Individual Knowledge Measurement: Organizational Knowledge Measured at the Individual Level

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TITLE PAGE

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Organizational Knowledge Measured at the Individual Level

1. Introduction

Foss (2009, p. 21) interprets Felin and Hesterly (2007) as suggesting that "…organizational knowledge is really an epiphenomenon of individuals with certain skills and knowledge; the true locus of knowledge is strictly individual". In the autopoietic view, knowledge is deemed as context-sensitive with its intrinsic nature implying that categories and meanings of knowledge mainly depend on individuals (Sabherwal and Becerra-Fernandez, 2003). These individuals, as the primary possessors of organizational knowledge and the sole executors of fundamental knowledge processes, are at the centre of the firm's knowledge system (Ragab and Arisha, 2018). Current knowledge management models, however, provide a corporate view of organization knowledge without considering the individual knowledge workers who lead the creation, sharing and application of knowledge that drives organizational performance (Rechberg and Syed, 2014). According to Ragab and Arisha (2018, p. 201), there is a tendency in knowledge management research to embrace an organizational view of knowledge, often overlooking its individual roots and this has resulted in limited efforts having been directed towards investigating organizational knowledge from an individual perspective. Hence, there is a need for individual knowledge measurement to ensure integration of an individual perspective in knowledge management research (Rechberg and Syed, 2014).

Given the prominence of knowledge measurement in empirical research (Borgatti and Carboni, 2007), it is striking how it is the least developed aspect of knowledge management (Matošková, 2016). This may partly be because measuring knowledge is considered to be complex and, in at least some cases, an impossible task (Matošková, 2016; Ragab and Arisha, 2013). Measuring knowledge that cannot be easily translated into words, numbers, or symbols, remains a gap in the field of knowledge management. To address this omission in knowledge management literature, the present research is focused on answering a critical question: *How do we measure the knowledge*

held by individuals in an organization?

As knowledge management researchers, we strongly believe that individual knowledge measurement is an essential precursor to effective knowledge management and until we can actually measure knowledge at the individual level, theories related to knowledge will remain incomplete. Accordingly, our research is based on the premise that organizational knowledge is individually held, and seeks to specifically measure the differences in reliance on fundamental classifications of knowledge between degrees of specialization. This approach builds on the emerging belief that when the amount of knowledge is measured at the individual level, the differences between various types of knowledge become more pronounced (Matošková, 2016), thereby making these underlying differences an essential condition of knowledge measurement.

At this point, it should be noted that there is an important distinction between substantive knowledge, defined by Kogut and Zander (1992) as knowledge of how a product is created or produced, and the more fundamental classifications of knowledge as tacit, codified, or encapsulated (Nonaka and Takeuchi, 1995; Polanyi, 1966; Teece, 2000; van den Berg, 2013), used in this study. Differences in substantive knowledge may explain why we see few true conglomerate firms that are successful. However, even in monoline firms, differences between reliance on tacit, codified, or encapsulated knowledge may be useful in distinguishing between adjacent stages of production and organizational roles, even when much substantive knowledge is commonly held (van den Berg, 2013).

Substantive knowledge may be considered specialized on an industry-by-industry basis (Demsetz, 1988). For example, Grant and Baden-Fuller (2004) relate value chain boundaries to the range and diversity of knowledge among various knowledge domains while Demsetz (1988) acknowledges that even within an industry that shares common substantive knowledge, there are differences in the knowledge on which individual firms rely. These differences are found because "the cost,

benefit, and imitability of knowledge assets largely depend on their *form*" (emphasis added) (Evans *et al*., 2014, p. 85). The implicit assumption is that not all stages of production rely on similar types of knowledge, and organizational roles can be differentiated based on characteristics of the underlying knowledge being utilized (McIver and Wang, 2016).

Against this backdrop, the second research question in this study is: *Does relative reliance on different types of knowledge (tacit, codified, and encapsulated knowledge) differ measurably in the presence of commonly held substantive knowledge?* We address this question by testing the proposition that relative reliance on tacit, codified, and encapsulated knowledge differs between adjacent stages of production and organizational roles, even in the presence of commonly held substantive industry knowledge. The results of this study provide important insights into how organizations and researchers may be able to measure knowledge at a granular level. Furthermore, the results highlight the pivotal role played by individuals within an organizational knowledge environment and may thereby help organizations allocate knowledge resources. Furthermore, measuring differences in the relative reliance of various forms of knowledge may assist knowledge workers in the identification of knowledge-based resources that may currently be hidden, unutilized, or underdeveloped.

2. Theoretical Background

This study is focused on the measurement of knowledge as it is perceived by individuals who create, disseminate, and experience the consequences of applying such knowledge. Organizational knowledge has been implicitly or explicitly examined in three conceptual streams that form the underpinnings for this study: (a) organizational learning theory; (b) the knowledge-based theory of the firm; and (c) Nonaka's theory of knowledge creation.

According to *Organizational learning theory*, learning in organizations takes place through individuals (Sabherwal and Becerra-Fernandez, 2003). The essence of this theory is that

experiential learning in organizations is dependent upon two things - the extent to which each specific individual learns, and the extent to which individual learning gets embedded in organizational memory. The theory highlights how individuals serve as the brains that foster cognition for organizations (Hedberg, 1981).

Similarly, *Knowledge-based theory* of the firm revolves around the cognitive development, organizational impacts, and role of individuals (Grant, 1996; Kogut and Zander, 1992). According to this theory, knowledge starts with the individual, while organizations strive to integrate this knowledge using a combination of processes and capabilities (Sabherwal and Becerra-Fernandez, 2003). Grant (1996), a major proponent of the knowledge-based theory, emphasizes that organizational competitiveness is based on the firm's ability to integrate individuals' specialized knowledge. The role of an organization is then to generate new combinations of the individual knowledge. While knowledge is created and held by individuals, the firm essentially acts as an institution for knowledge integration (Grant, 1996). Thus, according to the knowledge-based theory of the firm, knowledge starts with the individual, and firms consolidate this knowledge (Sabherwal and Becerra-Fernandez, 2003) employing a combination of processes and capabilities (Kaur, 2019; Kaur and Mehta, 2016).

The focal role played by individual-level learning is prominent in *Nonaka's theory of knowledge creation* (Nonaka, 1994; Nonaka and Takeuchi, 1995), which reiterates that an organization cannot create knowledge by itself. Instead, individual knowledge is the basis of organizational knowledge creation (Nonaka and Takeuchi, 1995; Sabherwal and Becerra-Fernandez, 2003). Nonaka and Takeuchi (1995) examine knowledge along ontological and epistemological dimensions. The epistemological dimension focuses on different types of knowledge while the ontological dimension relates to different levels at which this knowledge is held, namely, at the individual, group, organizational, and interorganizational levels (Sabherwal and Becerra-Fernandez, 2003).

The three theories agree on one important aspect i.e., knowledge creation originates at the individual level. Only after individual origination, does it diffuse through groups, organizations, and inter-organizational levels. This key understanding that knowledge originates with the individual lays the foundation for this study.

2.1 Types of Knowledge

Another lens which is pertinent to this research is presented in the *Theory of the Firm Revisited*, which suggests that advantages in production costs stem from the specialization of tasks, which in turn stem from the specialization of knowledge (Demsetz, 1988, p. 158). The firm, seen as an agreement to specialize (Demsetz, 1988; Grant, 2002), implies different marginal rates of technical substitution for the various factors of production between adjacent production stages. This suggests that individuals working in an organization, in adjacent stages of production, will operate with different types and combinations of knowledge, due to the unique production and cost functions of each form of knowledge.

The extant literature suggests that organizational knowledge may be categorized as belonging to one of three classifications, specifically, tacit, codified, and encapsulated knowledge (van den Berg, 2013). For this study we relied upon these three separate classifications as detailed in the next section.

2.1.1 Tacit Knowledge

The concept of tacit knowledge was introduced by Polanyi (1966) which has since then become one of the most widely discussed topics in knowledge management (Grant, 2007). Polanyi (1976, p. 336) describes tacit knowledge as the "power to know more than we can tell". Tacit knowledge is highly personal, practical, and context specific (Ambrosini and Bowman, 2001). It consists of mental models that are so deeply embedded in the individuals that these are deemed to be exclusively "attached to the knower" (Ambrosini and Bowman, 2001, p. 813). This specific kind

of knowledge must be learned, acquired, and accumulated through experience. It is difficult to formalize and is expensive to transfer and diffuse (van den Berg, 2013).

2.1.2 Codified Knowledge

Tacit knowledge is contrasted with explicit knowledge, which is the expressed knowledge that is communicated to others (Grant, 2007). According to Stover (2004, p. 164) "when explicit knowledge is documented, it becomes codified". The purpose of the codification of tacit knowledge is not only to facilitate retrieval of information, but also to enable the reuse of knowledge in new ways that entail reflection, criticism, learning, and ultimately the creation of new knowledge (Choo, 2000). According to Stover (2004), there are three separate but related steps in codifying knowledge once it has been made explicit. First, the organization must create warehouses of explicit knowledge, a process known as internal codification (Choo, 2000). Second, the organization must develop mechanisms that will refine the collected explicit knowledge, extract valuable content, and turn it into a more usable form. This step will add value to the knowledge through a taxonomy that includes controlled vocabulary, common language, and appropriate cross-referencing (Stover, 2004). Third, the organization must provide for delivery platforms that support the push and pull of content through subscriptions and through searchable databases for various individuals in the organization. These three steps turn raw knowledge into refined knowledge (Stover, 2004). As a result, codified knowledge may be considered a structured form of knowledge that is delineated in written reports, databases, and other organized media. An important aspect of codified knowledge is that it is non-rivalrous and nonexcludable and thus, it can be very inexpensively replicated, transferred, and diffused (van den Berg, 2013).

2.1.3 Encapsulated Knowledge

In addition to the popular tacit-explicit dyad proffered by Polanyi (1966), encapsulated knowledge is emerging as a crucial knowledge category. Van den Berg (2013, p. 163) draws attention to the

fact that the term 'explicit' implies observability, but not all non-tacit knowledge is observable. Observability has important implications for the transfer and replication of knowledge and the ability to appropriate value from its possession. It is therefore necessary to distinguish between non-tacit knowledge that is codified and observable and non-tacit knowledge that is encapsulated and not readily observable. Encapsulation of knowledge, as an alternative to codification, encompasses "transformation of substantive knowledge into a product that requires only functional knowledge for its utility" (van den Berg, 2013, p. 164). Consequently, appropriation of value i.e., ability of the owner of an economically valuable assemblage of knowledge to realize the value of that knowledge (Grant, 1996), is truly facilitated when knowledge is encapsulated. Encapsulation of knowledge offers various benefits. For instance, knowledge encapsulated in artefacts' design and functionality minimizes the cognitive load on users. Relatedly, the value of encapsulated knowledge is readily appropriable through the sale of commercially valuable items or devices, whereas the value of codified knowledge may be easily misappropriated absent a strict intellectual property regime (Teece, 2000).

In summary, knowledge may be *tacit*, held in the minds of the professionals who make up the organization, or *codified*, in documents decipherable by those same professionals, or it may be hidden from the employees in the form of knowledge *encapsulated* in the computer systems on which they rely. Boisot (1998) uses the construction of a building as a metaphor for distinguishing between the different repositories of knowledge. For instance, the accumulated stock of knowledge about the physical properties of materials used by the architects in drawing the building's plans, exemplifies tacit knowledge, whereas a construction blueprint serves as an example of codified knowledge, and a shaped brick used in constructing a building instantiates encapsulated knowledge (Boisot, 1998, pp. 12-13). Similarly, in the world of music, musicians rely on their tacit knowledge to make music, while a musical score represents a repository of codified knowledge to those who

able to read it. On the other hand, a piano represents encapsulated knowledge, since the way it is constructed to emit certain sounds is hidden from the pianist in the design and functionality of the instrument. Thus, the piano's economic value (to a pianist) comes from both not having to know-how to build one to enjoy its benefits and (to a piano maker) from being able to sell one's piano building skills (van den Berg, 2013, p. 169).

2.1.4 Classification of Knowledge by Perspectives

The three classifications of knowledge differ from several different perspectives or dimensions that may be useful in determining the most appropriate classification of a specific assemblage of knowledge. The six perspectives specifically, Locus, Transfer, Expression, Acquisition, Value and Observability are described below.

Locus of knowledge identifies whether the knowledge is being "held by a knowing agent" (Boisot, 1998, p. 12) or if it resides outside of the human mind. From the perspective of knowledge-as-object, tacit knowledge is not only located in the human mind, but it also requires co-location with another to be observed and transferred (van den Berg, 2008). Tacit knowledge, so described, cannot exist outside of a knowing agent (Boisot, 1998). Nevertheless, knowledge can be externalized beyond an individual creator by being embedded either in machines or other physical technology (Langlois, 2001, p. 82).

Transfer indicates how easily knowledge "diffuses within and across firm boundaries" (Argote *et al*., 2003, p. 574). This dimension focuses on the aspects of knowledge that allow it to be transmitted at low cost and ''without loss of integrity'' (Kogut and Zander, 1992, p. 386).

Expression of knowledge is manifested in its intrinsic nature. For instance, if knowledge remains inexpressible (tacit), it is excluded from the functionality or design of an artefact (van den Berg, 2008). On the other hand, if knowledge is expressible, it may be evinced in the functionality and design of an artefact (encapsulated) or through various formal systems such as the symbols used in

language (codified).

The *Acquisition* dimension examines whether knowledge is physically transferable and acquirable in a marketplace, thereby providing utility to those who have the tactic knowledge necessary to use it (van den Berg, 2008). The evolutionary force of knowledge acquisition depends not only on the speed and costs of creating new knowledge, but also on the rate at which knowledge can be transferred (Simon, 1999). This perspective centres on the extent to which knowledge may be exchanged for economic gain.

Value encompasses the extent to which the owner of an economically valuable quantity of knowledge commands significant economic benefits from that knowledge (Grant, 1996; Teece, 2000). Knowledge as a ‘‘value-endowing’’ resource has important strategic significance to a firm (Grant, 1996, p. 375). The three classifications of knowledge hold different values for a firm (van den Berg, 2013). For instance, appropriating value from codified knowledge is comparatively difficult since it is both a public and non-rivalrous good (Langlois and Robertson, 1996).

Observability implies explicitness, however, not all non-tacit knowledge is observable (van den Berg, 2008). 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. Encapsulated knowledge can then be distinguishable from codified knowledge primarily from the perspective of observability (van den Berg, 2013). Additionally, the perspective of observability brings important implications for transferability of knowledge and appropriability of its value (Teece, 2000; van den Berg, 2008).

In essence, these six perspectives, chosen on the basis of their strategic and economic significance to a firm, aid in distinguishing between the different classifications of knowledge and placing a

specific arrangement of knowledge closer to one classification than another. Table I summarizes the nature of the three classifications of knowledge in the context of these six perspectives.

--- Insert Table I about here ---

Differences between the three classifications along the six perspectives have strategic implications for the firm (van den Berg, 2013, p. 161). For example, tacit knowledge must be 'rented' from employees and other stakeholders as a firm cannot really own it (van den Berg, 2013). On the other hand, codified knowledge is subject to misappropriation absent a strong intellectual property rights regime, whereas encapsulated knowledge comes closest to describing a finished product for end-user consumption (Teece, 2000). Thus, the real value of knowledge lies in its design and functionality and the realization of benefits of knowledge depends on the unique combination of tacit, codified, and encapsulated knowledge chosen by individuals in the performance of their tasks (van den Berg, 2013).

Based on these inferences, it is reasonable to expect that individuals rely on different combinations of tacit, codified, and encapsulated knowledge in their productivity. Likewise, it is reasonable to expect that different stages of production along a value chain, translating into different organizational roles, will often rely on different combinations of tacit, codified, and encapsulated knowledge. Hence, the need to measure reliance on different types of knowledge between individual knowledge workers. A discussion of the setting of this study is presented next, followed by our method and results for estimating levels of relative reliance on the three classifications of knowledge in the subsequent sections.

2.2 Investment managers

The aim of this study is to measure organization knowledge at the individual level which essentially entails estimating individual knowledge. To achieve this aim, a survey was conducted to inquire how various Chartered Investment Managers (CIM®) put knowledge to productive use. Since,

choosing the 'knowers' is of utmost importance in measuring knowledge resources (Wilcox, King and Zeithaml, 2003), for the purpose of this study, we analyze the differences in the relative reliance on tacit, codified and encapsulated knowledge among CIMs who are vital to the functioning of the investment management industry.

The investment management industry has grown from a relatively small industry offering a relative handful of mutual funds to a multi-trillion-dollar industry offering thousands of securities with a multitude of investment policies and strategies (Bogle, 2005, p. 15). Even after the crash of the dot-com bubble and during the recent turmoil in financial markets, the industry has continued to thrive (Khorana and Servaes, 2012), highlighting the importance of the sector. While the investment management industry is generally considered to be a knowledge-based industry (van Gelderen and Huij, 2014), surprisingly little has been documented about the role individual knowledge plays. We see this as an opportunity to delve deeper into investment management by analyzing the role of knowledge in different stages of production (portfolio management versus client advising, for example). Furthermore, it should be noted that the choice of a single industry for this study adheres to the recommendation that researching homogenous business processes of a single industry can aid securing a higher level of statistical validity for the scale developed (Kaur, 2019). Finally, restricting our survey to Chartered Investment Managers ensures that we are able to distinguish between reliance on tacit, codified and encapsulated knowledge in a setting where considerable substantive knowledge is commonly held. The following section expands upon the concepts related to the substantive knowledge universally possessed by CIMs as a precursor to understanding the analysis that follows.

2.3 Learning as an Indicator of Individual Knowledge Assessment

The notion of learning is identified as a comprehensive concept in individual knowledge assessment (Ragab and Arisha, 2018). Polanyi (1967) states that knowledge is developed by

'indwelling', while Nonaka (1994) refers to this process of learning as 'internalization'. Knowledge and learning are often regarded as two sides of the same coin. In this regard, learning is commonly described as a knowledge acquisition process, while knowledge is sometimes defined as the outcome of learning through experience or study (Kogut and Zander, 1996). Ragab and Arisha (2018) confirm that managers' knowledge stems from learning that takes place in academic institutions and through personal development. Education and professional training emerge as principal factors contributing to learning and, ultimately, the acquisition of individual knowledge within organizations (Ragab and Arisha, 2018).

Since a firm's knowledge resides in individuals (Grant, 1996; Kogut and Zander, 1992), in investment management firms this equates to the knowledge distributed among investment managers. The identification and measurement of individual knowledge may aid in appraising organizational knowledge. According to Henry and Stier (2021), "the biggest resource for the investment management industry is its talent pool". Thus, a brief investigation into the formal training of CIMs is worthwhile in identifying the common substantive knowledge that these investment managers acquire.

According to the Canadian Securities Institute (CSI), CIMs, through their formal and experiential learning, develop a deep understanding of investment policy development, client risk tolerance, asset allocation, investment strategy, and equity and debt securities. Investment management training also encompasses learning about ethics, various strategies for building retail client and institutional portfolios, as well as the knowledge of regulatory and operational requirements to maintain an institutional investment firm. Building proficiency in investment management techniques equips these knowledge workers with a broad spectrum of skills needed to serve clients, including the ability to evaluate investment performance and explain returns to clients. Learning portfolio management techniques provides these knowledge workers with the advanced skillset

required to not only assume portfolio management roles for high-net-worth clients, but also to establish and maintain an investment management firm.

Due to a common curriculum, there exists a notable pool of substantive knowledge in which all CIMs share. Through formal training, investment managers, in both client advising and portfolio management roles, learn techniques to conduct environmental scans to formulate effective and efficient investment strategies for clients. Figure I, shows that commonly held substantive knowledge lies at the center of serving various clients and managing a variety of portfolios.

--- Insert Figure I about here ---

Previous studies suggest that there is a reason to believe that the reliance on fundamental knowledge-based factors should differ between adjacent stages of production. The knowledge management model developed by Hedlund and Nonaka (1993) argues that different knowledge types change between individuals and levels of organizations. Similarly, Inkpen and Dinur (1998, p. 454) state that "different processes involve different types of knowledge and different organizational levels". More recently, a study conducted by Haas and Hansen (2007) disputes the claim that different types of knowledge are substitutes for each other, thus suggesting that the different types of knowledge may be mutually exclusive.

On the other hand, some overlap of substantive knowledge between adjacent stages of production is naturally expected to enable fruitful communication between them. Haas and Hansen (2007) state that even though the different types of knowledge sharing cannot be considered as substitutes of each other, they may be undertaken simultaneously by individuals seeking to obtain knowledge from other parts of the firm. Thus, it would be reasonable to expect that investment managers spending different proportions of their time advising clients versus managing portfolios with varying investment strategies must still be relying on similar substantive knowledge to complete

similar tasks. However, different types of knowledge offer different benefits for different dimensions of task performance (Haas and Hansen, 2007).

The relative richness of tacit knowledge enables knowledge workers to develop customized and creative products for their clients (Lengel and Daft, 1984). Conversely, document-to-people (codified) knowledge sharing is more evident in cases that do not require more direct and constant communication (Haas and Hansen, 2007). Additionally, adapting electronic documents that reside in the firm's knowledge management system in different situations may reduce processing costs. Consequently, in a competitive environment, 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 client advising and portfolio management roles of Chartered Investment Managers. This assumption is based on the differences between the nature of three classifications of knowledge (van den Berg, 2013), as well as the suggestion that if knowledge management processes represent different ways of obtaining knowledge, it is useful to separate them conceptually and empirically (Haas and Hansen, 2007).

By limiting our survey population to Chartered Investment Managers, we ensured that survey respondents had overlapping substantive knowledge that came with earning the CIM® designation, regardless of which investment strategies they executed in the service of their various clients. So, the question really became one of whether or not the differences in fundamental measures of knowledge are of measurable magnitude between investment managers based on proportion of time spent advising clients versus managing portfolios, types of clients served, and variety of investment strategies employed. In this context, the following research hypotheses were postulated:

*H_1: Relative reliance on **tacit** knowledge differs measurably between proportion of time spent advising clients versus managing portfolios, variety of investment strategies employed, and types*

of clients served by investment managers.

*H_2: Relative reliance on **encapsulated** knowledge differs measurably between proportion of time spent advising clients versus managing portfolios, variety of investment strategies employed, and types of clients served by investment managers.*

*H_3: Relative reliance on **codified** knowledge differs measurably between proportion of time spent advising clients versus managing portfolios, variety of investment strategies employed, and types of clients served by investment managers.*

3. Methods

3.1 Research setting

The investment management industry is a major economic force in Canada and is both highly regulated and highly competitive (BLG, 2021). The data used in this research were collected by surveying Chartered Investment Managers in Canada. Data were self-reported by the respondents participating in an internet-based survey. The data were collected during a single week in March 2021.

3.2 Research population

Investment managers are a suitable population for this research because the industry is relatively knowledge-based with relatively little physical capital involved in the various productive activities undertaken. The trend to dematerialization appears to be continuing as evidenced by the Dematerialization White Paper published by the Canadian Capital Markets Association in 2001. The white paper suggested that further dematerialization would reduce significant inefficiencies for the industry (Canadian Capital Markets Association, 2001). Consequently, the variance in research results is expected to be less than if a more physical manufacturing type industry were examined.

3.3 Measures

In this research, relative rather than absolute, quantities of tacit, codified, and encapsulated knowledge are measured, since consensus on the measurement of absolute quantities of these forms of knowledge has so far eluded researchers. The intractability of obtaining absolute quantitative measures of these factors is bypassed in this research by measuring perceived relative reliance on tacit versus codified versus encapsulated knowledge along six dimensions. Knowledge-based factor intensities were measured by surveying relative perceived reliance on each classification of knowledge. Differences in knowledge-based factor intensities between adjacent stages of production (portfolio management, client advising) may be considered as indications of specialization. The survey instrument was constructed so that respondents were asked to provide relative ratings of their reliance on knowledge-based factors in the performance of their roles. Appendix A provides the portion of the survey used to collect these relative ratings. The ratings were transformed so that they are relative to total knowledge applied.

Eighteen independent items were identified, based on the three forms of organizational knowledge (tacit, codified, and encapsulated) and six perspectives of measurement (locus, transferability, expression, acquisition, value, and observability). These 18 items were designed to capture relative perceived reliance on the three knowledge-based factors of production (Birkinshaw and Fey, 2001; McEvily and Chakravarthy, 2002; Simon, 1999; Subramaniam and Venkatraman, 2001; van den Berg, 2013).

4. Data collection

4.1 Minimizing survey error

The use of self-reported measures gathered by surveying respondents carries with it some important risks. Dillman (2000) describes four sources of survey errors - sampling error, coverage error, measurement error, and non-response error and their consequences. 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 send email requests to 1,500 Chartered Investment Managers addresses this issue.

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 were provided for only those investment managers who wished to provide them on a public directory.

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. Before the survey was made available online it was successfully tested on smartphone and laptop screens using a variety of internet browsers.

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. Non-response error and measurement error were both minimized through careful survey design.

4.2 Representativeness

The research used primary data collected through online surveys of investment managers holding the CIM® designation. The investment managers were contacted by email to seek their participation in the survey. 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 approval of the principal investigator's university's Research Ethics Board.

Of the 1,500 invitational emails were sent to investment managers in the initial invitation to investment managers, 51 emails were undelivered for a variety of reasons ('no longer with us', 'address not found', 'denied by policy', etc.). An additional 44 were out of the office, on vacation, or on leave. A number of potential respondents reached out by phone or email to verify that the survey request was legitimate and not a scam. The overall response rate was 7.7% (108 out of the available 1,405) comparable to the overall response rate of 6.3% achieved in another survey of investment managers in the USA (Farnsworth and Taylor, 2006). Of the 108 respondents, 89 provided their consent to participate, but of those 10 did not provide any further information, resulting in data contributed by 79 individuals. Sampling within all firms was not completely random as some of the larger financial institutions have policies prohibiting participation in surveys. Table II provides an overview of the responding investment managers' levels of education and experience.

--- Insert Table II about here ---

4.3 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 then 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 3 and 2. 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 be rating the same tacit knowledge item with a relative weight of 0.667 (10 / (10+3+2)). 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 two forms combined.

The relative ratings were coded as 'AbcDef', where '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 Locus, Transfer, Expression, Acquisition, Value, and Observability, respectively.

The means of each of the ratio variables are displayed in Figure II. From every perspective, the mean of the relative weights assigned to encapsulated knowledge is lower than that assigned by respondents to the other two classifications of knowledge. The mean of the tacit knowledge weights exceeds the mean of the codified knowledge weights from three perspectives, while from two other perspectives, the means are about equal. Only from the Expression perspective does the mean of codified knowledge weights clearly exceed that of the other two categories of knowledge.

--- Insert Figure II about here ---

Table III presents the means, standard deviations, the minimums, and the maximums of each of the ratio variables from the relative ratings of the 18 raw survey ratings. There is some evidence of respondent fatigue as the number of responses decreases from the first question to the last. For robustness, responses consisting of less than 15 ratings were removed on the assumption that this

represented a respondent's unwillingness or inability to answer the questions thoughtfully.

--- Insert Table III about here ---

4.4. Content validity

Content validity for the knowledge-based survey items was previously 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.

4.5 Convergent validity

Table IV displays the Pearson correlations of the six items designed to measure relative reliance on tacit knowledge.

--- Insert Table IV about here ---

The item designed to measure relative reliance on tacit knowledge from the perspective of Observability, TacObs, appears to be less significantly correlated to the other 5 items, which all appear to be fairly well correlated. Tabachnick *et al.* (2007) suggest that the absence of any correlations above 0.3 should lead a researcher to reconsider factor analysis. Since six tacit item correlations exceed this standard with significance ($p < 0.01$), factor analysis may be considered appropriate.

Table V displays the Pearson correlation of the six items designed to measure relative reliance on codified knowledge. CodObs, appears to be less significantly correlated to the other 5 codified items. Since five codified item correlations exceed the Tabachnick *et al.* (2007) standard with significance ($p < 0.01$), factor analysis may be considered appropriate.

--- Insert Table V about here ---

Table VI displays the Pearson correlation of the six items designed to measure relative reliance on encapsulated knowledge. EncAcq and EncVal appear to be the most strongly correlated to the other items. Six of the encapsulated items exceed the Tabachnick *et al.* (2007) standard with significance ($p < 0.01$). Accordingly, factor analysis may be considered appropriate.

--- Insert Table VI about here ---

4.6 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 is, the higher is 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 *et al*., 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 (2003, p. 95), noting that "different methodologists and investigators begin to squirm at different levels of alpha", 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), indicates that, "no acceptable range has been established for this [Cronbach's alpha] index". Again, relying on Van de Ven and Ferry (1980), Powell (1992, p. 126), advises that, "for a scale of three items, alpha should fall between… 0.55 and 0.70 for a moderately broad construct".

Cronbach's alpha was calculated using Stata (StataCorp, 2021) to measure internal consistency/scale reliability based on average correlation among all six items designed to measure perceived relative reliance on encapsulated knowledge. The alpha of the standardized test scale is 0.70, which is respectable (DeVellis, 2003). Cronbach's alpha could be improved to 0.71 if EncLoc or EncExp were removed. Given the marginal increase in alpha, exploratory factor analysis was used to check dimensionality before generating the encapsulated knowledge scale. Table VII displays that removing any of the other items would reduce alpha below that of the test scale and reduce the scale's reliability.

--- Insert Table VII about here ---

Cronbach's alpha was calculated at 0.59 for a tacit knowledge scale using all six items. This level of alpha may be considered unacceptable (DeVellis, 2003). Table VIII shows that Cronbach's alpha could be improved if TacExp or TacObs items were removed. Accordingly, Cronbach's alpha was recalculated with both TacExp and TacObs items removed and found to increase to 0.69. Again, exploratory factor analysis was used to check dimensionality before generating the tacit knowledge scale.

--- Insert Table VIII about here –

A Cronbach's alpha of 0.53 was calculated for internal consistency/scale reliability of a codified knowledge scale if all items were included. Table IX shows that if CodLoc or CodObs items were removed, Cronbach's alpha could be increased and lead to a more reliable scale. Removal of both CodLoc and CodObs items increased Cronbach's alpha to 0.62, a level that suffices for early stages of basic research (Churchill, 1979). Also, exploratory factor analysis was used to check dimensionality before generating the codified knowledge scale.

--- Insert Table IX about here ---

4.7 Factor Analysis

Factor analysis may also be conducted to evaluate construct validity (Bagozzi *et al*., 1991) 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 *et al.* (1991) also point to the advantages of factor analysis over Campbell and Fiske's (1959) reliance on correlations for an assessment of convergent and discriminant validity.

The Stata module, FACTORTEST, (Azevedo, 2003) was applied to perform Bartlett's test for sphericity and calculate the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. Both tests should be used prior to a factor analysis.

For the six tacit knowledge items, 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. The KMO (Ullman, 2007) measure of sampling adequacy was 0.64, above the generally accepted minimum of 0.6 required for good factor analysis (Lattin *et al*., 2003). Kaiser (1970, p. 35) 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".

Performing a factor analysis on the four tacit knowledge items suggested by Cronbach's alpha using Stata (StataCorp, 2021) generated only one factor with an Eigenvalue > 1.0. With the 4-item scale, the factor loadings ranged between 0.515 and 0.724. The chi-square goodness-of-fit test was significant ($p < 0.001$). A parallel analysis for factor analysis (Horn, 1965; Ruscio and Roche, 2012) confirmed only one factor should be retained. As a result, the latent variable for relative reliance on tacit knowledge, TacScale, was generated using Stata's (StataCorp, 2021) factor, rotate, and predict commands on the four items, TacLoc, TacTra, TacAcq, and TacVal. Table X presents the factor loadings for the four items.

--- Insert Table X about here ---

For encapsulated knowledge items, 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. The KMO (Ullman, 2007) measure of sampling adequacy was 0.70, above the generally accepted minimum of 0.6 required for good factor analysis (Lattin *et al*., 2003).

Performing a factor analysis on the four encapsulated knowledge items suggested by Cronbach's alpha, retained only one factor with an Eigenvalue > 1.0. The factor loadings for the 4-item scale range between 0.432 and 0.875. The chi-squared goodness-of-fit test was also significant ($p < 0.001$). A parallel analysis for factor analysis (Horn, 1965; Ruscio and Roche, 2012) confirmed only one factor should be retained. As a result, the latent variable for relative reliance on encapsulated knowledge, EncScale, was generated using Stata's (StataCorp, 2021) factor, rotate, and predict commands on the four items, EncTra, EncAcq, EncVal, and EncObs. Table XI presents the factor loadings.

--- Insert Table XI about here ---

For codified knowledge items, 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. The KMO (Ullman, 2007) measure of sampling adequacy was 0.59, on the border of the generally accepted minimum of 0.6 required for good factor analysis (Lattin *et al*., 2003), although measures as low as 0.5 may also be considered acceptable.

Performing a factor analysis on the four codified knowledge items suggested by the Cronbach's alpha resulted in the retention of only one factor with an Eigenvalue > 1.0. The factor loadings for the 4-item scale ranged between 0.413 and 0.655. The chi-squared goodness-of-fit test was also significant ($p < 0.001$). A parallel analysis for factor analysis (Horn, 1965; Ruscio and Roche, 2012) confirmed only one factor should be retained. As a result, the latent variable for relative reliance on codified knowledge, CodScale, was generated using Stata's (StataCorp, 2021) factor, rotate, and predict commands on the four items, CodTra, CodExp, CodAcq, and CodVal. Table XII presents the factor loadings.

--- Insert Table XII about here ---

4.8 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 (DeVellis, 2003), also known as divergent validity (Campbell and Fiske, 1959). Four tacit knowledge items, four codified knowledge items, and four encapsulated knowledge items were selected to generate the three scales of relative reliance. To verify that these 12 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 items designed to measure relative reliance on tacit knowledge, the items designed to

measure relative reliance on codified knowledge, and the items designed to measure relative reliance on encapsulated knowledge were 0.380, 0.347, and 0.434, 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 0.135, -0.491, and -0.404. Discriminant validity between constructs may be demonstrated by correlations between them being significantly different from unity (Van de Ven and Ferry, 1980, p. 79). The two relatively large absolute values of the negative correlations between the encapsulated knowledge and the other two items, suggested the possibility that survey questions for the tacit and codified items, could perhaps have been better distinguished. Table XIII presents the average correlations.

--- Insert Table XIII about here ---

5. Results

5.1 Context

All investment managers rely on some combination of tacit, codified, and encapsulated knowledge in serving their clients and implementing investment strategies. However, it is reasonable to expect that investment managers' reliance on tacit, codified, and encapsulated knowledge will differ depending on the proportion of time spent advising (working with clients) versus time spent managing portfolios, the types of clients served, and the investment strategies employed. The three hypotheses were tested by analyzing the data to determine whether or not clients and investment strategies could be significant in predicting the type of knowledge employed by investment managers.

The strength with which investment strategies were followed was measured on a four-point scale as follows: 4 = always, 3 = frequently, 2 = sometimes, 1 = rarely. Respondents could also select 0 for never. Similarly, the strength with which clients were served was measured on a three-point

scale as follows: 3 = primarily, 2 = occasionally, 1 = rarely. Again, respondents could also select 0 to indicate never. Control variables, such as years of employment as investment managers, education, and other designations held, were also included in the analyses.

Forward stepwise regression models were constructed relating the independent (predictor) and control variables to the dependent variable scales estimating relative reliance on tacit, codified, and encapsulated knowledge. The significance level for addition of variables to the models was set at $p < 0.20$ and the significance level for removal of variables from the models was set at $p > 0.10$. Table XIV presents the regression results for all significant variables.

--- Insert Table XIV about here ---

5.2 Reliance on tacit knowledge

Testing of our first hypothesis generated mixed results. Relative reliance on tacit knowledge did not appear to be related to the proportion of time spend advising clients versus managing portfolios. There was some support for a relationship between reliance on tacit knowledge and engagement in one investment strategy. Relative reliance on tacit knowledge appeared to be significantly negatively related to the constant or frequent engagement in semi-passive equity investment strategies. Similarly, there appeared to be some support for relationships between reliance on tacit knowledge and clients served. Relative reliance on tacit knowledge appeared to be positively related to the occasional serving of trusts, estates, foundations or endowments, and other clients not captured in the specified client categories. None of the control variables appeared to significantly affect relative reliance on tacit knowledge. The adjusted R-squared for the tacit knowledge model was calculated by Stata (StataCorp, 2021) to be 0.376.

5.3 Reliance on codified knowledge

Testing of our second hypothesis also generated mixed results. Relative reliance on codified

knowledge appeared to be significantly positively related to the proportion of time investment manager spend advising clients. There was no support for a relationship between reliance on codified knowledge and any investment strategy. However, there appeared to be some support for relationships between reliance on codified knowledge and clients served. Relative reliance on codified knowledge appeared to be significantly negatively related to the occasional serving of high-net-worth individuals, and significantly positively related to never serving pensions or profit-sharing plans and occasionally serving other clients not captured in the specified client categories. A number of control variables appeared to significantly affect relative reliance on codified knowledge. Reliance on codified knowledge is apparently significantly positively related to the number of years respondents have been employed as investment managers and holding a Chartered Professional Accountant (CPA) designation. Reliance on codified knowledge appeared to be negatively related to holding four other designations in addition to the CIM®. These designations were Fellow of the Canadian Securities Institute (FCSI), Trust and Estate Practitioner (TEP), Certified Investment Management Analyst® (CIMA®), and Responsible Investment Specialist (RIS). The adjusted R-squared for the codified knowledge model was calculated by Stata (StataCorp, 2021) to be 0.598.

5.4 Reliance on encapsulated knowledge

Two of the three components of our third hypothesis, relating reliance on encapsulated knowledge to the proportion of time spent advising and clients served, were supported. Relative reliance on encapsulated knowledge appeared to be significantly negatively related to the proportion of time investment managers spend advising clients versus managing portfolios. Relative reliance on encapsulated knowledge also appeared to be positively related to primarily serving mutual fund or pooled fund clients and occasionally serving high-net-worth individuals. Relative reliance on encapsulated knowledge appeared to be significantly negatively related to never serving pensions

or profit-sharing plans. Only one control variable, the Financial Management Advisor (FMA) designation was positively related to reliance on encapsulated knowledge. The adjusted R-squared for the encapsulated model was calculated by Stata (StataCorp, 2021) to be 0.531, similar to that of the codified knowledge model.

6. Conclusion

This paper presented the findings derived from survey data designed to measure the relative reliance on tacit, codified, and encapsulated knowledge as factors of production in adjacent stages in the investment management industry. To the best of available knowledge, these findings suggest that evidence of specialization may be quantified using fundamental classifications of knowledge. The results suggest that reliance on different fundamental forms of knowledge in the employment of differing investment strategies in the service of differing clients are measurable, even in the presence of commonly held substantive knowledge.

6.1 Synthesis of Findings

This research examined the measurability of relative reliance on three fundamental classifications or forms of knowledge by investment management professionals. Researchers have typically categorized organizational knowledge as either tacit or explicit. This paper includes 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 was 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).

In the results section of this paper, the assumption of significant measurable differences in reliance on tacit, codified, and encapsulated knowledge between investment strategies and clients served was tested. The results of testing the hypotheses provided evidence suggesting that relative reliance

on tacit, codified, and encapsulated knowledge did differ between investment strategies and client types. While the strongest evidence was associated with tacit knowledge, there was also significant influence of a couple of investment strategies on reliance on codified and encapsulated knowledge by investment managers. This difference in the apparent applicability of tacit knowledge versus codified or encapsulated knowledge could possibly indicate that respondents could most reliably or easily report reliance on tacit knowledge.

6.2 Theoretical Implications

This study focused on answering two critical questions: (1) How can knowledge be measured at individual level? (2) Can we demonstrate differences in relative reliance on fundamental classifications of knowledge in the presence of commonly held substantive knowledge? We answered both of these questions affirmatively by developing a reliable and valid scale for measuring knowledge held at individual level and building a framework to support measurement of knowledge at a micro level. These endeavors assisted us in (a) addressing Simon's (1999) challenge of 'applying an economic calculus to knowledge' (p. 34), and (b) responding to the growing calls for evaluating individuals from a knowledge-based perspective (Borgatti and Carboni, 2007; Matošková, 2016; Ragab and Arisha, 2018; Rechberg and Syed, 2014). In previous research, knowledge has primarily been measured at the macro levels in organizations (Ragab and Arisha, 2018).

This study is significant because it reveals an avenue for unravelling questions and theories about organizational knowledge held at the individual level. Compared to existing literature focused on knowledge held at the organizational level, this study focuses on individually-held knowledge. This makes the study a significant attempt to ensure that theories of knowledge do not remain mere conjectures (Ragab and Arisha, 2018). The findings suggest that using an individual level approach may help us to better understand the complex foundations of knowledge at the organizational level.

We believe that the novel classification, evaluation, and measurement of knowledge at an individual level presented in this paper provides an essential development in strengthening theories of knowledge management (Matošková, 2016).

6.3 Practical implications

In addition to the impact on research, there are several managerial implications for organizations and managers. Measuring the knowledge of individuals may assist in the further development and retention of those individuals in an organization. Furthermore, organizations may be able to plan training and development of employees by targeting and focusing initiatives on the basis of the fundamental classifications of knowledge relied upon by those employees. In conclusion, the framework provided in this study may help in guiding the design and implementation of knowledge management strategies.

7. Limitations and Future Scope of Research

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 the three classifications of knowledge were based on self-reported ratings rather than on objectively observed phenomena, making them subject to measurement error. Second, the respondents to the survey are primarily associated with smaller firms that did not prohibit participation in academic surveys. Accordingly, this may limit the external validity of the results of this study.

Future research may focus on other professional organizations that by their nature rely predominantly on knowledge as their key resource. Once we have a more thorough understanding of how fundamental classifications of knowledge are utilized in these organizations, we may be able to extend knowledge management research further into more physical, manufacturing types of industries.

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Figure I: Common Substantive Knowledge

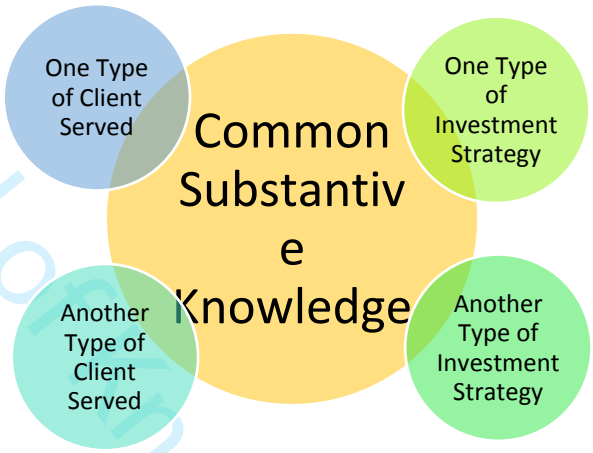


Table I: Typology of Knowledge by Perspective

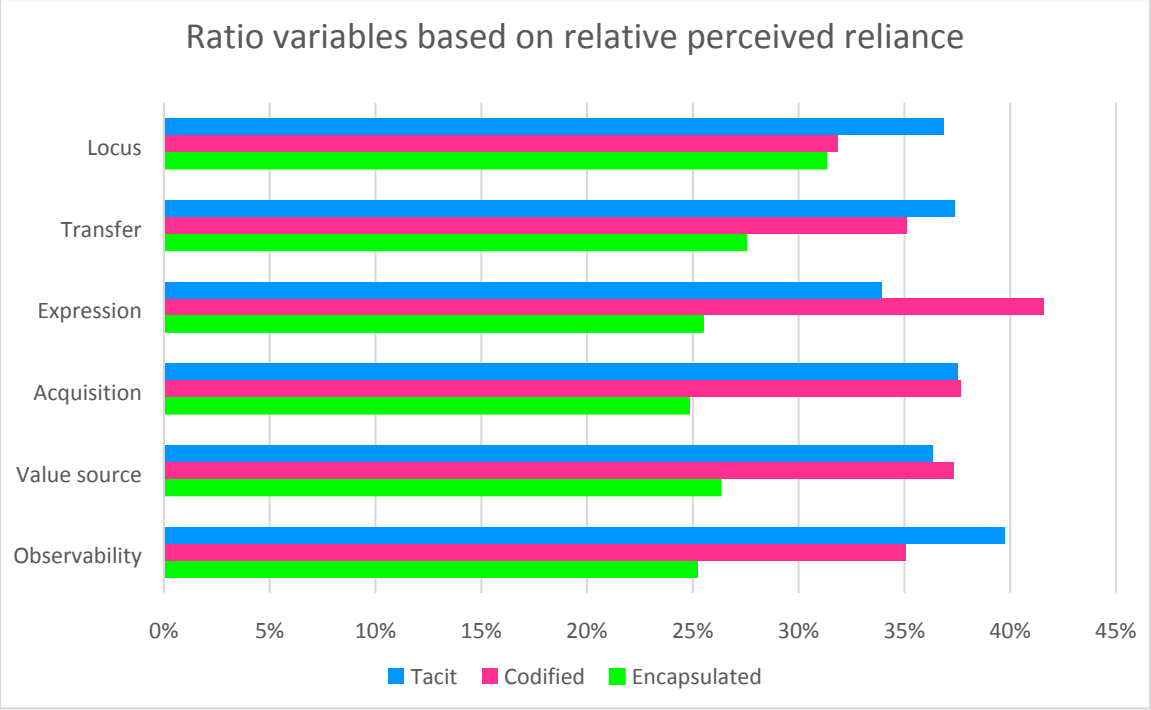
Perspective	***Tacit*** (implicit know-how resting in individual brains)	***Codified*** (explicit knowledge systematized as information)	***Encapsulated*** (explicit, nested know-how embodied in physical artefacts)	References
Locus	Human mind	Signs, symbols, codes, and display rules	Concealed in an artefact's design and embedded in machines and other physical technology	Boisot (1998), Grant (1996), Hedlund (1994), Langlois (2001)
Transfer	Hard to verbalize; costly to diffuse broadly	Requires common 'language'; Easy and low-cost transfer and storage	Speed, extent, and cost of transport all dependent on physical characteristics	Boisot (1998), Choo (2002), Hedlund (1994)
Expression	Implicit in action-based skills and conversation	Rules, routines, and recipes based on a system of symbols	Encapsulated in artefacts	Boisot (1998), Nelson and Winter (1982), Polanyi (1966), Simon (1999)
Acquisition process	Experiencing and doing, observation and imitation, internship, and apprenticeship.	Interpretation of signs, symbols, codes, and displays; dependent on IPR regimes	Acquired in markets through trade	Teece (1998), Winter (1987)
Source of Value	Capacity to make intuitive judgements, discoveries, and innovations	Informing the interpreter; low-cost replication; non-rivalrous nature	Use of the artefact incorporating the encapsulated knowledge	Demsetz (1988), Romer (1990), Teece (2000)
Observability	Requires co-location	Limited excludability	Requires costly experimentation and reverse engineering	Langlois and Robertson (1996), Saviotti (1998), Teece *et al.* (1997)

Table II: Investment manager profiles

Individual Knowledge Measurement

Years of experience as investment manager	Highest level of education attained					
	Secondary school diploma	College diploma	Bachelor's degree (BA, BBA, BCom, BSc, HBA, HBCom, LLB, JD, etc.)	Master's degree (LLM, MA, MBA, MFin, MSc, etc.)	Doctoral degree (DBA, MD, PhD, etc.)	Totals
0 to 5	1.5%	0.0%	6.0%	1.5%	0.0%	9%
6 to 10	1.5%	4.5%	10.4%	4.5%	0.0%	21%
11 to 15	0.0%	3.0%	9.0%	4.5%	1.5%	18%
16 to 20	1.5%	1.5%	4.5%	4.5%	1.5%	13%
21 to 25	3.0%	0.0%	14.9%	3.0%	0.0%	21%
26 to 30	0.0%	0.0%	7.5%	3.0%	0.0%	10%
Over 30	0.0%	0.0%	6.0%	1.5%	0.0%	7%
Totals	7%	9%	58%	22%	3%	100%

Figure II: Mean ratio variables by perspective



Individual Knowledge Measurement

Table III: Ratio variables based on relative perceived reliance

Perspective	Classification	Variable	Mean	Std. Dev.	Min	Max
Locus	Tacit	TacLoc	.3685	.0773	.2083	.7692
	Codified	CodLoc	.3182	.0736	.1111	.5000
	Encapsulated	EncLoc	.3133	.0674	.0769	.4545
Transfer	Tacit	TacTra	.3737	.0792	.1579	.6250
	Codified	CodTra	.3508	.0670	.1538	.5556
	Encapsulated	EncTra	.2754	.1106	.0500	.6250
Expression	Tacit	TacExp	.3394	.0965	.0769	.6000
	Codified	CodExp	.4157	.1220	.1667	.8333
	Encapsulated	EncExp	.2549	.0993	.0500	.5385
Acquisition	Tacit	TacAcq	.3751	.0568	.2500	.5263
	Codified	CodAcq	.3764	.0531	.2000	.5263
	Encapsulated	EncAcq	.2484	.0825	.0500	.5000
Value source	Tacit	TacVal	.3633	.0551	.2222	.5000
	Codified	CodVal	.3734	.0570	.2500	.5556
	Encapsulated	EncVal	.2633	.0768	.0500	.5000
Observability	Tacit	TacObs	.3973	.1112	.1500	.7143
	Codified	CodObs	.3506	.0998	.0952	.7143
	Encapsulated	EncObs	.2521	.1136	.0500	.6250

N = 69

Table IV: Pearson correlations of tacit knowledge items

	TacLoc	TacTra	TacExp	TacAcq	TacVal	TacObs
TacLoc	1					
TacTra	0.291*	1				
TacExp	-0.210†	-0.147	1			
TacAcq	0.449***	0.471***	-0.184	1		
TacVal	0.279*	0.340**	0.071	0.508***	1	
TacObs	-0.031	0.385**	-0.019	0.318**	0.055	1

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

Table V: Pearson correlations of codified knowledge items

	CodLoc	CodTra	CodExp	CodAcq	CodVal	CodObs
CodLoc	1					
CodTra	0.003	1				
CodExp	-0.0230	0.265*	1			
CodAcq	0.396***	0.356**	0.370**	1		
CodVal	0.118	0.162	0.419***	0.540***	1	
CodObs	-0.054	0.207†	0.172	0.033	0.001	1

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

Table VI: Pearson correlations of encapsulated knowledge items

	EncLoc	EncTra	EncExp	EncAcq	EncVal	EncObs
EncLoc	1					
EncTra	0.097	1				
EncExp	0.005	0.109	1			
EncAcq	0.216†	0.488***	0.355**	1		
EncVal	0.344**	0.460***	0.379**	0.795***	1	
EncObs	0.188	0.218†	0.173	0.296*	0.442***	1

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

Individual Knowledge Measurement

Table VII: Cronbach's alpha with all encapsulated knowledge items

	EncLoc	EncTra	EncExp	EncAcq	EncVal	EncObs
Cronbach's alpha if item deleted	0.71	0.68	0.71	0.59	0.57	0.69

Table VIII: Cronbach's alpha with all tacit knowledge items

	TacLoc	TacTra	TacExp	TacAcq	TacVal	TacObs
Cronbach's alpha if item deleted	0.54	0.45	0.63	0.46	0.56	0.62

Table IX: Cronbach's alpha with all codified knowledge items

	CodLoc	CodTra	CodExp	CodAcq	CodVal	CodObs
Cronbach's alpha if item deleted	0.57	0.46	0.43	0.40	0.45	0.57

Table X: Factor loadings for the tacit knowledge construct

	TacLoc	TacTra	TacExp	TacAcq	TacVal	TacObs
Factor loadings	0.519	0.563	Excluded	0.748	0.588	Excluded

Table XI: Factor loadings for the encapsulated knowledge construct

	EncLoc	EncTra	EncExp	EncAcq	EncVal	EncObs
Factor loadings	Excluded	0.536	Excluded	0.841	0.875	0.432

Table XII: Factor loadings for the codified knowledge construct

	CodLoc	CodTra	CodExp	CodAcq	CodVal	CodObs
Factor loadings	Excluded	0.408	0.554	0.697	0.653	Excluded

Individual Knowledge Measurement

Table XIII: Average correlations among and between construct items[a]

	Tacit (4)	Codified (4)	Encapsulated (4)
Tacit (4)	0.3895		
Codified (4)	0.1395	0.3523	
Encapsulated (4)	-0.3836	-0.4372	0.4309

[a] The numbers in brackets indicate the number of items associated with each construct

Table XIV: Stepwise forward linear regression of Tacit, Codified, and Encapsulated knowledge scales

	Tacit	Codified	Encapsulated
Proportion of time spent advising		1.260**	-2.020*
Investment strategies applied			
Semi-passive equity, always or frequently	-0.811**		
Types of clients served			
Mutual or pooled fund investors, primarily			0.661†
High net worth individuals, occasionally		-0.850***	1.214**
Pension funds, never		0.657***	-1.427***
Trusts, estates, foundations or endowments, occasionally	0.703*		
Other clients, not included elsewhere, occasionally	0.996†		
Control variables			
Years employed as an investment manager		0.051***	
FCSI designation		-0.755***	
FMA designation			1.138*
TEP designation		-0.822*	
CPA designation		1.107**	
CIMA designation		-2.468***	
RIS designation		-1.393*	
Constant	0.038	-1.642***	0.970
Model statistics			
Adjusted R^2	0.376	0.598	0.531
F-statistic	6.01**	9.60***	6.89***
N	26	53	27

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

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

Please choose the appropriate response for each item:

	1	2	3	4	5	6	7	8	9	10
information I obtain from documents (e.g., research reports, annual reports, websites, manuals, books).	○	○	○	○	○	○	○	○	○	○
personal judgement, insight, and skills I have developed.	○	○	○	○	○	○	○	○	○	○
functionality built into the technology I use (e.g., proprietary software, off-the shelf or canned software, Bloomberg terminal).	○	○	○	○	○	○	○	○	○	○

First identify the most important factor with a rating of 10. Next, rate each of the remaining two factors in turn on a scale of 1 to 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.

In my job, valuable knowledge is distributed... *

Please choose the appropriate response for each item:

	1	2	3	4	5	6	7	8	9	10
by sharing written documents (e.g., emails, reports).	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
through personal contact and interaction (e.g., conversations, meetings).	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
by transferring technology (e.g., quantitative models, algorithms, software programs).	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

First identify the most important factor with a rating of 10. Next, rate each of the remaining two factors in turn on a scale of 1 to 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.

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

Please choose the appropriate response for each item:

	1	2	3	4	5	6	7	8	9	10
apparent to other investment managers, in the activities we perform within our firm.	○	○	○	○	○	○	○	○	○	○
evident in the standards, routines, and procedures we have developed over time.	○	○	○	○	○	○	○	○	○	○
not evident, but hidden in the technology we use (e.g., quantitative models, proprietary algorithms, customized applications).	○	○	○	○	○	○	○	○	○	○

First identify the most important factor with a rating of 10. Next, rate each of the remaining two factors in turn on a scale of 1 to 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.

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

Please choose the appropriate response for each item:

	1	2	3	4	5	6	7	8	9	10
through personal experience.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
by studying and interpreting information.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
by purchasing functionality embedded in technology (e.g., hardware, software).	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

First identify the most important factor with a rating of 10. Next, rate each of the remaining two factors in turn on a scale of 1 to 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.

I create value by relying on... *

Please choose the appropriate response for each item:

	1	2	3	4	5	6	7	8	9	10
my unique insights or those of my team.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
formal and informal processes specific to my role as investment manager.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
the functionality embedded in the technology I use.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

First identify the most important factor with a rating of 10. Next, rate each of the remaining two factors in turn on a scale of 1 to 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.

The source of my productivity is... *

Please choose the appropriate response for each item:

	1	2	3	4	5	6	7	8	9	10
teachable to novice investment managers.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
decipherable from the documentation I use.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
hidden in difficult-to-replicate technology.	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

First identify the most important factor with a rating of 10. Next, rate each of the remaining two factors in turn on a scale of 1 to 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.

[redacted]

Reviewer 1:

1. Correct the inconsistencies and incomplete references.

Inconsistencies and incomplete references have been corrected.

2. The in-text Referencing needs to be carefully edited.

In-text referencing has been edited.

3. The manuscript should be carefully proofread by a native English speaker to edit language, punctuation and syntax inconsistencies.

The manuscript has been carefully proofread by two native English speakers. Language and punctuation have been corrected. Syntax inconsistencies have been removed.

Reviewer 2:

1. The 6 perspectives of Locus, Transfer, Expression, Acquisition, Value, and Observability are not explained in the paper. Table 1 uses the 6 perspectives to describe different types of knowledge, but the 6 perspectives themselves are not clearly explained. Why use these perspectives and what has been their use until now? You could simply provide one sentence for each perspective to define them, and a couple of sentences to justify using them.

The six perspectives were assembled after researching academic literature with the goal of being exhaustive and impartial.

For example, in strategic management literature, Felin and Hesterly (2007) argue that how a firm creates value depends on the **locus** of knowledge, while the ability to **transfer** knowledge affects competitiveness (Argote and Ingram, 2000).

A new section (namely, 2.1.4) has been added to define and justify the use of the six perspectives.

2. On figure II and table III, "locus" should appear instead of "location" for consistency with the selected perspective naming.

These errors have been corrected.