangible net worth or debt to equity ratios.
		63.7	Um, that will throw up flags very quickly.
64.0	Okay, in terms of these risks then, would you say that you look at them all kind of equally weighted or is there uh...	64.1	I think that they are in a sense equally weighted uh on sort of underlying is the management issue.
		64.2	Um, certainly we're dealing with finance, so it all comes back to finance so you have to just structure it in a financial manner.
		64.3	You know you could say financial is the ultimate risk from our perspective,
		64.3.1	and since we're not there actually managing the company
		64.3.2	or can have that much level of control as say an equity provider can with a seat on the board,
		64.3.3	or more intensive monitoring than we do,
		64.3.4	we have to structure ours to be more conservative,
		64.3.5	but hopefully still give us enough time to react before everything goes off the rails.
65.0	Okay. I guess that actually finishes up the questions.		

D.3 Interview Discussion Notes -- Expert S2

1. How would you define a technology-based venture?

- Looking for proprietary technology

- Looking for indications that a market exists for the proposed product. Specifically looking to see if the venture is already selling product. Typically do not consider products which have not already been introduced into the market. Therefore do not typically consider a venture which is only at the research and development stage - would rather refer them to other sources of financing such as equity financing.

2. Do you believe that these ventures have special decision attributes?

3. What characteristics do you believe differentiate a knowledge-intensive venture from technology-based venture?

- Don't typically differentiate between technology based and knowledge based or knowledge intensive ventures. Same kinds of assessment principles are applied to both types

- Key differences would be the time to ramp up into production which is very much faster for a knowledge based venture than for a technology based - manufacturing oriented - venture.

- Another key difference is in the product life-cycle time that is much shorter for knowledge intensive ventures - due to rapid changes in their markets. Technology based ventures tend to have longer cycles times

4. Do you believe that knowledge-intensive ventures have special decision attributes?

- Much shorter product cycle times and much higher profit margins.

- Much faster growth rates and shorter time until they can become very profitable and perhaps large ventures.

5. When assessing a early stage knowledge-intensive venture are you considering this as an 'investment' decision or as a 'lending' decision.

- Not making equity investments, rather still making loans that are interest bearing.

- Take much higher risk when making the lending decision than would be the case with small businesses in the retail or conventional manufacturing sectors.

- For these ventures the bank is taking a longer-term view. They are providing the loans to high risk ventures, as well and advice and management expertise if required with the objective of helping the company grow quickly into a good longer term bank customer. Looking to build a good relationship with the venture.

- Placing less emphasis on the strength of the venture's balance sheet since these ventures have very little in the way of conventional assets to secure a loan.

- Will not usually make early stage loans since the risk is too high. This is not only a 'corporate' policy, but also one that he agrees with. It is better for these types of ventures to seek other forms of investment than to have high levels of bank debit.

- Very early stage ventures create lending difficulties as they can't get operating loans because there are no operations and hence no accounts receivables.

- If a person approaches the bank for a loan while at the early stages of product development the loan would be given if there were collateral such as personal assets, but this is a high risk approach for the person looking for money.

6. What characteristics do you believe differentiate these two types of decisions?

- Did not ask this question

7. When assessing a knowledge-intensive venture, what are your specific objectives?

- Typically the ventures which are being considered are not yet profitable. They have done the initial research and development and have a product and sales, but a growing too fast for their cash flow. They are usually in debt and having some type of management difficulties.

- Quite often these ventures have only a small number of employees - maybe 6 - but are poised for rapid growth.

- Great deal of emphasis is on the quality and completeness of the management team.

- An important consideration is considering if the members of the management are likely to work together with the bank account managers. The decision to provide financing loans are very subjective in nature. Has a lot to do with the comfort level of the account manager and weather the account manager will be willing to champion this venture as it grows larger

- Look for top management commitment to the venture.

- Looking for indications that the team can work together and have experience.

- Track record of the key people is an important consideration. If either they are known to the bank or have developed successful ventures in the past.

- Look for indications that they seek outside sources of council such as accountants and lawyers or other technical sources and are willing to take advice from these sources.

- Examine the business plan to see if it makes sense. If some item seems to be unreasonable then the entire plan may become suspect, or at least will get closer examination. Look for realistic market projections on the size of the target market and who the customers will be.

- Prefer to deal with companies that have identified niche markets that they plan to try and enter.

- Look for key milestones in the business plan. Usually these milestones are financial in nature, such as projected sales.

8. What issues do you consider to be most relevant?

- Look at the business plan and try to monitor the company's progress against what they have stated in the business plan.

- Deviations from the plan are expected and will want some explanations if the performance of the company starts to deviate too far from the stated plan.

- Often will tier the financing based on the successful completion of milestones such as sales projections or the obtaining of key contracts.

- The completeness of the business plan is not as important as the management team's ability to articulate the plan.

- Hiring plans are important from the point of view that the account manager will want some idea of what the company is planning to do. Typically do not consider these are specific goals or milestones to be monitored.

- Unlike equity investors, the exit strategy does not consider if the company will go public or not. From the bank's point of view a good customer can be either a public or privately held company. Interest in the company plans to go public are more to have an idea of where the company is going and its status with any equity investors.

- Do not typically assess the venture technology. There are experts that the bank has access to from Toronto if they need more advice in this area. Since they are dealing with companies that already have a product and are either selling them or in the product launch at least, the assumption is made that the technology is sound.

- Will consider the situation with respect to knowledge assets in a knowledge intensive venture. Will look at who are the key technology people in the venture and whether the company has taken sufficient steps to safeguard itself from the loss of key technology people. This may include how the people with the key knowledge are being compensated.

- Also look at how intellectual property is being protected. Will look at who the lawyer for the venture is and whether steps to protect intellectual property are sufficient. This requires some understanding of what the intellectual property is.

- Finding that fewer companies are trying to patent. This appears to be primarily a result of the length of time and other costs associated with the patenting process. The fast product cycle times in knowledge - intensive industries is part of the problem. The products are changing so fast that by the time a patent has been obtained it may not be relevant. Prefer to rely on product lead as the competitive advantage rather than investing in obtaining a patent.

- Also try to assess if the product that the venture has now has any future. Looking at what future spin-offs may result from the product. Would consider it a high risk if there are no indications of the product future.

- Also look at how much the company is investing in product research and development to create future products. The companies that are typically seen only have one product so they need to be investing in future product development.

- For a small company 25% of its money going into product research and development is not unusual. Anything less than this would be a cause for concern. In some case a company with more established sales and larger than the typical small company may have as low as 10 - 15% of its funds going to product research and development.

9. Are there any specific sources of information that you tend to use during the assessment process?

- Business plan. Does not need to be very long and detailed. Not even necessarily complete as long as it can be understood what the company is trying to achieve and it is apparent that they have put some thought into were the are going and what they are doing to get there. Understand that the plan will be evolving in some cases. Important to understand why some changes are taking place.

- Interviews with the key management people. Looking for indication that the people in the company understand the problems and difficulties that they are either facing or about to face. Looking for indication that the key management team is unrealistic or overly optimistic about their situation.

10. Describe for me a recent example of a very early stage knowledge-intensive venture that you have assessed and decided to make an investment in?

- Recalled a company that was run as a small operation for several years producing software for the insurance industry.

- It had only one full tie employee and several part time employees that had other full time jobs.

- Got a new employee from the insurance industry.

- Went to see them regarding financing and found that they people in the company management had a very realistic outlook of what problems they were going to face, how they were going to develop their products and markets and what resources they needed. This provided a high level of confidence in the venture and as a result high confidence in providing a loan. "Seemed to be a company I could work with"

11. Were there any characteristics of this venture that made it unique?

- Started small and stayed small for several years until it 'decided' to grow. Had some years where it made money some years where it lost and had fairly constant sales in the 100K range.

- Now is growing rapidly and will have sales in the >> 10M range.

12. What features lead to the decision to invest?

- Confidence in the management team that they could successfully implement their business pan.

- Feeling that they understood the problems that they were going to face.

- Feeling that they understood the problems that the account manager faced and were willing to work with him.

- Feeling that the account manager could work with the management team.

- Product availability

- Expertise in the product niche they were going to initially enter.

13. Are there any aspects of this venture that you considered to be marginal and could have easily changed your mind on investing?

14. Describe for me a recent example of an early stage knowledge-intensive venture that you have assessed and decided <u>not</u> to make an investment in?

- One company that assessed and did not invest in was because there was a feeling that the senior manager / CEO was not fully committed to the venture.

- Can understand/deal with this if there are several other senior management people committed to the company but not if this is the only senior manager

14.1. What stage was the venture at?

15. Are there any characteristics of this venture that made it unique?

16. What features lead to the decision NOT to invest?

17. Are there any aspects of this venture that you considered marginal and could have easily changed your mind?

D.4 Interview Notes -- Expert S3

1. How would you define a technology-based venture?

- Does not typically differentiate between knowledge-based ventures and technology-based ventures.
- However, the early stage 'knowledge-based' ventures that are considered typically have little in the way of physical assets.
- Typically dealing with information technology companies or sometimes health related companies when talking about knowledge-based companies.
- Often considering companies which do not have market presence or products and have a high cash burn rate. Rather than having loans these ventures typically have venture capital funding.
- This bank has a variety of venture capital funds which may be tapped into for the venture.
- Typically looking to develop long term relationship with the company so that as it grows it will use the services of the bank.
- The general philosophy is to act as a business incubator. The role is to coach and council the venture. Help it understand problems it may face and help the company management deal with these problems.

2. Do you believe that these ventures have special decision attributes?

- People are the important asset.
- Lifecycles are faster for knowledge based ventures. This is important to consider when looking at the venture since the venture will need to be able to react and move quickly. This has some impact on the financing

3. What characteristics do you believe differentiate a knowledge-intensive venture from technology-based venture?

- For a typical lending situation might as well put the financial section of the business plan at the front since this is the most important thing the banker will look at. In the case of knowledge-based venture lending the financials are less important.

4. Do you believe that knowledge-intensive ventures have special decision attributes?

5. When assessing a early stage knowledge-intensive venture are you considering this as an 'investment' decision or as a 'lending' decision.

- Looking at the venture from both points of view.
- However, typically will deal with companies that would not be considered in conventional bank lending.

6. What characteristics do you believe differentiate these two types of decisions?

7. When assessing a knowledge-intensive venture, what are your specific objectives?

- Usually looking for proprietary technology
- What is the technological position of the venture and is it viable. This is more important than the financials on the venture.
- Team is important. Look at the history of the key people. Determine what is their background as much as possible during interviews with them. Do not do specific background and reference checking on the key people in most cases unless it is a very large investment.
- One approach to evaluating the key members of the management team is to look at their breadth of understanding of the various business issues that the venture will face. Consider how quickly the key people can answer questions covering the entire range of business issues. This provides some insight into the depth of the management team and how rapidly they can react to potential problem situations.
- Management is the key factor.
- When there are very little in the way of physical assets associated with the venture, the quality of the management team becomes much more important.
- Need to consider the impact on the venture if the management team is lost.
- What is the product and or technology potential. Is the venture in a niche market.

8. What issues do you consider to be most relevant?

9. Are there any specific sources of information that you tend to use during the assessment process?

- Often use outside experts such as NRC, consultants or people with experience in similar ventures.

10. Describe for me a recent example of a very early stage knowledge-intensive venture that you have assessed and decided to make an investment in?

- Do not use credit risk models as they would in conventional lending. However do have an assessment framework that is followed when dealing with new ventures.
- Look for focus in the product development.
- Look for depth in the product line. What is the potential for future products being developed based on the initial products.
- Want to make sure that there are spin-off products and next generations of products.
- Look to see if the management team has the ability to develop the next generations of products.
- In the management team look for technical capability and communications skills.
- Must have the technical capability to understand the technological problems that will be faced.
- Must be able to communicate to potential investors. Need to be able to sell the idea and to answer questions that are put to them.
- Major warning sign if the key management people cannot sell the idea behind the venture and its products.
- Often scientists and engineers have poor people skills and interpersonal communications skills that can lead to problems when presenting their ideas as well as poor team communications.
- Look at the team dynamics. Want a team that can work well together.
- Look at the infrastructure of the venture. Does it have the tools and other infrastructure necessary to develop the product.
- If there are areas where the management team or the development team are weak then need to address these.
- Look for how well the knowledge and skills of the development team fit. Ie: the skills mix.

- Look for the product's market potential.
- Only look at the business plan for information concerning the technical people and their skills.

11. Were there any characteristics of this venture that made it unique?

12. What features lead to the decision to invest?

13. Are there any aspects of this venture that you considered to be marginal and could have easily changed your mind on investing?

- Financial control problems. Did not have good financial controls in place, good person and was missing tools to help financial management such as computer and accounting software.
- The company got a financial officer who was satisfactory.

14. Describe for me a recent example of an early stage knowledge-intensive venture that you have assessed and decided <u>not</u> to make an investment in?

    14.1. What stage was the venture at?

15. Are there any characteristics of this venture that made it unique?

16. What features lead to the decision <u>NOT</u> to invest?

17. Are there any aspects of this venture that you considered marginal and could have easily changed your mind?

- A poorly written business plan will often lead to the venture not being considered. Need a business plan that is readable. Often technical people have problems getting their ideas across and this can show up in the business plan.
- If the business plan is produced using a software package it has the advantage of being easier to read.
- A business plan developed by another person, such as a consultant, for the venture usually will not be considered as being bad.
- NRC and IRAP often help many of the ventures that he deals with develop a business plan.

D.5 Interview Transcript -- Expert S3

Question		Response	
1.0	...Technology-based ventures. How would you define a technology-based venture versus one that's .... coming up as knowledge-based or knowledge intensive? In your eyes do you see any difference?	1.1	Well I think that it has to have some proprietary technology behind it or proprietary value to it.
		1.2	It can't just be shrink wrapped in someone else's software, distributing it to be what we would call information technology based.
2.0	Okay.	2.1	I mean they may still be part of KBI portfolio but uh, true KBI to me is uh companies that you know have a genuine focus on developing their own.
		2.2	They spend money on R&D, they invest in enhancing system products that they have proprietarily developed.
3.0	Okay.	3.1	So, they've created their own proprietary base and asset.
		3.2	You know, they buy the rights to software uh from someone else.
		3.3	They probably fall under that KBI bill but they're not quite often requiring the same kind of hand holding that some of the early route companies do.
4.0	Okay.	4.1	I mean, I was out this morning to a company and that company is not having sales yet at all.
		4.2	And they've been essentially burning cash for probably three years but they've had three successful rounds of equity raised to fund all of that.
5.0	Mhmm.	5.1	So, there really isn't a lot of banking that we can do for them at that point.
		5.2	All we're doing is facilitating introduction to a venture capital group, uh making sure that we're kind of involved in the process all along so that when they do hit commercialization, uh the bank that they choose to do the banking for them is not going to be the bank across the street -- its going to be the Royal.
		5.3	So, its kind of an investment of time on our part.
6.0	Does the bank across the street _____ (missed this) ?	6.1	Well, yeah.
		6.2	It's the Scotia Bank downstairs.
		6.3	Yeah.
		6.4	So its kind of what I call the incubation period and we have to be there in that incubation period.

6.5 Otherwise, we don't get to know the principles of the company, we don't get to know the applications of the technology.

6.6 So, we've made a pretty conscious effort to do that kind of stuff.

7.0 Okay, so your sort of objective is more incubating the company, looking at, you're trying to capture, looking long term trying to capture this guy as a long term customer.

7.1 Yeah.

7.2 And providing them with some value added contacts in either venture capital (because we've got a venture capital ____), or you know, introducing them to people who may potentially take the company public at some point with the Royal Bank group.

7.3 So, you know, this company I met with this morning, we had our experts out from the new?? (might be a company name Denew)??

7.4 securities that handle the IPO and the IP area.

7.5 Because they believe that these guys may have something there that's potential.

7.6 You know, and they usually do a pretty good assessment of whether they want to come up and see a client, they're coming all the way from Toronto.

7.7 And uh they've been out a couple times to see these guys because they believe that what they've created has actually uh got some real significant applications.

7.8 So, you know, when it is commercial it will be an easy sell on the markets.

8.0 So in terms of a knowledge based company with what, what sectors do you... is there a particular sector that you think of when looking at knowledge based?

8.1 Well, I mean, it usually ties in with IT but not always.

8.2 I mean there's um businesses that are people based, rather than asset based that we'd sometimes put into the KBI category.

8.3 Um, an example of that might be somebody's um personnel type service companies that are providing high technology employees.

		8.4	You know, they kind of fall into that other gray category where we say, you know, you don't have a huge asset base but to generate cash flow, and we're doing it on the basis strength of their people versus you know, saying we're going to lend x number of dollars against that asset.
9.0	Okay, in terms of um, companies that ... what I'm thinking of right now is product life cycle. Would you say that there's some marked difference in product life cycle with companies that have more knowledge base associated with the product, or...?	9.1	Um, you mean in terms of how long the product stays viable (reliable)?
10.0	Yeah.	10.1	Well, I mean if you look at software, I mean, that's why its so critical when we lend to software companies that we know the short and long term prospect of this company because they can change uh quickly (mudplay???) if they don't watch themselves.
		10.2	And by the time they get the product commercialized, uh, within thirty days it could be obsolete, uh, if something else better comes to the market.
11.0	Okay.	11.1	Which is all the more reason you want to kind of focus in on these companies early so that we understand exactly where their niche is in the particular market that they're going after, so.
12.0	Okay.	12.1	But the life cycle of the product would be very, very short.
		12.2	So, when you finance stuff you've got to kind of look at it that way.
13.0	Mhmm. Okay. Um, so then in terms of assessing early stage ventures, since you're acting more as an incubator, are you looking at them more from an investors point of view or are you looking at them all ...(phone ringing, can't hear this part)... like when you're doing the assessment part.	13.1	You look at it from both.
		13.2	The first part is, you know, ... (answers phone)

14.0	So, from your point of view then you're looking at it from both the sort of positional lending point of view but also an investment view?	14.1	Yeah, because the way we've structured our knowledge based industry group, we've kind of created as spectrum of sources of capital for companies that are knowledge based.
		14.2	So, we've said, okay in the early stage we can't bank them because there's no way that a traditional banker can give them any money.
		14.3	I mean, its equity capital they need.
		14.4	So, we created the Royal Bank Growth Co., which is a venture capital company to invest in early stage companies and even very small amounts, I mean 250 000, 500 000 amounts to get them started.
		14.5	And then, from there uh they can move into the next strata which is InterRoyal Bank Capital Corporation which deal with uh, in the small business venture fund which is a 50 million dollar fund.
		14.6	It goes from 250 to a million dollars in traditional venture capital.
		14.7	And then we've got a IT group that handles specifically, you know, KBI, IT type customers.
15.0	Okay.	15.1	And then of course at that point once we see you're likely fairly close to some commercialization opportunity, so that's when the bank comes in.
		15.2	I mean, there's some companies that, they've come in before that and we've provided them with additional traditional financing as a result of the structure of the play.
16.0	Okay, well, if a company comes in to you with a, for the first time, with a business plan, you know, the next great idea, what's sort of your first objectives when you're looking at this?	16.1	Well, you gotta really, you know, you've got to spend a lot more time figuring out their technology because that is always the critical fact.
		16.2	I mean if we don't understand they're positioned in the market and whether this thing's buyable or not, we have to do a very good assessment of that.
		16.3	We spend probably more time on that than we do on financial projections in the early stages because there's no point in giving us all kinds of projections if we're not convinced that its going to have a market appeal for it when it does reach the point that it's generating revenue.
17.0	Sure.	17.1	So, we tend to spend more time on those areas versus the traditional deal that comes into a banker.

		17.2	You know, and you might as well take the report and put the financials in the front because that's usually where the banker will go before they get to the meat of the document.
		17.3	We tend to you know, with KBI lending, we tend to step back a bit and say, okay, we understand there's going to be cash burn rates, there's going to be you know, balance sheet deficiencies but what do we really have here technology wise and can we understand the technology?
18.0	Okay, so in terms of understanding the technology, how do you go about doing that. Like...	18.1	Well, there's a couple of ways.
		18.2	I mean, one of them is we try to, where possible, we can use some outside expertise like National Research Council who does, they'll do an assessment which quite often they'll share with us if the clients has already gone to NRC.
19.0	Mhmm.	19.1	And then a lot of the other decision making is based on our experience of doing deals in those markets, whether its health care where we've got a similar company.
20.0	Okay, so again returning to the business plan, okay you're assessing the technology, is it viable, is there a market for it. Is there any other sort of specific issues that you consider relevant or try to..	20.1	Uh, management's obviously a key factor in it because you can't place the same reliance on physical assets.
21.0	Mhmm.	21.1	You'd better make sure the management team has the depth to them to take this product or this development and get it to commercialization.
		21.2	And that's always a big problem in these smaller companies is that some of them are great at developing things but lack the business acumen required to you know, sell it to investors and to...
		21.3	you know, I've seen a hell of a lot of ideas that are spectacular in terms of their applications but they never get from point A to point B because its the scientist or its the techie who can't necessarily communicate with uh guys that are in the investment business or guys like me that are in the banking business.

		21.4	So, the guy comes in with a spectacular idea, he spent five years researching it, all the studies to prove it but he can't position it you know, big picture wise to say why should I invest or why should I bank this company.
22.0	Okay.	22.1	You know, and we went through that a lot in some of these neural network type companies.
		22.2	You know, lots of these companies develop you know, significantly proprietary models for you know, neural network.
		22.3	And, you know, they had eight or nine of them with similar types of technology and much of it came down to how strong the management was to actually see how the commercial application could be used by Otis Elevator, or you know...
23.0	Okay. So then would you say it a fair statement that if the venture has its product is largely based on knowledge and not so much on technical or physical assets, then the management team becomes a higher priority in terms of your assessment?	23.1	Yeah.
		23.2	Oh yeah, for sure.
		23.3	It becomes a much bigger portion.
		23.4	That's your real risk.
		23.5	If you lose the management team that they'd come to you originally, you could be in deep trouble in a years time you know, because you don't have any assets to back yourself.
24.0	So, in terms of the completeness of the management team then, how um, do you explicitly look at whether they've got the basics covered or do you just look into whether they got a.....	24.1	Well, we try to conceive of whether they've got a grasp over the whole business in terms of knowing whether they're going, they've got a strategy around how they're going to get there, a team of people that you know, are able to put the strategy together and execute it.
		24.2	So we're looking at a lot of the history behind where were they before they got into this.
		24.3	You know, we spend a lot more background checking in terms of their capabilities.
25.0	So, in terms of background checking, is that something you would do through interviewing sort of employer references type	25.1	Now, usually we don't get into that part until we kind of assess okay, were they president of this company before, or what was the success, tell us about that company to try and get a sense of ...

thing?

26.0	Kind of a self report.	26.1	Yeah, yeah.
27.0	Yeah, okay.	27.1	Its difficult for us to begin checking references because that's not usually our role so we kind of have to rely somewhat on what we're told on our assessment based on questioning you know, how they handle certain things, not how much knowledge they have, capability.
28.0	So in terms of, how to practically word it, the credibility of the interviewee there, is there specific things that you're looking for?	28.1	Well you try, what you try and do is take them through a gamete of issues.
		28.2	So you ply from the financial right back to the personnel to marketing to, so you try and see how quickly, the CEO, how quickly they can move from one aspect to another and how good their understanding is of it when a question is asked about that area.
		28.3	Maybe, if they don't know what's going on in the business then, you know, it's tough for them to uh kind of react properly if they need to get this thing commercially viable.
29.0	Okay, in terms of again, sort of the organizational plan, you know, a lot of businesses plans will have sort of an org chart and you have one guy doing ten jobs. Is that something that flags fall into? (not sure if this what you said)	29.1	No that's not unusual, particularly in the technology field to have one guy doing many things in the early stages of it.
30.0	Mhmm.	30.1	Now once the infrastructure of people is in place then that tends to change.
		30.2	I mean, the company that I referred to earlier that does 15 million in sales, uh, when you look back at the history of the company, that company was doing 2 million dollars in (pause) 1993.
		30.3	So here they are in 1999, significant growth in sales, they now have a, a CEO that they hired from outside because the two founding members of the company realized that they really can't do some of the things that need to be done within that corporation.

31.0 Mhmm.

31.1 So, you know that's (pause)...so they realized that they needed the expertise of a CEO type person to handle this well.

32.0 Okay, so in terms of how the effort is being squared around in this small company, do you look for indications that they are overextended or over, you know, for instance if the key technical guy is also the head of manufacturing and the head of finance and things like that, would that be...

32.1 Well, I think it becomes more of a factor as they start to borrow more and need more financial reporting.

32.2 Yeah, that's when we start to say, okay you need a CFO in there.

33.0 Sure okay.

33.1 Yeah, so when I look at some of the smaller companies that I've got that are definitely KBI type customers, that's one of the things we try to coach and council them on.

33.2 We say, look, you need to have some expertise come in to do this financial management stuff and uh, you know, kind of help take it to the next level.

34.0 Sure, okay. Um in terms of the, if the company's, you know, especially in its early stages and it doesn't have a lot of physical assets everything is sort of knowledge assets, is how those are protected and how those are, how the knowledge is distributed in the company an issue that's relevant to your decision?

34.1 Uh yeah, we want to make sure that the right people have the right knowledge.

34.2 And so when you go look at the technical person, you look at the finance person you, as I said one of the big gaps that we always find on the small ones is that guys that developed it decide that they're going to be the ones running it.

34.3 It doesn't always work out the way they'd like.

35.0 Sure.

35.1 You know, the smart ones will recognize that you need to maybe add some people in the financial area once you've got some revenue or when you're approaching that revenue stream.

		35.2	But you know, its hard to convince people that that expenditure is worth doing but the one's that do it are far better off in the long run.
36.0	Mhmm. So in terms of whether they have the right knowledge base in the company to pull off what they want to do on the technical side, is that something you rely on outside expertise to judge?	36.1	No, usually its pretty much done internally for the smaller ones.
		36.2	I mean, some of the larger ones we might, uh larger deals, we might bring in a consultant but you know, its usually internalized until we get to a certain borrowing level.
37.0	Okay, so your assessment is basically using whatever CVs and stuff are part of the… (Business plan)	37.1	Part of the package, yeah sure.
38.0	Okay. So, you know, we've been talking about companies that you've recently been dealing with. I'm just wondering if you could sort of describe sort of the decision process for one that comes to mind.	38.1	Well, I guess it depends too on how much money they are borrowing.
39.0	Mhmm.	39.1	You know, if we are approving it within say a limit that I've got available for approval, then you know much of it becomes, the process becomes much quicker.
40.0	Okay.	40.1	If we've got to present it to a credit group then, you know, your presentation has got to include a lot more background material because the person looking at the deal may not have the same understand of the technology or the KBI that I do.
41.0	Okay.	41.1	And what we've tried to do at the bank is have designated people in credit risk management that have had the backgrounds in those areas so that the deals, you know I look at Kitchener, the guys down there, I'm not sure if you've interviewed them yet or not but
42.0	Dave Cross and	42.1	Dave Cross and Paul Seigal.

		42.2	I mean what they've done is um, they've had a credit guy on site that they've uh gradually I guess, taught the business uh in terms of this is what a typical company like this looks like.
43.0	Mhmm.	43.1	And so, you know, if you walked in Joe Banker from Burlington or something is going to say holy smokes, this is like different than what I would approve under standard asset financing arrangement.
		43.2	So you kind of customize your approval process to deal with those companies and their needs and why they're different you know.
44.0	Okay, so uh actually, it's interesting you say that. In terms of credit risk management, do you use like credit scoring models like you would in sort of traditional lending?	44.1	Yeah you do.
		44.2	You rate each you know, when we break it down it would be uh company and management, and financials, uh access to funds.
		44.3	All of those are kind of given a rating to say, here's how we rate this company on all those areas.
45.0	Okay, in terms of the, I'm trying to get to the management of the company then, what um attributes of the management team would you say are most important for you in deciding whether to deal with these guys or not?	45.1	(pause) I mean, I think its a combination of the technical capability, that is, knowing the business well enough that they can properly position themselves, I mean, or explain themselves to Joe Public or to investors.
		45.2	As I said, that , what really ends up turning off the tap sometimes is someone that can't get in front of a crowd of investors and explain in layman's terms, even analysts and even to investors, what they're actually, what their company does or what they seek to accomplish.
46.0	Oh, okay.	46.1	So, I mean communication skills uh I would say is an important factor we look at.
		46.2	Because it can determine whether the guy can raise equity --
		46.3	he can have great techies but you know, if they're limited in terms of their ability to communicate then you know..
		46.4	That that's one of the gaps that we do find, to be frank, in the technology area --

		46.5	is that some of them have been trained to be uh, good at technically, but their people skills and interactive skills are very weak.
47.0	Sure.	47.1	I think its just the nature of the beast.
		47.2	If you're a computer computer science graduate from a particular university, you may have spent most of your time in front of the screen and you know, maybe not have the same interactive.
48.0	Mhmm.	48.1	So, you know, that's one of the areas that we sometimes find is weak, you know, with the ability to communicate these issues.
		48.2	But not always.
		48.3	I mean there's some engineers and people like that are extremely good at uh communicating.
49.0	Mhmm.	49.1	And so we, you know its a generalization I would agree but it is one of the factors that we look at.
		49.2	How well, even if you had someone as the lead guy uh to get up and talk about it, eventually there may be some technical questions.
		49.3	How well can that person explain those technical issues?
50.0	Okay so it doesn't have to be the technical guru but he has to be the one that's good at speaking.	50.1	Yeah.
		50.2	I mean I've seen a series of companies where we haven't been able to do anything for and you look at it and and you say the idea is spectacular but the management, in terms of their ability to communicate with is doing an awful job.
		50.3	The business presentation isn't what it should be, uh, you know.
		50.4	The National Research Council has helped a little bit because what they try to do is help them put together the business plans.
		50.5	They've got you know money that they use to help fund the writing of the proper business plan.
		50.6	So you know, some of that has improved from what it was.
		50.7	You know, I can recollect two or three years ago you know, you'd see some of these proposals and you, you'd be ready to throw them in the garbage because they just weren't even legible or they didn't have enough detail in it to make any sort of determination of whether the thing was any good or not.

51.0	Sure. On the other end of the spectrum do, you know, there's the illegible business plan. What about the one's that come out of canned packages? You know, like you can go out and buy a 'biz plan', you know.	51.1	You know, those one's are usually a little better done but sometimes they're missing information within them.
		51.2	But we have a loan application package that is on disk that we give them as well so, you know, it certainly, uh, that's helped.
52.0	Okay, but in terms, I guess what I'm wondering more is uh, sort of at one end of the spectrum you have the one's the guy tried to write himself but are really bad. At the other end, you have the one's that somebody's done for him. Do those raise flags as well, or?	52.1	No, not necessarily.
		52.2	I mean, sometimes its just more professional, presentation wise to have it done for you.
53.0	Okay. In terms of a company you've recently invested in, would you say that, in terms of the management team, the dynamics inside of the team were something you looked at or is that something that...	53.1	Yeah, I mean its an important part of it.
		53.2	They've got to be able to work together for common development but uh, I think the uh, and I'll just think back to the one we just did and it was a six month long account.
		53.3	Uh really what it was there is that the company had some vision on where it wanted to go.
54.0	Mhmm.	54.1	So we placed a great deal of reliance on the CEO to to take them in that direction.
		54.2	We bought into the business plan, bought into the concepts that they had outlined in that.
55.0	So, really it came down to how well he presented his case then.	55.1	Yeah.
		55.2	Well, a lot of it come down to that.

56.0	Sure. Okay, in terms of this uh company that you were just describing, is there any sort of one thing that comes to mind that was almost a show stopper?	56.1	Almost didn't go through, you mean?
57.0	Yeah. something that was sort of, you were seeing and you didn't like and if it had been worse or different somehow, it would have changed your mind?	57.1	(pause). Um some of the uh financial management probably controls that we would have thought for a company that size that they would have, they didn't have.
58.0	Okay.	58.1	So, if that's been since resolved because they've brought another person in to consist with it.
		58.2	Some of the financial controls, and even some of the technologies we expected they would be using internally to manage (vanish??) their financial positions weren't there.
59.0	You mean in terms of computer equipment?	59.1	Yeah. Yeah.
		59.2	Electronic tie ins or accounts, things like that.
60.0	Okay, in terms of the technical people in the organization, you have a product team developing the product, do you look at how many products are concurrently being developed?	60.1	Yeah, we've got to make sure that their pipeline of products is deep enough that you know, when they get, you know kind of short in the existing main product line, that they've got something else in the pipe.
		60.2	I mean, just like any business you want to ask, okay, you did this last year but what have you got coming this year, to kind of assess their prospects.
		60.3	Or what do you have that's going to be coming in stream, you know five years from now?
		60.4	I mean in the health care industry, some of these biotech companies we've got, uh its very important that you say, okay, the product that you're focusing your phase three trials on is this one but what else do you have that's coming behind it to compliment it or provide additional potential commercial revenue for you.
61.0	Mhmm.	61.1	So, you know its just like the pharmaceuticals companies that come out with a blockbuster drug but there is always follow along development that's done on that drug. .
		61.2	Either they change the name or they call it..

62.0	Yeah, they tweak it somehow.	62.1	Yeah, they change the process.
		62.2	Just like improving any product but you've got to make sure they have that pipeline because if they loose uh customers to say a competitor that's very similar, then you know, you could be, they could be out of business rather quickly.
63.0	Okay. So in terms of again a small company developing products, is there an optimum number of products that they can be developing at any one time do you think?	63.1	It depends on the size of your infrastructure.
		63.2	I mean in the computer software area it could be one product that they're trying to perfect to get to the point that, you know they've got to do their beta testing on it and and all of that stuff.
64.0	Okay.	64.1	Uh, I wouldn't say that, I mean, you gotta make sure that they're not going all willy nilly all over the place.
		64.2	So you want to make sure its a focused pipeline.
		64.3	Like I've seen some companies that you start to look at their pipelines and how does this relate to where you want to be.
		64.4	You know.
65.0	Okay. Trying to go too many directions at once.	65.1	Yeah.
66.0	Okay. A couple of product questions. In terms of the infrastructure of the company, is that something that you make an explicit assessment of or do you just...	66.1	When you say infrastructure...
67.0	Like do they have the right design tools and do they have CAD systems and...	67.1	Yeah.
		67.2	You usually want to make sure they have the tools to do the job and, you know, are they compliant.
		67.3	Right now obviously the Y2K issues, you know, in technology is and important part of it.

68.0	Okay. And in terms of um the technology, the development team, the people in that team and the knowledge skills in there, do you look at how well the key knowledges are spread around in that team?	68.1	Yeah, oh yeah.
		68.2	Because you've got to, you want to make sure that they've got a good mix of skills within it.
		68.3	I mean, I've seen when we talk about the knowledge economy, an example, uh of a client, is a client I've got that does engineering work and all of the employees are essentially engineers, okay?
69.0	Mhmm.	69.1	Uh, the guy that does the day to day management of financial and business decision making is not an engineer but has a you know, significant track record in business - to run businesses.
		69.2	So, although these guys are all engineers and they're out doing work for Proctor & Gamble, and they're out doing work for Coca-Cola, Kraft, you know large customer base that do, uh, you know, design work for them on you know, systems that they're using in the plants.
		69.3	You've got to have someone there that can bring it all together and market it and sell it.
		69.4	Its a knowledge, there's no assets in this company other than computer CAD equipment and things like that.
70.0	Oh okay. Um, when you're looking at that mix is there any, sort of specific method or approach that you use, or just sort of looking at what they have in the CDs and what they're doing?	70.1	Um, there isn't really any methodology behind this.
		70.2	I mean, its not really an exact science because you, sometimes you end up taking some risk and you assess it and you say, okay, what's the viability of this.
		70.3	And you may be wrong, you may be right, so sometimes you just take a bit of a flyer on them and say, okay, we're prepared to put some money at risk on this because we believe that, although we, we're not sure where they're positioned, we do know that there is potential for this thing.
71.0	Okay.	71.1	And sometimes we've won and sometimes we've lost.

72.0 Okay, well that's it. That's all the main questions I had.

D.6 Interview Notes -- Expert S4

- Predominant industries involved with are telecommunications and software.
- To a lesser degree, involved with life-sciences and environmental sectors These sectors are emerging and growing fast.
- BMO does get involved in funding early stage ventures through its associated venture capital corporation.
- May do 'angel' investing
- Also involved in the TIPS program and western Canada development fund.

1. How would you define a technology-based venture?
2. Do you believe that these ventures have special decision attributes?
3. What characteristics do you believe differentiate a knowledge-intensive venture from technology-based venture?
4. Do you believe that knowledge-intensive ventures have special decision attributes?

- Software and semiconductor industries have faster life-cycles
- Electronics and component companies have a slower life-cycle than software.
- Telecommunications has slower life-cycles due to the high capitalization required
- The higher the knowledge content the faster the product life-cycles

5. When assessing a early stage knowledge-intensive venture are you considering this as an 'investment' decision or as a 'lending' decision.
6. What characteristics do you believe differentiate these two types of decisions?
7. When assessing a knowledge-intensive venture, what are your specific objectives?

- Look for the quality of the management, protection of intellectual property and export potential.
- Look for clear technological advantage and export opportunities

8. What issues do you consider to be most relevant?

- The architecture of the product is important, especially in software
- Look for niche markets
- It is important to consider adoption of the product and technology by the customer.
- Quality of the management team is very important.
- It is important that the management team be seasoned and has done it before. Not necessary to be in the same market as the proposed venture, but have experience moving a product into markets
- Look for a high degree of innovation and potential for market leadership
- Look to see if the venture is in a niche market
- Is there a well defined strategy - who is the market, who will buy the product, who will be the purchaser, how will these customers be reached.
- What is the potential for partnerships which will leverage the venture technology and or products
- Is the venture receptive to external advisors
- The management team of the venture is the number one consideration
- Also look to see if there is a strong board of directors
- Is the venture based on good science
- What is the potential to set up partnerships to develop the venture.
- The management team is important, but so is the development team.
- Need to consider how the intellectual property will be protected
- How have the development people been protected. Have they been identified. How are they compensated. Are there royalties or ESOPS
- If the key technology people cannot be identified or if they have not been satisfactorily protected then this is a potential are for concern
- Does the venture have a working prototype or have they been providing custom products in a related field up to this point.

- Often useful to ask if the venture could act as a high quality service company
- Can they be a successful design shop. Do they have the capability to develop high quality, innovative products
- Does the venture have an experienced engineering group
- If the management team has no business experience, do they have a plan to get experienced help. Is there someone in the group with business experience.
- Are the key people open about the needs, abilities, opportunities and risks.
- Good documentation on business plans, financial histories and the development of products and technologies.
- Does the venture have a lawyer familiar with IP issues.
- Want to try and assess if the management team has the ability to take the venture to the next level. Can they identify and articulate what is necessary to grow to the next level.
- Looking for ventures that have high growth potential.
- Will the venture create employment and grow or are the principals interested in selling the venture quickly
- Product and technology potential, management team and organization are the important considerations in the venture.
- Also looking for the possibility of being or becoming overextended in product development.
- Like to see product focus. Rather concentrate on one product rather than overextend resources and start missing milestones.
- It is important that the key knowledge assets of the venture are available for development and not going to be tied up with administrative tasks and other management functions.
- 2 or 3 products is too much development effort.
- Is the business plan succinct and easy to understand?
- Does the business plan have lots of typical buzz words and realistic projections

9. Are there any specific sources of information that you tend to use during the assessment process?

- Sources of background technical information are the web, other clients, other investment experts, external technology consultants, and government labs such as NRC.

- It is important to have a network of people to help in understanding and assessing the venture technology

- Often external experts will not understand the business implications, but can assess the technology, its future potential and the level of innovation of the technology or the product.

- When undertaking a major investment, will interview key management people for one - two hours, Will also interview customers and suppliers.

- Look at the customers to determine the potential for product adoption

- Look at the suppliers to get a better understanding of the risks

- For large scale interviews will also interview key technical people in the venture in addition to the management.

- Can often tell after an interview if the team members have an understanding of the business.

- Really looking at how the people operate. How are they with each other. Can they sell their ideas and are they credible.

- Do they have a seasoned project manager

- The CV with the business plan usually has information on the key technical people.

- When looking at how the people operate, looking to see if they have a professional attitude and approach to product development and business in general. How does the team interact.

- Often get to learn a lot about a team and the venture management during the course of interviews and business discussions

10. Describe for me a recent example of a very early stage knowledge-intensive venture that you have assessed and decided to make an investment in?

11. Were there any characteristics of this venture that made it unique?

12. What features lead to the decision to invest?

13. Are there any aspects of this venture that you considered to be marginal and could have easily changed your mind on investing?

- Ego can be a problem. Sometimes as a result of previous success people can become overconfident and unrealistic about the market potential of their product and the problems that the venture may face.

- This can lead to under-estimation of the difficulty in market adoption of the technology

- Like to see product - market focus.

14. Describe for me a recent example of an early stage knowledge-intensive venture that you have assessed and decided <u>not</u> to make an investment in?

    14.1. What stage was the venture at?

15. Are there any characteristics of this venture that made it unique?

16. What features lead to the decision <u>NOT</u> to invest?

17. Are there any aspects of this venture that you considered marginal and could have easily changed your mind?

- There can be a problem if planning is not realistic and resource requirements are under-estimated

- Need to see that there is an understanding of what technical risks exist in developing the product

- Without a good COO may consider that the risk is too high to consider investing

- Development over-extension is a major problem

- BMO venture capital group typically will do a much more complete skills inventory.

D.7 Interview Transcript -- Expert S4

	Question		Response
1.0	Garbled	1.1	from a niche manufacturer.
2.0	Okay.	2.1	You know, they may have built a product

		2.2	-- so I'm going to put these guys in the electrical or components kind of, that kind of space.
		2.3	They're slower moving but that can be very attractive
		2.3.1	**uh** financing vehicles for us because, you know, they may in fact
		2.3.2	**uh**, you know build products aimed at, you know, a particular market or..
		2.4	You know I can think of a couple companies we have that focus on certain vertical markets and have
		2.4.1	**um** product solutions aimed at those markets.
		2.5	**Uh**, they have a position of leadership today in those market.
		2.6	But to mature, like to mature to that point, they took several years.
3.0	I'm sure.	3.1	They didn't do it overnight.
		3.2	**So unlike uh**, you know, maybe the semiconductor space or the software space where it moves fast, they
		3.2.1	**um**, they look more like a traditional manufacturer.
		3.3	The reality is they aren't - because they're selling pretty rigorous stuff.
		3.4	Because they're usually a small company selling to large multinational clients.
4.0	Sure.	4.1	So that means their stuff, their gear, has to be first rate.
5.0	Sure	5.1	Whether its a software or hardware play.
		5.2	**But uh**, so I'll call that the electronics or the components industry.
		5.3	I find that a little bit slower.
		5.4	**Uh**, telecommunications is mature,
		5.4.1	**uh**, its moving fast but not fast in the sense that...
		5.5	**(pause)** I mean, architecture, architecture tends to have one and two year...
		5.6	you know this as much as I would...
		5.7	you know, it tends to, it goes cyclically, you know in terms of, you know, what space you're in --- whether it, **uh (pause)**
		5.8	...you know, whether its driven sort of depends upon what part of telecom we're talking about but, but I find it a very orderly business in a lot of ways -- communications.
		5.9	But its life cycles tend to flip year to year.
		5.10	Any major player in that space, who's selling gear to that space, obviously has to be well capitalized.
		5.11	You don't just set up shop, uh you know, and start building switches, you know.

6.0	Sure.	6.1	You know, I guess is what I'm getting at -- routers or whatever part, whatever play you're talking about.
		6.2	These companies tend to have matured over ten years, five to ten years,
		6.2.1	**um you know**, and they tend to be significant players either in the public market place or certainly well capitalized
		6.2.2	**uh,** with capital - private or seed capital before they become significant.
		6.3	So, we've got this very strange market going on but I suppose,
		6.3.1	**uh..** up here you have telecom that's moving fairly
		6.3.2	**(pause)**...slowly but its not -- I, I hesitate to say it because it's changing rapidly but you need a lot of horse power to play in that market and its a longer maturity.
7.0	Sure.	7.1	Software has a capacity to do this.
		7.2	Semiconductor space has the capacity to do this,
		7.2.1	**um,** recently I would have said in the last year more so.
		7.3	Even though the investment cycle is long, **uh** life sciences, biosciences
		7.3.1	**uh** tends to be evolving quicker out of the lab too.
8.0	Okay.	8.1	**What happens uh that space is uh,** if the idea is innovative and its a drug play or its a devices play, then it gets a lot of capital fast to grow it.
9.0	Okay.	9.1	You don't do it on the back of your hand.
		9.2	**Uh** and its very commonplace to see biotech plays start at five, ten, twelve million dollars in venture capital right from day one.
		9.3	So they can, you know, run their research.
		9.4	But it takes them several years, obviously, to get through the processes required to commercialize it.
		9.5	So, its a long cycle
		9.5.1	-- it requires a lot of capital.
		9.6	Um anyway...
10.0	Okay.		
10.0.1	Actually, that's kind of interesting because the biotech one is uh an interesting one from the research point of view because it, its uh,		
10.0.2	the faster life cycle ones tend to be the high knowledge	10.1	Yes.

content companies.

11.0	And whereas, uh biotech, it has this capitalization hurdle it has to go over...	11.1	Yes it does.
12.0	. ... Until that starts to take effect.	12.1	Yes.
		12.2	Yeah it desperately needs that so it can continue to do the research and the testing and
		12.2.1	**uh** you know that whole piece, you know, in order to be successful.
13.0	Yes. Okay.	13.1	This market has ultimately raised a lot of money **uh for uh** telecom plays.
		13.2	People understand telecom here and that's the business of Ottawa.
		13.3	**Uh,** recently more and more capital seems to be chasing life sciences plays here, you know.
		13.4	Gradually they're building a bit of an infrastructure -- very loose but a bit of an infrastructure is evolving.
		13.5	So, I see this capital come in fairly aggressively.
		13.6	It probably isn't aggressive -- it's probably the model.
		13.7	If I was in Montreal where bioscience is really what drives the market, um you know, I'd probably say well that's just the way its done.
14.0	Sure.	14.1	You know, you have to have five or ten million just to open the door.
		14.2	**Um,** typically for a software play, when we invest we often invest anywhere from a million to three million on average when we're an equity play -- that'll get us going and then some.
		14.3	If we've got good management,
		14.3.1	**you know uh,** you may have a successful company, at their adoption anyway.
		14.4	Taking it to the next level will take subsequent rounds but certainly, biotech would need a lot more than that to begin with.
15.0	So, when you're...when some guy comes in with his business plan and um you're looking at it,		

15.0.1 what kind of attributes are you looking at in that company to decide whether this is something specifically that you're interested in being, doing some angel investing, or whether you're going to just say "well, we'll provide you banking services but no thanks"?

15.0.2 Is there anything...

15.1 **Um yeah.**

15.2 I guess there are a few generic things that I would point to.

15.3 I want to be able to see that **uh** this company can **uh** -- I mean if its a product or its a technology play --

15.4 I want to see that they can, either through their innovation or good management, they can take a leadership position in the space their in.

16.0 Okay.

16.1 You know?

16.2 So I have to see a clear picture in terms of their market.

16.3 Are you bringing something?

16.4 Is your science innovative?

16.5 In other words are you solving a problem out there that's not solved today?

17.0 Okay.

17.1 And there may be five solutions to the same problem.

17.2 But I mean, I think what you really have to get to the rub of it is:

17.3 Look, does ABC company have an innovative solution here in this space?

17.4 And if so, is that a template for them to, you know, (pause) to grow a business in.

17.5 And I mean in that space.

17.6 So product or technology that plays the science is very important in that there is opportunity for growth and leadership in the segments they're attacking.

17.7 The strategy has to be well defined.

17.8 I read so many business that **uh**, that cover the generic bases.

17.9 In fact, you could almost start clawing out the buzz words in the business plan and then

		17.9.1	**uh (pause)** at the bottom at, the meat of it wouldn't be there.
		17.10.	Recently we were digesting (myself and my partner who does the seed stuff out of Toronto) a plan.
		17.11	And we both read the same plan and it was just like it hit us both with a wave that this chap had gotten a cyber dictionary and kind of pop, pop, pop, you know.
		17.12	He'd said all the right things but there was nothing there, okay?
18.0	Sure.	18.1	**So, uh,** a well defined strategy gives me a sense that
		18.1.1	**um,** management,
		18.1.2	now that they've identified the science,
		18.1.3	identified their advantage,
		18.1.4	they talk about who their clients are,
		18.1.5	who the users are and how best to get to them.
		18.2	What are the best strategies from a distribution or marketing point of view to get to them?
		18.3	What partnerships do we need?
		18.4	That's another thing - openness on the part of management.
		18.5	Receptivity to partnerships,
		18.5.1	to external advisors,
		18.5.2	**uh (pause) uh** a lot of plays you see, **uh,** I mean one of the first signs or one of the first things that sort of turns me off is a scientist that **(pause)** that lives on his own self worth, you know.
		18.6	He doesn't appear open.
		18.7	You can read it in his business case that he's not open to, you know, to bringing other people in to advise him or help him.
		18.8	**Um** so I'm really looking for someone that is flexible and open to
		18.8.1	**uh** advice but also open to
		18.8.2	**um** partnerships that will leverage the science out.
19.0	Sure.	19.1	Obviously if **um** if you really want sort of the slam dunk --
		19.1.1	you've got good technology now,
		19.1.2	you've got a business strategy (you can tinker with the business strategy.
		19.2	We can all argue to death whether that channel part was right or that market was the right one.
		19.3	And you're going to make mistakes, that's business eh, it's kind of preformed
		19.4	-- Um, if you've got seasoned management that have done it before.
		19.5	I'm not talking about, necessarily, with their money to play.
		19.6	Oh that's always nice because obviously that gives everybody a bit of comfort that they're going to

			stick.
		19.7	But more to the point that have successfully, you know, brought product to market.
		19.8	You know maybe in a different space, maybe in a different science.
20.0	Sure.	20.1	That's hugely important.
		20.2	**Um, and in uh,** in the absence of it, the ability to draw or the existence of strong board.
21.0	Okay.	21.1	Very important, even in early stage.
		21.2	A real solid technology play usually starts with a, you know, starts with a team.
		21.3	Not one or two people, a team.
22.0	Sure.	22.1	**Uh,** now if it's good science and and there's...
		22.2	if it's good science there'll be people already interested, open investing in the company, even early on, and are participating.
		22.3	So, management's really important, uh, really, really important.
		22.4	In fact, I used to do corporate finance,
		22.4.1	I used to do large project finance before this - buildings, shopping plazas, that sort of thing.
		22.5	So, I'll say it was location, location, location which is true.
		22.6	If its a retail, you know, mall, big box or whatever, whatever it is.
		22.7	Or for that matter, apartment building, you know, obviously location drives you know, whether people want to locate there.
		22.8	You know, traffic, customer traffic, ease of access if its a residential development.
		22.9	So that was the driver in that market.
		22.10	Here, I like to say that it's management, management, management.
		22.11	Give me soft technology, or technology that is aimed in the right direction, uh and great management, seasoned management.
		22.12	I'll take the seasoned management any day because they can take that product play, they can tweak it,
		22.12.1	they can **uh (pause)**, they can drive that market and
		22.12.2	**uh,** you know, they can be successful.
		22.13	They have a better chance of being successful than a company that just simply has great science.
		22.14	The two usually go hand in hand.
		22.15	It's rare that they don't go hand in hand.
		22.16	But sometimes you can see it, you can feel it and you go, no, I'm going to bet on this,

		22.16.1	**(pause)** on this enterprise, this entity because I really like the team.
23.0	Okay.		
23.0.1	So when you're um assessing whether its a good science or the technology, what resources do you draw on to uh determine that. Do you do that independent of...	23.1	Pretty wide, pretty wide.
		23.2	**Um**, generally speaking **um** I might use other clients, confidentially I mean, um ask about space.
		23.3	**Um** there is the internet.
		23.4	I mean just simply to do a bit of self study.
		23.5	But generally speaking, because of the advantage of having in house and investment council both on the public market side at NESBIT and inside Bank of Montreal Capital, I could very quickly go to a number of people.
		23.6	At Ventures West, if its a sector, I can actually go to a sector - someone that does, you know, does network management software.
		23.7	I can phone a guy who does it, you know and that's his thing and that's a good start.
		23.8	And I may, I may be right away thinking about partnership.
		23.9	So if I'm thinking about partnership, uh, say its a medical play, I might be thinking, geeze, you know, this is a good thing for uh, you know a fund that is focused we'll say.
		23.10	The Canadian Medical Discoveries Fund.
		23.11	Like focused at this space.
		23.12	So there's another source of information.
		23.13	Because you bring a partner in that in a sense is going to do more due diligence.
		23.14	An equity investor is cycles much longer than mine.
24.0	Sure.	24.1	I don't have the luxury of that cycle.
		24.2	Sometimes I have to act very quickly as a banker.
		24.3	If its a good opportunity I have two or three weeks to uh...
25.0	... to think about it and mull it over.	25.1	That's right, and then decide whether I'm going to proceed.
		25.2	**Uh, so uh,** so I don't have the same advantage that uh, you know that a venture capitalist might have.
		25.3	So, I often do that.

		25.4	I often go to straight to our uh, you know, straight to our investment house because there's confidentiality in that respect and they use a lot of external technology consultants themselves.
		25.5	They, they deal with straight product plays so they're probably going to have seen one or two or several, you know, business cases similar.
		25.6	And that leads on a bit of a research project, but its never um all that long.
		25.7	Um, you've got credentials of the individuals involved too that might lead you to an external source here or there.
		25.8	Sometimes you just know.
26.0	Okay. Just a gut feeling.	26.1	**Um (pause).**
		26.2	It's kind of an educated gut feel in that, you know, you've looked at this, you know, God here we go.
		26.3	Here's another application like this.
		26.4	Literally, you're reading - and if I in Ottawa am reading business plans that have a similar ilk one after another, you know, within a quarter or six months, um, I've got the latest hot tomalley I'll call it, you know.
		26.5	Then I know right off -- this is not unique so what can we make of it.
		26.6	Can we make anything of it?
		26.7	It's funny how a good idea jumps off the page.
27.0	Yeah.	27.1	Do you know what I mean?
28.0	Yeah.	28.1	**Uh, its kind of ....** I don't know if that answers it or not.
29.0	No, it does...	29.1	But there are lots of sources.
		29.2	There wasn't when I began -- it was terrible.
		29.3	One, I think it was almost being a little uh...
		29.3.1	**how can I say...** intimidated by the fact that I have a finance or accounting background, you know, I understand business, and I understand investment, but I mean, I'm not an engineer.
		29.4	So at first you're a bit intimidated by the, you know five years ago, by the technology.
30.0	Yeah.	30.1	But you quickly learn that the technology doesn't drive the deal.
31.0	Right.	31.1	As much as, you know, some of the basic business principles.
		31.2	So, you get a little less uncomfortable.
		31.3	So, once you've had a few years at it, you have sort of a network of people you can talk to.

		31.4	In the early going, the bank would hire, from time to time, external technology consultants.
		31.5	You know, basically they would hire out contracts but you know, this is, this is a problem.
		31.6	Well, you know, I never really thought this would work as a business case.
		31.7	I have someone coming with something unique.
		31.8	So now we go to ORTECH, for example, and we say uh, you know uh, do an assessment on this.
		31.9	Well who do I have assessing it exactly?
32.0	Yeah that's right. What's his credibility?	32.1	What does he know?
33.0	Yeah.	33.1	Has he got any design, you know, work in this area?
		33.2	You know.
		33.3	So quickly I realized that wasn't going to work.
		33.4	I had to find other ways.
		33.5	Um, in this city we're lucky.
		33.6	We have the National Research Council.
		33.7	We have a lot of science advisors.
		33.8	We have a lot of very good technical people that we can call on from within the government too that may know the science.
		33.9	They may not know whether its commercially viable but they may be able to say you know that's unique science, that's good science.
34.0	So when you're looking at the team, that's one aspect.		
34.0.1	What about the the knowledge assets and the venture internal.		
34.0.2	Like do you specifically take a look at uh, where the knowledge lies in the company and how its being...	34.1	How's it being controlled?
35.0	Yeah.	35.1	My concern is when I register um that the bank has a nice global form, this general security agreement.
		35.2	If you read it, it's everything but the kitchen sink, including intellectual property.
		35.3	Mind you, I wouldn't say our general registration is going to control intellectual property by any stretch of the imagination.

		35.4	Um but if we're really banking on it, if that's in the background, if things go south we can sell uh, you know, the product or the technology.
36.0	Sure.	36.1	Then we spend a little bit more time on it.
		36.2	I mean I have never personally done escrow on software code or controlled it.
		36.3	Um, again, I have a doubt as to whether the expense really justifies what I am trying to accomplish.
37.0	True.	37.1	You know its changing.
		37.2	The infrastructure of the product, the code is changing so quickly and its in the minds of uh the key development team that probably what I should focus on is who's building the product.
38.0	Okay.	38.1	And what sorts of arrangements are in place to keep them at the table.
39.0	Sure.	39.1	Incentives.
		39.2	**Uh, you know, uh** whether there's an esop in place, whether there's you know an opportunity basically for them to participate in the growth and the wealth of this company.
		39.3	**Um,** if there isn't, then I have a problem right from the get go.
		39.4	So we usually look to see that.
		39.5	Is this refined?
		39.6	**Uh,** do the key developers have a piece of the company?
		39.7	Do the key developers have employment contracts that have some solid control over their, you know, movement.
		39.8	Not just movement but the use of that technology.
		39.9	**Um** good technology companies typically focus on it.
		39.10	Its really funny.
		39.11	When we do our - and I haven't even got to IP yet – when we do our, do our technology seed fund..
40.0	Mhmm.	40.1	that's what the money is usually used for.
		40.2	Making sure they have control of the technology.
		40.3	That may be some simple patent work, you know, some of that being some legal, some legal advice.
		40.4	That's around a half million dollars - you could spend that real quick trying to get a patent or uh, whatever it is, you know control there and on structuring uh you know, software employment program.
		40.5	You know, making sure the labour side, the human side of the company is tidy.

		40.6	Those are the two areas that our money is used for primarily.
41.0	Do you spend any or how would you (pause)... You look at uh what knowledge passage is there in terms of the people. How about what's missing? Are you in a position to assess sort of the strength of those knowledge assets or what are you looking at, like when you say you know...	41.1	You mean is the patent good or?
42.0	Mmm, I'm thinking...	42.1	Or you mean the actual idea itself.
43.0	Uh, I guess I was thinking more along the lines, you mentioned you know do they have the esofts/ essops?? in place to keep the key people in place. Um in terms of you know, I guess there's two issues. One would be, how do you tell if that's the key person?	43.1	Yes.
44.0	And secondly, uh, how do you tell if there's uh, a key person missing?	44.1	Got ya.
		44.2	Well, um, unfortunately my cycle of uh (pause)... how can I say.
		44.3	My cycle in terms of decision is shorter than say an investors.
		44.4	So, I don't, I can't honestly say I can interview all of the key management personnel.
		44.5	I can't.
45.0	Sure.	45.1	I mean I look at the business case, I look at uh whose on on the staff, you know, there, what there skill set is, match it up to the product and say well yeah, we need developers in this area.
		45.2	We seem to have two or three that are key and these guys definitely have the requisite skills for that area.
46.0	Okay.	46.1	So from my point of view, its maybe a little generic.
		46.2	I'm just sort of doing a ticky checky and saying, they've got the right guy in finance, they've got the right guy you know here as a project manager, they've got seasoned project managers for their software development teams.
		46.3	Um you know, usually a good business plan will give me a fairly heavy duty or rigorous vite on you know, kind of analysis of their team.

		46.4	You know there may be five or ten pages just straight on people and I look at that fairly carefully.
		46.5	Um, on the other side, on the capital side, we spend a lot of time when we're investing, a lot of time.
		46.6	Uh the standard is one to two hour interview with each of the key personnel in the company.
		46.7	Um, we interview the suppliers, okay.
		46.8	We travel if we have to.
		46.9	We fly to the customers.
		46.10	If its, if its a company that's emerging and uh, you know, we're looking at maybe three to four major beta sites, we'll go talk to those beta sites.
		46.11	Go to wherever that company is -- Dallas or wherever it is -- and find out if they're really satisfied with the gear.
47.0	Yeah that's right.	47.1	Okay?
		47.2	Will they be uh good will ambassadors for the product.
		47.3	So uh so, on their side of things, one, they structure it with more money up front to cover some of their costs you know before they actually make the final, call it commitment.
		47.4	And two, they build a far greater return.
		47.5	They're targeting a return of 30 or 35% on their money.
48.0	True.	48.1	Technically, my spread is 3 or 4% so, so you know, there's a degree of what you can or cannot do.
49.0	Sure.	49.1	But uh, definitely the key management people say on a more macro level, are people that I would end up talking to in the process.
		49.2	Typically when we bank someone here, we've spent (pause)....Uh sometimes someone calls up and says Chris would you look at this deal and we do it.
		49.3	But a lot of the time we actually have this kind of informal way of getting to know them.
50.0	Sure.	50.1	You meet up here at a networking opportunity or you hear of someone you can call on.
		50.2	And then months may pass.
		50.3	So, by the time you've actually put pen to paper, you may have spent six or seven months getting to know this individual and getting to know their idea and their company.
		50.4	That happens more often than not.
51.0	Oh, okay.	51.1	And that usually is good foundation for a solid, you know decision, I think.
		51.2	I think that its important.

52.0	Okay, so then if somebody sort of...	52.1	You see how they operate too.
53.0	Yeah.	53.1	You know, even when its informal you... First off, I mean (pause) ... If a person can't sell themselves to me, and I can't sell them well (it goes both ways) but if they can't sell the idea, or explain the idea, bring it in, you know, to me, uh how are they going to sell the product?
		53.2	So there are a lot of signs that come across.
		53.3	Sometimes you go geeze, I don't get that guy.
		53.4	That guy doesn't work for me but maybe he's got a complimentary person within his team.
		53.5	So, you want to explore.
		53.6	You go, I like this idea but this guy's definitely not the right guy to sell it, right.
		53.7	So you dig deep and you find, classically you find two or three people with different skill sets.
54.0	Yeah.	54.1	And then that works.
		54.2	One might be strong on the marketing side, another person may be very good at, in the product development side, another person may be great in operations.
		54.3	Hey, you've got three people.
		54.4	If you can get three guys like that, bonus.
		54.5	Bonus round on the software company.
		54.6	You know, so...
55.0	Okay, so if somebody came into the office here out of the blue with uh a proposal, a project and somebody that you'd had, you know, opportunities for informal networking with, if they had the same proposal you would probably say that you would consider the one that you'd had more exposure to?	55.1	The person?
56.0	Yeah.	56.1	Hmm.
		56.2	Well not necessarily.
		56.3	I mean, uh, not to give too much to schmoozing, uh you know cause uh, no, I've still got to start with the fundamentals but I would say this, that it wouldn't hurt them.
		56.4	It would probably help them if they had uh, if they made a fairly professional approach. .
		56.5	Do you know what I mean?
		56.6	Or my view of them had been, you know, enhanced from the get go, that's not a bad thing, its probably a good thing.
		56.7	Because you now look at them and say well these guys have got some business skills

57.0 Sure.

57.1 You can tell.
57.2 You can tell though if someone's got that.

58.0 Okay, what I'd like to do right now is sort of have you think of the most recent case of one of these type of ventures that you made the decision to go with. And, specifically, was there anything sort of unique about that one that really, sort of you looked at it and said, that's a go?

58.1 Let's see.
58.2 Hmm.
58.3 There were quite a few recently.
58.4 Okay, well we have one that is uh, is in we'll say the semiconductor world, okay.
58.5 And um, the company was seven months old.
58.6 It had already successfully completed one design project, custom design project for a major telecommunications vendor.
58.7 Um, what did I like about the company?
58.8 Um, even though the company was very early stage, it already, uh, it had already gone to the extent of building or developing a board.
58.9 It brought an external board in.
58.10 It brought in a varied board, uh, (pause).
58.11 Basically, there were three gentlemen that drove this company.
58.12 Three, uh SONET/ASIC???? engineers, design engineers, chip designers that were seasoned and their vites were very good.
58.13 Just a nice cut.
58.14 They had worked sort of varied through three or four different entities, all of them.
58.15 They'd all started their NORTEL heritage many, many moons ago but ventured off into other places.
58.16 So uh, I liked the fact that they had the seasoning.
58.17 None of them had run a business though.

59.0 Okay.

59.1 What I was getting out of it was these guys were basically kick ass designers, uh you know, in the world of custom chips aimed at telecommunication or data communication you know needs.
59.2 I knew they had some skills in SONET which, you know, is kind of hard to find and uh, there's a lot of demand for these three guys, the bodies just on a per diem basis.
59.3 So they could be a very successful uh design shop as well as a product company.
59.4 And the company has that look.

59.5 That company has a look right now where it can go out and sell its services, its design services, and make very healthy margin, extremely healthy margin because these guys have the talent.

59.6 But what it really wants to do is take the design, and own the design, own the intellectual property and um, not just simply take 1% on the royalties stream but to drive the product and you know, to dominate it.

59.7 So, first cut is, you know they can build the widget and they can get paid for it.

59.8 So, they had sort of said, well what we're going to do before we take any venture capital then, we have some ideas about what we want to do design wise.

59.9 But what we'll do is we'll run a couple of contracts, do some custom design build uh, stuff, and put some money in the bank which is exactly what they did.

59.10 So its the first six months of their business, they put about a half million bucks in the bank.

59.11 Just straight profit off their first design contract - so I like this.

59.12 But what they're really aiming at is being a big player, a thirty or forty million dollar a year company.

59.13 Taking two or three concepts that there is a need for out there, you know, with convergence uh and you know, making them their own.

59.14 So, on the one hand, I've got a very safe services company that I like, anybody would want to bank, anybody who understood telecommunications or understood technology would bank this company.

59.15 But the next part of it was okay, we've got these ideas -- yeah I agree.

59.16 I've read about this, I've heard about this, these plays might work.

59.17 Um, there might be a market there for these designs.

59.18 In any event, they did seem to have what I call the horse power, you know, to become a product company.

60.0 Sure.

60.1 So what did they do?

60.2 They went out and when they brought the board in, they brought in people that were successful in bringing products to market in the space.

60.3 In fact, they brought in, they were able to attract uh an executive from a local public company that was in chip design space.

60.4 So, they brought in someone like that.

60.5 They brought in a key player from within one of the telecommunications companies.

60.6 Um, so they started building this board, then they brought in a kick ass lawyer.

		60.7	Now some say well why do you need a lawyer there?
		60.8	But a lawyer that specializes in technology practice, who understands intellectual property.
		60.9	I mean by the time they'd rounded up this board, and then there were the three guys, it was just, it was just a terrific board.
		60.10	I'm going gee, they've had the foresight to put these folks in place and of course these folks were attracted because they know they have design capability and need some council.
		60.11	Then they brought in an operations fellow.
		60.12	They hired a guy who they knew personally, but they hired him out of a major telecommunications company.
		60.13	They just hired him in, gave him very significant status, gave him a piece of the action, just points or whatever.
		60.14	And he was kind of a seasoned fellow and that was kind of, I call it a real rounding.
		60.15	I thought, this is great.
		60.16	They've now got someone that can really carry -- they can sell the concept and the design -- but this guy can really do operations.
		60.17	He had been responsible for hundreds, in fact, thousands of people in his previous job.
		60.18	Um and understood the....
61.0	**Tape problem**	61.1	... in the business plan from that point of view.
		61.2	You know, I spent a lot of time on who's there, but you know that going to tell me the broad stroke.
		61.3	It's going to say yeah, I've got the right guys in the company to do this.
		61.4	So, usually in my mind I sit there while I'm reading and I go, okay well he's going to do this, he's going to take care of this.
		61.5	I kind of dissect the company.
62.0	Yeah.	62.1	But, what it doesn't do, and I think what you're aiming at is what I was just describing our capital guys are doing, it doesn't follow the chains, the chain of command.
		62.2	Or in the case of a project, it doesn't follow it through and say "okay do we have all of the pieces of this puzzle to get the job done".
63.0	Yeah.	63.1	And they do in fact do that...and identify (pause)
		63.2	There investment, uh, they have an investment transaction.
		63.3	We have a lending transaction which is a form, you know?
64.0	Yeah.	64.1	For their investment committee.

		64.2	Mine's for my lending committee.
		64.3	That's what's uniquely different.
		64.4	When I read it it's obviously longer, there's more, it's more in depth.
		64.5	But there's a fairly heavy duty piece of it that focuses on management and not just management but talks about all the skill sets.
		64.6	It breaks them out -- production, operations, marketing, identifies the people and uh then breaks down their personal vites and then talks to the relationships.
		64.7	And then it almost always (pause) ... it's expected that risks are going to be identified.
		64.8	You are venture investing here.
		64.9	There are risks, right?
65.0	Sure	65.1	So it makes the writer... the model makes the writer identify those.
		65.2	At the end of the day there's probably seven or eight key risks... uh you know... significant risks that are identified by the investment group and there's invariably one or two that focus in on the skills inventory of the company.
		65.3	We have a weakness here.
		65.4	Someone's missing, something's missing.
		65.5	A condition of our investment -- often, often a condition of our investment is specific action on the HR side.
		65.6	In other words, we're going to invest.
		65.7	But within three months we intend, you know...they identify and its agreed on.
		65.8	It's sort of a preformed discussion.
		65.9	You know, we are missing an operations guy or a guy on production or were, we need a seasoned executive, marketing executive in US.
		65.10	And these are just examples, kind of random examples of three business cases where we invested.
		65.11	You know within 90 days, we've got to get that person in and we, it has to be one that satisfies you but us too as investors and a board.
		65.12	You know, so it is done on the investment side.
66.0	Hmm. Okay.	66.1	I don't know how you couldn't do it.
67.0	Well, you know. I think you pretty well have to do that as well.	67.1	Because, you know, that truly could uh fix you.
68.0	Yeah.	68.1	You know.
69.0	Okay, uh, I guess.		

(end of interview)

D.8 Interview Notes -- First Session Expert S5

1 Thank-you for participating in this phase of our research into investment decision-making.

- Investment vs loan decision making
- two totally different worlds
- two totally different risk-reward criteria

2 What is the typical company size to which you provide loans.

- companies are not normally classified by the number of employees.
- more relevant are net worth, sales and or loan size

3 The management skills of the people in the new venture

- definition is too narrow
- skills needed go beyond the management skills as important as they may be

4 Is there another issue that is important to consider?

- Entrepreneurial skills of the people in the new venture
- ability to organize
- obtain capital
- attract employees
- market/sell product
- carry on into the manufacturing phase

5 What rank would you have assigned this issue

- first

6 Experience and expertise

- some key points
- need for a good business case which will indicate technical viability of the product
- ability to manufacture
- market study
- identification and availability of resources, both people and materials
- financial viability and financing required
- confirmation of people who can make it happen
- too much emphasis on knowledge and experience
- the key point is does the venture have these individuals with the ability, including entrepreneurial spirit, to design, develop and market the product including all the business related activities including obtaining capital, attracting the necessary people, plan, establish budgets, organize and direct work activities etc.
- often there is a need for a marriage between those with the ability to design and develop new products and those that can make it happen.

7 Other comments

- As a general statement for what it may be worth the type of financing related to here would not likely be available on a stand alone basis through conventional bank loans and would require outside support.
- The primary reason is risk / reward
- There is a very small profit on small business loans and by necessity the risk must be low.
- this small profit also prohibits lending officers from spending the time necessary to properly assess the proposal
- Furthermore this is the bottom end of the market and in most cases involves junior lending officers who have neither the knowledge nor experience to do so.
- As a general statement, ventures such as described would require quasi-equity or equity.
- the usual source is venture capital companies

- having said this at least some of the major banks have specialty areas that specialize in knowledge based ventures

- Also, on a limited basis, they provide quasi-equity or equity through entities such as bank of Montreal capital corporation

- For your information, loans under say $1 million tend to be adjudicated by a computer program based upon input provided by a lending officer.

- ie: credit scoring

D.9 Interview Notes -- Expert S5 (E-mail exchanges)

1 How would you define a knowledge-based venture?

- I would define a knowledge-based venture as an economic undertaking which is primarily dependent upon the special knowledge and ability of one or more individuals to create, invent, discover or enhance upon an idea, process or product which can be developed and placed in marketable form on a commercially viable basis and where the successful creativity or development involved is a mandatory prerequisite to other business considerations or processes such as manufacturing, packaging or marketing.

- In more simple terms, the success of the venture is dependent, firstly, upon original or creative thinking with infrastructure, manufacturing or marketing processes which may be necessary being of second, albeit essential, consideration.

2 What markets come to mind when you think of a 'knowledge-based' venture?

- Markets which come to mind are computer hardware and software, medical or pharmaceutical products, specialized electrical components and certain defence products, etc.

- Not all companies engaged in these markets, of course, fit the definition of knowledge based ventures.

- I think of stand alone ventures rather than larger somewhat diversified entities.

- In my mind, a typical example would be a one or more individuals forming a venture

- to develop and market computer games.

- To the extent they have the technical knowledge and skills and the imagination and creativity to develop products which can stand up to or beat the competition, and likely the need to continue to do so, they may be successful.

- If not they are dead in the water.

3 What characteristics of these markets make them stand out from more 'traditional' industries or other 'high-tech' sectors of the economy?

- I see the characteristics of these markets as the need for a combination of specialized technical knowledge and skills and creativity.
- In my mind, the emphasis is not so much as segregating among different high tech industries but the form of the venture, i.e.: stand alone
- focused upon development or a narrow range of highly technical products and the attributed needed for success ie: technical knowledge and skills coupled with creativity.

4 what attributes or characteristics do you look for in the venture's product or service development team which indicate if it is based on original or creative thinking?

- This is a tough one for me to define.
- Its like porn, I can't define it but I know it when I see it.
- I guess the best I can come up with is that the product requires a high level of inventiveness, imagination, innovation and creativity.
- Same for the development team.

5 At the initial stages of this time of venture are you differentiating between the 'development team' and the 'management team'.

- Yes, very much so.
- To me success rests firstly upon the development team.
- The management team is critical but is of no use if the development team fails.
- Also, by my definition the development team requires specialized technical knowledge and skills.
- The management team can be more general management skills.
- In my experience, in a knowledge based venture the development team is the driving force, and usually the dominant force, with the key players tied to development.
- The management team may in some cases be individuals hired to bring some order out of chaos, ie: accounting, administration, possibly some marketing such as advertising or packaging.

- More often than not, there will be a small group of key players who are the developers and also provide overall general management supported by a management team.

- Having said this, a weakness in knowiedge based ventures can be skilled and capable innovators/developers who lack general or specialized management skills and fail to acquire or develop a supporting management team.

- A critical requirement for success of course is creative of innovative products but all can come to naught if there are not the skills required to finance, manufacture if needed and market.

6 Do you believe that these ventures have special attributes which must be considered when assessing them?

- In the context of assessment of a knowledge-based venture for investment or lending purposes, and assuming the venture is primarily on a stand alone basis, these ventures have special attributes which must be considered in that criteria required for a classical assessment is often not available or is of limited relevance.

- The key criteria is determining the ability of the key players to develop the creativity required which is essential to success and then mustering the capital, assets and management required to bring the venture to a successful conclusion.

- These attributes can be very difficult to determine and measure especially by an evaluator who is not intimately knowledgeable about the particular technological field involved.

- In view of absence or obscurity of key criteria, the risk factor for these ventures usually is at the high end of the risk spectrum.

7 What would be some examples of criteria other than the ability to develop a creative environment which you may consider to be relevant when assessing a 'knowledge-intensive' venture?

- Some examples would be, vision, drive, commitment, leadership, inspiration, judgement.

- Overall it is an assessment of the key players and their ability to make it happen.

- These are subjective and accordingly are difficult criteria to quantify.

- Far too often it is a gut feel.

8 when considering this type of venture, say a software or other IT type venture, what would you consider to be useful indicators or metrics of the venture's ability to develop a creative environment.

- Attributes of key players are as discussed.
- One or more of the key players has to have the vision, drive, enthusiasm and inspiration to make it happen.

9 When compared to a venture which has a higher 'physical technology' component - say a venture which is developing a product based on a custom electronic component - do you think that there is any significant difference which must be taken into account?

- A venture with a higher physical technology component may require more specialized equipment for development of its product.
- In some cases, a knowledge based venture may be largely represented by the minds of the key players with little supporting equipment other than the usual computers, etc.
- Others may also require specialized equipment.

10 When assessing a venture which requires knowledge and expertise to fully understand the technology issues involved, what sources of information do you consider to be important and useful?

- A good basic grasp of the technological issues is most helpful.
- However, this can be difficult to obtain.
- There is also the problem of a little knowledge can be dangerous.
- The usual reference library can help.
- Also industry periodicals, discussions with others in the field.
- In some cases the services of a professional independent consultant in the field can be of assistance.
- Often, detailed and inquiring discussions with the key players is the best bet.
- The bottom line is that it is difficult for an evaluator, who is not a specialist in the field, ie concentrated on a narrow segment of the market, to acquire a good level of expertise in a technical field.
- In my view, this is a major weakness in assessing a knowledge based venture.
- In my experience, an evaluator for general business has neither the time nor incentive to carry out the necessary research.
- Thus the argument for business of this nature to be handled by specialized evaluating teams where such are available or be avoided altogether.

11 In terms of lending decisions versus investment decisions, how does the basic focus of the assessment change, if at all, when considering a loan to a knowledge based venture which does not have significant physical assets rather than making an equity investment?

- In general terms, a traditional loan has a low net return and therefore must be of low risk.
- The low return also means that time and effort in evaluation must be kept to a minimum or return is eliminated.
- Not only the initial evaluation but also the ongoing monitoring.
- The latter can be offset if the loan is in a sufficiently large amount that the return will still compensate for the extra effort involved.
- This can be also offset by charging significant fees.
- Also, a traditional loan requires regular interest payments otherwise the lender is penalized.
- Additionally a loan requires clear cut repayment arrangements
- Generally over a relatively short period of time or again the lender may be penalized.
- Consequently, although the lender will look at cash flow as a source of payment of interest and principal, there is a tendency to support the loan by tangible assets especially for amount other than large figures.
- Loans supported primarily by cash flow such as project lending are usually confined to large loans where the return permits the detailed assessment required.
- Generally speaking, loans are a high volume product.
- On the other hand, an investment is usually for the long term with no requirements for interest or repayment and in hope of a large return.
- Also, generally speaking, investments are a low volume product.
- loans versus investments require a different mindset.
- Loans are not investment and investments are not loans.
- Generally speaking, lenders look back at past performance, present position and look ahead for the short term.
- Investors look at the long term , possibly very long.

- Also, sources of funds for loans and investments are different.
- For most lenders, loans are lending out someone else's money that has been entrusted to them.
- Investors usually fund investments - but not always- with funds devoted to this purpose.
- Generally speaking, loans to a knowledge based venture -- stand alone - represent high risk situations and are for a purpose which more properly should be represented by investment.
- As a venture becomes established and develops a track record, there may be room for a lender to participate for traditional purposes.
- ie: purchase of equipment or infrastructure or financing accounts receivable, etc.
- Consequently, financing of knowledge based ventures by lenders tends to be confined to specialized lending teams or through venture capital affiliated and subsidiaries.

12 Given the high level of risk in lending to these ventures, especially at an early stage, what attributes of the venture would bring this risk into an 'acceptable' region for a lender?

- Generally speaking, the only practical way to reduce risk to a lender is to require a sufficiently large investment or more likely require outside support by way of outside guarantees and or outside assets.
- Unfortunately, a lot of this stuff is more an art than a science.

Appendix E – Lending Expert Cognitive Maps

Table E.1
Aggregate Lender Assessment Concept

	Concept		Concept
C1	Venture Vulnerability	C34	Management Credibility
C2	Venture Type	C35	Management Cooperation
C3	Venture Protection	C36	Management Completeness
C4	Venture Maturity	C37	Management Communications
C5	Venture Market Understanding	C38	Management Commitment
C6	Venture Growth Potential	C39	Management Cohesiveness
C7	Venture Financability	C40	Investment Cycle
C8	Venture Credibility	C41	Industry Growth Potential
C9	Venture Attractiveness	C42	Financing Type
C10	Technology Potential	C43	Financial Resources
C11	Technology Credibility	C44	Financing Risk
C12	Technology Control	C45	Financing Availability
C13	Revenue Potential	C46	Development Team Vulnerability
C14	Required Financing	C47	Development Team Quality
C15	Required Cash-flow	C48	Development Team Management
C16	Required Capitalization	C49	Development Team Experience
C17	Proprietary Technology	C50	Development Team Credibility
C18	Product Potential	C51	Development Team Capabilities
C19	Product Maturity	C52	Development Risk
C20	Product Life-cycle	C53	Development Requirements
C21	Product Existence	C54	Development Focus
C22	Market Velocity	C55	Development Financing
C23	Market Growth Potential	C56	Cash-flow Potential Credibility
C24	Market Maturity	C57	Cash-flow Potential
C25	Market Forecast Credibility	C58	Business Plan Quality
C26	Market Leadership Potential	C59	Business Plan Existence
C27	Market Focus	C60	Business Plan Credibility
C28	Market Familiarity	C61	Business Plan Completeness
C29	Market Existence	C62	BOD Requirement
C30	Market Access	C63	BOD Quality
C31	Management Quality	C64	BOD Existence
C32	Management Experience	C65	BOD Completeness
C33	Management Lender Expectations		

Table E.2
Expert S1
Concept Connection Matrix

	C4	C7	C8	C9	C10	C13	C19	C21	C22	C23	C25	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	C41	C43	C44	C45	C52	C51	C53	C55	C56	C57	C58	C59	C60	C61	C64
C4				1		1	1											-1		1																
C7																																				
C8																															1			1		
C9																								-1												
C10				1						1														-1												
C13																															1					
C19				1		1																									1					
C21																																				
C22																													1							
C23				1		1																		-1							1					
C25																			1																	
C27																								-1												
C28																																				
C29						1			1																											
C30																																				
C31				1								1												-1												
C32											1					1		-1	1	1																
C33																				-1																
C34																1								-1												
C35				1																																
C36																1																				
C41				1		1				1																					1					
C43				1																				-1							1					
C44				-1																																
C45																								-1		-1										
C52				-1																																
C51																										-1										
C53																										1			1							
C55				1																											-1					
C56																																				
C57				1																				-1					1							
C58																																		1		
C59				1																																
C60				1																																
C61																																1				
C64				1															1																	

Table E.3
Expert S2
Concept Connection Matrix

	C1	C2	C3	C4	C6	C8	C9	C15	C17	C18	C19	C20	C22	C25	C27	C29	C31	C32	C34	C35	C36	C37	C38	C39	C43	C44	C50	C53	C57	C58	C59	C60
C1							-1																									
C2					1							1	1													1			1			
C3																																
C4			1				1	1			1							1							1	-1			1			
C6							1	1																					1			
C8							1																									
C9																																
C15																													-1			
C17	1						1			1																						
C18							1																									
C19						1	1	-1																		-1		-1				
C20	1										1																		-1			
C22						1						1																	-1			
C25																																1
C27							1																									
C29							1																									1
C31							1																						1			
C32																	1		1													
C34						1	1																			-1						
C35							1																									
C36							1										1			1												
C37																	1		1													
C38							1										1															
C39																	1															
C43																										-1						
C44							-1																									
C50						1																										
C53						1	-1																									
C57							1																									
C58																																1
C59																																1
C60						1	1																									

Table E.4
Expert S3
Concept Connection Matrix

	C2	C4	C9	C10	C11	C13	C14	C17	C18	C20	C22	C23	C27	C28	C31	C32	C34	C37	C39	C43	C44	C47	C51	C53	C54	C57	C58	C61
C2								1																1		1		
C4			1									1									-1					1		
C9																					-1							
C10			1						1			1																
C11				1																								
C13																										1		
C14																					1							
C17			1						1																			
C18						1						1																
C20									1												-1							
C22										-1			1															
C23			1																									
C27												1									-1					1		
C28			1																									
C31			1									1									-1					1		
C32															1		1											
C34			1																									
C37															1		1											
C39															1		1											
C43																												
C44																												
C47																							1					
C51									1																			
C53									-1																			
C54									1																			
C57			1																		-1							
C58			1																									
C61																											1	

Table E.5
Expert S4
Concept Connection Matrix

	C4	C5	C9	C10	C12	C16	C18	C21	C22	C23	C24	C26	C28	C31	C32	C34	C35	C36	C38	C39	C40	C46	C47	C48	C49	C50	C51	C59	C62	C63	C64	C65
C4																																
C5												1																				
C9																																
C10			1																													
C12			1																													
C16			-1																													
C18										1		1																				
C21			1				1																									
C22																					-1											
C23			1																													
C24			1			1			1																							
C26			1							1																						
C28			1																													
C31			1																										-1			
C32														1															-1			
C34														1															-1			
C35														1																		
C36														1															-1			
C38														1																		
C39														1																		
C40			-1																													
C46					1																											
C47			1																				1									
C48																							1									
C49																							1									
C50																							1									
C51																																
C59			1																													
C62			-1																													
C63			1																										-1			
C64			1																													
C65																														1		

Table E.6
Expert S5
Concept Connection Matrix

	C2	C4	C8	C9	C14	C18	C23	C27	C28	C31	C36	C37	C38	C40	C42	C43	C44	C45	C47	C51	C57
C2							1														
C4			1	1																	
C8				1																	
C9																		1			
C14															1		1				
C18				1			1														
C23																					
C27							1														
C28				1																	
C31				1														1			
C36										1											
C37										1											
C38										1											
C40				1											1		1				
C42																	1				
C43																	1	1			
C44				-1																	
C45																					
C47				1		1	1														
C51																			1		
C57															1		1				

Figure E.7
Aggregate Map

	Venture Vulnerability	Venture Type	Venture Protection	Venture Maturity	Venture Market Understanding	Venture Growth Potential	Venture Financeability	Venture Credibility	Venture Attractiveness	Technology Potential	Technology Credibility	Technology Control	Revenue Potential	Required Financing	Required Cashflow	Required Capitalization	Proprietary Technology	Product Potential	Product Maturity	Product Life-cycle	Product Exit	Market Velocity	Market Growth Potential	Market Maturity	Market Forecast Credibility	Market Leadership Potential	Market Focus	Market Familiarity	Market Existence	Market Access
1 Venture Vulnerability									-0.175																					
2 Venture Type						0.175											0.170			0.175		0.175	0.169							
3 Venture Protection																														
4 Venture Maturity			0.175					0.169	0.699				0.185		0.175				0.360				0.170							
5 Venture Market Understanding																										0.190				
6 Venture Growth Potential									0.175						0.175															
7 Venture Financeability																														
8 Venture Credibility									0.344																					
9 Venture Attractiveness																														
10 Technology Potential									0.545									0.170					0.355							
11 Technology Credibility										0.170																				
12 Technology Control									0.190																					
13 Revenue Potential																														
14 Required Financing																														
15 Required Cashflow																														
16 Required Capitalization									-0.190																					
17 Proprietary Technology	0.175								0.345									0.345												
18 Product Potential									0.344				0.170										0.529			0.190				
19 Product Maturity								0.175	0.360				0.185		-0.175															
20 Product Life-cycle	0.175																	0.170	0.175											
21 Product Exit									0.190									0.190												
22 Market Velocity								0.175												0.005							0.170			
23 Market Growth Potential									0.545				0.185																	
24 Market Maturity									0.190							0.190						0.190								
25 Market Forecast Credibility																														
26 Market Leadership Potential									0.190														0.190							
27 Market Focus									0.175														0.339							
28 Market Familiarity									0.529																					
29 Market Existence									0.175				0.185									0.185								
30 Market Access																														
31 Management Quality									0.869														0.170				0.185			
32 Management Experience																									0.185					
33 Management Expectations																														
34 Management Credibility								0.175	0.345																					
35 Management Cooperation									0.360																					
36 Management Completeness									0.175																					
37 Management Communications																														
38 Management Commitment									0.175																					
39 Management Cohesiveness																														
40 Investment Cycle									-0.021																					
41 Industry Growth Potential									0.185				0.185										0.185							
42 Financing Type																														
43 Financial Resources									0.185																					
44 Financing Risk									-0.529																					
45 Financing Availability																														
46 Development Team Vulnerability												0.190																		
47 Development Team Quality									0.359									0.169					0.169							
48 Development Team Management																														
49 Development Team Experience																														
50 Development Team Credibility								0.175																						
51 Development Team Capabilities									-0.185									0.170												
52 Development Risk																														
53 Development Requirements								0.175	-0.175									-0.170												
54 Development Focus																		0.170												
55 Development Financing									0.185																					
56 Cash-flow Potential Credibility																														
57 Cash-flow Potential									0.530																					
58 Business Plan Quality									0.360															0.185						
59 Business Plan Existence									0.185																					
60 Business Plan Credibility								0.175	0.360																					
61 Business Plan Completeness																														
62 BOD Requirement									-0.190																					
63 BOD Quality									0.190																					
64 BOD Exist									0.375																					
65 BOD Completeness																														

Figure E.7 Continued
Aggregate Map

	Management Quality	Management Experience	Management Expectations	Management Credibility	Management Cooperation	Management Completeness	Management Communications	Management Commitment	Management Cohesiveness	Investment Cycle	Industry Growth Potential	Financing Type	Financial Resources	Financing Risk	Financing Availability	Development Team Vulnerability	Development Team Quality	Development Team Management	Development Team Experience	Development Team Credibility	Development Team Capabilities	Development Risk	Development Requirements	Development Focus	Development Financing	Cash-flow Potential Credibility	Cash-flow Potential	Business Plan Quality	Business Plan Existence	Business Plan Credibility	Business Plan Completeness	BOD Requirement	BOD Quality	BOD Exist	BOD Completeness
1 Venture Vulnerability																																			
2 Venture Type																																			
3 Venture Protection														0.175									0.170				0.345								
4 Venture Maturity		0.175	-0.196		0.195								0.175	-0.345																					
5 Venture Market Understanding																											0.345								
6 Venture Growth Potential																																			
7 Venture Financeability																											0.175								
8 Venture Credibility																																			
9 Venture Attractiveness																											0.196			0.196					
10 Technology Potential														-0.355	0.169																				
11 Technology Credibility														-0.196																					
12 Technology Control																																			
13 Revenue Potential																																			
14 Required Financing																											0.355								
15 Required Cashflow												0.169		0.339																					
16 Required Capitalization																											-0.176								
17 Proprietary Technology																																			
18 Product Potential																																			
19 Product Maturity																																			
20 Product Life-cycle														-0.176									-0.175				0.196								
21 Product Exist														-0.170													-0.176								
22 Market Velocity										-0.190																									
23 Market Growth Potential														-0.196											0.195		-0.176								
24 Market Maturity																											0.196								
25 Market Forecast Credibility				0.195																															
26 Market Leadership Potential																														0.175					
27 Market Focus														-0.355																					
28 Market Familiarity																											0.170								
29 Market Existence																																			
30 Market Access																														0.175					
31 Management Quality														-0.355	0.169																				
32 Management Experience	0.720		-0.196	0.830	0.195																						0.345					-0.190			
33 Management Expectations					-0.196																											-0.190			
34 Management Credibility	0.375													-0.360																					
35 Management Cooperation	0.190																															-0.190			
36 Management Completeness	0.719				0.175																														
37 Management Communications	0.514			0.345																												-0.190			
38 Management Commitment	0.534																																		
39 Management Cohesiveness	0.535			0.170																															
40 Investment Cycle												0.169		0.169																					
41 Industry Growth Potential																																			
42 Financing Type														0.169													0.196								
43 Financial Resources														-0.191	0.169																				
44 Financing Risk																											0.196								
45 Financing Availability																																			
46 Development Team Vulnerability																																			
47 Development Team Quality																	0.190				0.170														
48 Development Team Management																	0.190																		
49 Development Team Experience																	0.190																		
50 Development Team Credibility														-0.196			0.190				-0.196														
51 Development Team Capabilities																	0.169																		
52 Development Risk																					-0.196														
53 Development Requirements																					0.195				0.195										
54 Development Focus																																			
55 Development Financing																											-0.195								
56 Cash-flow Potential Credibility																																			
57 Cash-flow Potential												0.169		-0.196											0.195										
58 Business Plan Quality																														0.360					
59 Business Plan Existence																														0.175					
60 Business Plan Credibility																																			
61 Business Plan Completeness																												0.355							
62 BOD Requirement																																			
63 BOD Quality				0.195																												-0.190			
64 BOD Exist																																			
65 BOD Completeness																																	0.190		

E.1 Simulation Results

Trial	Average Percent Change for Relationship Weights Occurring with Frequency Greater Than 0.5	Average Percent Change for Relationship Weights Occurring with Frequency Less Than 0.5	Overall Percent Change to Map Node Adding Additional Subject
1	0%	17%	6%
2	10%	13%	8%
3	7.5%	14%	4%
4	6%	25%	1%
5	6%	18%	3%
6	7%	18%	2%
7	6%	30%	6%
8	1%	28%	1%
9	7%	17%	6%
10	6%	28%	4%
11	10%	18%	0%
12	11%	17%	3%
13	12%	17%	10%
14	13%	17%	14%
15	12%	17%	10%
Mean	7.6%	22%	5%

Appendix F –Lenders and Viability Questionnaire

Table F.1
Lender Questionnaire Data

Subject	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
1	5	4	5	5	5	5	5	5	5	5	5	5
2	2	1	3	2	1	1	3	1	1	1	2	1
3	5	5	5	4	5	5	4	5	5	5	5	4
4	4	4	5	4	5	4	4	4	5	4	5	5
5	5	4	5	5	5	5	4	5	5	4	5	4
6	5	4	4	5	5	5	4	4	4	4	3	3
7	4	4	3	3	4	3	4	2	4	2	3	3
8	5	4	5	5	5	4	5	5	5	5	4	4
9	5	4	5	5	5	5	4	5	4	4	4	5
10	5	5	4	5	4	5	5	5	5	4	5	5
11	4	3	4	5	4	3	3	4	4	4	5	3
12	5	4	4	4	4	4	5	4	4	4	4	5
13	4	2	4	5	4	3	4	4	4	5	4	4
14	5	4	4	5	5	5	4		5		5	5
15	3	2	4	4	5	3	4	3	3	4	3	5
Mean	4.40	3.60	4.26	4.40	4.40	4.00	4.13	4.00	4.20	3.92	4.13	4.06
Std Dev.	0.91	1.12	0.70	0.91	1.06	1.20	0.64	1.24	1.08	1.14	0.99	1.16
N	15	15	15	15	15	15	15	14	15	14	15	15

Table F.1 Continued
Lender Questionnaire Data

Subject	X14	X15	X17	X18	X19	X20	X21	X16	X22	X23	X24	X25
1	4	4	5	4	3	4	2	5	2	5	4	5
2	2	4	4	4	2	2	1	3	3	4	4	4
3	2	5	4	2	2	2	1	5	2	5	4	5
4	4	4	4	3	4	4	3	3	3	4	4	4
5	3	5	5	2	3	2	2	3	3	4	4	4
6	4	5	5	3	3	3	2	4	3	4	4	4
7	5	4	3	4	2	4	4	2	3	4	4	4
8	4	4	4	3	3	3	3	5	4	4	4	5
9	3	5	5	3	3	2	2	3	4	3	4	4
10	3	5	4	4	4	2	3	3	2	4	4	4
11	4	4	4	3	3	3	2	3	2	4	4	3
12	2	4	5	4	4	1	1	2	5	4	4	3
13	3	4	5	4	4	3	2	4	4			3
14	3	5	5	2	2	3	2	3	2	5	5	4
15	4	5	3	4	2	2	2	3	2	4	5	3
Mean	3.33	4.46	4.33	3.26	2.93	2.66	2.13	3.40	2.93	4.14	4.14	3.93
Std Dev.	0.90	0.52	0.72	0.80	0.80	0.90	0.83	0.99	0.96	0.53	0.36	0.70
N	15	15	15	15	15	15	15	15	15	14	14	15

Table F.1 Continued
Lender Questionnaire Data

Subject	X26	X28	X29	X30	X31	X32	X34	X35	X36	X37	X38	X40
1	5	2	2	3	5	4	4	3	4	2	4	1
2	4	4	2	2	3	4	4	4	2	2	2	4
3	3	1	2	1	2	4	2	4	2	3	3	2
4	4	2	2	3	4	4	4	3	4	4	4	2
5	4	2	2	2	4	3	2	2	2	2	3	3
6	4	4	4	2	4	2	4	2	3	2	5	2
7	4	3	2	2	4	3	2	3	2	3	3	2
8	4	2	2	2	4	3	2	3	2	3	4	3
9	5	2	1	2	2	3	3	3	2	4	4	2
10	4	4	4	4	4	4	3	3	3	3	3	4
11	4	2	1	2	4	3	3	2	4	4	2	2
12	4	2	1	3	2	2	3	2	4	4	2	2
13	4	3	2	1	4	4	3	3	3	3	2	2
14	4	4		3	4	3	2	2	2	2	5	4
15	2	2	4	3	2	2	2	3			1	2
Mean	3.93	2.60	2.21	2.33	3.46	3.20	2.86	2.80	2.78	2.92	3.13	2.46
Std Dev.	0.70	0.99	1.05	0.82	0.99	0.77	0.83	0.68	0.89	0.83	1.19	0.92
N	15	15	14	15	15	15	15	15	14	14	15	15

Table F.1 Continued
Lender Questionnaire Data

Subject	X41	X42	X43	X44	X45	risk	complex	capable	mgmt
1	4	2	4	4	3	2	5	5	5
2	4	2	4	2	2	4	2	4	4
3	2	2	2	2	2	4	3	3	4
4	4	4	4	3	3				
5	3	3	4	2	2	3	4	4	4
6	2	2	2	5	3	3	2	5	4
7	4	4	4	3	3				
8	4	4	4	3	3	4	3	4	4
9	3	3	4	4	5	3	4	4	4
10	4	4	4	3	4				
11	2	3	3	2	3				
12	4	2	2	2	2				
13	4	3	3	3	3				
14	4	3	4	4					
15	4	2	5	3	5				
Mean	3.46	2.86	3.53	3.00	3.07	3.28	3.28	4.14	4.14
Std Dev	0.83	0.83	0.92	0.93	1.00	0.76	1.11	0.69	0.38
N	15	15	15	15	14	7	7	7	7

F.1 Questionnaire Variable Assignments

Table F.2
Questionnaire - Variable Assignments

	Questionnaire Variables
Technological Capability (TCAP)	X_5, X_8, X_{17}, X_{23}, X_{25}
Technological Synergy (TSYN)	X_9, X_{12}, X_{40}
Absorptive Capacity (AC)	X_1, X_2, X_4, X_6
Management Quality (MQ)	X_3, X_7, X_{24}, X_{26}, X_{28}, X_{37}
Organizational Effectiveness (OEFF)	X_{29}, X_{30}, X_{31}, X_{32}, X_{34}, X_{36}
Technological Vulnerability (TVUL)	X_{14}, X_{15}, X_{16}
Technological Complexity (TCMPLX)	X_{11}, X_{18}, X_{19}, X_{22}, X_{41}, X_{42}, X_{43}, X_{45}

Note: Variable numbers begin at first questionnaire question after the demographics section.

F.2 Lender Questionnaire Analysis Assumptions

1. Based on the results investor technological viability model analysis, the assumption will be made that the structural model has validity.
2. Based on the design of the questionnaire, it is assumed that the questions used as measurement variables will factor to the model variables as expected.
3. The correlation of these measurement variables to the model variables, that is the factor loading, would be sufficiently high that a simple un-weighted means aggregation can be used to develop the model variables.
4. Individuals who responded have had some experience with early stage ventures. This final assumption has some support based on the demographic information, given the size of venture and loans involved.

Table F.3
Pearson Correlation Analysis
Lender Questionnaire Respondents[1]

	Technological Synergy	Absorptive Capacity	Technological Capabilities	Technological Vulnerability	Technological Complexity	Management Quality	Organizational Effectiveness
Technological Synergy	1.00						
Absorptive Capacity	0.77****	1.00					
Technological Capabilities	0.51**	0.83****	1.00				
Technological Vulnerability	0.22	0.44	0.51**	1.00			
Technological Complexity	0.33	0.27	0.29	0.24	1.00		
Management Quality	0.52**	0.68****	0.67***	0.47*	-0.1	1.00	
Organizational Effectiveness	0.19	0.24	0.26	0.11	0.43	0.20	1.00

Bartlett χ^2: 45.3****
* $p \leq 0.1$
** $p \leq 0.05$
*** $p \leq 0.01$
**** $p \leq 0.005$

[1] The questionnaire included measures for perceived management quality and perceived capability to successfully create the proposed product. These were intended as measures of perceived quality potential. However, the number of cases where there was no response from the subject lowered the N of this question to less than seven responses and therefore was not included in the analysis. The perceived risk of the venture was included as a measure of viability (assuming higher perceived risk indicated lower perceived viability). This data is also omitted due to small N, however, analysis indicated that the direction of correlation is negative as expected.

Figure F.1
Technological Viability Relationship Diagram
Lender Subjects

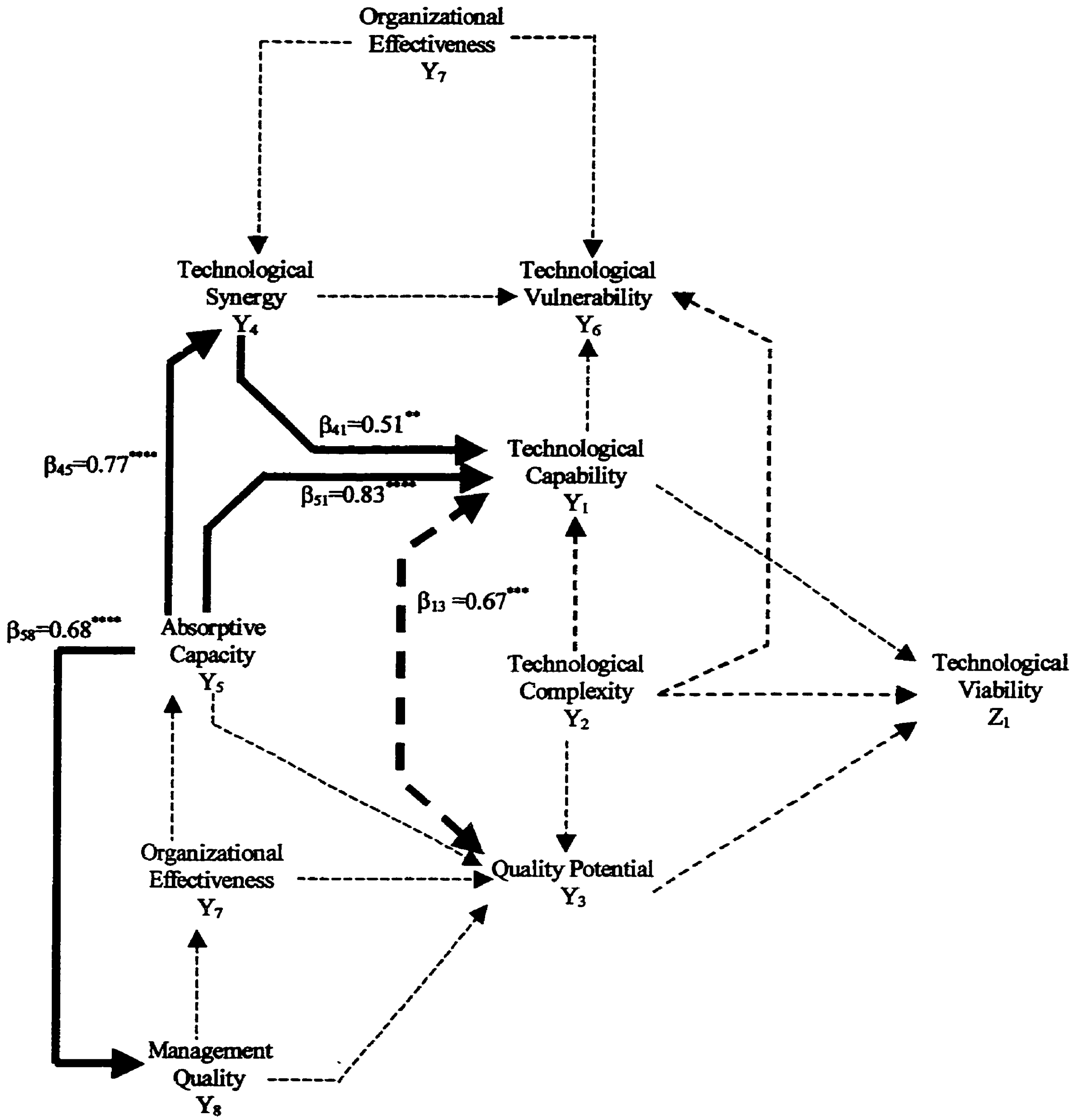


Table F.4
Summary of Investors and Lenders Significant Correlation

Relationship		Investor	Lender
Absorptive Capacity - Management Quality	β_{58}	0.5****	0.68****
Absorptive Capacity - Organizational Effectiveness	β_{57}	0.46***	--
Organizational Effectiveness - Management Quality	β_{78}	0.61****	--
Management Quality - Technological Capability		0.60****	0.67***
Organizational Effectiveness - Technological Synergy	β_{74}	0.4*	--
Absorptive Capacity - Technological Synergy	β_{45}	0.5****	0.77****
Technological Synergy - Technological Capability	β_{41}	0.73****	0.51**
Absorptive Capacity - Technological Capability	β_{51}	0.57****	0.83****

* $p \leq 0.1$
** $p \leq 0.05$
*** $p \leq 0.01$
**** $p \leq 0.005$

F.3 Questionnaire Cover Letter

The University of Waterloo

Faculty of Engineering
Department of Management Science
Waterloo, Ontario, Canada
N2L 3G1
Tel. and Fax: (519) 888-4567

Dear Sir/Madam;

The University of Waterloo's Institute for Innovation Research is currently undertaking research into the assessment of new, knowledge-intensive technology-based enterprises. These ventures present unique assessment issues, and the institute's research goal is to provide techniques and tools to aid in this endeavor.

As part of this research program, we are undertaking to model the decision process used when assessing this class of ventures at the early stages of their development. The objectives are to enhance understanding of this process and to set the stage for the future development of intelligent decision support tools.

To further this research we are requesting your participation by completing the attached questionnaire. The questionnaire should take less than 30 minutes to complete and may be returned in the envelope supplied. This survey has been reviewed and received ethics clearance through the Office of Research Ethics at the University of Waterloo. Any questions or concerns about the study or your participation can be directed to that office at 519-888-4567, Ext. 6005.

All completed questionnaires are anonymous, and the identity of participants will remain confidential. All results reported from this research will be aggregated and no individual responses will be used. Upon completion of this study, the results will be made available to the participants upon request. If you have any questions concerning this questionnaire or our research please contact Douglas Sparkes at (519) 888-4567 x 5381.

Thank-you for your participation

Sincerely,

Douglas Sparkes   Dr .Paul Guild

F.4 Lender Questionnaire

Thank you for participating in this phase of our research into investment decision making. Your responses will remain confidential and any reported findings will contain aggregated results only. Before beginning, please tell us a little about yourself.

How long have you been associated with this organization?	☐ Less than 1 Year ☐ 1 to 5 Years	☐ 6 to 10 Years ☐ 11 to 15 Years	☐ 16 to 20 Years ☐ More than 20 Years
What is your highest level of education?	☐ High School ☐ College Diploma	☐ Undergraduate Degree ☐ MBA	☐ Masters ☐ Ph.D.
How long ago did you finish your formal education?	☐ Less than 1 Year ☐ 1 to 3 Years	☐ 4 to 6 Years ☐ 7 to 10 Years	☐ 11 to 15 Years ☐ More than 15 Years
Which area of study best describes your educational background?	☐ Arts ☐ Science	☐ Business ☐ Engineering	☐ Mathematics ☐ Other ________
What is the typical company size to which you provide loans?	☐ 1-5 people ☐ 6-10 people	☐ 11 - 20 people ☐ 21 - 50 people	☐ 51 - 75 people ☐ more than 75 people
How long have you been involved in the evaluation of small companies? (Small = annual sales less and $2 Million and less than 20 employees)	☐ Less than 1 Year ☐ 1 to 3 Years	☐ 3 to 5 Years ☐ 5 to 10 Years	☐ 10 to 15 Years ☐ more than 15 Years
How many small ventures do you assess in a typical year? (Small = annual sales less and $2 Million and less than 20 employees)	☐ 1 - 10 ☐ 11 - 25	☐ 26 - 50 ☐ 51 - 75	☐ 76 - 100 ☐ more than 100

What industry sector would you consider to be most typical of the technology-based ventures that are familiar to you?

☐ Consumer Electronics	☐ Biotechnology	☐ Telecommunications	☐ Industrial Products
☐ Military / Aerospace	☐ Software	☐ Information Systems	☐ Other ____________

- In the following sections we would like your opinion concerning a number of issues which may arise when assessing a (knowledge-based / technology-based) venture.
- Please recall your most recent experience of assessing a (knowledge-based / technology-based) venture for the purpose of granting a loan and indicate your level of agreement with these statements or issues.
- Also, please keep in mind that we are interested in very small, early stage ventures having few than 20 members and annual sales less than $2 million.

The following statements concern the experience and expertise found within (ventures). Please indicate the level of importance you believe is associated with each of these statements by circling a number that reflects your opinion.

	No Importance	Little Importance	Moderate Importance	Great Importance	Extreme Importance	No Opinion
Evidence that the venture has the requisite knowledge for the development of its proposed product(s).	1	2	3	4	5	☐
Broad distribution of technical knowledge within the venture.	1	2	3	4	5	☐
Evidence that the product(s) development team has experienced leadership.	1	2	3	4	5	☐
Evidence that the venture has the knowledge required for deployment and support of its proposed product(s).	1	2	3	4	5	☐
Evidence that there is experience behind the planning and controlling of the development project(s).	1	2	3	4	5	☐
Identification of those individuals who are critical to the design and development of the product(s).	1	2	3	4	5	☐
Depth of senior management experience and expertise with the technologies comprising its proposed product(s).	1	2	3	4	5	☐
Identification of the technologies required for the creation of the new venture's product(s).	1	2	3	4	5	☐
Determining the availability within the venture of the resources required for the creation of the venture's product(s).	1	2	3	4	5	☐
Determining the maturity of the technologies that will provide potential competitive advantage.	1	2	3	4	5	☐
Identification of the technological risks associated with the development of the venture's product(s).	1	2	3	4	5	☐
The availability of infrastructure, other technologies and/or products that support the venture's product(s) in its target market.	1	2	3	4	5	☐

The following statements concern issues associated with **(venture)** vulnerability. Please indicate your level of **agreement** with each of these statements by circling a number by circling a number that reflects your opinion.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	No Opinion
Technologies crucial for a product to be competitive must be controlled by the venture.	1	2	3	4	5	☐
Individuals critical to the design and development of the product(s) must be clearly identified.	1	2	3	4	5	☐
Proprietary technologies must be controlled by the venture.	1	2	3	4	5	☐
Ventures that do not possess the experience and expertise to design and develop its product(s) have unacceptable investment risk.	1	2	3	4	5	☐
Ventures that require development of new technologies have unacceptable venture investment risk.	1	2	3	4	5	☐
When critical experience and expertise is concentrated in a few individuals, the venture is vulnerable to failure.	1	2	3	4	5	☐
Ventures whose product(s) are based on existing technologies are likely to succeed.	1	2	3	4	5	☐
Ventures must keep the research required to develop their product(s) to a minimum.	1	2	3	4	5	☐
Ventures with technologically complex product(s) have unacceptable venture investment risk.	1	2	3	4	5	☐

In terms of planning quality, please indicate your level of agreement with each of these statements by circling a number by circling a number that reflects your opinion.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	No Opinion
Without realistic product development planning, venture investment risk is unacceptable.	1	2	3	4	5	
Without a budget control scheme in place during product(s) development, venture investment risk is unacceptable.	1	2	3	4	5	
Clearly defined product development milestones reduce venture investment risk.	1	2	3	4	5	
A management process for product(s) design and development decisions reduces venture investment risk.	1	2	3	4	5	
A process for documentation management during product(s) design and development reduces venture investment risk.	1	2	3	4	5	
Involving individuals critical to product(s) development in other projects at the same time increases venture investment risk.	1	2	3	4	5	

Please consider the following statements about organizational factors and indicate your level of agreement with each of them by circling the number that best reflects your opinion.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	No Opinion
A bureaucratic management increases venture investment risk.	1	2	3	4	5	☐
Over-extension of critical design and development team members increases venture investment risk.	1	2	3	4	5	☐
The ability to make decisions quickly reduces venture investment risk.	1	2	3	4	5	☐
The organization of the product(s) design and development team contributes to cost overruns.	1	2	3	4	5	☐
The product(s) design and development team must be small to be effective.	1	2	3	4	5	☐
The organization of the product(s) design and development team contributes to delays.	1	2	3	4	5	☐
Concentration of product(s) technology experience and expertise in the senior management increases venture investment risk.	1	2	3	4	5	☐
A senior management who often makes 'snap' decisions increases the risk of failure.	1	2	3	4	5	☐
Having the technologies to support design, development and deployment of its product(s) has no impact on failure risk.	1	2	3	4	5	☐

Please consider the following statements regarding technological complexity and indicate your level of agreement with each of them by circling a number which best reflects your opinion.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	No Opinion
Ventures with product(s) based on new technologies have increased investment risk.	1	2	3	4	5	☐
Ventures with product(s) having only a few key technologies have reduced investment risk	1	2	3	4	5	☐
Ventures with product(s) based on established technologies have reduced investment risk.	1	2	3	4	5	☐
To maintain their competitive advantage, ventures must allocate as many resources as possible to research and development.	1	2	3	4	5	☐
The number of technologies required to create a venture's product(s) is an indication of investment risk.	1	2	3	4	5	☐

Finally, please continue to recall your most recent experience of assessing a (venture) for the purpose of granting a loan as you answer the following questions.

	Very Low	Low	Equal (50-50)	High	Very High	No Opinion
How would you rank the risk of this venture?	1	2	3	4	5	☐

	Not at all complex	Not very complex	Neutral	Complex	Very Complex	No Opinion
Did you consider the venture's product or service to be technically complex?	1	2	3	4	5	☐

	Very Weak	Weak	Neutral	Strong	Very Strong	No Opinion
Did you consider the venture to have the capabilities to crease the proposed product or service?	1	2	3	4	5	☐
How would you describe the overall management quality of the venture?	1	2	3	4	5	☐

Thank you for participating in our study.

F.5 Follow-up Letter

The University of Waterloo

Faculty of Engineering
Department of Management Science
Waterloo, Ontario, Canada
N2L 3G1
Tel. and Fax: (519) 888-4567

Dear Sir/Madame

Recently, the Institute for Innovation Research sent you a questionnaire as part of our investigation into new venture assessment practices. We would greatly appreciate your response within the next two weeks in order to be included in this study.

If you have already completed and returned this questionnaire, please disregard this note and accept our thanks.

Thank-You,

Doug Sparkes

Appendix G Ventures and Viability

To begin the discussion of ventures and viability, some concepts from control theory are discussed. The primary interest when considering a system is the relationship between the inputs and outputs in order to determine if system goals are being achieved (Brogan, 1982). Mathematically, a system may be considered as a mapping or transformation W: $u \rightarrow y$.

A common approach for describing complex, multiple input, multiple output (MIMO) systems is through the use of state-variables, x_i . These are the minimum set of parameters that completely define a system's status at any instant of time (Brogan, 1982). Therefore, if at any time, $t_0 \in T$, the values of the state variables, x_i (t_0) are known, then the system output, y (t_0) and the values x_i (t) can be uniquely determined provided the input $u_{[t0,t]}$ (t) is known.

The implication of this is that there are transformations, *g* and *h*, which maps the elements (t_0, t_1, $x(t_0)$, $u[t_0,t_1]$) to the state variables and outputs,

$$x(t_1) = g(t_0, t_1, x(t_0), u[t_0, t_1])$$
$$y(t_1) = h(t_1, x(t_1), u(t_1))$$

It can be shown (e.g.: Bajpai et aL., 1980; Brogan, 1982) that the state of a system at any time, t, is the state at t_0 plus the state trajectory (the graph of x(t) versus t) for the period [t_0, t]. This leads to the common representation of a system,

$$\lim_{\Delta t \to 0} \frac{\Delta x(t)}{\Delta t} = x' = f(x,u,t)$$
$$y(t) = L(x,u,t)$$
$$u(t) = U(x,t)$$

here the term u = *U*(x) represents the inclusion of feedback in the system, where state variables are being feed back to the inputs.

Now consider a simple linear system of arbitrary dimension whose dynamics are represented by;

$$x' = Ax + Bu$$
$$y = Lx$$

where A is a matrix defining the system structure and B is a vector defining the system inputs. Efforts to control such a system are based on a control law (e.g.: Palm, 1983) typically expressed as $u = Kx$. Simply stated, for a linear, constant coefficient system, there exists a control strategy, K, satisfying u = Kx. That is, input u (or inputs is the case of MIMO systems) can be determined from the control law K and measurement of the systems current states that will result in a stable system. Optimal control theory is based on determining the control law solution that optimizes a performance index, such as minimizing energy or time.

In practice, all states of a system may not be available for measurement and incorporation into the control. In other words, these states may be said to be unobservable. Thus, development of a control must also include the creation of an 'observer' or 'estimator' that is used to derive the unobserved states. For example, if a system requires position and velocity as states, but only velocity is observable then position can be estimated by integrating velocity.

In essence, the estimator attempts to model the system's dynamics such that its future states can be determined for application in the control. As can be seen, the control strategy for a system, K, can have may values, depending on what is observable, what is estimated and the performance criteria. Therefore, there exists a set of potential controls, sometimes referred to as regulators, that define a regulation space, R_G, where $R_G = \{K_i\}$. In terms of optimal control, the choice of control strategy becomes one of determining the optimum strategy from this space.

Nonlinear Systems

So far the discussion has focussed on simple linear systems, however, in reality most systems are nonlinear. Therefore the issue of control must be extended to nonlinear systems of arbitrary complexity, represented as $x' = f(x,u,t)$. Further, the control 'gain' used in the constant coefficient, linear system control law may now themselves be nonlinear elements.

There are many properties of linear systems which do not extend to nonlinear systems (Shinners, 1983).

1. Superposition, if $C_1(t)$ is the response of a linear system to input $r_1(t)$, and $C_2(t)$ is the response to $r_2(t)$, then $a_1r_1(t)+a_2r_2(t) \rightarrow a_1C_1(t)+a_2C_2(t)$. This property does not apply to nonlinear systems.

2. Stability. Stability in linear systems may be shown to be dependent only on the system's parameters. In the case of nonlinear systems, stability is a more complex concept and may depend on initial conditions and input characteristics as well as the system parameters[1]. Thus, a nonlinear system that exhibits stability with one type of input may not exhibit stability with another. Further, these systems may exhibit oscillations of fixed amplitude and period, which depending on convergence or divergence may be considered to be stable or unstable. Often stability must be considered in terms of acceptable levels of limit cycles.

3. In linear systems, interchanging the position of cascaded elements does not affect system behaviour. Hence a linear is relatively insensitive to its structure. This is not the case for nonlinear systems where the rearrangement of nonlinear cascaded elements may have a major impact on the system's behaviour.

[1] This leads to the concept of stability as defined by Liapunov. (Alternate spelling Lypunov)

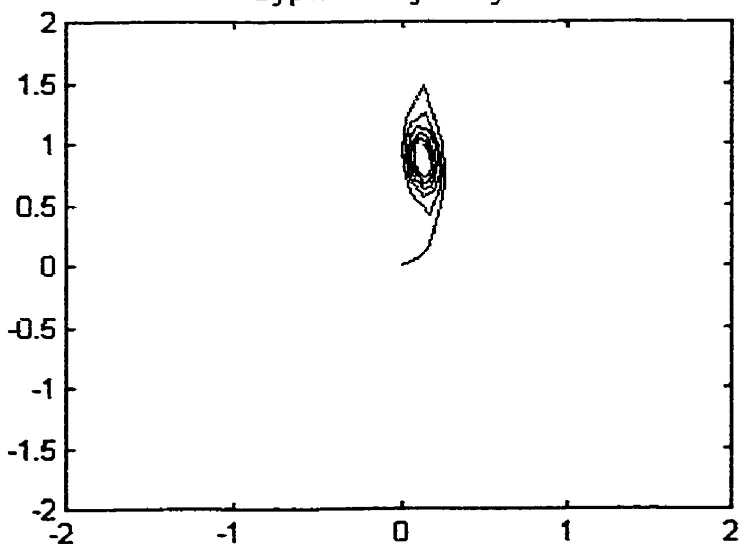
4. Hysteresis. Usually associated with different system trajectories dependent on the 'direction' of the input(s). A special case is when the response of the system to a small change in input may lead to a discontinuous change in the system behaviour[2].

The Notion of Trajectories

When considering the dynamics of a system, linear or nonlinear, the concept of trajectories emerge. If a system's dynamics are represented by $x' = f(x,u,t)$ then at any time, t, it may be completely defined by its states, x. (whether observable or not). Thus, at time t_0, the state of a system is defined by $X_0 = \{ x_1^{t_0}, x_2^{t_0}, \ldots, x_n^{t_0} \}$. In terms of the system's state-space this defines a point in that space. As the system evolves in time, a series of state points are generated, defining the system's state trajectory.

A common approach to examining these trajectories is through phase portraits, as shown for example in Figure G.1. A phase plane is defined as the plot of a state variable against its velocity.

Figure G.1
Typical Trajectory.



[2] This is related to bifurcations and catastrophes.

Stability

As discussed, for simple linear systems, the concept of stability is relatively straightforward. However, when considering complex nonlinear systems the concept of stability must also be revisited. A common approach to assessing stability is through the application of Liapunov stability criteria. This approach is based on determining the stability of a dynamic system through generalization of energy requirements. There are two general methods attributed to Liapunov.

The first method is for cases where a differential equation of the system can be solved. In this case, stability of the system is determined from the solution. The second method aims to determine stability without having to solve differential equations, an important feature for highly complex systems.

For Liapunov's second method, a function of the state variables is formed that has special properties. This function can then be compared to the sum of kinetic and potential energy and the derivative of the function with respect to time. If the time derivative of this function can be shown to be negative then the system is referred to as "asymptotically stable".

Viable Systems

So far the discussion of system dynamics has considered systems that are not evolving over time. In other words, the system parameters are not in themselves changing over time. Most analysis makes the implicit assumption that the structure of the system under consideration is time invariant. Viability theory (Aubin, 1991) examines the case on which the system itself is evolving over time under conditions of uncertainty. In terms of stability, this implies that a system that is stable at t_0, may cease to be stable at time t_1. Further, the nature of the system's evolution may not be known.

As discussed by Aubin (1991), viability theory provides a mathematical framework for examination of the evolution of macro-systems (large-scale, complex systems). These systems have three common features.

1. They have a non-deterministic engine of evolution. In other words, the paths of evolution for the system are not known in advance and at any instant several potential evolutionary paths may exist.

2. Viability is concerned with systems that must obey constraints at each instant. Violation of these constraints will result in a 'death penalty' for the system.

3. The inertia principle stating that controls for the system are changed only when the viability (re: death penalty) of the system is threatened.

The main purpose of viability theory is to explain the evolution of a system, governed by non-deterministic dynamics and viability constraints. Like Liapunov's second method, viability theory attempts to determine a system's viability constraints and regions without actually having to solve the system. When considering a system from the point of view of viability theory, it is important to consider its viability constraints. Considering a system defined as;

$$x'(t) = f(x(t), u(t))$$
$$u(t) \in U(x(t))$$

the first equation defines how the input to the system, u(t), results in the state of the system. These states are regarded as being the outputs of the system. The second equation, referred to as an inclusion, defines how the state output is feed back to the system input. This results in a set-valued map, U: X→Z referred to as an 'a priori feedback'. Z is a finite dimensional space defining the range of the control u(t). This describes the state-dependent constraints on the controls of the system under consideration. A solution to this system is a function t→ x(t), satisfying this system for some control t→u(t).

Viability constraints are described by a closed subset, K, of the state space. These are intended to describe the viability of the system because outside of K, the state of the system is no longer viable. This subset is viable under the control system described by f and U, if for every initial state, $x_0 \in K$, there exists at least one solution to the system starting at x_0 that is viable in the since that $\forall t \geq 0, x(t) \in K$ Therefore, the first problem is to characterize these subsets, and to have some value this must be achieved without solving the system and testing each solution's viability.

When considering a system described by f and U, and having viability constraints K, there exists a regulation map R_K that maps any state, x, to the subset $R_K(x)$ consisting of controls $u \in U(x)$. If, for every $x \in K$ there exists at least one viable control $U \in R_K(x)$, it can be said that K is the viability domain of the system.

To illustrate this further, consider the earlier discussion of linear systems and stability. It was pointed out that a set of controls exist defining a control law, u=Kx. Related to this is the concept of stability, in which the system output must be bounded to be considered as stable. Thus for the system there exists a range of states, x(t), for which the system will be stable, hence viable. Similarly, the range of controls will included in the regulation map R_K.

Ventures as Systems

The first question to be considered is whether a venture may be viewed from the perspective of viability theory. Many authors (e.g.: Beer, 1980) have discussed organizations as systems. Further, these systems may be viewed as interacting with their environments, e.g.: markets, suppliers, government regulations, and having many feedback paths. From the various internal and external interactions associated with a venture, it can easily be seen that a venture system will have very high complexity and many non-linearities. The interactions of the various individuals within the venture alone will introduce complexity and nonlinearity to the extent that the system may be viewed as intractable in terms of modelling.

From a theoretical perspective, a venture viewed as a complex, nonlinear macro-system having several interaction subsystems. Overall this system may be represented as $x' = f(x,u,t)$ where x' is the system velocity, resulting in a trajectory for the venture, and x are the venture-system states and u are the inputs into this venture-system. The idea of venture trajectories is not unlike those proposed by Abernathy and Utterback (1988) and Dosi (1982) among others.

Having assumed that at a conceptual level a venture-system may be represented as a function of state variables, the next question that arises is if this type of system has characteristics common to viability problems. Returning to Aubin's (1991) features of macro-systems exhibiting viability characteristics, venture's can be examined.

1. Existence of a non-deterministic engine of evolution. By non-deterministic it is implied that at each instant there are several available, feasible, evolutions that depend upon the present state of the system and possibly its evolutionary history. Unlike the deterministic paradigm that asserts that the evolution of macro-systems can be predicted, this view concedes the existence of non-deterministic disturbances and errors on the system resulting from incomplete information.

   In the case of both established and early-stage ventures, the entire concept of strategy formulation (e.g. Porter, 1991) lies in the belief that at any point in time there are opportunities and/or threats that provide the venture with several available and feasible future development paths. Further, these paths are subjected to many non-deterministic factors, for example competitor and consumer reactions to actions taken by the venture. In the case of new early-stage ventures, this is further compounded by the uncertainties introduced by evolving internal relationships.

2. The second characteristic, the 'death penalty' feature is obvious in the case of ventures. At each instant there are constraints, either known or unknown, which must be obeyed by the venture-system. The penalty for not remaining within the viability region defined by these constraints is that it may cease operations and/or become

insolvent, i.e: go into bankruptcy. In the case of ventures, there are another group anecdotally referred to as the 'living dead'. These ventures may continue to operate, but seem to be constantly within the reaches of collapse. An interesting speculation is that these ventures exist at or neat the viability region boundary.

3. The third characteristic to be considered is the so-called 'inertia principle'. This states that the controls of a system are changes only when system viability (recall the death penalty) is threatened. In terms of venture-systems, it would be very uncommon to have operational policies and strategies changing rapidly. The level of confusion and effort that this would require would surely lead to the venture's demise. Rather, venture policies and strategies typically remain constant with periodic reviews. These reviews only result in changes when conditions, either internal or external, indicate that change is required in the best interests of the venture.

   An interesting implication of the inertia principle may be seen in the literature on venture evolution. Several authors (e.g.: Zimmerer and Scarborough, 1996) have described the periods of turmoil ventures pass through as they evolve. Often, if a venture is to successfully pass through these transition points, and survive, major internal changes to the management, internal operational policies and strategies are required.

Early-Stage Ventures and Assessment

Of particular interest in this research is the assessment of early-stage technology-based ventures. In terms of assessing such a venture-system's viability the 'tracking property' of viability theory has some interesting implications.

The Tracking Principle

As discussed by Aubin (1991), consider a system of two differential inclusions;

$$x'(t) \in F(x(t), y(t))$$
$$y'(t) \in G(x(t), y(t))$$

where F maps F:X x Y→X and G:X x Y→Y. Further, consider that there exists a map, H:X→Y referred to as an observation map. The tracking property of viability theory may be stated as:

> For every $x_0 \in$ Dom (H) and every $y_0 \in H(x_0)$ there exists solutions (x(),y()) to this system of differential inclusions such that $\forall t \geq 0, y(t) \in H(x(t))$.

Viability theory further states that the tracking property is equivalent to the fact that the graph of H is a viability domain of (x,y) →F(x,y) x G(x,y). The tracking property is therefore equivalent to saying that H is a solution to the system of partial differential inclusions. As further discussed by Aubin (1991), since there are links between F, G, and H they can be used in several ways.

1. Knowing F and H, find G or selections of g of G such that the tracking property holds. This is the so-called 'observation' problem.
2. Knowing G, sometimes referred to as the exo-system, find F or selections f of F such that the tracking property holds. This is the so-called 'tracking' problem.
3. Knowing F and G, find the observation map, H, that satisfies the tracking property.

Further, the tracking property states that there exists a solution to the 'reduced' differential inclusion $x'(t) \in F(x(t), h(t))$ such that (x(),y(): = h(x())) is a solution to the initial system of differential inclusions. Thus, knowledge of the observation map, H, permits the system to be sub-divided.

Observation and Decomposition

The idea of the observation problem, as described by Aubin (1991), is to observe solutions of a complex system, $x'(t) \in F(x(t), y(t))$ by a system, $y'(t) \in G(y(t))$., where G: Y→Y provides simpler dynamics. This permits highly complex systems, with high dimensionality, to be observed by simpler systems. This simpler system (the system model) is created to provide explanations of the evolution of the unknown system, and can be shown to be valid through the tracking property. (See Aubin (1991) Chapter 8). From this point of view, evolution of knowledge about a system defined by $x'(t) \in F(x(t), y(t))$ amounts to increasing the observation space and modifying or replacing the observation model, $y'(t) \in G(y(t))$.

The tracking property is also of interest in that it permits the decomposition or systems and the hierarchy of subsystems. Hierarchical decomposition can occur whenever the observation map is a composition product of several sub-maps, determining successive levels of hierarchy. The evolution of each level is linked to the state of the lower level, and is regulated by controls depending upon the evolution of the lower level state control.

The Tracking Principle and Venture Assessment

The tracking property of viability theory has interesting implications for venture assessment and questions related to the use of assessment criteria. In terms of the observation property, this provides insight into the use of different sets of assessment criteria by various assessors. In essence each of them has constructed a model of the actual venture-system which attempts simplify the systems dynamics and make it manageable. As the assessor increases the level of knowledge about the venture-system, the model can also be modified. As there is no unique observation model or observation map between the complex venture-system and the model created by the assessor, it is not surprising that there will be different sets of criteria involved for individual maps.

Another aspect of the tracking property that of interest when considering the assessment of new early-stage ventures is decomposition. As the venture-system has high dimensionality and consists of complex set of interactions, it is important to be able to decompose the system and assess viability at lower levels. In the case of early-stage technology-based ventures there is literature that indicates that technological viability is a critical consideration when assessing these venture. The decomposition property permits examination of this aspect of viability, while acknowledging that there will be other aspects of the system which are important.

Early-Stage Venture Viability

To determine the viability constraints, it is necessary to have a model of the venture-system. Beginning with the project execution model (K.G. Cooper, 1993), extensions may be made that provide insight into new venture viability assessment. For simplicity, it is assumed throughout this analysis that the various evolutionary phases occur sequentially, with little concurrency, for ventures of the size and age being considered here. A further assumption is that the product or service definition at the end of the formulation phase is stable enough that the amount of effort can be identified. With this model as a basis, several concepts may be identified that will have a significant development phase impact. Specifically, technological capability, technological complexity and quality potential.

Cooper's model, Figure G.2, implies that as rework is discovered in the system it is simply feed back for re-execution. This appears to overlook the tendency for increased task interdependence as technological complexity increases, and hence the potential for the rework to have a 'ripple' effect through the development process. In the proposed model, this is represented by rework effort penalty, which accounts for the additional effort as the discovery of rework is delayed.

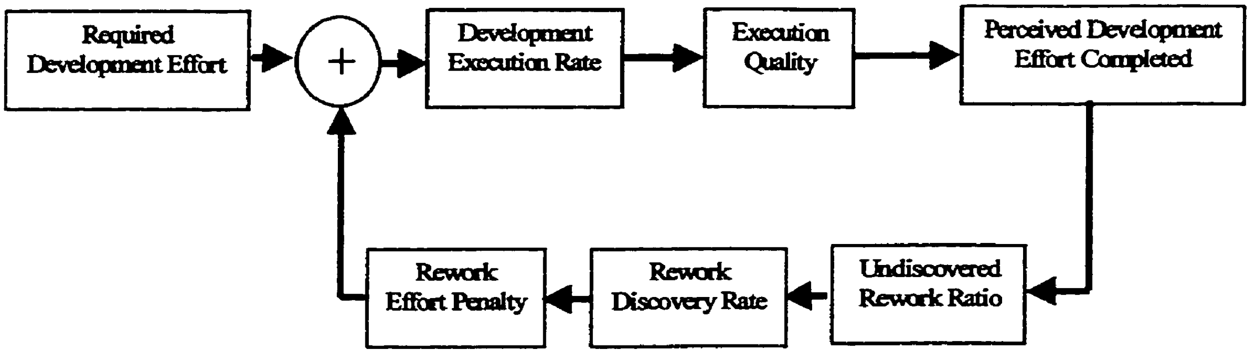
Based on the issues identified, the following relationships may be identified in the development phase model.

Required Effort $\rightarrow f$ (complexity)
Execution Rate $\rightarrow f$ (complexity, capabilities)
Execution Quality $\rightarrow f$ (complexity, capabilities, quality potential)
Rework Ratio $\rightarrow f$ (complexity, capabilities, quality potential)

Rework Discovery Rate → f (complexity, capabilities, quality potential)

Rework Effort Penalty → f (complexity)

Figure G.2
Development Phase Execution Model



As indicated by these relationships, technological viability is defined as consisting of three major components; technological capability, technological complexity and the venture's potential to execute a high quality development phase, referred to here as development quality potential. In terms of systems and viability theory, these components may be considered to define sets of state variables and associated constraints that must be estimated when determining system technological viability.

The first of these components, technological capability, may be decomposed into three interrelated issues; technological synergy, absorptive capacity, and technological vulnerability.

Technological Capability → g (technological synergy, absorptive capacity, technological vulnerability)

Technological Complexity → g(technological variety, technological maturity)

Quality potential is defined as the ability of the venture to develop a product with minimal energy, and hence is a function of the organization's effectiveness and efficiency in resource allocation and usage. Therefore it is defined as having two dimensions, management quality and organizational effectiveness.

$$\text{Quality Potential} \rightarrow g\ (\text{organizational effectiveness, management quality})$$

Summary of Viability Postulates

In summary, four basic postulates have been put forward that serves as the basis for developing a viability assessment framework.

1. A venture can only evolve along trajectories that are viable within its technological capabilities. In other words, a venture cannot follow paths that require technological capabilities that it does not possess or cannot sustain.

2. A venture can only remain viable as long as the technologies upon which it is based remain viable.

3. As system complexity increases, and hence system uncertainty, the number of potential technological trajectories also increases, with the possibility of a venture's movement outside its viability region.

4. A venture can remain viable only if it has the capability to control the allocation of resources and effort such that total energy is minimized. In other words, this is a function of the efficiency and effectiveness of the venture in terms of its development process.

Proposed Viability Constraints

Based on these postulates and the relationships identified in the development stage venture model, the following set of viability constraints is proposed. For this discussion, it will be assumed that ventures may be described by what Aubin (1991) describes as 'functional viability'.

As discussed, system evolution is defined by a set of differential equations or inclusions, which describe the velocity of the states at each instant of time. Further, this velocity is dependent upon the system state at that very instant. In some cases, referred to as functional differential inclusions, the state velocity also depends upon the history of the system's evolution up to a point in time. This approach permits the inclusion of system events and characteristics such as delays, anticipation, cumulated consequences into its dynamics. From the perspective of venture assessment, this facilitates the inclusion of many venture characteristics, for example the cumulative effect of poor hiring decisions.

In terms of functional viability, viability constraints are also dependent upon the history of the evolution of the system. As discussed by Aubin (1991), this leads to the characterization of a system's viability by a 'functional tangential condition'. This states that for any past evolution there exists at least a velocity tangent to the set of evolutions satisfying the functional viability constraints. In practical terms, what does this mean in terms of venture assessment?

Consider the first viability postulate: a venture can only evolve along trajectories that are viable within its technological capabilities. In other words, a venture cannot follow paths that require technological capabilities[3] that it does not possess or cannot sustain. Based on the model, this requires the following initial conditions for a venture.

1. Synergy: for $t = t_0$: Available Technology Base $\geq$ Required Technology Base
2. Absorptive Capacity: for $t = t_0$:
   Available Knowledge Base $\geq$ Required Knowledge Base

As the system evolves, the available knowledge and technology base must remain at least 'tangent' to the requirements. This results in the next set of constraints:

3. Synergy: $\dfrac{\partial(Available\_Tech\_Base)}{\partial t} \geq \dfrac{\partial(Required\_Tech\_Base)}{\partial t}$

[3] Within these constraints, required technology and knowledge is defined as the minimum set essential for product realization.

4. Absorptive Capacity:

$$\frac{\partial(Available\_Knowledge\_Base)}{\partial t} \geq \frac{\partial(\mathrm{Re}\,quired\_Knowledge\_Base)}{\partial t}$$

5. Technological Vulnerability: $\frac{\partial(Tech\_Control)}{\partial t} \geq 0$

Note that while no initial condition is specified for technological vulnerability, it does appear as an evolutionary constraint. This implies that initially the venture must have access to its required technologies, then as it evolves any associated vulnerability must not be increasing. This condition is closely related to the technology base constraint in that an increasing vulnerability in all likelihood will also be reflected in problems maintaining the required technology base.

The next set of constraints implied by the model is associated with technological complexity and its risk factors. These indicate that all viable trajectories require that these complexity factors be tangent or decreasing. Intuitively, no venture-system may remain viable for long if these requirements are increasing over time.

6. Complexity: $\frac{\partial(Breakthrough\_Risk)}{\partial t} \leq 0$

7. Complexity: $\frac{\partial(Integration\_Risk)}{\partial t} \leq 0$

8. Complexity: $\frac{\partial(Obsolecence\_Risk)}{\partial t} \leq 0$

The final set of constraints relates to quality potential. In terms of initial conditions, the venture-system requires a minimum level of quality potential, hence its components must be greater than a minimum, non-zero, level. As the venture evolves, the constraints require that the effectiveness of the venture in terms of resource allocation and communications be increasing over time. Similarly, the management quality must also be increasing over time.

9. Quality Potential: for $t = t_0$:

$$Organizational\_Effectiveness \geq \min(Organizational\_Effectiveness) > 0$$

10. Quality Potential: for $t = t_0$: $ManagementQuality \geq \min(ManagementQuality) > 0$

11. Quality Potential: $\dfrac{\partial(Organizational\_Effectiveness)}{\partial t} \geq 0$

12. Quality Potential: $\dfrac{\partial(Management\_Quality)}{\partial t} \geq 0$

Model Development

To explore the concept of viability further, a simulation model of an early-stage venture is created and examined. A problem which is apparent when considering this model is the subjective nature of the key variables. That is, they are easily expressed linguistically but are difficult to quantify. To facilitate this investigation, a fuzzy model was developed, and implemented in Matlab.

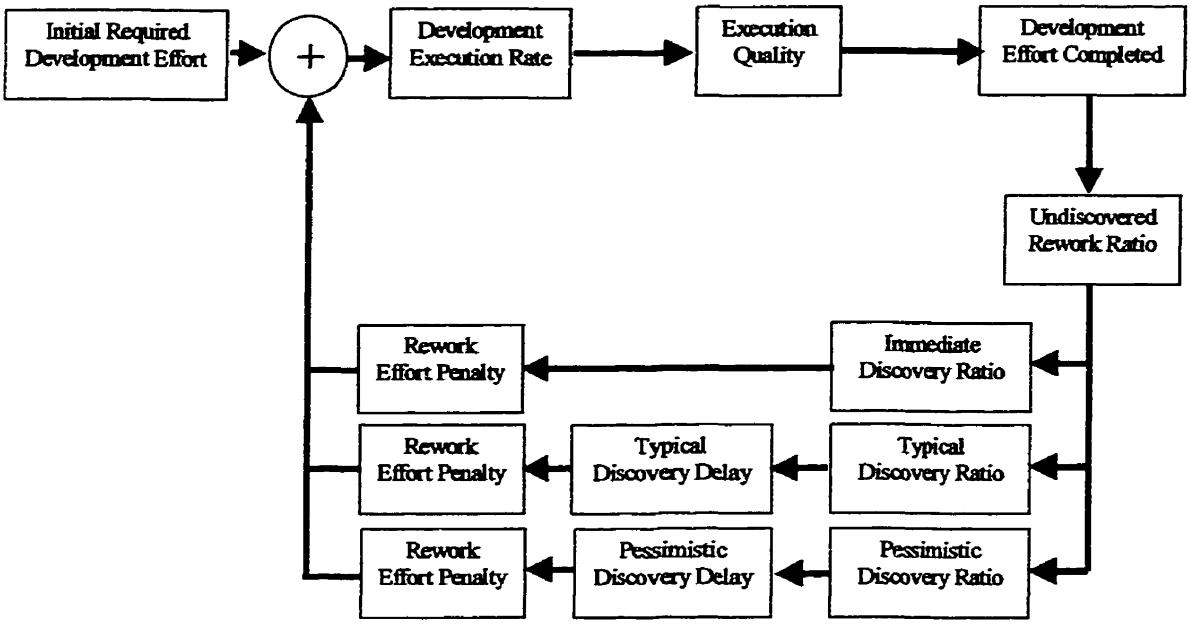
At this stage, the model assumes that the three principle inputs, technological capability, complexity and quality potential, are time invarient. This model simplification does not impede the examination for viability regions, which was run for a several thousand iterations over the input range.

To assess system viability, it is necessary to develop a performance measure which can be used to determine venture-system stability and the viability region. Basically a venture which is ruled to be unstable,using excessive energy, is defined as being not viable. The viability index developed for these experiments compares the energy consumed by a venture, *g(t)*, to that of an ideal venture, *h(t)*, i.e. perfect capabilities, quality potential, and no discovery delays or rework penalties. Finally, the work function is mapped to [0,1] using an exponential.

$$\text{Viability Index: } v = e^{-\int_0^{\infty}(g(t)-h(t))^2 \partial t}$$

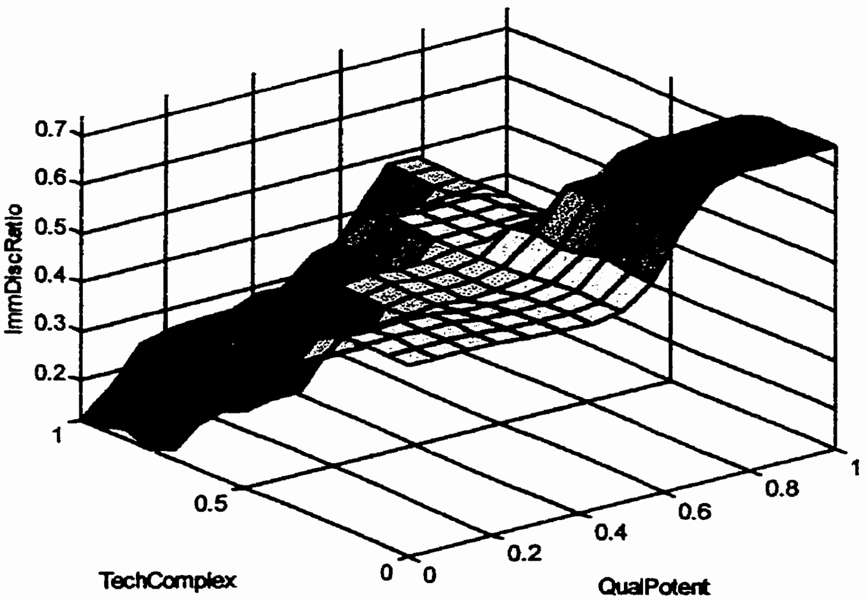
The overall block diagram of the simulation model is shown in Figure G.3. Each of these major blocks includes a fuzzy associateive memory (FAM) defining its input-output rules. Typical surface plots for these FAMs are shown in Figure G.4 and Figure G.5.

Figure G.3
Venture Model Block Diagram



A simplification was made in implimentation of this model. As shown in Figure G.3, the discovery ratios are modelled as three types, immediate, typical, pessimistic. While this may be modelled probilisticly, this approximation of a beta distribution (e.g.: ref) was used because it was considered to more accurately reflect the way individuals view the problem. Further, this was considered to be relevant for future data collection for future model development

Figure G.4
Immediate Rework Discovery FAM Rules



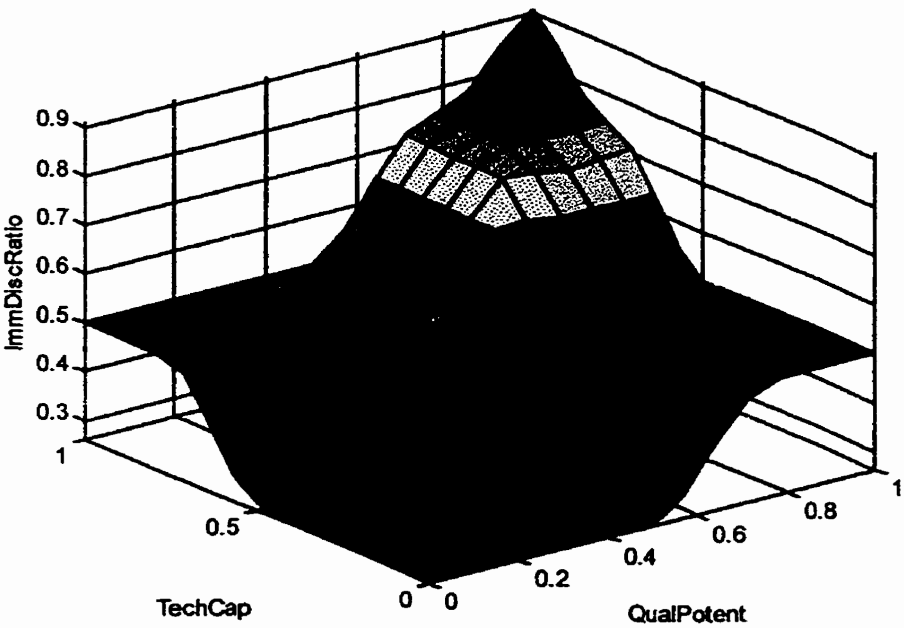
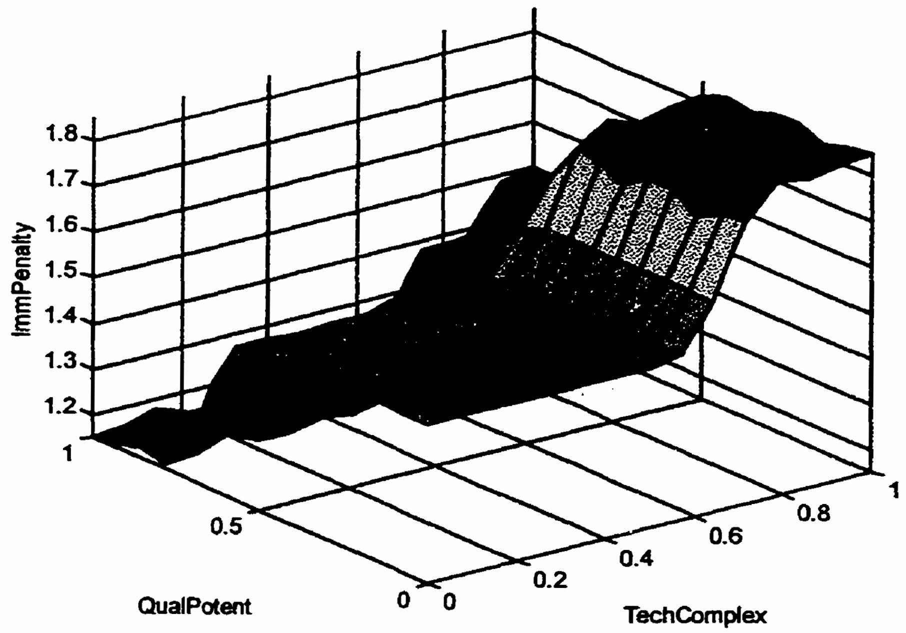


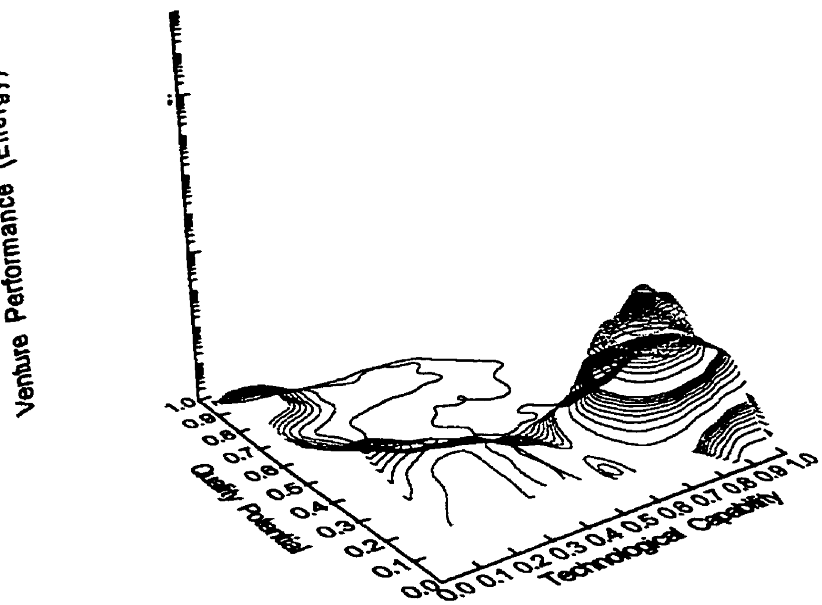
Figure G.5
Immediate Discovery Penalty FAM Rules



Simulation Results

The resulting simulation model was iterated over the range of input variables, with the output being the energy function. When this output is examined, plots similar to Figure G.6 may be created. This plot indicates the regions that would be considered viable and not viable on the quality potential-technological capability plane. As can be seen, this plot indicates that the viability region is associated with technological capability and quality potential greater than a minimum. The greatest energy expenditure occurs in the region having low quality potential and relatively high technological capability. This is anecdotally supported, and has been observed in situations where ventures have significant technical talent but no direction.

Figure G.6
Sample Model Output (Energy)



Appendix H Prototype Venture Assessment Tool

Introduction

The objective of this tool is to provide a framework for assessing and screening early-stage, technology-based ventures. To this end, the attached scorecard and graphics are intended as a diagnostic, providing an assessment of the venture's potential to successfully develop its proposed product or service.

The Assessment and Screening Process

This tool is intended for use while reviewing the venture's business plans and/or during interviews with the individuals involved in the proposed venture.

The scorecard consists of three major sections; Technological Capability, Technological Complexity and Quality Potential. Please see the following section for definitions of these and other terms. Each section has a set of subsections that focus on a specific aspect of the venture. For each subsection there are a list of common indicators. This is not an exhaustive list, rather it is a guide to the types of issues to be considered.

For each subsection, there is a 7-point scale to rate the proposed venture. These scales range from most favorable (7) at the top to least favorable at the bottom (1).

Upon reviewing the proposed venture, provide a rating for each of the subsections. Based on the scores in each group, provide an overall score for the section. To assess venture viability, convert the section scores (Technological Capability, Technological Complexity and Quality Potential) to range from 0 to 1. Plot the relative position of each section score on the graphs provided.

Each graph is divided into three regions; 'viable', 'marginally viable' and 'not viable'. Ventures that are consistently in the 'viable' region may be expected to successfully complete the product development phase. Ventures that are indicated as 'non-viable' have serious deficiencies that make it unlikely that they will successfully complete product development.

Those ventures indicated to be in the 'marginally viable' region may be expected to complete product development but with significant delays and associated cost overruns. The areas of marginal viability indicate where remedial action may be required.

It is recommended that this tool be used throughout the product development phase to monitor the venture's progress and identify potential changes that threaten its ability to reach product launch.

Definition of Key Concepts

1. Technological Capabilities:

The physical technologies, knowledge, skills and infrastructure embodied by the venture that provides it with the capacity to create its proposed product(s).

1.1 Technological Synergy:

The 'goodness-of-fit' between the proposed product's required technological capabilities, and those available within the venture. This not only includes the required physical technologies, knowledge and skills, but also supporting technologies, facilities and equipment.

1.2 Absorptive Capacity:

Absorptive capacity is related to the prior experience contained within the venture. It provides a basis for recognizing the value of new information, as well as its assimilation and application. This includes knowledge of the most recent scientific and technological developments relevant to the development of the venture's proposed products.

1.3 Technological Vulnerability:

The degree of control the venture has over the critical technologies, knowledge and skills necessary for the creation of its proposed product(s). This also entails the potential impact on the venture if access to a critical technology or knowledge resource becomes unavailable to the venture.

2. Technological Complexity:

The degree of uncertainty related to the creation of the venture's proposed product(s) due to factors including the newness of the technologies, the number of technologies and the novelty of their application.

2.1 Breakthrough Risk:

The degree to which technological or scientific advancement is required to realize the creation of the venture(s) proposed product(s).

2.2 Integration Risk:

The degrees to which technologies are being interrelated or combined in new and novel ways to create a venture's proposed product(s). These technologies may be either new or relatively mature in themselves, while their coordinated application is critical to the product(s) creation.

2.3 Obsolescence Risk:

The degree to which the critical technologies that form the basis of the venture's proposed product(s) may be replaced by a competing technology. These competing technologies may be newer, or may represent another possible implementation with greater potential benefits.

3. Quality Potential:

The venture's capacity to create its proposed product(s), such that it is ready for market launch, within an expected period of time and with its available resources.

3.1 Management Quality:

The experience and capacity of the venture's management team to successfully lead the venture through development of its proposed product and into market introduction.

3.2 Organizational Effectiveness:

The venture's ability to efficiently and effectively communicate and allocate critical knowledge and infrastructure resources to the development of its proposed product.

Technological Capability

Overall Rating

- O 7 Exceptionally Strong
- O 6 Strong
- O 5 Slightly Above Average
- O 4 Average
- O 3 Slightly Below Average
- O 2 Weak
- O 1 Exceptionally Weak

		Common Indicators
Technological Synergy	O 7 Exceptionally Strong O 6 Strong O 5 Slightly Above Average O 4 Average O 3 Slightly Below Average O 2 Weak O 1 Exceptionally Weak	• Availability of base technologies. • Availability of key technologies. • Availability of Support technologies.
Absorptive Capacity	O 7 Exceptionally Strong O 6 Strong O 5 Slightly Above Average O 4 Average O 3 Slightly Below Average O 2 Weak O 1 Exceptionally Weak	• Available base architectural knowledge. • Available key architectural knowledge. • Availability of supporting knowledge. • Knowledge distribution. • Knowledge redundancy.
Technological Vulnerability	O 7 Exceptionally Strong O 6 Strong O 5 Slightly Above Average O 4 Average O 3 Slightly Below Average O 2 Weak O 1 Exceptionally Weak	• Key technology control. • Proprietary technologies control.

Technological Complexity

Overall Rating

- O 7 Exceptionally High
- O 6 High
- O 5 Slightly Above Average
- O 4 Average
- O 3 Slightly Below Average
- O 2 Low
- O 1 Exceptionally Low

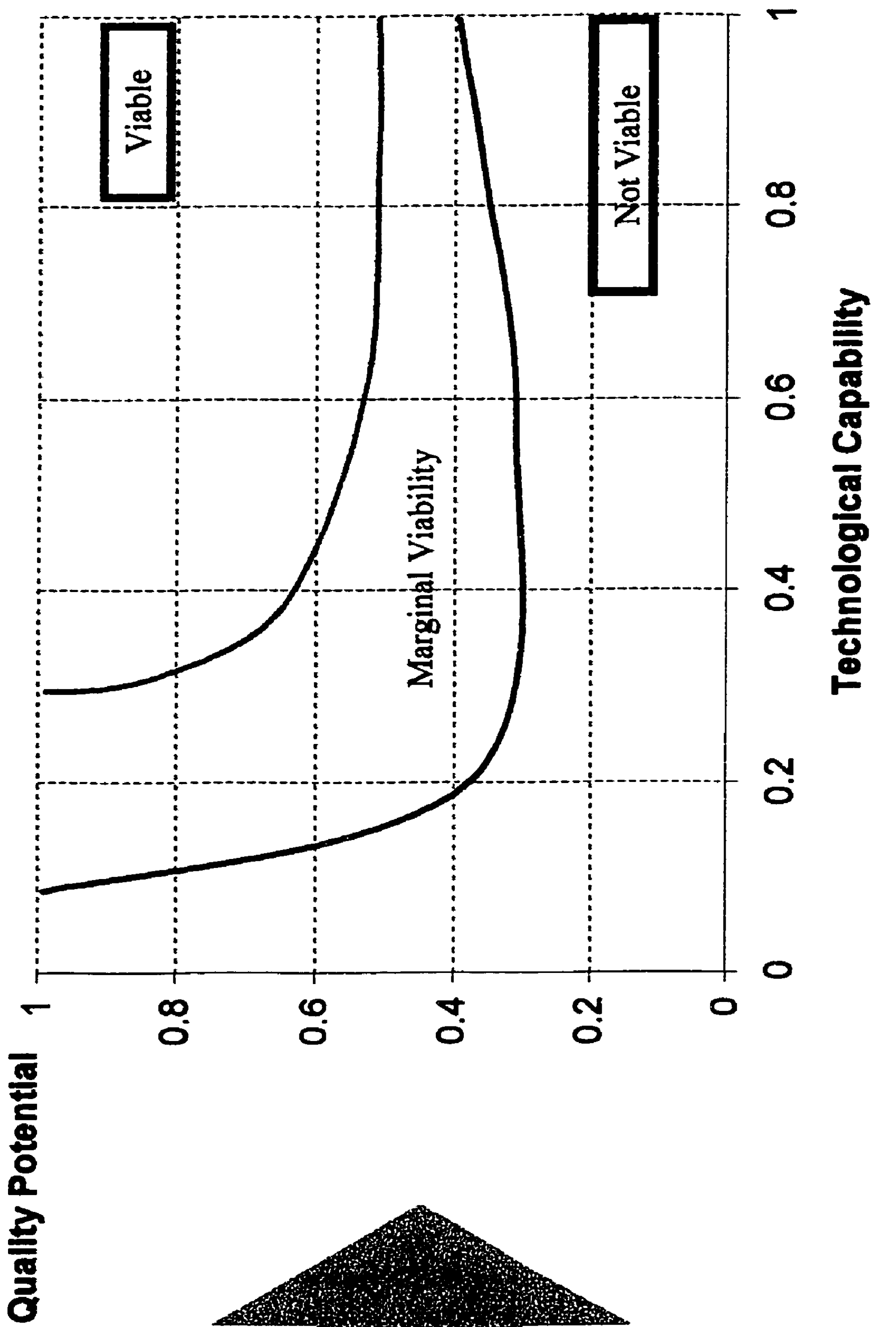
		Common Indicators
Breakthrough Risk	O 7 Exceptionally High O 6 High O 5 Slightly Above Average O 4 Average O 3 Slightly Below Average O 2 Low O 1 Exceptionally Low	• Technology development requirement. • Emerging key technologies. • Novelty of technology application.
Integration Risk	O 7 Exceptionally High O 6 High O 5 Slightly Above Average O 4 Average O 3 Slightly Below Average O 2 Low O 1 Exceptionally Low	• Number of component technologies. • Emerging or new key technologies. • Novelty of technology application.
Obsolescence Risk	O 7 Exceptionally High O 6 High O 5 Slightly Above Average O 4 Average O 3 Slightly Below Average O 2 Low O 1 Exceptionally Low	• Maturity of key technologies. • Maturity of key complimentary technologies. • Maturity of competing key technologies.

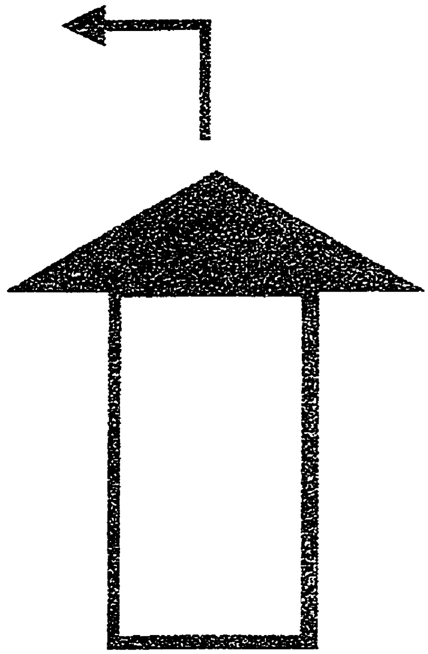
Quality Potential

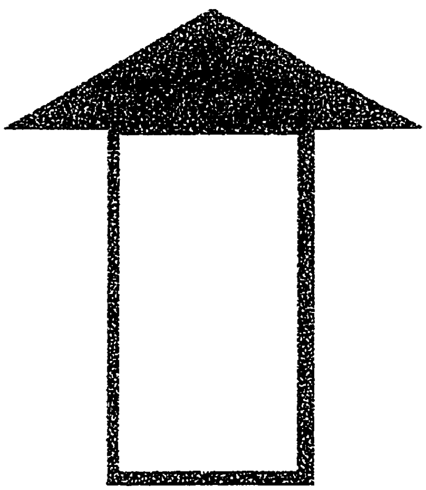
Overall Rating

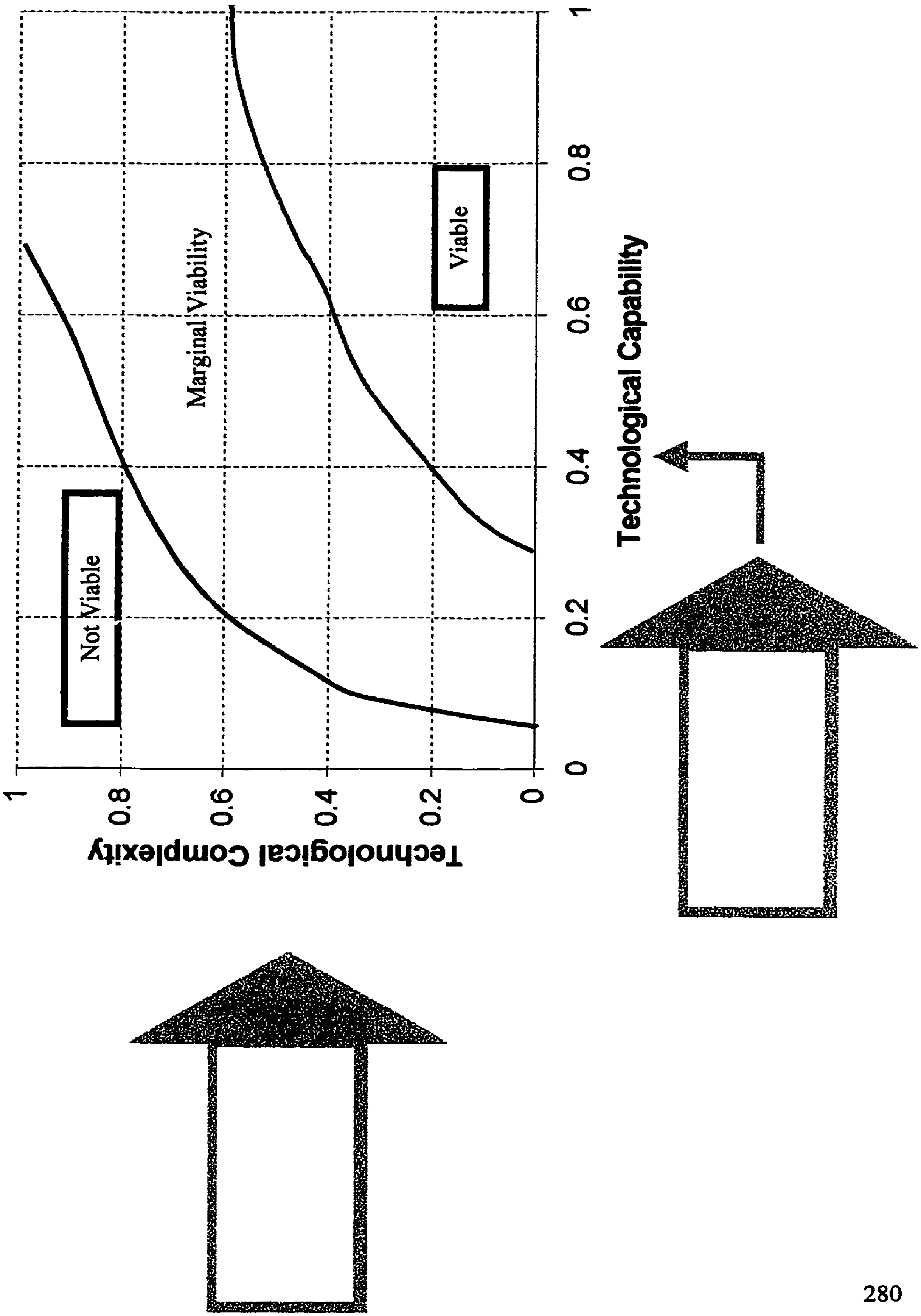
O 7 Exceptionally Strong
O 6 Strong
O 5 Slightly Above Average
O 4 Average
O 3 Slightly Below Average
O 2 Poor
O 1 Exceptionally Poor

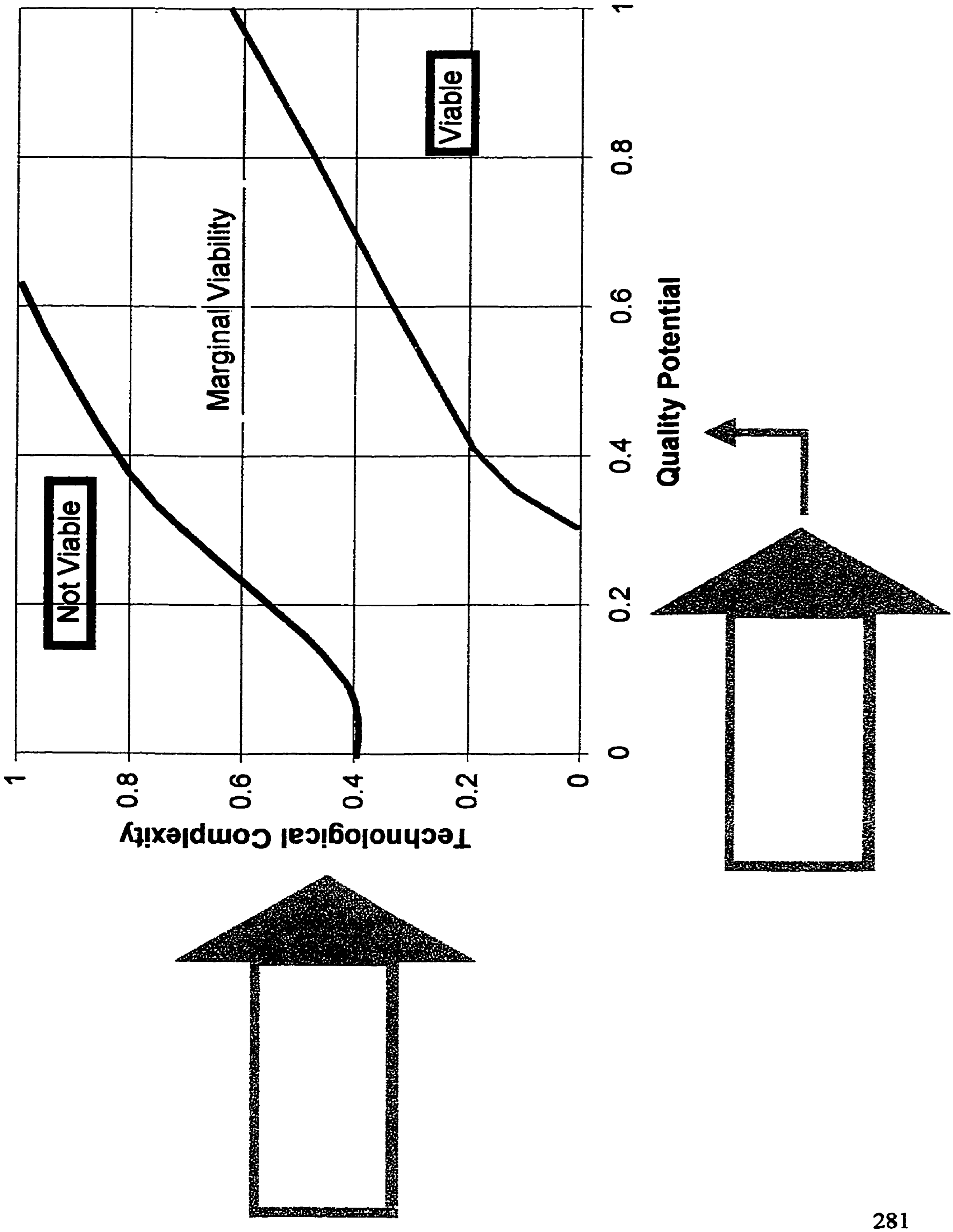
		Common Indicators
Management Quality	O 7 Exceptionally Strong O 6 Strong O 5 Slightly Above Average O 4 Average O 3 Slightly Below Average O 2 Poor O 1 Exceptionally Poor	• Presence of key development milestones. • Presence of budget control measures. • Ability to control design decisions. • Presence of a quality control plan. • Design process documentation plan. • Design team leadership experience.
Organizational Effectiveness	O 7 Exceptionally Strong O 6 Strong O 5 Slightly Above Average O 4 Average O 3 Slightly Below Average O 2 Poor O 1 Exceptionally Poor	• Concurrence of development projects. • Levels of hierarchy • Resource allocation effectiveness • Organizational communications effectiveness


Quality Potential
Technological Capability
Viable
Marginal Viability
Not Viable
0
0.2
0.4
0.6
0.8
1






Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
0
0.2
0.4
0.6
0.8
1



Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
0
0.2
0.4
0.6
0.8
1

Appendix I – Case Assessment Data

I .1 Bell (1991) Short Cases

Subject R:		Analytica	Gensym	Gateway	Cirrus	MASPAR	Ovation
Tech. capability:	Tech. synergy	4	6	6	6	5	1
	Absorptive capacity	6	5	6	6	6	1
	Tech. vulnerability	3	2	6	6	4	2
Overall rating		4.25	5	6	6	5	1
Tech.complexity:	Breakthrough risk	5	5	4	5	6	5
	Integration risk	5	6	5	4	6	5
	Obsolescence risk	6	4	1	1	4	2
Overall rating		5.3	5	4	4	6	4
Quality potential:	Management quality	1	3	6	6	6	2
	Org. effectiveness	3	4	5	5	4	1
Overall rating		2	3	5	5	5	1.5

Subject S1:		Analytica	Gensym	Gateway	Cirrus	MASPAR	Ovation
Tech. capability:	Tech. synergy	5	6	6	6	4	2
	Absorptive capacity	4	6	6	6	5	2
	Tech. vulnerability	3	5	6	6	3	5
Overall rating		5	6	6	7	4	2
Tech. complexity:	Breakthrough risk	4	5	5	6	6	5
	Integration risk	5	4	4	5	5	6
	Obsolescence risk	4	3	4	3	5	4
Overall rating		5	4	5	5	5	5
Quality potential:	Management quality	2	3	4	6	4	2
	Org. effectiveness	2	3	2	6	4	3
Overall rating		3	3	4	6	4	3

Subject S2:		Analytica	Gensym	Gateway	Cirrus	MASPAR	Ovation
Tech. capability:	Tech. synergy	5	7	7	6	6	1
	Absorptive capacity	4	6	7	6	6	2
	Tech. vulnerability	3	2	6	4	4	3
Overall rating		4	5	7	5	5	2
Tech. complexity:	Breakthrough risk	6	6	5	6	7	6
	Integration risk	6	6	5	5	5	7
	Obsolescence risk	6	6	4	6	6	6
Overall rating		6	6	5	6	6	6
Quality potential:	Management quality	2	4	5	6	6	2
	Org. effectiveness	1	6	7	6	6	1
Overall rating		1	5	6	6	6	1

Subject S3:		Analytica	Gensym	Gateway	Cirrus	MASPAR	Ovation
Tech. capability:	Tech. synergy	5	6	7	7	7	1
	Absorptive capacity	5	6	6	6	6	2
	Tech. vulnerability	4	6	6	6	6	1
Overall rating		5	6	6	6	6	1
Tech. complexity:	Breakthrough risk	4	5	3	3	6	6
	Integration risk	7	7	3	3	7	7
	Obsolescence risk	6	6	2	2	2	5
Overall rating		6	6	4	3	5	6
Quality potential:	Management quality	1	3	7	7	7	3
	Org. effectiveness	1	4	7	7	7	1
Overall rating		1	4	7	7	7	2

Subject S4:		Analytica	Gensym	Gateway	Cirrus	MASPAR	Ovation
Tech. capability:	Tech. synergy	2	6	7	5	5	2
	Absorptive capacity	2	6	7	4	6	3
	Tech. vulnerability	2	5	6	6	6	4
Overall rating		2	6	6	5	6	3
Tech. complexity:	Breakthrough risk	6	5	3	3	5	6
	Integration risk	6	5	2	4	6	6
	Obsolescence risk	6	6	3	6	5	6
Overall rating		6	5	3	4	5	6
Quality potential:	Management quality	2	6	6	4	6	2
	Org. effectiveness	1	6	7	5	7	2
Overall rating		2	6	6	5	6	2

I.2 Case A Assessment

Subject S1:		Initial	Supplement A	Supplement B
Technological capability:	Technological synergy	N	N	N
	Absorptive capacity	N	N	N
	Technological vulnerability	N	N	N
Overall rating		6	4	2
Technological complexity:	Breakthrough risk	N	N	N
	Integration risk	N	N	N
	Obsolescence risk	N	N	N
Overall rating		2	6	6
Quality potential:	Management quality	N	N	N
	Organizational effectiveness	N	N	N
Overall rating		6	4	2

Subject S2:		Initial	Supplement A	Supplement B
Technological capability:	Technological synergy	5	4	4
	Absorptive capacity	6	5	4
	Technological vulnerability	6	3	3
Overall rating		6	4	4
Technological complexity:	Breakthrough risk	6	6	6
	Integration risk	7	7	7
	Obsolescence risk	5	6	6
Overall rating		6	6	6
Quality potential:	Management quality	4	3	2
	Organizational effectiveness	5	3	2
Overall rating		4	3	2

Subject S3:		Initial	Supplement A	Supplement B
Technological capability:	Technological synergy	6	6	6
	Absorptive capacity	6	6	6
	Technological vulnerability	2	2	1
Overall rating		5	5	4.3
Technological complexity:	Breakthrough risk	6	6	6
	Integration risk	4	4	6
	Obsolescence risk	3	3	3
Overall rating		4.3	4.3	5
Quality potential:	Management quality	3	3	2
	Organizational effectiveness	2	2	2
Overall rating		2.5	2.5	2

Subject S4:		Initial	Supplement A	Supplement B
Technological capability:	Technological synergy	7	5	4
	Absorptive capacity	6	5	4
	Technological vulnerability	7	3	3
Overall rating		6	4	4
Technological complexity:	Breakthrough risk	5	7	7
	Integration risk	6	7	7
	Obsolescence risk	2	5	5
Overall rating		5	6	6
Quality potential:	Management quality	5	3	2
	Organizational effectiveness	5	3	2
Overall rating		5	3	2

Subject S5:		Initial	Supplement A	Supplement B
Technological capability:	Technological synergy	6	5	5
	Absorptive capacity	5	4	4
	Technological vulnerability	4	3	3
Overall rating		5	4	4
Technological complexity:	Breakthrough risk	4	6	6
	Integration risk	6	6	6
	Obsolescence risk	5	6	6
Overall rating		5	6	6
Quality potential:	Management quality	5	4	4
	Organizational effectiveness	4	3	3
Overall rating		5	4	4

I.3 Case B Assessment

		R	S1	S2	S3	S4
Technological capability:	Technological synergy	3	2	2	4	1
	Absorptive capacity	3	3	2	3	2
	Technological vulnerability	2	1	2	1	1
Overall rating		2	2	2	3	1
Technological complexity:	Breakthrough risk	6	7	5	6	7
	Integration risk	6	4	6	4	5
	Obsolescence risk	2	5	3	6	6
Overall rating		6	5	5	5	6
Quality potential:	Management quality	2	2	2	2	1
	Organizational effectiveness	4	4	3	4	1
Overall rating		3	3	2.5	3	1

I.4 Case B Assessment Comments

	Major Assessment Comments
R	• Requires expertise in bio-informatics. • Significant genetics and biochemistry R&D. • Software and web development required. • Do they have the statistics background? • Will they get patents on software? • Gene-chips seem critical but no control by company. • Website would also be controlled externally? • What is the status of gene-chips and testing technology? • Dealing with fairly new technology, what are the competitors?
S1	• No biologists in the development team and no scientific personnel currently in place. • No preliminary R&D data to indicate viability. • No evidence of supporting scientific knowledge, some seems to exist with the CEO? • Very difficult to visualize the R&D steps. • Entire venture depends on a presently unknown team or alliance with appropriate scientific research group.

	• They have ideas of who they would approach but no connection yet solidified. • Unclear how they really successful when going to "outmaneuver" huge competition. • A huge advancement of R&D required to create the venture. • The idea seems reasonably novel with reasonable consideration of due process required. • Uncertain how they would make the required leap from genome map to oral intake. • Plenty of room to move by mature companies - if they idea is viable I don't see how they would survive (competition). • Maybe the business ends are covered but overseer of R&D absent - how will they get off the ground? • The knowledge required is not apparent from the CVs - molecular biologists • Biochemists dominate the pharmaceutical market but this involves genetic knowledge.
S2	• Is making the chip possible? No information available on this although it is key to successful product. • What is their interpretation software based on? • The knowledge within the current team is minimal to non-existent, but willing to hire experts. • Not quite clear to what extent the chip reader and gene chip have to be developed or are an available standard technology. • If not available yet, and solely dependent on this technology with no alternatives. • Not demonstrating any knowledge that links genetic information to nutrient requirements. • It seem that there might be a substantial amount of research required to establish even the evidence of such a link. • Linking genetic information to nutrient requirements seems to be a new idea, but not developed any further or supported by any available information. • Approach may be replaced or already covered by companies that base this evaluation of supplementary needs of their customers on factors such as general health, diet, lifestyle, etc. • The technology used to make gene chips might already be quite mature. • No information given regarding product development - highly organized in terms of business strategy. • Team very young with no product development experience. • No milestones presented in terms of product development • No explanation of budget requirements for product development. • 18 months for complete product development seems to be quite optimistic - hiring a large number of experts (10 Ph.D.s in genetics and

	biochemistry) does not necessarily speed up R&D since prior information is often needed for next research step.
S3	• Do not control the chip or updates. • Rely on competition for partnerships. • Once consumers know what supplements are required they can purchase them anywhere. • Charging for follow-ups may cause a problem. • All directors and CEO inexperienced. • Technology complex.
S4	• They have no technological capabilities • Minimal background in area • Hope to partner or hire to gain all needed technology, skills, etc. • My understanding is that understanding what DNA sequences do is a big, hard problem. • Knowledge is growing fast in this area • No management experience, marketing VPs experience is as a lifeguard. • Proposed strategic alliances are nearly impossible to execute. • Is this a technology company or a marketing one?

I.5 Case B Bell-Mason Diagnostic Assessment

Category		R	S2	S3	S4	Majority
Technology Position	Does the venture have access to the technologies necessary to successfully create its products?	0	0	0	0	0
	Does the venture understand the external standards important to its products?	0	0	0	0	0
	Does the venture have the ability to control the product design process?	0	0	0	0	0
	Does the venture have the ability to produce realistic product development plans and schedules?	0	0	0	0	0
	Does the venture have the ability to develop engineering specifications for its product?	1	0	0	0	0
	Does the venture have the ability to develop manufacturing specifications for its products?	0	0	0	0	0
	Does the venture have a chief technical officer in place?	1	1	1	0	1
	Does the venture have an engineering team and culture which encourages creativity?	0	0	0	0	0
	Does the venture have a strong product architecture and a product architect in place?	0	0	0	0	0
	Does the venture have the technical resources to successfully develop its products?	0	0	0	0	0
	Are the venture's products based on a technology that will allow the generation of future product generations?	1	1	1	0	1
	Does the engineering organization have strong management skills?	1	0	0	0	0

Category		R	S2	S3	S4	Majority
Products	Do the products have well-defined and unique features that support the price and match the competitive market requirements?	1	1	1	1	1
	Do the products have the functions to support the price and match the competitive market requirements?	1	0	0	0	0
	Do the products have benefits that support the price and match the competitive market requirements?	1	1	0	0	1
	Can the company build the next generation of its follow-on products?	0	0	0	0	0
Manufacturing	Does the company have a well-defined organization and processes to produce products at cost, quality and schedules required by its customers?	0	0	0	0	0
	Does the company manage its raw materials and finished goods inventories in an optimal fashion according to just-in-time principles?	0	0	0	0	0
	Does the company introduce products into manufacturing rapidly, accompanied by clear product and process specifications?	0	0	0	0	0

Category		R	S2	S3	S4	Majority
Business Plan and Vision	Does the company have a written 5-year plan that is working and realistic and emphasizes the company's next two years of operations?	0	1	1	1	1
	Does the business plan provide an integrated overview of all aspects of the firm?	1	1	1	1	1
	Does the business plan identify the corporate vision and mission?	1	0	1	1	1
	Does the business plan identify what the lasting technological advantages of the company?	0	1	0	0	0
	Does the business plan specify a product strategy?	1	1	1	1	1
	Does the business plan identify market segmentation and associated competitive market positions?	1	0	1	1	1
	Does the business plan identify the people and reward structure within the company?	0	0	0	1	0
	Does the business plan identify the financial and financing requirements of the company?	1	0	0	1	1

Category		R	S2	S3	S4	Majority
Marketing	Does the company have a marketing plan that identifies what the products are?	1	1	1	1	1
	Does the marketing plan identify who the customers will be?	1	1	1	1	1
	Does the marketing plan identify how customers will use the product?	1	1	1	1	1
	Does the marketing plan identify why the customers will choose the company's products over the competition?	0	1	0	0	0
	Does the marketing plan identify where the company's products will be sold and what distribution channels will be used?	1	1	1	1	1
	Does the marketing plan identify the time frame and cost model for selling the company's products?	1	0	0	0	0
	Does the marketing plan contain a detailed plan for supporting product marketing?	0	0	1	0	0
	Does the marketing plan outline the resources required to market the company's products?	0	0	0	0	0
	Does the marketing plan include a schedule with milestones for implementing the company's plan?	1	1	1	0	1
	Does the company have a marketing organization and leader that can implement the marketing plan?	0	0	0	0	0
Sales	Does the company have a highly motivated sales force?	0	0	0	0	0
	Does a proven leader head the sales group?	0	0	0	0	0
	Does the sales group have experience in the target markets?	0	0	0	0	0

Category		R	S2	S3	S4	Majority
CEO	Does the CEO have the ability to establish the pace and culture of the company?	0	0	0	0	0
	Does the CEO recruit high quality people for critical positions in the company?	1	0	0	0	0
	Does the CEO have demonstrated management, team-building and leadership abilities?	0	0	0	0	0
	Does the CEO have the ability to manage in a resource-constrained environment?	0	0	0	0	0
	Is the CEO likely to be able to manage the company through its various stages of growth?	0	0	0	0	0
	Can the CEO attract the required capital, board members, key customers and strategic partners?	0	0	0	0	0
Management Team	Is the management team composed of high-quality people with measurable experience and expertise in the various areas required by the company?	0	0	0	0	0
	Is the management team capable of attracting high quality personnel, as well as leading and managing them, to their respective areas of responsibility?	0	1	1	0	1
	Can each of the management team play several positions in their areas of responsibility, rather than simply managing a "team of people"?	1	0	0	0	0
	Do the members of the management team function collectively as an integrated team, rather than a collection of egocentric or warring individuals?	1	1	1	1	1
Board of Directors	Is the board composed of individuals whose experience and expertise enhance the company's competence in its current and future stages of growth?	0	0	0	0	0
	Do board members act as reviewers and counselors for sales and finance rather than behaving like corporate decision makers?	0	0	0	0	0
	Is the board of directors reviewing the company's strategic plans and direction as well as providing the CEO with advice about current operations?	0	0	0	0	0

Category		R	S2	S3	S4	Majority
Cash Flow	Does the company have enough cash to operate at its current stage of growth?	0	0	0	0	0
	Does the company have enough cash to carry it to its next stage of growth?	0	0	0	0	0
	Is the available cash below a three-month supply at the current rate of expenditure?	0	0	0	1	0
	Can the organization either obtain adequate funds from operations or obtain additional funding through a relatively predictable financing channel within the next three-moth period?	0	0	0	0	0
Finance	Are multiple investors willing to contribute to the next stage in the company's growth, based on the corporate, product, and market outlook of the company?	0	0	0	0	0
Operations	Is the company operating according to an overall plan?	0	1	1	1	1
	Are there only a minimal number of changes being made to the plan as the company operates at its current stage of growth?	1	0	0	0	0
	Has the company met major milestones in its operating plan?	0	0	1	0	0
	Does everyone in the company operate according to a formal plan with a schedule?	0	1	1	0	1
	Does the company operate using management by objectives?	0	0	0	1	0
	Is everyone in the company informed about company operations through effective staff meetings?	0	0	0	1	0
	Do management have meeting which review activities, set objectives and direction, identify problems and resolve problems and conflicts effectively?	0	0	0	1	0
	Are the meetings minutes recorded and archived?	0	0	0	0	0
	Are processes in place to control spending to assure progress against a plan?	0	0	0	0	0
	Are processes in place to control hiring to assure progress against a plan?	0	0	0	0	0

I. 6 Overall Acceptance Questionnaire

Question		Concept							
1	The three major factors identified in the methodology are important for assessing the likelihood that these ventures will survive.	Appropriate	5	6	6	6	6	7	N
4	In terms of assessing the technological viability of these ventures the proposed methodology is complete.	Appropriate	5	3	5	3	5	5	5
6	The 'sub-concepts' associated with the three major factors are important for assessing the likelihood that these ventures will survive.	Appropriate	5	6	6	6	7	6	5
9	The graphical interpretation of the results agreed with my perception of the venture's technological viability.	Appropriate	6	6	6	4	5	6	6
3	The definitions accompanying the methodology worksheet were clear.	Clarity	6	6	6	5	4	6	5
5	The scales used with each concept are appropriate.	Clarity	4	6	6	5	6	6	5
7	The graphical interpretation of the results is easily understood.	Clarity	7	6	6	5	6	7	7
2	The graphical interpretation of the results is a useful approach.	Usefulness	5	5	5	6	6	7	6
8	The proposed methodology would provide a useful assessment tool when considering these ventures.	Usefulness	5	6	6	6	6	6	6
10	The proposed methodology would be useful tool only after significant modifications.	Usefulness	6	2	2	N	2	2	2

Appendix J: Viability Plots

As part of the proposed assessment tool, plots of the viability regions are supplied. The process involved in the creation of these graphs is outlined here.

Step 1:

The proposed model simulation was iterated over the range of each of the input variables. This resulted in a 1000 data point file indicating combinations of inputs and calculated energy. These plots are not based on the viability index.

Step 2:

The file was partitioned into three regions, viable, marginal and not viable. This partition was arbitrary and is based on an assessment of the phase plots associated with different energy levels.

Step 3:

For each of the input variable pairs, the log(energy) was plotted as a 3D scatter plot and examined.

Step 4:

Individual scatter plot for 'not viable', 'marginal' and 'viable' regions were plotted for each input variable pair. Unambiguous 'viable' and 'not viable' regions were identified on each scatter plot. Direction of 'increasing energy' noted on each plot.

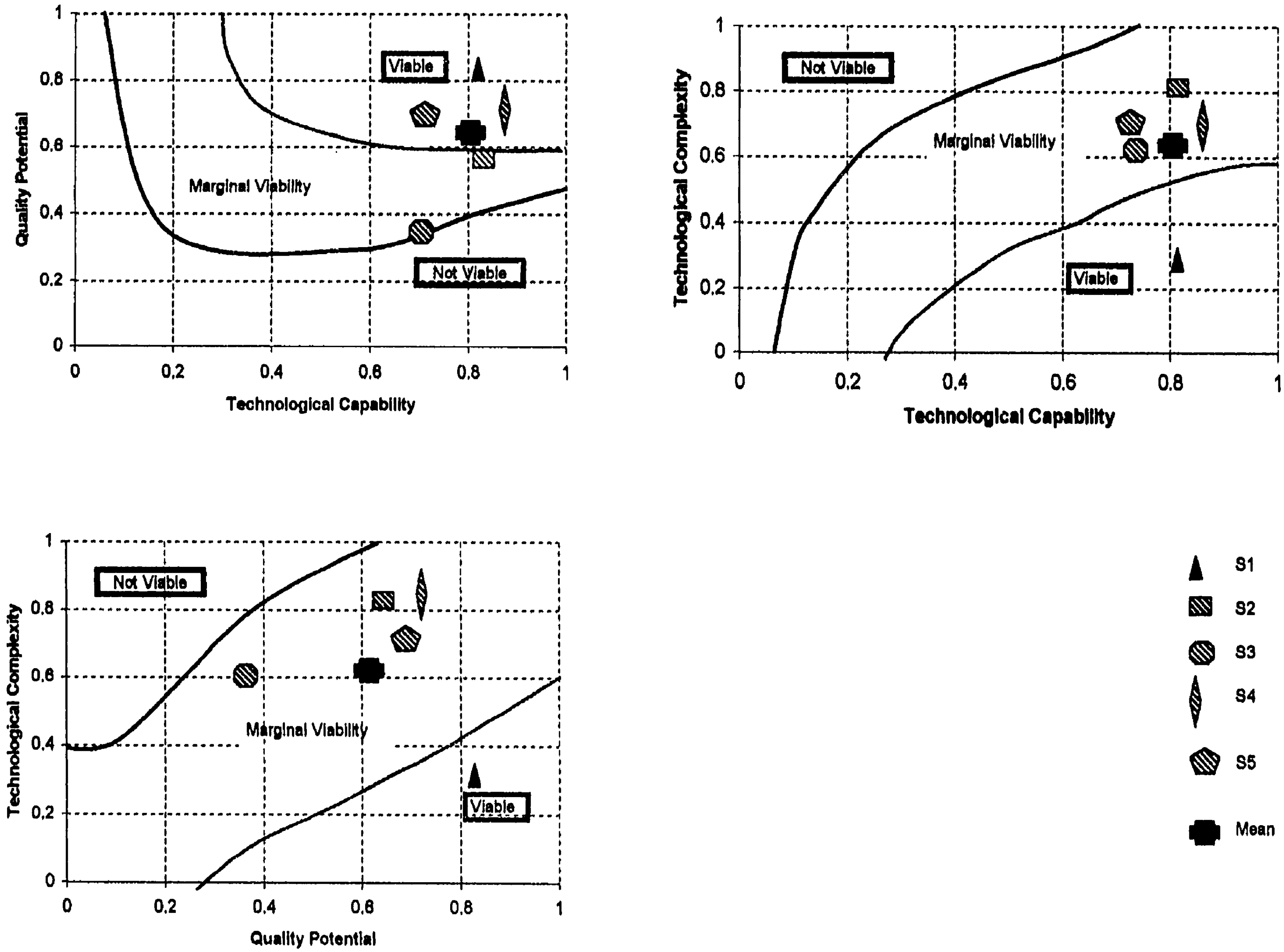
Step 5:

Each of the 'not viable' scatter plots was examined using 'slices' of the third variable. For example, the technological capability-quality potential pair was cut using technological complexity. Points where influence of the third variable became significant were noted. The point at which the cut variable began to have less influence on the plot was set as the upper bound on 'not viable'. Similarly, the 'lower boundary' for viable region was set. Remaining area was defined as marginal. As the boundaries for viable, marginal and not viable were arbitrarily assigned, areas of apparent overlap when examining the regions were defined as marginal.

Additional Plot Modifications.

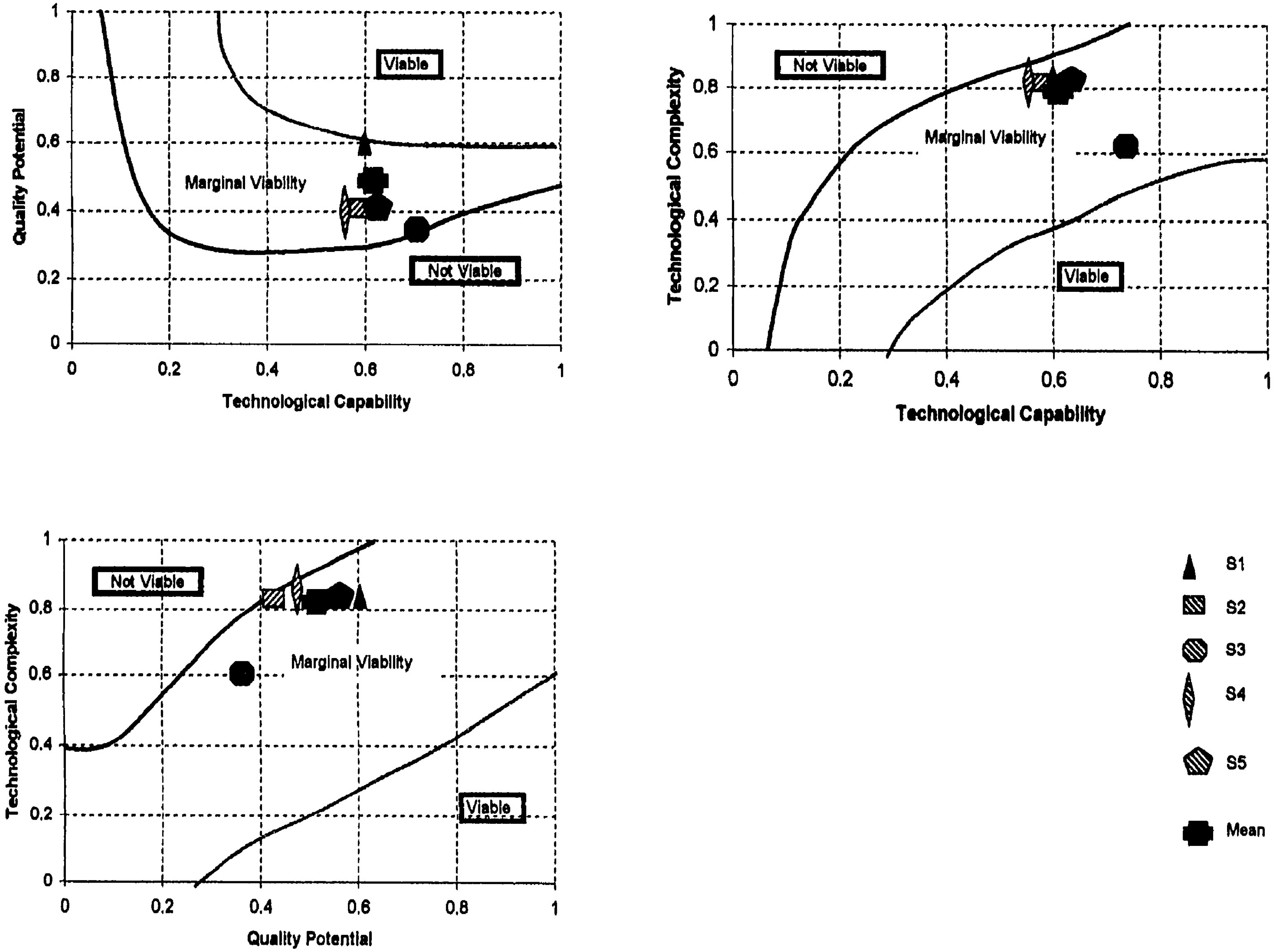
In the case of the technological complexity - technological capability plot it was noted that the not viable region tended to expand in the upper left quadrant as the quality potential cut decreased. Further, the marginal viability tended to have 'increasing energy' for low capability. As a result, the 'not viable' region was extended to the lower left quadrant at Technological Capacity of 0.1. This also corresponds with theoretical requirement for a minimum, non-zero technological capability to exist for viability. Similarly, a minimum, non-zero quality potential is expected for quality potential and this was reflected in the technological complexity - quality potential plot.

Case A (T0)



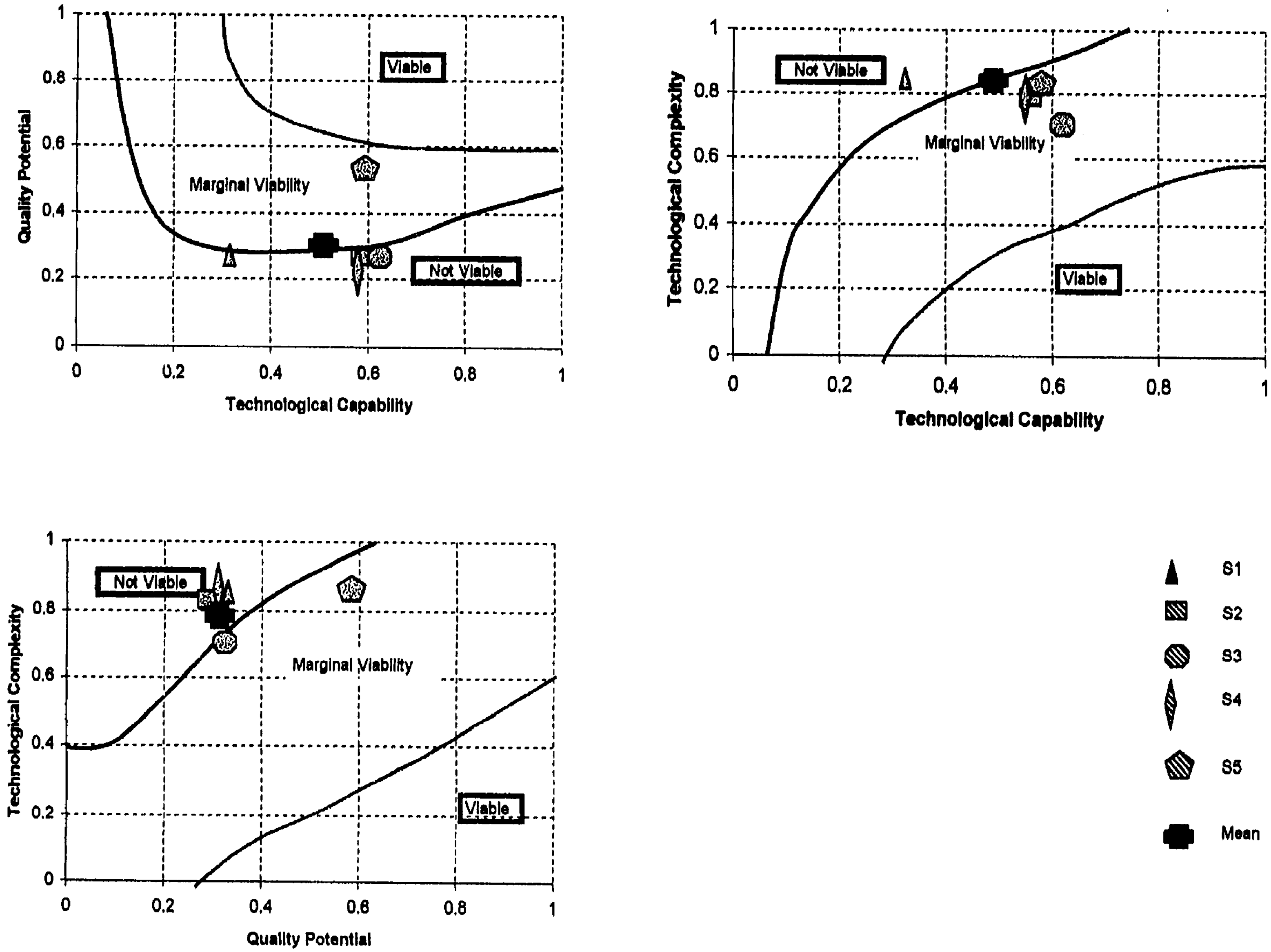
Quality Potential
Technological Capability
Viable
Marginal Viability
Not Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
Not Viable
Marginal Viability
Viable
S1
S2
S3
S4
S5
Mean

Case A (T1)

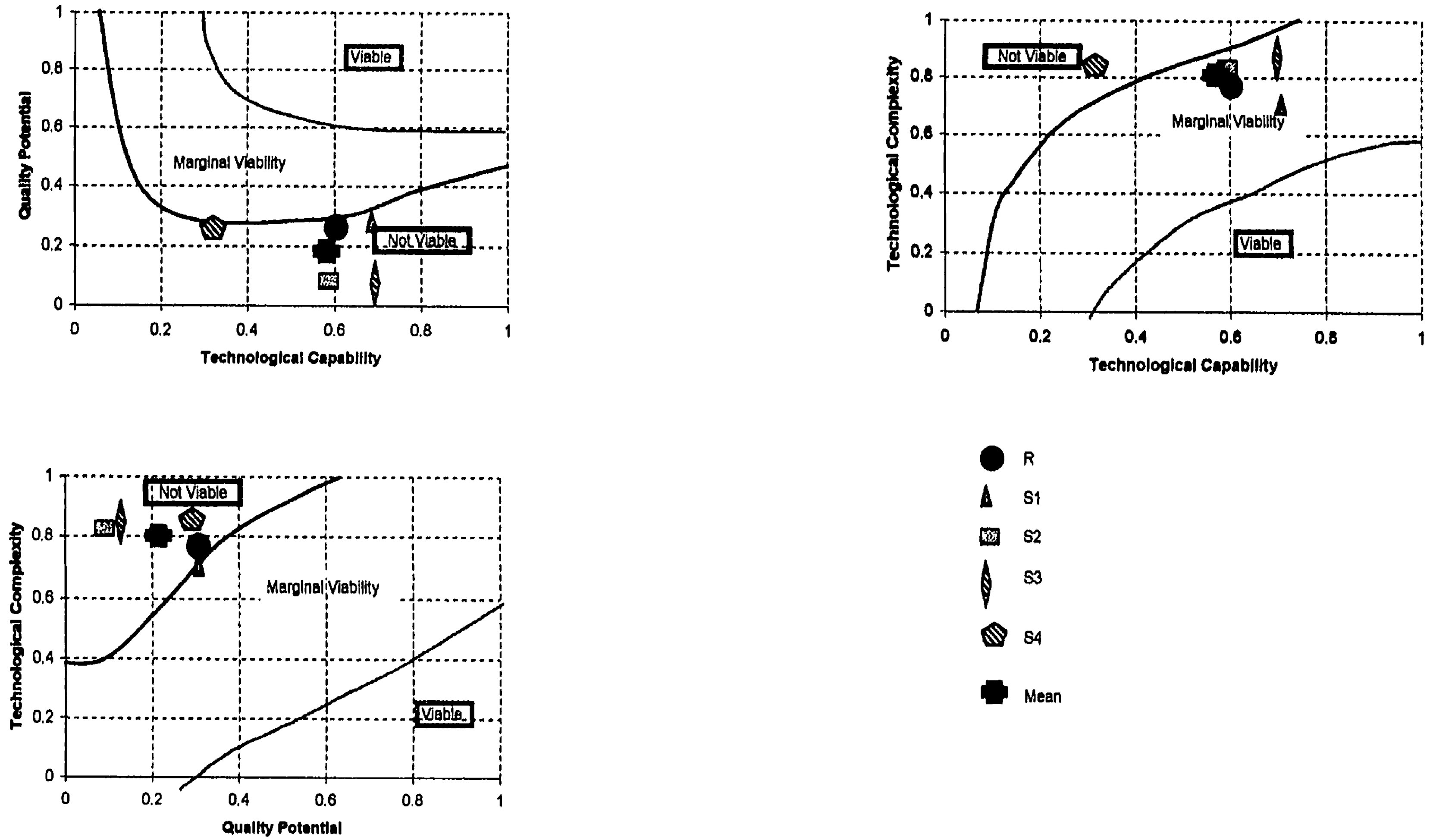


Viable
Marginal Viability
Not Viable
Quality Potential
Technological Capability
0
0.2
0.4
0.6
0.8
1
Not Viable
Marginal Viability
Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
S1
S2
S3
S4
S5
Mean

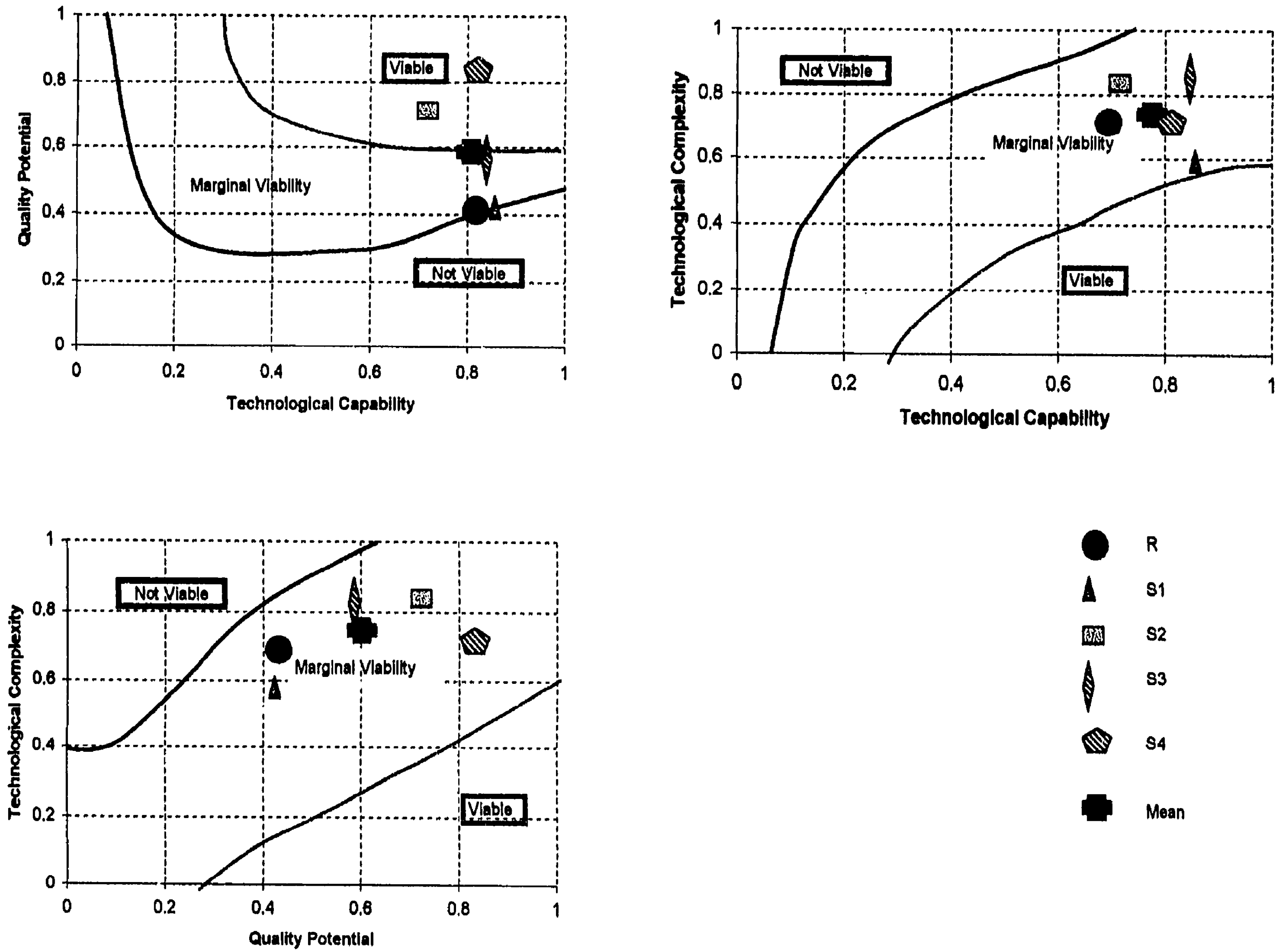
Case A (T2)



Viable
Marginal Viability
Not Viable
Quality Potential
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
S1
S2
S3
S4
S5
Mean

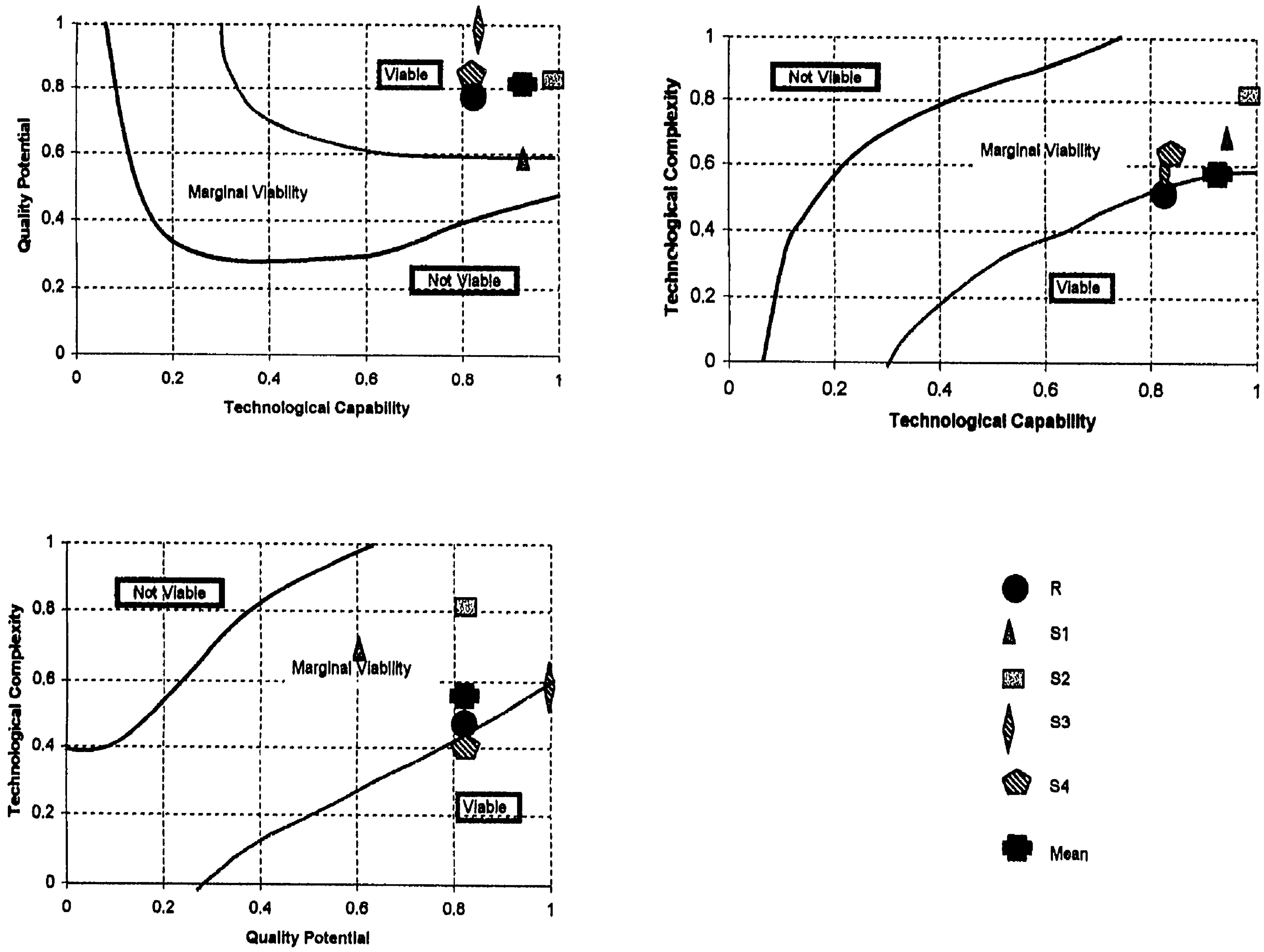

Viable
Marginal Viability
Not Viable
Quality Potential
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
R
S1
S2
S3
S4
Mean

Gensym



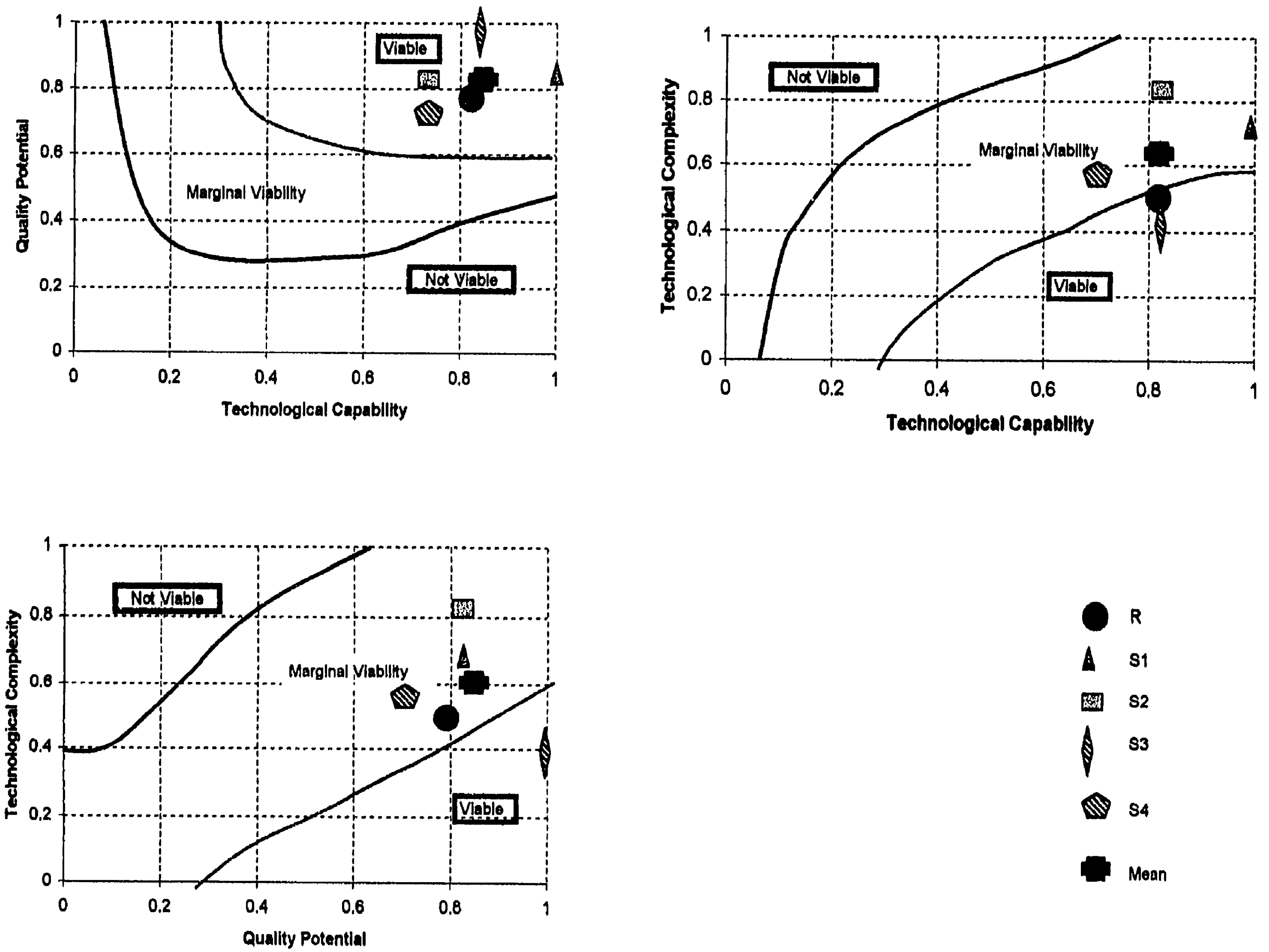
Viable
Marginal Viability
Not Viable
Quality Potential
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
R
S1
S2
S3
S4
Mean

Gateway

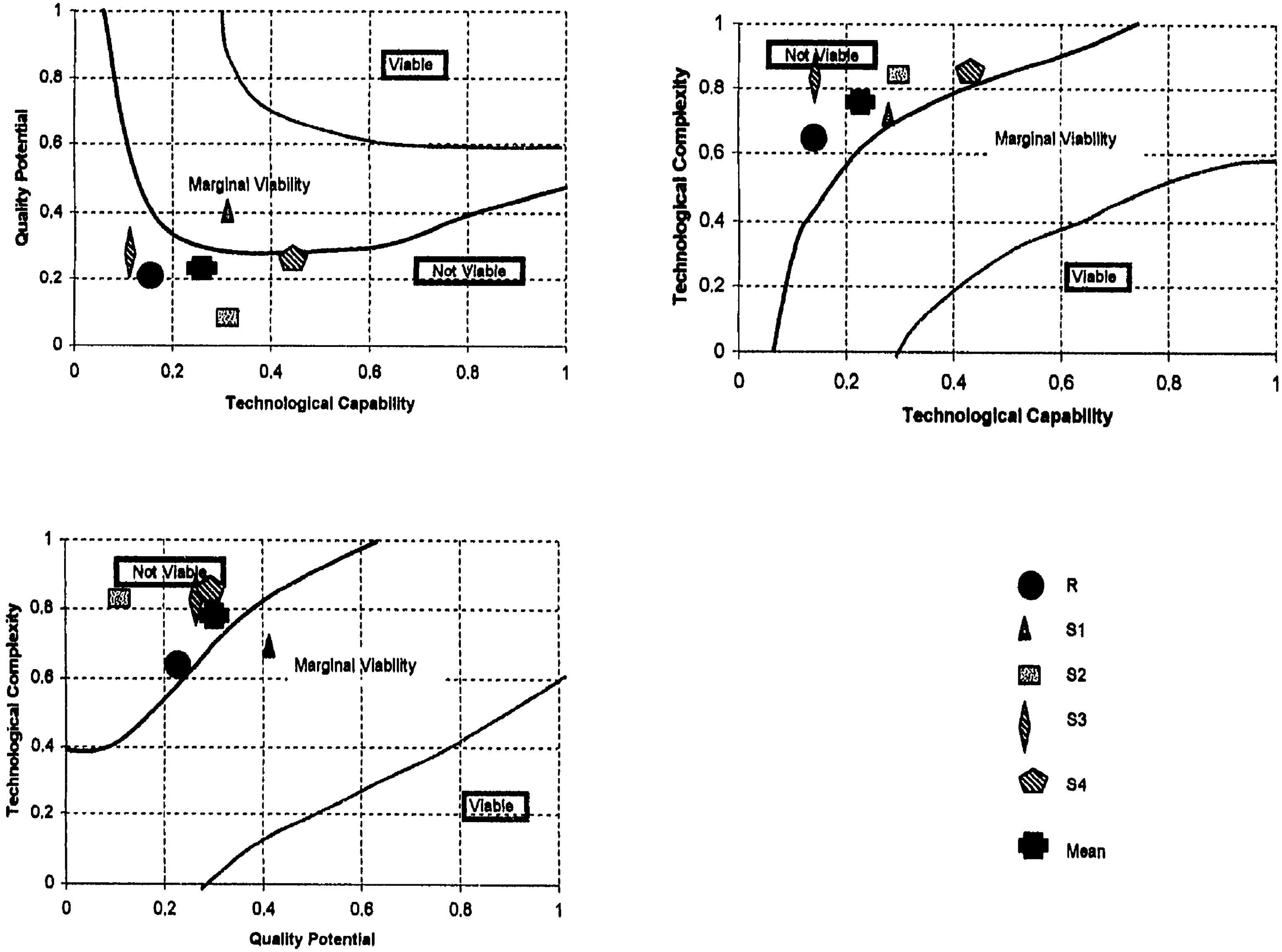


Viable
Marginal Viability
Not Viable
Quality Potential
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
R
S1
S2
S3
S4
Mean

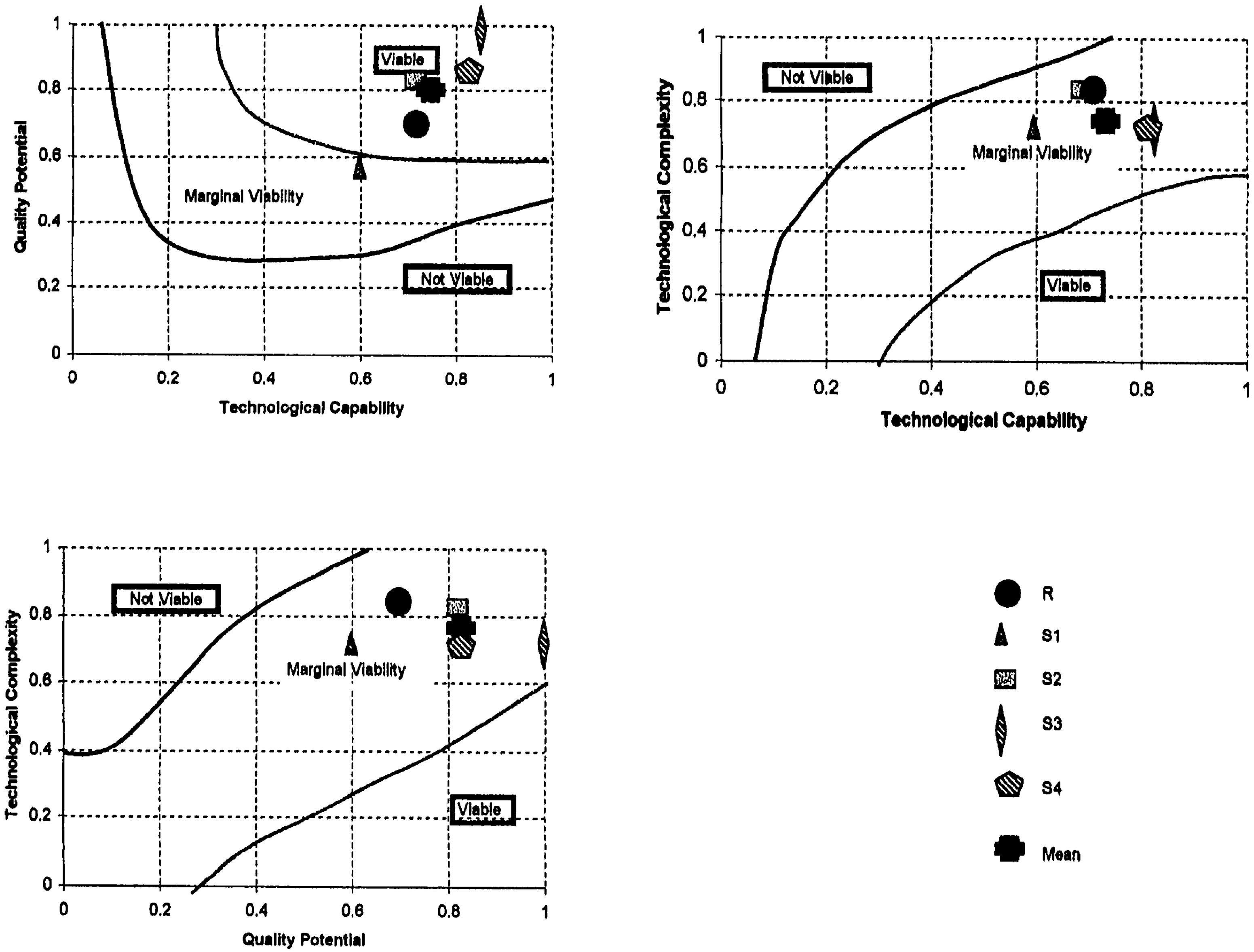
Cirrus


Viable
Marginal Viability
Not Viable
Quality Potential
Technological Capability
0
0,2
0,4
0,6
0,8
1
Not Viable
Marginal Viability
Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
R
S1
S2
S3
S4
Mean

Ovation

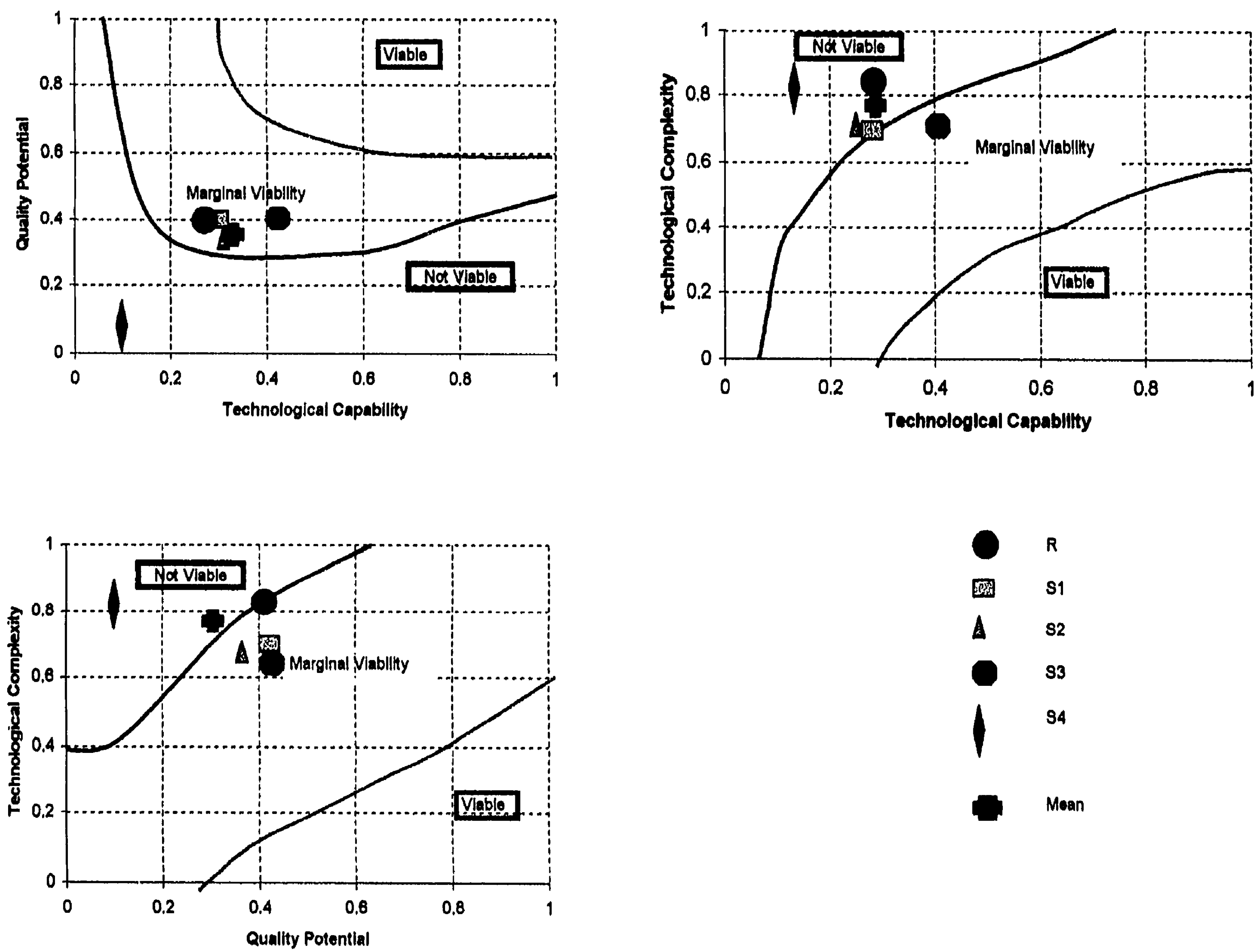

Quality Potential
Technological Capability
Viable
Marginal Viability
Not Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
Not Viable
Marginal Viability
Viable
R
S1
S2
S3
S4
Mean

MASPAR



Quality Potential
Technological Capability
Viable
Marginal Viability
Not Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
Not Viable
Marginal Viability
Viable
R
S1
S2
S3
S4
Mean

Case B



Viable
Marginal Viability
Not Viable
Quality Potential
Technological Capability
0
0.2
0.4
0.6
0.8
1
Not Viable
Marginal Viability
Viable
Technological Complexity
Technological Capability
Not Viable
Marginal Viability
Viable
Technological Complexity
Quality Potential
R
S1
S2
S3
S4
Mean

References

Abernathy, W. J. and Utterback, J. 1988. "Patterns of Industrial Innovation." Strategic Management of Technology, R. Burgelman and M. A. Maidique Editors. Homewood, Irwin, Ca. 141 - 148.

Abraham, F. D. 1988. "A Visual Introduction to Dynamical Systems Theory for Psychology." Aerial Press Inc. Santa Cruz. California.

Affifi, A. A. and Clark V. 1990. "Computer-Aided Multivariate Analysis." Van Nostrand Reinhold, New York, New York.

Alvesson, M. 1995. "Management of Knowledge-Intensive Companies". Walter de Gruyter. Berlin.

Asher, H.B. 1976. "Causal Modeling". Sage Publications. Beverly Hills, California.

Astebro, T. and Bernhardt, E. 1995. "Commercial Bank Loan Screening as a Predictor of Performance and Survival of Startup Businesses". Presented to the First International Stockholm Seminar on Risk Behavior and Risk Management. Stockholm, Sweden, 12 - 14 June.

Aubin, J.P. 1991. "Viability Theory." Systems and Control: Foundations and Applications Series. Birkhouser. Boston. Massachusetts

Ayal, I. and Raban, J. 1990. "Developing Hi-Tech Products for World Markets." IEEE Transactions on Engineering Management. August. Vol. 37. No. 3. 177 - 184.

Bachher, J. S. 1994. "Decision Making Criteria Used by Canadian Equity Investors to Evaluate Early Stage Technology Based Companies." Department of Management Sciences. University of Waterloo. Waterloo, Ontario

Bachher, J. S., Diaz de Leon, E., and Guild, P. 1999. "Decision Criteria Used by Investors to Screen Technology-Based Ventures." Proceeding of 1999 Portland International Conference on the Management of Engineering and Technology. Portland State University. 269 - 273.

Bajpai, A. C., Mustoe, L. R., and Walker, D. 1980. "Specialist Techniques in Engineering Mathematics." John Wiley and Sons. Toronto.

Balachandra, R. and Friar, J.H. 1997. "Factors for Success in R&D Projects and New Product Innovation: A Contextual Framework." IEEE Transactions on Engineering Management. August. Vol. 44., No. 3. 276 - 287.

Baldwin, J.R. 1995. Innovation: The Key to Success in Small Firms. Research Paper Series, Analytical Studies Branch. Statistics Canada.

Beer, S. 1985. Diagnosing the System for Organizations. John Wiley and Sons, Toronto.

Bell, C.G. and McNamara, J.E. 1991. High-Tech Ventures: the Guide for Entrepreneurial Success. Addison-Wesley Publishing Company, Reading, Mass.

Bell, C.G. and McNamara, J.E. 1993. "The Technology Balance Sheet." IEEE Engineering and Management Review, Spring, 4 - 15.

Benson, B., Sage, A.P., and Cook, G. 1993. "Emerging Technology Evaluation Methodology: with Application to Micro-electromechanical Systems". *IEEE Transactions on Engineering Management*, Vol. 40., No. 2, May. 114 - 123.

Bouwman, M.J. 1983. "Human Diagnostic Reasoning by Computer: An Illustration from Financial Analysis." Management Science. June. Vol. 29, No. 6. 653 - 672.

Brogan, W.L. 1982. "Modern Control Theory." Printice-Hall, Inc. Englewood Cliffs, New Jersey.

Calantone, R. J., Di Benedetto, C. A., and Schmidt, J. B. 1999. "Using the Analytic Hierarchy Process in New Product Screening." Journal of Product Innovation Management. Vol. 16. 65 - 76.

Camerer, C. F. and Johnson, E. J. 1991. "The Process-Performance Paradox in Expert Judgement: How Can Experts Know so Much and Predict so Badly?" Toward a General Theory of Expertise, Edited by Ericsson, K. A. and Smith, J. Cambridge University Press. New York, New York. 195 - 217.

Capon, N., Farley, J. U., Lehmann, D. R. and Hulbert, J. M. 1992. "Profiles of Product Innovators Among Large U.S. Manufacturers." Management Science. February. Vol. 38. No. 2. 157 - 169.

Chen, S. and Hwang, C. 1992. Fuzzy Multiple Attribute Decision Making: Methods and Applications. Springer-Verlag, Berlin.

Cohen, W.M. and Levinthal, D.A. 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Sciences Quarterly, 35, 128 - 152.

Cook, T.D. and Campbell, D.T. 1979. Quasi-experimentation: Design and Analysis Issues for Field Settings. Houghton Miffin Company. Boston, Massachusetts.

Cooper, K.G. 1993. "The Rework Cycle." IEEE Engineering Management Review. Fall. 4 - 12.

Cooper, R.G. 1988. "The New Product Process: A Decision Guide for Management." *Journal of Marketing Management*, Vol. 3., No. 3, 238 -253.

Cooper, R.G. 1993. "Winning at New Products: Accelerating the Process from Idea to Launch". Addison-Wesley Publishing Company. Reading, Massachusetts.

Cooper, R.G. and Kleinschmidt, E.I. 1987. "What Makes a New Product a Winner: Success Factors at the Project Level". *R&D Management*, Vol.17, No. 3, 238 - 253.

Cooper, R.G. and Kleinschmidt, E.I. 1988. "Success Factors in Product Innovation." IEEE Engineering Management Review. December. Vol. 16. No. 4. 19 - 26.

Cox, E. 1994. The Fuzzy Systems Handbook: A Practioner's Guide to Building, Using, and Maintaining Fuzzy Systems. Academic Press, Inc. Cambridge, Massachusetts.

Davidson, J., Pedrycz, W., and Goulter, I. 1993. "A Fuzzy Decision Model for the Design or Rural Natural Gas Networks". Fuzzy Sets and Systems. North-Holland, 53, 241 - 252.

Dawes, R. M. 1982. "The Robust Beauty of Improper Linear Models in Decision Making." Judgement Under Uncertainty: Heuristics and Biases, Edited by D. Kahneman, P. Slovic, A. Tversky. Cambridge University Press. New York, New York. 391 - 407.

Dornbusch, R. and Fischer, S. 1978. "Macroeconomics." McGraw Hill, Inc. New York, New York.

Dorner, D. and Scholkopf, J. 1991. "Controlling Complex Systems; or, Expertise as 'Grandmother's Know-How'." Toward a General Theory of Expertise, Edited by Ericsson, K. A. and Smith, J. Cambridge University Press. New York, New York. 218 - 239.

Dosi, G. 1982. "Technological Paradigms and Technological Trajectories." Research Policy, Vol. 11. 147 - 162.

Drucker, P. F. 1986. "Innovation and Entrepreneurship: Practice and Principles." Harper Row Publishers. New York, New York.

Dutta, S. 1993. "Fuzzy Logic Applications: Technological and Strategic Issues". IEEE TEM, 40, 3, August, 237 - 254.

Erickson, T.J., Magee, J.F., Roussel, P.A., Saad, K.N. 1991. Managing Technology As A Business Strategy. IEEE Engineering Management Review. Spring. 34 - 39.

Ericsson, K.A. and Simon, H.A. 1984. Protocol Analysis: Verbal Reports as Data. The MIT Press. Cambridge, Mass.

Fedrizzi, M., Fedrizzi, M., and Ostasiewicz, W. 1993. "Towards Fuzzy Modelling in Economics". Fuzzy Sets and Systems, 54, North-Holland, 259 -268.

Fischoff, B. 1990. "Debiasing." Judgement Under Uncertainty: Heuristics and Biases, Edited by D. Kahneman, P. Slovic, A. Tversky. Cambridge University Press. New York, New York. 422-444.

Firebaugh, M.W. 1989. "Artificial Intelligence: A Knowledge-Based Approach." PWS-Kent Publishing Company. Boston. Mass.

Ford, D. 1988. "Develop Your Technology Strategy". Long Range Planning. October. Vol. 21. No. 5. 85 - 96.

Foster, R.N. 1986. "Timing Technological Transitions." Technology in the Modern Corporation. Edited by M. Horwitch. Pergamon. New York, New York.

Fox, J. 1984. "Linear Statistical Models and Related Methods: With Application to Social Research." John Wiley and Sons. New York, New York.

Gleik, J. 1987. "Chaos: Making a New Science." Penguin Books. New York. New York.

Gleitman, H. 1992. "Basic Psychology." W. W. Norton & Company, New York, New York

Gonzalez, A.J., and Dankel, D.D. 1993. The Engineering of Knowledge-Based Systems: Theory and Practice. Prentice Hall. Englewood Cliffs, New Jersey.

Grant, K. P., Baumgardner, C. R., and Shane, G. S. 1997. "The Perceived Importance of Technical Competence to Project Managers in the Defense Acquisition Community." IEEE Transactions on Engineering Management. February. Vol. 44. No. 1. 12 - 19.

Greenberg, J., Baron, R. A., Sales, C. A., and Owen, F. A. 1996. "Behaviour in Organizations." Printice-Hall Canada Inc. Toronto.

Guild, P.D. and Bachher, J.S. 1996. "Equity Investment Decisions for Technology Based Ventures." International Journal of Technology Management. Vol. 12. 787 - 795.

Halbrink, J. O. 1990. "Technology Decomposition Theory and Magnetic Disk Technology." IEEE Transactions on Engineering Management. November. Vol. 37. No. 4. 284 - 290.

Hall, J. and Hofer, C.W. 1993. Venture Capitalists' Decision Criteria in New Venture Evaluation. IEEE Engineering Management Review. Summer. 49 - 58.

Henderson, B. D. 1991. "The Origin of Strategy." Strategy, Montgomery, C.A. and Porter, M. E. eds. Harvard Business Review. Boston. Massachusetts.

Hofer, C. W. and Sandberg, W. R. 1987. "Improving New Venture Performance: Some Guidelines for Success." *American Journal of Small Business*. Summer. Vol. 12. No. 1. 11 - 25.

Hruschka, H. 1988. "Use of Fuzzy Relations in Rule-Based Decision Support Systems for Business Planning Problems". European Journal of Operations Research. Vol. 34. 326 - 337.

Jackman, M. and Pavelin, C. 1988. "Conceptual Graphs". Approaches to Knowledge Representation: An Introduction. Edited by G. A. Ringland and D. A. Duce. Research Studies Press Ltd. Letchworth, Hertfordshire, England.

Jemkins, C. H. and Bella, D.A. 1993. "A Non-linear Perspective of Organizations; Part One - Excellent Organizations." Working Paper. Department of Mechanical Engineering, South Dakota School of Mines and Technology. Rapid City. South Dakota.

Jia, L. and Zhang, X. 1994. "Distributed Intelligent Railway Traffic Control Based on Fuzzy Decision Making". Fuzzy Sets and Systems. Vol. 62. 255 - 265.

Johne, F.A. and Snelson, P.A. 1988. "Success Factors in Product Innovation: A Selective Review of the Literature". *Journal of Product Innovation Management*. No. 5. 114 - 128.

Kacprzyk, J. and Fedrizzi, M. 1988. "A 'Soft' Measure of Consensus in the Setting of Partial (Fuzzy) Preferences." European Journal of Operations Research. Vol. 34. 316 - 325.

Kahneman, D. and Tversky, A. 1990a. "Judgement Under Uncertainty: Heuristics and Biases." Judgement Under Uncertainty: Heuristics and Biases, Edited by D. Kahneman, P. Slovic, A. Tversky. Cambridge University Press. New York, New York. 3 - 22.

Kahneman, D. and Tversky, A. 1990b. "Intuitive Prediction: Biases and Corrective Procedures." Judgement Under Uncertainty: Heuristics and Biases, Edited by D. Kahneman, P. Slovic, A. Tversky. Cambridge University Press. New York, New York. 414 - 421.

Kahneman, D. and Tversky, A. 1990c. "Evidential Impact of Base Rates." Judgement Under Uncertainty: Heuristics and Biases, Edited by D. Kahneman, P. Slovic, A. Tversky. Cambridge University Press. New York, New York. 153 - 160.

Kasiecieh, S.K., Ravinder, H.V., and Yourstone, S.A. 1993. " Proposed Design of a DSS for the Justification of Advanced Manufacturing Technologies". IEEE Transactions on Engineering Management. November. Vol. 40. No. 4. 398 - 403.

Kassicieh, S. K., Radosevich, H. R., and Banbury, C.M. 1997. "Using Attitudinal, Situational, and Personal Characteristics Variables to Predict Future Entrepreneurs from National Laboratory Inventors." IEEE Transactions on Engineering Management. August. Vol. 44. No. 3. 248 - 257.

Keller, G., Warrack, B. and Bartel, H. 1994. "Statistics for Management and Economics." Duxbury Press. Belmont, Ca.

Kirkwood, K.W. 1992. "An Overview of Methods for Applied Decision Analysis." Interfaces. November - December. Vol. 22. No. 6. 28 - 39.

Kosko, B. 1992. Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence. Prentice Hall. Englewood Cliffs, New Jersey.

Kosko, B. 1997. Fuzzy Engineering. Prentice Hall. Englewood Cliffs, New Jersey.

Kosko, B. and Isaka, S. 1993. "Fuzzy Logic". Scientific American. July. 76 - 81.

Kosko, B. and Dickerson, J. 1994. "Fuzzy Virtual Worlds." AI Expert. July. 25 -31.

Kraemer, H.C. and Thiemann, S. 1987. "How Many Subjects: Statistical Power Analysis in Research." Sage Publications. Newbury Park, Ca.

Kumar, V., Persaud, A.N.S., and Kumar, U. 1996. "To Terminate or Not an Ongoing R&D Project: A Managerial Dilemma." IEEE Transactions on Engineering Management. August. Vol. 43. No. 3. 273 - 284.

Lefebvre, L. A., Lefebvre, E., and Harvey, J. 1996. "Intangible Assets as Determinants of Advanced Manufacturing Technology Adoption in SME's: Towards an Evolutionary Model." IEEE Transactions on Engineering Management. August. Vol. 43. No. 3. 307 - 322.

Levine, J. M. and Moreland, R. L. 1990. "Progress in Small Group Research." Annual Review of Psychology. Vol. 41. 585 - 634.

Li, X., Ang, L. A., and Gay, R. 1997. "An Intellegent Scenario Generator for Strategic Business Planning." Computers in Industry. Vol. 34. 261 - 269.

Liang, T. 1992. "A Composite Approach to Inducing Knowledge for Expert System Design." Management Science. January. Vol. 38. No. 1. 1 - 17.

Liberatone, M.J. and Styliarou, A.C. 1995. "Expert Support Systems for New Product Development Decision-Making: A Modeling Framework and Applications". *Management Science*, Vol. 41, No. 8, August. 1296 - 1316.

Liou, T. and Wang, M. 1994. "Subjective Assessment of Mental Workload: A Fuzzy Linguistic Multi-criteria Approach." Fuzzy Sets and Systems. Vol. 62. 155 - 165.

Liu, Z. Q. and Satur, R. 1999. "Contextual Fuzzy Cognitive Map for Decision Support in Geographic Information Systems." IEEE Transactions on Fuzzy Systems. October. Vol. 7. No. 5. 495 - 507.

Lin. C. T. and Lee, C. S. G. 1996. "Neural Fuzzy Systems: A Neuro-Fuzzy Synergism to Intellegent Systems." Printice Hall. Upper Saddle River, New Jersey.

Maeda, H. and Murakami, S. 1993. "The Use of Fuzzy Decision-Making in a Large-Scale Computer System Choice Problem." Fuzzy Sets and Systems. Vol. 54. 235 - 249.

MacNeill, D., Martin, F. and Thro, E. 1994. "Fuzzy Logic: A Practical Approach." Academic Press, Inc. Cambridge, Massachusetts.

Mansfield, E. 1979. "Microeconomics". W.W. Norton and Company, New York.

Mayer, M. H. and Roberts, E. B. 1988. Focusing Product Technology for Corporate Growth. Sloan Management Review, Summer. 7 - 16.

Mayer, R. E. 1992. Thinking, Problem Solving and Cognition. W. H. Freeman and Company. New York, New York.

McNamara, G. and Bromiley, P. 1993. "Research Report: Assessing The Risks of Small Business Borrowers". *The Journal of Commercial Lending*. October, Vol. 76., No. 2, 23 - 31.

Meier, W., Weber, R., and Zimmermann, H.J. 1994. "Fuzzy Data Analysis: Methods and Applications." Fuzzy Sets and Systems. 19 - 28.

Meldrum, M.J. and Millman, A.F. 1991. Ten Risks in Marketing High-Technology Products. IEEE Engineering Management Review, Winter. 38 - 43.

Mendenhall, W. 1975. "Introduction to Probability and Statistics." Duxbury Press. Belmont, Ca.

Mon, D., Cheng, C. and Lin, J. 1994. "Evaluating Weapon Systems Using Fuzzy Analytic Hierarchy Process Based on Entropy Weight." Fuzzy Sets and Systems. Vol. 62. 127 - 134.

Moody, J.W., Will, R.P., and Blanton, J.E. 1996. Enhancing Knowledge Elicitation Using the Cognitive Interview. Expert Systems with Applications. Vol. 10, No. 1, Elsevier Science. 127-133.

Myers, R.H. 1986. "Classical and Modern Regression with Applications." Duxbury Press. Boston, Massachusetts.

Nelson, M. M. and Illingworth, W. T. 1991. "A Practical Guide to Neural Networks." Addison-Wesley Publishing Company, Reading, Mass. .

Nielsen, J. 1994. Estimating the Number of Subjects Needed for Thinking Aloud Test. International Journal of Human Computer Studies. Sept. Vol 41. No. 3. 385-397

Nielsen, J. 2000. Why You Only Need to Test With 5 Users. http://www.useit.com/alertbox/20000319.html

Noori, H. 1990. Managing the Dynamics of New Technology: Issues in Manufacturing Management. Prentice Hall, Englewood Cliffs, New Jersey.

Norton, J. A. and Bass, F. M. 1993. "Evolution of Technological Generations: The Law of Capture." IEEE Engineering Management Review. Summer. Vol. 21. No. 2. 29 - 37.

Novak, V. 1985. "The Origin and Claims of Fuzzy Logic." Fuzzy Sets, Applications, Methodological Approaches and Results. International Workshop on Fuzzy Sets Applications, Akademie-Verlag, Berlin.

Nutt, P.C. and Backoff, R.W. 1986. "Mutual Understanding and its Influence on Formulation During Planning." Technology Forecasting and Social Change. Vol. 29. 13 - 31.

Olson, J.R. and Biolsi, K.J. 1991. Techniques for Representing Expert Knowledge. Towards a General Theory of Expertise: Prospects and Limits. Edited by Ericsson, K.A. and Smith, J. Cambridge University Press. New York, New York. 240 - 285.

Osterlund, J. 1997. "Competence Management by Informatics in R&D: The Corporate Level." IEEE Transactions on Engineering Management. May. Vol. 44. No. 2. 135 - 145.

Ozer, M. 1999. "A Survey of New Product Evaluation Models." Journal of Product Innovation Management. Vol. 16. 77 - 94.

Ozernoy, V.M. 1992. "Choosing the 'Best' Multiple Criteria Decision-Making Method". INFOR. May. Vol. 30. No. 2. 159 - 171.

Palm, W. J. 1983. 'Modeling, Analysis and Control of Dynamic Systems." John Wiley and Sons. Toronto, Ontario.

Pegels, C.C. and Thirumurthy, M.V. 1996. The Impact of Technology Strategy on Firm Performance. IEEE Transactions on Engineering Management. 43(3), August. 246 - 249.

Pinto, J.K. and Mantel, S.J. 1990. The Causes of Project Failure. IEEE Transactions on Engineering Management, Vol. 37, No. 4., November. 269 - 276.

Porter, M. E. 1991. "How Competitive Forces Shape Strategy." Strategy, editors Montgomery, C. A. and Porter, M. E. Harvard Business Review Book. 11- 25.

Prahalad, C.K. and Hamel, G. 1990. "The Core Competence of the Corporation". *Harvard Business Review*, May-June, 79 - 81.

Prahalad, C.K. and Hamel, G. 1992. "Part 1: The Core Competence of the Corporation". IEEE Engineering Management Review, Fall, 5 - 14.

Prasad, L. and Rubinstein, A. H. 1992. "Conceptualizing Organizational Politics as a Multidimensional Phenomenon: Empirical Evidence from a Study of

Technological Innovations." IEEE Transactions on Engineering Management. Vol. 39. No. 1. February. 4 - 12.

Rabino, S. and Wright, A. 1993. "Accelerated Product Introductions and Emerging Managerial Accounting Perspectives". *IEEE Engineering Management Review*. Fall. 40 - 47.

Radford, K. J. 1977. Complex Decision Problems: An Integrated Strategy for Resolution. Reston Publishing Company. Reston, Virgina.

Roberts, E.B. 1991. "Evolving Toward Product and Market Orientation; The Early Years of Technology-Based Firms". *IEEE Engineering Management Review*. Summer, Vol. 19, No. 2, 86 - 96.

Roberts, E.B. and Mayer, M.H. 1991. "Product Strategy and Corporate Success." IEEE Engineering Management Review. Spring. Vol. 19. No. 1. 4 - 18.

Roetzheim, W. H. 1994. "Enter the Complexity Lab: Where Chaos Meets Complexity." Sauls Publishing. Indianapolis. Indiana.

Rothwell, R. and Zegveld, W. 1985. "Innovation and the Small and Medium-sized Firm: Their Role in Employment and Economic Change". F. Printer, London.

Sandri, S.A., Dubois, D., and Kalfsbeek, H.W. 1995. Elicitation, Assessment, and Pooling of Expert Judgments Using Possibility Theory. IEEE Transactions on Fuzzy Systems, Vol. 3, No. 3, August. 313 - 335.

Satur, R. and Liu, Z. Q. 1999. "A Contextual Fuzzy Cognitive Map Framework for Geographic Information Systems." IEEE Transactions on Fuzzy Systems. October. Vol. 7. No. 5. 481 - 494.

Seaver, B.L., and Kostas, T. 1992. "Identification of Influential Subsets in Least Squares Regression Using Fuzzy Procedures." DSI. November. 22 - 24.

Schilling, M.A. and Hill, C.W.L. 1998. "Managing the New Product Development Process: Strategic Imperatives." IEEE Engineering Management Review. Winter. Vol. 26. No. 4. 55 - 68.

Schmidt, R.L. 1993. "A Model for R&D Project Selection with Combined Benefit, Outcome and Resource Interactions." IEEE Transactions on Engineering Management. November. Vol. 40. No. 4. 403 - 410.

Shepherd, D.A. 1999. "Venture Capitalists' Assessment of New Venture Survival." Management Science. May. Vol. 45, No.5. 621 - 632.

Shinners, S. M. 1978. "Modern Control System Theory and Applications." Addison-Wesley Publishing Company. Don Mills, Ontario.

Slatter, S. 1992. "Successful Startup Strategies." IEEE Engineering Management Review. Winter, 65 - 79.

Slevin, D.P. and Pinto, J.K. 1988. "Balancing Strategy and Tactics in Project Implementation." IEEE Engineering Management Review. December. Vol. 16. No. 4. 44 - 52.

Sobek, D. K., Liker, J. K. and Ward, A. C. 1998. "Another Look at How Toyota Integrates Product Development." IEEE Engineering Management Review. Winter. Vol. 26. No.4. 69 - 78.

Sonneborne, M. and Wilemon, D. 1990. "Sustaining Innovativeness in Emerging High-Tech Companies." IEEE Engineering Management Review. Summer. Vol. 18. No. 3. 5 - 15.

Souder, W.E. 1983. "Project Selection and Economic Appraisal". Von Nostrand Reinhold. New York. New York.

Sparkes, D. and Guild, P.D. 1999. "Assessing New Venture Viability." Presentation at the Portland International Conference on the Management of Engineering and Technology. Portland State University.

Steers, R.M. 1991. Introduction to Organizational Behaviour. Harper Collins Publishers. New York. New York.

Stewart, T.A. 1991. "Brainpower". *Fortune*. June. 44 - 60.

Stewart, T.A. 1994. "Your Company's Most Valuable Asset: Intellectual Capital". *Fortune*. October. 229 - 231.

Stewart, V and Stewart, A. 1981. "Business Applications of Repertory Grid." McGraw-Hill, London.

Straube, B. 1985. "Model Building and Fuzzy Systems." Fuzzy Sets, Applications, Methodological Approaches and Results. International Workshop on Fuzzy Sets Applications, Akademie-Verlag, Berlin.

Taber, R. 1994. "Fuzzy Cognitive Maps Model Social Systems." AI Expert. July. 19 - 23.

Talluri, S. and Sarkis, J. 1997. "Extensions in Efficiency Measurement of Alternative Machine Component Grouping Solutions Via Data Envelopment Analysis." IEEE Transactions on Engineering Management. August. Vol. 44. No. 3. 299 - 304.

Wang, S. 1994. "Generalizing Fuzzy Membership Functions: A Monotonic Neural Network Model." Fuzzy Sets and Systems. Vol. 61. 71 - 81.

Waterman, D.A. and Newell, A. 1971. "Protocol Analysis as a Task for Artificial Intelligence". Artificial Intelligence, Vol. 2, 285-318.

Wheelwright, S.C. and Clark, K.B. 1992. "Competing Through Development Capability in a Manufacturing-Based Organization." Fall. IEEE Engineering Management Review. Vol. 20. No. 3. 26 - 37.

White, G.R. 1978. "Management Criteria for Effective Innovation". *Technology Review*. February. 21 - 28.

Wilkinson, G. 1992. "How Credit Scoring Really Works". *Credit Scoring and Credit Control*. Oxford University Press - Clarendon Press, Toronto.

Wind, Y. and Maharjan, V. 1988. "New Product Development Process: A Perspective for Reexamination". *Journal of Product Innovation Management*. Vol. 5, No. 4, 304 - 311.

Yager, R. R. and Rybalov, A. 1998. "Full Reinforcement Operators in Aggregation Techniques." IEEE Transactions on Systems, Man and Cybernetics: Part B: Cybernetics. Vol. 28, No. 6. December. 757 - 769.

Yanaru, T., Hirotja, T., and Kimura, N. 1994. "An Emotion-Processing System Based on Fuzzy Inference and Subjective Observations." International Journal of Approximate Reasoning. Vol. 10. 99 - 122.

Zedah, L. 1993. "Possibility Theory and Soft Data Analysis." Readings in Fuzzy Sets for Intellegent Systems. Edited by Dubois, D., Prade, H. and Yager, R. R. Morgan Kaufmann Publishers, Inc. San Mateo, California.

Zikmund, W.G. 1994. "Business Research Methods." Harcourt Brace College Publishers. Toronto.

Zif, J., and McCarthy, D.J. 1997. "The R&D Cycle: The Influence of Product and Process R&D on Short-Term ROI." IEEE Transactions on Engineering Management. May. Vol. 44. No. 2. 114 - 123.

Zimmerer, T.W., and Scarborough, N. M. 1996. "Entrepreneurship and New venture Formation." Prentice Hall, Upper Saddle River, New Jersey.