KNOWLEDGE-BASED VERTICAL INTEGRATION:
THE NATURE OF KNOWLEDGE
AND ECONOMIC FIRM BOUNDARY LOCATION

by

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ABSTRACT

This research extends the knowledge-based view of the firm as it relates to organizational structure. In particular, this research provides evidence that fundamental classifications of knowledge are measurable, in relative terms, as factors of production. It then relates differences in relative quantities of these classifications of knowledge to the presence or absence of inter-firm boundaries. Finally, this study provides evidence that financial performance may be related to the alignment of organizational structure with knowledge-based factors of production.

This study contributes to strategic management theory by offering a potential solution to the difficulties of measuring knowledge as a factor of production. The research was motivated by the belief that it is the cost and value of knowledge that determines economic efficiency (Simon, 1999). By surveying professionals in the mutual fund industry for their relative reliance on three classifications of knowledge, this study suggests a set of measures of knowledge-based factors of production. These measures in turn support the testing of hypotheses related to the vertical integration (or de-integration) of adjacent stages of production.
Researchers have typically categorized organizational knowledge as either tacit or explicit. This research develops the concept of *encapsulated* knowledge as a fundamental classification of knowledge. Encapsulated knowledge is neither tacit nor explicit, because it is externalized and implicit. Progress in measuring knowledge is made by distinguishing between knowledge that resides in human minds (tacit), knowledge that is codified as information (codified), and knowledge that is embodied in the design and functionality of physical artefacts (encapsulated).

Relative reliance on the fundamentally different knowledge-based factors of production was found to vary between adjacent stages of production, despite the essential overlap of jointly held substantive knowledge. Portfolio managers are generally less (more) reliant on tacit (encapsulated) knowledge than other investment management professionals in the mutual fund complex. In addition, portfolio managers whose firms are de-integrated from the mutual fund management firms were found to be more (less) reliant on tacit (encapsulated) knowledge than their integrated counterparts. Finally, alignment between mutual fund structure and reliance on knowledge-based factors of production was found to affect performance of mutual funds.
ACKNOWLEDGEMENTS

I am reminded of the words used recently by James March at the beginning of a lecture, to recognize that one’s own work is not done in isolation, but is instead built with the involvement of others: “The voice with which I speak is, strictly speaking, not my own” (March, 2006). In this dissertation you will ‘hear’ a number of voices, some of whom I would like to identify individually.

First and foremost, I am extremely grateful to my thesis co-supervisors, Chun Wei Choo and Brian Silverman. Chun Wei advised me throughout my journey as a Ph.D. student, agreeing to nurture my interest in knowledge management from the outset. He patiently supported and encouraged my change in interest from a relatively narrow focus on the measurement of intellectual capital to a broader strategic focus on the knowledge-based view of the firm. His constant but gentle campaign encouraging me to explicate my thoughts in greater detail miraculously transformed me from someone who expressed himself primarily by spreadsheets into the author of this dissertation.

Brian first introduced me to the skills of critically evaluating empirical studies in strategic management and his guidelines for doing so are still piloting my reading. When I was struggling to identify a research topic, it was Brian who directed my interest in the knowledge-based view of the firm toward researching concept of firm boundary location first proposed by Demsetz (1988). It was also Brian who dispelled the uneasiness I felt attending my first Academy of Management meeting.

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This dissertation is dedicated to my grade one teacher, Kathleen P. (Kay) O’Hagan (March 22, 1912 – February 9, 2007), whose devotion to teaching instilled in me the joy of learning.
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1 INTRODUCTION

1.1 Overview

“In a world with perfect information, organizational design… is of little moment. In practice, it is of central concern to businesses” (Stiglitz, 2002, p.511).

This introduction seeks to establish a context for empirically testing a knowledge-based explanation of the location of firm boundaries. The general question to be answered is, ‘Can a knowledge-based view of the firm inform us about inter-firm boundary location?’ This research provides evidence that not only can a knowledge-based view (KBV) be informative in explaining the presence or absence of firm boundaries, but also that firms that select boundaries according to differences in knowledge-based factors of production will outperform those that do not.

1.2 Context

1.2.1 Situating the Research

The recognition of the importance of knowledge in economics and the distribution of knowledge in various forms between various economic actors sets the context for this paper.

The proliferation of the term ‘Knowledge Economy’ in common parlance indicates a pervasive awareness of the economic value of knowledge (for dissenting opinion, see Godin (2006)). While the term may be relatively new, the proposition that current advanced economies differ fundamentally from previous incarnations is questionable. It may be that societies have lately come to the realization that the knowledge intensity of goods and services is considerably higher today than it was in some not-too-distant past, that the knowledge intensity of goods and services is increasing, and that this intensification is accelerating (OECD, 1999). Whereas previous generations may not have noticed significant changes in knowledge intensity during their lifetimes, the current rate of increase is now quite noticeable within a single human
generation. The onset of the knowledge economy may be defined as some arbitrary proportion GDP being generated by the service sector, or some arbitrary proportion of the work force employed in non-manufacturing, non-agricultural occupations (Beckstead & Vinodrai, 2003), but arguably economies have always been knowledge-based.

Awareness of the importance of knowledge in economics, and the merits of giving it greater analysis in research, was possibly first advocated by the Austrian economist von Hayek. He took issue with the unexamined assumption in neo-classical economics that knowledge was pervasive and costless:

“Clearly there is… a problem of the Division of Knowledge which is quite analogous to, and at least as important as, the problem of the division of labour. But while the latter has been one of the main subjects of investigation ever since the beginning of our science, the former has been as completely neglected, although it seems to me to be the really central problem of economics as a social science” (von Hayek, 1937, p.49) (emphasis in original).

Von Hayek (1945) also suggested that the limited knowledge of individuals working independently and central planners directing an entire economy restrict the effectiveness of both.

“We cannot expect that this [economic] problem will be solved by first communicating all this knowledge to a central board which, after integrating all knowledge, issues its orders. We must solve it by some form of decentralization” (Hayek, 1945, p.524) (emphasis in original).

More recently, Jensen and Meckling (1996) stressed that to optimize decision-making, it is important that the decision authority and the relevant knowledge be co-located. They suggested that individual optimizing behaviour drives the distribution of decision-making rights in the economy, and that the distribution reflects the limitations of individuals’ knowledge (Jensen & Meckling, 1996). This recognition of that the distribution of knowledge between various actors is important for economic efficiency sets the context for this research.
1.2.2 Purpose of Firm Boundary Research

The purpose of this research is to explain the presence or absence of inter-firm boundaries using a knowledge-based view of production and to explore any concomitant performance implications. This research is motivated by a desire to improve our understanding of how firms create value and by a desire to advance the development of a strategic theory of the firm using a knowledge-based view. Improved understanding of firm boundary determination has both academic and practical implications. Determination of the locations of firm boundaries is one aspect for which a theory of the firm must have an explanation (Foss & Mahnke, 2000), and “[a]ny advance in understanding where to draw firm boundaries must ultimately improve the quality of managerial decision-making in this area (Phelan & Lewin, 2000, p.306).”

Evidence suggests that heterogeneity in firm performance may be due to differences in the relative ability of firms to identify and select the optimal location of boundaries in a value chain across which to conduct market transactions (Montgomery & Wernerfelt, 1988; Robins & Wiersema, 1995; Singh & Zollo, 2004). In other words, firms that integrate excessively or insufficiently, backward or forward, bear higher than necessary production, distribution or coordination/governance costs and are at a competitive disadvantage relative to those that are superior at locating their boundaries. Careful consideration in making “make-or-buy” and “use-or-sell” decisions is therefore of strategic consequence.

1.2.3 Nature of the Problem

Firms continually decide whether or not to abandon a process currently performed in-house to upstream or downstream firms and whether or not to extend into upstream or downstream activities. The determination of economic inter-firm boundary location is a key strategic concern. Correctly deciding which activities are more economically organized “in a
unified firm (AB) rather than in two autonomous firms (A and B)” (Williamson, 1999, p.1097) is no simple undertaking. The question of firm boundary location is important since it attempts to establish the productive activities a firm should undertake in-house, which products it should purchase or activities it should outsource, and when it should sell its product to the next segment of the value chain (Demsetz, 1988; Pfaffmann, 1998).

1.2.4 Identification of the Issue

Much of the evidence relating vertical integration to profitability is based on concepts grouped under the general heading of transaction cost economics (TCE), a concept introduced by Coase (1937), and later elaborated by Williamson (1975; 1979; 1981) and others. Evidence based on TCE theory suggests that integration may lead to enhanced returns by reducing switching costs (Monteverde & Teece, 1982), enhancing monitoring of sales forces (Anderson, 1985), protecting relationship-specific investments (Joskow, 1987), and reducing small numbers bargaining and intellectual property rights expropriation hazards (Pisano, 1990).

On the other hand, there is also evidence that de-integrating for production purposes may enhance firm performance, countering a possible over-emphasis on transaction cost avoidance as motivation for vertical integration. While TCE is said to subsume economizing on production costs (Williamson, 1979), empirical research has generally focused on economizing on transaction costs and assumed the absence of differential production costs (Langlois & Foss, 1999) (for exceptions see (Hoetker, 2005; Mayer & Salomon, 2006; Walker & Weber, 1984)). Threats of technological uncertainty and obsolescence in industries with many participants, argue against integration (Balakrishnan & Wernerfelt, 1986). Research also suggests that firms more capable at measuring innovation performance will prefer alliances over integration (Robertson &
Gatignon, 1998), and those with strong technological capabilities may de-integrate even in the face of ex-post contract renegotiation hazards (Mayer & Salomon, 2006).

One perspective that has lacked significant attention has been the examination of vertical integration or de-integration in terms of minimizing total knowledge acquisition costs between firms. Given differences in comparative advantages between firms in the generation of economically valuable knowledge, it would seem logical to locate firm boundaries so as to take advantage of these differences:

“Because it is uneconomical to educate persons in one industry in the detailed knowledge used in another, recourse is had to developing or encapsulating this knowledge into products or services that can be transferred between firms cheaply because the instructions needed to use them do not require in-depth knowledge about how they are produced… A production process reaches the stage of yielding a saleable product when downstream users can work with, or consume, the ‘product’ without themselves being knowledgeable about its production” (Demsetz, 1988, p.159).

“A single firm works a product into new, simpler-to-use… products until the diversity of uses further downstream is so great as to require this firm… to bear greater costs of information acquisition and maintenance that are avoided by potential users… Title to ‘the’ product is likely to change hands when this point in the development of product… is reached… The boundary defining degree of vertical integration will have been established (Demsetz, 1988, p.160)”.

Heterogeneity in firm performance may therefore be impacted by differences in the relative ability of firms to identify and select the optimal location of boundaries in a value chain across which to transact. The goal of this research is to identify and model measures of knowledge-based factors to explain the location of inter-firm boundaries and to test for accompanying performance impacts.

1.3 Research Questions

This research responds to the challenge of optimizing firm boundary location by “applying an economic calculus to knowledge” (Simon, 1999, p.34). The conceptual and
empirical framework presented in this study suggests that differences in cost and technical efficiency of knowledge-based factors of production between adjacent stages along a value chain are a function of specialization over time. These different costs and technical efficiencies in turn shape the economics of inter-firm boundary location. Put another way, this research addresses the following questions.

*Are there differences in fundamental knowledge-based factors of production between adjacent stages of a value chain?*

*Do differences in knowledge-based factors of production explain the presence or absence of inter-firm boundaries?*

*Are there any performance implications related to aligning organizational structure with knowledge-based factors of production?*

### 1.4 Research Setting

#### 1.4.1 The Mutual Fund Industry

The mutual fund industry is a major economic force in Canada with about CAD 700 billion in assets under management (Q1, 2007). Assets under management (AUM) are also growing at exceptional rates, increasing more than ten-fold since 1992. The following table displays annual increases in mutual fund assets under management for the latest four years as reported for its members by the Investment Funds Institute of Canada (IFIC, 2007).

**Table 1: Annual increase in mutual fund assets under management**

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual increase in AUM</th>
<th>Year-end AUM (CAD billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>12.1%</td>
<td>438.9</td>
</tr>
<tr>
<td>2004</td>
<td>13.3%</td>
<td>497.3</td>
</tr>
<tr>
<td>2005</td>
<td>14.6%</td>
<td>570.0</td>
</tr>
<tr>
<td>2006</td>
<td>15.8%</td>
<td>660.2</td>
</tr>
</tbody>
</table>
According to Investor Economics Inc. (2006), cost reduction motivates both internalizing and externalizing portfolio management by mutual fund management. Internalizing is also motivated by a desire to control the value chain, a strategy which appears to be especially preferred by deposit-taking institutions (2006). An interview with the CEO of a mutual fund management firm confirmed the focus on costs in making the integration/de-integration decision. Research presented in Chapter 5 indicates that portfolio managers who are external to the mutual fund management firm manage about 37% of the 3,856 mutual funds studied. This is somewhat higher than the 28% of long term funds considered sub-advised by Investor Economics (2006). This difference is partly definitional and partly due to the population examined.

1.4.2 Primary Data

Primary data used in this research was collected by surveying portfolio managers and other investment professionals in the mutual fund industry. This data was self-reported by the respondents participating in one of two Internet-based surveys. The data was collected from mid-2006 into the first quarter of 2007. Copies of the two surveys are presented in Appendix D and Appendix E.

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1 An interviewee at Investor Economics Inc. indicated portfolio managers are only considered de-integrated if the mutual fund management firm has no meaningful ownership of the portfolio manager, with meaningfulness defined subjectively on the basis of known relationships and the circumstances of the parties involved. The long-term mutual funds examined by Investor Economics Inc. in their 2005 sub-advisory report managed only about 15% of all of the assets under management by members of the Investment Funds Institute of Canada and represent less than half of the number of funds examined in this research.
1.4.3 Secondary Data

Secondary data was provided by Fundata Canada Inc. The data was generously provided at no charge for academic purposes and consisted of individual mutual fund performance measures as well as details about mutual fund management firms and individual portfolio managers.

1.5 Organization of the Study

The next chapter provides a review of the literature pertaining to this study. The subsequent chapter discusses the methodology applied. The two chapters after that present the findings. The first findings chapter, Chapter 4, explores the measurement of relative reliance on tacit, codified, and encapsulated knowledge and answers the first research question. It concludes with evidence that two of these fundamental knowledge-based factors of production are reliably measurable and that they differ between adjacent stages of production in a knowledge-based industry. The second findings chapter, Chapter 5, relates differences in relative reliance on knowledge-based factors of production to the presence or absence of an inter-firm boundary (vertical de-integration or integration), and ends with a two-stage model capable of relating mutual fund performance to knowledge-based factors in the case of de-integrated mutual funds. The final chapter provides a summary of the study.

1.5.1 Significance of the Study

Some organizations have been more successful than others in terms of economic efficiency. These organizations have been able to generate economic rents. The determination of why some firms are able to enjoy sustained competitive advantage and persistently obtain economic rents while others appear to be unable is of interest to both academics and practitioners of strategic management. Empirical evidence indicates that management decisions regarding the
extent of vertical integration may be a significant factor in explaining heterogeneity in firm performance (Balakrishnan & Wernerfelt, 1986; Joskow, 1987; Monteverde & Teece, 1982; Pisano, 1990; Walker & Weber, 1984).

There is also evidence that the effectiveness of vertical integration in contributing to competitive advantage changes over time (Afuah, 2001), and that various factors impinge on the rate of adapting to appropriate forms of vertical alignment (Nickerson & Silverman, 2003). Related research suggests that contracting complementarity may result in greater vertical integration than would be expected if inter-firm boundary decisions, for the supply of individual components, are made in isolation (Novak & Stern, 2007). Contracting complementarity\(^2\) is driven by interactions among components and systems. In research which directly relates vertical integration to performance, Forbes and Lederman (2007) find that vertical integration improves airlines’ network performance, especially in adverse weather conditions. All this evidence suggests that vertical integration/de-integration decisions carry with them performance implications.

\subsection*{1.5.2 Delimitations and Limitations of the Research}

Delimitations refer to boundaries of the research set by the researcher that may limit the generalizability of the results beyond that of the selected population. Limitations refer to shortcomings of the research that were not or could not be controlled.

This research is delimited by relying on data from Canadian mutual funds. It did not include data collected from pension funds, although some of the surveyed portfolio managers

\footnote{Defined as increasing marginal returns to vertical integration for a given vertical integration choice in the level of vertical integration on related choices (Novak & Stern, 2007).}
and other investment management professionals are also responsible for the management of pension fund assets. Also, the respondents to the survey are associated with mutual fund management firms that manage, on average, more assets than the population of such firms. Accordingly, this may limit the external validity of the results of this study.

There are a number of limitations of this research, which suggest that the results should be interpreted with caution. First, measures of relative reliance on three classifications of knowledge were based on self-reported ratings rather than on objectively observed phenomena, making them subject to considerable measurement error. Second, a number of control variables were not available to be incorporated in the research. For example, the control variables used by Chen, Hong and Kubik (2006), in their research on outsourcing fund management were not used. The control variables in their research, and omitted from this study, were however found to be insignificant (Chen et al., 2006).

1.6 Summary

This chapter began by introducing the ‘Knowledge Economy’ as the context for this research. The nature of the problem was then described as correctly deciding when two adjacent stages of production should be integrated into a single firm or de-integrated i.e., separated by an inter-firm boundary. Evidence from other research linking the vertical integration/de-integration decision to firm performance was then presented. The purpose of this research was stated as the identification and modelling of measures of knowledge-based factors to explain inter-firm boundary location and possibly related effects on firm performance. Three overarching research questions that this study addresses were then set out and the Canadian mutual fund industry was described as the research setting. Finally the significance of the study in seeking to explain
heterogeneity in firm performance and the relationship of organizational structure to performance, as well as delimitations and limitations of the research were presented.
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“Firms... form a pattern of economic organization that takes into account the need for acquiring knowledge in a more specialized fashion...” The “vertical boundaries of a firm are determined by... the economics of conservation of expenditures on knowledge” (Demsetz, 1988, p.160). Using a knowledge-based view of the firm, this research proposes that inter-firm boundaries appear between upstream and downstream stages along a value chain as a result of marginal comparative advantages that emerge from knowledge specialization. This literature review explores the concepts related to the knowledge-based view of the firm (KBV) and considers issues of vertical integration.

2.1 Introduction

The next three sections briefly discuss specialization, the difficulties involved in transferring knowledge, and organizational solutions offered to overcome these difficulties, as background to the key constructs (see Figure 1). The subsequent section touches upon characterizations of knowledge, and includes the paradox of knowledge replication, the difference between information and know-how, and the trade-off between codifiability and complexity. The issue of appropriation of the value of knowledge is also discussed in this section, which concludes with an overview of productivity and knowledge, and a definition of organizational knowledge.
The last section of this chapter discusses the typology of organizational knowledge used in this research. It begins with the classification of knowledge as tacit, codified, or encapsulated, continues with discussions of, the relationship between information and knowledge, the nature of organizational knowledge, and ends with operational definitions for tacit, codified, and encapsulated knowledge. The chapter ends with a brief summary that includes the limitations of the literature review.

2.2 Specialization

2.2.1 Knowledge, Productivity, and Specialization

Demsetz (1988; 1991) is recognized for emphasizing the importance of the role of production in the knowledge-based view of the firm. Firms, like individuals, can improve their economic prospects through specialization in knowledge acquisition. The idea that
specialization is productive is generally attributed to Adam Smith in his discussion of the division of labour among individual workers within a firm. Demsetz (1988; 1991) extends Adam Smith’s idea to consider productive specialization among firms. Firms are “repositories of specialized knowledge and of the specialized inputs required to put this knowledge to work” (Demsetz, 1988, p.158). Hence, “Economic organization, including the firm, must reflect the fact that knowledge is costly to produce, maintain, and use [and that] …there are economies to be achieved through specialization” (Demsetz, 1988, p.158). The division of knowledge leads to human-capital deepening and furthers the division of labour, which in turn leads to productivity increases and economic efficiency. In economically efficient systems of organization the location of a firm boundary will be indicative of differences in knowledge-based comparative advantages on the two sides of that boundary as a result of specialization (Becker & Murphy, 1992; Demsetz, 1988, 1991; Grant, 2002).

Demsetz (1988) argues that Adam Smith’s observations regarding specialization by individuals has a parallel application when firms are considered the unit of analysis. Demsetz defines the firm as “an agreement to *specialize* (1988, p.156)” (emphasis in original). And specialization is defined as the production for persons who are not members of the firm’s team. This distinguishes specialization from self-sufficiency, which, at the other end of the specialization-generalization spectrum, implies production by and for the same person. This characteristic of the firm is consistent with price theory in which the firm does not consume what it produces, but sells it to others (Demsetz, 1988).

The economic value of specialization and its knowledge-based origin has also been recognized in labour economics. Nobel laureate Gary S. Becker and co-author Kevin M. Murphy (1992, pp. 1138, 1139, 1140) argue that specialization maximizes comparative advantage. The
issue of specialization has historically been analyzed from a physical labour perspective, beginning with Adam Smith’s discussion of pin making. Becker and Murphy extend Smith’s discussion by focusing on the specialization from a knowledge perspective, suggesting, “Specialization is what produces most comparative advantage… [and] much of the growth in specialization over time has been due to an extraordinary growth in knowledge” (1992, pp. 1140,1145).

2.2.2 The Firm and Specialization

It is uneconomical to bring into a firm that knowledge which can be more productively managed outside of it, and likewise to outsource that portion of business in which a firm enjoys a comparative knowledge advantage. Accordingly, the most economically efficient degree of vertical integration is one in which comparative advantages in knowledge define firm boundaries and lead to inter-firm trade.

Grant (2002, p.112) agrees that specialization defines the firm. According to Grant (2002, p.112), the firm exists because it provides “conditions under which individuals can integrate their specialist knowledge” and because knowledge for production “requires greater specialization than is needed for its utilization”. This difference between knowledge required to produce and knowledge required to use a product is termed the “fundamental asymmetry in the economics of knowledge (Grant, 2002, p.112).” Grant goes so far as to claim that “[t]he assumptions that there are gains from specialization in knowledge acquisition and storage, and that production requires the input of a wide range of specialized knowledge… is fundamental to all theories of the firm” (2002, p.112) (emphasis added).
2.3 Transferring Knowledge

2.3.1 When People and Firms Specialize

“Knowledge properties affect… how easily it diffuses within and across firm boundaries” (Argote, McEvily, & Reagans, 2003, p.574). The knowledge-based view assumes, among other things, the following about knowledge. Transference of tacit knowledge (skills, know-how, and contextual knowledge) is costly and slow, being only manifest in application, and transference or communication of explicit knowledge between individuals and organizations is easy (Grant, 2002). The transfer of tacit knowledge requires a greater degree of intimacy and permanence than does the transference of codified or encapsulated knowledge (Hedlund, 1994). The decision to transfer knowledge within the firm or across a firm boundary is impacted by the relative costs of doing so, which in turn is based on attributes of knowledge (Kogut & Zander, 1992; Teece, 1996, 1998; Zander & Kogut, 1995).

Difficulties in transferring or handing off intermediate product between adjacent stages of production may be expected to increase as specialization progresses. The creation of jargon in science and technology-specific terminology in value-adding organizations may be taken as evidence of specialization. Lawrence and Lorsch (1967) suggest that advances in science increase the need for differentiation in organizations, and that integration is essentially antagonistic to this specialization.

A number of solutions have potential to overcome the problem of division in knowledge generated by specialization. The following three management alternatives correspond roughly to transferring one the three classifications of knowledge (tacit, codified, or encapsulated).

Knowledge may be considered both as a process output from an upstream stage and as a factor of production in the adjacent downstream stage (Postrel, 2002). The transfer of tacit
knowledge is facilitated by the use of “trans-specialists” who are trained in the production processes of adjacent stages (Postrel, 2002). There is a high cost to educating specialists in various stages of production about knowledge in an adjacent stage, but this may be avoided by training only a limited number of trans-specialists (Postrel, 2002).

Firms that face high levels of technological bifurcation may benefit by transferring knowledge in a codified form (Cowan, David, and Foray, 2000). Knowledge in a codified form may be quickly and inexpensively transferred across technological boundaries.

Finally, Demsetz (1988) suggests that difficulties in transferring knowledge may be overcome by low cost knowledge encapsulation. Encapsulating knowledge in the form of a (intermediate) product by an upstream stage reduces the costs of knowledge utilization by the adjacent the downstream stage.

While specialization leads to efficiency among individuals and firms, the diseconomies of retaining all specialization within a single firm leads to markets for specialized products between firms along a value chain. Firms can be expected to specialize in products in which they have a comparative advantage. Comparative advantages surface as the relative abilities of firms engaging in knowledge-based productive activities increasingly diverge over time. The divergence of abilities that result from specialization will be manifested in the divergence of relative costs of transferring tacit, codified and encapsulated knowledge within and among firms (Jacobides, 2005).

2.3.2 From Specialization to Comparative Advantage to De-Integration

Consider, for example, the use of different classifications of knowledge in three adjacent stages of production, stages A, B, and C, within three similar firms, X, Y, and Z. Figure 2 depicts these stylized firms producing with equal efficiency in each stage before any specialization
occurs. Each stage may rely more or less on a particular classification of knowledge as an input to production, initially in equal quantity for all three firms. Production in stage A, for example, may be relatively more reliant on tacit knowledge, stage B on codified knowledge, and stage C on encapsulated knowledge.

**Figure 2: Three firms producing in three adjacent stages before specialization**

![Bar chart showing productivity levels before specialization](chart)

Over time, continued specialization may be expected to lead to efficiency differences among the stages and firms. As each stage carries on its productive activities, it may gradually accumulate specific production and organization knowledge that allows it to produce more efficiently (Foss, 1997). For example, firm X with a relatively greater reliance on tacit knowledge could become relatively more efficient in stage A; firm Y with a relatively greater reliance on codified knowledge could become relatively more efficient in stage B; and firm Z with a relatively greater reliance on encapsulated knowledge could become relatively more
efficient in stage C. Figure 3 depicts the relative productivity of these same three firms in each stage, but now with the effects of specialization evident. Each of the firms may still retain production in all three stages, perhaps in separate divisions, even as the distinctiveness of the three stages increases over time.

Figure 3: Three firms developing comparative advantages in different stages of production

![Comparative Advantages With Specialization](chart)

As specialization increases the disparity in efficiency of production among the three stages within each firm, the marginal cost of integrating all three classifications of knowledge within each single firm will exceed the costs of de-integrating and specializing in a single stage (Grant & Baden-Fuller, 2004; Jensen & Meckling, 1992). In effect, the most productive stage within each firm will be subsidizing the relatively less productive stages. Competitive market pressure will motivate firms to exit those stages in which they are less productive in favour of expansion in the stage in which specialization has led to a comparative advantage. The favouring
of one stage/division over another may be accelerated if divisions are free to source from, and sell into, a competitive market and are not restricted to intra-firm dealing (Zenger & Hesterly, 1997). Continuing with the example, a comparative advantage may eventually lead firm X to produce only in stage A, and exit stages B and C. Firm X would then sell the product of stage A to firm Y, which would similarly have exited stages A and C. Firm Y would then sell the product of stage B to firm Z, which would have exited stages A and B to concentrate on production in stage C. Figure 4 depicts each of the three firms, de-integrated, with production in a single stage each and markets having developed between them. Continued specialization in each of these single stages may lead them to evolve to a point where they themselves divide into multiple distinct stages. This is a stylized example of how specialization in knowledge leads to de-integration, but it may help explain why “Situations where it makes sense to maintain positive amounts of understanding across specialties are relatively rare in the economy as a whole” (Postrel, 2002, p.314).
2.3.3 Inter-firm or divisional boundaries

It is possible that firms X and/or Y and/or Z, in addition to specializing in specific stages of production, also merge. In such a case vertical de-integration would not be observed, but arguably such mergers are generally expected to reduce production efficiency. There are, for example, very few efficient ‘farm-to-fork’ firms, just as there are very few ‘jacks-of-all-trades’, in evidence in an efficient modern economy. Instead, horizontal integration or expansion of scale in a single stage may be more probable than vertical integration (Holmström & Roberts, 1998). Vertical de-integration of stages using inter-firm boundaries reduces managerial diseconomies of scope (Jacobides & Hitt, 2005; Lawrence & Lorsch, 1967a, 1967b), permits more focused management (Jacobides & Hitt, 2005; Prahalad & Bettis, 1986), and perhaps most importantly,
unleashes further specialization along unique technological paradigms and trajectories (Dosi, 1982).

The focus on differences in knowledge between *adjacent* stages of production along a value chain enhances the generalizability of the research outcomes. Focusing on adjacent stages ensures the presence of considerably more common knowledge than if the stages were not adjacent. This has the effect of minimizing the probability that the presence of an inter-firm boundary is merely due to an inability to integrate vastly different knowledge domains. It is not surprising that stages of production at the both ends of a very long value chain are not integrated in a single firm, but an interesting research setting occurs at the margin, when two adjacent stages share considerable common knowledge. When common knowledge is shared, the search for a knowledge-based explanation for de-integration is focused on fundamental classifications of knowledge and more likely generalizable to various value chains.

### 2.4 Organizational Solutions

Two literatures have made important contributions to the question of firm boundary location, transaction cost economics (TCE) and the resource-based view of the firm (RBV). Both literatures are part of a more general framework known as organizational economics (Silverman, 2002) (see also, Foss, 2003). Despite the tremendous advancements that research in TCE has contributed, there are still some theoretical gaps. For example, in its strictest form, TCE assumes homogeneity in productive capability. Although proponents of the TCE perspective acknowledge that both transaction costs and heterogeneous production capabilities must be taken into account when considering organizational structure (Riordan & Williamson, 1985), this has rarely been done in empirical research (notable exceptions include, Argyres, 1996; Poppo & Zenger, 1998; Silverman, 1999). In defence of TCE’s assumption of homogeneity in productive capability,
when departures are initially made from conventional wisdom, isolating the focus of research is often necessary for explanatory progress to take place (Mäki, 2004).

Because firms may not be perfect substitutes in production of goods and services, it is also necessary to enquire into the firms behind the market alternative and their relative production efficiencies. The vertical integration/de-integration decision “depends on a comparison of all the gains and losses that attach to external procurement relative to in-house production” (Demsetz, 1991, p.163) (emphasis in original). The claim that the firm is at a disadvantage relative to the market in production costs (Riordan & Williamson, 1985) raises the question of how the market produces, if not through the activities of another firm. The emphasis in KBV research on production costs differs from that taken by those who favour explanations emphasizing primarily the high costs of transacting in markets (Williamson, 1975, 1985).

The resource-based view of the firm (Barney, 1991, 2001; Penrose, 1959; Peteraf, 1993; Wernerfelt, 1984) is the relatively recent precursor of the knowledge-based view of the firm. The difference is that in the latter, knowledge is considered the resource of interest (Grant, 1996; Machlup, 1984). The assumption that knowledge is the critical input in production and primary source of value is fundamental to the knowledge-based view of the firm (Grant, 1996, p.112). The application of knowledge economizes on the amount of space, time, energy and material used in the conduct of human affairs (Boisot, 1998).

The knowledge-based view of the firm arguably completes the resource-based view of the firm: “Knowledge, in fact, is an additional and necessary dimension attaching to every resource. Without the ‘knowledge’ of how to profitably use a resource, it is not a resource, it has no value. Resources without knowledge have no meaning” (Lewin & Phelan, 2000, p.71)
Knowledge may be thought of as the meta-resource that coordinates the mobilization of all other firm resources (Choo & Bontis, 2002).

For resources to confer competitive advantages, they must be imperfectly imitable (Barney, 1991). The knowledge a firm has about the coordination, combination and application of its resources may, in itself, be the most unique and inimitable resource, especially if the firm’s other resources are lacking in distinctiveness (Grant, 1996; Penrose, 1959). Knowledge, especially in its tacit form, is arguably the most inimitable resource because of, among other things, its nested heterogeneity (Felin & Hesterly, 2007), causal ambiguity (Lippman & Rumelt, 1982), and the time compression diseconomies it engenders (Dierickx & Cool, 1989).

The knowledge-based view of the firm (KBV) is a theoretical perspective in the literature of strategic management that, as its name suggests, emphasizes knowledge as the key

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3 Whether or not the Knowledge-Based View of the firm constitutes a theory has been the subject of considerable debate. See for example, Foss (1996; 1996) and Phelan & Lewin (2000). According to one notable proponent of KBV, “The emerging knowledge-based view of the firm is not a theory of the firm in any formal sense” (Grant, 2002, p135)

4 A universally accepted definition for knowledge does not exist. Boisot differentiates among knowledge, information and data as follows: “Knowledge builds on information that is extracted from data… Data is a [sic] discrimination between physical states… that may or may not convey information to an agent. Whether it does or no depends on an agent’s prior stock of knowledge… [W]hereas data can be characterized as a property of things, knowledge is a property of agents predisposing them to act in particular circumstances. Information is that subset of the data residing in things that activates an agent – it is filtered from the data by the agent’s perceptual or conceptual apparatus… Information, in effect establishes a relationship between things and agents. Knowledge can be conceptualized as a set of
elucidatory concept. The definition of knowledge differs among theorists of various disciplines, and even among theorists in the same discipline. In the fields of economics and strategic management this is no different. Grant suggests that a “focus on the role of knowledge as a factor of production” (2002, p.133) unifies KBV. Drucker (1993) and Arrow (1999) have also proposed that knowledge be considered as a factor or production.

The framework constructed for this research suggests that tacit, codified, and encapsulated classifications of knowledge be considered as factors of production. These classifications of knowledge are not the only ones that could be applied, but they may be considered more fundamental than for example the distinction between functional and substantive knowledge. The fundamental distinctions of tacit, codified, and encapsulated knowledge are expected to be revealing in explaining inter-firm boundary location, even when adjacent stages of production rely on common substantive knowledge.

Boisot’s relationship between information and knowledge may be classified as a cognitivist epistemology (von Krogh & Roos, 1995). Citing Bruner (1964), von Krogh and Roos suggest that in this epistemology, “A person actively constructs knowledge… by relating incoming information to a previously acquired frame of reference” (1995, p13)

Substantive knowledge is knowledge of how a product is developed and produced, while functional knowledge is knowledge of how to use a product’s capabilities (Kogut & Zander, 1992).
2.4.1 KBV and Firm Boundaries

Demsetz (1988) was arguably first to combine an economic and knowledge-based perspective in explaining the location of firm boundaries. Demsetz (1988) describes the boundaries of firms being located as a function of (i) low cost knowledge encapsulation (in production) on the part of the supplier, and (ii) low information costs (in product utilization) on the part of the consumer of such encapsulated knowledge. These differential knowledge costs are posited by Demsetz to be important in making the conventional “make-or-buy” (or “develop further-or-sell”) decision. This may be interpreted as suggesting that the encapsulation of difficult-to-transfer tacit knowledge facilitates the economic separation of producer and consumer and the formation of an inter-firm boundary. Encapsulation of knowledge into products whose use minimizes cognitive load enables this economizing.

Demsetz’s proposition regarding firm boundary location rests on three important assumptions: first, that tacit knowledge may be transferred more efficiently within a firm than across an inter-firm boundary, second, that there exist economic benefits to encapsulating knowledge, and third, that there are costs associated with organizing supplier and consumer within a single firm.

As specialization increases the disparity in efficiency of production between specialized division within a firm, the marginal cost of integrating all specialized knowledge within a single firm will exceed the costs of decentralization, and eventually lead to de-integration into separate firms (Grant & Baden-Fuller, 2004; Jensen & Meckling, 1992). Competitive market pressure will motivate firms to exit those divisions in which they are less productive in favour of expansion of those divisions in which specialization has led the firm to obtain a comparative advantage.
2.5 Characterizations of Knowledge

2.5.1 Paradox of Replication

Codifiability and complexity impact the costs of replicating knowledge. Unless a firm is able to increase the knowledge of its individuals or convert its skills into “organizing principles”, it will forever remain a small craft shop (Kogut & Zander, 1992). The paradox of replication is that advantages achieved through reductions in the cost of intra-firm knowledge transfer, say through codification, also increase the risk that knowledge will be imitable by competitors. While firms may desire to simplify their knowledge and increase internal efficiency, doing so also increases accessibility to the knowledge for external parties. But increasing transferability through codification also involves some loss of complexity, since codification “rarely occurs without a transformation in the nature of the knowledge” (Kogut & Zander, 1992, p.390). Kogut and Zander provide the production of software code as an example transformation of substantive knowledge into a product requiring functional knowledge to be used.

“The reason why software has been successful is that it is codified so as to demand a lower fixed cost on the part of the general user. The user is required to understand the function of the program without the knowledge of the substantive technology. (A function is an attribute to the product; substantive technology is the knowledge by which the product is created or produced.)… [T]he possibility to separate the expertise to generate the technology and the ability to use it… permits the nesting of a firm’s knowledge” (Kogut & Zander, 1992, p.390) (emphasis added).

Kogut and Zander’s (1992) reference to ‘nesting’ a firm’s knowledge and saving the user the cost of acquiring the substantive knowledge of production resonates with Demsetz’s (1988) emphasis on knowledge encapsulation to achieve an economic market exchange. Teece’s (2000) reference to the need to embed know-how to enable extraction of value reinforces this concept. Osterloh and Frey (2000) go so far as to claim that, “[t]acit knowledge can be efficiently marketed only if it is encapsulated…” (emphasis added).
2.5.2 *Information and Know-how*

Kogut and Zander (1992) suggest that the term knowledge, as it is informally used, actually consists of information (declarative knowledge) and know-how (procedural knowledge). An important characteristic of information is that it can be transmitted at low cost and “without loss of integrity” because the pattern of formation or rules governing the formation of statements, or language and grammar is commonly known or standardized between sender and recipient (Kogut & Zander, 1992, p.386).

Information may also be defined as structured and formatted data-sets that require knowledge to interpret and process them (Boisot, 1998; Cowan et al., 2000; David & Foray, 2002). Information remains inert until acted upon by a knowledgeable agent whose cognitive context imparts it with meaning (Cowan et al., 2000; David & Foray, 2002). David and Foray also emphasize information’s low cost of replication (2002).

Know-how, on the other hand, is practical skill or expertise permitting efficient execution and must be learned and acquired or accumulated over time through experience (Kogut & Zander, 1992; von Hippel, 1988). Possession of this category of knowledge empowers an agent to mental or manual action, and may be thought of as cognitive capacity (David & Foray, 2002). The replication of know-how is an expensive undertaking due to the difficulty of explicitly articulating what we know (David & Foray, 2002).

The key differences between the two categorizations have significant economic ramifications. Information is the focus of pricing in the economics of exchange, while know-how is the focus in transforming inputs into outputs in the economics of production (Kogut & Zander, 1992).
Choo, drawing on Polanyi (1966) and Nonaka and Takeuchi (1995), differentiates between tacit knowledge as “knowledge that is uncodified” (1998, p.111) and explicit knowledge as “knowledge that can be expressed formally using a system of symbols” (1998, p.112). Choo also includes object-based knowledge, “found in artifacts such as products” under the heading of explicit knowledge (2006, p.141).

The term explicit, however, implies observability, and not all non-tacit knowledge is observable. Observability has important implications for transferability, replication and appropriation. Choo (2006, p.141), for example, recognizes that object-based explicit knowledge may remain unobservable unless it is unpacked through reverse engineering, inspection, or compositional analysis. It may therefore be useful to distinguish between non-tacit knowledge that is codified and observable and non-tacit knowledge that is encapsulated and not readily observable.

2.5.3 Codifiability and Complexity

Two of the attributes of knowledge identified by Kogut & Zander (1992) as impacting the costs of knowledge replication and imitation are codifiability and complexity. The first, codifiability, refers to the difficulty of a firm in structuring knowledge “into a set of identifiable rules and relationships that can be easily communicated” (Kogut & Zander, 1992, p.387). Generally, know-how is less detachable from the individual who holds it, but it may also be difficult to “identify the relevant information which operates as the data to an actor or set of actions” (Kogut & Zander, 1992, p.387). Increasing codifiability decreases the cost of knowledge transfer.

The second characteristic of knowledge impacting transfer is complexity. Complexity may be considered as increasing as the number of operations or steps required to solve a task
increase or the number of parameters defining a system increase (Kogut & Zander, 1992, p.387). Increasing complexity increases the cost of knowledge transfer. These two characteristics of knowledge are interdependent with progress in knowledge codifiability potentially being able to offset increasing costs of knowledge transfer attributable to mounting knowledge complexity.

2.5.4 Appropriating the Value of Knowledge

Codifiability and complexity also impact the appropriability of value from both information and know-how. Appropriability, as it is used here, refers to the ability of the owner of an economically valuable quantity of knowledge to realize the value of that knowledge (Grant, 1996). The encapsulation of tacit know-how in a product permits its indirect appropriation (Grant, 1996). Appropriating value from codified knowledge, or information, is on the other hand difficult since it is both a public and non-rivalrous good (Langlois & Robertson, 1996). The public nature of information means that others cannot be kept from using it (or made to pay for it) once it has been made available. The non-rivalrous nature means that one person’s use of the information does not make it less available to others. These two characteristics of information or codified knowledge essentially preclude appropriability in markets, absent a strong intellectual property rights regime.

2.5.5 Organizational Knowledge

A universally accepted definition of knowledge does not exist. Epistemologists and philosophers have been struggling with this abstract concept for thousands of years. It would be the height of pretension to assume that what has occupied great minds for eons will be swiftly resolved here. Grant humbly offered little beyond “the simple tautology of ‘that which is known’…” (1996, p.110). Like Grant, I too declare that “this is not an arena in which I choose to compete” (1996, p.110).
For the purposes of this empirical research, however, some operational notion of knowledge is required. Grant suggests that knowledge is “the most strategically-significant resource of the firm” (1996, p.375). Grant’s conception proposes that knowledge is a resource and may therefore be considered an extension of the resource-based view of the firm (Eisenhardt & Santos, 2002). While this is not the only representation of knowledge in the strategy field, empirical literature has largely focussed on the conception of “knowledge as resource” (Eisenhardt & Santos, 2002, p.158). Grant’s theoretical foundations of KBV have “become probably the most widely used perspective on knowledge in the strategy field” (Eisenhardt & Santos, 2002, p.144). As pervasive as it is in empirical strategy literature, Grant’s perspective may still be debated and perhaps enhanced as follows.

First, reference to knowledge as a resource raises the question of whether, or how, it differs from any other resource. Choo states that “…information is more than just another factor of production. Information is the resource that enables the effective combination and utilization of the other factors of production - it is in effect, the meta-resource that coordinates the mobilization of the other assets in order for the organization to perform” (2002, p.xiii). Arguably, knowledge is a better description for the meta-resource to which Choo refers, since information also needs to be combined, utilized, and mobilized to generate value. Knowledge is a meta-resource since it is transcends basic resources and is the unique source of economic growth and value. “Economic growth occurs whenever people take resources and rearrange them in ways that are more valuable” (Romer, 1993, p.184). Resources are defined by knowledge of them, rather than by mere physical attributes (Lee, 1991). “…a piece of copper ore is just a rock unless one has the knowledge to mine, melt, refine, alloy, mill, shape, and ship it… Whether some physical quantity is a resource or not depends crucially on our knowledge about it. It took
centuries for people to learn how to use sand to make glass, and now sand in the form of silicon chips fuels the information age” (Bailey, 2001). Sand only constitutes a resource when knowledge is applied to it (Bailey, 2001). To claim some object has value therefore requires some knowledge of that object.

The second way in which Grant’s conception may be enhanced would be to include some reference to another approach to knowledge that has emerged in the strategy literature, the one that “focuses more on the process of knowing than on knowledge as an objective and transferable resource” (Eisenhardt & Santos, 2002, p.141). This approach to knowledge which has its roots in psychology and sociology (see, for example, Spender & Grant, 1996; von Krogh & Roos, 1995) emphasizes the social and cultural setting in which the process of knowing is effected (Eisenhardt & Santos, 2002). Western philosophy on the process of knowing has traditionally been bifurcated. Rationalists have argued that knowledge (justified, true belief) stems from thought and reflection (the process of reasoning), while empiricists have argued that knowledge is gained through experience. The characterization of knowledge to be used in this research proposal will not debate the merits of rationalism versus empiricism, but merely accept that both capture something of what knowledge means.

2.5.6 An Operational Definition of Knowledge

Based on the above analysis and building on Grant’s conception, knowledge may be conceived of as the value endowing meta-resource that originates from thought, reflection, or experience. Considering knowledge as ‘value endowing’ gives it strategic significance (Grant, 1996, p.375), and emphasizes economic importance of knowledge as a firm asset (Boisot, 1998; Teece, 1998, 2000). It also implies the possibility of differences in the valuation of a given
knowledge asset as assessed by two or more evaluators and that this value may be context specific (Starbuck, 1992).

Reference to knowledge being a ‘meta-resource’ raises its importance above that of basic resources while still hinting at its role in sustaining a firm’s competitive advantage. Resources can only be considered such in the presence and application of knowledge.

The origins of knowledge are described as ‘thought, reflection or experience’ to recognize that both rationalist and empiricist approaches to knowledge may be value-endowing. This part of the concept recognizes that value is derived from the mind, both passively receiving sense data through experience, and actively structuring that data into a coherent and stable image. It also recognizes the recent strategy literature that emphasizes socio-cultural aspects of the process of knowing. “Knowledge can be understood as both a thing… and as a process of… knowing… As a practical matter, organizations need to manage knowledge both as object and process” (Zack, 1999, p.46).

2.6 Typology of Organizational Knowledge

Organizational knowledge is categorized as belonging to one of three classifications: tacit, codified, and encapsulated. This corresponds to the three repositories described by Boisot (1998). This typology for knowledge has been chosen because differences between each form, along a number of perspectives, have strategic implications for a firm. The choice of what combination of each type of knowledge is applied within various stages of production is expected to impact performance. Some empirical evidence suggests that specific combinations of tacit and codified knowledge, described as “a ‘focused codification strategy’,… greatly facilitates knowledge flows and thereby can help to boost performance of companies” (Schulz & Jobe, 2001, p.161).
Boisot (1998, pp.12-13) describes three repositories of knowledge which economize on the use of physical resources, **knowledge residing in individual brains**, **knowledge codified as information**, and **knowledge embodied in physical artefacts**. He uses the construction of a building as a metaphor for distinguishing between them. The accumulated stock of knowledge of human behaviour in space, and of the physical properties of materials, used by the architects in drawing the buildings plans is an example of the first repository. Construction drawings and plans are examples of the second, and a shaped brick used in constructing a building is an example of the last (Boisot, 1998). Based on these distinctions as well as those of Polanyi (1966), Kogut and Zander (1992), Nonaka (1994), and Choo (1998), for the purposes of this research, organizational knowledge will be classified as **tacit**, **codified**, or **encapsulated**.

Each of these three classifications of knowledge differs along a number of perspectives that have strategic and economic implications. Tacit knowledge, for example, as practical skill or expertise permitting efficient execution, must be learned, acquired, and accumulated through experience (Nelson & Winter, 1982; Winter, 1987). Tacit knowledge may also be considered procedural know-how (Kogut & Zander, 1992). It has the unique characteristic of being absolutely necessary to interpret and process the structured and formatted data-sets that constitute codified knowledge (Boisot, 1998; Cowan et al., 2000; David & Foray, 2002). It is also expensive to transfer and diffuse requiring complex structures of interaction (Choo, 2002).

Codified knowledge has the unique attributes of being non-rivalrous and non-excludable (Langlois & Robertson, 1996; Saviotti, 1998). Unlike tacit knowledge, codified knowledge may be very inexpensively replicated, transferred and diffused (Boisot, 1998; Romer, 1990). The codification of knowledge facilitates inexpensive intra-firm knowledge transfer, but also
increases the risk of misappropriation outside the firm. Strategic consideration of imitability and replicability of codified knowledge strongly influences firm boundary decisions (Teece, 1998).

Encapsulated knowledge differs from both tacit and codified in its eminent marketability (Teece, 2000). Knowledge encapsulated in artefacts’ design and functionality minimizes the cognitive load on users (Gorga, 2007). While the value of codified knowledge may be easily misappropriated absent a strict intellectual property regime, the value of encapsulated knowledge is readily appropriable through the sale of commercially valuable items or devices (Demsetz, 1988; Teece, 2000). The encapsulation of knowledge facilitates the retention of complexity, a complexity that is necessarily reduced when knowledge is codified.

There appear to be important strategic and economic perspectives along which tacit, codified, and encapsulated knowledge differ. The costs and benefits of any given productive activity relying on these knowledge-based factors may therefore be expected to be dependent on the unique combination of tacit, codified and encapsulated knowledge chosen. It would therefore be reasonable to expect that firms will select those combinations of tacit, codified, and encapsulated knowledge-based factors of production that they find most economic. It would likewise be reasonable to expect that different stages of production along a value chain will often rely on different combinations of tacit, codified, and encapsulated knowledge. Gulati, Lawrence and Puranam (2005) found strong support for their hypothesis that supplying and procuring units are more differentiated when de-integrated than when integrated in a single firm. Similarly, one could predict that when the economic combinations of tacit, codified, and encapsulated knowledge differ beyond some yet to be determined (and probably industry-specific) threshold, between adjacent stages of production, the high cost of integrating both specialized stages within a single firm will encourage vertical de-integration.
The next table layers Boisot’s (1998) three distinctions of knowledge over the tacit/explicit model suggested by Polanyi (1966), Nonaka (1994), and Choo (1998), and the know-how/information model of Kogut and Zander (1992). Knowledge residing in individual brains (Boisot, 1998) is equated to tacit knowledge (Choo, 1998; Nonaka, 1994; Polanyi, 1966), while explicit knowledge (Choo, 1998; Nonaka, 1994; Polanyi, 1966) is classified as being either codified as information or encapsulated in a physical artefact (Boisot, 1998). Similarly, know-how (Kogut & Zander, 1992) is classified as either residing in individual brains or nested in physical artefacts (Boisot, 1998). The three classifications of knowledge displayed in the following table, tacit, codified, and encapsulated, are used in the research as knowledge-based factors of production.

**Table 2: Three classifications of knowledge**

<table>
<thead>
<tr>
<th>Tacit</th>
<th>Codified</th>
<th>Encapsulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge residing in individual brains</td>
<td>Knowledge codified as information</td>
<td>Knowledge embodied in physical artefacts</td>
</tr>
<tr>
<td>Tacit knowledge</td>
<td>Explicit knowledge</td>
<td>Explicit knowledge</td>
</tr>
<tr>
<td>Know-how</td>
<td>Information</td>
<td>Know-how (nested)</td>
</tr>
</tbody>
</table>

2.6.1 *The Relationship between Knowledge and Information*

The relationship between knowledge and information (and data) is articulated by Boisot (1998, p.12), as follows.

“Knowledge builds on information that is extracted from data… Data is a [sic] discrimination between physical states… that may or may not convey information to an agent. Whether it does or not depends on an agent’s prior stock of knowledge… Whereas data can be characterized as a property of things, knowledge is a property of agents predisposing them to act in particular circumstances. Information is that subset of the data residing in things that activates an agent – it is filtered from the data by the agent’s perceptual or conceptual apparatus… Information, in effect establishes a relationship between things and agents. Knowledge can be conceptualized as a set of probability distributions held by an agent and orienting his or her actions. These either
consolidate or undergo modification with the arrival of new information. In contrast to information, knowledge cannot be directly observed. Its existence can only be inferred from the action of agents”.

Boisot’s relationship between information and knowledge may be classified as a cognitivist epistemology (von Krogh & Roos, 1995). Drawing on Bruner (1964), they suggest that in this epistemology, “A person actively constructs knowledge… by relating incoming information to a previously acquired frame of reference” (von Krogh & Roos, 1995, p.13). Boisot’s description of the relationship between knowledge and information is similar to that described by Machlup (1984) and Nonaka (1994). According to Choo, the utilization of information is capable of producing “a change in the individual's state of knowledge and a capacity to act” (1998, p.62). Alavi and Leidner posit that “information is converted to knowledge once it is processed in the mind of individuals and knowledge becomes information once it is articulated” (2001, p.109).

Nonaka distinguishes between information and knowledge by stating that “knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder” (1994, p.15). His distinction between explicit knowledge and information, however, is not clear. His description of explicit knowledge, as discrete or digital and “captured in records of the past such as libraries, archives, and databases…” (Nonaka, 1994, p.17), and “expressed in words, and numbers and shared in the form of data, scientific formulae, specifications, manuals, and the like” (Nonaka & Konno, 1998, p.42) appears to be more of a description of information rather than one of knowledge.

2.6.2 The Nature of Organizational Knowledge

The three classifications of knowledge, tacit, codified, and encapsulated, have been chosen based on differences in fundamental attributes that undergird all forms of substantive
knowledge. The next table provides six perspectives that may be useful as an aid in determining the most fitting classification for distinguishing a specific assemblage of knowledge. These perspectives provide a framework for the construction of a test instrument. They were chosen on the basis of their strategic and economic significance to a firm. For example, the degree to which knowledge is tacit has significant implications for the location of firm boundaries:

“…[B]oundary issues (such as vertical integration) are… strongly influenced by tacit knowledge and imitability/replicability considerations. …[T]he tacit component of knowledge cannot frequently be transferred absent the transfer of personnel and organizational systems/routines. Tacit knowledge and its transfer properties help determine the boundaries of the firm…” (Teece, 1998, pp. 75-76).

It is anticipated that differences in the nature of knowledge, as expressed in the following table, can be demonstrated to be fundamental in shaping the differences in relative productivity of tacit, codified and encapsulated knowledge between adjacent stages of production. While productive activity may be considered transformation of tacit knowledge into some form of explicit knowledge (Hedlund, 1994), few (if any) stages of production along a value chain are able to rely exclusively on tacit, codified or encapsulated knowledge. After all, “…there is a limit to the extent to which one factor of production can be substituted for another…”(Robinson, 1933, p.330).

It is possible that a specific incorporation of knowledge may not clearly fall into one of the three chosen classifications. It may therefore be more useful to think of a given assemblage of knowledge as having attributes or perspectives that place it predominantly in one classification rather than in another, instead of rigidly categorizing to one exclusive classification (Saviotti, 1998).

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Tacit</th>
<th>Codified</th>
<th>Encapsulated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perspective</td>
<td>Tacit</td>
<td>Codified</td>
<td>Encapsulated</td>
</tr>
<tr>
<td>-----------------------------------------</td>
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<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Locus or knowledge substrate (Boisot, 1998, p.156)</td>
<td>Human mind; “Tacit knowledge probably comes packaged most efficiently in the form of individuals” (Hedlund, 1994, p.79)</td>
<td>Signs, symbols, codes and display rules</td>
<td>Concealed in an artefact’s design and technology; imbedded in machines and other physical technology (Gorga, 2007; Langlois, 2001)</td>
</tr>
<tr>
<td>Transfer and diffusion (Boisot, 1998, p.156)</td>
<td>Difficult to verbalize; requires “rich modes of discourse” (Choo, 2002, p.265) and “physical co-presence” (Boisot, 1998, p.46); requires some “intimacy and permanence” (Hedlund, 1994); costly to diffuse broadly</td>
<td>Easy and low cost transfer and storage; subject to involuntary transfer; requires common ‘language’</td>
<td>Speed, extent, and cost of transport all dependent on physical characteristics</td>
</tr>
<tr>
<td>Expression</td>
<td>Implicit in action-based skills (Polanyi, 1966) and conversation (Simon, 1999)</td>
<td>Rules, routines and recipes based on a system of symbols (Nelson &amp; Winter, 1982)</td>
<td>Embodied in artefacts (Boisot, 1998; Langlois, 2001); “a tangible product is knowledge in a highly articulated form”(Hedlund, 1994, p.79)</td>
</tr>
<tr>
<td>Acquisition Process</td>
<td>Experiencing and doing, observation and imitation, costly internship and apprenticeship (Nelson &amp; Winter, 1982) “…teachable even though not articulable” (Winter, 1987, p.171)</td>
<td>Interpretation of signs, symbols, codes, and displays; dependent on IPR regimes</td>
<td>Acquired in markets through trade</td>
</tr>
<tr>
<td>Source of Economic Value</td>
<td>Capacity to make intuitive judgements, discoveries and innovations</td>
<td>Informing the interpreter; Low cost replication; non-rivalrous nature (Romer, 1990)</td>
<td>Function of the artefact without requiring substantive knowledge; consumption; appropriability (Nickerson &amp; Zenger, 2004)</td>
</tr>
<tr>
<td>Observability</td>
<td>Requires co-location</td>
<td>Limited excludability (Langlois &amp; Robertson, 1996; Saviotti, 1998)</td>
<td>Requires costly experimentation and reverse engineering</td>
</tr>
</tbody>
</table>

Each of the perspectives used to classify knowledge has strategic implications for the firm. For example, tacit knowledge must be rented from a firm’s employees, suppliers, and perhaps customers. Absent slavery, the firm cannot really own it. Codified knowledge is to a large extent commonly held, and that which is not, is subject to misappropriation absent a strong intellectual property rights regime. Encapsulated knowledge comes closest to describing a finished product for end-user consumption. Its value lies in the design and functionality delivered by the substantive knowledge concealed within it.
2.6.3 Tacit Knowledge

According to Spender (1996, p.67), “Tacit knowledge is defined variously as that which is gained experientially or, stressing the privacy of personal experience, in terms of its incommunicability. It is probably more informative to focus on tacit knowledge’s inseparability from the processes of its creation and application, and we shall define tacit knowledge as that which has not yet been abstracted from practice” (emphasis added). Choo suggests that tacit knowledge is “The implicit knowledge used by organizational members to perform their work skilfully” (2002, p.264) (emphasis added). Both authors join may others in referring to Michael Polanyi’s oft-quoted observation that some knowledge appears to be inexpressible. From a perspective of knowledge as object however, Boisot emphasizes that knowledge must be “held by a knowing agent” (Boisot, 1998, p.12).

In keeping with Boisot’s emphasis on the locus of knowledge, tacit knowledge is formalized as the value endowing meta-resource originating from thought, reflection, or experience that remains resident in the human mind. Not only is tacit knowledge located in the human mind, but based on the previous table, tacit knowledge i) requires co-location with another to be observed and transferred, ii) is expressed through enactment by the holder, iii) is teachable to an apprentice, and iv) is valuable for its unique insight. Tacit knowledge, so described cannot exist outside of a knowing agent.

Tacit knowledge is arguably the most valuable of the three classifications for two reasons. First, tacit knowledge is the basis from which the other two types are derived. Both codified and encapsulated are arguably tacit knowledge incorporated outside of the human mind. Second, while tacit knowledge has value independent of the other two classifications of knowledge, the converse is not the case. Both codified and encapsulated knowledge are
dependent on the presence of tacit knowledge for value to be realized. “Deprived of their tacit co-efficients, all spoken words, all formulae, all maps and graphs are strictly meaningless.” (Polanyi, 1969, p.195).

2.6.4 Codified Knowledge

Zollo’s (1998) detailed conception of codified knowledge accords with Boisot’s distinguishing knowledge on the basis of locus, while emphasizing empiricism and process as well as content. According to Zollo, codified knowledge is “accumulated experience... analyzed, abstracted, and incorporated in check-lists, manuals, blueprints, computer programs, etc., that provide the content (‘know-what’), the methodology (‘know-how’), and eventually the rationale (‘know-why’) for the execution of a certain task” (1998, p.26). This extensive description most closely resembles the commonly interchanged term explicit knowledge (see, for example, Teece, 2000). Langlois (2001)\(^6\) and Stenmark (2002)\(^7\) however, argue that strictly defined, all knowledge is structural or tacit, and that what is passed off as explicit or codified knowledge is actually information. Despite these arguments, the term, ‘codified knowledge’ is used in this research to describe information in recognition of its ultimate source. “[K]nowledge is not created codified… Knowledge is always at least partially tacit in the minds of those who create

\(^6\) “...symbolic transmissions are information, not knowledge. They are codes that activate the rule-based categorization systems of the receptor structure in a meaningful way” (Langlois, 2001, p80: 80) (emphasis in original).

\(^7\) “I… question the phrase explicit knowledge and claim that all knowledge is tacit and explicit knowledge is in fact information” (Stenmark, 2002: 5).
it” (Saviotti, 1998, p.848). Accordingly, **codified knowledge** is characterized as the value **endowing meta-resource originating from thought, reflection, or experience that is expressed as information using systems of symbols**. (See sub-section 2.3.1 for a discussion on the relationship between knowledge and information).

Codified knowledge may be described as knowledge that is symbolic, inexpensively replicable, representing a recipe, and able to inform those who have the tacit knowledge necessary to observe, read, and interpret it. The value of codified knowledge lies in its inexpensive replicability. As mentioned in the discussion on tacit knowledge, codified knowledge requires tacit knowledge to be de-coded and understood. “…[S]imply because knowledge is codified does not mean that it is necessarily well understood by all recipients” (Helfat & Raubitschek, 2000, p.962).

2.6.5  *Encapsulated Knowledge*

The construct, encapsulated knowledge, is being introduced in this research proposal as a potential addition to the knowledge-based view of the firm. The concept is not entirely new however, since it has been hinted at in strategic management literature. Kogut and Zander, in a discussion of the separation of substantive (creative or productive) and functional (utilization) knowledge, relate the ability to bring about this partition to “the nesting of a firm’s knowledge” (1992, p.390). Boisot (1998) in describing how knowledge economizes on the use of physical resources (space, time, and energy) lists three structures in which knowledge is incorporated. According to Boisot, knowledge is built up in individual brains, in documents, and in “the information structures latent in physical things” (1998, p.13). Teece, in a discussion of how the value of knowledge may be extracted by firms suggests that “[m]uch knowledge is of limited commercial value unless bundled in some way” and that to “command significant value” it must
be “embedded in products” (2000, p.37). Thus knowledge may be found “embodied in an item or device” (Teece, 2000, p.37). Finally, Langlois suggests that “knowledge can… be externalized beyond an individual creator by being imbedded either in machines and other physical technology” (2001, p.82), while Gorga and Halberstam define one form of knowledge as “embedded in physical assets, such as machines or products” (2007, p.18).

Arguably, the knowledge described above by Kogut and Zander (1992), Boisot (1998), and Teece (2000), Langlois (2001, p.82), and Gorga and Halberstam (2007, p.18) is neither tacit nor explicit. Encapsulated knowledge is not tacit because it resides outside of the human mind. Furthermore, if one accepts a strict interpretation of tacit knowledge as that which is inexpressible, then knowledge evinced in the functionality and design of a manufactured artefact is clearly excluded. Encapsulated knowledge may also be distinguished from tacit knowledge in that it is a product of the application of tacit (and perhaps codified) knowledge upon physical or material objects.

It is also not very useful to include encapsulated knowledge under the more general term, explicit knowledge. Encapsulated knowledge is not precisely explicit, even though this term has generally been juxtaposed with tacit knowledge, because it is knowledge concealed from its users, and explicitness implies observability. Encapsulated knowledge is distinguishable from codified knowledge primarily from the perspective of observability, which has implications for the appropriability of value. The observability of explicit, codified knowledge makes it susceptible to misappropriation (Teece, 2000). Encapsulated knowledge, on the other hand, facilitates the marketing of knowledge since it can only be partially misappropriated through expensive reverse engineering (Teece, Pisano, & Shuen, 1997, p.526).
Finally, both codification and encapsulation are motivated by a desire to inexpensively transfer knowledge. While codification is a process that reduces complexity, encapsulation preserves complexity. The value of encapsulation lies in the avoidance of the necessity to have substantive knowledge to make functional use of the encapsulated knowledge. Encapsulated knowledge provides a form of substantive “knowledge-substitution” (Gorga, 2007). For example, utility can be realized from the use of the encapsulated knowledge inherent in a computer or an automobile apart from having the substantive knowledge of how they were produced or why they work (Pfaffmann, 1998, 2000).

Based on the references to the concept of encapsulated knowledge in the literature, and the attributes of encapsulated knowledge that distinguish it from other existing categorizations, the following is offered. Encapsulated knowledge is the value endowing meta-resource originating from thought, reflection, or experience that is embedded in an artefact’s design and functionality. As such, encapsulated knowledge may be considered that knowledge which is found in a complex physical form, concealed from the casual observer, but physically transferable and acquirable in a marketplace, and providing utility to those who have the tactic knowledge necessary to use it. Presumably, the vast majority of transactions that occur in consumer markets involve the purchase of some form of encapsulated knowledge.

Only in a few exceptional situations will production not rely upon some combination of tacit, codified, and encapsulated knowledge. In the vast majority of cases, a mixture of all three knowledge-based factors will contribute to production.

2.7 The Mutual Fund Industry

The mutual fund management industry in Canada is the population under study for this research. Some of the literature on the mutual fund industry that has a bearing on this research
includes that which suggests consideration and inclusion of various control variables, instead of exclusive reliance on knowledge-based factors of production. Reliance on knowledge-based factors of production in adjacent stages in a value chain may be affected by other factors that differ between those stages. To take this into consideration, an examination is needed of differences in various attributes that might impact the type of knowledge relied upon in those stages. Attributes such as level and type of education of knowledge workers, as well as the extent of their experience are but a few examples of variables that might impact mutual fund performance.

Philopot and Peterson (2006), in a study of real estate mutual funds, found modest evidence that funds managed by a team of portfolio managers (multi-managed) had lower risk-adjusted returns relative to funds managed by single portfolio managers (single-managed). They also found that more experienced portfolio managers were more likely to manage portfolios with higher risk. On the other hand, their results indicated that professional certification (for example, Chartered Financial Analyst designation) and experience had no effect on excess returns (Philopot & Peterson, 2006).

The findings of Philopot and Peterson (2006) stand in contrast to a number of other studies. Empirical results obtained by Prather and Middleton (2002) suggested no appreciable difference in outcomes between single- and multi-managed funds. Similarly, Golec (1996) found that portfolio managers with a MBA degree outperformed those who did not, and Chevalier and Ellison (1999) found evidence that the quality of the college attended by the portfolio manager impacted mutual fund performance.
Ding and Wermers (2006) found evidence positively relating underperformance in smaller mutual funds to portfolio manager experience, which they interpreted as evidence of portfolio manager entrenchment.

Mutual fund literature discussing de-integration of the portfolio management function includes a paper by Sharpe (1981) in which he discusses the proclivity of large pension funds to outsource to multiple portfolio managers and the theoretical effect of this practice on overall performance. Building on the theory linking knowledge to organizational structure proposed by Jensen and Meckling (1996), Cashman and Deli (2006) found an equilibrium between the opportunity cost of outsourcing decision rights to de-integrated portfolio managers with specific knowledge and the agency costs associated with monitoring those outsourced decision rights. Consistent with this equilibrium, they found that risk-adjusted returns for de-integrated portfolio management are greater than they would have been had the funds been managed internally, but no different from returns generated by other mutual funds (Cashman & Deli, 2006). Chen, Hong and Kubik (2006) found contrary evidence that suggested externally managed mutual funds underperformed internally managed ones in another study of integrated and de-integrated portfolio management. They also found support for their hypotheses that de-integrated portfolio managers faced a higher probability of contract termination due to poor performance and deviated less from the norm in risk-taking (Chen et al., 2006). Bauer, Frehen, Lum, and Otten (Bauer, Frehen, Lum, & Otten, 2007), in another study of investment performance, could not find any evidence that outsourcing portfolio management either created or destroyed value for defined benefit pension plans.

In a study of intra-industry focus, Siggelkow (2003) found evidence that U.S. mutual funds belonging to more focused mutual fund management firms outperformed those belonging
to less focused firms. Firm profitability, driven primarily by cash inflow from investors, was however, found to be negatively correlated with focus, perhaps suggesting that investors are willing to forgo some performance for the convenience of ‘one-stop shopping’ (Siggelkow, 2003).

2.8 Summary

This chapter provided a brief literature review to set the stage for the challenge of applying a knowledge-based theory of the firm to resolve the research questions. The KBV topics just reviewed provide an examination of a collection of papers and monographs emphasizing the work of a limited number of economists and strategy researchers, and only as they relate to firm boundary issues. The review of the KBV literature suggests three classifications of knowledge as factors of production that may be instrumental in enhancing our understanding of inter-firm boundaries. In addition, a review of some of the related literature on the mutual fund industry provided some suggestions for industry-specific control variables to be considered, instead of relying exclusively on knowledge-based factors of production to interpret observed phenomena.

2.8.1 Limitations

Many others have contributed to the richness of the knowledge-based view of the firm from related or different perspectives. Limitation of time and space preclude examination of all contributions to KBV. Some seminal works not discussed here include von Hayek’s (1945) perspective that the economics is a problem of knowledge utilization, and Arrow’s (1974) observation that organizational behaviour may be understood through a better appreciation of the ‘scarcity’ of information management abilities.
This review of KBV is focussed on the application of knowledge and passes over the broad topics of knowledge creation (Nonaka, 1994) and assimilation (Cohen & Levinthal, 1990). Also absent from this review are discussions comparing KBV and TCE (Conner & Prahalad, 1996; Foss, 1996a, 1996b). The review of selected mutual fund research also neglects to discuss to other mutual fund research that has so richly contributed to the discipline of finance.
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3 Theory Development and Methodology

3.1 Introduction

This chapter begins with the conceptual framework section, which introduces the research questions. The following section discusses four research propositions. A model with dependent, independent, and control variables is specified in the subsequent section. Two sections that describe the research population and the data collection in some detail follow. The chapter closes with a general description of the hypotheses to be tested and a brief summary.

3.2 Conceptual Framework

Figure 5 provides an overview of the conceptual model. It suggests that primary survey data measuring relative reliance on three knowledge-based factors of production in combination with secondary mutual fund data may be able to shed light upon the research questions. The measurement of the key constructs is dealt with in detail in the next chapter.
3.3 Theory Development

The background applicable to this research was reviewed in the previous chapter. Several propositions will now be discussed. These propositions are based on key constructs delineated in Chapter 2, which provides rationale for selecting the three classifications of knowledge. In addition, differences between these three classifications along six perspectives are discussed for their strategic importance to the firm. Relying on the key constructs of the previous chapter, the
next sub-sections formalize the propositions relating vertical integration, structure, and performance to specialization in knowledge-based factors of production. These general propositions are then tested in later chapters using a number of hypotheses specific to the mutual fund industry.

3.3.1 Measuring Specialization

In his seminal *The Theory of the Firm Revisited*, Demsetz (1988) suggests that firms exist to create economic value by lowering the cost of production of a good or service below the cost that is achievable through the self-provision of the same product by individuals or households. Foss (1997, pp. 310-311) ascribes the discovery of this efficiency to Adam Smith because “…the whole of every man’s attention becomes naturally to be directed towards one very simple object” (1986, p.114). Advantages in production costs stem from specialization of tasks which in turn stem from specialization of knowledge (Demsetz, 1988, p.158).

The firm seen as an agreement to specialize (Demsetz, 1988; Grant, 2002), suggests different marginal rates of technical substitution between the various factors of production between adjacent production stages. In other words, adjacent stages of production will operate with different combinations of tacit, codified, and encapsulated knowledge, as modeled in the next figure, due to differences between the unique production and cost functions in upstream and downstream stages.

Demsetz (1988) describes the boundaries of firms being located as a function of (i) low cost knowledge encapsulation (in production) on the part of the supplier, and (ii) low information costs (in product utilization) on the part of the consumer of such encapsulated knowledge. Specialization in knowledge may emerge as differences in knowledge-based factor intensities between adjacent stages of production, reflecting differences in the relative cost of the factors
and differences in the production function between stages. This may be the case even when they share a common substantive knowledge. Differences are expected to emerge in knowledge-based capabilities critical to sustaining a comparative advantage because their development is path dependent, firm-specific, and socially embedded, having evolved over some period of time (Barney, 1991; Dierickx & Cool, 1989). Hatch and Dyer (2004, p.1156) found “…empirical evidence that rivals cannot quickly or costlessly imitate or substitute for the value of firm-specific human capital”. It would therefore be reasonable to expect to observe differences in knowledge-based factor intensities along a value chain or system. The acknowledgement that two distinct stages of production exist makes it unsurprising that these adjacent stages of production probably rely disproportionately on tacit, codified, or encapsulated knowledge. What would be surprising would be that the relative reliance on all three classifications of knowledge was identical for two adjacent stages of production.

The different locations of points “A” and “B” in the Figure 6 indicate differences in knowledge-based factor intensities between the upstream and downstream stages. In the figure, the upstream production stage has relatively higher tacit knowledge intensity than the downstream firm, which has relatively higher codified knowledge intensity. While differences in factor intensity along a value chain have been observed when the traditional economic factors of labour and capital have been measured, differences in knowledge-based factor intensity have yet to be reported.

Using knowledge-based factors of production to explain de-integration of adjacent stages of production and the introduction of a market interface finds a parallel in the explanation of fragmentation in the economics of international trade. The term, fragmentation, introduced by Jones and Kierzkowski (1990) “refers to the growing complexity of the modern chain of
production, which divides and redivides previously integrated systems into ever more specialized and distinguishable units” (Curzon Price, 2001, p.88). Fragmentation has its origin in factor intensity differences that underpin the Heckscher-Ohlin theorem (Heckscher, 1919; Ohlin, 1933), which basically claims that trading partners will produce and sell those products in which they have a capital or labour advantage. Developments in technology have advanced the fragmentation of vertically integrated production processes into separate segments. The increase in specialization is related to comparative advantages in the separate segments and leads to a reduction in production cost from what it was before fragmentation. “Breaking down the integrated process into separate stages of production opens up new possibilities for exploiting gains from specialization” (Jones & Kierzkowski, 2001, p.88). A more detailed explanation of fragmentation may be found in Jones, Kierzkowski & Chen (2005, pp. 311-313).

Relationships have been found between factor input proportions and direction of specialization in a number of strategic management studies. For example, Farjoun (1994) found evidence that firms diversify into (or specialize in) industry groups that rely on similar combinations of human expertise. Human expertise was defined as consisting of, among other things, types of knowledge possessed by individuals, and was characterized by a tacit dimension (Farjoun, 1994). Similarly, Silverman (1999) found that firms are likely to diversify or specialize in a pattern that takes advantage of the relative strength of their technological resource base.

The initial contribution of this research involves the measurement of specialization using knowledge-based factor intensities. To test hypotheses relating knowledge-based factor intensities to inter-firm boundaries and to performance the assumption that relative reliance on tacit, codified, and encapsulated knowledge differs between adjacent stages of production was first tested.
Relative, rather than absolute, quantities of these factors of production will be gauged to reveal knowledge-based factor intensity, since agreement on what constitutes absolute quantitative measures of knowledge appears to be currently unobtainable (Down, 2000). Knowledge-based factor intensities may be considered a modernization of the microeconomic concept of labour or capital factor intensities as traditionally applied in a manufacturing-based economy.

Figure 6: Differences in knowledge-based factor intensities

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Labour (capital) factor intensity is the relative importance of labour (capital) versus capital (labour) or other factors in production, and is usually compared across firms, industries and nations. Factor intensities may be defined by ratios of factor quantities employed.
3.4 Research Propositions

3.4.1 Vertical Integration and De-integration

The benefits of specialization are reaped by firms that concentrate their efforts in those stages of production in which they have a comparative advantage while exiting those stages in which they are at a disadvantage. The work of Demsetz (1988), Pfaffmann (1998; 2000) & Jacobides & Hitt (2005), suggests that the position of firms, both upstream and downstream of an inter-firm boundary or market interface, will be selected so as to maximize their productive efficiencies along a value chain. While upstream and downstream firms sharing an inter-firm boundary will be engaged in complementary tasks due to their adjacency in the value chain (Pfaffmann, 2000), they will be engaged in dissimilar tasks based on their specialized knowledge. Due to their respective knowledge specialization, each firm will be able to enjoy a comparative advantage\(^9\) in the productive activities associated with its specialty.

Argyres (1996) proposed that firms vertically integrate into those activities in which they had relatively superior capabilities and outsource those in which they have inferior capabilities. He found support for his proposition in that lack of shared or intersecting knowledge between

\[^9\] If there is more than one way to produce an output, firms can exploit comparative advantages (Varian, 2003). The law of comparative advantage states that producers will specialize in the production of goods and services for which they have the lowest marginal opportunity cost. Comparative advantage was shown by David Ricardo to be more generally applicable than absolute advantage (1817). Even if one of two parties to a potential market exchange has an absolute advantage in the production of both two products to be traded, that party can still increase its utility beyond that available at its production possibility frontier by specializing in the production of that good or service in which it has a comparative advantage, and trading for that in which it has a comparative disadvantage.
two adjacent activities in a value chain led to a boundary between them (Argyres, 1996). One relatively tacit-knowledge-based activity, mould-making, occurred in an upstream firm while the second relatively more formalized-knowledge-based activity, design engineering, was located in the downstream firm under study (Argyres, 1996). This example of vertical de-integration occurred despite “the molds’ complete customization and high cost imply[ing] high physical asset specificity”, which would argue for vertical integration according to traditional transaction cost economic theory (Argyres, 1996, p.137).

One reason for separating adjacent stages that differ in knowledge-based factor intensities into separate firms is to avoid managerial diseconomies of scope (Jacobides & Hitt, 2005; Lawrence & Lorsch, 1967). Firm-wide application of common management practices (Prahalad & Bettis, 1986), or technological paradigms and trajectories (Dosi, 1982), may hinder productivity in some stages of the value chain, where more focused management could enhance it (Jacobides & Hitt, 2005).

The knowledge-based view of the firm typically suggests that differences in substantive knowledge are positively related to observations of inter-firm boundaries. There is however an important distinction between substantive knowledge, defined by Kogut and Zander (1992, p. 390) as knowledge of how a product is created or produced, and the more fundamental classifications of knowledge as tacit, codified, or encapsulated, used in this study. While differences in substantive knowledge may suggest why few true conglomerates exist (Demsetz, 1988), the latter may be useful in explaining inter-firm boundaries when substantive knowledge is commonly held.

Substantive knowledge may be considered specialized on an industry by industry basis (Demsetz, 1988). For example, Demsetz (1988, p.157) argues that, “Steel firms specialize in
different stocks of knowledge and equipment than do firms in investment banking or industrial chemicals.” Similarly, Grant and Baden-Fuller (2004, p. 69) relate de-integration to the range and diversity of knowledge among various knowledge domains.

Demsetz (1988, p.157), however, also acknowledges that even within an industry that shares common substantive knowledge, there are differences in the knowledge on which individual firms rely. The extant knowledge-based research has focused on differences in substantive knowledge to the near-exclusion of differences in more fundamental classifications of knowledge. The propositions put forth in this research suggest that measurements of the fundamental classifications of tacit, codified and encapsulated knowledge, as differentiated in Table 3, may be instrumental in explaining vertical integration / de-integration within an industry reliant on common substantive knowledge.

Grant and Baden-Fuller (2004, p.69) hypothesize that “Increasing marginal costs of knowledge integration within the firm imply that, where products require a broad range of different knowledge types, efficiency of integration is maximized through separate firms specializing different areas of knowledge…” While differences in measured knowledge-based factor intensities between adjacent stages of production may represent specialization, it does not predict the location of inter-firm boundaries. The magnitude of differences in knowledge-based factor intensities found in adjacent vertical stages of a value chain, however, may be reflective of the extent of specialization and be associated with de-integration. Figure 7 depicts small and large differences in knowledge-based factor intensities.
Heterogeneity of productive capabilities between divisions within a firm in effect means that some stages of production are subsidizing the production costs of others within the firm. Rajan and Zingales (2000) suggest that, in a competitive market, making transparent the cross-subsidies implicit in vertically integrated firms puts pressure on these firms to break up. As a result of knowledge specialization leading to productive capability heterogeneity between stages, “the dominant business model in any given tier of the market will tend to shift over time from vertically integrated firms to a horizontally stratified population of specialized firms” (Christensen, Verlinden, & Westerman, 2002, p.956). This does not rule out other theories of industry structure (TCE, for example), not reviewed here, that could predict this outcome.

The left-hand graph in the previous figure depicts relatively small knowledge intensity differences between the production (and cost) functions of the upstream stage, at point “A” and the adjacent downstream stage, at point “B”. Accordingly, it is expected that there is less
knowledge-based pressure for separating the adjacent stages by an inter-firm boundary. The less unique the combination of knowledge inputs of the adjacent stages’ production function, the greater the probable intersection of substantive knowledge associated with productive tasks. In the extreme, if points “A” and “B” are co-located, it could indicate essentially no difference in underlying substantive knowledge. In that case, one could expect of the two vertical stages of production to be combined in a single firm.

The right-hand graph in the previous figure however, depicts relatively large knowledge-based factor intensity differences between the upstream stage (point “A”) and downstream stage (point “B”). It is therefore expected that there is a greater economic incentive for these adjacent production stages to be separated. The different locations of points “A” and “B” in the right-hand graph of the previous figure may be considered indicative of two knowledge-mature products. As a result of knowledge maturity, the substantive knowledge used in production in the two stages may differ more extensively. As a result, it is more economical for the downstream producer to purchase the specialized competences of the upstream firm as codified or encapsulated knowledge without having to acquire the underlying substantive knowledge (Pfaffmann, 1998; 2000). Similarly, it is more economical for the upstream firm to sell an intermediate product rather than develop it further through the downstream stage. Based on this construction, the following is proposed.

**Proposition 1:** The presence of an inter-firm boundary between adjacent stages in a value chain is positively related to the size of the differences in relative reliance on tacit, codified, and encapsulated knowledge between those stages.

If the evidence supports this proposition, it would indicate that the differences in the three classifications of knowledge between adjacent production stages may be indicative of differences
in knowledge-based productivity and/or differences in knowledge acquisition costs, which in turn, is explanatory of which activities are more economically organized “in a unified firm (AB) rather than in two autonomous firms (A and B)” (Williamson, 1999, p.1097).

Evidence in support of hypotheses testing this proposition could extend Kogut and Zander’s contention that “It is the difference in the knowledge… between the creators and the users (possessing complementary skills) which determine the firm boundary…” (1993, p.631) (emphasis added). It would suggest that the focal difference is in the relative reliance on the knowledge-based factors employed by adjacent stages. Evidence may indicate that sufficient differences in any one or more of tacit knowledge intensity, codified knowledge intensity or encapsulated knowledge intensity, between adjacent stages is related to the presence or absence of inter-firm boundaries.

3.4.2 Industry Maturation and Modularity

The mutual fund industry was considerably more integrated in its infancy than it is today (Bogle, 2004). While the majority of portfolio managers are still integrated with mutual fund management firms, a significant de-integration of many of functions within the industry has taken place. Balconi (2002) suggests that codification and encapsulation in computer-based technology leads to vertical de-integration, and Macher and Mowery (2004) associate industry maturation in computers and chemicals industries with technical standardization and codification of formerly tacit knowledge. This suggests that over time standardization changes relative factor intensities, and specifically that relative reliance on codified and encapsulated knowledge increases in a given stage of production while relative reliance on tacit knowledge declines over time.
In addition, if a mutual fund is considered a modular product offered by a mutual fund management firm, then the need for communication is reduced and portfolio managers’ tacit knowledge may remain hidden. The inner working of a portfolio manager’s firm does not need to be shared with the mutual fund management firm (Hoetker, 2006). The mutual fund management firm can switch between portfolio management firms and portfolio managers can work for different mutual fund management firms (Schilling & Steensma, 2001). Demand heterogeneity (Schilling & Steensma, 2001) in the variety of mutual funds, especially investor demand for a variety of fund newly in vogue, may be quickly met by a mutual fund management firm through contracting with an external portfolio management firm specializing in the new variety. This was one reason given in an interview by a CEO of a mutual fund management firm for the de-integration of a particular mutual fund’s portfolio managers. It is plausible therefore that the novelty of the new type of fund may require a relatively increased level of reliance on tacit knowledge on the part of its portfolio manager(s).

Finally, Grant (1996, p.119) suggests that decisions relying on tacit knowledge are decentralized according to the “principle of co-location”. While codified and encapsulated knowledge are relatively transferable, specific knowledge as defined by Jensen and Meckling (1992) is comprised of tacit knowledge which is difficult to transfer to, and aggregate in, one location. Accordingly, decision-making which is relatively more reliant on idiosyncratic tacit knowledge should be de-centralized (Grant, 1996). Similarly, Cashman and Deli (2006) drawing on von Hayek (1945) suggest that there are potential gains to outsourcing decision rights to de-integrated portfolio managers if integrated portfolio managers do not possess the requisite knowledge. Relying on Jensen and Meckling (1992), they argue that the costs of knowledge transfer between portfolio managers and other investment management professionals are higher.
when security pricing is most analytically intensive (Cashman & Deli, 2006). They believe that this is the case because it is more difficult to transfer the knowledge required to understand a security valuation when that security valuation is complex (Cashman & Deli, 2006).

The analytic intensity of security valuation is argued to become increasingly complex as one moves from the management of government debt, to corporate debt, then to domestic equity, and finally to foreign equity. For example, Cashman and Deli (2006) argue that because equity represents a residual claim on the assets of a firm and generally involves greater risks, pricing is more complex for equity securities than for debt securities. Cashman and Deli (2006) find that de-integration of portfolio management corresponds to this increasing analytic intensity. Increasingly complex analytic intensity of security valuation may be associated with increasing relative reliance on tacit knowledge. This suggests that over time standardization changes relative factor intensities and that industries evolve by codifying and encapsulating knowledge, formerly tacit. This allows value chains to lengthen and increases the number of market interfaces that may appear between an increasing number of productive stages. Tacit knowledge does not disappear from any stage, but is most intensely relied upon in those stages where it is most productive. In the mutual fund industry setting, (downstream stage) fund manufacturing has arguably become increasingly more reliant on codified and encapsulated knowledge, while (adjacent upstream stage) portfolio managers who are relatively more reliant on tacit knowledge have become de-integrated while those who are relatively less reliant on tacit knowledge have remained integrated.

The following is therefore proposed from the perspective of the integrating (mutual fund management) firm.
**Proposition 2:** A greater probability of de-integration for a given stage of production will be positively associated with a greater reliance on tacit knowledge in that stage.

Because the measurement of reliance on tacit knowledge is calculated relative to reliance on both codified and encapsulated knowledge, support for Proposition 2 necessarily translates into a reduced relative reliance on codified and/or encapsulated knowledge. Grant’s (1996) suggestion that knowledge amenable to aggregation may be centralized for decision-making may be interpreted as suggesting that stages of production relying on relatively more on codified and/or encapsulated knowledge have a greater probability of being integrated.

This proposition is not necessarily counter to what is suggested by TCE, even though tacit knowledge is associated with learning by doing. According to Williamson (1985), learning by doing is a condition that gives rise to substantial human asset specificity and therefore favours integration over de-integration. Williamson (1985) also predicts that integration of adjacent stages of production is positively related to the depth of human asset specificity. However, Williamson limits human asset specificity to those cases where “skills are deepened and specialized to a particular employer” (Williamson, 1981, p.563) (emphasis added). To the extent then, that relative reliance on tacit knowledge of a given stage of production is not specific to a single firm it may be reasonable from a TCE perspective for a firm to contract for that stage’s output in a competitive market.

The proposition is also not counter to what is suggested by KBV. According to Kogut and Zander (1996), tacit knowledge tends to be transferred within a firm rather than in a market. This however does not preclude the manufacture of an intermediate product (such as an investment portfolio) by an external firm relying on a relatively high quantity of tacit knowledge as an input to production. Even though the input to the production process is arguably tacit
knowledge intensive, the output may be considered as readily marketable encapsulated knowledge. If on the other hand, the input to production is relatively more reliant on codified or encapsulated knowledge centralized decision-making may be facilitated (Grant, 1996) and adjacent stages of production will be integrated in a single firm.

3.4.3 Structure and Performance

In many industries we often observe two vertically adjacent stages of production integrated in a single firm in some cases and simultaneously de-integrated in two separate firms in other cases. Proposition 1 suggests that vertically adjacent stages in a value chain are more likely to be found separated by an inter-firm boundary the greater the difference between their knowledge-based factor intensities. Integration of adjacent stages of a value chain into a single firm when their knowledge-based factor intensities are very different implies a lack of efficiency. Similarly, de-integration of adjacent stages when their knowledge-based factor intensities are close to equivalent could indicate potential loss of economies of vertical integration. In other words, adjacent stages represented by points “A” and “B” in Figure 7 should be found to be more profitable if, as displayed in the left-hand graph they were integrated, and as displayed in the right-hand graph they were de-integrated. Accordingly, it is reasonable to expect that, to the extent that adjacent stages are not integrated or de-integrated as submitted in Proposition 1, they will be performing at sub-optimal levels. Table 4 presents the expected relationship between organizational structure, knowledge-based factor intensities, and expected relative performance based on Proposition 1.

Table 4: Performance as a function of structure and differences in knowledge-based factor intensities

<table>
<thead>
<tr>
<th>Organizational Structure</th>
<th>Difference in Knowledge-based Factor Intensities between Adjacent Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
</tr>
</tbody>
</table>
Birkinshaw, Nobel and Ridderstråle (2002) found evidence for their hypothesis that characteristics of knowledge are important predictors in the determination of inter-unit integration in R&D organizations. However, evidence that alignment between knowledge characteristics and organizational structure was related to performance was more ambiguous (Birkinshaw et al., 2002). They caution however, that the results of their study should be seen as exploratory and not necessarily generalizable to other settings (Birkinshaw et al., 2002).

Cashman and Deli (2006) found evidence that risk-adjusted returns for de-integrated portfolio management was greater than if the mutual funds had been managed internally. They also found evidence of a relationship between complex, difficult-to-transfer knowledge and de-integration of portfolio management (Cashman & Deli, 2006). Their results would suggest that mutual funds not structured as submitted by Proposition 2 perform at sub-optimal levels. Table 5 presents the relationship between organizational structures, relative reliance on tacit knowledge by portfolio managers, and expected relative performance, based on Proposition 2.

<table>
<thead>
<tr>
<th>Organizational Structure</th>
<th>Reliance on Tacit Knowledge in one stage relative to an adjacent stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relatively Higher</td>
</tr>
<tr>
<td>Integrated</td>
<td>Lower</td>
</tr>
<tr>
<td>De-integrated</td>
<td>Higher</td>
</tr>
</tbody>
</table>

Note that Proposition 1 and Proposition 2 will be in conflict if de-integrated portfolio managers (upstream stage) are equally, or less, reliant on tacit knowledge as other investment management professionals (downstream stage) in a mutual fund management firm.
Given the mixed results of previous studies, and the competing explanations suggested by Propositions 2 and 3, the relationship between organizational structure and firm performance will be analyzed according to the following proposition.

*Proposition 3: Firms that are integrated or de-integrated on the basis of evidence from Proposition 1 or Proposition 2 will perform better than those that are not.*

Evidence supporting Proposition 3 on the basis of evidence in favour of Proposition 1 would suggest that not only do differences in the nature of knowledge between adjacent production stages explain why those stages are integrated in a single firm or separated by an inter-firm boundary, but that failure to organizationally structure adjacent stages on the basis of differences in knowledge-based factor intensities also carries economic penalties. Alternatively, evidence supporting Proposition 3 on the basis of evidence in favour of Proposition 2 would suggest that not only do differences relative reliance on tacit knowledge between adjacent production stages explain why those stages are integrated or de-integrated, but that organizationally structuring adjacent stages on the basis of tacit knowledge differences impacts performance.

### 3.5 Specification of the Model

#### 3.5.1 Measuring Organizational Knowledge

Each stage along a value chain is expected to make use of that combination of factors of production that is uniquely most efficient (output maximizing while cost minimizing). It is therefore expected that different combinations of tacit, codified and encapsulated knowledge inputs will be evident between adjacent stages of production. This assumption, based on differences in the nature of the three classifications of knowledge, will form the basis for explaining the presence or absence of firm boundaries and related performance implications.
Part of the contribution of this research will address the issue that “…little research exists that even begins to identify and measure tacit knowledge (TK) within an organisation” (Richards & Busch, 2003). While economists may generally agree on how quantities and costs of labour and capital may be measured, consensus on the measurement of absolute quantities and costs of tacit, codified and encapsulated knowledge has yet to be achieved (Down, 2000). The intractability of obtaining absolute quantitative measures of these factors will be circumvented in this research by seeking to measure the perceived relative reliance of a production or cost function on tacit versus codified versus encapsulated knowledge along the perspectives laid out in the following table. The decision to rely on measures of relative perceived reliance was deliberately made in this research to make possible an empirical analysis of organizational knowledge.

3.5.2 Knowledge Intensity

To label a specific stage of production as “[k]nowledge-intensive imitates economists' labelling of firms as capital-intensive or labour-intensive” (Starbuck, 1992, p.715). The terms, capital-intensity, labour-intensity, and knowledge-intensity all refer to inputs, which is appropriate for this research since it “makes a good basis for analysing internal structure and operations ” (Starbuck, 1992, p.715).

In the research being proposed here, tacit, codified, and encapsulated knowledge are being put forward as factors of production, and will be measured as perceived by those in the best position to distinguish between the factors. It follows then that perceived relative reliance on tacit, codified, and encapsulated knowledge in production and cost functions may be considered analogous to capital and labour factor intensities. Accordingly, the term factor intensity and relative perceived reliance will be used interchangeably, the former being descriptive of the
concept, and the latter descriptive of the data collection process. Therefore, in an attempt to be as consistent as possible with microeconomic tradition, **tacit knowledge intensity** is measured as the perceived reliance on tacit knowledge relative to the sum of perceived reliance on tacit, **codified and encapsulated knowledge**. Similarly, **codified knowledge intensity** is measured as the perceived reliance on codified knowledge relative to the sum of perceived reliance on tacit, codified, and encapsulated knowledge. Finally, **encapsulated knowledge intensity** is measured as the perceived reliance on encapsulated knowledge relative to the sum of perceived reliance on tacit, codified, and encapsulated knowledge. In this research, the relative perceived reliances on knowledge-based factors of production are employed as the measures of knowledge-based factor intensities.

3.5.2.1 Tacit Knowledge Intensity

A particular stage of production may be considered tacit-knowledge intensive if the perceived reliance on tacit knowledge exceeds the perceived reliance on both codified and encapsulated knowledge. In keeping with the description of tacit knowledge presented in the last chapter, production that relies predominantly on knowledge resident in human minds may be considered tacit knowledge intensive. The core production and cost functions of professional services firms such as consultancies and legal and marketing firms would therefore be expected to exhibit tacit knowledge intensity. Tacit knowledge intensive production often involves the application of expertise to novel problems and is frequently found in organizations that provide services to external business clients.

3.5.2.2 Codified Knowledge Intensity

A particular stage of production may be considered codified-knowledge intensive if perceived reliance on codified knowledge exceeds the perceived reliance on both tacit and
encapsulated knowledge. According to the description of codified knowledge provided in the preceding chapter, production predominantly reliant on knowledge expressed as information using systems of symbols is codified knowledge intensive. Fast food franchise firms such as MacDonald’s and Subway, with their strictly adhered to operating manuals, come immediately to mind as examples of firms likely to exhibit codified knowledge intensity. In addition, a number of core high volume production functions of financial services firms such as banks and trusts would likely be codified knowledge intensive.

3.5.2.3 Encapsulated Knowledge Intensity

If perceived reliance on the encapsulated knowledge exceeds the perceived reliance on both codified and tacit knowledge in a particular stage of production, it may be considered encapsulated-knowledge intensive. Encapsulated knowledge is described in the previous chapter as knowledge that is embedded in an artefact’s design and functionality. Robotic automobile body assembly, road construction, and injection moulding are but three examples of a myriad of encapsulated knowledge intensive activities. Encapsulated knowledge intensity is more likely to be found in various stages of production in the manufacturing sector of an economy.

3.5.3 Definition and Measurement of Variables

3.5.3.1 Independent Variables

As discussed at the start of this chapter, absolute quantities of tacit, codified, and encapsulated knowledge are not directly measurable. This impediment was addressed in this research by reliance on relative quantities. Knowledge-based factor intensities were used as independent variables and measured by surveying relative perceived reliance on each classification of knowledge. Differences in knowledge-based factor intensities between adjacent stages of production in a value chain may therefore be considered as indications of
specialization. Each stage may be considered to produce an output using that unique combination of knowledge-based input factors which is output maximizing while cost minimizing. The survey instrument was therefore constructed so that respondents were asked to provide relative ratings of their reliance on knowledge-based factors used in production. The ratings were transformed so that they totalled to 1 and were relative to one another.

Eighteen independent items were identified, based on the three classifications of organizational knowledge (tacit, codified, and encapsulated) and six perspectives of measurement (location, transferability, expression, acquisition, source of value, and observability). These eighteen items were collected for two adjacent stages of production (upstream and downstream). These 18 independent items were designed to capture relative perceived reliance on the three knowledge-based factors of production.

Table 6: Independent knowledge-based variables

<table>
<thead>
<tr>
<th>Stage of Production</th>
<th>Classification of Knowledge</th>
<th>Tacit</th>
<th>Codified</th>
<th>Encapsulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream</td>
<td>$T_u$</td>
<td>$C_u$</td>
<td>$E_u$</td>
<td></td>
</tr>
<tr>
<td>Downstream</td>
<td>$T_d$</td>
<td>$C_d$</td>
<td>$E_d$</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Definitions of independent variables

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Independent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_u$</td>
<td>Tacit knowledge intensity in the upstream stage, as measured by reliance on tacit knowledge as a proportion of total knowledge-based inputs to the upstream stage’s production.</td>
</tr>
<tr>
<td>$T_d$</td>
<td>Tacit knowledge intensity in the downstream stage, as measured by reliance on tacit knowledge as a proportion of total knowledge-based inputs to the downstream stage’s production.</td>
</tr>
<tr>
<td>$C_u$</td>
<td>Codified knowledge intensity in the upstream, as measured by reliance on codified knowledge as a proportion of total knowledge-based inputs to the upstream stage’s production.</td>
</tr>
<tr>
<td>$C_d$</td>
<td>Codified knowledge intensity in the downstream stage, as measured by reliance on codified knowledge as a proportion of total knowledge-based inputs to the downstream stage’s production.</td>
</tr>
</tbody>
</table>
3.5.3.2 Dependent Variables

Two main dependent variables have been identified, namely, de-integration and performance. The first dependent variable to be explained is the presence or absence of an inter-firm boundary along a value chain (de-integration). Specifically, the dependent variable is a binary variable indicating whether an upstream stage of production and an adjacent downstream stage of a value chain are integrated in one firm or de-integrated into two separate and unaffiliated firms.

Some adjacent stages of production may be separated by less than a definitive inter-firm boundary. For example, a downstream stage (a mutual fund management firm consisting primarily of investment management professionals) may have an investment interest in an upstream stage (a portfolio management firm consisting primarily of portfolio managers) of greater than 0% but less than 100%, and vice versa. For the purposes of this research, adjacent stages of production will be considered **de-integrated** when they share *no ownership in common*. Any evidence of common ownership, even if only partial, will be considered as evidence of integration. In practice however, there is no public record of ownership below 10%, so the actual demarcation is at that level.

The second dependent variable to be explained is the firm performance, more specifically, the relative performance of pairs of adjacent stages of production. Measurements of performance in both stages of the value chain are required to test Proposition 3. A number of possible performance measures were considered, but only three were available in the secondary
data, compounded annual returns, risk measures, and risk-adjusted returns. Only the latter was used since it incorporated both of the other measures and increased returns are related to increased levels of risk (Markowitz, 1952, 1959).

3.5.3.3 Control Variables

There is some conflicting evidence (see, for example, Brown & Goetzmann, 1995; Chen, Hong, Huang, & Kubik, 2004) that economies of scale exist in both size of mutual funds and in the size of a fund family. Accordingly, a control variable for the value of assets under management (lnAssets) was included as a proxy for size to capture the effects that a size factor may have on mutual fund performance.

To avoid the possibility that excessive differences in common substantive knowledge may be a factor in the determination of firm boundary location, adjacent stages of production were deliberately chosen for this research. This controlled for the possibility that the activities conducted in the stages differed to such an extent that they share very little common knowledge.

Understandably, dissimilar collections of assets will experience divergent performance in various market environments. Accordingly, it is highly improbable that dissimilar mutual funds will experience the same amount of growth during any given interval. Control variables that recognized differences in risk and return of mutual funds based on an industry-wide accepted definition were incorporated in the analysis. The Canadian Investment Funds Standards Committee (CIFSC) provides a list of 38 mutual fund categories on their website (www.cifsc.org), which capture some of the differences in risk and return.

Other control variables available from the data were also tested to determine if they demonstrated any significance.
3.6 Research Population

3.6.1 Mutual funds

The population for this research consists of two adjacent stages of production selected from capital markets industry in Canada. This study focused on two entities involved in the intermediation of capital markets between the corporate or governmental issuers of public securities such as stocks, bonds, debentures, etc., and non-institutional retail investors. The two entities chosen were the portfolio managers and other professionals employed in mutual fund management firms. Portfolio managers are also referred to as portfolio advisors, especially when they are employed by a sub-advisory firm not related to the mutual fund management firm. Other investment management professionals include those involved in marketing and wholesale distribution of mutual funds, meeting regulatory requirements, managing information technology, and other functions involved in the production of conventional mutual funds. In the mutual fund value chain that connects the issuers of stocks and bonds to retail investors, portfolio managers were considered upstream from fund managers, who were adjacent and downstream.

3.6.2 Appropriateness

Mutual fund managers and portfolio advisors are an appropriate population for this research for a number of reasons. First, while the majority of mutual funds are operated by affiliated fund managers and portfolio advisors, there is a significant and growing trend towards vertical de-integration, known in the industry as making use of sub-advisory services (Costello, 1999; O'Brien, 2001). Vertical de-integration is not uniform among the various mutual fund asset classes, with some such as money market funds rarely being sub-advised while about half of the assets in specialty health mutual funds are sub-advised in the US. Similar heterogeneity exists among Canadian mutual fund categories. The presence of both integrated and de-integrated
mutual funds provides an opportunity to examine how the nature of knowledge may inform the decision to integrate, or de-integrate, two adjacent productive activities.

Second, the capital markets industry is relatively knowledge-based with relatively little physical capital involved in the various productive activities undertaken. This trend to dematerialization appears to be continuing as evidenced by the Dematerialization White Paper published by the Canadian Capital Markets Association (2001). That white paper suggested that further dematerialization would reduce significant inefficiencies for the industry (2001). Some mutual fund web sites indicate that paper-based certificates of ownership of a security are no longer being available but have been replaced by digital certificates. Consequently, the variance in research results is expected to be less than if a more physical manufacturing industry were examined.

Third, information regarding mutual funds is also fairly accessible. General information on most mutual funds can be easily accessed from web sites operated by Fundata, Globefund, and Morningstar. More specific detailed information on each mutual fund can be found on the SEDAR web site. SEDAR is the System for Electronic Document Analysis and Retrieval is operated by the Canadian Securities Administrators and CDS INC, a subsidiary of The Canadian Depository for Securities Limited, to make Canadian public securities filings easily accessible to the public. Considering all of the above, it is believed that mutual funds provide fertile ground for determining whether or not a knowledge-based view of the firm can contribute to the explanation of the presence or absence of firm boundaries.
3.6.3 Population Definition

According to the Canadian Securities Administrators\(^{10}\) (2004), “A public mutual fund is a pool of money that is managed on behalf of investors by a professional money manager. The manager uses the money to buy stocks, bonds or other securities according to specific investment objectives that have been established for the fund”. Each mutual fund is a separate legal entity. Mutual funds are distributed to the Canadian public under a prospectus filed with the provincial and territorial securities commissions under National Instrument 81-101 and Companion Policy 81-101CP. The main instrument of the provincial securities regulators governing conventional mutual funds is National Instrument 81-102 and Companion Policy 81-102CP.

The Securities Act of Ontario is the legislation that governs the bulk of the mutual fund industry in Canada since the industry is centred in Toronto, Ontario, and securities legislation falls under provincial jurisdiction. The Ontario Securities Commission (OSC) is charged by the Securities Act of Ontario to administer the act and perform the duties assigned to it under the act. The purposes of this Act are “(a) to provide protection to investors from unfair, improper or fraudulent practices; and (b) to foster fair and efficient capital markets and confidence in capital markets” (Securities Act, 2007). This act defines a mutual fund, with some exceptions, as an issuer whose primary purpose is to invest money provided by its security holders, and whose securities entitle the holder to receive on demand a proportionate interest in the value of the

\(^{10}\) The Canadian Securities Administrators is a forum for the 13 securities regulators of Canada's provinces and territories to coordinate and harmonize regulation of the Canadian capital markets. While various studies have suggested that Canada adopt national securities regulator, constitutionally, securities market regulation has been the purview of the provinces and territories.
In the same act, an issuer is defined as “a person or company who has outstanding, issues or proposes to issue, a security” (Securities Act, 2007). Likewise, a security is further defined to be, among other things, any document commonly understood to be a security and specifically “any agreement under which the interest of the purchaser is valued for purposes of conversion or surrender by reference to the value of a proportionate interest in a specified portfolio of assets” (Securities Act, 2007). That inclusion effectively defines as securities, the units or shares that investors receive in exchange for investing cash in a mutual fund.

“The essential nature of a mutual fund is that its value is based on the current value of its assets less the current value of its liabilities and investors in a mutual fund have the right to redeem their interest ‘on demand’ at the net asset value of their interest. The assets of a mutual fund are owned by the mutual fund and investors are entitled to a pro rata share of those assets by holding units or shares of the mutual fund” (Canadian Securities Administrators & Canadian Council of Insurance Regulators, 1999). “Both open-ended investment trusts (mutual fund trusts) and corporations (mutual fund corporations) are permitted, although open-ended investment trusts are more common, due to the more favourable flow-through tax treatment…” (Canadian Securities Administrators & Canadian Council of Insurance Regulators, 1999).

A mutual fund is an “open-ended” investment fund, which means that investors can contribute money to the fund at any time as well as redeem their units or shares to the fund at any time. When units or shares of a mutual fund are redeemed the investor receives an amount of money based on the current market value of the fund's portfolio. Fund managers charge fees, based on the value of the fund’s assets, for administering the fund and compensating the various service providers in the value chain. These service providers include portfolio managers who are
contracted by mutual fund management firms to make securities selection decisions. Mutual fund management firms charge fees to their unit holders (or shareholders), based on the value of a fund's assets, for administering a mutual funds and managing its investment portfolio.

3.6.4 Industry Structure

All mutual funds that are open-ended investment trusts have a trustee and all mutual fund corporations have a board of directors. Despite being governed by a trustee or board of directors, “virtually all the operations and functions of mutual funds are carried out by a sponsor or promoter… without any involvement of, or oversight by, independent third parties. The manager may well be the trustee of the fund” (Securities Act, 2007). The research being proposed here examines the relationship between two particular functions among a number of related tasks performed by the industry. The relationship between portfolio managers and other investment management professionals of the mutual fund management firm is the focus of this research.

3.6.5 Portfolio Managers

The Securities Act of Ontario defines a portfolio manager as “an adviser registered for the purpose of managing the investment portfolio of clients through discretionary authority granted by the clients” (Securities Act, 2007). It further defines an adviser as “a person or company engaging in or holding himself, herself or itself out as engaging in the business of advising others as to the investing in or the buying or selling of securities” (Securities Act, 2007). Portfolio managers who provide investment advice or manage the investments of a mutual fund must be registered with a securities commission and are bound to comply with the regulations applicable to advisers (Canadian Securities Administrators & Canadian Council of Insurance Regulators, 1999). For the majority of mutual funds the mutual fund management firm acts in the role of portfolio adviser, but if the mutual fund management firm is not itself
managing the assets of the mutual fund, it must contract with a registered adviser to provide such services to the mutual fund (Canadian Securities Administrators & Canadian Council of Insurance Regulators, 1999). Securities legislation requires certain proficiency (both required courses and experience) of officers and directors of individuals or firms that act as portfolio advisers. For the purposes of this research, which is limited to the mutual fund industry, the single term “portfolio manager” will be used, in place of the two legal definitions in the Securities Act of Ontario, which are designed to be more expansive. A portfolio manager is defined in this research as the individual that selects the securities to be held by mutual funds, and purchases and sells securities on behalf of the mutual fund unit holders according to the investment policy of the fund. This functional definition permits a distinction between the portfolio management and fund manufacturing roles that other investment management professionals in a mutual fund management firm assume. For a small but growing proportion of mutual funds, the portfolio manager role is contracted to a third party. Figure 8 depicts the functions performed by the various entities of a mutual fund complex. Note that the more common trust structure is presented. A corporate structure is sometimes used instead of a trust structure, but only rarely so.
Figure 8: Mutual Fund Complex

- Public Corporations, Governments, etc.
  - Issues Securities to the Public
    - Selects External and/or Internal
    - Research Question
    - Portfolio Manager
      - Buys and Sells Securities to Manage Investments
        - Upstream Stage
      - Transfer Agent and Registrar
        - Maintains List of All Investors in Fund
        - Has Title to Securities on Behalf of Unitholders
      - Custodian
        - Holds Securities on Behalf of Fund
      - Auditor
        - Audits and Gives Opinion on Fund's Financial Statements
      - Principal Distributor
        - Issues Units to the Public
          - Coordinates Sale of Units to Investors
            - Registered Dealer (Broker or Financial Planner)
              - Assists in the Selection of Individual Mutual Funds
                - Retail Investor (Unitholder)
3.6.6 Investment Management Professionals

The mutual fund industry is segmented among a number of functions. The Securities Act of Ontario defines an investment fund manager as “a person or company who has the power and exercises the responsibility to direct the affairs of an investment fund” (Securities Act, 2007). The investment fund manager is “a separate body corporate that directs the business and affairs of the mutual fund (including the responsibility for managing the portfolio assets of the mutual fund) and that is generally the sponsor of the mutual fund (and may also be the trustee of the fund)” (Canadian Securities Administrators & Canadian Council of Insurance Regulators, 1999). The term fund manufacturer is also used to describe the investment fund manager since they construct mutual funds that they then promote and operate. For the purposes of this research, the term, ‘fund manager’ will be avoided to reduce ambiguity. It may be construed to refer to the firm hired by a trustee to manage a mutual fund, an individual who manages a mutual fund management firm, or even be conflated with the role of portfolio manager. Instead, the term investment management professional will be defined as one of the individuals that establish one or more mutual funds, are responsible for administering the fund(s), and directly or indirectly market them. This functional definition based on the individual permits a distinction between the manufacturing and portfolio management roles within a mutual fund management firm. It should be recognized however, that in the smallest of mutual fund management firms this distinction is practically non-existent.

3.6.7 Other Entities

In addition to fund managers and portfolio advisers, a number of other entities participate in the value chain that delivers the product to the retail investor. The trustee is the entity that has title to the securities owned by the fund on behalf of the unit holders. Trustees can be
individuals, registered trust companies or the same corporate entity that acts as mutual fund management firm. “The structure of a mutual fund trust is largely determined by a declaration of trust or trust deed (subject to restrictions and requirements imposed by securities regulations governing mutual funds). These trust documents dictate the affairs and operations of the mutual fund trust and also appoint a trustee for the mutual fund (who agrees to act as trustee on the terms set out in the trust document)” (1999). “Trustees of mutual funds in Ontario must either be a registered trust company or the manager of the mutual fund…” (1999). Trustees are governed by the common law of trustees and by provincial and federal trust legislation (1999).

Transfer Agents and the Registrar are responsible for maintaining a list of all investors in the fund (2004). Registrar and transfer agency services are frequently outsourced. Valuation services and recordkeeping are two other administrative functions of the fund manager that are also frequently outsourced (1999).

All mutual funds also have custodians that hold the assets of the mutual funds. Custodians are corporations that are separate from, though not necessarily unaffiliated with, the mutual fund management firm and the principle distributor (1999). A custodian must be either a Canadian chartered bank or a registered provincial trust company with shareholders equity of at least $10 million or a wholly owned subsidiary of such an entity having shareholders equity of $10 million (1999).

Auditing of mutual funds is conducted by independent accountants retained by the fund manager to audit each year, and report on the financial statements of the fund. While the fund manager retains the auditor, a change in auditors requires the approval of the mutual fund’s unit holders or shareholders.
A principal distributor co-ordinates the sale of mutual fund units to investors, either directly, or through a network of registered dealers (2004). Many fund managers also act as principle distributor. A large proportion of fund managers, however, use an external entity as principal distributor to act as its agent in selling securities to the public (1999).

This study examines the phenomena of the portfolio management function being integrated with the mutual fund management firm in the majority of cases but being de-integrated in a significant number of other cases. Specifically, a knowledge-based view of the firm is applied to determine if it can explain why some mutual funds are ‘sub-advised’, while in-house portfolio managers are employed by other mutual funds.

3.6.8  De-integration

This research seeks an explanation for why the portfolio manager role and those of other investment management professionals may in the majority of cases be found integrated in one firm, and in other cases de-integrated in two separate firms. A mutual fund may be termed to be ‘sub-advised’ when an individual from an organization outside the mutual fund management firm is contracted to act as portfolio manager. The term, ‘sub-advised’ is used by the industry to describe such an arrangement because the fund management firm retains ultimate legal responsibility for managing the mutual fund, and is responsible for monitoring the portfolio manager on behalf of the mutual fund’s unit holders. When a mutual fund is sub-advised, the mutual fund management firm is legally required to notify investors through the fund’s prospectus.

For the purposes of this research, however, not all mutual funds whose prospectuses claim that they are sub-advised will be considered de-integrated. For example, the prospectus of a mutual fund may indicate that CIBC is the mutual fund management firm, its subsidiary CIBC
Asset Management Inc. is the portfolio manager, and TAL Global Asset Management Inc. is the fund’s ‘sub-adviser’. For the purposes of this research, the mutual fund would not be considered to be de-integrated since TAL is a wholly owned subsidiary of CIBC. Accordingly, a mutual fund management firm and a portfolio management organization will be considered de-integrated when the individual that acts as portfolio manager is not an employee of the mutual fund management firm or any other firm known to be affiliated. This definition corresponds to that used by at least one other research organization studying sub-advisory services (Financial Research Corporation).

3.7 Data Collection

Rationale

Data was collected from two sources, one primary and one secondary. Primary data was collected from portfolio managers and other investment management professionals using an Internet based survey. Secondary data was collected from Fundata Canada Inc., which agreed to provide its data at no cost for academic purposes. Collection of items designed to measure relative reliance on tacit, codified and encapsulated knowledge necessitated the use of surveys. To date, no secondary source of such data is available.

3.7.1 Minimizing Survey Error

The use of self-reported measures gathered by surveying respondents carries with it some important risks. Dillman (2000) begins by describing four sources of survey error and their consequences, sampling error, coverage error, measurement error, and non-response error.

Sampling error occurs as a result of surveying less than the entire survey population and is generally reduced by increasing the size of the randomly selected sample. The approach taken in this research to reduce sampling error was to approach the Chief Investment Officer of every known mutual fund management firm and request a census of their population. While this did not
eliminate sampling error, it did introduce a randomness generated by the decisions of multiple individuals rather than by a single researcher. In addition, Dillman and Bowker (2001) suggest that controlling access to Web-based surveys as was done for this survey also reduces sampling error.

Coverage error is the result of a reduced probability of some members of a population of being surveyed. It occurs “when the list from which the sample is drawn does not include all elements of the population” (Dillman, 2000, p.9). Coverage error is reduced by “allowing all members of the survey population to have an equal or known nonzero chance of being sampled for participation in the survey” (Dillman, 2000, p.11). The survey for this research was subject to some coverage error as contact details for all potential respondents were not readily available. Email addresses for almost all potential respondents were generally obtainable with a reasonable level of search effort.

Measurement error occurs as a result of poor wording or survey construction such that inaccurate or uninterpretable answers are obtained. Measurement error can occur from inattention to how a survey will look on different computer screens or from survey design characteristics that may lead a respondent to either abandon the survey altogether or send incomplete information. In the survey for this research, wording of the items was pilot tested for clarity and comprehensibility. Since the survey was Web-based it had was successfully tested on screens with resolutions as low as 800 by 600 pixels using the two most popular Internet browsers (Internet Explorer and Firefox).

Non-response error refers to the difference between characteristics of those who respond to a survey and those that do not, when those characteristics are important to the research. The next section on survey design addresses how non-response error was minimized.
3.7.1.1 Common Method Variance

An additional survey problem discussed by Podsakoff and Organ (1986) is common method variance, which is often caused by the consistency motif and social desirability (see also (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003)). This problem can arise because in self-reporting surveys “…[w]e are generally not asking people to report a specific fact or a finite event. We are asking persons to go well beyond that and to engage in a higher-order cognitive process – a process that involves not only recall but weighting, inference, prediction, interpretation, and evaluation. Many times during a brief interval, we are requiring the respondents to work at a fairly high level of abstraction. Thus the data we obtain are already a few steps removed from the level of discrete stimuli and responses” (Podsakoff & Organ, 1986, p.533).

The problem of common method variance arises when we attempt to interpret correlations between two or more variables collected from the same respondents. Any flaw in the source of one measure similarly taints the other measures. The problem of common method variance was generally avoided in this research by restricting the survey primarily to the collection of data for the independent variables. Dependent and control variables were generally provided by secondary data made available by Fundata Canada Inc.

3.7.2 Survey Design

The design of a survey should attempt to achieve two objectives, reduction of non-response, and reduction of measurement error (Dillman, 2000). Dillman has found social exchange theory to be helpful in guiding the organization and presentation of surveys to potential respondents (2000). According to social exchange theory, three elements affect the motivation of recipients to engage in the human interaction involved in completing a survey: rewards, costs,
and trust (Dillman, 2000; Homans, 1961; Kelley & Thibaut, 1978; Thibaut & Kelley, 1959). Rewards are the gains recipients receive from participating in a survey, while costs are the sacrifices recipients make and opportunities they forgo to obtain the rewards. Trust is the expectation that in the long run, the potential rewards of participating in a survey will exceed the potential costs. Good survey design should maximize reward, minimize cost, and establish trust so that recipients of a survey are motivated to complete it (Dillman, 2000).

Rewards may be provided to survey recipients by a) demonstrating respect for them, b) thanking them, c) asking them for advice, d) supporting shared values, e) providing tangible rewards, f) asking interesting questions, g) giving social validation, and h) stressing the scarcity of the opportunity to respond (Dillman, 2000).

The survey constructed for this research demonstrated respect for the respondents and gave social validation by requesting the respondents to indicate their accreditations. This acknowledged that the researcher was aware of the high quality of the professionals working in, and special designations relevant to, the mutual fund industry. In addition, recipients were offered the opportunity for feedback comparing their responses to aggregate statistics and a hyperlink to the completed study. Finally, all respondents were thanked at the end of the survey. The effectiveness of these rewards was demonstrated by 61% of respondents requesting a hyperlink to the completed study and by 19% requesting a comparison of their responses to the aggregate.

An open-ended question near the end of the survey rewarded respondents with a request for their advice. Shared values were demonstrated in wording emphasizing cost minimization in the email inviting potential respondents to participate in the survey. While the questions may not have been interesting to all potential respondents, they were probably complex enough to
pleasantly stimulate the majority of them. The scarcity of the opportunity to respond was expressed at the outset. The invitational email indicated that the survey was restricted to a select group of professionals in the mutual fund industry.

Costs to potential respondents may be reduced by a) avoiding subordinating language, b) avoiding embarrassing the potential respondent, c) avoiding inconveniencing the potential respondent, d) avoiding lengthy or difficult surveys, e) minimizing requests for personal information, and f) keeping requests similar to others to which the recipient has already responded (Dillman, 2000).

The survey developed for this research contained neither subordinating language nor any emotion-laden or embarrassing questions. Since the survey was Web-based, it was available to potential respondents 24 hours per day, seven days per week, providing each recipient of an invitational email the flexibility to complete the survey at a time convenient to them. Based on interviews with those involved in the industry, the length of the survey was kept to a minimum to reduce cost to the respondents. Minimizing survey length, however, resulted in questions that were more complex and difficult to answer. Given that the target population was generally well educated, the complexity of the questions did not appear to be an obstacle to obtaining responses. The only two questions of a personal nature were those that provided the potential respondents with an opportunity to pride themselves. The first question requested the potential respondent to provide the title of their position in the organization, while the second item asked the potential respondent to list the accreditations they held. Not knowing what other surveys these recipients had been asked to complete, similarity of this survey to others would only have occurred by chance.
Trust may be established by a) providing a token of appreciation in advance, b) enlisting the sponsorship of a legitimate authority, c) making the survey appear important, and d) invoking third party exchange relationships (Dillman, 2000).

No advance token of appreciation was provided with this survey. The decision to forego the advance was based on a number of reasons. First, the survey is Web-based and the invitation to participate was made by email. Thus the connection between the receipt of a tangible token and the invitation to participate in the survey would likely have been lost on potential respondents. Second, the delivery of a tangible token would necessitate the collection of postal addresses for each of the potential respondents, generating an additional cost that was not necessary for delivery of the survey itself. Third, the delivery of electronic gift certificates or cash by email, while possible, also entails redemption costs for the recipient. These costs may include “(a) direct costs of incentive redemption, (b) the cost in terms of time required to set up an account or to type in gift certificate information, (c) the inconvenience of having to redeem an incentive such as a gift certificate with an online merchant, and (d) the potential cost difference if, for example, a $5 gift certificate is redeemed for something that costs more” (Birnholtz, Horn, Finholt, & Bae, 2004, p.356).

Enlistment of a legitimate authority was achieved in two ways. First, both the invitational email and the survey itself indicate that the research was being conducted at the University of Toronto, Canada’s largest research university. Second, invitations to participate in the research were preceded by an email to each potential respondent from his or her Chief Investment Officer or Chief Executive Officer, notifying them of the forthcoming invitation. Finally, the invitational emails sent to each potential respondent referenced the University of Toronto in the subject
header. No other ‘exchange’ relationships are invoked since Dillman (2000) appears to be silent as to how these are to be discovered.

Communicating the three elements of social exchange involves the application of graphic design and layout concepts, as well as the use of words. Surveys convey meaning in two ways, through graphical symbols and written words, and these two means of communication should work in concert with one another to ease the response burden.

Dillman’s Tailored Design differs from its predecessor, Total Design Method, in that it incorporates knowledge of the survey population, sponsorship effects, and content, to tailor a survey specifically to use bolster the elements of social exchange, rather than assume a “one-size-fits all approach” (Dillman, 2000, p.24). By increasing rewards, reducing respondent cost, and engendering trust, Tailored Design aims to maximize the quantity and quality of response, thereby reducing non-response and measurement error.

3.7.2.1 Question Structure

A well-designed survey question for a self-administered survey should a) be similarly interpretable by each potential respondent, b) provide the potential respondent with the opportunity to respond accurately, and c) encourage the potential respondent to answer (Dillman, 2000). To successfully meet these three goals, each question should a) require an answer, b) anticipate the potential respondents’ various contexts and the amount of thought they must bring to bear, c) minimize the complexity and maximize the recency of recall, d) maximize potential respondents’ willingness to reveal the requested information, e) motivate the potential respondents to answer, e) minimize potentially biasing visual stimuli, f) be comparable in a variety of collection modes, and g) be purged of known defects if survey sponsor permits.
Selection of question structure is the primary tool available for addressing these needs (Dillman, 2000).

There are three basic ways a question may be structured. Questions may be a) open-ended, with no answer choices provided, b) closed-ended, with ordered response categories, or c) closed-ended with unordered response categories (Dillman, 2000).

Open-ended questions may be appropriate if the surveyor does not know, and is therefore unable to list, possible answers to a question. This type of question may also be appropriate if the research is exploratory and trying to uncover as many possible answers as respondents may offer. The main disadvantage of open-ended questions is the inability to gather adequate answers. The quality of response to vague open-ended questions depends on the willingness of respondents to think hard about the questions and provide a complete answer. Accuracy of responses to open-ended questions may be improved by the addition of categories or units for reporting. Another option for improving responses to relatively vague open-ended questions is to decompose such questions into a number of more specific component questions.

Closed-ended questions with ordered responses are most useful when evaluative responses are being solicited. This type of question is generally easiest to answer as it only involves “envisioning a scale and figuring out where on that scale one fits…” (Dillman, 2000, p.43). Questions of this structure typically present one concept in the stem and provide another in the answer choices. The answer choices are generally a list of “scalar concepts” often referred to as “vague quantifiers” and “subject to considerable measurement error” (Dillman, 2000, p.44). Making questions easy to answer increases the burden on the writer who must decide on the number of answer choices to offer and if, and how, to label them. A lack of labels provides
simplicity and eases the amount of comprehension demanded of respondents, but it may also make the question more abstract and each answer choice less meaningful.

Closed-ended questions with unordered responses are used to compare discrete categories. The task of evaluating and choosing between different concepts generally requires relatively more effort on the part of the respondent than answering questions with ordered responses. The amount of information to be processed by the respondents is simply greater. Selecting between two unordered answer choices may not be difficult, but as the number of answer choices increases so too does the effort demanded of the respondent. To avoid an overly long list of answer choices, questions may be partially open-ended (with an ‘Other – Please Specify’ choice). Using partially closed-ended questions limits analysis as the closed-ended responses and open-ended responses cannot be compared because stimuli for the two differ.

All three types of questions were used in the survey. Two open-ended questions were included, one to solicit the position titles of respondents and an exploratory question seeking to gather as many possible answers about respondents firms’ use of knowledge or information. An advantage of using a Web-based survey is that “open-ended questions, a traditional shortcoming of paper questionnaires, receive… more complete answers” (Dillman, 2000, p.366).

The most valuable questions of this survey were closed-ended questions with ordered responses. Even though Dillman (2000) suggests these questions are easiest to answer, the six questions using this structure were complicated with elicitations of numerical judgments. The increase in cognitive demand of using weight elicitation questions is not expected to be a deterrent to the potential respondents who are generally well educated and analytical by nature. Increasing the cognitive demand of each of the closed-ended questions enabled the survey to
capture rich data with fewer questions from a population disinclined toward completing lengthy surveys. The type of weight elicitation method used in this survey is discussed in a later section.

One closed-ended unordered response question was included in the survey to collect respondents’ accreditations. It included the most likely answers, but is partly open-ended since it includes an ‘Other – Please Specify’ choice.

3.7.2.2 Question Wording

Dillman (2000) details 19 principles for combining words and structure. These are listed in the following table, along details describing how these principles were applied in the survey constructed for this research.

<table>
<thead>
<tr>
<th>Table 8: Question wording principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wording Principle</td>
</tr>
<tr>
<td>Use simple words instead of specialized ones – more potential respondents will understand them.</td>
</tr>
<tr>
<td>Use as few words as possible and avoid redundancy – potential respondents’ tendency to skip over words increases with the length of a question and the amount of redundancy.</td>
</tr>
<tr>
<td>Use complete sentences.</td>
</tr>
<tr>
<td>Use numerical quantifiers to eliminate possible wide variations in interpretation of vague quantifiers.</td>
</tr>
<tr>
<td>Do not demand excessive precision from respondents – they may simply guess.</td>
</tr>
<tr>
<td>Use equally positive and negative categories for scalar questions to maintain balance and avoid biasing answers in one direction or another.</td>
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<tr>
<td>If used, place the “undecided” category at the end of a scale and distinguish it from a neutral score.</td>
</tr>
<tr>
<td>Balance closed-ended unordered questions’ answer choices – using biased language may lead to more or less frequent selection of biased categories.</td>
</tr>
<tr>
<td>Wording Principle</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Balance closed-ended ordered question stems – focusing on only one end of a scale in a question stem limits the range of the scale in respondents’ minds (if surveying respondents from societies with a tendency to acquiesce, questions must also be structured to minimize this possibility).</td>
</tr>
<tr>
<td>Eliminate “check all that apply” questions – respondents are likely to exhibit primacy effects, selecting from among the first answers presented, and to exhibit satisficing behaviour, stopping once they have selected what they believe to be a satisfactory number of choices.</td>
</tr>
<tr>
<td>Use mutually exclusive response categories.</td>
</tr>
<tr>
<td>Use cognitive design techniques to enhance respondent recall.</td>
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<tr>
<td>Refer to appropriate time frames.</td>
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<tr>
<td>Ensure technical accuracy.</td>
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<tr>
<td>Write questions to permit comparison with previously collected data.</td>
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<tr>
<td>Avoid the use of double negatives.</td>
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<tr>
<td>Avoid questions with two components.</td>
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<tr>
<td>Reduce the negative impact of objectionable questions.</td>
</tr>
<tr>
<td>Avoid asking respondents to make unnecessary calculations.</td>
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</tbody>
</table>

3.7.2.3  Survey Structure

Although Dillman’s (2000) suggestions on constructing a questionnaire are based on the use of a paper-based survey, some of the principles also apply to Web-based surveys. Dillman (2000) lists 28 principles for information organization in his chapter entitled, “Constructing the Questionnaire”. The following table lists those principles along with details describing how these principles were applied in the Web-based survey structure.
Table 9: Question structure principles

<table>
<thead>
<tr>
<th>Structure Principle</th>
<th>Incorporated</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize the need to reread portions</td>
<td>Yes.</td>
<td>Instructions were placed in front of the answer categories.</td>
</tr>
<tr>
<td>Place instructions with the questions.</td>
<td>Yes.</td>
<td>Rather than listing instructions at the beginning of the survey, they were repeated as necessary at the beginning of each question.</td>
</tr>
<tr>
<td>Place questions with the same response categories</td>
<td>No.</td>
<td>“[I]f... the sponsor wants individuals to contemplate each item separately, it is advisable to present each of them as individual items” (Dillman, 2000).</td>
</tr>
<tr>
<td>Ask only one question at a time.</td>
<td>Yes.</td>
<td>This also avoided the need for respondents to scroll down the Web page to read successive questions.</td>
</tr>
<tr>
<td>Restrict the use of matrices.</td>
<td>Yes.</td>
<td>No questions using matrices were included.</td>
</tr>
<tr>
<td>Begin questions in the upper left corner of the page.</td>
<td>Yes.</td>
<td>All potential respondents were expected to be familiar with western cultures’ norm of beginning to read from this location.</td>
</tr>
<tr>
<td>Use size and colour to identify starting points.</td>
<td>Yes.</td>
<td>The starting point of each item on the survey was ‘Item x of y’ written in red coloured font.</td>
</tr>
<tr>
<td>Identify the beginning of questions in a consistently.</td>
<td>Yes.</td>
<td></td>
</tr>
<tr>
<td>Number questions simply and consecutively.</td>
<td>Yes.</td>
<td></td>
</tr>
<tr>
<td>Use a consistent foreground and background.</td>
<td>Yes.</td>
<td>With the exception of page headers and navigational instructions, all text was 13 point black Arial-type font on a white background.</td>
</tr>
<tr>
<td>Limit the use of reverse print.</td>
<td>Yes.</td>
<td>Reverse print was not used.</td>
</tr>
<tr>
<td>Space question subcomponents closer than questions</td>
<td>Not applicable.</td>
<td>Each question was presented on a separate Web page.</td>
</tr>
<tr>
<td>Use bold font for questions and normal font for answers.</td>
<td>Yes.</td>
<td></td>
</tr>
<tr>
<td>Place special instructions inside questions, not standalone.</td>
<td>Not exactly.</td>
<td>One example question and answer was provided at the beginning of the survey for the more cognitively demanding questions.11</td>
</tr>
<tr>
<td>Optional instructions should be separated by font variations.</td>
<td>Yes.</td>
<td>An explanation of the example question and answer was provided in italic font.</td>
</tr>
<tr>
<td>Do not place instructions in a separate section.</td>
<td>Yes.</td>
<td>Seems obvious.</td>
</tr>
<tr>
<td>Use lightly coloured shades as background.</td>
<td>No.</td>
<td>The background was left white to avoid any association with a brand colour of any of the firms being surveyeded.</td>
</tr>
<tr>
<td>Use white answer fields when the background is shaded.</td>
<td>Partly.</td>
<td>The answer fields were white, but outlined in black to highlight them.</td>
</tr>
<tr>
<td>List answer categories vertically.</td>
<td>Yes.</td>
<td>Aesthetically pleasing and easy to read.</td>
</tr>
<tr>
<td>Place answer fields consistently.</td>
<td>Yes.</td>
<td>For most questions, answer fields appeared on the left in a</td>
</tr>
</tbody>
</table>

11 Joanna Lumsden of the National Research Council of Canada generously provided this suggestion after reviewing a draft version of the survey. Her advice was sought since the survey is designed to elicit weight estimations for the calculation of marginal rates of substitution and Lumsden’s (2005) paper, “Guidelines for the Design of Online-Questionnaires” recommended that Web-based surveys not be used to collect magnitude estimation data. Her final words on the issue, “I think it [the survey] is easy to complete BUT it might be a good idea to show a completed example…” (Lumsden, 2006).
<table>
<thead>
<tr>
<th>Structure Principle</th>
<th>Incorporated</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use numbers or simple answer boxes.</td>
<td>Yes.</td>
<td>All but the open-ended questions required a number or a mouse click.</td>
</tr>
<tr>
<td>Vertically align question sub-components.</td>
<td>Yes.</td>
<td>Similar questions were also vertically aligned.</td>
</tr>
<tr>
<td>Avoid arranging questions in more than one column.</td>
<td>Yes.</td>
<td>All but one question, with three distinct answer categories familiar to the respondents, were single banked.</td>
</tr>
<tr>
<td>Maintain consistent spacing between answer choices.</td>
<td>Yes.</td>
<td>The questions were provided with evenly spaced answer locations to convey equal 'distance' between them.</td>
</tr>
<tr>
<td>Maintain consistent direction of scales between questions.</td>
<td>Not applicable.</td>
<td>Question stubs were separated from answer stubs to prevent words from being skipped.</td>
</tr>
<tr>
<td>Use short lines.</td>
<td>Yes.</td>
<td>The logic of the single skip question was handled by the survey software and hidden from the respondent.</td>
</tr>
<tr>
<td>Use major visual changes to signify skip patterns.</td>
<td>Not applicable.</td>
<td>The survey did not contain any subtly changing questions.</td>
</tr>
<tr>
<td>Signify important subtle changes sparingly and in a visually consistent manner.</td>
<td>Not applicable.</td>
<td></td>
</tr>
</tbody>
</table>

### 3.7.2.4 Pre-Testing

The purpose of pre-testing or pilot testing is to evaluate the survey instrument for its clarity and comprehensibility to the target population as well as for its motivational qualities. A pre-test and follow-up interviews were conducted with one portfolio management organization. Three portfolio managers’ comments were sought, particularly with regard to wording of the survey. A short interview protocol had been developed for the purpose of eliciting feedback. Changes to the survey were made based on this feedback and on an analysis of the pre-test survey responses.

### 3.7.2.5 Survey Implementation

Dillman (2000) identifies five needed elements for high response rates with paper-based surveys. These elements were incorporated completely, or on a modified basis into the Web-based survey for this research.

The first element is a respondent-friendly questionnaire. The previous section on survey structure detailed how the web-based survey met this requirement. While having only a modest
impact on survey non-response (less than a half dozen respondents chose not to complete the survey), this element had a more positive influence on reducing item non-response.

The second element refers to multiple contacts by first class mail. While first class mail is not applicable to a Web-based survey (and evidence indicates that respondents generally do not link paper notifications and emails), multiple contacts were still made. In place of a pre-notice letter, each potential respondent was emailed a notice from his or her Chief Investment Officer or Chief Executive Officer encouraging his or her participation. The email described the research and that participation was voluntary. A sample email, cleansed of identifying details, is presented in Appendix A. One Chief Investment Officer notified his staff of the forthcoming survey at the regularly scheduled morning meeting.

The portfolio managers and the other investment professionals were sent an invitational email once their senior executive had notified them of the forthcoming survey. The invitational email was modeled on Dillman’s “Example of cover letter” (2000, p.162), and a sample is presented in Appendix B. The emails’ subject header read, “Mutual Fund Research at the University of Toronto”

About one week after the emailing of the invitational email, a follow-up email was sent to those who had not yet responded (and who have not opted out of receiving further emails). The email was identical to the original invitational email except the subject header was preceded by the words, ‘Friendly reminder - ’. One week after that, the process was repeated, but this time with subject header prefaced with the words, ‘Second friendly reminder - ’. About half of the survey responses from any particular organization were received after the first invitational email was sent, and the other half of the responses were usually received after the first friendly reminder email. The second friendly reminder email also appeared to trigger a few straggling
responses. A third friendly reminder was sent once, but an examination of the quality of the answers received revealed that the respondents appeared to be more interested in avoiding any further reminders than in providing quality answers.

The third implementation element is the inclusion of envelopes with real first-class stamps. This is not applicable to Web-based survey. Replying to the Web-based survey was facilitated by a single mouse click on the hyperlink embedded in all the invitational emails. No return email was required.

The fourth implementation element is personalization of correspondence. This was accomplished by addressing each of the potential respondents by first name in each invitational email. The www.SurveyMonkey.com survey software used to issue the invitational emails and collect individual responses facilitated this personalization. The personalization was not however overdone by creating a sense of insincerity with “extreme effort to insert personal references” (Dillman, 2000, p.152).

The fifth and final implementation element is the inclusion of a token prepaid financial incentive. This element was not implemented since evidence is mixed as to whether or not promises of this sort enhance response rates (Church, 1993) and interview results confirmed such an incentive would be ineffectual. The impracticality of providing tangible tokens via email or web page is discussed in the previous section on survey design.

3.7.2.6 Special Populations

Dillman (2000) devotes an entire chapter to the surveying of businesses. Since this research was aimed at mutual fund management firms, suggestions from this chapter were also incorporated in the proposed survey. First, the importance of addressing surveys to individuals rather than to firms is stressed. The example provided by Dillman indicated that “a response rate
of 72% [was achieved] for surveys addressed to individual persons compared to 40% when addressed only to the company” (2000, p.324). All of the potential respondents for this research were contacted by email addressed to them individually.

Second, Dillman (2000) suggests that business surveys often ask individuals to report for the entire business entity rather than for themselves personally. While this may often be the case, the survey for this research was primarily focused on individual respondents and only sparingly requested them to make attribution judgements. Rather than ask individuals to think of the whole business entity, the survey results of all of the individuals from any given organizational entity were used in any characterization of that entity.

Third, the organization entity must be identified (Dillman, 2000). For this research, the organization and its leading executive were identified in each invitational email.

Fourth, the list of potential respondents should be up-to-date. A list of potential respondents was provided to each Chief Investment Officer or Chief Executive Officer at the time their organization was requested to participate in the research. The list was gleaned from Web-based sources such as, for example, prospectuses and Annual Information Forms. The senior executive was made aware that the list was dated. Instead of requesting the senior executive’s assistant update, the suggestion was made to simply email a notification of the forthcoming survey to an updated list of potential respondents and copy the researcher. This ensured that invitational emails were sent to the appropriated individuals.

Fifth, there may be variation in the business units being surveyed that may be relevant to some of the units’ personnel but irrelevant to others. It is important to take this into account and not “overwhelm respondents with details relevant only to other businesses in the sample” (Dillman, 2000, p.326). The survey for this research generally avoided this potential problem.
because it was aimed at individuals in a relatively homogenous industry. Two customized
versions of essentially the same survey were used, one focused more on portfolio managers and
the second focused more on the other investment management professionals.

Dillman provided some positive omens for a high response rate for the survey for this
study. One such cause for optimism was the suggestion that university-sponsored surveys may be
relatively successful in eliciting responses from businesses because they do not pose a
competitive threat. Another was the possibility that an emailed survey may be able to overcome
the low response rates generated by paper-based surveys of businesses. A third portent of a high
response rate was the incorporation of respondent identification in the survey software, since this
facilitates multiple contacts.

Dillman (2000) lists nine principles for surveying businesses. These are listed in the
following table along with details of how they were incorporated in the research.

<table>
<thead>
<tr>
<th>Business Survey Principle</th>
<th>Incorporated</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the respondent and the means of contact.</td>
<td>Yes.</td>
<td>Only individuals involved in mutual fund administration and portfolio management were targeted.</td>
</tr>
<tr>
<td>Plan for a mixed mode design.</td>
<td>No.</td>
<td>Evidence suggests that with reliance on email only “Responses were received more quickly, item nonresponse was lower, and open-ended questions… received more complete answers” (Dillman, 2000, p.366). In addition, “the making of all our contacts by email produce[s] higher response rates than substituting a paper prenotice or thank you / reminder” (Dillman, 2000, p.400)</td>
</tr>
<tr>
<td>Develop a friendly questionnaire.</td>
<td>Yes.</td>
<td>Post-pilot test interviews were used to unearth any unfriendliness in the survey instrument.</td>
</tr>
<tr>
<td>Provide instructions with the question, rather than separately.</td>
<td>Yes.</td>
<td>Each question was preceded with appropriate instructions.</td>
</tr>
<tr>
<td>Conduct on-site cognitive interviews to tailor the survey.</td>
<td>Yes.</td>
<td>Post-pilot test interviews were being conducted.</td>
</tr>
<tr>
<td>Target gatekeepers.</td>
<td>Circumvented.</td>
<td>Each potential respondent’s personal email was used. Since Chief Investment Officers or Chief Executive Officers essentially acted as gatekeepers where surveys were concerned, the co-operation of these individuals was obtained prior to contacting potential respondents.</td>
</tr>
<tr>
<td>Business Survey Principle</td>
<td>Incorporated</td>
<td>Details</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>Consider follow-up</td>
<td>Not</td>
<td>All respondents were thanked at the end of the survey, and many selected to receive feedback.</td>
</tr>
<tr>
<td>communication for repeated surveys.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Be cautious with incentives.</td>
<td>Not</td>
<td>Post-pilot test interviews suggested that the offer of an incentive would not improve the response rate.</td>
</tr>
<tr>
<td>Tailor questions to sub-groups</td>
<td>Yes.</td>
<td>The survey was slightly customized for portfolio managers and other investment management professionals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.7.2.7 Internet Surveys

Dillman (2000) suggests 14 principles for conducting Web-based surveys. Those principles and how they are incorporated in this research is detailed in the following table.

**Table 11: Web-based survey principles**

<table>
<thead>
<tr>
<th>Web-based Survey Principle</th>
<th>Incorporated</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduce the survey with a motivational ‘welcome’ page.</td>
<td>Yes.</td>
<td>The welcome page introduced the research and its potential benefits to the respondent.</td>
</tr>
<tr>
<td>Limit access to only those people in the sample.</td>
<td>Yes.</td>
<td>Entry to the survey was only obtained through a link embedded in an individualized email sent only to individuals in the sample.</td>
</tr>
<tr>
<td>Make the first question interesting but easy.</td>
<td>Partially.</td>
<td>The first six questions were all interesting, but may have been cognitively demanding.</td>
</tr>
<tr>
<td>Present each question in a format similar to a paper self-administered survey.</td>
<td>Yes.</td>
<td>The survey could easily have been printed to make a very acceptable paper-based version.</td>
</tr>
<tr>
<td>Restrain the use of colour and maintain figure/background consistency.</td>
<td>Yes.</td>
<td>Only two colours were used and these were restricted to the headers of each page. The colours were selected from the 216 that are deemed to be ‘Web-safe’. The survey instructions and questions are all provided in black text on white background.</td>
</tr>
<tr>
<td>Avoid differences in appearance due to different screen or browser configurations.</td>
<td>Yes.</td>
<td>The survey was successfully tested on screens with resolutions as low as 800 by 600 pixels using the two most popular browsers (Internet Explorer and Firefox). The text automatically wrapped and avoided the need to scroll horizontally if the survey is open in a tiled screen, with one exception. On the single Web page with the seven-point Likert scale horizontal scrolling was required for low resolution screens so that equal distances could be maintained between category choices.</td>
</tr>
<tr>
<td>Provide specific necessary navigational instructions where they are needed.</td>
<td>Yes.</td>
<td>Each Web page ended with appropriate navigational hyperlinks (for example, “&lt;&lt;Back”, “Next&gt;&gt;”, and “Done&gt;&gt;”)</td>
</tr>
<tr>
<td>Use drop-down menus sparingly.</td>
<td>Yes.</td>
<td>The survey contained no drop-down boxes.</td>
</tr>
<tr>
<td>Do not require answers before</td>
<td>Yes.</td>
<td>All requirements for answers were removed. It was possible to navigate through all of the survey once agreement and consent to participate had been given.</td>
</tr>
<tr>
<td>Web-based Survey Principle</td>
<td>Incorporated</td>
<td>Details</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>permitting navigation.</td>
<td>incorporated</td>
<td>Navigation in either direction did not erase data already entered but did permit answers to be changed.</td>
</tr>
<tr>
<td>Provide skip instructions that encourage responding.</td>
<td>Not applicable</td>
<td>The only skip question was one of consenting, or of withholding of consent to participate, and the survey software handled the logic automatically.</td>
</tr>
<tr>
<td>Construct the survey so that respondents may scroll down to subsequent questions.</td>
<td>No</td>
<td>Each question was either relatively complex or had a different design than the preceding question. Questions were therefore been presented on their own individual Web pages. The need to scroll was essentially avoided.</td>
</tr>
<tr>
<td>Consider double-banking questions with a large number of possible responses.</td>
<td>Yes</td>
<td>The question with the largest number of possible responses was triple-banked to correspond to the three overarching categories of mutual fund strategies (equity, fixed income, alternative). An individual respondent would likely only find one bank applicable to their situation.</td>
</tr>
<tr>
<td>Convey a sense of where the respondent is in the completion process.</td>
<td>Yes</td>
<td>The starting point of each item on the survey was indicated with “Item x of y” written in red coloured font. The text-based indicator can be used on any computer in any software situation with impunity.</td>
</tr>
<tr>
<td>Minimize the use of questions with measurement problems.</td>
<td>Essentially</td>
<td>Only one question contained a request to ‘check all that apply’ type of question, and the list of options was relatively short.</td>
</tr>
</tbody>
</table>

### 3.7.3 Measurement Estimation Questions

“…there are many ways of eliciting numerical judgments from which the relative standing of a set of to-be-judged objects can be established. However, the psychology associated with survey response suggests that the choice of weight elicitation method is neither arbitrary and will not necessarily lead to equivalent results” (Bottomley & Doyle, 2001, p.553).

#### 3.7.3.1 Point Allocation

With the point allocation (PA) process, respondents face the problem of meeting a budget – not exceeding the number of points available for allocation, but also not falling short of using all the budgeted points (Doyle, Green, & Bottomley, 1997). Even though previous evidence indicates that market research measuring preference using a constant sum procedure is superior to that of some other evaluative measures as predictors of brand choice (Silk & Urban, 1978), more recent evidence has emerged that indicates the point allocation (also known as constant sum or fixed sum) process is subject to consistent elicitation-dependent bias, and that a direct
rating (DR) process may be preferable (Bottomley, Doyle, & Green, 2000; Doyle, 1999; Doyle et al., 1997).

Evidence indicates that respondents using PA give nearly 50% more weight to their most important factor than do those using DR. The least important factor is conversely underweighted (Bottomley, Doyle, & Green, 2000). It appears that weights may be “constructed in the process of elicitation” (Slovic, 1995, p.364) and that “the idealized model… in which a linear relationship between rank and weight is suggested” does not appear to be attainable using a point allocation method (Doyle et al., 1997, p.70). Even though the point allocation and direct rating methods “are implicitly assumed to be interchangeable”, they are not (Doyle et al., 1997, p.68).

3.7.3.2 Direct Rating

The DR process is itself preferred to the PA process since people using DR tended to produce allocations that were linear when ranked from most to least important, while those using PA produce weights that are non-linear (Doyle, 1999; Doyle et al., 1997). The direct rating method is also subject to bias, especially as the number of choices being weighted increases.

3.7.3.3 Max100

In the survey constructed for this research, potential respondents were asked to assign the most important factor in the set of three a rating of 10, and then to rate the other two factors relative to it, and to each other on a scale of 0 to 9.9. This process was based on one using a scale of 0 to 100 and called, “Max100” (Bottomley & Doyle, 2001). The Max100 process was used since evidence indicates it appears to be more reliable than a direct rating (DR) process (Bottomley & Doyle, 2001), which in turn appears to be more reliable than a point allocation (or constant sum or fixed sum) process (Bottomley et al., 2000; Doyle et al., 1997). Experimental evidence suggests that the Max100 process has higher internal consistency demonstrated through
test-retest reliability measures than the DR process, which in turn has higher reliability than the point allocation (PA) process. Respondents using Max100 display fewer rank reversals than those using DR between test and retest. In addition, convergent validity is suggested by evidence of a broad level of agreement between Max100 and DR processes of elicitation. Finally, survey respondents generally prefer using the Max100 process (Bottomley & Doyle, 2001).

The Max100 process improves upon the DR process by providing an anchor from which to assign relative values. The absence of such an anchor burdens a potential respondent with a search for a starting value to apply to one of a number of factors. As such, the Max100 process can be considered a burden-reducing improvement on the DR process.

3.8 Reliability and Validity

3.8.1 Reliability

Reliability is a measure of the degree to which measures will yield the consistent results, free from error (Garson, 2002). Reliability is the ratio of the true measure to the observed (true plus error) measure. It is a necessary but not sufficient condition for validity. Error may affect the observed measure through the methodology used (method error) and randomly (random error). When random error is due to random traits of the subjects it may also be called trait error. The extent of error may be detected by examining the data for reliability. There are three common approaches for estimating reliability, test-retest, parallel forms, and internal consistency. Since only one individual per stage of production is involved in responding to the survey instrument, a measure of inter-rater reliability will not be required.

3.8.1.1 Test-retest reliability

Test-retest reliability is assessed by administering the same test on two separate occasions, to the same respondents, and calculating the correlation between the two sets of items
(Garson, 2002). If a test is reliable, and it is administered more than once to the same subject, that subject’s measures should be very close to one another (Gliner & Morgan, 2000). Test-retest reliability is established prior to conducting a survey rather than as a part of it (Gliner & Morgan, 2000).

Test-retest reliability measurement may be conducted along with checks for validity in a pilot study conducted on a sample chosen from a population similar to the target population. Administering the same test twice to a similar population minimizes carryover effects in the target population. One of the problems of using the same instrument for the test and retest of a study is that participants may use the experience gained on the former to alter their scores on the latter (Gliner & Morgan, 2000). Another problem with the test-retest reliability approach is the risk that an inappropriate interval length may be chosen between tests. If the interval is too short, carryover effects subjects may contaminate responses. If the interval is too long, the variables being measured may have changed during the intervening time (Gliner & Morgan, 2000).

3.8.1.2 Parallel forms reliability

Parallel forms reliability, also known as split-halves reliability and equivalent forms reliability, is measured by administering two forms or equivalent batteries of items that measure the same thing, in the same instrument, to the same subjects and calculating the correlation between the two sets of scores. This approach to measuring reliability was not used since it risked a reduction in the sample size due to survey fatigue. What was more important in this research was that the survey instrument had consistency between items measuring the same concepts. Therefore, rather than administer two forms of the same survey, the results of a single form of the survey were administered and analyzed for internal consistency.
3.8.1.3 Internal Consistency Reliability

Internal consistency reliability, sometimes also referred to as inter-item reliability is measured by administering a single form of a test and calculating a reliability estimate based using one of a number of internal consistency equations. Three classifications of knowledge-based factor intensity (tacit, codified, and encapsulated) were measured according to the relative perceived reliance on each classification. The survey instrument was designed to solicit responses along the six perspectives (locus, transfer, expression, acquisition process, source of value, and observability) delineating the three classifications of knowledge, as described in section 2.3. For every construct, the researcher should ideally have four or more indicators (Garson, 2002, p.15). With six perspectives being used to measure each of the three constructs, the probability that the constructs could be reliably measured was enhanced.

The results of a single administration of the survey instrument were used to determine internal consistency. The most common methods of determining internal consistency are the Kuder-Richardson Formula 20 (KR20) method and Cronbach’s alpha method. Both of these methods can be used when data from several items that are combined to make a composite score (Gliner & Morgan, 2000) and measure how well a set of items measures a single latent construct. Both provide conservative estimates of the reliability. The KR20 however, can only be applied if the test items are scored dichotomously. Since the measures of knowledge-based factor intensities will be ratio variables, Cronbach’s alpha method was applied to measure internal consistency reliability. In addition, confirmatory factor analysis and structural equation modeling were also used to test internal consistency.
3.8.2 Strengthening Validity

3.8.2.1 Internal Validity

Internal validity refers to the extent to which variables other than the independent variables may be responsible for some or all of the observed effects on the dependent variable. Researchers must take into account potential alternative explanations for any hypothesized causal relationship. The control variables listed in 3.5.3 were used to promote internal validity.

Another potential threat to internal validity is evaluation apprehension. Evaluation apprehension is the natural reluctance of test subjects to share information about their beliefs and activities, and to provide self-aggrandizing answers. This was minimized by excluding any potentially emotion-laden or value-laden items from the test instrument.

3.8.2.2 Construct Validity

Construct validity depends on the clarity of the operational definition of the constructs (Garson, 2002). Clarity of definition allows specific indicators to be selected for the constructs. The use of an instrument based on the six perspectives delineated in section 2.3 was expected to enhance construct validity. Statistical tests were conducted to test that the items selected for each construct are at least moderately correlated among themselves (convergent validity) and that for different constructs items are not so highly correlated as to conclude they measure a similar construct (discriminant validity) (Garson, 2002).

3.8.2.3 Content Validity

Content validity refers to the degree to which the items of the measure represented a proper sample of the theoretical content of the construct (Nunnally & Bernstein, 1994). Content validity was promoted in this study by reliance on items similar to those previously used (for
example, those listed in Appendix C). In addition, a pilot study was conducted to modify the test instrument to advance only those items that related to the content they sought to measure.

### 3.8.2.4 Statistical Validity

Statistical validity is concerned with the conclusions drawn from the research (Garson, 2002). Type I errors (rejection of the null hypotheses and acceptance of a non-existing relationship) are minimized in this study by testing a priori hypotheses, rather than attempting to fit data to a large number of possible relationships posteriori in a search for significance. Statistical significance tests are reported despite the suggestion by some that doing so may be detrimental or even dangerous to scientific progress (for a list of researchers, see Armstrong, 2007). Statistical significance measures the probability of the data given the null hypothesis, and not the converse. If a sufficiently large sample size is used almost any variable may be found to be significant. The effect size, however, may be so small that the magnitude of the relationship is insubstantial. Therefore, this study generally reports both the risks of Type II error as well as Type I error. “…[I]n social science, the predominance of minimizing only type I errors – rejecting the null hypothesis when it is true - remains” (Kai-Uwe Brock, 2003, p.90) “Whereas Type I errors can be considered mistakenly believing there are significant differences when they actually do not exist, Type II errors may be viewed as mistakenly overlooking significant differences that do exist” (Mone, Mueller, & Mauland, 1996, pp. 103-104). Type II errors were minimized by ensuring a sufficient sample size, and considering possible interaction effects. Ultimately, “it may be appropriate to increase one’s significance criterion to weight the risks of Type I and Type II error in keeping with their social and scientific costs” (Cohen, 1982, p.253).
3.8.3  Avoidance of Bias

3.8.3.1  Common Methods

Common methods bias describes variance that is attributable to the measurement method rather than to the constructs the measures represent (Podsakoff et al., 2003). Common methods bias has been largely avoided by relating the primary data collected from survey respondents to secondary data collected from an unrelated source. Most of the hypotheses tested corresponded to a “Situation 1” (Podsakoff et al., 2003, pp. 897-898), for which additional statistical remedies are likely unnecessary.

3.8.3.2  Social Desirability

One benefit of using data from two different sources is minimization of single source bias (Podsakoff & Organ, 1986). Single source bias may result in apparent relationships between variables that are actually the result of artificial covariances between them. The apparent relationships may simply be due, for example, to social desirability bias. With only part of the data coming from surveys, single source bias will be limited to relationships focused only on the survey data. Social desirability may, for example, have biased respondents toward exaggerating their accreditations.

3.8.3.3  Fundamental Attribution Error

Fundamental attribution error refers to the tendency of respondents to exaggeratingly attribute personality-based explanations for the behaviours of others. One item on the surveys may have been subject to this error. It requested the respondent to indicate the ‘decodifiability’ by a peer of the knowledge on which they relied to be productive. The results of this item were excluded from analysis because they did not correlate well with measures of other items designed to measure to the same construct.
3.8.4 Data Collection

An overall strategy was required to collect the data for each of the independent and dependent variables identified during the construction of the hypotheses. In addition, data had to be collected for control variables that had the potential to influence the strength or direction of the hypothesized relationships between the independent and dependent variables.

3.8.5 Secondary Industry Data

There are two main components to data collection for this research. One is the collection of secondary mutual fund data for the purpose of obtaining measurements of the dependent and control variables. Fundata Canada Inc. (Fundata) generously agreed to provide data at no cost for academic purposes. The company provides over 800 fields of data on over 7,000 funds, and has been a source of mutual fund data since 1987. Canada’s National Post newspaper daily reports mutual fund data supplied by Fundata. In addition, Fundata covers more funds than some of its competitors since the company is a supplier to many dealers and brokerages and must carry all Fund series, including institutional, F-series, US$, etc. for them. Finally, Fundata also includes in its database, hedge funds, labour sponsored, segregated, pooled portfolios and other investment funds of interest to smaller select groups of investors. Some of the data fields provided control variables while others provided dependent variables.

3.8.6 Primary Survey Data

The second component was the collection of the relative perceived reliance on tacit, codified, and encapsulated knowledge-based factors of production by portfolio managers and other investment management professionals. The survey was designed to yield quantitative measurements of the independent variables listed in sub-section 4.4. Appendix C provides a selection of portions of survey instruments that have been used in previous empirical research.
seeking to measure tacit knowledge, among other variables. Based on these instruments and the key constructs developed in section 2.3, a two survey instruments were developed (see, Appendix D for the survey for portfolio managers and Appendix E for the survey for other investment management professionals). Values for knowledge-based factor intensities were derived from this survey instrument. Agreement on what constitutes absolute quantitative measures of knowledge, however, appears to be currently unobtainable (Down, 2000). One of the contributions of this research was the development of a survey instrument, which, while not collecting absolute values, captured relative perceived reliance on tacit, codified, and encapsulated knowledge. As a result, this research depended heavily, but not exclusively, on data that was primary, perceptual, relative, and quantitative.

3.8.6.1 Ethics Approval

Expedited ethics approval was obtained from the University of Toronto Social Sciences & Humanities Research Ethics Board in June 2006. The bases presented for expedited approval were (i) the proposed research posed ‘minimal risk’; (ii) it appropriately protected privacy and confidentiality, (iii) it did not involve research with children; and (iv) it only involved the employment of survey and interview evaluation. An ‘Ethics Review Application’, ‘Ethics Review Protocol’, and a brief justification of why the research qualifies for expedited review were completed. The informed consent page had already been prepared and included in the online survey instrument and formed part of the application.

3.8.7 Survey Instrument

The goal of the survey instrument was to collect primary data on the independent variables. Survey statements are grouped along the perspectives provided in Table 2, namely,
locus or knowledge substrate, transfer and diffusion, expression, acquisition process, source of economic value, and observability.

Two online survey instruments were designed to elicit the relative reliance of knowledge workers on three classifications of knowledge: tacit, codified, and encapsulated. Relative reliance is being used in this research as a proxy for knowledge-based factor intensity. The knowledge workers were portfolio managers and other investment management professionals who work in the Canadian mutual fund industry. The portfolio manager and other investment professional surveys posed different questions only after the questions eliciting relative reliance on three classifications of knowledge had been posed. A reformatted portfolio manager survey may be viewed for a limited time at:

https://www.surveymonkey.com/s.aspx?sm=3JlDlFo5XAyKodd_2fCbbjPA_3d_3d,

and a reformatted survey for other investment management professional may be viewed at:


The links point to versions of the surveys that do not require any answers in order to proceed through all the items. The surveys were reformatted as a result of a software upgrade, but images of the original surveys are provided in Appendices E and F.

To elicit relative reliance on tacit, codified and encapsulated knowledge, potential respondents were asked to assign the most important factor, in sets of three, a rating of 10, and then to rate the other two factors relative to it on a scale of 0 to 9.9. This process is based on the “Max100” process suggested by Bottomley and Doyle (2001) since evidence indicates it appears to be more reliable than a direct rating process (Bottomley & Doyle, 2001), which in turn appears to be more reliable than a point allocation (or constant sum or fixed sum) process (Bottomley et al., 2000; Doyle et al., 1997). Experimental evidence suggests that the Max100
process has higher internal consistency demonstrated through test-retest reliability measures than the DR process, which in turn has higher reliability than the point allocation (PA) process. Respondents using Max100 display fewer rank reversals than those using DR between test and retest. In addition, convergent validity is suggested by evidence of a broad level of agreement between Max100 and DR processes of elicitation. Finally, survey respondents generally prefer using the Max100 process (Bottomley & Doyle, 2001), possibly because it avoids a budgeting exercise.

3.8.8 Data Treatment

Survey results gathered online using www.SurveyMonkey.com for 219 individuals were downloaded in zip files distinguished by firm and respondent role. The contents of the zip files were then collected in a spreadsheet structured to align the values of common variables among the different files. Some of the variables were specific to portfolio managers, others were specific to other investment management professionals, and a number were common to both. Categorical variables containing text were recoded as 1. Variables for questions that captured relative weights were recoded as proportions (for example, ratings of 10 and 5 for the application of equity and fixed income strategies by Portfolio managers would be recoded as .67 and .33 respectively).

3.9 Hypotheses

This final section links the research questions to the relevant propositions and the propositions to the relevant hypotheses. The three research questions were introduced in the first chapter, the four propositions were introduced at the beginning of this chapter, and the hypotheses are discussed and tested in the subsequent two chapters.
3.9.1 First Research Question

The first research question asks, ‘Are there differences in fundamental knowledge-based factors of production between adjacent stages of a value chain?’ The assumption made at the beginning of this chapter was that relative reliance on tacit, codified, and encapsulated knowledge differs between adjacent stages of production. To examine the validity of this assumption in the mutual fund industry, a number of analyses were conducted and reported upon in the last section of next chapter.

While there is no reason to believe that reliance on knowledge-based factors of production should differ between stages, there is also no reason to believe that they should be the same. If there are two separate and distinct production stages, I believe there will be at least some differences in the factors of production, and the question becomes one of whether or not the differences are of measurable magnitude.

The first sections of Chapter 4 are concerned with measuring relative reliance on knowledge by upstream portfolio managers and other downstream investment management professionals. In the last section of Chapter 4, the assumption of differences between these two stages was directly test using t-tests. Since measures of control variables were collected, these were also tested to see if they could contribute to explaining differences in relative reliance on knowledge-based factors of production between portfolio managers and other investment management professionals. Tested control variables included years of experience and levels of accreditation. The only significantly \( p > 0.05 \) influential control variable was the Chartered Financial Analyst (CFA) designation, so results are only reported for the various tests applied using this variable. For a robustness check, linear regressions were performed with relative
reliance on tacit and encapsulated knowledge as dependent variables and with stage of production and CFA status as independent dummy variables.

3.9.2 Second Research Question

The second research question asks, ‘How can differences in knowledge-based factors of production explain the presence or absence of inter-firm boundaries?’ Proposition 1 proposes that, ‘The presence of an inter-firm boundary between adjacent stages in a value chain is positively related to the size of the differences in relative reliance on tacit, codified, and encapsulated knowledge between those stages’, while Proposition 2 proposes, ‘A greater probability of de-integration for a given stage of production will be positively associated with a greater reliance on tacit knowledge in that stage’. To implement testing of these propositions in the mutual fund industry, a number of related hypotheses were tested and reported upon in Chapter 5:

H1a: Relative reliance on tacit knowledge differs between de-integrated and integrated portfolio managers.

H1b: Relative reliance on encapsulated knowledge differs between de-integrated and integrated portfolio managers.

H1c: Relative reliance on tacit knowledge by portfolio managers differs between mutual funds in categories that have a high probability of being de-integrated and those in categories that have a low probability.

H1d: Relative reliance on encapsulated knowledge by portfolio managers differs between mutual funds in categories that have a high probability of being de-integrated and those in categories that have a low probability.
Hypotheses 1a and 1b test Propositions 1 and 2 directly, by relying exclusively on measures of relative reliance on tacit and encapsulated knowledge of integrated and de-integrated portfolio managers in the mutual fund industry. These hypotheses were tested using the actual organizational structure of each individual mutual fund. Hypotheses 1c and 1d differed from H1a and H1b by testing on the basis of membership in one of two groups CIFSC categories. One group had a higher probability of de-integration relative to the other group.

The results of testing H1a through H1d suggested that, contrary to Proposition 1, it was not the magnitude of difference in knowledge-based factors that was related to de-integration. Instead, the results suggested that greater reliance on tacit knowledge in a stage was related to de-integration, in accordance with Proposition 2.

Cashman and Deli’s (2006) found that mutual funds invested primarily in foreign equity had a greater probability of being de-integrated than those invested primarily in domestic equity, which in turn had a greater probability of being de-integrated than those invested primarily in fixed income securities. Two t-tests were conducted to determine whether or not the sample of mutual funds for this study were confirmatory. The results of the following hypotheses were found to be supportive.

H2a: Foreign equity mutual funds are more likely to be de-integrated than domestic equity mutual funds

H2b: Domestic equity mutual funds are more likely to be de-integrated than fixed income mutual funds.

Cashman and Deli’s (2006) argued that greater de-integration of mutual funds was driven by portfolio management requiring greater analytical intensity related to complex security valuation. To probe whether or not greater analytical intensity was positively related to relative
reliance on tacit knowledge and negatively related to encapsulated knowledge, the following hypotheses were tested and the results found to be supportive.

H2c: Relative reliance on tacit knowledge by portfolio managers managing foreign equity mutual funds is greater than that for managing domestic equity mutual funds.

H2d: Relative reliance on encapsulated knowledge by portfolio managers managing foreign equity mutual funds is less than that for managing domestic equity mutual funds.

H2e: Relative reliance on tacit knowledge by portfolio managers managing domestic equity mutual funds is greater than that for managing fixed income mutual funds.

H2f: Relative reliance on encapsulated knowledge by portfolio managers managing domestic equity mutual funds is less than that for managing fixed income mutual funds.

H2a through H2f relied on t-tests. For a robustness check and to determine the possible impact of control variables, three regressions were performed to test the following hypothesis.

H2g: The probability of de-integration of a mutual fund is related to the portfolio manager’s relative reliance on tacit, and encapsulated knowledge.

A logistic regression was used with organizational structure (integrated or de-integrated) as the dependent variable. The first stage ignored the knowledge-based factors, which were introduced in the second stage. Relative reliance on encapsulated knowledge was found to be a statistically significant variable. The second regression was linear and used the average probability of de-integration for each CIFSC category of used as the dependent variable. The values of the dependent variable are displayed in Figure 13. Relative reliance on encapsulated knowledge was again found to be a statistically significant variable. A final logistic regression used organizational structure as the dichotomous dependent variable and a multinomial variable for Foreign Equity, Domestic Equity, and Fixed Income, based on Cashman and Deli (2006). In
this final test, relative reliance on tacit knowledge by portfolio manager was found to be statistically significant.

3.9.3 Third Research Question

The third research question asks, ‘Are there any performance implications related to aligning organizational structure with knowledge-based factors of production?’ Proposition 3 proposes that, ‘Firms that are integrated or de-integrated on the basis of evidence from Proposition 1 or Proposition 2 will perform better than those that are not’. To implement testing of this proposition in the mutual fund industry, the following hypothesis is tested in the last section of Chapter 5:

H3: Alignment between mutual funds’ structure and knowledge-based factors of production affects performance.

A two-stage Heckman (1976; 1979) procedure was followed using a binary logistic regression in the first stage and a linear regression in the second. The two-stage procedure was used to circumvent a potential endogeneity issue. Since organizational structure (integrated or de-integrated) is chosen so as to maximize performance, it may not be independent of the performance variable. The results suggest that mutual funds predicted to be de-integrated and actually integrated appear to under-perform those that are actually de-integrated, somewhat in accordance with Proposition 3.

A summary of all the hypotheses tested and the results of the tests are presented in the final chapter.

3.10 Summary

This chapter began with a conceptual framework that indicated relative reliance on three classifications of knowledge might be instrumental in providing answers to the research
questions. Three propositions were introduced; the first two propositions suggested two possible reasons for finding adjacent stages of production separated by an inter-firm boundary, while the third proposition suggested that organizing according to knowledge-based factors influences firm performance. Models with de-integration and performance as dependent variables, knowledge-based factors as independent variables, and control variables were then specified. This was followed by a description of the mutual fund industry in Canada as the research population. The data collection principles employed were then discussed in detail. The chapter concluded with a section that introduced the hypotheses and linked them to the propositions and the research questions.
“We are increasingly concerned… with knowledge as a factor of production, having costs and values that we must try to estimate in order to make correct decisions for the conduct of business… We have discovered that applying an economic calculus to knowledge… is often, because of… intangibility… far more difficult than costing and valuing… production machinery. Yet, whether we can make the measurements accurately or not, it is precisely these costs and values that determine the efficiency and profitability of our activities…” (Simon, 1999, p.34).

4.1 Introduction

Knowledge is perceived to be an important, if not the most fundamental, factor of production (Simon, 1999). Despite the important role it plays in production, empirical evidence testing Demsetz’s (1988) linking of knowledge to the patterning of firm boundaries appears to be nonexistent. The absence of evidence is primarily due to the difficulty of measuring knowledge, particularly as a factor of production that differs between stages along a value chain. This chapter proposes a method to effect such measurement based on the results of research on primary data. It begins with an analysis of the survey respondents, continues with the data analyses, and ends with the results of the tested hypotheses.

4.2 Profile of the Survey Respondents

The research used primary data collected through online surveys of portfolio managers and other investment management professionals in the Canadian mutual fund industry.

The Chief Investment Officers of 95 mutual fund management firms were contacted by email to seek their approval to survey their portfolio managers and other investment management professionals. In a few cases, where a firm did not appear to have a position of Chief Investment Officer, the Chief Executive Officer was approached by email. An example of such email is
provided in Appendix F. A few responded to the first emailed request, but the highest response was received following a second email. The second email included an attachment indicating that the research had received Ethics Review Board approval. A few more responded to a third request.

4.2.1 Representativeness of Survey Sample

Of the senior executives (Chief Investment Officers or Chief Executive Officers) of the 95 organizations contacted, 10 (11%) explicitly declined to participate, 21 (22%) agreed to permit me to survey their portfolio managers or other investment management professionals, and the remainder (67%) were non-respondent. The 21 firms who participated had a Herfindahl-Hirschman Index or HHI (based on assets under management) of 0.175, while the 42 largest mutual fund firms constituting the Investment Funds Institute of Canada (IFIC) had a HHI of 0.076. The HHI is a measure of market concentration and may be interpreted as an indication of intra-industry competition – the higher the index, the more concentrated the market and the less competitive the industry. The HHI calculated for the sampled firms is higher than that of firms in the population, limiting the representativeness of the survey sample and generalizability of the research results.

Sampling within all firms was not random. A few of the firms agreeing to participate required the negotiation of a ‘representative’ list of potential respondents because the senior executive would only agree to the surveying of a limited number of his or her portfolio managers or other investment management professionals.

A total of 358 invitational emails were sent to portfolio managers (252) and other investment management professionals (106) in the 21 firms. The overall response rate was 61.2% (219), and essentially equal for portfolio managers (60.7%, 152) and for other investment
management professionals (62.3%, 66). The excellent individual response rate of > 60% is tempered by the reality that not all potential firm employees were available to be sampled and only 22% of the invited firms participated. Nevertheless, the response rate compares favourably with the overall response rate of 6.3% achieved in a recent survey of portfolio managers in the USA (Farnsworth & Taylor, 2006). The distribution of respondents among the firms is in the following table.

Table 12: Respondents by firm and role

<table>
<thead>
<tr>
<th>Firm ID</th>
<th>Portfolio Managers</th>
<th>Other Investment Professionals</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>14</td>
<td>16</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>19</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>22</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>19</td>
<td>25</td>
<td>0</td>
<td>25</td>
</tr>
</tbody>
</table>
The portfolio managers and other investment management professionals who responded to the surveys differed in their years of experience, with portfolio managers generally being more experienced. Almost half of the portfolio managers had in excess of 10 years experience, while over 60% of other investment management professionals had less than 5 years experience. The next table presents the experience profiles of both groups. A Pearson chi-square test on the cross tabulation of years of experience and role suggests that there is a significant difference in experience between the two roles.

**Table 13: Respondent experience by role**

<table>
<thead>
<tr>
<th>Experience</th>
<th>Portfolio manager</th>
<th>Other investment professional</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 2 years</td>
<td>10 (5.7%)</td>
<td>17 (9.7%)</td>
<td>27 (15.3%)</td>
</tr>
<tr>
<td>2 to 5 years</td>
<td>24 (13.6%)</td>
<td>18 (10.2%)</td>
<td>42 (23.9%)</td>
</tr>
<tr>
<td>5 to 10 years</td>
<td>30 (17.0%)</td>
<td>14 (8.0%)</td>
<td>44 (25.0%)</td>
</tr>
<tr>
<td>10 to 20 years</td>
<td>41 (23.3%)</td>
<td>3 (1.7%)</td>
<td>44 (25.0%)</td>
</tr>
<tr>
<td>Over 20 years</td>
<td>17 (9.7%)</td>
<td>2 (1.1%)</td>
<td>19 (10.8%)</td>
</tr>
<tr>
<td>Total</td>
<td>122 (69.3%)</td>
<td>54 (30.7%)</td>
<td>176</td>
</tr>
</tbody>
</table>

Chi-square = 31.594, df = 4, p < 0.001

### 4.3 Descriptive Statistics

A summary of the knowledge-based survey variables follows. The variables are identified with one of six perspectives (Location, Transfer, Expression, Acquisition, Value Source, and Observability), followed by one of three classifications of knowledge (Tacit, Codified, or Encapsulated).
4.3.1 Survey Instruments

Two online surveys were constructed – one for portfolio managers and a second for all other investment management professionals. The six most important questions were essentially identical for both surveys and were placed at the beginning. Subsequent questions were customized for either portfolio managers or other investment management professionals. Appendices D and E contains paper copies of the online surveys.

4.3.2 Data Transformation

Each individual’s responses to a survey were collected using Internet-based software from Survey Monkey (www.SurveyMonkey.com) and downloaded electronically using a comma separated values (.csv) format. The collected responses were imported into a spreadsheet for cleaning and preliminary transformation.

If a respondent failed to provide three ratings for one of the six questions designed to capture relative reliance on tacit, codified, and encapsulated, that item was removed for that respondent. Such items were removed because they did not permit the calculation of a relative measure, without an assumption regarding the missing rating. Questions for which a respondent rated one of the items at zero were not removed, provided that the other two items were also rated.

4.3.2.1 Ratio variables from relative ratings

For the six survey questions designed to capture relative reliance on tacit, codified, and encapsulated knowledge, potential respondents were asked to rate the most important factor among three with a value of 10 and to rate the remaining two items relative to 10 (and to each other). The respondent ratings for reliance on the three classifications of knowledge were therefore transformed into relative measures, summing to 1. For example, ratings of 10, 8, and 2
for reliance on tacit, codified, and encapsulated knowledge, respectively, would be transformed to 0.500, 0.400 and 0.100.

The raw ratings by themselves provided only ranking information, and comparing the raw ratings as interval data between respondents would be misleading. For example, a respondent rating a tacit knowledge item 10, and the other 2 items also at 10, is providing a very different weighting to tacit knowledge than another respondent also rating the tacit knowledge item at 10, but the other two items at 5. The first respondent would be rating the tacit knowledge item (and the other two items) with a relative weight of 0.333 (10 / (10+10+10)), while the second respondent would rating the same tacit knowledge item with a relative weight of 0.500 (10 / (10+5+5)). In other words, the first respondent is declaring his or her relative reliance on tacit knowledge is equal to his or her relative reliance on the two other forms, while the second respondent is declaring his or her relative reliance on tacit knowledge to be twice his or her reliance on the other forms.

The relative ratings were coded as ‘KAbcDef’, where ‘K’ indicated a measure of Knowledge, ‘Abc’ as Tac, Cod, and Enc identified the classification of knowledge as tacit, codified, or encapsulated, respectively, and ‘Def’ as Loc, Tra, Exp, Acq, Val, and Obs identified the perspective of the measure as Location, Transfer, Expression, Acquisition, Value, and Observability, respectively.

The ratio variables from the relative ratings of the 18 raw survey ratings are presented in the following table. There is some evidence of respondent fatigue as the number of responses decreases from the first question to the last.

<p>| Table 14: Relative perceived reliance on classifications of knowledge by perspective |
|---------------------------------|----------------|---------|------|--------|--------|--------|--------|</p>
<table>
<thead>
<tr>
<th>Perspective</th>
<th>Classification</th>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
</table>

126
4.3.2.2 Normality

Before the ratio variables were standardized, they were reviewed for normality, which may have been impaired by skewness and/or kurtosis. Normality of measurements is necessary to perform valid t-tests and linear regressions. Stata’s (StataCorp, 2005) ‘ladder’ function was used to produce a list of potential transformations that could improve the normality for each of the 18 survey items. The function searches a subset of the ladder of powers for a transformation that will convert a non-normally distributed variable into one that is closer to being normally distributed.
distributed. The ladder function tests a number of potential transformations include taking the log, the square root or raising the item to some power. This provides a quantitative approach to the selection of the appropriate transformation, which could otherwise be somewhat of an art. Transformations were performed as indicated by the lowest chi-square (highest probability chi-square) to improve normality (Tukey, 1977). Specifically, raw values for KCodLoc were squared and those for KCodAcq, KEncLoc, KEncTra and KEncObs were raised to the exponent 0.5 according to recommendations gleaned from the ‘laddering’ results. After the transformations, the 18 items were standardized. The following table presents the statistics used to determine the need for transformation. A dot instead of a chi-square value is indicative of a very large number, and a dot instead of a probability value means that it is not possible to calculate the probability because of zeros or negative values.

<table>
<thead>
<tr>
<th>Table 15: Items with ladder-of-powers transformations</th>
</tr>
</thead>
<tbody>
<tr>
<td>x³</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>KCodAcq</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>KEncLoc</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>KEncTra</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>KEncObs</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

After the recommended transformations, the items were standardized and re-coded with a leading “Z” to indicate standardization.
4.4 Measuring Knowledge-Based Factors of Production: An Exploratory Analysis

Reliability tests were conducted on the standardized ratio items designed to measure relative reliance on the three classifications of knowledge. Selected standardized items were then averaged to produce three scales or indexes measuring relative reliance on tacit, codified, and encapsulated knowledge.

4.4.1 Content Validity

Content validity for the knowledge-based survey items was established through personal interviews with four portfolio managers, which involved a review of the proposed wording of the survey. Changes were made to the questions based on the feedback received from the portfolio managers who were asked to appraise item appropriateness. This field-based validation of the survey questions was followed by a pre-test that resulted in some further wording changes on the question of observability of the three classifications of knowledge.

4.4.2 Convergent Validity

4.4.2.1 Tacit Knowledge

Pearson correlations of the six items designed to measure relative reliance on tacit knowledge follow.

<table>
<thead>
<tr>
<th></th>
<th>KTacLoc</th>
<th>KTacTra</th>
<th>KTacExp</th>
<th>KTacAcq</th>
<th>KTacVal</th>
<th>KTacObs</th>
</tr>
</thead>
<tbody>
<tr>
<td>KTacLoc</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KTacTra</td>
<td>0.367***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KTacExp</td>
<td>0.310***</td>
<td>0.436***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KTacAcq</td>
<td>0.490***</td>
<td>0.471***</td>
<td>0.312***</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KTacVal</td>
<td>0.482***</td>
<td>0.436***</td>
<td>0.355***</td>
<td>0.362***</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>KTacObs</td>
<td>0.173*</td>
<td>0.100</td>
<td>0.148*</td>
<td>0.108</td>
<td>0.282***</td>
<td>1</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10
The item designed to measure relative reliance on tacit knowledge from the perspective of Observability, ZKTacObs, appears to be less significantly correlated to the other 5 items, which all appear to be fairly well correlated. With the exception of the item measuring from the perspective of Observability, all correlations are positive, greater than 0.310, and significant ($p < 0.001$), demonstrating considerable convergent validity. Tabachnick & Fidell (2007) suggest that the absence of any correlations above 0.3 should lead a researcher to reconsider factor analysis. Since all tacit item correlations exceed this standard, factor analysis may be considered appropriate.

4.4.2.2 Codified Knowledge

Pearson correlation of the six items designed to measure relative reliance on codified knowledge follow, with only three variables, ZKCodLoc, ZKCodTra and ZKCodAcq appearing to demonstrate any significant ($p < 0.001$) amount of correlation. An absence of convergence with and among the other three items (ZKCodExp, ZKCodVal, and ZKCodObs) was demonstrated by the negative correlations, as well as the absence of any positive correlations greater than 0.098. The raw ratings of the apparently correlated items (LocationCodified, TransferCodified and AcquisitionCodified) demonstrated even greater and significant ($p < 0.001$) convergent validity with correlations of 0.269, 0.429, and 0.477. This indicates that the process of transforming the raw ratings to relative items may have reduced the correlations.

Table 17: Pearson correlations of codified knowledge items

<table>
<thead>
<tr>
<th></th>
<th>KCodLoc</th>
<th>KCodTra</th>
<th>KCodExp</th>
<th>KCodAcq</th>
<th>KCodVal</th>
<th>KCodObs</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCodLoc</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KCodTra</td>
<td>0.347***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KCodExp</td>
<td>0.010</td>
<td>-0.031</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KCodAcq</td>
<td>0.367***</td>
<td>0.247***</td>
<td>-0.076</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.4.2.3 Encapsulated Knowledge

Pearson correlation of the six items designed to measure relative reliance on encapsulated knowledge follow. All of the items appear to be well correlated with each other. The positive correlations, all greater than 0.287 and significant ($p < 0.001$), demonstrate considerable convergent validity.

Table 18: Pearson correlations of encapsulated knowledge items

<table>
<thead>
<tr>
<th></th>
<th>KEncLoc</th>
<th>KEncTra</th>
<th>KEncExp</th>
<th>KEncAcq</th>
<th>KEncVal</th>
<th>KEncObs</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEncLoc</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KEncTra</td>
<td>0.489***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KEncExp</td>
<td>0.326***</td>
<td>0.579***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KEncAcq</td>
<td>0.543***</td>
<td>0.626***</td>
<td>0.473***</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KEncVal</td>
<td>0.485***</td>
<td>0.580***</td>
<td>0.448***</td>
<td>0.815***</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>KEncObs</td>
<td>0.287***</td>
<td>0.515***</td>
<td>0.572***</td>
<td>0.509***</td>
<td>0.527***</td>
<td>1</td>
</tr>
</tbody>
</table>

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

4.4.3 Scale Reliability

According to DeVellis (2003, p.27), scale reliability measures “the proportion of variance attributable to the true score of the latent variable”. The internal consistencies of scales may be assessed using Cronbach's alpha (Cronbach, 1951). Internal consistency reliability is concerned with the homogeneity of the items constituting a scale (DeVellis, 2003). Alpha is a commonly employed measure of the inter-item correlation, varying from 0 to 1. The higher the alpha, the
higher the internal consistency of a scale. Scale reliability increases and measurement error decreases as the number of items for a scale increase (Churchill, 1979).

The acceptability of a given alpha is a subjective decision, but an alpha of 0.70 is considered acceptable in many cases (DeVellis, 2003; Lattin, Carroll, & Green, 2003; Nunnally, 1978). Churchill (1979, p.68) drawing on Nunnally (1967) suggests that, “What is ‘low’ for alpha depends on the purpose of the research. For early stages of basic research… reliabilities of .50 to .60 suffice and that increasing reliabilities beyond .80 is probably wasteful”. In contrast, in life and death or similar situations in which important decisions are made with respect to specific test scores, “a reliability of .90 is the minimum that should be tolerated, and a reliability of .95 should be considered the desirable standard” (Nunnally, 1967, p.226). Similarly, DeVellis, noting that “Different methodologists and investigators begin to squirm at different levels of alpha” (2003, p.95), indicates that he personally uses the following scales: below .60, unacceptable; between .60 and .65, undesirable; between .65 and .70, minimally acceptable; between .70 and .80, respectable; between .80 and .90, very good; above .90, suggestive of scale shortening. DeVellis (2003) qualifies his ranges as guidelines for research instruments used with group data and suggests that they are unacceptably low for scales requiring critical accuracy for important individual assessments such as required in clinical diagnostic testing.

In research on the subject of organizational structure, Powell (1992, p.126), drawing on the work of Van de Ven and Ferry (1980), indicated that, “no acceptable range has been established for this [for Cronbach’s alpha] index”. Again relying on Van de Ven and Ferry (1980), Powell (1992, p.126), advised that “for a scale of three items, alpha should fall between… 0.55 and 0.70 for a moderately broad construct”.

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4.4.3.1 Encapsulated Knowledge

Cronbach’s alpha was calculated using SPSS (SPSS for Windows, 2006) to measure internal consistency / scale reliability based on average correlation among all six items designed to measure perceived relative reliance on encapsulated knowledge. In this case, removing any of the items would also reduce alpha below that of the test scale and reduce the scale’s reliability. The alpha of the standardized test scale is 0.863, which is very good (DeVellis, 2003), but possibly wasteful (Churchill, 1979). Since Cronbach’s alpha is not improved even if KEncLoc is deleted, the mean of all six items was calculated to generate the encapsulated knowledge scale.

<p>| Table 19: Cronbach's alpha if encapsulated knowledge items are removed |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Cronbach’s alpha if item deleted</th>
<th>KEncLoc</th>
<th>KEncTra</th>
<th>KEncExp</th>
<th>KEncAcq</th>
<th>KEncVal</th>
<th>KEncObs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.865</td>
<td>0.829</td>
<td>0.852</td>
<td>0.819</td>
<td>0.823</td>
<td>0.848</td>
<td></td>
</tr>
</tbody>
</table>

4.4.3.2 Tacit Knowledge

Cronbach’s alpha is maximized at 0.769 for a tacit knowledge scale if the item, ZKTacObs, measuring relative reliance on tacit knowledge from the perspective of observability is removed. This level of alpha is respectable (DeVellis, 2003). If any remaining items were removed, Cronbach’s alpha would be reduced and lead to a less reliable scale. Accordingly, five items were retained to generate the tacit knowledge scale.

<p>| Table 20: Cronbach's alpha if tacit knowledge items are removed |
|---------------------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Cronbach’s alpha if item deleted</th>
<th>KTacLoc</th>
<th>KTacTra</th>
<th>KTacExp</th>
<th>KTacAcq</th>
<th>KTacVal</th>
<th>KTacObs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.720</td>
<td>0.714</td>
<td>0.753</td>
<td>0.723</td>
<td>0.724</td>
<td>Removed</td>
<td></td>
</tr>
</tbody>
</table>

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4.4.3.3 Codified Knowledge

A maximum Cronbach’s alpha of 0.586 was achieved for internal consistency / scale reliability after removing the items from the perspectives of expression, value source, and observability.

Table 21: Cronbach’s alpha if codified knowledge items are removed

<table>
<thead>
<tr>
<th>Cronbach’s alpha if item deleted</th>
<th>KCodLoc</th>
<th>KCodTra</th>
<th>KCodExp</th>
<th>KCodAcq</th>
<th>KCodVal</th>
<th>KCodObs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.369</td>
<td>0.537</td>
<td>Removed</td>
<td>0.516</td>
<td>Removed</td>
<td>Removed</td>
<td>Removed</td>
</tr>
</tbody>
</table>

A higher Cronbach’s alpha of 0.655 was obtained when the raw ratings (LocationCodified, TransferCodified, and AcquisitionCodified) were used. The raw ratings demonstrated somewhat higher reliability than the transformed and standardized relative items.

Previous efforts seeking to measure the relative reliance of workers on codified knowledge are unknown, so it is not surprising that a low Cronbach’s alpha is observed. The Cronbach’s alpha of 0.586 is for a relatively new broad construct, is based on three items, and just falls within the range judged by Van de Ven and Ferry (1980) and Powell (1992), to be considered acceptable. Also, according to Churchill (1979) this level of alpha may suffice for early stages of basic research.

Cronbach alpha provides an underestimate of composite reliability of latent variables based on congeneric items (Raykov, 1997a). Congeneric items measure the same latent variable, but with possibly different precision and units of measurement (Lord & Novick, 1968). Cronbach alpha underestimates reliability when items are congeneric due to the violation of ‘tau-equivalence’ assumption inherent in its calculation (Raykov, 1997b). Respondents to the survey items used to measure relative reliance on tacit, codified, and encapsulated knowledge may have varied in the precision with which they responded among the six perspectives as they were
presented. To the extent that the six perspectives (location, acquisition, expression, transfer, value source, and observability) caused variation in respondents’ precision, the survey items may be considered congeneric measures. Using AMOS (Arbuckle, 2006b), estimates of composite reliability were calculated based on models suggested by (Graham, 2006). The results are presented in the following table. The parallel model is also provided for completeness.

Table 22: Composite reliabilities by model and latent variable

<table>
<thead>
<tr>
<th></th>
<th>Tacit</th>
<th>Codified</th>
<th>Encapsulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel</td>
<td>0.771</td>
<td>0.585</td>
<td>0.867</td>
</tr>
<tr>
<td>Tau-equivalent *</td>
<td>0.773</td>
<td>0.588</td>
<td>0.878</td>
</tr>
<tr>
<td>Congeneric</td>
<td>0.773</td>
<td>0.596</td>
<td>0.865</td>
</tr>
</tbody>
</table>

* Assumption for Cronbach’s alpha

The assumptions for precision equivalence, scale equivalence, and error equivalence that are represented by the parallel, tau-equivalent, and congeneric models in the table above appear to have little effect on the measurement of composite reliability of the items measuring relative reliance on tacit knowledge. For codified knowledge, however, composite reliability appears increased when a congeneric model is assumed. For encapsulated knowledge, the tau-equivalent model of composite reliability appears to present the highest measure of composite reliability.

Even when the least restrictive model of composite reliability (congeneric) is assumed to apply to the items designed to measure relative reliance on codified knowledge, the level of reliability is still below the 0.70 guideline suggested by DeVellis (2003), Lattin (2003) and Nunnally (1978).

A higher composite reliability of 0.721 was obtained for a codified knowledge variable when the raw ratings (LocationCodified, TransferCodified, and AcquisitionCodified) were used. The raw ratings demonstrated somewhat higher reliability than the transformed and standardized
relative items. It appears however, that the latent variable of reliance on codified knowledge, on a relative basis, was not reliably measurable by the survey items used.

4.4.4 Confirmatory Factor Analysis

Confirmatory factor analyses may also be conducted to evaluate construct validity (Lattin et al., 2003, p.188) and as a test for unidimensionality. Unidimensionality is the existence of a single construct or latent variable underlying the observed items. A high Cronbach’s alpha alone does not preclude the possibility that a scale may be measuring a multi-dimensional construct. Bagozzi, Yi, and Phillips (1991) also point to the advantages of confirmatory factor analysis over Campbell and Fiske’s (1959) reliance on correlations for an assessment of convergent and discriminant validity.

4.4.4.1 Tacit Knowledge

Performing a maximum likelihood factor analysis on all six tacit knowledge items using SPSS (SPSS for Windows, 2006) generated only one factor with an Eigenvalue > 1.0 that accounted for almost 45% of the variance. The KMO (Kaiser, 1970) measure of sampling adequacy is 0.774, above the generally accepted minimum of 0.6 required for good factor analysis (Ullman, 2007), although measures as low as 0.5 may also be considered acceptable. Bartlett’s test of sphericity was significant ($p < 0.001$), suggesting the null hypothesis, that the correlation matrix is an identity matrix with no significant correlations among at least some of the variables, may be rejected. With the 6-item scale, the minimum factor loading of KTacObs of

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12 Kaiser (1974, p35) suggests the following evaluation levels for an index of factorial simplicity, “in the 0.90s, marvelous; in the 0.80s, meritorious; in the 0.70s, middling; in the 0.60s, mediocre; in the 0.50s, miserable; below 0.50, unacceptable”.

---
0.256 was well below the remaining loadings, which ranged between 0.553 and 0.684, and below the generally acceptable value of 0.70 (Lattin et al., 2003, p.184). Eliminating the item with the lowest factor loading, KTacObs, increased the variance explained by one factor to 52%. The Eigenvalue of the one factor was 2.604. With only 5 items, the factor loadings ranged between 0.534 and 0.666. The chi-square goodness-of-fit test was significant ($p < 0.01$). As a result, only five items were averaged to generate the latent variable for relative reliance on tacit knowledge, KTacScale. The following table presents the factor loadings.

**Table 23: Factor loadings for the tacit knowledge construct**

<table>
<thead>
<tr>
<th>Factor loadings</th>
<th>KTacLoc</th>
<th>KTacTra</th>
<th>KTacExp</th>
<th>KTacAcq</th>
<th>KTacVal</th>
<th>KTacObs</th>
</tr>
</thead>
</table>

4.4.4.2 Encapsulated Knowledge

Performing a factor analysis on all six encapsulated knowledge items retained only one factor with an Eigenvalue of 3.604 that accounted for over 60% of the variance. The KMO measure of sampling adequacy was 0.830 and Bartlett’s test of sphericity was significant ($p < 0.001$). The factor loadings for the 6-item scale range between 0.560 and 0.905. The chi-squared goodness-of-fit test was also significant ($p < 0.001$). As a result, all six items were averaged to generate the latent variable for relative reliance on encapsulated knowledge, KEncScale. The following table presents the factor loadings.

**Table 24: Factor loadings for the encapsulated knowledge construct**

<table>
<thead>
<tr>
<th>Factor loadings</th>
<th>KEncLoc</th>
<th>KEncTra</th>
<th>KEncExp</th>
<th>KEncAcq</th>
<th>KEncVal</th>
<th>KEncObs</th>
</tr>
</thead>
</table>

137
4.4.4.3 Codified Knowledge

Performing a factor analysis on the 3 codified knowledge items that generate the highest alpha retained one that accounted for almost 55% of the variance. The KMO measure of sampling adequacy (0.619) was acceptable (> 0.60), and Bartlett’s test of sphericity was significant ($p < 0.001$). The factor loadings for the 3-item scale ranged between 0.484 and 0.718. No chi-square goodness-of-fit statistic was calculated since the number of degrees of freedom was non-positive, being equal to zero. With only three items available to load onto a single factor, no items could be eliminated. The following table presents the factor loadings.

**Table 25: Factor loadings for the codified knowledge construct**

<table>
<thead>
<tr>
<th>Factor loadings</th>
<th>KCodLoc</th>
<th>KCodTra</th>
<th>KCodExp</th>
<th>KCodAcq</th>
<th>KCodVal</th>
<th>KCodObs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.718</td>
<td>0.484</td>
<td>Excluded</td>
<td>0.511</td>
<td>Excluded</td>
<td>Excluded</td>
<td></td>
</tr>
</tbody>
</table>

An examination was made of the surveys (see Appendix D or Appendix E) to uncover why only three items could be retained for a codified knowledge construct. The examination indicated that the single construct indicated by the factor analysis might be described as “documented information”. The three retained items are from measurements of responses to statements containing the words, “information I obtain from documents”, “written documents”, or “by studying and interpreting information”. In retrospect, three of the items not included in codified knowledge may have been excluded for two unrelated reasons. Two of the items may have been excluded because they may were perceived to refer to undeclared norms in the form of “rules, routines and processes” and “procedures”. While these norms may still be considered as codified knowledge, they were perhaps not considered as explicit as documented information. The item based on the perspective of observability may have exhibited poor correlation because it was perceived as requesting an assessment of the learning ability of a third party rather than as
a description of knowledge, per se. In that respect it, the item may have suffered from attribution error.

4.4.5 Discriminant validity

Just as high positive correlations are indicative of convergent validity, small correlations between items may be taken as an indication of discriminant validity (Campbell & Fiske, 1959), also known as divergent validity (DeVellis, 2003). Five tacit knowledge items, three codified knowledge items, and all six encapsulated knowledge items were selected to generate the three scales of relative reliance. To determine that these 14 items discriminated between three different constructs, the correlations between them were compared. To be discriminating, one would expect high positive correlations between items designed to measure the same construct and small negative or positive correlations between items designed to measure different constructs. The mean correlation between the five selected standardized items designed to measure relative reliance on tacit knowledge, the three designed to measure relative reliance on codified knowledge and all six designed to measure relative reliance on encapsulated knowledge were 0.402, 0.320, and 0.518, respectively. Before transformation and standardization these mean correlations were 0.344, 0.392, and 0.551 for relative reliance on tacit, codified, and encapsulated knowledge, respectively. These results lend support to the convergent validity results discussed in the previous section. The mean correlation between the items designed to measure the three different constructs were 0.081, -0.457, and -0.280. Discriminant validity between constructs may be demonstrated by correlations between them being significantly different from unity (Campbell & Fiske, 1959). The relatively large absolute value of the negative correlation between the tacit and encapsulated knowledge items (0.457), suggested the possibility that the two constructs could perhaps be measuring two extremes of a single
construct. However, the magnitude of the mean correlation should be considered with caution as the transformations from raw ratings may have introduced some correlation due to the transformations relying on a common denominator that included both tacit and encapsulated terms. The mean correlation between the raw ratings designed to measure the three constructs were relatively small at 0.096, -0.206, and -0.003 (almost completely orthogonal), suggesting evidence of discriminant validity. The following table presents the average correlations.

Table 26: Average correlations among and between construct items and raw ratings<sup>a</sup>

<table>
<thead>
<tr>
<th></th>
<th>Standardized items</th>
<th>Raw ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tacit (5)</td>
<td>Codified (3)</td>
</tr>
<tr>
<td>Tacit (5)</td>
<td>0.402</td>
<td></td>
</tr>
<tr>
<td>Codified (3)</td>
<td>0.081</td>
<td>0.320</td>
</tr>
<tr>
<td>Encapsulated (6)</td>
<td>-0.457</td>
<td>-0.280</td>
</tr>
</tbody>
</table>

<sup>a</sup>The numbers in brackets indicate the number of items or raw ratings associated with each construct

To determine if the constructs defined by theory could be distinguished solely on the basis of maximization of inter-item correlation, an additional exercise was conducted. Cronbach’s alpha was calculated for all 18 items and then selectively maximized by removing the items generating the largest increase alpha with their removal, one item at a time. Using this process, Cronbach’s alpha reached its first maximum (0.863) when all the items for codified knowledge and tacit knowledge were removed and only the six encapsulated knowledge items remained. The process was repeated using the 12 tacit and codified knowledge items removed in the first pass. Cronbach’s alpha reached its second maximum (0.769) when five tacit knowledge items remained. The process was repeated one more time using the six codified knowledge items and the one tacit knowledge item removed in the second pass. Cronbach’s alpha reached its third maximum (0.586) when three codified knowledge items and one tacit knowledge item were
removed. The process was halted at this point, since alphas below 0.55 for a three item scale should not be considered unless the scale represents a “Broad Construct” (Van de Ven & Ferry, 1980, p.79).

4.4.6 Structural Equation Modeling

Structural Equation Modeling was also used to assess factor validity. A specification search was performed using AMOS 7.0 (Arbuckle, 2006b) to derive a measurement model. Since measurement models are being evaluated in the absence of a structural model, this process follows the recommendations of Anderson and Gerbing (1988). Specification of a model is the first step in structural equation modeling and is a confirmatory rather than exploratory technique (Ullman, 2007). The specification search in AMOS 7.0 (Arbuckle, 2006b) is an automated model-building and model-trimming process. Six arrows connected each of the measured items to one of the three latent variables consistent with the theory. All model arrows were made optional to permit the program the maximum flexibility in specifying the optimum model. The variances on each of the three latent variables were fixed at 1 to achieve identification (Gerbing & Hunter, 1982). This is also known as imposing a unit variance identification (Kline, 2004) and standardizes the latent variable. The other option is the imposition of a unit loading identification constraint on a single path from one of the observed variables to the latent variable. In the models presented below, both identification methods result in the same overall fit because each

13 Also termed observed variables, indicators, or manifest variables (Ullman, 2007).

14 Also termed unobserved variables, factors, or constructs (Ullman, 2007).
latent variable is examined apart from the other two, thus precluding the phenomenon of
constraint interaction (Kline, 2004; Steiger, 2002).

The AMOS 7.0 specification search stops when the adjusted Browne-Cudeck (1989)
criterion (adjusted BCC) is minimized. This criterion imposes a slightly greater penalty for
model complexity than does the Akaike (1973) information criterion (AIC). The BCC is adjusted
by the addition of a constant (Burnham & Anderson, 1998) so that its smallest value is limited to
zero (Arbuckle, 2006a). Using minimization of the adjusted BCC generally appears to end
specification searches when both AIC and normed chi-square (chi-square / degrees of freedom)
are also minimized.

The results of the modeling are shown in the following path diagrams. Each diagram
consists of observed or manifest variables, indicated by the rectangles, and unobserved or latent
variables, indicated by ellipses. Small circles with labels beginning with ‘e’ represent error
variables. The arrows in each path diagram represent the direction of causality from the latent
variable or factor to the observed variables, with the path coefficients quantifying the amount of
variance in the observed variables caused by the underlying latent variable. The path
coefficients correspond to factor loadings and are reported as standardized estimates ranging
from 0.00 to 1.00.

A number of measurements are calculated for each of three models (measurement,
independence, saturated). The measurement model is the one specified in the quest for factor
validity. The measurement model should fit between the independence model and the saturated
model. In the independence model, the co-variances of the observed variables are fixed at 0, but
their variances are unconstrained (Arbuckle, 2006a). In the saturated (or just-defined, or
unconstrained) model there are no constraints on the variances and co-variances of the observed
variables so the model fits perfectly (Arbuckle, 2006a). The measurement model is built with correlations and constraints, and so should fit between the other two.

**4.4.6.1 Encapsulated Knowledge**

The following table ranks the ten best measurement models in descending order (nine best, excluding the saturated / unconstrained model) found by the specification search for encapsulated knowledge. Note that even though adjusted BCC was used to rank the models, ranking by chi-square, or normed chi-square (chi-square / degrees of freedom), or root mean square error of approximation (RMSEA) would not result in any rank reversals.

**Table 27: Ten best models specified for encapsulated knowledge**

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Model Name</th>
<th>df</th>
<th>$\chi^2$</th>
<th>Adjusted BCC</th>
<th>$\chi^2$ / df</th>
<th>p-value</th>
<th>RMSEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sat</td>
<td>[Saturated]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td>0.000</td>
</tr>
<tr>
<td>44</td>
<td>Measurement</td>
<td>9</td>
<td>60.775</td>
<td>42.142</td>
<td>6.753</td>
<td>0.000</td>
<td>0.167</td>
</tr>
<tr>
<td>38</td>
<td>Measurement</td>
<td>10</td>
<td>130.371</td>
<td>109.667</td>
<td>13.037</td>
<td>0.000</td>
<td>0.242</td>
</tr>
<tr>
<td>39</td>
<td>Measurement</td>
<td>10</td>
<td>135.601</td>
<td>114.897</td>
<td>13.560</td>
<td>0.000</td>
<td>0.247</td>
</tr>
<tr>
<td>40</td>
<td>Measurement</td>
<td>10</td>
<td>136.888</td>
<td>116.185</td>
<td>13.689</td>
<td>0.000</td>
<td>0.248</td>
</tr>
<tr>
<td>41</td>
<td>Measurement</td>
<td>10</td>
<td>185.538</td>
<td>164.834</td>
<td>18.554</td>
<td>0.000</td>
<td>0.292</td>
</tr>
<tr>
<td>28</td>
<td>Measurement</td>
<td>11</td>
<td>197.448</td>
<td>174.674</td>
<td>17.950</td>
<td>0.000</td>
<td>0.287</td>
</tr>
<tr>
<td>29</td>
<td>Measurement</td>
<td>11</td>
<td>206.172</td>
<td>183.398</td>
<td>18.743</td>
<td>0.000</td>
<td>0.293</td>
</tr>
<tr>
<td>30</td>
<td>Measurement</td>
<td>11</td>
<td>213.269</td>
<td>190.495</td>
<td>19.388</td>
<td>0.000</td>
<td>0.299</td>
</tr>
<tr>
<td>31</td>
<td>Measurement</td>
<td>11</td>
<td>245.708</td>
<td>222.934</td>
<td>22.337</td>
<td>0.000</td>
<td>0.322</td>
</tr>
</tbody>
</table>

The results of the specification search may be confirmed using the traditional chi-square difference test of nested models (hierarchical analysis), provided the sample size is not too small (Tabachnick & Fidell, 2007). When samples are small, large differences may appear non-significant, and when samples are large, even small differences may appear significant. Model 44 in the table above is the preferred measurement model and is based on all six observed items,
while models 38 through 41 are nested comparisons of model 44 with one less path to an observed item. Model 38 comes closest to the preferred measurement model in terms of normed chi-square, adjusted BCC, and RMSEA. The chi-square difference is $69.596 (130.371 – 60.775)$ with one degree of freedom ($10 – 9$). Since this difference is significant ($p < 0.001$), model 44 is preferred over model 38 (and models 39 through 41 because they have higher chi-square values than model 38). The following figure displays the preferred measurement model: model 44.
The numbers beside each of the arrows in the figure above are standardized estimates of regression weights and represent the amount of change in the observed variable for a one standard deviation change in the latent variable. These numbers correspond to standardized coefficients in linear regression and should be equal to the factor loadings obtained using confirmatory factor analysis. For the encapsulated knowledge model, estimated standardized
regression weights ranged from 0.58 to 0.90, consistent with the results obtained with the factor analysis in the previous section. The numbers above each of the observed variables represent estimates of squared multiple correlation of each of the relationships and therefore range from 0.35 to 0.81.

There are various opinions on what constitutes acceptable factor loadings, but Tabachnick and Fidell (2007, p.649) suggest only variables with loadings of 0.32 and higher are interpretable, as a rule of thumb. According to Comrey (1992), loadings of 0.71 or greater may be considered excellent; loadings from 0.63 to .070 may be considered very good; loadings from 0.55 to 0.62 may be considered good; loadings from 0.45 to 0.54 may be considered fair; loadings from 0.32 to 0.44 may be considered poor; and loadings below 0.32 should be discarded. These categories of loadings corresponds to overlapping variances (squared multiple correlation estimates) ranging from > 0.50 to < 0.10 in intervals of 0.10. “The squared multiple correlation of a variable is the proportion of its variance that is accounted for by its predictors” (Arbuckle, 2006a, p.78). In other words, the square of the factor loadings indicate the “percent of variance” in the measured item explained by the latent variable (Nunnally, 1978, p.336). The measurement model estimates for encapsulated knowledge are displayed in the following table.

Table 28: Measurement model estimates for encapsulated knowledge

<table>
<thead>
<tr>
<th>Item</th>
<th>Standardized estimate</th>
<th>Standard error of the estimate</th>
<th>Critical ratio</th>
<th>Squared multiple correlation estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZKEncLoc</td>
<td>.589***</td>
<td>0.066</td>
<td>8.834</td>
<td>0.346</td>
</tr>
<tr>
<td>ZKEncTra</td>
<td>.719***</td>
<td>0.063</td>
<td>11.427</td>
<td>0.518</td>
</tr>
<tr>
<td>ZKEncExp</td>
<td>.576***</td>
<td>0.067</td>
<td>8.510</td>
<td>0.332</td>
</tr>
<tr>
<td>ZKEncAcq</td>
<td>.902***</td>
<td>0.057</td>
<td>15.924</td>
<td>0.814</td>
</tr>
<tr>
<td>ZKEncVal</td>
<td>.872***</td>
<td>0.058</td>
<td>15.036</td>
<td>0.761</td>
</tr>
<tr>
<td>ZKEncObs</td>
<td>.621***</td>
<td>0.069</td>
<td>9.052</td>
<td>0.385</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10
The standardized estimates of the loadings in the table above ranged from good (0.576, 0.589, 0.621) to excellent (0.719, 0.872, 0.902) using Comrey’s (1992) criteria. All estimates were significant ($p < 0.001$). The standard errors of the estimates were small and the critical ratios (equal to the estimate divided by its standard error) were all large.

The table below lists various model fit statistics. Fit indices are designed to avoid problems of sample size and distributional misspecification associated with conventional chi-square tests (Bentler & Bonett, 1980), but designating specific cut-off values for each fit statistic is difficult (Hu & Bentler, 1999). Currall and Judge (1995), drawing on Tanaka (1993), suggest that because the final interpretation of what is an acceptable cut-off value is subjective, the final interpretation is left to the reader. Shook, Ketchen, Hult, and Kacmar, (2004) in a review of structural equation modeling in strategic management research, suggested that multiple fit statistics should be reported to convince readers that the researcher did not select only those fit statistics supportive of the research. Of the multiple fit statistics, Gerbing and Anderson (1992) suggest the most robust and stable are Bollen’s (1989) incremental fit index (IFI) or DELTA2, the relative non-centrality index (RNI), and the comparative fit index (CFI).

**Table 29: Model fit summary for encapsulated knowledge**

<table>
<thead>
<tr>
<th>Fit statistic</th>
<th>Measurement model</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMIN (likelihood ratio chi-square)</td>
<td>60.775</td>
<td>Lower = better</td>
</tr>
<tr>
<td>DF (degrees of freedom)</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>$P$</td>
<td>0.000</td>
<td>Reject measurement model if sample size is ‘small’</td>
</tr>
<tr>
<td>CMIN/DF</td>
<td>6.753</td>
<td>Very rough rule of thumb, should be &lt; 2 (Ullman, 2007)</td>
</tr>
<tr>
<td>NFI (normed fit index)</td>
<td>0.898</td>
<td>At the limit (0.9) for requiring model re-specification</td>
</tr>
<tr>
<td>RFI (rho 1)</td>
<td>0.762</td>
<td>Closer to 1 = better</td>
</tr>
<tr>
<td>IFI (incremental fit index)</td>
<td>0.912</td>
<td>Acceptable (&gt; 0.9)</td>
</tr>
<tr>
<td>TLI (Tucker-Lewis index)</td>
<td>0.790</td>
<td>Closer to 1 = better</td>
</tr>
<tr>
<td>Fit statistic</td>
<td>Measurement model</td>
<td>Remarks</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>-------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>CFI (comparative fit index)</td>
<td>0.910</td>
<td>Acceptable (&gt; 0.9)</td>
</tr>
<tr>
<td>PRATIO (parsimony ratio)</td>
<td>0.429</td>
<td>Degrees of freedom of measurement model divided by degrees of freedom of the independence model</td>
</tr>
<tr>
<td>PNFI (parsimony normed fit index)</td>
<td>0.385</td>
<td>NFI times PRATIO; Higher = better</td>
</tr>
<tr>
<td>PCFI (parsimony comparative fit index)</td>
<td>0.390</td>
<td>CFI times PRATIO; Higher = better</td>
</tr>
<tr>
<td>NCP (non-centrality parameter)</td>
<td>51.775</td>
<td>Used to calculate RMSEA</td>
</tr>
<tr>
<td>F0</td>
<td>0.251</td>
<td>Used to calculate RMSEA</td>
</tr>
<tr>
<td>RMSEA (root mean square error of approximation)</td>
<td>0.167</td>
<td>Close-fitting model &lt; 0.05; Good model &lt; 0.06; Adequate model &lt; 0.08; Poor model &gt; 0.10</td>
</tr>
<tr>
<td>AIC (Akaike information criterion)</td>
<td>96.775</td>
<td>Smaller = better (Saturated/Unconstrained AIC = 54.000)</td>
</tr>
<tr>
<td>BCC (Browne-Cudeck criterion)</td>
<td>98.041</td>
<td>Smaller = better (Saturated/Unconstrained BCC = 55.899)</td>
</tr>
<tr>
<td>ECVI (expected cross-validation index)</td>
<td>0.470</td>
<td>Smaller = better (Saturated/Unconstrained ECVI = .262)</td>
</tr>
<tr>
<td>MECVI (modified ECVI)</td>
<td>0.476</td>
<td>Smaller = better (Saturated/Unconstrained MECVI = .271)</td>
</tr>
<tr>
<td>HOELTER 0.05</td>
<td>58</td>
<td>Sample size is greater, explaining P above</td>
</tr>
<tr>
<td>HOELTER 0.01</td>
<td>74</td>
<td>Sample size is greater, explaining P above</td>
</tr>
</tbody>
</table>

The likelihood ratio chi-square statistic, CMIN, should not be significant if the measurement model is a good fit (Arbuckle, 2006a). By this criterion, the measurement model is rejected as not being a good fit with the data (P = .000). With large sample sizes, this criterion is known to more likely to result in a rejection of the measurement model, and a Type II error. A ‘large’ sample size can result in trivial differences between sample and estimated population covariance matrices appearing significant (Ullman, 2007). The results of Hoelter’s N test (see below) suggest that the large sample size may be the reason for significance. One reason a number of fit statistics have been developed and are still under vigorous development is this limitation of the chi-square statistic (Ullman, 2007).

NFI is the Bentler-Bonett (1980) normed fit index, which varies from 0 to 1, with 1 being a perfect fit. By convention, NFI values below .90 indicate a need to re-specify the measurement.
model. The NFI for the measurement model for encapsulated knowledge is acceptable by this criterion.

Bollen’s (1986) RFI is a measure of the relative fit index, and a RFI close to 1 indicates a good fit. The RFI is obtained from the NFI calculation by the inclusion of a term for degrees of freedom. The RFI for the measurement model for encapsulated knowledge is 0.762.

Bollen’s (1989) IFI is a measure of the incremental fit index, and a value of IFI close to 1 indicates a good fit with values above .90 considered acceptable. This measure addresses the problem of large variability in the TLI (Ullman, 2007). The IFI for the measurement model for encapsulated knowledge is .912 and is acceptable by this criterion.

TLI is the Tucker-Lewis index (1973) is also known as the Bentler-Bonett (1980) non-normed fit index (NNFI). This measure adjusts the NFI by including degrees of freedom in the calculation (Ullman, 2007). A TLI close to 1 indicates a good fit. The TLI for the measurement model for encapsulated knowledge is 0.790.

Bentler’s (1990) comparative fit index (CFI) is identical to McDonald and Marsh’s (1990) relative non-centrality index (RNI), except that the CFI is truncated to fall in the range of 0 to 1. A CFI close to 1 indicates a very good fit with values above .90 considered acceptable. (IFI and TLI are not guaranteed to vary from 0 to 1, but the CFI does vary from 0 to 1.) The CFI for the measurement model for encapsulated knowledge is .910 indicating an acceptable fit.

PRATIO is the parsimony ratio, which is the ratio of the degrees of freedom in the model relative to degrees of freedom in the independence (null) model. Although the PRATIO is not a goodness-of-fit test, it forms part of goodness-of-fit measures like PNFI and PCFI. The latter two are measures of parsimony that score well for models with relatively few parameters to estimate in relation to the number of variables and relationships. PNFI is the parsimony-normed fit index
and is equal to the PRATIO times NFI. PCFI is the parsimony comparative fit index and is equal to PRATIO times CFI. PNFI and PCFI are .385 and .390 respectively. Higher values are indicative of better models.

NCP is the non-centrality parameter. The NCP and the F0 are used in the computation of RMSEA. The RMSEA is the root mean square error of approximation (Browne & Cudeck, 1993) and is also known simply as the root mean square (Steiger & Lind, 1980). It incorporates the discrepancy function criterion (comparing observed and predicted covariance matrices) and the parsimony criterion. By convention, there is close model fit if RMSEA less than or equal to 0.05; a model is reasonable if RMSEA is less than or equal to 0.08; and a model with RMSEA greater than 0.10 indicates a poor fit (Browne & Cudeck, 1993). In addition, Ullman (2007) drawing on Hu and Bentler (1999) suggests that a RMSEA of 0.06 or less indicates a good-fitting model. By this criterion, the measurement model is a poor fit (RMSEA = 0.167).

The measures below are based on information theory and are appropriate when comparing models that have been estimated using maximum likelihood estimation, as in this case. The AIC is the Akaike information criterion (Akaike, 1978) and may be interpreted as the likelihood of the model given the data (Akaike, 1978; Bozdogan, 1987; Burnham & Anderson, 1998). Better and more parsimonious models exhibit smaller AIC values. Since there is no standard measure of ‘small enough’ the AIC is useful when comparing competing models, especially since it does not require nesting (Ullman, 2007).

The BCC is the Browne-Cudeck criterion (Browne & Cudeck, 1989) criterion. A model with lower BCC is usually preferred over one with a higher BCC. The BCC is equivalent to the AIC except for that addition of a constant. By using BCC as the selection criteria, AMOS
(Arbuckle, 2006b) is able to compare and rank models in the specification search even they are not nested.

The ECVI is the expected cross-validation index and is a variant of AIC. The same ranking between models will be generated by both AIC and ECVI (Browne & Cudeck, 1992). As with AIC, a lower ECVI is preferred to a higher ECVI.

The MECVI is the modified expected cross-validation index and is a variant of BCC. It is identical to BCC, accept for a scaling factor (Arbuckle, 2006a). As with BCC, a lower MECVI is preferred to a higher MECVI.

The measures of Hoelter's critical N (1983) represent the largest sample size at which a researcher should accept the model at the .05 or .01 levels. The small values for Hoelter’s critical N suggests a reason the significant P value above: the sample size of 204 is about three (alpha = 0.01) or four (alpha = 0.05) times the value of this fit criteria.

Goodness-of-fit index (GFI) and adjusted goodness-of-fit index (AGFI) values were not reported by AMOS (Arbuckle, 2006b), but these have apparently fallen out of favour recently. This may be because GFI and AGFI both tend to increase as sample size is increased, or as the number of items per latent variable is decreased, particularly when sample size is small (Anderson & Gerbing, 1988; Fan, Thompson, & Wang, 1999; Marsh, Balla, & McDonald, 1988). In addition, Byrne (2001), drawing on Jöreskog (1993), notes that GFI and AGFI can theoretically be negative.

4.4.6.2 Tacit Knowledge

The following table ranks the ten best measurement models in descending order (nine best, excluding the saturated / unconstrained model) found by the specification search for tacit knowledge.
The results of the specification search may be confirmed for nested models using the traditional chi-square difference test (Tabachnick & Fidell, 2007). Model 1 in the table above is the preferred measurement model and is based on all six observed items, while model 58 is a nested comparison of model 1 with one less path to an observed item. Model 58 comes closest to the preferred measurement model in terms of normed chi-square, adjusted BCC and RMSEA. The chi-square difference is 9.398 (32.654 – 23.256) with one degree of freedom (10 – 9). Since this difference is significant ($p = 0.002$), model 1 is preferred over model 58. The following figure displays the results of the specification search for tacit knowledge: model 1.

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Model Name</th>
<th>df</th>
<th>$\chi^2$</th>
<th>Adjusted BCC</th>
<th>$\chi^2 / df$</th>
<th>p</th>
<th>RMSEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sat</td>
<td>[Saturated]</td>
<td>0</td>
<td>0.000</td>
<td>55.899</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Measurement</td>
<td>9</td>
<td>23.256</td>
<td>60.522</td>
<td>2.584</td>
<td>0.000</td>
<td>0.088</td>
<td></td>
</tr>
<tr>
<td>58 Measurement</td>
<td>10</td>
<td>32.654</td>
<td>67.850</td>
<td>3.265</td>
<td>0.000</td>
<td>0.105</td>
<td></td>
</tr>
<tr>
<td>34 Measurement</td>
<td>10</td>
<td>70.657</td>
<td>105.853</td>
<td>7.066</td>
<td>0.000</td>
<td>0.172</td>
<td></td>
</tr>
<tr>
<td>43 Measurement</td>
<td>11</td>
<td>79.689</td>
<td>112.815</td>
<td>7.244</td>
<td>0.000</td>
<td>0.174</td>
<td></td>
</tr>
<tr>
<td>59 Measurement</td>
<td>11</td>
<td>103.992</td>
<td>137.117</td>
<td>9.454</td>
<td>0.000</td>
<td>0.203</td>
<td></td>
</tr>
<tr>
<td>50 Measurement</td>
<td>10</td>
<td>95.040</td>
<td>130.236</td>
<td>9.504</td>
<td>0.000</td>
<td>0.203</td>
<td></td>
</tr>
<tr>
<td>61 Measurement</td>
<td>11</td>
<td>105.371</td>
<td>138.497</td>
<td>9.579</td>
<td>0.000</td>
<td>0.204</td>
<td></td>
</tr>
<tr>
<td>51 Measurement</td>
<td>11</td>
<td>106.902</td>
<td>140.027</td>
<td>9.718</td>
<td>0.000</td>
<td>0.206</td>
<td></td>
</tr>
<tr>
<td>64 Measurement</td>
<td>10</td>
<td>98.042</td>
<td>133.238</td>
<td>9.804</td>
<td>0.000</td>
<td>0.207</td>
<td></td>
</tr>
</tbody>
</table>

Table 30: Ten best models specified for tacit knowledge
For this tacit knowledge model, estimated standardized regression weights range from 0.26 to 0.67, corresponding to squared multiple correlation estimates of 0.07 to 0.44.

Chi Square = 23.256 (9 df) 

p = 0.006

Figure 10: Results of specification search for relative reliance on tacit knowledge
Table 31: First measurement model estimates for tacit knowledge

<table>
<thead>
<tr>
<th>Item</th>
<th>Standardized estimate</th>
<th>Standard error of the estimate</th>
<th>Critical ratio</th>
<th>Squared multiple correlation estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZKTacLoc</td>
<td>.661***</td>
<td>0.071</td>
<td>9.276</td>
<td>0.436</td>
</tr>
<tr>
<td>ZKTacTra</td>
<td>.664***</td>
<td>0.071</td>
<td>9.315</td>
<td>0.440</td>
</tr>
<tr>
<td>ZKTacExp</td>
<td>.535***</td>
<td>0.075</td>
<td>7.144</td>
<td>0.287</td>
</tr>
<tr>
<td>ZKTacAcq</td>
<td>.648***</td>
<td>0.072</td>
<td>9.039</td>
<td>0.420</td>
</tr>
<tr>
<td>ZKTacVal</td>
<td>.666***</td>
<td>0.072</td>
<td>9.287</td>
<td>0.444</td>
</tr>
<tr>
<td>ZKTacObs</td>
<td>.258**</td>
<td>0.082</td>
<td>3.135</td>
<td>0.066</td>
</tr>
</tbody>
</table>

*** *p < 0.001; ** *p < 0.01; * *p < 0.05; † *p < 0.10

The standardized estimates of the loadings in the table above range from uninterpretable (0.258) to fair (0.535) to very good (0.648, 0.661, 0.664, 0.666) (Comrey & Lee, 1992; Tabachnick & Fidell, 2007). All estimates were significant (*p < 0.01).

The specification search for the tacit knowledge latent variable resulted in a preferred measurement model that included all six observed items. This differs from the result of factor analysis, which resulted in one less item (ZKTacObs was removed during factor analysis). The item measuring tacit knowledge from the perspective of observability (ZKTacObs) had a factor loading of only 0.26, which is less than the generally acceptable value of 0.40 (Lattin et al., 2003) and below the value of 0.32 where it may be considered interpretable (Tabachnick & Fidell, 2007) and should thus be discarded (Comrey & Lee, 1992). The squared multiple correlation estimate was less than 0.07 indicating that the latent variable explained less than 7% of the variance in ZKTacObs. Therefore, in keeping with Lattin (2003), Tabachnick (2007), and Comrey (1992), model 58 was retained for the measurement model. Model 58, which is consistent with the results of the factor analysis in the previous section, is displayed in the following figure.
For the proposed tacit knowledge model, regression weights ranged from 0.54 to 0.67, consistent with the results previously obtained with the factor analysis in the previous section. The squared multiple correlation estimates of the relationships ranged from 0.29 to 0.45.
Table 32: Estimates for selected tacit knowledge model

<table>
<thead>
<tr>
<th>Item</th>
<th>Standardized estimate</th>
<th>Standard error of the estimate</th>
<th>Critical ratio</th>
<th>Squared multiple correlation estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZKTacLoc</td>
<td>0.658***</td>
<td>0.071</td>
<td>9.200</td>
<td>0.433</td>
</tr>
<tr>
<td>ZKTacTra</td>
<td>0.673***</td>
<td>0.071</td>
<td>9.443</td>
<td>0.453</td>
</tr>
<tr>
<td>ZKTacExp</td>
<td>0.535***</td>
<td>0.075</td>
<td>7.125</td>
<td>0.287</td>
</tr>
<tr>
<td>ZKTacAcq</td>
<td>0.685***</td>
<td>0.072</td>
<td>9.175</td>
<td>0.433</td>
</tr>
<tr>
<td>ZKTacVal</td>
<td>0.649***</td>
<td>0.072</td>
<td>8.978</td>
<td>0.422</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

The measurements of the model are also good. The lowest squared multiple correlation estimate is 0.287, and this is a reasonable value to obtain in social sciences research. With the other squared multiple correlation estimates > 0.422, this indicates that the model is able to account for a large proportion of the variance in the observed variables. The following table compares the various fit statistics for both the preferred measurement model generated by the specification search and the selected measurement model based on the factor analysis.

Table 33: Comparative model summaries for tacit knowledge

<table>
<thead>
<tr>
<th>Fit statistic</th>
<th>Preferred model (1)</th>
<th>Selected model (58)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMIN (likelihood ratio chi-square)</td>
<td>23.256</td>
<td>32.654</td>
<td>Lower = better</td>
</tr>
<tr>
<td>DF (degrees of freedom)</td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.006</td>
<td>0.000</td>
<td>Reject measurement model if sample size is ‘small’</td>
</tr>
<tr>
<td>CMIN/DF</td>
<td>2.584</td>
<td>3.265</td>
<td>Very rough rule of thumb, should be &lt; 2 (Ullman, 2007)</td>
</tr>
<tr>
<td>NFI (normed fit index)</td>
<td>0.909</td>
<td>0.873</td>
<td>Model 1 is acceptable (&gt; 0.9), model 58 is not.</td>
</tr>
<tr>
<td>RFI (rho 1)</td>
<td>0.788</td>
<td>0.732</td>
<td>Closer to 1 = better</td>
</tr>
<tr>
<td>IFI (incremental fit index)</td>
<td>0.942</td>
<td>0.908</td>
<td>Acceptable (&gt; 0.9)</td>
</tr>
<tr>
<td>TLI (Tucker-Lewis index)</td>
<td>0.859</td>
<td>0.798</td>
<td>Closer to 1 = better</td>
</tr>
<tr>
<td>CFI (comparative fit index)</td>
<td>0.939</td>
<td>0.904</td>
<td>Acceptable (&gt; 0.9)</td>
</tr>
<tr>
<td>Fit statistic</td>
<td>Preferred model (1)</td>
<td>Selected model (58)</td>
<td>Remarks</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>---------------------</td>
<td>---------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>PRATIO (parsimony ratio)</td>
<td>0.429</td>
<td>0.476</td>
<td>Degrees of freedom of measurement model divided by degrees of freedom of the independence model</td>
</tr>
<tr>
<td>PNFI (parsimony normed fit index)</td>
<td>0.390</td>
<td>0.415</td>
<td>NFI times PRATIO; Higher = better</td>
</tr>
<tr>
<td>PCFI (parsimony comparative fit index)</td>
<td>0.403</td>
<td>0.430</td>
<td>CFI times PRATIO; Higher = better</td>
</tr>
<tr>
<td>NCP (non-centrality parameter)</td>
<td>14.256</td>
<td>22.654</td>
<td>Used to calculate RMSEA</td>
</tr>
<tr>
<td>F0</td>
<td>0.069</td>
<td>0.110</td>
<td>Used to calculate RMSEA</td>
</tr>
<tr>
<td>RMSEA (root mean square error of approximation)</td>
<td>0.088</td>
<td>0.105</td>
<td>Close-fitting model &lt; 0.05; Good model &lt; 0.06; Adequate model &lt; 0.08; Poor model &gt; 0.10 Smaller = better (Saturated/Unconstrained AIC = 54.000)</td>
</tr>
<tr>
<td>AIC (Akaike information criterion)</td>
<td>59.256</td>
<td>66.654</td>
<td>Smaller = better (Saturated/Unconstrained AIC = 54.000)</td>
</tr>
<tr>
<td>BCC (Browne-Cudeck criterion)</td>
<td>60.522</td>
<td>67.850</td>
<td>Smaller = better (Saturated/Unconstrained BCC = 55.899)</td>
</tr>
<tr>
<td>ECVI (expected cross-validation index)</td>
<td>0.288</td>
<td>0.324</td>
<td>Smaller = better (Saturated/Unconstrained ECVI = .262)</td>
</tr>
<tr>
<td>MECVI (modified ECVI)</td>
<td>0.294</td>
<td>0.329</td>
<td>Smaller = better (Saturated/Unconstrained MECVI = .271)</td>
</tr>
<tr>
<td>HOELTER 0.05</td>
<td>150</td>
<td>116</td>
<td>Sample size is greater, explaining P above</td>
</tr>
<tr>
<td>HOELTER 0.01</td>
<td>192</td>
<td>147</td>
<td>Sample size is greater, explaining P above</td>
</tr>
</tbody>
</table>

Most fit statistics deteriorated moving from model 1 to model 58 with the exceptions of PRATIO, PNFI, and PCFI, which improved. The improvements are due to model 58 being more parsimonious than model 1, having one fewer paths to an observed item. The IFI and CFI are still in the acceptable range with the selected measurement model, but the NFI is below the traditional 0.9 standard of acceptability (Bentler & Bonett, 1980). The RMSEA for the selected measurement model is also considered poor (Browne & Cudeck, 1993).

4.4.6.3 Codified Knowledge

The following table ranks the ten best measurement models in descending order (nine best, excluding the saturated / unconstrained model) found by the specification search for codified knowledge. Note that even though adjusted BC was used to rank the models, ranking by normed chi-square, or by RMSEA would not result in any rank reversals.
Table 34: Ten best models specified for codified knowledge

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Model Name</th>
<th>df</th>
<th>( \chi^2 )</th>
<th>Adjusted BCC</th>
<th>( \chi^2 / df )</th>
<th>p</th>
<th>RMSEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sat</td>
<td>[Saturated]</td>
<td>0</td>
<td>0.000</td>
<td>11.169</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Measurement</td>
<td>12</td>
<td>13.675</td>
<td>0.000</td>
<td>1.140</td>
<td>0.000</td>
<td>0.026</td>
</tr>
<tr>
<td>28</td>
<td>Measurement</td>
<td>11</td>
<td>13.224</td>
<td>1.619</td>
<td>1.202</td>
<td>0.000</td>
<td>0.031</td>
</tr>
<tr>
<td>29</td>
<td>Measurement</td>
<td>11</td>
<td>13.532</td>
<td>1.927</td>
<td>1.230</td>
<td>0.000</td>
<td>0.033</td>
</tr>
<tr>
<td>30</td>
<td>Measurement</td>
<td>11</td>
<td>13.536</td>
<td>1.932</td>
<td>1.231</td>
<td>0.000</td>
<td>0.033</td>
</tr>
<tr>
<td>38</td>
<td>Measurement</td>
<td>10</td>
<td>13.036</td>
<td>3.502</td>
<td>1.304</td>
<td>0.000</td>
<td>0.038</td>
</tr>
<tr>
<td>39</td>
<td>Measurement</td>
<td>10</td>
<td>13.128</td>
<td>3.594</td>
<td>1.313</td>
<td>0.000</td>
<td>0.039</td>
</tr>
<tr>
<td>40</td>
<td>Measurement</td>
<td>10</td>
<td>13.386</td>
<td>3.852</td>
<td>1.339</td>
<td>0.000</td>
<td>0.041</td>
</tr>
<tr>
<td>44</td>
<td>Measurement</td>
<td>9</td>
<td>12.938</td>
<td>5.474</td>
<td>1.438</td>
<td>0.000</td>
<td>0.046</td>
</tr>
<tr>
<td>19</td>
<td>Measurement</td>
<td>12</td>
<td>42.338</td>
<td>28.664</td>
<td>3.528</td>
<td>0.000</td>
<td>0.111</td>
</tr>
</tbody>
</table>

The results of the specification search may be confirmed using the traditional chi-square difference test (Tabachnick & Fidell, 2007). Model 18 in the table above is the preferred measurement model and is based on only three observed items (ZKCodLoc, ZKCodTra, ZKCodAcq), while model 28 is a nested comparison of model 18 with one additional path to an observed item. Model 28 comes closest to the preferred measurement model in terms of normed chi-square, adjusted BCC and RMSEA. The chi-square difference is 0.451 (13.675 – 13.224) with one degree of freedom (12 – 11). Since this difference is not significant (\( p = 0.502 \)), model 18 is not significantly better than model 28. The following table lists the p-values of the chi-square differences between the preferred measurement model generated by the specification search and other nested models.

Table 35: Comparison of preferred measurement model with nested models

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Observed items in measurement model</th>
<th>df</th>
<th>( \chi^2 )</th>
<th>( \Delta \chi^2 )</th>
<th>p-value of ( \Delta \chi^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>ZKCodLoc, ZKCodTra, ZKCodAcq *</td>
<td>12</td>
<td>13.675</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Model Number</td>
<td>Observed items in measurement model</td>
<td>df</td>
<td>$\chi^2$</td>
<td>$\Delta \chi^2$</td>
<td>p-value of $\Delta \chi^2$</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------</td>
<td>----</td>
<td>---------</td>
<td>--------</td>
<td>-----------------</td>
</tr>
<tr>
<td>28</td>
<td>ZKCodLoc, ZKCodTra, ZKCodAcq, and ZKCodVal</td>
<td>11</td>
<td>13.224</td>
<td>0.451</td>
<td>0.502</td>
</tr>
<tr>
<td>29</td>
<td>ZKCodLoc, ZKCodTra, ZKCodAcq, and ZKCodObs</td>
<td>11</td>
<td>13.532</td>
<td>0.142</td>
<td>0.706</td>
</tr>
<tr>
<td>30</td>
<td>ZKCodLoc, ZKCodTra, ZKCodAcq, and ZKCodExp</td>
<td>11</td>
<td>13.536</td>
<td>0.139</td>
<td>0.709</td>
</tr>
</tbody>
</table>

* Result of specification search

The p-values indicate a lack of significant differences between a number of possible measurement models. This may be a reflection of the low reliability of model 18 as calculated in the previous section 4.4.3.3. The following figure displays the results of the specification search for codified knowledge.

Figure 12: Results of specification search for codified knowledge

Chi Square = 13.675 (12 df) 
$p = .322$
For the proposed codified knowledge model, regression weights ranged from 0.48 to 0.72, consistent with the results previously obtained with the factor analysis in the previous section. The squared multiple correlation estimates of the relationships ranged from 0.23 to 0.52.

Table 36: Measurement model estimates for codified knowledge

<table>
<thead>
<tr>
<th>Item</th>
<th>Standardized estimate</th>
<th>Standard error of the estimate</th>
<th>Critical ratio</th>
<th>Squared multiple correlation estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZKCodLoc</td>
<td>.718***</td>
<td>0.115</td>
<td>6.226</td>
<td>0.516</td>
</tr>
<tr>
<td>ZKCodTra</td>
<td>.484***</td>
<td>0.093</td>
<td>5.174</td>
<td>0.234</td>
</tr>
<tr>
<td>ZKCodAcq</td>
<td>.510***</td>
<td>0.096</td>
<td>5.319</td>
<td>0.260</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

The standardized estimates of the loadings in the table above range from fair (0.848, 0.510) to excellent (0.718) (Comrey & Lee, 1992). All estimates are significant (p < 0.001). The table below lists various model fit statistics for the preferred measurement model.

Table 37: Model fit summary for codified knowledge

<table>
<thead>
<tr>
<th>Fit statistic</th>
<th>Measurement model</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMIN (likelihood ratio chi-square)</td>
<td>13.675</td>
<td>Lower = better</td>
</tr>
<tr>
<td>DF (degrees of freedom)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.322</td>
<td>Rejects null hypothesis of a “bad model fit”</td>
</tr>
<tr>
<td>CMIN/DF</td>
<td>1.140</td>
<td>Very rough rule of thumb, should be &lt; 2 (Ullman, 2007)</td>
</tr>
<tr>
<td>NFI (normed fit index)</td>
<td>0.811</td>
<td>Unacceptable (&lt; 0.9)</td>
</tr>
<tr>
<td>RFI (rho 1)</td>
<td>0.670</td>
<td>Closer to 1 = better</td>
</tr>
<tr>
<td>IFI (incremental fit index)</td>
<td>0.972</td>
<td>Acceptable (&gt; 0.9)</td>
</tr>
<tr>
<td>TLI (Tucker-Lewis index)</td>
<td>0.943</td>
<td>Closer to 1 = better</td>
</tr>
<tr>
<td>CFI (comparative fit index)</td>
<td>0.967</td>
<td>Acceptable (&gt; 0.9)</td>
</tr>
<tr>
<td>PRATIO (parsimony ratio)</td>
<td>0.571</td>
<td>Degrees of freedom of measurement model divided by degrees of freedom of the independence model</td>
</tr>
<tr>
<td>PNFI (parsimony normed fit index)</td>
<td>0.464</td>
<td>NFI times PRATIO; Higher = better</td>
</tr>
<tr>
<td>PCFI (parsimony comparative fit index)</td>
<td>0.553</td>
<td>CFI times PRATIO; Higher = better</td>
</tr>
<tr>
<td>Fit statistic</td>
<td>Measurement model</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>NCP (non-centrality parameter)</td>
<td>1.675</td>
<td>Used to calculate RMSEA</td>
</tr>
<tr>
<td>F0</td>
<td>0.008</td>
<td>Used to calculate RMSEA</td>
</tr>
<tr>
<td>RMSEA (root mean square error of approximation)</td>
<td>0.026</td>
<td>Close-fitting model &lt; 0.05; Good model &lt; 0.06; Adequate model &lt; 0.08; Poor model &gt; 0.10</td>
</tr>
<tr>
<td>AIC (Akaike information criterion)</td>
<td>43.675</td>
<td>Smaller = better (Saturated/Unconstrained AIC = 54.000)</td>
</tr>
<tr>
<td>BCC (Browne-Cudeck criterion)</td>
<td>44.730</td>
<td>Smaller = better (Saturated/Unconstrained BCC = 55.899)</td>
</tr>
<tr>
<td>ECVI (expected cross-validation index)</td>
<td>0.212</td>
<td>Smaller = better (Saturated/Unconstrained ECVI = .262)</td>
</tr>
<tr>
<td>MECVI (modified ECVI)</td>
<td>0.217</td>
<td>Smaller = better (Saturated/Unconstrained MECVI = .271)</td>
</tr>
<tr>
<td>HOELTER 0.05</td>
<td>317</td>
<td>Sample size is greater, explaining P above</td>
</tr>
<tr>
<td>HOELTER 0.01</td>
<td>395</td>
<td>Sample size is greater, explaining P above</td>
</tr>
</tbody>
</table>

Despite the ability of structural equation modeling to specify a model for codified knowledge with a number of acceptable fit statistics, this variable is not included in any statistical tests in subsequent sections (Similarly, the selected model for the tacit knowledge is not the preferred model resulting from the specification search). Instead, I decided to go forward with the more traditional results based on the Cronbach’s alpha tests and confirmatory factor analyses of previous subsections. This decision was made because the results of the multiple fit statistics of the structural equation models were less unequivocal than the statistical results of the Cronbach’s alpha tests and the confirmatory factor analyses.

4.4.7 Discriminant validity using Structural Equation Modeling

Bagozzi, Yi, and Phillips (1991) found the traditional Campbell and Fiske (1959) procedure of determining discriminant validity lacking, especially for neglecting differences in magnitudes between pairs of correlations which are related to the degree of convergent and discriminant validity. One recommended technique is to compare a constrained structural equation model with an unconstrained one to see if their chi-squares differ significantly (Bagozzi
et al., 1991). Since there are more than two latent variables or constructs, this technique is must be applied to each pair. Discriminant validity was tested by calculating the difference in chi-square between unconstrained and constrained models of construct pairs following the example of McEvily and Zaheer (McEvily & Zaheer, 1999) and presented in the following table. Unconstrained models allowed the correlation between the latent variables to vary freely, while the constrained models constrained the correlations between them to unity (perfect correlation). A significantly lower chi-square value for the unconstrained models relative to the constrained models supported the discriminant validity for all three constructs.

<table>
<thead>
<tr>
<th>Latent variables (constructs)</th>
<th>Model</th>
<th>Chi-square (df)</th>
<th>Chi-square difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tacit and encapsulated</td>
<td>Unconstrained</td>
<td>312.742 (43)</td>
<td>454.515***</td>
</tr>
<tr>
<td></td>
<td>Constrained</td>
<td>767.257 (44)</td>
<td></td>
</tr>
<tr>
<td>Tacit and codified</td>
<td>Unconstrained</td>
<td>213.333 (19)</td>
<td>97.471***</td>
</tr>
<tr>
<td></td>
<td>Constrained</td>
<td>310.804 (20)</td>
<td></td>
</tr>
<tr>
<td>Encapsulated and codified</td>
<td>Unconstrained</td>
<td>240.932 (26)</td>
<td>282.147***</td>
</tr>
<tr>
<td></td>
<td>Constrained</td>
<td>523.079 (27)</td>
<td></td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10
df = degrees of freedom

4.4.8 External validity

External validity or generalizability refers to the extent that research findings are applicable to other contexts than the one researched. Specific contexts include other subject populations, other settings, and other time periods. “…[R]esearch progress does not require external validity for any single research study” (Calder, Phillips, & Tybout, 1982, p.243), but progress does require falsifiability to enable future studies to confirm, refute, or expand findings. Generalizability is not tested in this study and delimitations are discussed in section 1.5.2.
4.4.9 Lack of a Reliable Measure for Codified Knowledge

Both the scale reliability tests and the confirmatory factor analysis failed to produce a reliably measurable latent variable of reliance on codified knowledge. Accordingly, all statistical tests in the following sections and chapters were conducted without any measurements of relative reliance on codified knowledge.

4.5 Differences between Portfolio Managers and other Investment Management Professionals

4.5.1 Background

All mutual funds have portfolio managers. Some mutual funds have multiple portfolio managers (multi-managed) and some only have one (single-managed). Some portfolio managers are involved in the management of only one mutual fund and some are involved in the management of a number of mutual funds. Every combination of mutual fund to portfolio manager relationship exists (one-to-one, one-to-many, many-to-one, and many-to-many). In other words, one mutual fund may have one portfolio manager or more than one portfolio manager, and a number of mutual funds may be managed by a single portfolio manager, or by a group or team of portfolio managers. Each of these relationships may consist of portfolio managers whose firm is affiliated, or not, with the fund management organization. In the case of multi-managed funds, the fund management organization may be affiliated with all, none, or some of the portfolio managers’ organizations. Since the research attempts to explain the presence or absence of inter-firm boundaries, the cases involving multi-managed funds with mixed affiliation were excluded.

All portfolio managers rely on some combination of tacit, codified, and encapsulated knowledge to manage a mutual fund. In the cases of single-managed mutual funds, only one
portfolio manager’s relative reliance on tacit, codified, and encapsulated knowledge is applicable. In the cases of multi-managed funds, the relative reliance of multiple portfolio managers on tacit, codified, and encapsulated knowledge must be taken into account.

4.5.2 Relative Reliance on Knowledge-based Factors of Production

Measures of the relative reliance of 147 individual portfolio managers on tacit, codified, and encapsulated knowledge were collected through the survey. Measures for tacit and encapsulated knowledge may be considered reliable and these were compared to the relative reliance on tacit and encapsulated knowledge of 57 other professionals involved in the management of mutual funds.

The assumption made at the beginning of Chapter 3 suggested that adjacent stages of production are reliant on different combinations of knowledge. It is expected that an analysis of the data will demonstrate a significant difference between the means of relative reliance on knowledge-based factors for the two population segments.

4.5.2.1 Inter-Stage Difference in Reliance on Tacit Knowledge

Using the standardized scale developed in section 4.4, a comparison of mean relative reliance on tacit knowledge by portfolio managers and other investment management professionals suggests that portfolio managers are less reliant on tacit knowledge than other investment management professionals. Similar tests were performed on unstandardized scales, with similar results. The next table illustrates the difference between the two groups of professionals.

Table 39: Difference in relative reliance on tacit knowledge by role

<table>
<thead>
<tr>
<th></th>
<th>Portfolio managers</th>
<th>Other investment management professionals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Relative reliance on tacit knowledge</td>
<td>-0.096</td>
<td>0.969</td>
</tr>
</tbody>
</table>
Levene’s test for the variances of the two groups of professionals generated a small value for the F-statistic with a $p$-value greater than 0.05. This indicates that the null hypothesis of homoscedasity may be rejected, which is the desired outcome (Cohen, Cohen, West, & Aiken, 2003, p.133). Levene's test is a test of the hypothesis that all variances are equal against the alternative that the variances are not all equal. Levene’s Test is an alternative to the Bartlett test, which is known to be more sensitive to departures from normality. Generally, even when the null hypothesis of homoscedasity may not be rejected ($p < 0.05$), the results of the t-tests are for practical purposes indistinguishable.

The magnitude of the difference between mean relative reliance on tacit knowledge between portfolio managers and other investment management professionals is about 0.344, and the difference is significant ($p < 0.05$). This evidence suggests that relative reliance on tacit knowledge differs between portfolio managers and other investment management professionals.

Effect size “serves as an index of the degree of departure from the null hypothesis” (Cohen, 1988, p.10). Cohen’s ‘d’ was calculated to be 0.34 units of within-population standard deviation (Cohen, 1992; Rosnov, Rosenthal, & Rubin, 2000), which may be interpreted as a small-to-medium effect size (Cohen, 1988). By convention, Cohen’s ‘d’ effect sizes of 0.20, 0.50, and 0.80 are considered small, medium, and large, respectively (Cohen, 1988). Small effect sizes are typical in new areas of research inquiry where the variable is a new measure for which data has not previously been collected (Cohen, 1988). The power of the test (or the probability of correctly rejecting a false null hypothesis, calculated as 1 minus the probability of a Type II error or 1 minus beta) was determined to be 59% (DSS Research, 2006; Faul, Erdfelder, Lang, & Buchner, 2007a, 2007b) when alpha was set at 0.05 (two-tailed).
4.5.2.2 Inter-Stage Difference in Reliance on Encapsulated Knowledge

A comparison of the mean relative reliance on encapsulated knowledge by portfolio managers and other investment management professionals, using the standardized scale developed in section 4.4 found evidence of a difference, but only at the 0.101 level. Similar tests were performed on unstandardized scales, with similar results.

If the assumption is restated as a one-sided test: “Portfolio managers are relatively more reliant on encapsulated knowledge than other investment management professionals”, then the alpha is one-tailed, and the results barely significant. With a one-tailed test, the evidence could then be interpreted to suggest that portfolio managers are more reliant on encapsulated knowledge than other investment management professionals (\( p = 0.0505 \), one-tailed).

Cohen’s ‘d’ was calculated to be 0.26 units of within-population standard deviation (Cohen, 1992; Rosnov et al., 2000), which may be interpreted as a small-to-medium effect size (Cohen, 1988). The power of the test was calculated to be 38% (DSS Research, 2006; Faul et al., 2007a, 2007b) when alpha was set to 0.05 (two-tailed) and 50% when alpha was set to 0.10 (two-tailed). In other words, when alpha is 0.10 there is a 50% probability that the test would correctly reject the null hypothesis when it is actually false.

<table>
<thead>
<tr>
<th>Table 40: Differences in relative reliance on encapsulated knowledge by role</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Relative reliance on encapsulated knowledge</td>
</tr>
</tbody>
</table>

*** \( p < 0.001 \); ** \( p < 0.01 \); * \( p < 0.05 \); † \( p < 0.10 \)

4.5.3 The effects of the CFA designation

The variety of roles performed by other investment management professionals relative to the more circumscribed portfolio manager role suggests that the probability that other investment
management professionals are holders of the Chartered Financial Analyst (CFA) designation will be lower than that for portfolio managers. A cross tabulation indicates that the proportion of portfolio managers who are CFA holders (74.3%) is higher than the proportion of other investment management professionals who are CFA holders (44.1%). To analyse whether or not this was significant, a chi-square test was conducted to determine if the Role and CFA variables were independent. The results were significant ($p < 0.001$) indicating that the null hypothesis of independence may be ruled out, and that Role and CFA variables are related. The evidence suggests that portfolio managers are significantly more likely to be holders of the CFA designation than other investment management professionals.

Table 41: CFA designation status by role

<table>
<thead>
<tr>
<th>Role</th>
<th>CFA holder</th>
<th>Non-holder</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio manager</td>
<td>110 (53%)</td>
<td>38 (18%)</td>
<td>148 (71%)</td>
</tr>
<tr>
<td>Other investment professional</td>
<td>26 (13%)</td>
<td>33 (16%)</td>
<td>59 (29%)</td>
</tr>
<tr>
<td>Total</td>
<td>136 (66%)</td>
<td>71 (34%)</td>
<td>207</td>
</tr>
</tbody>
</table>

Chi square = 17.137, df = 1, $p < 0.001$

For a robustness check, and to assess the effect of the CFA designation linear regressions were performed with relative reliance on tacit and encapsulated knowledge as the dependent variable and with dummy variables for role (1 = portfolio manager) and CFA designation (1 = holder) as independent variables. The results lend support to the assumption that relative reliance on different knowledge-based factors differs between adjacent stages of production, although the adjusted R-squares of the regressions are both less than 0.066.

Evidence suggests the role of portfolio manager appears to be significantly negatively related to reliance on tacit knowledge ($p$-value = 0.009), while holding the CFA designation appears to only to be marginally positively related ($p$-value = 0.078). This also suggests that
holding a CFA designation tends to counteract a portfolio manager’s low reliance on tacit knowledge.

Effect size serves as measure of the degree of departure from no effect (Cohen, 1988). Cohen’s ‘$f^2$’ index\(^ {15}\) was calculated to be 0.04, which may be interpreted as a small-to-medium effect size (Cohen, 1988). By convention, $f^2$ effect sizes of 0.02, 0.15, and 0.35 are considered small, medium, and large, respectively (Cohen, 1988). The power of the test was calculated to be 73\% (Faul, Erdfelder, Lang, & Buchner, 2007b, 2007a) when alpha was set at 0.05 (two-tailed).

Evidence suggests the role of portfolio manager appears to be significantly positively related to reliance on encapsulated knowledge ($p$-value = 0.011), while holding the CFA designation appears to be significantly negatively related ($p$-value = 0.001). This suggests also that holding a CFA designation tends to counteract a portfolio manager’s high reliance on encapsulated knowledge.

Cohen’s ‘$f^2$’ index was calculated to be 0.07, which may be interpreted as a small-to-medium effect size (Cohen, 1988). The power of the test was calculated to be 93\% (Faul et al., 2007b, 2007a) when alpha was set at 0.05 (two-tailed).

The following table summarizes the linear regression models for relative reliance on the two classifications of knowledge by role and CFA accreditation. Unstandardized regression coefficients are provided as well as adjusted $R^2$, F-statistic for the $R^2$, and model significance. The intercept terms were insignificant ($p$-values = 0.397 and 0.765 for the tacit and encapsulated regression model intercepts, respectively).

\[^{15} f^2 = R^2 / (1 - R^2) \]
Table 42: Linear regression of tacit and encapsulated knowledge on independent variables of role and CFA accreditation

<table>
<thead>
<tr>
<th></th>
<th>Tacit</th>
<th>Encapsulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.125</td>
<td>0.044</td>
</tr>
<tr>
<td>Role</td>
<td>-0.421**</td>
<td>0.402*</td>
</tr>
<tr>
<td>CFA</td>
<td>0.269†</td>
<td>-0.504**</td>
</tr>
</tbody>
</table>

Model statistics

<table>
<thead>
<tr>
<th></th>
<th>Tacit</th>
<th>Encapsulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R^2)</td>
<td>0.039</td>
<td>0.066</td>
</tr>
<tr>
<td>F-statistic</td>
<td>4.078*</td>
<td>7.150**</td>
</tr>
<tr>
<td>Significance</td>
<td>0.018</td>
<td>0.001</td>
</tr>
</tbody>
</table>

N = 204

*** \(p < 0.001\); ** \(p < 0.01\); * \(p < 0.05\); † \(p < 0.10\)

4.5.4 Other relationships

Other relationships, between variables for which data was collected from the respondents and relative reliance on knowledge-based factors of production, were tested but, with the exception of one, none were found to be significant \((p < 0.05)\). Some of the variables tested included years of experience, levels of accreditation, and for portfolio managers, type of strategy employed.

The exceptional relationship was between portfolio management strategies employed and the relative reliance on encapsulated knowledge. Portfolio managers were asked to report the relative importance of the various strategies (equity, fixed income, and alternative) that they employed. A significant positive correlation was found between reliance on encapsulated knowledge and the application of alternative strategies, and a significant negative correlation was found between the reliance on encapsulated knowledge and the application of equity strategies. This suggests that portfolio managers implementing alternative strategies are perhaps more reliant on canned computer models and other forms of encapsulated knowledge while those
implementing equity strategies are perhaps more reliant on tacit and/or codified knowledge. No significant relationship was found between the relative reliance on tacit knowledge and the portfolio management strategy employed. The following table displays the correlations.

Table 43: Pearson correlations between equity, fixed income, and alternative strategies and relative reliance on knowledge-based factors of production

<table>
<thead>
<tr>
<th>Strategy applied</th>
<th>Tacit</th>
<th>Encapsulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>.101</td>
<td>-.187*</td>
</tr>
<tr>
<td>Fixed Income</td>
<td>-.039</td>
<td>.039</td>
</tr>
<tr>
<td>Alternative</td>
<td>-.104</td>
<td>.219**</td>
</tr>
</tbody>
</table>

N = 147

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

4.6 Summary

This chapter presented the findings derived from survey data designed to measure the relative reliance on tacit and encapsulated knowledge as factors of production in adjacent stages in the mutual fund industry. To the best of my knowledge, these findings provide the first evidence that measures of knowledge (albeit in relative terms) may be collected and employed as factors of production in the examination of adjacent stages of production in an industry. The results suggest that portfolio managers, as an upstream stage of production in the mutual fund industry, are less reliant on tacit knowledge and more reliant on encapsulated knowledge than other investment management professionals in the adjacent downstream stage. It also appears that relative reliance on encapsulated knowledge is positively related to the application of alternative portfolio strategies by portfolio managers and negatively related to the application of equity portfolio strategies.
4.6.1 Synthesis of Findings

These findings may be variously interpreted, but the results of analysis provide evidence that suggests that the assumption that relative reliance on tacit, codified, and encapsulated knowledge differs between adjacent stages of production goes some distance in answering the first research question, ‘Are there differences in fundamental knowledge-based factors of production between adjacent stages of a value chain?’ While codified knowledge was not reliably measured, relative reliance on tacit and encapsulated knowledge does appear to differ between adjacent stages of production in the mutual fund industry. In the sample population, the upstream stage’s lower (higher) reliance on tacit (encapsulated) knowledge relative to the downstream stage was offset by the effect of the CFA designation. This could possibly indicate that the training undertaken to achieve the CFA designation may lead holders of the designation to become more reliant on tacit knowledge.

4.6.2 Limitations

The distinction between portfolio managers and other investment management professionals as two adjacent stages of production is somewhat subjective and may be less discrete than assumed in this study. Many value chains are not strictly linear, and even though the model of the mutual fund complex shown in Figure 8 in Chapter 3 presents a linear model, this is likely only representative of the structure of the roles and functions performed by the majority of the individuals who responded to the survey. One can imagine, for example, a relatively small ‘boutique’ firm where the delineation of responsibilities is not so clear as represented in Figure 8. Portfolio managers who also perform some of the functions of the other investment management professionals could reasonably be expected to rely on a combination of knowledge-based factors that reflects those additional functions, and which would be different
from the combination of knowledge-based factors of those exclusively engaged in portfolio management. In addition, those other investment management professionals who indicated that Portfolio Analysis was one of their areas of responsibility could be considered upstream of portfolio managers and/or could be considered apprentices preparing to eventually take on the role of portfolio manager. When those other investment management professionals who perform portfolio analysis are reclassified with portfolio managers, the statistics for the two t-tests measuring difference in relative reliance on tacit and encapsulated knowledge both increase in significance. This suggests that the distinction between designations of portfolio managers and other investment management professionals is less discrete than a simple bifurcation would suggest and that the functions performed by some individuals may straddle two adjacent stages of production.
5.1 Introduction

Argote, McEvily and Reagans (Argote et al., 2003, p.579) suggest that, “More research is needed on how knowledge is embedded… and the effect of where knowledge is embedded on performance outcomes”. This chapter seeks to advance that research, by first relating measures of relative reliance on tacit and encapsulated knowledge to the presence or absence of inter-firm boundaries (vertical de-integration or integration), then by relating these knowledge-based factors of production to performance. This chapter begins with a description of the secondary data used in conjunction with the primary survey data to test the hypothesis. It describes in detail how the two sources of data were combined. A section that tests for relationships between relative reliance on tacit and encapsulated knowledge, and vertical integration and de-integration follows. In the last section of this chapter, the relationship between organizational structure and performance is examined, with relative reliance on tacit and encapsulated knowledge being used as predictors of both.

5.2 Secondary Data

The secondary mutual fund data consisted of a number of linked tables provided by Fundata Canada Inc (Fundata). The data came in nine separate files that contained a variety of tables. Two files contained fields associated with 10,116 mutual fund records. Another file contained fields associated with 3,891 portfolio manager records. Yet another file contained fields relating mutual funds to individual portfolio managers and contained data on 30,131
A final file contained fields relating various risk and performance measures to records of some 6,270 mutual funds for various periods ending December 31, 2006.

The performance measures were dated as of December 31, 2006 and conformed to National Instrument 81-106, ‘Investment Fund Continuous Disclosure’ and the related Form 81-106F, ‘Contents of Annual and Interim Management Report of Fund Performance’. This instrument and policy took effect on June 1, 2005 and consolidated and harmonized all of the continuous disclosure requirements for investment funds across Canada. Required performance measures include year-by-year returns, and annual compound returns for ten, five, three, and one year periods, and if an investment fund was a reporting issuer for less than ten years, annual compound return since inception. Also required for comparison purposes are one or more appropriate broad-based securities market indices.

To extend the research, mutual funds with available performance measurements were linked to the survey data collected from the portfolio managers who managed them.

16 As discussed in section 4.5, all mutual funds have portfolio managers and every combination of mutual fund to portfolio manager relationship exists (one-to-one, one-to-many, many-to-one, and many-to-many). Each unique association of a portfolio manager with a mutual fund is considered a single relationship. For example, one portfolio manager managing a single mutual fund would be considered a single relationship. Likewise, three portfolio managers managing a single mutual fund or one portfolio manager single-handedly managing three mutual funds would both be considered three relationships. Finally, a group of four portfolio managers sharing the investment management of four mutual funds would be considered 16 relationships.
5.2.1 Organizing the Data

Almost half of the 30,131 relationship records provided by Fundata had ended some time before the end of 2006. Relationships that were no longer in effect were removed so that only records of those relationships in effect to the end of 2006 would be considered. 17,384 relationships remained in effect at the end of 2006. The 17,384 relationship records were compared with the 6,270 mutual fund records in the file with risk and performance data fields. The 6,270 mutual funds were found to involve 9,949 relationships with portfolio managers, for an average of just over 1.6 relationships per mutual fund.

These 9,949 relationships were carefully examined and divided between those that consisted of a single portfolio manager and mutual fund (single-managed), and those where more than one portfolio manager was involved with a given mutual fund (multi-managed).

5.2.1.1 Determining Structure

The 9,949 relationships were also painstakingly examined on a fund-by-fund basis to determine whether or not the portfolio managers’ firms were affiliated with the mutual fund managers’ organizations or not. If the portfolio management organization was part of the fund management firm or if they shared common ownership in excess of 10%, then the portfolio manager was deemed to be affiliated and with the mutual fund and the organizational structure was considered to be vertically integrated. If no ownership link was found, then the portfolio manager was considered to be unaffiliated with the mutual fund, and the organizational structure was considered vertically de-integrated. For example, a mutual fund sponsored by Sun Life, or a fund managed by CI Funds Management Inc., for which an individual from McLean Budden acted as portfolio manager would be considered a vertically integrated relationship, since Sun Life Financial Inc. indirectly owns about 35% of CI Fund Management Inc. as well as about 55%
of McLean Budden Limited. Similarly, all mutual funds sponsored by Canada Life Assurance Company and London Life Insurance Company, for which individuals from Mackenzie Financial Corporation acted as portfolio managers, would be considered vertically integrated through ultimate common ownership by Power Corporation of Canada.

The demarcation at 10% ownership was selected for practical reasons. Firms are not required to report ownership levels below 10% to securities regulators and therefore information regarding ownership levels below 10% is not publicly available. Interestingly, one senior executive who was interviewed hinted that one potential motivation for de-integration could be the circumvention of the requirement to report ownership in a publicly traded company in excess of 10%. While the 10% delineation is arbitrary, it has its basis in securities law, and any other threshold, such as that described in Footnote 1, would be just as arbitrary.

5.2.1.2 Refining Relationships

Of all of the original 9,949 relationships between portfolio managers and investment funds, 1,587 were excluded from further analysis for one of three reasons. Some relationships were excluded because they consisted of mixed affiliations (both affiliated and unaffiliated portfolio managers associated with a single fund). Other relationships were excluded because the

17 The wording according to the Ontario Securities Act, Section 101(1) is: “Every offeror that acquires beneficial ownership of, or the power to exercise control or direction over, or securities convertible into, voting or equity securities of any class of a reporting issuer that, together with such offeror’s securities of that class, would constitute 10 per cent or more of the outstanding securities of that class, (a) shall issue and file forthwith a news release containing the information prescribed by the regulations…” (Securities Act, 2007).
portfolio management organization was not identified. And still other relationships were excluded because they consisted of some combination of identified and unidentified portfolio management organizations. The decision to exclude these relationships differs from that taken by Chen, Hong, and Kubik (2006) to designate funds with mixed portfolio management affiliation as de-integrated. The decision to exclude these relationships in this study was based on the goal of this research to allocate performance effects between affiliated and unaffiliated portfolio managers on a fund-by-fund basis, and the impossibility of doing so with mixed portfolio management.

Finally, a further 1,503 single-managed relationships were removed because the Fundata tables did not identify an individual portfolio manager. The distribution of all of the relationships is displayed in the following table.

Table 44: Relationships between portfolio managers and mutual funds by organizational structure and all management modes

<table>
<thead>
<tr>
<th></th>
<th>Single-managed</th>
<th>Multi-managed</th>
<th>Mixed or Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affiliated/Integrated</td>
<td>1595</td>
<td>2421</td>
<td></td>
<td>4016</td>
</tr>
<tr>
<td>Unaffiliated/De-Integrated</td>
<td>779</td>
<td>2064</td>
<td></td>
<td>2843</td>
</tr>
<tr>
<td>Mixed or Unknown</td>
<td></td>
<td></td>
<td>3090</td>
<td>3090</td>
</tr>
<tr>
<td>Total</td>
<td>2374</td>
<td>4485</td>
<td>3090</td>
<td>9949</td>
</tr>
</tbody>
</table>

The 6,859 usable relationships remaining after excluding the 3,090 relationships in the Mixed and Unknown category are displayed in the following table.
Table 45: Relationships between portfolio managers and mutual fund management firms by organizational structure and known management mode

<table>
<thead>
<tr>
<th></th>
<th>Single-managed (One)</th>
<th>Multi-managed (&gt; One)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affiliated/Integrated</td>
<td>1,595 (23%)</td>
<td>2,421 (35%)</td>
<td>4,016 (59%)</td>
</tr>
<tr>
<td>Unaffiliated/De-integrated</td>
<td>779 (11%)</td>
<td>2,064 (30%)</td>
<td>2,843 (41%)</td>
</tr>
<tr>
<td>Total</td>
<td>2,374 (35%)</td>
<td>4,485 (65%)</td>
<td>6,859</td>
</tr>
</tbody>
</table>

The original 9,949 relationships involved 5,894 mutual funds as displayed in the following table. The 894 integrated multi-managed funds corresponded to the 2421 integrated multi-managed relationships, or about 2.7 portfolio managers per integrated multi-managed fund. The 642 de-integrated multi-managed funds corresponded to the 2,064 de-integrated multi-managed relationships, or about 3.2 portfolio managers per de-integrated multi-managed fund.

Table 46: Mutual funds by organizational structure and all management modes

<table>
<thead>
<tr>
<th></th>
<th>Single-managed (One)</th>
<th>Multi-managed (&gt; One)</th>
<th>Mixed or Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated</td>
<td>1595</td>
<td>894</td>
<td></td>
<td>4016</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>779</td>
<td>642</td>
<td>1984</td>
<td>2843</td>
</tr>
<tr>
<td>Mixed or Unknown</td>
<td></td>
<td></td>
<td>1984</td>
<td>1984</td>
</tr>
<tr>
<td>Total</td>
<td>2374</td>
<td>1536</td>
<td>1984</td>
<td>5894</td>
</tr>
</tbody>
</table>

The table containing performance measurement fields for 6,270 mutual funds provided by Fundata was found to have some funds’ fields unpopulated. This slightly reduced the number of available mutual funds from 5,894 to 5,811, which were used as the basis for further analyses. It also reduced the 1,595 integrated single-managed relationships in the previous two tables to 1,569 integrated single-managed mutual funds in the next table. Since these relationships are all one-to-one, they would otherwise be equal to the number of integrated single-managed mutual funds, as are the 779 de-integrated single-managed relationships and mutual funds.
The 5,811 mutual funds belonged to one of the 38 fund categories defined by the Canadian Investment Funds Standards Committee (www.cifsc.org) as presented in the following table.

<table>
<thead>
<tr>
<th>CIFSC Category</th>
<th>Number of Funds</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Equity</td>
<td>614</td>
<td>10.6%</td>
</tr>
<tr>
<td>Canadian Equity</td>
<td>531</td>
<td>9.1%</td>
</tr>
<tr>
<td>Canadian Balanced</td>
<td>501</td>
<td>8.6%</td>
</tr>
<tr>
<td>U.S. Equity</td>
<td>468</td>
<td>8.1%</td>
</tr>
<tr>
<td>Global Balanced</td>
<td>310</td>
<td>5.3%</td>
</tr>
<tr>
<td>Canadian Bond</td>
<td>288</td>
<td>5.0%</td>
</tr>
<tr>
<td>Canadian Equity (Pure)</td>
<td>257</td>
<td>4.4%</td>
</tr>
<tr>
<td>Global Balance - Equity Focus</td>
<td>250</td>
<td>4.3%</td>
</tr>
<tr>
<td>Canadian Dividend and Equity Income</td>
<td>218</td>
<td>3.8%</td>
</tr>
<tr>
<td>Alternative Strategies</td>
<td>217</td>
<td>3.7%</td>
</tr>
<tr>
<td>International Equity</td>
<td>210</td>
<td>3.6%</td>
</tr>
<tr>
<td>Canadian Money Market</td>
<td>207</td>
<td>3.6%</td>
</tr>
<tr>
<td>Canadian Income Balanced</td>
<td>169</td>
<td>2.9%</td>
</tr>
<tr>
<td>Canadian Balanced - Equity Focus</td>
<td>161</td>
<td>2.8%</td>
</tr>
<tr>
<td>Canadian Small-Cap Equity</td>
<td>113</td>
<td>1.9%</td>
</tr>
<tr>
<td>European Equity</td>
<td>95</td>
<td>1.6%</td>
</tr>
<tr>
<td>Labour Sponsored Venture Capital</td>
<td>88</td>
<td>1.5%</td>
</tr>
<tr>
<td>U.S. Small- and Mid-Cap Equity</td>
<td>87</td>
<td>1.5%</td>
</tr>
<tr>
<td>Specialty or Miscellaneous</td>
<td>85</td>
<td>1.5%</td>
</tr>
<tr>
<td>Foreign Bond</td>
<td>82</td>
<td>1.4%</td>
</tr>
<tr>
<td>Natural Resources</td>
<td>79</td>
<td>1.4%</td>
</tr>
<tr>
<td>Canadian Income Trusts</td>
<td>72</td>
<td>1.2%</td>
</tr>
<tr>
<td>Canadian Tactical Asset Allocation</td>
<td>72</td>
<td>1.2%</td>
</tr>
<tr>
<td>CIFSC Category</td>
<td>Number of Funds</td>
<td>Percent</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Science &amp; Technology</td>
<td>71</td>
<td>1.2%</td>
</tr>
<tr>
<td>Canadian Balanced - Fixed Income Focus</td>
<td>70</td>
<td>1.2%</td>
</tr>
<tr>
<td>Canadian Short Term Bond and Mortgage</td>
<td>66</td>
<td>1.1%</td>
</tr>
<tr>
<td>North American Equity</td>
<td>65</td>
<td>1.1%</td>
</tr>
<tr>
<td>High Yield Bond</td>
<td>54</td>
<td>0.9%</td>
</tr>
<tr>
<td>Asia ex-Japan Equity</td>
<td>53</td>
<td>0.9%</td>
</tr>
<tr>
<td>Emerging Markets Equity</td>
<td>46</td>
<td>0.8%</td>
</tr>
<tr>
<td>Asia/Pacific Rim Equity</td>
<td>36</td>
<td>0.6%</td>
</tr>
<tr>
<td>Health Care</td>
<td>31</td>
<td>0.5%</td>
</tr>
<tr>
<td>Japanese Equity</td>
<td>30</td>
<td>0.5%</td>
</tr>
<tr>
<td>Financial Services</td>
<td>29</td>
<td>0.5%</td>
</tr>
<tr>
<td>Canadian Focus Equity</td>
<td>25</td>
<td>0.4%</td>
</tr>
<tr>
<td>U.S. Money Market</td>
<td>23</td>
<td>0.4%</td>
</tr>
<tr>
<td>Real Estate</td>
<td>21</td>
<td>0.4%</td>
</tr>
<tr>
<td>Precious Metals</td>
<td>17</td>
<td>0.3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,811</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The 3,856 usable mutual funds remained after excluding the funds in the Mixed and Unknown category from the 5,811 available mutual funds. A chi-square test was conducted to determine if the organizational structure (integrated or de-integrated) and management mode (multi-managed or single-managed) variables were related. The results were significant ($p < 0.001$) indicating that the null hypothesis of independence may be ruled out, and that organizational structure and management mode variables are significantly related. The following table illustrates the distribution.
Table 48: Mutual funds by organizational structure and known management mode

<table>
<thead>
<tr>
<th></th>
<th>Single-managed (One)</th>
<th>Multi-managed (&gt; One)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated</td>
<td>1,569 (40.7%)</td>
<td>869 (22.5%)</td>
<td>2,438 (63.2%)</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>779 (20.2%)</td>
<td>639 (16.6%)</td>
<td>1,418 (36.8%)</td>
</tr>
<tr>
<td>Total</td>
<td>2,348 (60.9%)</td>
<td>1,508 (39.1%)</td>
<td>3,856</td>
</tr>
</tbody>
</table>

Chi square = 33.404, df = 1, p < 0.001

5.3 Combining Knowledge-Based Factors with Boundary and Performance Data

Of the 147 portfolio managers who responded to the survey, 87 could be identified as individual portfolio managers in the secondary mutual fund data. The remaining 60 were likely included in the secondary data as part of a ‘team’ of portfolio managers. Unfortunately, there was no definitive method of learning the identities of the individuals constituting each team for the various periods under evaluation. The 87 portfolio managers were found in 619 relationships with mutual funds or about seven mutual funds for each portfolio manager.

The distribution of relationships is skewed with a few portfolio managers related to a large number of mutual funds. It appears that these portfolio managers manage many essentially identical funds. These ‘clone’ funds are simply white label products re-branded for sale by a variety of mutual fund management firms and/or distributors. It is also possible that some portfolio managers, if they have a good reputation, are assigned for marketing purposes to multi-managed mutual funds to lend credibility to otherwise unfamiliar teams. Being spread over an exceptionally large number of mutual funds probably limits their influence on the performance of each individual mutual fund.

Of the 619 relationships, 198 (32%) were between mutual funds and portfolio managers whose firms were unaffiliated (de-integrated) with the mutual fund management firm, and 421 (68%) were between mutual funds and portfolio managers whose firms were affiliated
(integrated). Also, 171 (28%) of the 619 relationships were single-managed (i.e., the mutual fund had only one portfolio manager). Of the 171 single-managed relationships, 140 (82%) were between mutual funds and portfolio managers whose firms were classified as integrated and 31 (18%) were de-integrated. The table below describes the distribution of the 619 relationships for which at least one portfolio manager was identified as having been surveyed.

<table>
<thead>
<tr>
<th></th>
<th>Single-managed (One)</th>
<th>Multi-managed (&gt; One)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated</td>
<td>140 (23%)</td>
<td>281 (45%)</td>
<td>421 (68%)</td>
</tr>
<tr>
<td>De-integrated</td>
<td>31 (5%)</td>
<td>167 (27%)</td>
<td>198 (32%)</td>
</tr>
<tr>
<td>Total</td>
<td>171 (28%)</td>
<td>448 (72%)</td>
<td>619</td>
</tr>
</tbody>
</table>

The measurements for relative reliance on tacit and encapsulated knowledge of the 87 identifiable portfolio managers were added to the database of 5,811 mutual funds, as applicable. For the 171 single-managed relationships, the measurements of the knowledge-based variables were entered on a one-to-one basis (i.e., the measurements from a single portfolio manager were added to the one mutual fund for which that portfolio manager was identified).

There is an implied assumption that a portfolio manager’s relative reliance on tacit and encapsulated knowledge does not vary between the funds she or he manages. This assumption is questionable, especially in the case of a portfolio manager responsible for funds requiring the application of more than a one strategy. The table in section 4.5.4 suggests that relative reliance on encapsulated knowledge is related to the portfolio management strategy being applied, and a cursory review of the 171 mutual funds suggests that at least nine portfolio managers managed funds with different strategies.
For the multi-managed mutual funds, the knowledge-based measures of the portfolio managers identified with the mutual fund were averaged and then entered. Some multi-managed funds had only one respondent portfolio manager, many had two, and one had five. This process introduced two potential inaccuracies. First, in the cases where less than all of a mutual fund’s portfolio managers are surveyed, the knowledge-based measurements of the non-respondent portfolio managers are excluded from consideration. The implied assumption is that non-respondent portfolio managers’ average relative reliance on tacit and encapsulated knowledge is equal to the average of those who responded.

Second, simply averaging the knowledge-based measures of the portfolio managers assumes that they are all equally influential in the management of a multi-managed mutual fund. This assumption implies that disproportionate influence does not exist between a team of portfolio managers of a multi-managed fund. The implied assumption is limits the accuracy of the knowledge-based measures, unless the assets of a fund are purposefully proportionately managed.

5.3.1 Organizational Structure and Management Mode

The 619 portfolio management relationships were with 430 individual mutual funds, 319 of which had portfolio managers who were considered integrated and 111 of which were considered de-integrated. The larger percentage of integrated mutual funds was similar to the distribution of all 3,856 mutual funds for which both organizational structure and management mode were known. On the other hand, the 60/40 distribution of 259 multi-managed and 171 single-managed mutual funds was a reversal from the 40/60 distribution found with the 3,856 mutual funds. A chi-square test was conducted to analyse whether or not the relationship between organizational structure and management mode previously tested with the 3,856 mutual
funds was also significant with the subset of 430 for which measures of relative reliance on tacit and encapsulated knowledge had been estimated.

The results were significant ($p < 0.01$) indicating that the null hypothesis of independence may be ruled out, and that organizational structure and management mode variables are also significantly related for this subset. The following table illustrates the distribution.

<table>
<thead>
<tr>
<th></th>
<th>Single-managed (One)</th>
<th>Multi-managed (&gt; One)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated</td>
<td>140 (32.6%)</td>
<td>179 (41.6%)</td>
<td>319 (74.2%)</td>
</tr>
<tr>
<td>De-integrated</td>
<td>31 (7.2%)</td>
<td>80 (18.6%)</td>
<td>111 (25.8%)</td>
</tr>
<tr>
<td>Total</td>
<td>171 (39.8%)</td>
<td>259 (60.2%)</td>
<td>430</td>
</tr>
</tbody>
</table>

Chi square = 8.756, df = 1, $p < 0.01$

5.3.2 Comparison of All Respondent Portfolio Managers to Only Those Linked with Mutual Funds

Since measures of relative reliance on tacit and encapsulated knowledge by the portfolio managers of these 430 funds were estimated, a comparison was made between the relative reliance on tacit and encapsulated knowledge of the portfolio managers linked to the mutual funds and the mean of all those who responded to the entire survey. The mean relative reliance on tacit knowledge of the 147 portfolio managers who responded to the survey was -0.0961 (standardized). The mean relative reliance on encapsulated knowledge for these same portfolio managers was 0.0722 (standardized). A t-test was conducted to examine if there were any significant differences between these values and those of the respondent portfolio managers. The evidence suggests that the relative reliance on tacit knowledge for the management of the 430 mutual funds (0.0628) appears to be significantly higher than the mean of all the respondent portfolio managers ($p < 0.001$). At the same time, relative reliance on encapsulated knowledge
for the management of the 430 mutual funds (-0.1908) is significantly lower than the mean of all the respondent portfolio managers ($p < 0.001$).

Cohen’s ‘d’ was calculated to be 0.19 (Cohen, 1992) for the effect size of the difference between relative reliance on tacit knowledge by all surveyed portfolio managers and that calculated for mutual fund portfolio management. This may be interpreted as a small effect size (Cohen, 1988). The power of the test was calculated to be 73% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed), and 91% when alpha was set at 0.01 (two-tailed).

Cohen’s ‘d’ was calculated to be 0.31 (Cohen, 1992) for the effect size of the difference between the relative reliance on encapsulated knowledge by all surveyed portfolio managers and that calculated for mutual fund portfolio management. This may be interpreted as a small-to-medium effect size (Cohen, 1988). The power of the test was calculated to approach 100% (Faul et al., 2007b; 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the t-test results.

Table 51: Difference between estimated reliance on tacit and encapsulated knowledge by all surveyed portfolio managers and by specific mutual fund portfolio managers

<table>
<thead>
<tr>
<th></th>
<th>Respondent portfolio managers</th>
<th>Estimated for mutual funds based on subset of portfolio managers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test value</td>
<td>Mean</td>
</tr>
<tr>
<td>Relative reliance on tacit knowledge</td>
<td>-0.0961</td>
<td>0.0628</td>
</tr>
<tr>
<td>Relative reliance on encapsulated knowledge</td>
<td>0.0722</td>
<td>-0.1908</td>
</tr>
</tbody>
</table>

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

5.3.3 Synthesis of Findings

Most mutual funds in the larger sample of 3,856 were integrated and single-managed, but most of the mutual funds in the smaller subset of 430, for which measures relative reliance on knowledge-based factors were calculated, were mostly integrated and multi-managed. This
difference is likely an artefact of the process that was applied to link knowledge-based measures to specific mutual funds. It may simply be that those portfolio managers who responded to the survey were more likely to be part of a team managing a particular fund than those portfolio managers who did not respond to the survey. If this is the case, it and could help explain the results presented in the previous table. A comparison of the mean relative reliance on tacit knowledge for single-managed and multi-managed funds found evidence of greater (lesser) reliance on tacit knowledge when funds were multi-managed (single-managed) \((p < 0.001)\). The increased (decreased) reliance on tacit (encapsulated) knowledge by portfolio managers linked to mutual funds, relative to all surveyed portfolio managers, may be driven by the requirement to create value collectively in an environment dominated by multi-managed mutual funds.

5.4 Knowledge and Inter-firm Boundaries

This study suggested that the presence or absence of an inter-firm boundary is related to differences in the relative reliance on tacit and encapsulated knowledge between the funds’ portfolio managers. Directionally, portfolio managers of de-integrated mutual funds should be even less reliant on tacit knowledge, (to differ more from other investment management professionals) than their integrated counterparts, according to Proposition 1. Alternatively, according to Proposition 2, portfolio managers of de-integrated mutual funds may be relatively more reliant on tacit knowledge than their integrated counterparts.

5.4.1 The Presence or Absence of an Inter-Firm Boundary

A t-test was conducted comparing the mean relative reliance on tacit knowledge of the portfolio managers of 111 de-integrated mutual funds with those of the 319 integrated mutual funds.
**H1a: Relative reliance on tacit knowledge differs between de-integrated and integrated portfolio managers.**

Evidence suggests portfolio managers, de-integrated from the mutual fund management firms of the funds they are managing, are more reliant on tacit knowledge than portfolio managers that are integrated \((p < 0.001)\).

Cohen’s ‘d’ was calculated to be 0.57 (Cohen, 1992) for the effect size of the difference between relative reliance on tacit knowledge by de-integrated portfolio managers and by integrated portfolio managers. This may be interpreted as a medium-to-large effect size (Cohen, 1988). The power of the test was calculated to be 97\% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the t-test results.

| Table 52: Difference in relative reliance on tacit knowledge between de-integrated and integrated portfolio managers |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                  | De-integrated   | Integrated      |                  |                  |                  |                  |
|                                  | Mean            | S.D.            | N               | Mean            | S.D.            | N               | t-statistic     |
| Relative reliance on tacit knowledge | 0.414           | 0.850           | 111             | -0.061          | 0.809           | 319             | 5.134***        |

*** \(p < 0.001; ** \(p < 0.01; * \(p < 0.05; † \(p < 0.10

Analysis in Chapter 4 indicated that portfolio managers in general were relatively less reliant on tacit knowledge than other investment management professionals. The result of testing H1a argues against acceptance of Proposition 1, which suggested that de-integrated portfolio managers would be even less reliant on tacit knowledge than other investment management professionals. On the other hand the result of testing H1a does support Proposition 2, which suggests that de-integrated stages will rely more on tacit knowledge than their integrated counterparts.
A t-test was also conducted comparing the mean reliance on encapsulated knowledge of the portfolio managers of 111 de-integrated mutual funds with those of 319 integrated mutual funds.

\textit{H1b: Relative reliance on encapsulated knowledge differs between de-integrated and integrated portfolio managers.}

Evidence suggests portfolio managers de-integrated from the mutual fund management firms are less reliant on encapsulated knowledge than portfolio managers that are integrated ($p < 0.001$, two-tailed).

Cohen’s ‘d’ was calculated to be 0.83 (Cohen, 1992) for the effect size of the difference between relative reliance on tacit knowledge by de-integrated portfolio managers and by integrated portfolio managers. This may be interpreted as a large effect size (Cohen, 1988). The power of the test was calculated to approach 100\% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the t-test results.

<table>
<thead>
<tr>
<th>Table 53: Difference in relative reliance on encapsulated knowledge between de-integrated and integrated portfolio managers</th>
</tr>
</thead>
<tbody>
<tr>
<td>De-integrated</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Relative reliance on encapsulated knowledge</td>
</tr>
</tbody>
</table>

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

Analysis in Chapter 4 indicated that portfolio managers in general were relatively more reliant on encapsulated knowledge than other investment management professionals. The result of testing H1b also argues against acceptance of Proposition 1, which suggested that de-integrated portfolio managers would be even more reliant on encapsulated knowledge than other investment management professionals. On the other hand the result of testing H1b does
indirectly support Proposition 2. Since Proposition 2 suggested that de-integrated stages will rely relatively more on tacit knowledge than their integrated counterparts, it necessarily implies that de-integrated portfolio managers will rely relatively more on encapsulated (and perhaps codified) knowledge. This is because the measures of knowledge-based factors of production are calculated relative to each other (section 3.5).

5.4.2 Differences in Knowledge by Fund Category

The probability of finding portfolio managers integrated or de-integrated varies by the category of mutual fund managed. The following figure displays the percentage of funds that are de-integrated by fund category defined by the Canadian Investment Funds Standards Committee (CIFSC) (www.cifsc.org). CIFSC, a mutual fund industry association, uses 38 categories of mutual funds that are designed to reduce confusion in making comparisons among a proliferation of mutual funds. The number in parentheses appended to each fund category label in the figure represents the total number of funds in that category. A total 3,586 of funds for which structure (de-integrated or integrated) was known and portfolio management was not mixed (i.e., not managed by both integrated and de-integrated portfolio managers) were included. The probability of de-integration by fund category was calculated as part of the work done in section 5.2.
Figure 13: Probability of vertical de-integration by CIFSC fund category
To strengthen the evidence generated by testing hypotheses H1a and H2b, tests were conducted on the basis of fund categories. The 433 mutual funds, for which knowledge-based measures were available, were divided into two approximately equal sized groups – those in categories demonstrating a relatively high probability of de-integration and those demonstrating a relatively low probability of de-integration. There were 214 mutual funds in 12 categories that had a greater than 37% probability of being de-integrated and 211 mutual funds in 26 categories that had a less than 37% probability of being de-integrated. To detect whether or not a relationship existed between relative reliance on tacit knowledge and categories of funds with high and low probabilities of de-integration the following hypothesis was tested.

**H1c:** Relative reliance on tacit knowledge by portfolio managers differs between mutual funds in categories that have a high probability of being de-integrated and those in categories that have a low probability.

Evidence suggests portfolio managers managing funds in categories with a high probability of de-integration are more reliant on tacit knowledge than portfolio managers managing funds in categories with a low probability of de-integration ($p < 0.0005$, one tailed). Cohen’s ‘d’ was calculated to be 0.52 (Cohen, 1992) for the effect size of the difference between relative reliance on tacit knowledge by de-integrated portfolio managers and by integrated portfolio managers. This may be interpreted as a medium effect size (Cohen, 1988). The power of the test was calculated to be 98% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the results.
Table 54: Difference in relative reliance on tacit knowledge between high and low probability of de-integration groups of fund categories

<table>
<thead>
<tr>
<th></th>
<th>Funds in categories with a high (&gt;37%) probability of being de-integrated</th>
<th>Funds in categories with a low (&lt;37%) probability of being de-integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative reliance on tacit knowledge</td>
<td>Mean 0.279  S.D. 0.955  N 214</td>
<td>Mean -0.149  S.D. 0.653  N 219</td>
</tr>
<tr>
<td></td>
<td>t-statistic -5.428***</td>
<td></td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

To detect whether or not a relationship existed between relative reliance on encapsulated knowledge and categories of funds with high and low probabilities of de-integration the following hypothesis was tested.

H1d: Relative reliance on encapsulated knowledge by portfolio managers differs between mutual funds in categories that have a high probability of being de-integrated and those in categories that have a low probability.

Evidence suggests portfolio managers managing funds in categories with a high probability of de-integration are less reliant on encapsulated knowledge than portfolio managers managing funds in categories with a low probability of de-integration (p < 0.0005, one-tailed). Cohen’s ‘d’ was calculated to be 0.57 (Cohen, 1992) for the effect size of the difference between relative reliance on encapsulated knowledge by de-integrated portfolio managers and by integrated portfolio managers. This may be interpreted as a medium-to-large effect size (Cohen, 1988). The power of the test was calculated to be 99% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the results.
Table 55: Difference in relative reliance on encapsulated knowledge between high and low probability of de-integration groups of fund categories

<table>
<thead>
<tr>
<th></th>
<th>Funds in categories with a high (&gt; 37%) probability of being de-integrated</th>
<th>Funds in categories with a low (&lt; 37%) probability of being de-integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Relative reliance on encapsulated knowledge</td>
<td>-0.431</td>
<td>0.892</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

The results of testing H1c and H1d were both found to be supportive of the premise that relative reliance on knowledge-based factors of production is related to firm structure, and substantiated the results reported for H1a and H1b.

5.4.3 Analytical intensity of complex security valuation

Cashman and Deli (2006) found evidence suggesting that portfolio management requiring greater analytical intensity related to complex security valuation was positively associated with the probability of de-integration. Specifically, they found that mutual funds invested primarily in foreign equity had a greater probability of being de-integrated than those invested primarily in domestic equity, which in turn had a greater probability of being de-integrated than those invested primarily in fixed income securities (Cashman & Deli, 2006). To test Cashman and Deli’s (2006) assertion that portfolio management requiring greater analytical intensity related to complex security valuation was positively associated with the probability of de-integration the following hypothesis was tested. An inspection of the names of the CIFSC fund categories and their respective probabilities of de-integration in Figure 13 already provides anecdotal evidence supporting this assertion.

H2a: Foreign equity mutual funds are more likely to be de-integrated than domestic equity mutual funds.
Evidence from all mutual funds identified as foreign equity or domestic equity, not just those for which knowledge-based factors are known, suggests that foreign equity mutual funds have a greater probability of being managed by de-integrated portfolio managers than domestic equity mutual funds ($p < 0.001$). Cohen’s ‘d’ was calculated to be 0.26 (Cohen, 1992) for the effect size of the difference in probability of de-integration between foreign equity and domestic equity mutual funds. This may be interpreted as a small-to-medium effect size (Cohen, 1988). The power of the test was calculated to be 99% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the results.

Table 56: Difference in probability of de-integration between foreign equity and domestic equity mutual funds

<table>
<thead>
<tr>
<th></th>
<th>Foreign equity mutual funds</th>
<th>Domestic equity mutual funds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Probability of de-integrated organizational structure</td>
<td>0.52</td>
<td>0.500</td>
</tr>
</tbody>
</table>

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

To apply the same analysis of Cashman and Deli (2006) relating analytical intensity related to complex security valuation to the probability of de-integration, the following hypothesis was tested on domestic equity and fixed income mutual funds.

**H2b: Domestic equity mutual funds are more likely to be de-integrated than fixed income mutual funds.**

Evidence from all mutual funds identified as domestic equity or fixed income, not just those for which knowledge-based factors are known, suggests that domestic equity mutual funds have a greater probability of being managed by de-integrated portfolio managers than fixed income mutual funds ($p < 0.001$). Cohen’s ‘d’ was calculated to be 0.45 (Cohen, 1992) for the effect size of the difference in probability of de-integration between domestic equity and fixed income mutual funds.
income mutual funds. This may be interpreted as a small-to-medium effect size (Cohen, 1988).

The power of the test was calculated to approach 100% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the results.

<table>
<thead>
<tr>
<th>Probability of de-integrated organizational structure</th>
<th>Mean</th>
<th>S.D.</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>N</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic equity mutual funds</td>
<td>.39</td>
<td>0.488</td>
<td>842</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed income mutual funds</td>
<td>.19</td>
<td>0.396</td>
<td>598</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.184</td>
<td>***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

The results of testing H2a and H2b replicate Cashman and Deli’s (2006) findings that mutual funds invested primarily in foreign equity had a greater probability of being de-integrated than those invested primarily in domestic equity, which in turn had a greater probability of being de-integrated than those invested primarily in fixed income securities.

5.4.4 Tacit Knowledge and Analytic Intensity

Greater analytical intensity suggests greater reliance on tacit knowledge and lesser reliance on encapsulated knowledge. To determine whether or not analytical intensity as suggested by Cashman (2006) may be positively related to relative reliance on tacit knowledge and negatively related to encapsulated knowledge, tests were conducted on mutual funds broadly categorized as foreign equity, domestic equity, and fixed income. Of the 433 mutual funds for which knowledge-based measures were available, 311 fell into the broad categories of foreign equity, domestic equity, and fixed income. The remaining mutual funds that did not fit into one of these three broad categories consisted mainly of balanced and specialty funds. The 311 mutual funds were divided into 117 foreign equity funds, 120 domestic equity funds, and 74 fixed income funds. To detect whether or not evidence of analytical intensity of security valuation
were related to measures of relative reliance on tacit knowledge, the following hypothesis was tested.

\[ H2c: \text{Relative reliance on tacit knowledge by portfolio managers managing foreign equity mutual funds is greater than that for managing domestic equity mutual funds.} \]

This hypothesis is supported. Evidence suggests portfolio managers managing foreign equity mutual funds are more reliant on tacit knowledge than portfolio managers managing domestic equity mutual funds \((p < 0.001)\). Cohen’s ‘d’ was calculated to be 0.71 (Cohen, 1992) for the effect size of the difference between relative reliance on tacit knowledge for foreign equity mutual funds and domestic equity mutual funds. This may be interpreted as a medium-to-large effect size (Cohen, 1988). The power of the test was calculated to be 98\% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the results.

**Table 58: Difference in relative reliance on tacit knowledge between foreign equity and domestic equity mutual funds**

<table>
<thead>
<tr>
<th></th>
<th>Foreign equity mutual funds</th>
<th>Domestic equity mutual funds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Relative reliance on tacit knowledge</td>
<td>0.574</td>
<td>0.968</td>
</tr>
</tbody>
</table>

*** \( p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10 \)

To detect whether or not a relationship existed between relative reliance on encapsulated knowledge and the portfolio management of foreign equity mutual funds and domestic equity mutual funds the following hypothesis was tested.

\[ H2d: \text{Relative reliance on encapsulated knowledge by portfolio managers managing foreign equity mutual funds is less than that for managing domestic equity mutual funds.} \]

This hypothesis was supported. Evidence suggests portfolio managers managing foreign equity mutual funds are less reliant on encapsulated knowledge than those managing domestic
equity mutual funds ($p < 0.001$). Cohen’s ‘d’ was calculated to be 0.79 (Cohen, 1992) for the effect size of the difference between relative reliance on encapsulated knowledge for foreign equity mutual funds and domestic equity mutual funds. This may be interpreted as a medium-to-large effect size (Cohen, 1988). The power of the test was calculated to approach 100% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the results.

Table 59: Difference in relative reliance on encapsulated knowledge between foreign equity and domestic equity mutual funds

<table>
<thead>
<tr>
<th></th>
<th>Foreign equity mutual funds</th>
<th>Domestic equity mutual funds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Relative reliance on encapsulated knowledge</td>
<td>-0.723</td>
<td>0.798</td>
</tr>
</tbody>
</table>

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

The results of testing H2c and H2d provide evidence that relative reliance on tacit knowledge and on encapsulated knowledge are positively and negatively related, respectively, to differences in analytic intensity between foreign and domestic equity securities valuation proposed by Cashman (2006). To detect whether or not similar evidence is also present between domestic equity and fixed income mutual funds, the following was tested.

H2e: Relative reliance on tacit knowledge by portfolio managers managing domestic equity mutual funds is greater than that for managing fixed income mutual funds.

This hypothesis was supported. Evidence suggests portfolio managers managing domestic equity mutual funds are more reliant on tacit knowledge than portfolio managers managing fixed income mutual funds ($p < 0.001$). Cohen’s ‘d’ was calculated to be 0.52 (Cohen, 1992) for the effect size of the difference between relative reliance on tacit knowledge for domestic equity mutual funds and fixed income mutual funds. This may be interpreted as a
medium effect size (Cohen, 1988). The power of the test was calculated to be 56% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the results.

Table 60: Difference in relative reliance on tacit knowledge between domestic equity and fixed income mutual funds

<table>
<thead>
<tr>
<th>Relative reliance on tacit knowledge</th>
<th>Domestic equity mutual funds</th>
<th>Fixed income mutual funds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Relative reliance on tacit knowledge</td>
<td>-0.033</td>
<td>0.713</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

To detect whether or not a relationship existed between relative reliance on encapsulated knowledge, and the portfolio management of domestic equity mutual funds and fixed income mutual funds the following hypothesis was tested.

H2f: Relative reliance on encapsulated knowledge by portfolio managers managing domestic equity mutual funds is less than that for managing fixed income mutual funds.

This hypothesis was supported. Evidence suggests portfolio managers managing domestic equity mutual funds are less reliant on encapsulated knowledge than those managing fixed income mutual funds (p < 0.001). Cohen’s ‘d’ was calculated to be 0.63 (Cohen, 1992) for the effect size of the difference between relative reliance on encapsulated knowledge for domestic equity mutual funds and fixed income mutual funds. This may be interpreted as a medium-to-large effect size (Cohen, 1988). The power of the test was calculated to be 82% (Faul et al., 2007b, 2007a) when alpha was set at 0.001 (two-tailed). The following table presents the results.

Table 61: Difference in relative reliance on encapsulated knowledge between domestic equity and fixed income mutual funds

<table>
<thead>
<tr>
<th>Relative reliance on encapsulated knowledge</th>
<th>Domestic equity mutual funds</th>
<th>Fixed income mutual funds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Relative reliance on encapsulated knowledge</td>
<td>Domestic equity mutual funds</td>
<td>Fixed income mutual funds</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>-0.117</td>
<td>0.729</td>
<td>120</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

The results of testing H2e and H2f also suggest that the idea of greater analytic intensity required to perform domestic equity valuation relative to fixed income, as proposed by Cashman (2006), is positively related to reliance on tacit knowledge and negatively related to reliance on encapsulated knowledge. These results, combined with the results of testing H2a, H2b, H2c, and H2d suggest that the analytical intensity of security valuation put forth by Cashman and Deli (2006) as the reason for de-integration may be positively related to reliance on tacit knowledge and negatively related to reliance on encapsulated knowledge. The following figure presents a summary of the findings from testing H2a to H2f. The size and labels of the spheres represent the probability of de-integration. The scale of both axes is in units of standard deviation.
5.4.5 Testing with Control Variables

The probability of an inter-firm boundary between portfolio managers and other investment management professionals (de-integration of a mutual fund) may be moderated by a number of variables. Mutual fund management firms may, for example, believe that their in-house portfolio management capability is limited in foreign securities, or limited in less traditional hedge funds or synthetic funds, and therefore contract for the necessary skills from
external portfolio managers. Using dummy variables for each of seven investment regions (Canada, USA, North America, Europe, Japan, International, and Global), hedge fund status, and synthetic fund status, the following hypothesis was tested using a logistic regression.

\[ H2g: \text{The probability of de-integration of a mutual fund is related to the portfolio manager’s relative reliance on tacit, and encapsulated knowledge.} \]

The data does not present any significant evidence suggesting that the probability of de-integration is impacted by whether or not a mutual fund is a hedge fund or a synthetic fund \((p > 0.5)\). There is evidence, however, that suggests that three of the seven investment regions influence the probability of de-integration with any significance. Model I in the following table displays the estimated coefficients for only those three investment regions. The specific investment regions that were eventually found to be significant were Canada \((p = 0.013)\), Europe \((p < 0.001)\), and Global \((p = 0.006)\), but Canada only became significant once the knowledge-based variables were added in Model II. The positive coefficient estimates for each of the variables suggest that the probability of de-integration increases for mutual funds invested in any of these regions.

In a second step, the variables for relative reliance on tacit and encapsulated knowledge were added. Estimated coefficients for both of these variables were negative suggesting that increased relative reliance on either tacit or encapsulated knowledge decreases the probability of de-integration, but only the estimate for relative reliance on encapsulated knowledge was

\[ \text{________________________} \]

\[ 18 \text{ The global investment region characterizes mutual funds whose portfolios may include securities from anywhere in the world, while the international investment region characterizes mutual funds whose portfolios are invested outside of Canada and the USA.} \]
significant ($p < 0.001$). Model II in the following table displays the estimated coefficients for all significant variables plus relative reliance on tacit knowledge. Note that the improvement in the $-2 \log$ likelihood from Model I to Model II was significant.

Table 62: Logistic regression estimates for a de-integrated organizational structure using investment regions

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Model I</th>
<th>Model II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.535*** (0.295)</td>
<td>-2.338*** (0.358)</td>
</tr>
<tr>
<td>Investment region is Canada</td>
<td>0.280 (0.332)</td>
<td>0.918* (0.371)</td>
</tr>
<tr>
<td>Investment region is Europe</td>
<td>3.240*** (0.823)</td>
<td>3.615*** (0.823)</td>
</tr>
<tr>
<td>Investment region is Global</td>
<td>0.892* (0.369)</td>
<td>1.146** (0.369)</td>
</tr>
<tr>
<td>Relative reliance on tacit knowledge</td>
<td></td>
<td>-0.388 (0.244)</td>
</tr>
<tr>
<td>Relative reliance on encapsulated knowledge</td>
<td></td>
<td>-1.260*** (0.246)</td>
</tr>
<tr>
<td>$N$</td>
<td>430</td>
<td>430</td>
</tr>
<tr>
<td>$-2 \log$ likelihood</td>
<td>463.336 (3)***</td>
<td>418.983 (5)***</td>
</tr>
<tr>
<td>Improvement in $-2 \log$ likelihood</td>
<td>27.812 (3)***</td>
<td>44.353 (2)***</td>
</tr>
</tbody>
</table>

$^a$ Positive coefficients indicate a greater probability of de-integration. Standard errors are in brackets.
$^b$ *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$
$^c$ $-2 \log$ likelihood for the null model was 491.148. Degrees of freedom are in brackets.

The results of Model II provide support for H1b, even after the inclusion of control variables, but do not provide any support for H1a. The coefficient for Investment Region = Canada is positive, which is contrary to what one would expect given the results of testing H2a.
and H2d, but consistent with the results from testing H2b and H2f. It is possibly due to the variable being associated with more domestic equity funds than fixed income funds.

The probability of de-integration for a mutual fund was calculated for each of the 38 categories of defined by the Canadian Investment Funds Standards Committee, since it was observed in the 3,856 mutual funds for which information was available that it varied by category. This information, presented in the following table, is also available graphically in Figure 13.

Table 63: Probability of de-integration by CIFSC category

<table>
<thead>
<tr>
<th>Canadian Investment Funds Standards Committee category</th>
<th>Probability of de-integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian Tactical Asset Allocation</td>
<td>65.7%</td>
</tr>
<tr>
<td>Emerging Markets Equity</td>
<td>61.3%</td>
</tr>
<tr>
<td>International Equity</td>
<td>57.8%</td>
</tr>
<tr>
<td>U.S. Equity</td>
<td>57.6%</td>
</tr>
<tr>
<td>Global Equity</td>
<td>53.1%</td>
</tr>
<tr>
<td>Canadian Equity (Pure)</td>
<td>47.6%</td>
</tr>
<tr>
<td>European Equity</td>
<td>44.4%</td>
</tr>
<tr>
<td>Canadian Equity</td>
<td>43.7%</td>
</tr>
<tr>
<td>Asia ex-Japan Equity</td>
<td>42.5%</td>
</tr>
<tr>
<td>Canadian Balanced</td>
<td>42.2%</td>
</tr>
<tr>
<td>Health Care</td>
<td>38.7%</td>
</tr>
<tr>
<td>Global Balanced - Equity Focus</td>
<td>36.7%</td>
</tr>
<tr>
<td>U.S. Small- and Mid-Cap Equity</td>
<td>35.9%</td>
</tr>
<tr>
<td>Canadian Small-Cap Equity</td>
<td>34.4%</td>
</tr>
<tr>
<td>Asia/Pacific Rim Equity</td>
<td>33.3%</td>
</tr>
<tr>
<td>Specialty or Miscellaneous</td>
<td>33.3%</td>
</tr>
<tr>
<td>Foreign Bond</td>
<td>32.7%</td>
</tr>
<tr>
<td>Canadian Balanced - Equity Focus</td>
<td>31.6%</td>
</tr>
<tr>
<td>Canadian Investment Funds Standards Committee category</td>
<td>Probability of de-integration</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>High Yield Bond</td>
<td>28.9%</td>
</tr>
<tr>
<td>Science &amp; Technology</td>
<td>26.8%</td>
</tr>
<tr>
<td>Canadian Bond</td>
<td>25.9%</td>
</tr>
<tr>
<td>Alternative Strategies</td>
<td>23.8%</td>
</tr>
<tr>
<td>Canadian Dividend and Equity Income</td>
<td>23.0%</td>
</tr>
<tr>
<td>Global Balanced</td>
<td>21.2%</td>
</tr>
<tr>
<td>Natural Resources</td>
<td>20.6%</td>
</tr>
<tr>
<td>Canadian Short Term Bond and Mortgage</td>
<td>20.5%</td>
</tr>
<tr>
<td>Canadian Income Balanced</td>
<td>17.2%</td>
</tr>
<tr>
<td>Canadian Income Trusts</td>
<td>15.8%</td>
</tr>
<tr>
<td>Japanese Equity</td>
<td>13.6%</td>
</tr>
<tr>
<td>Real Estate</td>
<td>13.3%</td>
</tr>
<tr>
<td>Canadian Money Market</td>
<td>8.5%</td>
</tr>
<tr>
<td>Precious Metals</td>
<td>8.3%</td>
</tr>
<tr>
<td>Financial Services</td>
<td>4.5%</td>
</tr>
<tr>
<td>Labour Sponsored Venture Capital</td>
<td>3.8%</td>
</tr>
<tr>
<td>Canadian Balanced - Fixed Income Focus</td>
<td>3.4%</td>
</tr>
<tr>
<td>Canadian Focus Equity</td>
<td>0.0%</td>
</tr>
<tr>
<td>North American Equity</td>
<td>0.0%</td>
</tr>
<tr>
<td>U.S. Money Market</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

The probability of de-integration associated with each CIFSC category was compared with the relative reliance on tacit and encapsulated knowledge, on a fund-by-fund basis. The results in the table below suggest that the probability of de-integration based on category of funds is positively (although not significantly) related to reliance on tacit knowledge and negatively (and significantly) related to reliance on encapsulated knowledge.
Table 64: Pearson correlations between relative reliance on knowledge-based factors of production and probability of de-integration by fund category

<table>
<thead>
<tr>
<th>Knowledge-based factor</th>
<th>Probability of de-integration by fund category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative reliance on tacit knowledge</td>
<td>0.044</td>
</tr>
<tr>
<td>Relative reliance on encapsulated knowledge</td>
<td>-0.281***</td>
</tr>
</tbody>
</table>

N = 433
*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

On the basis of the significant correlation in the previous table, and to perform a robustness check H2g was also tested using a linear regression model and the probability of de-integration by CIFSC category from the next to previous table as the dependent variable.

Evidence suggests that some regions are significantly related to the probability of de-integration, which is not that surprising given that the 38 categories used to generate the dependent variable are also somewhat regionally derived. Relative reliance on tacit knowledge is not significant, but relative reliance on encapsulated knowledge is significant. Model III in the following table presents a regression without the knowledge-based variables but with the significant investment regions.

Model IV includes both knowledge-based factors of production. The results are consistent with the results of the logistic regression. The adjusted R-square improves almost 6% from Model III to Model IV while the coefficients for the investment regions decrease in size. Evidence is found for increased probability of de-integration for mutual funds invested in Europe, International and USA (consisting more of foreign equity than fixed income), consistent with the results from H2a. Evidence is also found for decreasing the probability of de-integration as relative reliance on encapsulated knowledge increases, consistent with H2d. Note the intercept term still explains most of the nearly 37% average probability of de-integration of all mutual funds. The following table presents the results.
Table 65: Linear regression of the probability of de-integration on the independent variables of relative reliance on tacit and encapsulated knowledge and investment regions

<table>
<thead>
<tr>
<th></th>
<th>Model III</th>
<th>Model IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.343***</td>
<td>0.338***</td>
</tr>
<tr>
<td>Investment region is Europe</td>
<td>0.101*</td>
<td>0.083*</td>
</tr>
<tr>
<td>Investment region is International</td>
<td>0.121***</td>
<td>0.118***</td>
</tr>
<tr>
<td>Investment region is USA</td>
<td>0.123***</td>
<td>0.103***</td>
</tr>
<tr>
<td>Relative reliance on tacit knowledge</td>
<td>-0.005</td>
<td></td>
</tr>
<tr>
<td>Relative reliance on encapsulated knowledge</td>
<td>-0.048***</td>
<td></td>
</tr>
</tbody>
</table>

Model statistics

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>433</td>
<td>433</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.099</td>
<td>0.157</td>
</tr>
<tr>
<td>F-statistic</td>
<td>16.762***</td>
<td>17.141***</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10

A logistic regression test of H2g was also conducted, blending the test relating organizational structure (H2a and H2b) with the tests relating Cashman and Deli’s (2006) categories for analytic intensity to relative reliance on tacit knowledge (H2c and H2e).

Evidence suggests that relative reliance on tacit knowledge is a gauge that may be used to measure the analytic intensity of security valuation put forward by Cashman and Deli (2006).

Model V in the following table presents a logistic regression using only a multinomial variable for Foreign Equity and Domestic Equity relative to Fixed Income. The category of Foreign Equity relative to Fixed Income is significant in explaining the probability of de-integration; the category of Domestic Equity relative to Fixed Income is not significant.

Model VI includes the variable of relative reliance on tacit knowledge by the mutual fund’s portfolio manager(s). The results are consistent with the results of testing H2a and H2c.

The improvement in the -2 log likelihood was significant. The loss of significance for the
Foreign Equity relative to Fixed Income coefficient with the introduction of the significant tacit knowledge variable in Model VI suggests that relative reliance on tacit knowledge may be an effective quantifier of analytic intensity in security valuation.

Two alternatives to Model VI were also tested. One alternative added a relative reliance on encapsulated variable, while the other alternative replaced the relative reliance on tacit knowledge with relative reliance on encapsulated knowledge. With either alternative, the Foreign Equity relative to Fixed Income coefficient still becomes insignificant with the addition of the encapsulated knowledge variable, but the Domestic Equity relative to Fixed Income coefficient begins to approach significance ($p = 0.09$).

**Table 66: Logistic regression estimates for a de-integrated organizational structure using Cashman and Deli’s categories of analytic intensity\(^a,b,c\)**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Model V</th>
<th>Model VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.455*** (0.297)</td>
<td>-1.283*** (0.303)</td>
</tr>
<tr>
<td>Foreign Equity relative to Fixed Income</td>
<td>1.064** (0.353)</td>
<td>0.533 (0.399)</td>
</tr>
<tr>
<td>Domestic Equity relative to Fixed Income</td>
<td>-0.279 (0.392)</td>
<td>-0.487 (0.402)</td>
</tr>
<tr>
<td>Relative reliance on tacit knowledge</td>
<td></td>
<td>0.557** (0.179)</td>
</tr>
<tr>
<td>$N$</td>
<td>308</td>
<td>308</td>
</tr>
<tr>
<td>-2 Log likelihood</td>
<td>327.002 (2)***</td>
<td>316.625 (3)***</td>
</tr>
<tr>
<td>Improvement in -2 Log likelihood(^c)</td>
<td>21.576 (2)***</td>
<td>10.377 (1)***</td>
</tr>
</tbody>
</table>

\(^a\) Positive coefficients indicate a greater probability of de-integration. Standard errors are in brackets.

\(^b\) *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

\(^c\) -2 Log likelihood for the null model was 348.578. Degrees of freedom are in brackets.
5.4.6 Synthesis of Findings

The evidence from H1a and H1b, provides one possible answer to the second research question, ‘How can differences in knowledge-based factors of production explain the presence or absence of inter-firm boundaries?’ Proposition 1 proposed that ‘The presence of an inter-firm boundary between adjacent stages in a value chain is positively related to the size of the differences in relative reliance on tacit, codified, and encapsulated knowledge between those stages’. Surveyed portfolio managers were less (more) reliant on tacit (encapsulated) knowledge than other surveyed investment management professionals in the mutual fund industry. Therefore, for Proposition 1 to be supported, the reliance on tacit (encapsulated) knowledge by de-integrated portfolio managers should have decreased (increased) even further from that relied upon by other investment management professionals. The results of testing H1a and H1b do not support Proposition 1.

Proposition 2 proposed that ‘A greater probability of de-integration for a given stage of production will be positively associated with a greater reliance on tacit knowledge in that stage’. The greater relative reliance on tacit knowledge may also be interpreted as a reduced relative reliance on encapsulated knowledge because the measures were constructed relative to one another. The results of testing H1a and H2b suggest that Proposition 2 is supported.

The testing of H1c and H1d provided significant and powerful evidence that suggested the probability of de-integration, for individual mutual funds based on each mutual fund’s CIFSC category, was positively affected by relative reliance on tacit and negatively affected by relative reliance on encapsulated knowledge by the funds’ portfolio managers. The size of the effect ranged from medium to large (Cohen, 1988). The evidence was consistent with that of H1a and H1b.
The results of testing of H2a and H2b provide confirmatory evidence for Cashman and Deli’s (2006) findings suggesting that foreign equity mutual funds are more likely to be de-integrated than domestic equity mutual funds, which in turn are more likely to be de-integrated than fixed income mutual funds. The results of testing H2c through to H2f suggest that relative reliance on tacit (encapsulated) knowledge is positively (negatively) related to the analytical intensity of complex security valuation as characterized by the broad categories of foreign equity, domestic equity, and fixed income (Cashman & Deli, 2006). The results of testing H2a through H2f appears to provide an answer for the second research question of how do differences in knowledge-based factors of production explain the presence or absence of inter-firm boundaries. These results taken together appear to suggest that increasing analytic intensity of complex security valuation as revealed by increasing (decreasing) relative reliance on tacit (encapsulated) knowledge gives rise to an increasing probability of an inter-firm boundary.

A final premise, embodied in H2g, combines variables from the t-tests, H2a through to H2f, and examines whether or not the effects suggested by these hypotheses are affected by other variables. H2g is first tested using a logistic regression incorporating moderating effects from hedge-fund status, synthetic fund status, and investment region. The results of the first logistic regression suggest that whether or not a mutual fund is a hedge fund, or a synthetic fund, does not impact the probability that it will be de-integrated. The results also lend support to the evidence from H1b and H1d, that relative reliance on encapsulated knowledge is negatively related to the probability of de-integration. The negative co-efficient for the relative reliance on tacit knowledge in H2g Model II is unexpected given the evidence from testing H1a and H1c, but it may not be too troubling. First, it should be noted that the co-efficient was not significant ($p > 0.10$). Second, the evidence from testing H2a and H2b, in combination with the evidence
from testing H2c and H2e suggest that the significant positive coefficients for investment regions of Canada, Europe, and Global may capture the effect of relative reliance on tacit knowledge. Note that the coefficients for all the investment regions of Canada, Europe and Global are positive supporting evidence from H2c and H2e, and that they are larger for foreign mutual funds (Europe and Global) than for the domestic one (Canada), supporting evidence from H2a.

The probability of de-integration of a mutual fund for which knowledge-based factors of production were measured is just under 37%. The second test of H2g used a linear regression to provide some indication of how a portfolio managers’ relative reliance on encapsulated knowledge affects this probability. Evidence from H2g Model IV suggests that the majority of the probability of de-integration (almost 34% out of the 37%, captured in the intercept term) remains unexplained. There is significant evidence to suggest that one may expect an increase in the probability of de-integration if a mutual fund invests predominantly in one of the regions of Europe (8.3%), International (11.8%) or USA (10.3%). There is also significant evidence that the probability of de-integration decreases about 5% for a one standard deviation increase in relative reliance on encapsulated knowledge. No significant change in the probability of de-integration is directly attributable to relative reliance on tacit knowledge. The effect of relative reliance on tacit knowledge may be indirectly captured in the significant and positive coefficients found for investments in foreign regions, consistent with H2a and H2c. The inclusion of variables measuring relative reliance on tacit and encapsulated knowledge in Model IV improves the adjusted R², from 9.9% in Model III, to 15.7%.

The third test of H2g is a logistic regression that directly tests whether or not relative reliance on tacit knowledge may be used as a measure of analytic intensity in security valuation as suggested by Cashman and Deli’s (2006). The results in Model V confirm the findings of H2a
and H2b, that Foreign Equity mutual funds are more likely de-integrated than Domestic Equity and Fixed Income funds. The results of Model VI confirm the findings of H1a and H1c, that the probability of de-integration is positively related to relative reliance on tacit knowledge. Models V and VI combined suggest that greater analytic intensity in security valuation is revealed in this research as greater relative reliance on tacit knowledge. The addition of the significant tacit knowledge variable is the only difference between Model V and Model VI causes the Foreign Equity relative to Fixed Income variable to loose its significance.

5.5 Structure and Performance

5.5.1 Does Structure Matter?

According to the literature reviewed in Chapter 1, the governance structure of productive activities appears to impact performance, so it is a fair question to test with the data available for this research. The short answer is, yes, structure matters for returns and for risk. But, for risk-adjusted returns evidence is mixed, consistent with an efficient market hypothesis (Fama, 1970). Since returns are related to risk (Markowitz, 1952, 1959), the emphasis in this section is on risk-adjusted returns. There are some interesting findings, however, when returns and risk are examined independently, and these are briefly reported.

5.5.2 Returns Based on Structure

Structure matters for returns independent of risk. Returns are higher for de-integrated mutual funds than for integrated ones for shorter and longer durations ending December 31, 2006, but they are higher for integrated mutual funds for medium durations. As the following table shows, differences in returns are generally only significant ($p < 0.05$) for the shorter durations when sample sizes exceed 3,000. Interestingly, the standard deviation of returns is less for de-integrated mutual funds for all measurement periods. This suggests that portfolio
managers who are de-integrated from the mutual fund management firms may on average be managing risk within a tighter band than integrated portfolio managers. The difference in standard deviation of returns could also be an artefact of the CIFSC categories of funds. It may be that the deviation of returns is higher for those CIFC categories that have a higher probability of de-integration, and lower for those categories with a lower probability of de-integration.

Table 67: Descriptive statistics for returns and t-test for differences in mean returns between integrated and de-integrated mutual funds for periods ending December 31, 2006

<table>
<thead>
<tr>
<th>Structure</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Mean Difference</th>
<th>Effect Size (α = .001, 2-tailed)</th>
<th>Power of the Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-month simple</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>2097</td>
<td>1.787</td>
<td>2.193</td>
<td>-.674***</td>
<td>0.33 (small to med.)</td>
<td>~100%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>1196</td>
<td>2.460</td>
<td>1.907</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-month simple</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>2110</td>
<td>6.797</td>
<td>6.406</td>
<td>-1.727***</td>
<td>0.29 (small to med.)</td>
<td>~100%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>1190</td>
<td>8.524</td>
<td>5.346</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-month simple</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>2024</td>
<td>8.889</td>
<td>7.669</td>
<td>-2.469***</td>
<td>0.34 (small to med.)</td>
<td>~100%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>1174</td>
<td>11.358</td>
<td>6.812</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-year simple</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1967</td>
<td>11.051</td>
<td>11.238</td>
<td>-1.210**</td>
<td>0.34 (small to med.)</td>
<td>~100%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>1146</td>
<td>12.262</td>
<td>8.815</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-year compound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1775</td>
<td>9.857</td>
<td>8.709</td>
<td>-.728*</td>
<td>0.09 (&lt; small)</td>
<td>16%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>992</td>
<td>10.585</td>
<td>7.128</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-year compound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1636</td>
<td>9.005</td>
<td>7.054</td>
<td>-.421</td>
<td>0.06 (&lt; small)</td>
<td>4%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>934</td>
<td>9.426</td>
<td>6.205</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-year compound return</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1429</td>
<td>9.990</td>
<td>7.685</td>
<td>-.403</td>
<td>0.06 (&lt; small)</td>
<td>2%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>820</td>
<td>10.394</td>
<td>6.680</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-year compound return</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1207</td>
<td>5.908</td>
<td>6.599</td>
<td>.493</td>
<td>0.08 (&lt; small)</td>
<td>5%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>650</td>
<td>5.415</td>
<td>6.035</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-year compound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>988</td>
<td>4.684</td>
<td>6.971</td>
<td>.997**</td>
<td>0.15 (&lt; small)</td>
<td>32%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>524</td>
<td>3.687</td>
<td>5.994</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-year compound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>835</td>
<td>4.836</td>
<td>6.800</td>
<td>1.224**</td>
<td>0.19 (&lt; small)</td>
<td>42%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>410</td>
<td>3.612</td>
<td>6.355</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.5.3 Risk Based on Structure

Structure matters for all risk measures observed, independent of returns. De-integrated mutual funds appear to be riskier judging by the means of every risk measure, and the differences in risk are significant ($p < 0.05$) for all but the 10-year beta, and 10-year R-squared. The variation in risk, however, is less for de-integrated mutual funds for every risk measure. This suggests that portfolio managers who are de-integrated from mutual fund management firms may be assuming more risk than their integrated counterparts control that risk in a tighter band. This observation supports Chen, Hong and Kubik (2006) who found evidence that de-integrated portfolio managers deviated less from the norm in risk-taking. They attributed this behaviour by de-integrated portfolio managers to the higher probability of contract termination they faced in the event of poor performance (Chen et al., 2006). The following table presents the comparison of the risk measures.

<table>
<thead>
<tr>
<th>Structure</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Mean Difference</th>
<th>Effect Size ($\alpha = .001$, 2-tailed)</th>
<th>Power of the Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-year compound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>680</td>
<td>6.024</td>
<td>6.030</td>
<td>.416</td>
<td>0.07 (&lt; small)</td>
<td>1%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>290</td>
<td>5.608</td>
<td>5.358</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-year compound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>546</td>
<td>5.760</td>
<td>4.583</td>
<td>.004</td>
<td>~0.0 (&lt; small)</td>
<td>0.1%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>217</td>
<td>5.764</td>
<td>3.610</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-year compound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>465</td>
<td>5.807</td>
<td>4.152</td>
<td>-.286</td>
<td>0.08 (&lt; small)</td>
<td>0.7%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>174</td>
<td>6.093</td>
<td>3.325</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Since inception</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>2115</td>
<td>7.595</td>
<td>8.550</td>
<td>.858**</td>
<td>0.11 (&lt; small)</td>
<td>44%</td>
</tr>
<tr>
<td>De-integrated</td>
<td>1196</td>
<td>6.738</td>
<td>6.376</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$
| Table 68: Descriptive statistics of risk measures and t-test for differences in mean risk between integrated and de-integrated mutual funds for periods ending December 31, 2006 |
|-------------------------------|-------------|-------------|----------------|-----------------|-----------------|-----------------|
|                               | Structure   | N           | Mean          | Standard Deviation | Mean Difference | Effect Size (α = .001, 2-tailed) | Power of the Test |
| 3-year beta                   | Integrated  | 1523        | .855          | .4203             | -.154***        | 0.39 (small to med.)              | ~100%            |
|                               | De-integrated | 926       | 1.01          | .3701             |                 |                               |                 |
| 5-year beta                   | Integrated  | 1099        | .881          | .3614             | -.105***        | 0.30 (small to med.)              | ~100%            |
|                               | De-integrated | 643       | .986          | .3335             |                 |                               |                 |
| 10-year beta                  | Integrated  | 406         | .830          | .4161             | -.043           | 0.12 (< small)                   | 2%               |
|                               | De-integrated | 170       | .874          | .2891             |                 |                               |                 |
| 3-year R-squared              | Integrated  | 1522        | .723          | .2228             | -.063***        | 0.31 (small to med.)              | ~100%            |
|                               | De-integrated | 926       | .786          | .1771             |                 |                               |                 |
| 5-year R-squared              | Integrated  | 1097        | .749          | .2077             | -.054***        | 0.28 (small to med.)              | 99%              |
|                               | De-integrated | 643       | .803          | .1727             |                 |                               |                 |
| 10-year R-squared             | Integrated  | 401         | .695          | .2259             | -.031†          | 0.15 (< small)                   | 5%               |
|                               | De-integrated | 164       | .726          | .1765             |                 |                               |                 |
| 3-year standard deviation     | Integrated  | 1636        | 2.55         | 1.404             | -.230***        | 0.18 (< small)                   | 89%              |
|                               | De-integrated | 934       | 2.78         | 1.059             |                 |                               |                 |
| 5-year standard deviation     | Integrated  | 1207        | 2.92         | 1.696             | -.362***        | 0.24 (small to med.)              | 95%              |
|                               | De-integrated | 650       | 3.29         | 1.259             |                 |                               |                 |
| 10-year standard deviation    | Integrated  | 465         | 3.43         | 2.181             | -.523**         | 0.26 (small to med.)              | 35%              |
|                               | De-integrated | 174       | 3.95         | 1.842             |                 |                               |                 |
| 3-year volatility             | Integrated  | 1635        | 4.42         | 2.437             | -.774***        | 0.34 (small to med.)              | ~100%            |
|                               | De-integrated | 934       | 5.19         | 2.080             |                 |                               |                 |
| 5-year volatility             | Integrated  | 1206        | 4.52         | 2.494             | -.864***        | 0.36 (small to med.)              | ~100%            |
|                               | De-integrated | 650       | 5.38         | 2.205             |                 |                               |                 |
| 10-year volatility            | Integrated  | 465         | 4.11         | 2.436             | -.938***        | 0.41 (small to med.)              | 90%              |
|                               | De-integrated | 174       | 5.05         | 2.170             |                 |                               |                 |

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10 (two-tailed)
5.5.4 Risk-Adjusted Returns and Structure

Three risk-adjusted return measures were examined: Jensen’s Alpha (1968; 1969), the Treynor Index (1965), and the Sharpe Ratio (1966). These measures are related as indicated in the following formulas (Bodie, Kane, & Marcus, 1993, p.804):

Jensen’s measure is calculated as $\alpha_p = \bar{r}_p - \left[ \bar{r}_f + \beta_p \left( \bar{r}_M - \bar{r}_f \right) \right]$;

Treynor’s measure is calculated as $\left( \bar{r}_p - \bar{r}_f \right) / \beta_p$;

Sharpe’s measure is calculated as $\left( \bar{r}_p - \bar{r}_f \right) / \sigma_p$;

where $\alpha_p$ = Jensen’s Alpha, $\bar{r}_p$ = average portfolio return over the sample period, $\bar{r}_f$ = the average risk-free interest rate over the sample period, $\beta_p$ = the portfolio’s beta over the sample period (a measure of systematic risk equal to the standard deviation of portfolio returns relative to that of the market), and $\bar{r}_M$ = the average return on the market portfolio over the sample period. $\left( \bar{r}_p - \bar{r}_f \right)$ is also defined as the excess return, and $\bar{r}_f + \beta_p \left( \bar{r}_M - \bar{r}_f \right)$ is the capital asset pricing model or CAPM (Lintner, 1965; Mossin, 1966; Sharpe, 1964).

Whether or not structure is related to risk-adjusted performance depends on the measure used to gauge performance and on the duration over which the measure is applied. Integrated mutual funds appear, on average, to outperform de-integrated ones when measured by 3-year Jensen’s Alpha, 3-year Sharpe Ratio, 5-year Jensen’s Alpha, 5-year Sharpe Ratio, 5-year Treynor Index, and 10-year Jensen’s Alpha. On the other hand, de-integrated mutual funds appear, on average, to outperform integrated ones when measured by 3-year Treynor Index, 10-year Sharpe Ratio, and 10-year Treynor Index. Mixed results are not surprising given that both returns and risk are higher for de-integrated than for integrated mutual funds. Higher returns offset by higher
risk may approximately match lower returns offset by lower risk and explain why risk-adjusted performance differences vary over time and between the measures chosen to judge performance.

### Table 69: Descriptive statistics of risk-adjusted returns

<table>
<thead>
<tr>
<th>Structure</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year Jensen’s Alpha</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1523</td>
<td>.017</td>
<td>.4528</td>
<td>.0116</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>926</td>
<td>-.099</td>
<td>.4140</td>
<td>.0136</td>
</tr>
<tr>
<td>3-year Sharpe Ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1523</td>
<td>.271</td>
<td>.2914</td>
<td>.0075</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>926</td>
<td>.268</td>
<td>.2474</td>
<td>.0081</td>
</tr>
<tr>
<td>3-year Treynor Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1523</td>
<td>.354</td>
<td>.7329</td>
<td>.0188</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>926</td>
<td>.397</td>
<td>.3529</td>
<td>.0116</td>
</tr>
<tr>
<td>5-year Jensen’s Alpha</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1099</td>
<td>-.059</td>
<td>.4429</td>
<td>.0134</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>643</td>
<td>-.116</td>
<td>.4144</td>
<td>.0163</td>
</tr>
<tr>
<td>5-year Sharpe Ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1099</td>
<td>.172</td>
<td>.3845</td>
<td>.0116</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>643</td>
<td>.147</td>
<td>.3903</td>
<td>.0154</td>
</tr>
<tr>
<td>5-year Treynor Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>1097</td>
<td>.244</td>
<td>.5263</td>
<td>.0159</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>643</td>
<td>.235</td>
<td>.4334</td>
<td>.0171</td>
</tr>
<tr>
<td>10-year Jensen’s Alpha</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>401</td>
<td>.056</td>
<td>.4516</td>
<td>.0226</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>164</td>
<td>-.001</td>
<td>.4409</td>
<td>.0344</td>
</tr>
<tr>
<td>10-year Sharpe Ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>406</td>
<td>.286</td>
<td>.3778</td>
<td>.0187</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>170</td>
<td>.311</td>
<td>.3851</td>
<td>.0295</td>
</tr>
<tr>
<td>10-year Treynor Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>406</td>
<td>.323</td>
<td>.3825</td>
<td>.0190</td>
</tr>
<tr>
<td>De-Integrated</td>
<td>170</td>
<td>.342</td>
<td>.3513</td>
<td>.0269</td>
</tr>
</tbody>
</table>

A t-test was performed to explore whether or not the differences in risk-adjusted returns between integrated and de-integrated mutual funds were significant. The following table suggests that differences in 3-year Jensen’s Alpha and 5-year Jensen’s Alpha are significant \((p < 0.05)\), but all other differences are insignificant.
Table 70: T-test for equality of risk-adjusted returns of integrated and de-integrated mutual funds for periods ending December 31, 2006

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>Mean Difference</th>
<th>Effect Size (α = .05, 2-tailed)</th>
<th>Power of the Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year Jensen’s Alpha</td>
<td>6.309</td>
<td>2447</td>
<td>.115***</td>
<td>0.27 (small to med.)</td>
<td>~100%</td>
</tr>
<tr>
<td>3-year Sharpe Ratio</td>
<td>0.269</td>
<td>2447</td>
<td>.003</td>
<td>0.01 (&lt; small)</td>
<td>6%</td>
</tr>
<tr>
<td>3-year Treynor Index</td>
<td>-1.959</td>
<td>2343</td>
<td>-.043†</td>
<td>0.08 (&lt; small)</td>
<td>44%</td>
</tr>
<tr>
<td>5-year Jensen’s Alpha</td>
<td>2.683</td>
<td>1740</td>
<td>.058**</td>
<td>0.13 (&lt; small)</td>
<td>77%</td>
</tr>
<tr>
<td>5-year Sharpe Ratio</td>
<td>1.270</td>
<td>1328</td>
<td>.024</td>
<td>0.06 (&lt; small)</td>
<td>25%</td>
</tr>
<tr>
<td>5-year Treynor Index</td>
<td>.391</td>
<td>1552</td>
<td>.009</td>
<td>0.02 (&lt; small)</td>
<td>7%</td>
</tr>
<tr>
<td>10-year Jensen’s Alpha</td>
<td>1.375</td>
<td>310</td>
<td>.057</td>
<td>0.13 (&lt; small)</td>
<td>28%</td>
</tr>
<tr>
<td>10-year Sharpe Ratio</td>
<td>-.710</td>
<td>312</td>
<td>-.025</td>
<td>0.07 (&lt; small)</td>
<td>11%</td>
</tr>
<tr>
<td>10-year Treynor Index</td>
<td>-.580</td>
<td>343</td>
<td>-.019</td>
<td>0.05 (&lt; small)</td>
<td>9%</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10 (two-tailed)

5.6 Knowledge-based Structure and Performance

According to Chen, Hong, and Kubik (2006), the role of structure in performance of mutual funds has been largely ignored. This section of the research represents one attempt to remedy that situation.

It is safe to assume that mutual fund management firms purposely decide to integrate or de-integrate the portfolio management function. We can generally expect mutual fund management firms to make their integration/de-integration decision so as to maximize their mutual funds’ performance. Because the organizational structure is self-selected, we are unable to compare performance of the integrated and de-integrated strategies directly.

Periodically, a mutual fund management firm reviews its funds’ performances and the portfolio managers managing those funds. Those reviews may lead to a mutual fund management firm deciding to integrate previously de-integrated portfolio management, to de-integrate previously integrated portfolio management, or to make no change at all. A mutual fund
management firm makes a similar decision when it decides to launch a new mutual fund in the marketplace.

If there are common unobserved factors that influence both the mutual fund management firm’s decision to vertically integrate or de-integrate the portfolio function for a mutual fund and the mutual fund’s performance, then a self-selection bias is present and ‘evidence’ drawn from any analysis of performance based exclusively on the fund’s structure may be incorrect. CEOs of mutual fund management firms may know of some performance-related reasons to integrate or de-integrate portfolio management to that is not included as variables in this research.

Since mutual fund management firms self-select to integrate or de-integrate portfolio management, presumably with the expectation that their decision is performance maximizing, then it is reasonable to expect that performance will be conditional upon unobserved factors influencing the management firm’s integration/de-integration decision. Mutual fund management firms may decide to de-integrate portfolio management or to integrate it based on unobserved characteristics of the management firm and/or of the portfolio manager(s). Inappropriate attribution of mutual fund performance to the integration/de-integration decision could result if the management firm’s decision process is not addressed, and there are unobserved factors influencing the decision. Regressing performance on the results of this decision can only be accurate if mutual fund management firms err so much in making this decision that the outcome is random, or if *all* factors affecting performance are identified and included in the performance estimation model (Shaver, 1998). Since neither of those conditions appears plausible, a two-stage least squares regression model was chosen to correct for the potential bias, modeled on the work of Shaver (1998) and Leiblein, Reuer & Dalsace (2002). The following hypothesis tests the relationship between structure and performance using the two-stage model.
H3: Alignment between mutual funds’ structure and knowledge-based factors of production affects performance.

SPSS (SPSS for Windows, 2006) provides a two-stage least squares function, but its features are limited. The two-stages of a Heckman (1976; 1979) procedure were therefore performed separately, applying a binary logistic regression in the first stage and a linear regression in the second stage.

Mutual funds identified as primarily investing in the region of Canada were used for the first stage as well as the second because this region had the largest number of funds for which measures of relative reliance on knowledge-based factors of production were available. Models were also created that included all regions\(^\text{19}\), or only Canada and Global (the two largest), but these did not generate significant estimates, either in the first stage or in the second, and so were not reported. There were 248 mutual funds investing primarily in the region of Canada for which measures of knowledge-based factors were available.

5.6.1 First stage structure estimates

Logistic regression was used as the ‘selection model’ since it facilitates the calculation of an inverse Mills ratio (Lambda) indirectly from the saved results, a feature not currently available using the probit regression in SPSS (Smits, 2003). The probabilities of de-integration were estimated for each mutual fund in the region of Canada using the logit model, and were then transformed to what they would have been had a probit model been used. Then using the quasi-probit values, Lambda was calculated for both integrated and de-integrated mutual funds.

\(^{19}\)The seven investment regions used to characterize mutual funds in the secondary data are Canada, USA, North America, Europe, Japan, Global, and International (defined as outside North America).
The probability of de-integration, Structure, was estimated using binomial logistic regression with independent variables for the size of the mutual fund management firm (lnAssets), for the management mode (SingleOrMultiManaged), for the relative reliance of the portfolio manager on tacit knowledge (ZZKTacScale), and for the relative reliance of the portfolio manager on encapsulated knowledge (ZZKEncScale).

In the following table, Model I presents a baseline model that consists of an intercept term and variables indicating the natural logarithm of the management firms’ assets under management (CAD millions), and whether a fund was managed by a single portfolio manager or multi-managed. Another possible control variable for which data was available, percentage of known portfolio managers with a CFA designation, was found not to be significant and so is not reported. Even though they were not available for this research, Chen, Hong, and Kubik (2006) found that control variables of fund family size, past fund flows, turnover, and fund age did not drive performance. The dependent variable is Structure; for de-integrated mutual funds, Structure = 1 and for integrated funds, Structure = 0.

The negative intercept coefficients of Models I and II indicate that the 248 mutual funds are predominantly integrated. The positive coefficients for assets under management indicate that the probability of de-integration increases with the size of the mutual fund management firm. The negative coefficient for the management mode dummy variable indicates that de-integrated mutual funds are more likely to be multi-managed than single-managed.

Model II introduces measures of relative reliance on tacit knowledge and encapsulated knowledge. The negative coefficient for relative reliance on encapsulated knowledge is consistent with the results of testing H1b, H1d and H2g. The statistically significant negative coefficient for relative reliance on tacit knowledge, however, is not expected given the results of
testing H1a and H1c. The surprisingly negative coefficient may be attributable to the negative average value for relative reliance on tacit knowledge (-0.18, standardized) by the portfolio managers of the 248 mutual funds investing in Canada. This differs significantly ($p < 0.001$) from the average relative reliance on tacit knowledge by the portfolio managers of the remaining 185 mutual funds (0.39, standardized). A negative coefficient multiplied by, on average, a negative value for tacit knowledge, results in a positive effect on de-integration.

Based on the improvements of the log likelihood measures, the results of Model II were used in the calculation of the inverse Mills ratio (LambdaCanada), which in turn was used to derive the estimates in the linear regression model for performance in the second stage.

**Table 71: Logistic regression estimates for first-stage mutual fund structure models**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Model I</th>
<th>Model II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-5.440***</td>
<td>-8.147***</td>
</tr>
<tr>
<td></td>
<td>(1.551)</td>
<td>(2.381)</td>
</tr>
<tr>
<td>Millions of Assets Under Management (ln)</td>
<td>0.448**</td>
<td>0.670**</td>
</tr>
<tr>
<td></td>
<td>(0.152)</td>
<td>(0.227)</td>
</tr>
<tr>
<td>Single Portfolio Manager per Mutual Fund</td>
<td>-0.580†</td>
<td>-0.793*</td>
</tr>
<tr>
<td></td>
<td>(0.333)</td>
<td>(0.379)</td>
</tr>
<tr>
<td>Relative Reliance on Tacit Knowledge</td>
<td></td>
<td>-1.690***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.431)</td>
</tr>
<tr>
<td>Relative Reliance on Encapsulated Knowledge</td>
<td></td>
<td>-2.267***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.396)</td>
</tr>
<tr>
<td>$N$</td>
<td>248</td>
<td>248</td>
</tr>
<tr>
<td>-2 Log likelihood</td>
<td>247.170 (2)***</td>
<td>203.780 (4)***</td>
</tr>
<tr>
<td>Improvement in -2 Log likelihood</td>
<td>15.268 (2)***</td>
<td>43.390 (2)***</td>
</tr>
</tbody>
</table>

*a* Positive coefficients indicate a greater probability of de-integration.

$b$ *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

$c$ -2 Log likelihood for the null model was 262.438. Degrees of freedom are in brackets.

The predicted probability of de-integration was saved as the variable, PredStructureRegionCanada. PredStructureRegionCanada was translated into the equivalent probit variable, ProbStructureRegionCanada, since logistic regression was used in the estimation of the saved variable (SPSS command: “compute ProbStructureRegionCanada = probit
PredStructureRegionCanada”). A second variable predicting membership in one of the two
groups defined by Structure, PredGroupRegionCanada, was generated by Model II and also
saved.

5.6.2 Calculating a correction for self-selection (Lambda).

LambdaCanada, the inverse Mill’s ratio, was calculated separately for each de-integrated
and integrated mutual fund, using the quasi-probit measure, ProbStructureRegionCanada. The
following SPSS formulas were applied (Jeroen Smits, 2003).

If a mutual fund was de-integrated, Structure = 1 and,

$$\lambda_{Canada} = \left(\frac{1}{\sqrt{2\pi}}\right) \times e^{-\frac{\text{probit}_{Canada}^2}{2}} / \text{cdfnorm}(\text{probit}_{Canada})$$

If a mutual fund was integrated, Structure = 0 and,

$$\lambda_{Canada} = \left(\frac{1}{\sqrt{2\pi}}\right) \times e^{-\frac{\text{probit}_{Canada}^2}{2}} \left(1 - \text{cdfnorm}(\text{probit}_{Canada})\right)$$

5.6.3 Second stage performance estimates

In the second stage regression, the 3-year Jensen’s Alpha (1968) in excess of the mean
for mutual funds in the investment region of Canada was selected as the dependent variable. The
mean 3-year Jensen’s Alpha was calculated to be \(-0.018428\) for the 248 mutual funds. Jensen’s
Alpha\(^{20}\) is a risk-adjusted performance measure that represents the average return on a portfolio

\(^{20}\) An alpha is usually calculated by linear regression of a portfolio’s excess return over 36 to 60 months on
related market portfolio return. The beta is the slope coefficient and measures portfolio risk relative to
market risk. The alpha is the intercept term. For example, if a mutual fund portfolio has a 36-month return
of 25%, and the risk-free interest rate is 5%, then the excess return of the mutual fund portfolio is 20%. If
over and above that predicted by the capital asset pricing model (CAPM), given the portfolio’s beta (measure of risk relative to the market portfolio) and the average return on the market portfolio. This risk-adjusted measure of performance is used to determine if portfolio managers are earning any returns in excess of what would be expected based on the risk associated with their portfolios. A positive alpha suggests that a portfolio manager is able to select securities that perform better than their risk profile would suggest and a negative alpha suggests the opposite.

This particular measure of performance was selected because it is a risk-adjusted and differences between integrated and de-integrated mutual funds estimated for this measure appeared significant. There were no shorter-term risk-adjusted performance measures to be tested because a minimum of 36 months of data is needed to calculate a measure of risk. Longer-term measures of risk-adjusted performance were not used because of the increased probability that portfolio managers associated with each mutual fund would not have been managing it for the entire period under consideration. A repeat of the previous t-test for equality of risk-adjusted returns, but limited to the 174 mutual funds used in the second stage, confirmed that only differences in 3-year Jensen’s Alpha and 5-year Jensen’s Alpha between integrated and de-integrated funds are significant ($p < 0.05$).

One of the explanatory variables in the first stage is excluded from the second stage for identification purposes (Amemiya, 1985; Johnston & DiNardo, 1997; Maddala, 1983). The

during the same 36 months the market generates a return of 9% in excess of the risk-free rate, and the beta of the mutual fund portfolio is 2.0 (indicating twice the risk of the market portfolio), then the expected excess return given the risk is $2 \times 9\% = 18\%$. Since the actual excess return is 20%, the alpha is 2% or 200 basis points.
variable selected for exclusion is lnAssets. This variable is included in the first stage since smaller firms are less likely to have the sufficient assets under management to warrant the hiring of external portfolio managers. The significant positive coefficient for lnAssets in Models I and II of the first stage appear to support this. From a performance perspective, though, the size of a mutual fund management firm’s total assets under management is not a statistically significant variable (Busse, Goyal, & Wahal, 2007). The variable SingleManaged, however, was retained in the second stage since there is some evidence that whether a mutual fund is single-managed or multi-managed affects performance (Chen et al., 2004).

An additional variable, CategoricalExcessAlpha, was introduced to recognize that performance could be a function of membership in a particular CIFSC category. In any given period of an economic cycle some categories of investments apparently out-perform others (Chang & Lewellen, 1984; Chen, Roll, & Ross, 1986; Ferson & Schadt, 1996). For example, Kosowski (2006) found evidence that growth/income and balanced/income funds outperform aggressive growth and growth funds during recessions. The variable CategoricalExcessAlpha acted like a fixed effect, but without adversely affecting the degrees of freedom. It was calculated as the average Jensen’s Alpha for a CIFSC fund category in excess of the mean Jensen’s Alpha for the entire sample. Fourteen values for CategoricalExcessAlpha were calculated, one for each of the CIFSC categories included in the sample.

In the following table, Model I presents a baseline specification that consists of an intercept term, control variables, and a linear dependent variable, the 3-year Jensen’s Alpha (1968) in excess of the mean. This model does not control for self-selection, so it was possibly misspecified based on the arguments presented at the beginning of this section. Model I does not assign any significant positive coefficient for the intercept or the management mode variables.
The estimated coefficient for the variable CategoricalExcessAlpha is positive and significant ($p < 0.001$) suggesting that CIFSC category membership is influential in determining above average performance. The negative coefficients for relative reliance on tacit and encapsulated knowledge are both statistically significant ($p < 0.01$) and suggest that increased reliance on these two factors is associated with below average performance. The coefficient estimate for the structure dummy variable was positive and significant ($p < 0.05$) suggesting that those mutual funds whose portfolio managers are not integrated with the mutual fund management firm exhibit better performance in terms of their ability to generate above average Jensen’s Alpha. This is consistent with the findings on risk-adjusted returns presented in previous tables. Model I is provided as a reference to determine if there is any change in the estimated coefficient for the structure variable when a correction for self-selection (LambdaCanada) is added.

Model II differs from Model I only by the addition of the correction for self-selection (LambdaCanada). The estimated coefficients for the variables common to both models remain essentially unchanged. The negative estimated coefficient for LambdaCanada indicates that the greater a mutual fund management firm’s propensity to de-integrate the portfolio management function, the higher will be a mutual fund’s performance. Dolton and Makepeace (1987) provide details on the interpretation of the self-selection co-efficient term. The lack of significance for the estimated coefficient for the self-selection coefficient suggests that a mutual fund management firm’s decision to integrate or de-integrate portfolio management does not appear to be endogenous to performance (Leiblein et al., 2002; Shaver, 1998).

Model III includes the structural alignment variable (StructuralAlignmentCan), which was set to 1 when actual observed organizational structure (Structure) and organizational structure predicted from the first stage (PredGroupRegionCanada) both agreed, and 0 otherwise.
While the negative estimated coefficient for the structural alignment variable (StructureAlignmentCan) appears to suggest that structural alignment reduces supernormal performance, the estimate is not significant. The estimated coefficient for LambdaCanada, however, does come close to becoming significant ($p = 0.104$), suggesting that there are unobserved characteristics that influence the decision to integrate or de-integrate in Model III.

The estimated coefficients in Models I, II and III are estimated without regard for whether a mutual fund is actually integrated or de-integrated. Models IV and V extend these models by separately considering integrated and de-integrated mutual funds.

Model IV splits the sample used in Model III between those 134 mutual funds that are integrated and those 40 that are de-integrated. This facilitates a comparison of coefficient estimates between integrated and de-integrated mutual funds.

The estimated coefficients for the management mode variable for both Integrated and De-integrated versions of Model IV are significant, even though this coefficient was insignificant in Models I, II, and III. The coefficient estimates suggest that being single-managed reduces the performance of integrated mutual funds while it increases performance of de-integrated mutual funds. The magnitude of the management mode coefficient estimate is about two and one-half times greater for the de-integrated mutual funds than integrated ones.

The estimated coefficients for the CIFSC category variable were both significant and relatively large in magnitude for both Integrated and De-integrated versions of Model IV. These coefficient estimates suggest that performance for both integrated and de-integrated mutual funds is largely dependent on the CIFSC category in which a mutual fund belongs. The magnitude of this coefficient estimate is over twice as large for de-integrated mutual funds as it is for integrated mutual funds.
The estimated coefficient for relative reliance on tacit knowledge, which was significant in Model III, became less significant for integrated mutual funds and non-significant for de-integrated mutual funds in Model IV. Similarly, the estimated coefficient for relative reliance on encapsulated knowledge, which was also significant in Model III, became less significant for integrated mutual funds and non-significant for de-integrated mutual funds in Model IV. The loss of significance of these coefficient estimates for the De-integrated version suggests that the estimated coefficients for relative reliance on knowledge-based factors of production do not differ significantly from zero.

There are, however, limitations on the significance tests (Tabachnick & Fidell, 2007, p. 148). Even though there may be a high covariance between a dependent variable and a very important independent variable, the analysis may be non-significant in a multiple regression if that independent variable’s covariance is shared with another independent variable. This may be the case, even if the combination of the independent variables is responsible for a large R Squared. The adjusted R Squared increased from 35.3% in Model III to 45.3% in the De-integrated version of Model IV, even though the estimated coefficients for the relative reliance on knowledge-based factors of production became non-significant.

Model V is identical to Model IV except for the inclusion of two structural alignment variables to replace the single variable used in Model III. In the integrated version of Model V, the structural alignment variable (IntegratedAndAlignedCan) is set to 1 when a mutual fund is integrated and predicted to be integrated, and 0 otherwise. In the de-integrated version of Model V, the structural alignment variable (DeIntAndAlignedCan) is set to 1 when a mutual fund is de-integrated and predicted to be de-integrated, and 0 otherwise. The two estimated coefficients for these variables were both found to be statistically insignificant.
The change in the F-statistic in moving from Model I to Model II was not found to be significant nor was the change in F-statistic in moving from Model II to Model III. Similarly, the movement from Model IV to Model V did result in a significant change in the F-statistic. It appears, at least based on the magnitude of the coefficients in this study, that performance was greatly affected by membership in particular CIFSC categories, and to a lesser extent a function of structure and management mode. The following table presents all of the models for predicting 3-year Jensen’s Alpha (in excess of the mean) for the investment region of Canada.

Table 72: Estimates for second-stage mutual fund performance models

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
<th>Model IV</th>
<th>Model V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept</td>
<td>Intercept</td>
<td>Intercept</td>
<td>Intercept</td>
<td>Intercept</td>
</tr>
<tr>
<td></td>
<td>-0.050</td>
<td>-0.012</td>
<td>0.144</td>
<td>-0.017</td>
<td>-0.015</td>
</tr>
<tr>
<td></td>
<td>(0.042)</td>
<td>(0.055)</td>
<td>(0.138)</td>
<td>(0.045)</td>
<td>(0.079)</td>
</tr>
<tr>
<td>Management Mode (Single-managed = 1, Multi = 0)</td>
<td>-0.069</td>
<td>-0.080</td>
<td>-0.090</td>
<td>-0.139*</td>
<td>-0.138†</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.060)</td>
<td>(0.061)</td>
<td>(0.066)</td>
<td>(0.152)</td>
</tr>
<tr>
<td>CategoricalExcessAlpha (CIFSC category mean Alpha minus sample mean Alpha)</td>
<td>0.903***</td>
<td>0.873***</td>
<td>0.849***</td>
<td>0.817***</td>
<td>0.817***</td>
</tr>
<tr>
<td></td>
<td>(0.124)</td>
<td>(0.126)</td>
<td>(0.128)</td>
<td>(0.130)</td>
<td>(0.131)</td>
</tr>
<tr>
<td>Relative Reliance on Tacit Knowledge</td>
<td>-0.228**</td>
<td>-0.236**</td>
<td>-0.231**</td>
<td>-0.196*</td>
<td>-0.196*</td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
<td>(0.071)</td>
<td>(0.071)</td>
<td>(0.083)</td>
<td>(0.166)</td>
</tr>
<tr>
<td>Relative Reliance on Encapsulated Knowledge</td>
<td>-0.200**</td>
<td>-0.218**</td>
<td>-0.217**</td>
<td>-0.137†</td>
<td>-0.136†</td>
</tr>
<tr>
<td></td>
<td>(0.065)</td>
<td>(0.067)</td>
<td>(0.067)</td>
<td>(0.076)</td>
<td>(0.081)</td>
</tr>
<tr>
<td>Structure (De-Integrated = 1, Integrated = 0)</td>
<td>0.159*</td>
<td>0.221*</td>
<td>0.234*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.072)</td>
<td>(0.091)</td>
<td>(0.92)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LambdaCanada (Correction for Self-Selection)</td>
<td>-0.101</td>
<td>-0.202</td>
<td></td>
<td>-0.003</td>
<td></td>
</tr>
<tr>
<td>Structural Alignment (Predicted = Actual)</td>
<td></td>
<td>-0.129</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.093)</td>
<td></td>
<td>(0.123)</td>
<td></td>
</tr>
<tr>
<td>Integrated and Aligned (Predicted = Actual)</td>
<td></td>
<td></td>
<td>-0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.121)</td>
<td></td>
</tr>
<tr>
<td>De-integrated and Aligned (Predicted = Actual)</td>
<td></td>
<td></td>
<td></td>
<td>0.126</td>
<td>0.126</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.193)</td>
</tr>
<tr>
<td>N</td>
<td>174</td>
<td>174</td>
<td>174</td>
<td>134</td>
<td>134</td>
</tr>
<tr>
<td>Model F</td>
<td>19.64***</td>
<td>16.59***</td>
<td>14.48***</td>
<td>15.09***</td>
<td>11.98***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.09***</td>
<td>7.24***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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The model estimates in the Integrated and De-integrated columns of Model IV in the Table 72 can be used to assess the superiority of one organizational structure over another (Shaver, 1998). The comparison of predicted performance between actual and predicted mutual fund structures is provided in Table 73. Predicted performance is measured as the 3-year Jensen’s Alpha in excess of the mean for Investment Region = Canada. Actual structure is a given and predicted structure, PredGroupRegionCanada, was generated using Model II of Table 71. Given the lack of significance of the coefficient estimates for relative reliance on tacit and encapsulated knowledge in the De-integrated version of Model IV, the results in Table 73 should be interpreted with caution.

An estimated average performance measure for integrated mutual funds, -0.039 as reported in the top left cell of Table 73, was predicted by multiplying the coefficient estimates of the Integrated column of Model IV by the values of the corresponding independent variables of the integrated mutual funds. It is also possible to estimate the average performance of de-integrated mutual funds had they been integrated. This was done by multiplying the coefficient estimates of the Integrated column of Model IV by the values of the corresponding independent variables of the de-integrated mutual funds, and provided an estimated average performance measure of 0.025 as reported in the bottom left cell of Table 73.
The same process can be applied using the coefficient estimates of the De-integrated column of Model IV. Multiplying these coefficient estimates by the values of the corresponding independent variables of the de-integrated mutual fund attributes provided an estimated average performance measure of 0.288 as reported in the bottom right cell of Table 73. It is also possible to estimate the average performance of integrated mutual funds had they be de-integrated. This was done by multiplying the coefficient estimates of the De-integrated column of Model IV by the values of the corresponding independent variables of the integrated mutual funds, and provided an estimated average performance measure of 0.168 as reported in the top right cell of Table 73.

The results of this process may be interpreted as follows. The left column of Table 73 suggests that mutual funds predicted to be integrated and actually integrated are not expected to outperform those predicted to be integrated but actually de-integrated. Similarly, the right column of Table 73 suggests that mutual funds predicted to be de-integrated and actually de-integrated can be expected to outperform those predicted to be de-integrated but actually integrated. These results suggest that the De-integrated version of Model IV is able to successfully predict performance, but that the Integrated version of Model IV is not. Possible explanations for the asymmetrical results are discussed in the next section.

<table>
<thead>
<tr>
<th>Table 73: Predicted mutual fund performance from Model IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Structure</td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>Integrated</td>
</tr>
<tr>
<td>De-Integrated</td>
</tr>
<tr>
<td>Average of All Funds</td>
</tr>
</tbody>
</table>

*Calculations are 3-Year Jensen’s Alpha in excess of the mean for Investment Region = Canada*
5.6.4 Synthesis of Findings

The evidence from testing H3 provides one possible answer to the research question, ‘Are there performance implications related to aligning organizational structure with knowledge-based factors of production?’ Proposition 3 proposed that ‘Firms that are integrated or de-integrated on the basis of evidence from Proposition 1 or Proposition 2 will perform better than those that are not’. While Proposition 1 was not supported, Proposition 2 was supported by the evidence (see Table 66). Proposition 2 proposed that, ‘A greater probability of de-integration for a given stage of production will be positively associated with a greater reliance on tacit knowledge in that stage’.

The testing of H3 provided evidence that mutual funds that are de-integrated outperform those that are integrated when the organizational structure is predicted to be de-integrated on the basis of relative reliance on knowledge-based factors of production. When organizational structure was predicted to be integrated, however, integrated mutual funds did not outperform those that were de-integrated.

One probable reason for the asymmetrical support for H3 may lie with the observations, presented in Table 68, that variation in risk for integrated mutual funds is significantly greater for every measure of risk than it is for de-integrated mutual funds. Since Jensen’s Alpha is a risk-adjusted measure of performance, it is possible that for the sub-sample tested, the relatively greater variation in risk for integrated mutual funds contributed to an incongruently low calculated mean performance value for integrated mutual funds that were predicted to be integrated (top left cell of Table 73).

Another probable reason for only partial support for H3 may be the large magnitude of the CategoricalExcessAlpha coefficient. This variable, as described in the beginning of Section
5.6.3, is an artefact of a particular time-period - the 36 months ending December 31, 2006. The effect of using this particular snapshot in time, captured in the CategoricalExcessAlpha coefficient, may have been so strong as to diminish the impacts of the other variables.

Another possible reason that mutual funds predicted to be integrated did not outperform those that were de-integrated may have been the restriction of the sub-sample used to test the hypothesis to mutual funds investing primarily in Canada. This restriction may have unduly limited the effects, presented in Figure 14, that were found when H2a to H2f were tested on a larger more diverse sample.

Finally, there is some evidence that mutual fund management firms make decisions regarding the integration / de-integration for a number strategic reasons not captured in this study. For example, all of ClaringtonFunds Inc.’s mutual funds were sub-advised (de-integrated) as a matter of principle, in the belief that it is a mutual fund management firms’ responsibility to select the best portfolio managers, rather than attempt to manage portfolios in-house. On the other hand, one chief investment officer indicated in an interview that their organization only relied on integrated portfolio managers to keep information flows internal to the organization. Finally, one chief executive officer claimed that whether a mutual fund was managed in-house (integrated) or sub-advised (de-integrated) depended primarily on which was less expensive. The absence of variables designed to capture these considerations probably limited the predictive capability of the models, and may have contributed to the asymmetrical results.

5.7 Summary

5.7.1 Results

The analyses in this chapter provide, I believe, the first evidence that knowledge-based factors of production may be related to the presence or absence of an inter-firm boundary
(vertical integration or de-integration). In addition, it appears that de-integrated mutual funds outperform integrated mutual funds when knowledge-based factors of production argue for a de-integrated organizational structure.

5.7.2 Limitations

The dependent variable for performance, 3-year Jensen’s Alpha in excess of the mean for mutual funds in the Canadian Investment region, is assumed to be generated exclusively by the portfolio manager(s) associated with the mutual funds as of December 31, 2006. Turnover of these mutual funds’ portfolio managers, as well as evolution of manager’s skills, limits the extent to which the measures of relative reliance on tacit and encapsulated knowledge remained constant over the 3-year period. In addition, the organizational structure of each mutual fund was determined as of December 31, 2006. The integration of formerly de-integrated mutual funds and the de-integration of formerly integrated mutual funds, limits the extent to which organizational structure remained constant over the 3-year period used to measure performance. The results linking structure to performance and relative reliance on knowledge-based factors of production are therefore all the more remarkable.

This study suffers from, survivorship bias and omissions bias, both of which are unavoidable. Survivorship bias exists because only those mutual funds in existence as of December 31, 2006 were included in the research. Those mutual funds, which may have been in existence at the beginning of the 3-year performance period, but were extinct at the end, were excluded. Only the surviving mutual funds could be studied empirically with the available data. The effect of this bias is unclear, but it is relevant to the extent that integrated and de-integrated mutual funds were differentially affected. Similarly, the absorption of one mutual fund by another during the 3-year period is not considered in this study. Frequently, under-performing
mutual funds, and relatively small mutual funds acquired by a mutual fund management firm during the takeover of another firm, are assimilated into larger, more successful funds. It seems reasonable to expect however, that extinction and absorption of mutual funds are randomly distributed between both integrated and de-integrated mutual funds.

Omissions bias refers to the fact that some of the funds in existence as of December 31, 2006 were excluded because they were not in existence at the beginning of the 3-year period used to measure performance. Because 36 months are necessary to calculate the 3-year Jensen’s Alpha, there was insufficient data available for these mutual funds. This bias is similar to survivorship bias, but is focused on the omission of existing mutual funds rather than on the omission of failed mutual funds. It is relevant to the extent that integrated and de-integrated mutual funds were differentially omitted. It seems reasonable, however, to expect that the omission of mutual funds is randomly distributed between the two organizational structures of funds.
6.1 **Introduction**

This research has studied knowledge as a factor of production used by portfolio managers and other investment professionals in the Canadian mutual fund industry. This final chapter summarizes the research findings and discusses the implications for future research and management practice.

6.2 **Research Contribution**

“…[E]xisting literature on the knowledge-based view of the literature makes important contributions to our understanding of the firm” (Nickerson & Zenger, 2004, p.617). This dissertation extends existing research on the knowledge-based view of the firm in three ways. First, it operationalized the measurement of different classifications of knowledge, by collecting relative reliance on these classifications from six different perspectives. By doing so, it provided a refinement of recent survey instruments through the development of a more comprehensive quantitative instrument for measuring organizational knowledge. The development of the construct of encapsulated knowledge is also a unique contribution of this study. It adds a third important expression of knowledge with characteristics that distinguish it from the more traditional tacit-explicit dichotomy.

The second contribution of this dissertation is a confirmation that relative reliance on the three fundamental classifications of knowledge differs along adjacent stages in a value chain. While it would be surprising if this were not the case, confirmatory evidence of the assumption was necessary before subsequent hypotheses could be tested.

The third, and perhaps most valuable, contribution of this study is that it presents evidence that relates reliance on tacit and encapsulated knowledge in adjacent stages of
production to the presence or absence of an inter-firm boundary between those stages. A stage with a relatively high reliance on tacit knowledge was found to be more likely de-integrated from an adjacent downstream stage than if such a stage was less reliant on tacit knowledge. Similar findings were found for reliance on encapsulated knowledge, but with the opposite affect. Arguably, these findings add definition to the analytic intensity of security valuation suggested by Cashman and Deli (2006) as the basis for variation in degree of vertical integration of mutual funds.

The fourth contribution of this research is that it was able to generate a model that suggested that organizing firms according to differences in relative reliance on knowledge impacts their performance. The model suggested that mutual funds de-integrated according to a number of factors, including relative reliance on encapsulated knowledge, out-performed those that were integrated. A challenge remains in determining the criteria for selecting one model over the other.

6.3 Summary of Research Findings

Differences in the knowledge relied upon in production may effectively be measured between adjacent stages of production. Chapter 4 described how relative reliance on tacit, codified, and encapsulated knowledge may be measured. While the measurement of relative reliance on codified knowledge exhibited little reliability, the measurement of relative reliance on tacit knowledge and especially encapsulated knowledge proved very reliable. Chapter 5 then combined knowledge-based factors of production with boundary and performance data from the mutual fund industry.

This research questioned whether or not vertical integration or de-integration and performance may be explained by an examination of the knowledge-based factors of production
used in adjacent stages of production. Whether or not relative reliance on different knowledge-based factors differed between adjacent stages of production was tested in Chapter 4. Given that portfolio managers and other investment management professionals relied differentially on relatively tacit and encapsulated knowledge, the relationship between relative reliance on these knowledge-based factors of production and vertical integration was tested in Chapter 5. Relationships were found between the variation in relative reliance on tacit and encapsulated knowledge by portfolio managers and whether or not they were integrated or de-integrated with the mutual fund’s management firm. Some evidence was also presented in Chapter 5, which indicated that performance of a mutual fund is related to the relative reliance on tacit and encapsulated knowledge by the portfolio manager(s) even after correcting for self-selection.

The assumption that there are differences in the fundamental knowledge-based factors of production between adjacent stages of production was, unsurprisingly, found to be true for portfolio managers and other investment management professionals in the mutual fund industry. The evidence suggested that the answer to the first research question, ‘Are there differences in fundamental knowledge-based factors of production between adjacent stages of production’ is ‘Yes’.

Given the evidence that portfolio managers and other investment management professionals rely on different combinations of tacit and encapsulated knowledge, evidence was sought to answer the second research question. It asked, ‘Do differences in knowledge-based factors of production explain the presence or absence of inter-firm boundaries’? The relative reliances on tacit and encapsulated knowledge by investment management professionals, other than portfolio managers, were taken as fixed reference points. Hypotheses were then tested, focusing on the relative reliance on tacit and encapsulated knowledge by various categorizations
of portfolio managers. The following table summarizes the findings of hypotheses relating organizational structure (whether portfolio managers were integrated in, or de-integrated from, the mutual fund management firms for which they managed portfolios) to reliance on tacit and encapsulated knowledge.

Table 74: Summary of findings relating knowledge-based factors of production to organizational structure

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Support</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a Relative reliance on tacit knowledge differs between de-integrated and integrated portfolio managers.</td>
<td>Yes, portfolio managers de-integrated from the mutual fund management firms of the funds they are managing appear more reliant on tacit knowledge than portfolio managers that are integrated. ***</td>
<td>187</td>
</tr>
<tr>
<td>1b Relative reliance on encapsulated knowledge differs between de-integrated and integrated portfolio managers.</td>
<td>Yes, portfolio managers de-integrated from the mutual fund management firms of the funds they are managing appear less reliant on encapsulated knowledge than portfolio managers that are integrated. ***</td>
<td>188</td>
</tr>
<tr>
<td>1c Relative reliance on tacit knowledge by portfolio managers differs between mutual funds in categories that have a high probability of being de-integrated and those in categories that have a low probability.</td>
<td>Yes, portfolio managers managing funds in categories with a high probability of de-integration appear more reliant on tacit knowledge than portfolio managers managing funds in categories with a low probability of de-integration. ***</td>
<td>191</td>
</tr>
<tr>
<td>1d Relative reliance on encapsulated knowledge by portfolio managers differs between mutual funds in categories that have a high probability of being de-integrated and those in categories that have a low probability.</td>
<td>Yes, portfolio managers managing funds in categories with a high probability of de-integration appear less reliant on encapsulated knowledge than portfolio managers managing funds in categories with a low probability of de-integration. ***</td>
<td>192</td>
</tr>
</tbody>
</table>

*** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10; †† p = 0.101

Additional hypotheses were tested to characterize in greater detail the results obtained from testing H1a to H1d. The following table summarizes the findings of testing hypotheses relating organizational structure to Cashman and Deli’s (2006) categories of analytic intensity of
security valuation (Foreign Equity, Domestic Equity, and Fixed Income) as well as relative reliance on tacit and encapsulated knowledge.

**Table 75: Summary of findings characterizing organizational structure**

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Support</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a Foreign equity mutual funds are more likely to be de-integrated than domestic equity mutual funds.</td>
<td>Yes, mutual funds identified as foreign equity appear to have a greater probability of being managed by de-integrated portfolio managers than do domestic equity mutual funds. ***</td>
<td>193</td>
</tr>
<tr>
<td>2b Domestic equity mutual funds are more likely to be de-integrated than fixed income mutual funds.</td>
<td>Yes, mutual funds identified as domestic equity appear to have a greater probability of being managed by de-integrated portfolio managers than do fixed income mutual funds. ***</td>
<td>194</td>
</tr>
<tr>
<td>2c Relative reliance on tacit knowledge by portfolio managers managing foreign equity mutual funds is greater than that for managing domestic equity mutual funds.</td>
<td>Yes, portfolio managers of foreign equity mutual funds appear to be more reliant on tacit knowledge than portfolio managers of domestic equity mutual funds. ***</td>
<td>196</td>
</tr>
<tr>
<td>2d Relative reliance on encapsulated knowledge by portfolio managers managing foreign equity mutual funds is less than that for managing domestic equity mutual funds.</td>
<td>Yes, portfolio managers of foreign equity mutual funds appear to be less reliant on encapsulated knowledge than portfolio managers of domestic equity mutual funds. ***</td>
<td>196</td>
</tr>
<tr>
<td>2e Relative reliance on tacit knowledge by portfolio managers managing domestic equity mutual funds is greater than that for managing fixed income mutual funds.</td>
<td>Yes, portfolio managers of domestic equity mutual funds appear to be more reliant on tacit knowledge than portfolio managers of fixed income mutual funds. ***</td>
<td>197</td>
</tr>
<tr>
<td>2f Relative reliance on encapsulated knowledge by portfolio managers managing domestic equity mutual funds is less than that for managing fixed income mutual funds.</td>
<td>Yes, portfolio managers of domestic equity mutual funds appear to be less reliant on encapsulated knowledge than portfolio managers of fixed income mutual funds. ***</td>
<td>198</td>
</tr>
</tbody>
</table>
The probability of de-integration of a mutual fund is related to the portfolio manager’s relative reliance on tacit, and encapsulated knowledge.

Yes. A logistic regression (Model II) suggests the odds of de-integration of 430 mutual funds are increased for those invested in the regions of Canada *, Europe ***, and Global **, and the odds of de-integration are decreased with increasing reliance on encapsulated knowledge ***. A linear regression (Model IV) suggests the probability of de-integration for 433 mutual funds is increased for those invested in the regions of Europe *, International ***, and USA **, and the probability of de-integration is decreased with increasing reliance on encapsulated knowledge ***. Another logistic regression (Model VI) suggests the odds of de-integration of 308 mutual funds are increased with increasing reliance on tacit knowledge ***

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$; †† $p = 0.101$

The final hypothesis tested for a relationship between performance and alignment of organizational structure with knowledge-based factors of production. The following table summarizes the findings of testing the hypotheses on 174 mutual funds invested primarily in the region of Canada for which both knowledge-based factors were measured and 3-year Jensen’s Alphas were available.

**Table 76: Summary of findings relating performance to organizational structure founded on knowledge-based factors of production**

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Support</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2g</td>
<td>The probability of de-integration of a mutual fund is related to the portfolio manager’s relative reliance on tacit, and encapsulated knowledge.</td>
<td>Yes. A logistic regression (Model II) suggests the odds of de-integration of 430 mutual funds are increased for those invested in the regions of Canada *, Europe ***, and Global **, and the odds of de-integration are decreased with increasing reliance on encapsulated knowledge ***. A linear regression (Model IV) suggests the probability of de-integration for 433 mutual funds is increased for those invested in the regions of Europe *, International ***, and USA **, and the probability of de-integration is decreased with increasing reliance on encapsulated knowledge ***. Another logistic regression (Model VI) suggests the odds of de-integration of 308 mutual funds are increased with increasing reliance on tacit knowledge ***.</td>
</tr>
</tbody>
</table>

| 3 | Alignment between mutual funds’ structure and knowledge-based factors of production affects performance. | Limited. One model (IV), appears to be able to correctly predict excess performance for de-integrated mutual funds by employing management mode *, a fund category effect ***, and relative reliance on tacit * and encapsulated † knowledge. | 219 |

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$; †† $p = 0.101$
6.4 Limitations of Present Research

As a result of what has become widely known as the Yale R&D study, Winter (1987) cautioned that generalizations made from the study must be made with caution since industries operate with diverse combinations of productive knowledge. “One obvious strategic implication of this diversity is that lessons derived from the experience in one industry may be very misleading guides to knowledge-related strategic choices in another” (Winter, 1987). Therefore, the contributions of this research may be limited to what may be considered knowledge-intensive or dematerialized industries. The population selected for this research had certain characteristics that made it amenable to this study (see Chapter 3). To discover if the findings of this study are generalizable, it will need to be replicated in other industries.

For simplicity, this study combined all of the various functions performed by non-portfolio managers into one over-arching role: other investment management professional. This simplification necessarily overlooks the rich variation in actual roles of those individuals. The availability of a larger population of ‘investment management professionals’ in future research could facilitate the collection of more clustered measurements of the knowledge-based factors around more definitive roles.

The measurements of relative reliance on tacit, codified, and encapsulated knowledge were not based on direct observations, but were self-reported. Measurement error entered this research because a different individual reported each participant’s responses. It would be preferable in future research if measurements could be made more consistent by collecting them directly using a single external observer.
6.5 Recommendations for Further Research

Further research is needed to improve the reliability of the survey instrument in collecting measurements of relative reliance on codified knowledge. A measure of codified knowledge is expected to be an important factor of production to consider in explaining the presence and absence of inter-firm boundaries. The survey instrument used for this study was unable to collect a reliable measure of reliance on codified knowledge. This may have been due to the blending of items referring to both ‘documented information’ and undeclared norms in the form of ‘rules, routines and processes’ and ‘procedures’ under the classification of codified knowledge. In future surveys, these two forms of codified knowledge may be treated separately. In addition, it is possible that measures of reliance on codified knowledge included more residual ‘noise’ than measures of tacit and encapsulated knowledge if respondents perceived the latter two classifications more precisely. Future survey instruments could include a residual variable or factor of production (e.g., ‘Other, not included above’) to reduce error in the codified knowledge variable.

Future research may begin by testing generalizability of this study in related industries represented by the NAICS code 5239 - Other Financial Investment Activities, since these share many of the attributes of the population sampled for this research. With some exceptions\(^2\), this industry group includes establishments primarily engaged in, or acting as agents in, the purchase and sale of financial contracts, or providing investment services such as portfolio management, investment advice, and trust, fiduciary, and custody services. Research may also extend into

\(^2\) Exceptions include investment bankers, securities dealers, commodity contracts dealers, securities brokerages, commodity contracts brokerages, securities exchanges, and commodity exchanges.
industry groups that may not quickly come to mind when discussing knowledge-based industries. Industries heavily reliant on material resources in their production processes could be surprisingly amenable to study, since knowledge may be considered a necessary dimension of every production process (Lewin & Phelan, 2000).

Another avenue of research to worth pursuing involves the observation that risk and returns to de-integrated mutual funds are generally higher than those for integrated mutual funds. It may be that reliance on codified and/or encapsulated knowledge reduces both returns and risk, while reliance on tacit knowledge increases both. If that is the case, it could have implications for many types of production processes outside of the mutual fund industry.

### 6.6 Implications for Management Practice

The theory and evidence presented in this research suggest that in making firm boundary-setting decisions, firms should assess differences in knowledge-based factor intensities between adjacent stages of production. Managers should be aware of differences in the relative reliance on tacit and encapsulated knowledge in the production processes along of a value chain. Where adjacent stages of production are for the most part reliant on encapsulated knowledge (knowledge embedded in the functionality and design of an object), integration of the stages within a single firm should be considered. Where a stage of production is predominantly reliant on tacit knowledge (knowledge that remains resident in the human mind), consideration should be given to separating that stage, from those relatively more reliant on encapsulated knowledge, with an inter-firm boundary.

The survey methodology used in this research may provide a starting point for the collection of data regarding knowledge-based factors of production. While measuring absolute values of knowledge-based factors may be elusive (Down, 2000), relative measurements may
provide an adequate alternative. Managers may find that an awareness of the relative magnitudes of knowledge-based factors used in production processes can be a supplementary instrument for determining when to vertically integrate or de-integrate adjacent stages along a value chain. This study makes no claim to comprehensiveness in weighing all factors to be considered in making decisions regarding vertical integration, but my hope is that it offers a perspective that proves to be valuable to managers charged with the responsibility of making these decisions.

6.7 Summary

The primary goal of this research was to investigate if a knowledge-based view of the firm could inform us about the presence or absence of inter-firm boundaries. An accompanying goal was to examine if structuring organizations guided by a knowledge-based view could impact firm performance. Three questions were posed.

The first question asked, “Are there differences in fundamental knowledge-based factors of production between adjacent stages of a value chain”? Evidence suggests that portfolio managers and other investment management professionals relied on different combinations of tacit and encapsulated knowledge. In general, portfolio managers appear relatively less (more) reliant on tacit (encapsulated) knowledge than other investment management professionals.

The second question asked, “Do differences in knowledge-based factors of production explain the presence or absence of inter-firm boundaries”? Evidence suggests that portfolio managers, de-integrated from the management firms of the mutual funds they are managing, are more (less) reliant on tacit (encapsulated) knowledge than integrated portfolio managers.

Cashman and Deli (2006) previously modeled the analytic intensity of security valuation by proxy using foreign equities, domestic equities, and fixed income classes of securities. It now appears that reliance on tacit knowledge by portfolio managers may be a more direct and positive
measure of the analytic intensity of security valuation, and explain the different proportions of de-integration found between the various classes of securities.

The third question asked, “Are there performance implications related to aligning organizational structure with knowledge-based factors of production”? Evidence is limited, but one model based on relative reliance on tacit and encapsulated knowledge by portfolio managers is predictive of performance. The evidence suggests that de-integrated mutual funds will outperform integrated mutual funds when the model predicts de-integration, and performance is measured as Jensen’s Alpha in excess of the average.

As a study of how a knowledge-based view of the firm may explain inter-firm boundary location and its impact on firm performance, this research produced results that advanced both the theoretical and empirical frontier.
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APPENDIX A: EXAMPLE NOTIFICATION EMAIL SENT BY CHIEF INVESTMENT OFFICER

I have been approached by a graduate student at the University of Toronto, Herman van den Berg, about having [name of organization] participate in a confidential survey that will be used for his doctoral thesis.

I have corresponded with Herman and he seems like a very thoughtful individual. His topic, knowledge-based inputs to portfolio management, should be very interesting to many of us.

The survey itself is approximately 15 minutes, and will be done online. If you have the time and inclination to give back to the educational community, please help out Herman. Participation is strictly voluntary.

There are two surveys:
One for portfolio managers (To:)
One for all other investment management professionals (Cc:)
Herman will send the appropriate survey to you.

Thanks,
[First name of Chief Investment Officer]
Dear [FirstName],

My name is Herman van den Berg and I am conducting my Ph.D. thesis research in Management Strategy at the University of Toronto, focusing on the Knowledge-Based View of the firm. I need your help, as one of a select group of portfolio managers, in determining how unique combinations of human capital, information, and technology are put to productive use in a knowledge-based organization. Kindly assist me in advancing this research by participating in a short (~15 minute) confidential online survey. Simply click on the following link: [SurveyLink].

Results of the survey will be made available to you, providing you with some idea of how your responses compare with those of other portfolio managers. In addition, [Name of Chief Investment Officer] will be receiving feedback comparing aggregate responses from [Name of Firm] to that collected from competing firms, but he (she) will not be provided with your individual responses.

If you have any questions, please email me at herman.vandenberg@utoronto.ca.

Thank you for participating.

Herman A. van den Berg, M.B.A.

Ph.D. Candidate & Principal Investigator

University of Toronto

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

[RemoveLink]
APPENDIX C: OTHER SURVEY INSTRUMENTS USED FOR KNOWLEDGE MEASUREMENT

Simonin

In research examining the role played by the ‘causally ambiguous’ nature of knowledge in the process of knowledge transfer between strategic alliance partners, Simonin (1999) empirically investigated the effects of knowledge tacitness, as well as other factors, on technological knowledge transfer. The construct, tacitness, was reliably measured with a reported $\alpha = 0.72$. Questionnaire items included (Simonin, 1999, p.621):

<table>
<thead>
<tr>
<th>Item</th>
<th>Strongly agree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1. Your partner’s technology/process know-how is easily codifiable [sic] (in blueprints, instructions, formulas, etc.).</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>X2. Your partner’s technology/process know-how is more explicit than tacit.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

Subramaniam and Venkatraman

In an empirical study of the influence of transferring and deploying tacit knowledge about overseas markets on trans-national new product development capabilities, Subramaniam and Venkatraman (2001, p.377) used the following to measure (Cronbach Alpha: 0.81) the extent of tacitness in overseas information, using a 7-point scale:

Please indicate the characteristics of the your project information acquired…

<table>
<thead>
<tr>
<th>The information acquired:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Was simple</td>
<td>Was complex</td>
</tr>
<tr>
<td>Was easy to comprehensively document in manuals or reports</td>
<td>Was difficult to</td>
</tr>
<tr>
<td></td>
<td>comprehensively</td>
</tr>
<tr>
<td></td>
<td>document in manuals</td>
</tr>
<tr>
<td></td>
<td>or reports</td>
</tr>
<tr>
<td>Was easy to comprehensively understand from written documents</td>
<td>Was difficult to</td>
</tr>
<tr>
<td></td>
<td>comprehensively</td>
</tr>
<tr>
<td></td>
<td>understand from</td>
</tr>
<tr>
<td></td>
<td>written documents</td>
</tr>
<tr>
<td>Was easy to precisely communicate through written</td>
<td>Was difficult to</td>
</tr>
<tr>
<td></td>
<td>precisely communicate</td>
</tr>
</tbody>
</table>
Please indicate the characteristics of the your project information acquired…

The information acquired:

<table>
<thead>
<tr>
<th>documents</th>
<th>through written documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was obvious to all competitors</td>
<td>Had subtle nuances known only to a few competitors</td>
</tr>
<tr>
<td>Was easy to identify without personal experience…</td>
<td>Was difficult to identify without personal experience…</td>
</tr>
</tbody>
</table>

**McEvily and Chakravarthy**

McEvily and Chakravarthy (2002), in an empirical study seeking to clarify whether and how, among other things, the tacitness of a firm’s knowledge affected the persistence of its performance advantages, found that tacitness of technological knowledge are useful for defending a firm’s major product improvements from imitation. In their survey they included the following sample survey items to measure tacitness (McEvily & Chakravarthy, 2002, p.295):

- We can predict which varieties of a component… to use to improve… performance.
- We can predict how much of a particular component to use to improve… performance.
- We can explain why using certain varieties of component results in specific… performance characteristics.
- We can explain why using certain amounts of component results in specific… performance characteristics.

**Birkinshaw and Fey**

In a recent study in which Birkinshaw and Fey (2001) tested, among other things, the relationship between the nature of knowledge assets and a firm’s ability to generate competitive advantage from those knowledge assets, the following, drawing on Winter (1987) and Zander and Kogut (1995), was included as part of a survey: The whole scale was reversed. Cronbach's Alpha = 0.64.” (Birkinshaw & Fey, 2001, p.14)
“Tacitness of knowledge. Indicate the extent to which you agree with the following statements about your company:

(1) new R&D personnel can easily learn their job by studying a complete set of blueprints
(2) new R&D personnel can easily learn their job by talking to experienced personnel
(3) educating and training R&D personnel is a quick and easy job
(4) a competitor can easily learn how to manufacture our product by studying the employees at work
(5) a competitor can easily learn how to manufacture our product by taking it apart and examining it carefully
(6) a competitor can easily learn how to manufacture our product by testing it in use.

Leiponen

In an empirical study that found evidence that innovation in business services was associated with both tacit and explicit collective knowledge, and with explicit individual knowledge, Leiponen (2003, p.34) used the results of a questionnaire which contained estimation variables for knowledge assets as follows:

<table>
<thead>
<tr>
<th>Knowledge assets</th>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EXPERT</td>
<td>Expert skills (0/1) (individual tacit knowledge)</td>
</tr>
<tr>
<td></td>
<td>EDUCATION</td>
<td>Share of employees with higher education (%) (individual explicit knowledge)</td>
</tr>
<tr>
<td></td>
<td>TEAM</td>
<td>Competitiveness based on teams’ knowledge (0/1) (collective tacit knowledge)</td>
</tr>
<tr>
<td></td>
<td>SOLUTION</td>
<td>Service solutions (0/1) (collective explicit knowledge)</td>
</tr>
<tr>
<td></td>
<td>LICENSING</td>
<td>The firm licenses technology to external parties (0/1) (collective explicit knowledge)</td>
</tr>
</tbody>
</table>

Choi and Lee

In a recent empirical study that found evidence that both tacit and explicit knowledge are important in capitalizing on corporate knowledge, Choi and Lee (2003) measured the following perceptual constructs on a six point Likert scale.
<table>
<thead>
<tr>
<th>Items</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explicit-oriented</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Knowledge (know-how, technical skill, or problem solving methods) is well codified in my company</td>
</tr>
<tr>
<td>2</td>
<td>Knowledge can be acquired easily through formal documents and manuals in my company</td>
</tr>
<tr>
<td>3</td>
<td>Results of projects and meetings should be documented in my company</td>
</tr>
<tr>
<td>4</td>
<td>Knowledge is shared through codified forms like manuals or documents in my company</td>
</tr>
<tr>
<td><strong>Tacit-oriented</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>My knowledge can be easily acquired from experts and co-workers in my company</td>
</tr>
<tr>
<td>2</td>
<td>It is easy to get face-to-face advises from experts in my company</td>
</tr>
<tr>
<td>3</td>
<td>Informal dialogues and meetings are used for knowledge sharing in my company</td>
</tr>
<tr>
<td>4</td>
<td>Knowledge is acquired by one-to-one mentoring in my company</td>
</tr>
</tbody>
</table>
Knowledge-Based Inputs to Portfolio Management

Welcome

We invite you as one of a select group of portfolio managers to take part in this academic survey.

You will have the opportunity at the end of this survey to request a comparison of your responses to aggregate statistics.

The aim of this survey is to collect data on the different combinations of human capital, information, and technology used by portfolio managers. It is expected that research based on this data will improve our understanding of how the relative reliance on each type of input varies with analytic approaches emphasized (e.g., fundamental or quantitative), the strategies pursued (e.g., passive or active), the type of portfolio managed (e.g., equity, fixed income), and the category of client served (e.g., retail, institutional).

If you have any questions about this survey, please contact:
Herman van den Berg, Ph.D. Candidate, University of Toronto, at +1.416.997.0464 or at herman.vandenberg@utoronto.ca, or

Brian S. Silverman, Professor and J.R.S. Prichard and Ann Wilson Chair in Management, Rotman School of Management, University of Toronto at brian.silverman@rotman.utoronto.ca, or

Chun Wei Choo, Professor, Faculty of Information Studies, University of Toronto at cw.choo@utoronto.ca.
Knowledge-Based Inputs to Portfolio Management

Confidentiality

We respect and will protect the confidentiality of every respondent.

While it is our intent to publish and make public presentations based on the research, your name and that of your organization will remain confidential.

Data collected will be analyzed to produce aggregate statistics only. No individual responses will ever be reported.

Only the principal investigator will have access to the data. The data will be electronically stored in a secure location and all identifying information will be removed.
Knowledge-Based Inputs to Portfolio Management

Introduction

This survey takes on average about 15 minutes to complete.

It begins with six groups of three statements each, which you will be asked to rate. A completed example is provided.

Six items designed to situate you and your work within the investment industry follow this.

The survey ends with one open-ended question.
Knowledge–Based Inputs to Portfolio Management

Consent Form

I understand that I am under no obligation to agree to participate in this survey and that I may exit this survey at any time without negative consequences.

I understand that my specific answers and comments will be kept confidential, and that I may decline to answer any question.

I understand that neither my name nor the name of my organization will be identified in any report or presentation that may arise from the study.

I have completely read the above, and

☐ I agree and consent to participate.
☐ I withhold my consent.

<< Back  Next >>
Knowledge-Based Inputs to Portfolio Management

Completed Example

The first nine questions require magnitude estimations. The following is a completed example.

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

When buying an automobile, I want...

8.0 ...an above average vehicle safety rating.
4.0 ...an excellent price.
10.0 ...the best manufacturer.

The completed example indicates that the respondent believes the selection of the best manufacturer is the most important factor. It also indicates that a good safety rating is only eight-tenths as important as selecting the best manufacturer, but twice as important as getting an excellent price. Finally, it indicates that selection of the best manufacturer is two and one-half times as important as getting an excellent price.
Knowledge-Based Inputs to Portfolio Management

Item 1 of 14 Location of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

To do my job well, I rely on...

[ ] ...functionality built into the technology I use (e.g., computer, canned software, Blackberry, etc.).

[ ] ...personal judgement, insight, and skills I have developed.

[ ] ...information I obtain from documents (e.g., research reports, annual reports, websites, manuals, books, etc.).
Knowledge-Based Inputs to Portfolio Management

Item 2 of 14 Transfer and Diffusion of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

In my job, valuable knowledge is transferred through...

- personal contact and interaction (e.g., conversations, meetings, etc.).
- transferring technology (e.g., quantitative models, algorithms, programs, etc.).
- written documents (e.g., email, reports, etc.).
Knowledge-Based Inputs to Portfolio Management

Item 3 of 14 Expression of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

**My organization's competitive position relies on knowledge that is...**

- [ ] ...evident in the rules, routines, and procedures we have developed over time (e.g., filters, screens, flags, etc.).
- [ ] ...evident in the activities we perform within our firm.
- [ ] ...not evident, but hidden in the technology we use (e.g., quantitative models, proprietary algorithms, customized applications, etc.).
Knowledge-Based Inputs to Portfolio Management

Item 4 of 14 Acquisition of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

My ability to do my job well relies on knowledge I acquire...

☐ by studying and interpreting information.

☐ through personal experience.

☐ through the purchase of functionality embedded in technology.
Knowledge-Based Inputs to Portfolio Management

Item 5 of 14 Source of Value of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

I create value by relying on...

☐ ...the functionality embedded in the technology I use.

☐ ...formal and informal processes specific to my role.

☐ ...my unique insights or those of my team.
Knowledge-Based Inputs to Portfolio Management

Item 6 of 14 Observability of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

The source of my productivity is...

☐ ...decodable by competing firms’ portfolio managers.

☐ ...hidden in difficult-to-replicate technology.

☐ ...a mystery to newly minted portfolio managers.
Knowledge-Based Inputs to Portfolio Management

Item 7 of 14 Analytic Approach

Please identify your primary analytic approach with a rating of 10.
Next, rate any other analytic approaches you use in turn on a scale of 0 to 9.9 to indicate how important they would be compared to your primary analytic approach, and to each other.

The higher the rating an analytic approach receives, the more important it is. If an analytic approach is half as important as another, it should receive half as high a rating.

Any analytic approach you do not use may be left unrated. It will automatically be assigned a rating of 0.

In my work, I use the following analytic approaches:

- Fundamental Bottom Up Analysis
- Fundamental Top Down Analysis
- Quantitative Bottom Up Analysis
- Quantitative Top Down Analysis
- Quantitative Ratio Analysis
- Technical Trend or Momentum Analysis
- Multifactor Analysis (Fundamental and/or Quantitative and/or Technical)
- Sentiment Analysis (Self Reported)
- Positioning Analysis (Observed)
- Flow of Funds Analysis
- Intermarket Analysis
- Brokerage Research Analysis (Assimilation)
Knowledge-Based Inputs to Portfolio Management

Item 8 of 14 Portfolio Management Strategy

Please identify your **primary** portfolio management strategy with a rating of 10. Next, rate any other portfolio management strategies you apply in turn on a scale of 0 to 9.9 to indicate how important they would be compared to your primary strategy, and to each other.

The higher the rating a strategy receives, the more important it is. If a strategy is half as important as another, it should receive half as high a rating.

Any strategy you do not use may be left unrated. It will automatically be assigned a rating of 0.

**I apply the following Equity strategies**

- Passive – Full Index Replication
- Passive – Sampling
- Passive – Programming
- Semi–Active – Enhanced Indexing
- Active – Market Timing
- Active – Sector Rotation
- Active – Value Stock Selection
- Active – Growth Stock Selection
- Other

**I apply the following Fixed Income strategies**

- Passive – Full Index Replication
- Passive – Sampling
- Semi–Active – Enhanced Indexing
- Active – Interest Rate Anticipation
- Active – Valuation (Rich/Cheap)
- Active – Credit (Yield Spread)
- Other

**I apply the following Alternative strategies**

- Market Neutral
- Long and Short
- Global Macro
- Event Driven
- Arbitrage
- Other

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Knowledge-Based Inputs to Portfolio Management

Item 9 of 14 Types of Assets Managed

Please identify the category of portfolio that consumes most of your time with a rating of 10.

Next, rate all of the other categories of portfolios you manage in turn on a scale of 0 to 9.9 to indicate how much of your time they consume compared to your primary category, and to each other.

The higher the rating a category receives, the more time it consumes. If a category consumes only half as much of your time as another, it should receive half as high a rating.

Any category you do not manage may be left unrated. It will automatically be assigned a weight of 0.

I manage the following categories of portfolios:

- Money Market (including Canadian Money Market and U.S. Money Market)
- Specialty or Miscellaneous (including Labour Sponsored Venture Capital, Alternative Strategies, Canadian Income Trust)
- Industry Sector (Financial Services, Healthcare, Natural Resources, Precious Metals, Real Estate, Science & Technology)
- Canadian Equity (including Canadian Small Cap Equity, Canadian Dividend and Equity Income, Canadian Equity (Pure), and Canadian Focus Equity)
- U.S. Equity (including U.S. Small and Mid Cap Equity, and North American Equity)
- Global Equity (including International Equity)
Other Foreign Equity (including Japanese Equity, Asia ex-Japan Equity, Asia/Pacific Rim Equity, Emerging Markets Equity, European Equity)

Global Balanced (including Global Balanced – Equity Focus)

Canadian Balanced (including Canadian Tactical Asset Allocation, Canadian Income Balanced, Canadian Balanced – Fixed Income Focus, and Canadian Balanced – Equity Focus)

Fixed Income (including Canadian Bond, Canadian Short Term Bond and Mortgage, High Yield Bond, Foreign Bond)

Hedge Funds

Private Equity (including Venture Capital, Mezzanine, and Buy Out)

Infrastructure (Power Plants, Toll Roads, Electricity Transmission Grids, Airports, etc.)

Real Estate (Tangible Property)

Other (e.g., Managed Futures, Commodities, etc.)
Knowledge-Based Inputs to Portfolio Management

Item 10 of 14 Types of Clients Served

Portfolio managers may manage assets for a number of different types of clients. Please read all of the following categories of clients and then apportion a total of 100 points among them to reflect the percentage of your time you spend serving each.

- [ ] Mutual or Pooled Fund Investors
- [ ] High Net Worth Individuals
- [ ] Pensions or Profit Sharing Plans
- [ ] Governments (including Hospitals)
- [ ] Trusts, Estates, Foundations, and Endowments
- [ ] Charitable Organizations
- [ ] Investment and Venture Capital Companies
- [ ] Financial Institutions
- [ ] Other Corporations (Treasury)
- [ ] Trade Unions
- [ ] Other (not listed above)
Knowledge-Based Inputs to Portfolio Management

Item 11 of 14 Accreditation

Please indicate all the degrees and professional designations you hold.

- B.A.
- B.Sc.
- B.B.A.
- B.Com.
- M.A.
- M.Sc.
- M.B.A.
- I.M.B.A.
- Ph.D.
- Chartered Financial Analyst (CFA)
- Chartered Alternative Investment Analyst (CAIA)
- Chartered Market Technician (CMT)
- Chartered Accountant (CA)
- Chartered Business Valuator (CBV)
- None, I'm self-taught
- Other (please specify)

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Knowledge-Based Inputs to Portfolio Management

Item 12 of 14 Professional Experience

Please indicate the number of years you have been employed as a professional portfolio manager.

<table>
<thead>
<tr>
<th>Option</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2 years</td>
<td></td>
</tr>
<tr>
<td>2 to 5 years</td>
<td></td>
</tr>
<tr>
<td>5 to 10 years</td>
<td></td>
</tr>
<tr>
<td>10 to 20 years</td>
<td></td>
</tr>
<tr>
<td>&gt; 20 years</td>
<td></td>
</tr>
</tbody>
</table>

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Knowledge-Based Inputs to Portfolio Management

Item 13 of 14 Other Comments

Some interesting thoughts about the productive use of knowledge, information, and technology may have occurred to you while completing this survey.

Is there anything else about the use of knowledge and information in your organization that you would like to add?
Knowledge-Based Inputs to Portfolio Management

Item 14 of 14 Feedback

Please indicate whether or not you would like to receive feedback indicating how your responses compare to aggregate statistics.

☑ No, thank you.

☑ Yes, please email comparative statistics.

☑ Yes, please email comparative statistics and send me a link to the entire thesis once it becomes available.

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Knowledge-Based Inputs to Portfolio Management

Thanks!

Your participation is appreciated.

Herman A. van den Berg, M.B.A.
Ph.D. Candidate & Principal Investigator
University of Toronto

herman.vandenberg@utoronto.ca
Knowledge-Based Inputs to Investment Management

Welcome

We invite you as one of a select group of investment management professionals to take part in this academic survey.

You will have the opportunity at the end of this survey to request a comparison of your responses to aggregate statistics.

The aim of this survey is to collect data on the different combinations of human capital, information, and technology used by investment management professionals. It is expected that research based on this data will improve our understanding of how the relative reliance on each type of input varies with the type of work performed.

If you have any questions about this survey, please contact:
Herman van den Berg, Ph.D. Candidate, University of Toronto, at +1.416.997.0464 or at herman.vandenberg@utoronto.ca, or
Brian S. Silverman, Professor and J.R.S. Prichard and Ann Wilson Chair in Management, Rotman School of Management, University of Toronto at brian.silverman@rotman.utoronto.ca, or
Chun Wei Choo, Professor, Faculty of Information Studies, University of Toronto at cw.choo@utoronto.ca.
Knowledge-Based Inputs to Investment Management

Confidentiality

We respect and will protect the confidentiality of every respondent.

While it is our intent to publish and make public presentations based on the research, your name and that of your organization will remain confidential.

Data collected will be analyzed to produce aggregate statistics only. No individual responses will ever be reported.

Only the principal investigator will have access to the data. The data will be electronically stored in a secure location and all identifying information will be removed.
Knowledge-Based Inputs to Investment Management

Introduction

This survey takes on average about 15 minutes to complete.

It begins with six groups of three statements each, which you will be asked to rate. A completed example is provided.

Six items designed to situate you and your work within the investment industry follow this.

The survey ends with one open-ended question.
Knowledge-Based Inputs to Investment Management

Consent Form

I understand that I am under no obligation to agree to participate in this survey and that I may exit this survey at any time without negative consequences.

I understand that my specific answers and comments will be kept confidential, and that I may decline to answer any question.

I understand that neither my name nor the name of my organization will be identified in any report or presentation that may arise from the study.

I have completely read the above, and

☑️ I agree and consent to participate.
☑️ I withhold my consent.
Knowledge-Based Inputs to Investment Management

Completed Example

The first nine questions require magnitude estimations. The following is a completed example.

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

When buying an automobile, I want...

8.0 ...an above average vehicle safety rating.
4.0 ...an excellent price.
10.0 ...the best manufacturer.

The completed example indicates that the respondent believes the selection of the best manufacturer is the most important factor. It also indicates that a good safety rating is only eight-tenths as important as the selecting the best manufacturer, but twice as important as getting an excellent price. Finally, it indicates that selection of the best manufacturer is two and one-half times as important as getting an excellent price.
Knowledge-Based Inputs to Investment Management

Item 1 of 12 Location of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

To do my job well, I rely on...

- [ ] functionality built into the technology I use (e.g., computer, canned software, Blackberry, etc.).
- [ ] personal judgement, insight, and skills I have developed.
- [ ] information I obtain from documents (e.g., research reports, annual reports, websites, manuals, books, etc.).
Knowledge-Based Inputs to Investment Management

Item 2 of 12 Transfer and Diffusion of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

In my job, valuable knowledge is transferred through...

- [ ] ...personal contact and interaction (e.g., conversations, meetings, etc.).

- [ ] ...transferring technology (e.g., quantitative models, algorithms, programs, etc.).

- [ ] ...written documents (e.g., email, reports, etc.).
Knowledge-Based Inputs to Investment Management

Item 3 of 12 Expression of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

My organization's competitive position relies on knowledge that is...

☐ ...evident in the rules, routines, and procedures we have developed over time (e.g., flags, screens, etc.).

☐ ...evident in the activities we perform within our firm.

☐ ...not evident, but hidden in the technology we use (e.g., quantitative models, proprietary algorithms, customized applications, etc.).
Knowledge-Based Inputs to Investment Management

Item 4 of 12 Acquisition of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

My ability to do my job well relies on knowledge I acquire...

- [ ] ...by studying and interpreting information.
- [ ] ...through personal experience.
- [ ] ...through the purchase of functionality embedded in technology.
Knowledge-Based Inputs to Investment Management

Item 5 of 12 Source of Value of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

I create value by relying on...

- [ ] ...the functionality embedded in the technology I use.
- [ ] ...formal and informal processes specific to my role.
- [ ] ...my unique insights or those of my team.

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Knowledge-Based Inputs to Investment Management

Item 6 of 12 Observability of Knowledge used in Production

Please identify the most important factor with a rating of 10.

Next, rate each of the remaining two factors in turn on a scale of 0 to 9.9 to indicate how important they would be compared to the most important factor, and to each other.

The higher the rating a factor receives, the more important it is. If a factor is half as important as another, it should receive half as high a rating.

The source of my productivity is...

- [ ] decodable by my peers in competing firms.
- [ ] hidden in difficult-to-replicate technology.
- [ ] a mystery to newly hired colleagues.
Knowledge-Based Inputs to Investment Management

Item 7 of 12 Position Title

Individuals with various roles and responsibilities contribute to the success of the investment industry.

Please provide the title of the position you hold within your firm.
Knowledge-Based Inputs to Investment Management

Item 8 of 12 Accreditation

Please indicate all the degrees and professional designations you hold.

| ☐ | College Diploma |
| ☐ | B.A. |
| ☐ | B.Sc. |
| ☐ | B.B.A. |
| ☐ | B.Com. |
| ☐ | M.A. |
| ☐ | M.Sc. |
| ☐ | M.B.A. |
| ☐ | I.M.B.A. |
| ☐ | Ph.D. |
| ☐ | Chartered Financial Analyst (CFA) |
| ☐ | Chartered Alternative Investment Analyst (CAIA) |
| ☐ | Chartered Market Technician (CMT) |
| ☐ | Chartered Accountant (CA) |
| ☐ | Chartered Business Valuator (CBV) |
| ☐ | None, I'm self-taught |
| ☐ | Other (please specify) |

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Knowledge-Based Inputs to Investment Management

Item 9 of 12 Professional Experience

Please indicate the number of years you have been employed in your current role.

- < 2 years
- 2 to 5 years
- 5 to 10 years
- 10 to 20 years
- > 20 years

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Knowledge-Based Inputs to Investment Management

Item 10 of 12 Area of Responsibility

Please select the area(s) of responsibility that most closely describes the work you perform.

- Marketing
- Retail Sales
- Institutional Sales
- Investment Advising
- Other Client Interface
- Research
- Portfolio Analysis
- Trading
- Finance
- Other Front Office
- Transactions Operations
- Customer Analytics
- Client Reporting
- Regulation
- Compliance
- Risk Management
- Legal
- Information Technology
- Other Middle Office
- Accounting
- Settlements
- Clearances
- Records Maintenance
- Other Back Office
- Other (please specify)
Knowledge-Based Inputs to Investment Management

Item 11 of 12 Professional Experience

There are many important roles and responsibilities in various areas of investment management.

From your perspective in your organization, the relationship between Portfolio Management and your area of the organization is...

- Extremely Unproductive
- Very Unproductive
- Somewhat Unproductive
- Neither
- Somewhat Productive
- Very Productive
- Extremely Productive
- Not Applicable

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Knowledge-Based Inputs to Investment Management

Item 12 of 12 Other Comments

Some interesting thoughts about the productive use of knowledge, information, and technology may have occurred to you while completing this survey.

Is there anything else about the use of knowledge and information in your organization that you would like to add?
Knowledge-Based Inputs to Investment Management

Feedback

Please indicate whether or not you would like to receive feedback indicating how your responses compare to aggregate statistics.

☐ No, thank you.

☐ Yes, please email comparative statistics.

☐ Yes, please email comparative statistics and send me a link to the entire thesis once it becomes available.
Knowledge-Based Inputs to Investment Management

Thanks!

Your participation is appreciated.

Herman A. van den Berg, M.B.A.
Ph.D. Candidate & Principal Investigator
University of Toronto

herman.vandenber@utoronto.ca
APPENDIX F: EXAMPLE EMAIL SENT TO CHIEF INVESTMENT OFFICER REQUESTING PERMISSION TO SURVEY

[Firstname Lastname]
Director & Chief Investment Officer
[Firm name]

Dear Firstname,

My name is Herman van den Berg and I am conducting my Ph.D. thesis research in Management Strategy at the University of Toronto, focusing on the Knowledge-Based View of the firm. I need your help in determining how unique combinations of human capital, information, and technology are put to productive use in a knowledge-based organization. The results of this research are being made available to all who are selected to participate in a short (10 to 15 minute) confidential online survey. A significant number of Canadian investment management firms are already participating in the study. Since [Firm name] is [some details about the firm indicating that the researcher knows something about the firm, such as the value of its assets under management], I would like to extend an opportunity to participate in this survey to your portfolio managers and your firm’s other investment management professionals. I would be happy to meet with you to discuss the research in greater detail, provide you with a survey instrument for your review, and answer any questions you may have. May I count on the participation of [Firm name]?

I look forward to your response.

Sincerely,

Herman

--

Herman A. van den Berg
Ph.D. Candidate
University of Toronto

ph1: (416) 304-1041
ph2: (416) 997-0464
www.fis.toronto.edu/phd/vandenberg

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