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The Importance of Internal and External Knowledge Sourcing and Firm Performance: A Latent Class Estimation

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Abstract

The present research examines the differential impact of the importance of internally and externally sourced information and knowledge and its relationship to absorptive capacity and firm performance. In addition, this analysis deals directly with the unobservable heterogeneity amongst firms that is generally viewed as the raison d'être for a unique resource based perspective of organizational performance. Latent class finite mixture regression models are used that show that a single model relating knowledge sourcing, absorptive capacity and firm performance is inadequate in explaining even a minor portion of the variation between firms that is seen.

Keywords: Knowledge Sourcing, Absorptive Capacity, Latent Class Modelling, and Finite Mixture Regression

Introduction

The notion that knowledge is a source of competitive advantage has been advocated extensively in the management literature (i.e., Winter, 1987; Quinn, 1992; Nonaka and Takeuchi, 1995) and remains one of the most complex yet compelling areas of discussion among strategy scholars and practitioners. There are numerous theoretical and empirical studies examining the relationship between knowledge and firm performance. The essence of these studies is that the higher the level of knowledge acquired or accumulated, the greater the level of firm performance. For example, both Stuart (2000) and Steensma and Lyles (2000) found that a major contributing factor to the growth, innovation rate and survival of interorganizational alliances was the resources and knowledge flowing from the alliance partners. Similarly, Lane et al., (2001) showed that knowledge acquired by an IJV from its parent company contributed to its performance. In related work, McEvily and Chakravarthy (2002) established that the complexity and tacitness of a firm's technological knowledge contributed to shielding its product innovation from imitation, hence reinforcing the importance of knowledge-based advantage as a source of sustained firm performance.

A close examination of the literature finds two gaps that the current paper attempts to address. The first of these is the distinction between acquisition of knowledge that is internal to the firm and that which is external to the firm. Although something of a gross oversimplification, most studies either deal with direct transfers of information and knowledge between individuals in an organization (von Hippel, 1994; Szulanski, 1996; Leonard and Sensiper, 1998; Tsai, 2001) or transfers and spillovers between organizational entities (Mowery et al., 1996; Lane and Lubatkin, 1998; Lorenzoni and Lipparini, 1999; Lane et al., 2001) such as between consultants and firms or alliance partners. In the current work we attempt to examine: (1) the marginal importance of internal versus external sourcing of knowledge and (2) the differential role being played by absorptive capacity — i.e., the organization's ability to assimilate this knowledge (Cohen and Levinthal 1990) — with respect to these different types of sources. This is relevant since it is argued that firms invariably rely on a combination of internal and external knowledge and it is unlikely that the management and impact of this differential knowledge will be identical. As we will discuss in later sections, few studies have dealt with this and we will have something to say about the extent to which this might be true.

A second area where the literature has been inadequate, and wholly so, is in dealing with the heterogeneity of firms with respect to knowledge sourcing. The underlying assumption of the quantitative modelling used in strategy to date is that: (1) what matters are the observed differences between firms and (2) unexplained error variance is nothing more than random. Although these may be correct assumptions, their validation is ultimately an empirical, and not a theoretical, question. To address this issue we utilize latent class finite mixture regression to evaluate the existence of relevant but unobserved heterogeneity amongst firms—i.e., that heterogeneity that exists for substantive reasons but may not be explained directly with the observable measures available. Latent class mixture regression models 'search' for the correct number of models underlying the data while estimating the posterior probability that any specific model is relevant for any specific firm. This technique allows us to determine whether or not the different models apply to different groups of firms and to do so simultaneous with the estimation of the models themselves. Although extensively used in marketing and other fields, mixture modelling has had almost no exposure in the organization and strategy literature (the one exception being DeSarbo, Jedidi and Sinha (2001) and this is arguably a marketing application).

The combination of these two issues—the importance of internal/external knowledge sourcing and heterogeneity between firms—allows us to deal with a key component of modern resource based thinking that the origins of competitive advantage reside in unique firm specific attributes. By utilizing latent class mixture regression we apply techniques that are more in line with the theoretical assumptions underlying the resource based theory of the firm. While focussing on both internal and external knowledge sourcing we deal with the combinative ability of the organization to add external knowledge to the pool of internal knowledge circulating throughout the firm.

In the following sections, we develop the paper's hypotheses through an examination of the existing literature on two fronts—firstly, the area of knowledge sourcing and its impact on firm performance and secondly, the role of the firm's absorptive capacity as a moderating variable in the relationship between knowledge sourcing and firm performance. We then move on to a general discussion and our methodology. We show that mixtures of firms do exist that is receiving differential gains from different knowledge sources and their application of absorptive capacity. In addition, we show that standard linear modelling techniques (ordinary least squares) that do not account for firm heterogeneity are inadequate at discovering this complex set of relationships.

A Model of Knowledge Sourcing and Firm Performance

Many studies have investigated the nature of knowledge sourcing and the impact on firm performance. The basic premise of these studies is that a firm needs to constantly source or acquire new knowledge in order to renew capabilities, innovate, and guard against technological obsolescence and competitive imitation. It is very much the essence of Teece et al.'s (1997: 516) notion of dynamic capabilities—i.e., the firm's ability to "integrate, build, and reconfigure internal and external competences to address rapidly changing environments".

External Knowledge Sourcing and Firm Performance

The importance of knowledge sourcing is present in earlier studies on boundary spanning activities in innovative environments. Various studies on R&D management (Tushman and Katz, 1980; Ebadi and Utterback, 1984) have indicated that in a dynamic technology-intensive research environment, the ability to span organizational boundaries is extremely important. Dollinger's (1984) study on small business entrepreneurs revealed a strong relationship between boundary spanning activity and organizational performance. In the biotechnology industry, "research breakthroughs demand a range of intellectual and scientific skills that far exceed the capabilities of any single organization" (Powell et al., 1996: 118). In the area of pharmaceutical research, Henderson and Cockburn (1994: 67) have shown that the ability to "encourage and maintain an extensive flow of information across the boundaries of the firm" is important to the productivity of drug discovery.

Similarly, the area of interorganizational relationships contains a significant amount of work on knowledge sourcing and firm performance. Early attention was focused on exchange and reciprocity as the main drivers of interorganizational linkages (Levine and White, 1961), while the resource dependent view (Pfeffer and Salancik, 1978) focused on issues of power and control over scarce resources. More recent studies in this area have looked at the role of interorganizational links as a source of innovation and firm performance.. In a series of longitudinal studies, Mitchell and Singh (1996) and Miner et al., (1990) concluded that interorganizational linkages played a significant role in buffering firms against adverse environmental impact (and hence increasing their chances of survival). Bresman et al. (1999) found evidence of knowledge transfer in international acquisitions in the form of communication and visits. In addition, their case study research revealed that later stage transfer involved "high levels of collaboration, sharing of resources, and transfers of individuals between units…the knowledge in such cases was more tacit than in early-stage transfers" (Bresman et al., 1999: 456). Stuart et al.'s (1999) study on biotechnology firms revealed that firms with prominent alliance partners enjoyed greater valuations at IPO than firms lacking such connections. In a later study on interorganizational alliances, Stuart (2000) concluded that firms exhibited higher growth rates when in partnerships with large and innovative alliance partners. Andersson et al.'s (2002) study on MNCs found that new product and process development conducted in conjunction with external customers and suppliers were positively related to expected market performance.

The area of organizational networks contains a substantial number of studies investigating the issues of knowledge sourcing, innovation and performance. The major premise of this body of work is that "a firm's networks allow it to access key resources from its environment, such as information, access, capital, good, services and so on that have the potential to maintain or enhance a firm's competitive advantage" (Gulati et al., 2000). Studies (e.g., Dyer, 1996; Almeida and Kogut, 1999) have found evidence to support the role of networks as a source of knowledge and innovation, which contributes to the performance of firms. More recently, Baum et al. (2000)'s study on biotechnology startup firms found that initial performance increased with the size of the start-up's alliance network. Dyer and Nobeoka (2000: 365) investigated the knowledge-sharing routines developed within Toyota's production network and concluded that "if the network can create a strong identity and effective coordinating rules, then it may be superior to a firm as an organizational form at creating and recombining knowledge owing to the greater diversity of knowledge that resides within a network".

The importance of social capital as a source of knowledge is becoming increasingly prevalent in the literature. Network scholars (e.g., Pfeffer and Salancik 1978; Burt, 1992; Liebeskind et al., 1996) emphasize the significance of social relationships as a firm resource, acknowledging that "beneath most formal ties….lies a sea of informal relations….that carries benefits beyond the particular exchange designated in a formal agreement" (Powell et al., 1996: 120). Social capital scholars emphasize the benefits embedded in social relationships, such as the development of intellectual capital (Nahapiet and Ghoshal, 1998), resource exchange and product innovation (Tsai and Ghoshal, 1998) and knowledge acquisition (Yli-Renko et al., 2001).

Internal Knowledge Sourcing and Firm Performance

Discussion so far has focused on the importance of interorganizational relationships and networks as a source of resources, knowledge and sustained performance for firms. However, the internal network is potentially an equally important resource for knowledge as personal networks within the firm are often the first point of contact for employees. Soo et al.'s (2002) case studies on professional services organizations revealed that employees depended heavily on their personal networks for information and knowledge. Freeman (1991: 501) argues that "both empirical and theoretical research has long demonstrated the importance for successful innovation of both external and internal networks of information and collaboration".

There exists a broad range of research examining the role of internal knowledge sharing and transfer as a source of competitive advantage. Grant (1996: 113) argues the importance of understanding "the organizational processes through which firm access and utilize the knowledge possessed by their members. Argote and Ingram (2000: 150) argue that "by embedding knowledge in interactions involving people, organizations can both effect knowledge transfer internally and impede knowledge transfer externally". This certainly followed consistently from Brown and Duguid's (1991) notion of 'communities-of-practice', which acknowledge that people often work, learn and innovate within informal communities that are usually not recognized in formal organizational designs or job descriptions. This is further reinforced by Paulus and Yang's experiment (2000) suggesting that idea generation and sharing conducted in a group environment resulted in enhanced creativity and performance, as opposed to individual idea generation.

The importance of effective knowledge sharing and transfer within the firm is an area that has received considerable attention in the literature—e.g., Szulanski (1996) examined the factors impacting the transfer of best practices within the firm; O'Dell and Grayson (1998) emphasized issues such as reward systems, technological support and leadership to ease the difficulties inherent in the transfer of internal best practices; Hansen's (2002) study on knowledge networks revealed that the possession of related knowledge and short network paths increased the likelihood of knowledge sharing among business units.. Foss and Pedersen (2002) studied the determinants of knowledge transfer from subsidiaries to other MNC-units and found that both the level of internally and externally sourced knowledge were important determinants of the knowledge sharing.

The Need for Both Internal and External Knowledge Sourcing

The issue of whether the firm engages in internal or external knowledge sourcing and the impact of the different acquisition behaviours on firm performance has interesting implications. Both types of sourcing behaviours are important for the firm as they are generally viewed as mutually interdependent and complementary learning processes (Bierly and Chakrabarti, 1996).

Several studies have investigated the different knowledge sourcing patterns undertaken by firms and concluded that both internal and external sources of knowledge are equally important. In their study on pharmaceutical firms, Bierly and Chakrabarti (1996) uncovered four generic knowledge strategy groups—i.e., 'explorers', 'exploiters', 'loners' and 'innovators'—and found that firms with a good balance of both internal and external learning with a tendency towards more radical learning (i.e., 'innovators' and 'explorers') exhibited consistently higher levels of profitability. In a similar study of the optical disk industry, Rosenkopf and Nerkar (2001) found that explorations that span both organizational and technological boundaries had the highest impact on technological developments. Iansiti and Clark's (1994) case studies on the automobile and mainframe computer industries revealed that consistently high performing firms engaged in active internal and external integration—that is, the ability to tap into external sources of information and knowledge, as well as the ability to coordinate and communicate across organizational subunits. Nobel and Birkinshaw (1998) examined the nature of communication and control in international R&D operations and ascertained that international creators (with more responsibilities to innovate rather than to improve and adapt) maintain strong internal and external networks of relationships. Rulke et al. (2000) revealed that store managers in the retail food industry relied on both internal and external sources of information for organizational self-knowledge (i.e., managers' knowledge of their units' capabilities and shortcomings). Nagarajan and Mitchell (1998) looked at the lithotripsy industry and concluded that different types of technological changes were associated with the methods of knowledge acquisition—that is, firms relied on interorganizational relationships for encompassing and complementary changes, and internal R&D for incremental changes.

From this discussion we can make three related hypotheses:

Hypothesis 1A: Firms relying on high levels of internal knowledge sourcing exhibit higher levels of performance than firms relying on low levels of internal knowledge sourcing.

Hypothesis 1B: Firms relying on high levels of external knowledge sourcing exhibit higher levels of performance than firms relying on low levels of external knowledge sourcing.

Hypothesis 1C: Firms relying on higher levels of both internal and external knowledge sourcing exhibit higher levels of performance than firms relying on only internal or only external sources of knowledge.

Hypotheses 1A and 1B relate to estimating the direct effects of the importance of knowledge source and hypothesis 1C on the interaction of the two sources together.

The Role of Absorptive Capacity

Although numerous studies have shown that both the external and internal environment of the firm constitutes valuable resources for knowledge and learning, there exists another important element, the firm's own capabilities to recognize, absorb and apply the knowledge. Cohen and Levinthal's (1990) concept of absorptive capacity has been widely studied in relation to its impact on organizational knowledge sourcing, learning and performance.

A plethora of work has found evidence to support the notion that absorptive capacity plays an important role in the firm's ability to acquire knowledge and learn from various sources. In their study of strategic alliances, Mowery et al. (1996) examined the role of absorptive capacity in the firm's ability to acquire its partner's capabilities and found that experience in an area related to the alliance partner's increased the chances of inter-firm knowledge transfer. Similarly, Pennings and Harianto (1992) found support for the hypothesis that prior accumulated experience in a certain technological area increased the likelihood of innovation adoption. In their study on international joint ventures, Lane et al. (2001) concluded that the ability to understand and apply external knowledge contributed to learning and performance. Veugelers (1997: 314) revealed that when a firm engages in R&D cooperation, the impact on its own R&D was shown to be significant only when absorptive capacity (i.e., full-time staffed R&D department) was present, hence supporting "the idea that indeed absorptive capacity is necessary to be able to capitalize on the complementarities between internal and external know-how".

Absorptive Capacity and Firm Performance

Cohen and Levinthal's (1990) definition of the concept includes the ability to recognize and assimilate new knowledge and apply it to commercial ends, thus suggesting the need for knowledge absorption as well as knowledge utilization. Unfortunately, the predominant measure of absorptive capacity—either R&D expenditure or some measure of R&D employment—is confounded with innovative investment and is only an instrumental reflection of an organization's underlying practices.

In their reconceptualization of the concept, Zahra and George (2002: 185) identified two subsets of absorptive capacity: (1) "**potential capacity** compris[ing] knowledge acquisition and assimilation capabilities," and (2) "**realized capacity** center[ing] on knowledge transformation and exploitation". The authors propose that although potential absorptive capacity (PACAP) allows firms greater flexibility in reconfiguring their resource base, it is realized absorptive capacity (RACAP) that converts knowledge into performance. Consistent with Zahra and George's (2002) position, there is evidence that the interaction of both network centrality and absorptive capacity contributed significantly to business unit innovation and performance (Tsai 2001). This finding suggests that although an organization has access to knowledge sources through its network links, its ability to absorb and exploit such knowledge depends on its level of absorptive capacity—that is, "high absorptive capacity is associated with a better chance to successfully apply new knowledge toward commercial ends, producing more innovations and better business performance" (Tsai, 2001: 1003).

Building on the work of Zahra and George (2002) and Tsai (2001), we acknowledge the importance of realized absorptive capacity in allowing firms to absorb, apply and exploit knowledge towards commercial ends. Although Cohen and Levinthal's (1990) conceptualisation pertains to the ability to absorb and apply external knowledge, we extend this to the absorption and application of internal knowledge as well, following Szulanski's (1996) finding that absorptive capacity plays a crucial role in the effectiveness of internal knowledge transfer. Hence, we argue that it is not only important for firms to actively source knowledge (both internally and externally) but that the application of that knowledge for commercial ends depends on its level of absorptive capacity. We are also cognizant of the distinction between practices that make knowledge acquisition relevant (PACAP) and the ability to make those practices work (RACAP). To test this, we formulate the following hypotheses:

Hypothesis 2A: The relationship between internal knowledge sourcing and firm performance is moderated by organizational incentives to absorb and apply that knowledge (absorptive capacity)

Hypothesis 2B: The relationship between external knowledge sourcing and firm performance is moderated by organizational incentives to absorb and apply that knowledge (absorptive capacity)

The basic underlying model structure we posit is shown in Figure 1 with the relevant hypotheses highlighted.

Insert Figure 1 Here

Firm Heterogeneity

According to the resource based theory of the firm it is the unique, externally non-replicable, durable, path dependent, causally ambiguous assets of the firm that allow it to accrue rents and to sustain its position to do so vis-à-vis its competitors (Wernerfelt 1984; Barney 1986; Peteraf 1993). If this is indeed the case it is unlikely that firms will be influenced identically even by similar environments or that their reactions to those environments would, or even should, be the same. In addition, it seems equally unlikely that the factors that would determine latent similarity between firms would necessarily be found by examining observable characteristics such as the normal controls found in the literature—size, employee numbers, industry, and so on.

A number of recent studies have attempted to come to grips with both the characterization and empirical modelling of firm heterogeneity. Noda and Collis (2001) take a process approach in asking how intraindustry heterogeneity can arise and, once having arisen, be sustained in a competitive environment. They concentrate on the mixture of converging and diverging forces at the industry and firm level. McEvily and Zaheer (1999) use a network model to understand how geographic clusters maintain their unique set of competences. From our standpoint, the important point of this work is that these authors, amongst others, show the sustainability of heterogeneity and that heterogeneity is not random. Accordingly, we propose the following hypothesis:

Hypothesis 3: A single model is inappropriate in understanding the relationship between the type of knowledge sourcing, absorptive capacity and performance.

Although firm heterogeneity is considered one of the pinnacles of modern strategy thinking and the distinctive characteristic that separates much of this work from a purely industrial organization (IO) perspective, much of this work has been beset by methodological issues that make it difficult to distinguish random effects from true heterogeneity. In addition, the empirical work that has been done relating to heterogeneity deals mainly with intraindustry homogeneity and heterogeneity—i.e., either relating to strategic groups or how firms in the same industry differ. An equally important question from a research methodology perspective is the mixture of similarities and differences across firms in different industries. Traditional industry-level IO analysis mistakenly assumes homogeneity (with some random differences) amongst firms within the same industry and substantial differences between industries. The resource-based theory (RBV) makes no such constraining assumption but fails to explain why firms across 'industries' might be driven by similar structural models but differ significantly from firms within their own 'industry'. Furthermore, empirical RBV studies to date use methods that account only for observed differences between firms through the use of control variables, and even then account mainly for observed heterogeneity associated with the dependent variable. This might increase the predictive validity associated with the dependent variable but does nothing to determine the nature of heterogeneity associated with the entire model.

Methodology

We applied two sets of empirical analyses to survey data collected from key informants from 317 firms with the intent of determining the validity of the model presented in Figure 1 and to understand the degree of firm heterogeneity with respect to knowledge sourcing and performance. The first analysis was a simple OLS regression to determine whether or not the model proposed operates in the aggregate. The second analysis applies finite mixture-modelling techniques (assuming mixtures of normal distributions) to determine whether different forms of the model apply to different groups within the sample. A description of the sample and constructs used is described next followed by a general overview of mixture models and their relevance to the current research. The individual measures are described in Figure 1.

Construct Measures

All the constructs utilized—internal and external knowledge sourcing, absorptive capacity and firm performance—are measured by multiple item reflective scales. Each is discussed in detail in the sections below. All survey questions (except those pertaining to performance, firm and industry demographics) use a 7-point Likert scale (the items and exact wording of questions are listed in Appendix 1).

Internal and External Knowledge Sourcing

This study is unique in looking at a broad cross-section of existing firms and questioning the marginal value of the source of knowledge acquired by the firm. Given that no measures were available we created six items that we used to reflect the degree to which the firm relies on internal sources versus external sources of knowledge. Respondents were asked to indicate the importance of internal staff—colleagues within the business unit and firm—and external parties—customers, suppliers, competitors, consultants, unrelated organizations, etc.—as "sources of information and/or know-how" for the following activities: (1) the generation of new ideas, (2) product/service innovation, (3) product/service enhancements, (4) process improvements, and (5) organizational innovations and improvements. The Cronbach alpha for these measures was 0.84 for the case of internal knowledge sourcing and 0.82 for external knowledge sourcing.

Absorptive Capacity

To measure the concept of absorptive capacity**,** we go beyond the Cohen and Levinthal's (1990) emphasis on R&D investment, recognizing that this may not be applicable across industries, particularly when related to services. Hence, in order to develop generalizable measures as well as adhering tightly to the authors' conceptual definitions, we use measures that capture the essence of Zahra and George's (2002) notions of PACAP and RACAP. First, we account for *active information-sharing behaviors* (effectively a proxy for RACAP) by measuring the degree to which respondents actively seek external information, record it for future reference, use the acquired information in their work, and distribute the information to fellow colleagues. Second, we recognize that the development of absorptive capacity is essentially path-dependent; that is, it is a function of both past and on-going *investments in knowledge accumulation* (effectively a proxy for PACAP). To measure this, we investigated the degree to which respondents participate in academic/industry conferences, update their skills through training and self-learning, and keep abreast with the latest technology and knowledge related to their organization's business. Our measures are organizational—i.e., they deal with the extent to which the firm has policies and procedures that encourage employees to seek external information and invest in knowledge accumulation.

It is important to emphasize that our operationalization of absorptive capacity is both broader and more direct than previous empirical work where the emphasis is on the *proxies* of absorptive capacity. For example, Pennings and Harianto (1992) measure past accumulated technological experience as a proxy for absorptive capacity. Lane and Lubatkin (1998) hypothesize that absorptive capacity is a function of the similarity between the student and teacher firms' compensation practices and organizational structures. In contrast, we employ a more direct approach by examining the extent to which a range of *actions* are taken to recognize, absorb and assimilate new external information and knowledge into the organization.   The Cronbach alpha for this measure is 0.89.

<u>Firm Performance</u>

Firm performance was measured as a perceptual measure using both market measures—market share and annual sales growth—and financial measures—after-tax return on investment and growth in total after-tax profits. These are commonly used in the strategy and marketing literatures (e.g., Banbury and Mitchell, 1995) and reflect the multidimensional pressures managers face on a day-to-day basis. These measures were treated as reflective indicators of an existing latent 'performance' construct. The Cronbach alpha for this measure was 0.83.

Sample

Our survey instrument was extensively pre-tested through interviews and a pilot sampling trial. Soo et al. (2002) outlines the nature of the tests used to validate the survey and ensure convergent and discriminant validity.

The survey was mailed to 2,137 organizations (all with more than 20 employees) randomly selected from 17 manufacturing and service industries (based on two-digit SIC codes). The objectives of this procedure were to ensure generalizability of results across industries and to target industries where issues of knowledge acquisition and innovation are *important and relevant*. Specifically, we targeted industries facing dynamic and competitive environments—hence the need for continuous knowledge acquisition and learning. The issue of relevance is also crucial to obtaining a reasonable response rate and high quality responses (questions are more easily understood if they are important and relevant).

The questionnaire was addressed to the CEO or managing director of each organization. To minimize the limitations of using single informant methodology, we took precautions to ensure informant competency. First, the key objectives of the study and its central themes were outlined in a cover letter. If the CEO was unable to complete the survey, they were asked to give it to a middle/senior level manager with sufficient knowledge of the study's objectives. Second, we included criteria for assessing informant competency, such as tenure in the organization, industry and current position.

The number of responses totaled 343 (yielding a 16 percent response rate). After eliminating surveys due to large proportions of missing data, the final 289 responses used in the analysis were seen to be fairly evenly distributed across manufacturing (44%) and service (56%) sectors as well as across the 17 industries. Firm size was also well distributed, with 40% small firms (100 or less employees), 30% medium-sized firms (100 to 400 employees) and 30% large firms (more than 800 employees). The average and median sizes of these firms were 2,024 and 175 employees respectively. Tests of the distribution of returned surveys indicate that no industry or size bias existed in the responses received.

Insert Table 1 Here

Analysis of respondent characteristics indicated that they had sufficient knowledge of the key issues of the study—all respondents occupied middle-senior management roles, and the average tenure at the organization, industry and current position were 12, 17 and 5 years respectively. Following the procedures of Armstrong and Overton (1976) we also tested for non-response bias by examining the construct means of early versus late respondents, and found no significant differences.

With surveys such as this there is always a concern about single respondent bias. In a related study, our survey was used in conjunction with six case studies (Soo et al., 2002) and an identical model was estimated for each company. In this situation, as many as 120 responses were received from a single firm, hence we had both repeated measures of firm variables and estimates of the variance of individual measures. Although the models differed in the magnitude of various effects (as one would expect), the general form of the model and key conclusions remained valid. To test for common method bias, we applied Harmann's *ex post* one-factor test (Podsakoff and Organ 1986), across the entire survey, which includes the measures used here. 19 distinct factors where needed to explain the 80 per cent of the variance in the measures used with the largest factor only accounting for 17 per cent of the variance. Hence, there was no 'general factor' in the data that would represent a common method bias.

Method of Estimation

Mixture models are useful in estimating the likelihood that a specific firm fits into a class of firms for which a particular model applies (see Wedel and Kamakura (2000) for a general explanation). More specifically, mixture models assume that we are interested in decomposing a population of firms (indexed by k), for which we have a set of n observations $\mathbf{y}_n = (y_{nk})$, that we believe is a mixture of S segments in proportions $\pi_1, \ldots, \pi_S$ (note: all indicators in **bold** are vectors). *A priori* we have no idea from which segment each particular firm comes but we do know that the likelihood of the firm coming from each of the segments is constrained to be 1; i.e., $\sum_{s=1}^{S} \pi_S = 1$. Given that the observations y_{nk} come from segment s, the conditional distribution function of $\mathbf{y}_n$ can be represented as $f_s(\mathbf{y}_n \mid \theta_s)$, where θ_s is the vector of unknown parameters associated with the specific density function chosen; e.g., normal, Poisson, multinomial, Dirichlet, exponential gamma or inverse Gaussian. Mixture models are estimated using maximum likelihood, where the vector $\phi = (\pi, \theta)$ is estimated based on the likelihood of ϕ being $L(\phi; \mathbf{y}) = \prod_{n=1}^{N} f(\mathbf{y}_n|\phi)$ where, $f(\mathbf{y}_n|\phi) = \sum_{s=1}^{S} \pi_s f(\mathbf{y}_n|\phi_s)$ represents the unconditional probability of $\mathbf{y}_n$ given ϕ. Once an estimate of ϕ is obtained, it is a simple task of using Bayes theorem to calculate the posterior probability that any firm n with $\mathbf{y}_n$ comes from any segment s, $p_{ns} = \pi_s f(\mathbf{y}_n|\theta_s) / \sum_{s=1}^{S} \pi_s f(\mathbf{y}_n|\theta_s)$.

Mixture regression models, the procedure used here, are estimated identically to mixture models except that we are interested in predicting the means of the observations in each segment by using a set of explanatory variables (Wedel and DeSarbo 1995). We can therefore identify for each segment s, a linear predictor, η_{nsk}, that is the product of a set of P explanatory variables, $\mathbf{X}_p = (\mathbf{X}_{nkp})$, and parameters, $\boldsymbol{\beta}_s = (\beta_{sp})$, such that $\eta_{nsk} = \sum_{p=1}^{P} X_{nkp}\beta_{sp}$. η_{nsk} is related to the mean of the distribution, μ_{sk}, through a link function $g(\bullet)$ that varies with the distribution chosen.[1] In the mixture regression case the parameters being estimated are once more $\phi_s = (\pi_s, \theta_s)$, with $\theta_s = (\beta_s, \lambda_s)$, where λ_s is a measure of dispersion in the distribution of

[1] For example, in the case of the normal distribution the link function would be simply, $\eta_{nsk} = \mu_{sk}$.

segment s (in the case of the normal distribution, λ_s would be the variance of the observations in the segment).

Like any clustering technique, the appropriateness of mixture models is determined first by theory and second by the ability to find meaningful and significant differences in the population at hand. There is no single criterion for the choice of the number of segments. One such set of criteria, known as information criteria, are based on assessing the degree of improvement in explanatory power adjusted for the number of degrees of freedom taken up by the estimation of additional parameters (essentially adjusting for over parameterization); C = –2*Ln(L) + Pd, where L is the likelihood, P is a penalty equal to the number of parameters estimated and d is a constant. The most common information criteria are the Akaike (1974) information criteria (AIC), which arises when d=2, and the consistent Akaike information criterion (CAIC), where d = Ln(N+1) and N is the number of firms.[2] The CAIC is more conservative and is skewed to models with fewer segments as it imposes an additional sample size penalty. In addition to dealing with over parameterization as the number of segments increase, one needs to be assured that the segments are sufficiently distinctive. To do this, one needs to compare the estimated posterior probabilities of segment membership. Celeux and Soromenho (1996) propose a normed entropy criterion—NEC(S) = E_S/[lnL(S) – lnL(1)], where E_S is an entropy measure[3] accounting for the separation in the estimated posterior probabilities and [lnL(S) – lnL(1)] adjusts for over parameterization relative to a single segment model. E_S is measured as $1 - \sum_{n=1}^{N}\sum_{s=1}^{S} - p_{ns}\ln(p_{ns})/N$, where p_{ns} is the posterior probability of firm n being in segment s.[4]

The problem ultimately comes down to the fact that no single criteria appears able to determine the 'correct' number of segments and one must rely on this information as well as the structure of the models arising and how they relate to the theory being tested.

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[2] All these criteria have limitations and there are numerous others that have been proposed. The general rule is that those based on a variant of the likelihood ratio test, such as AIC or CAIC, are to be used in conjunction with more sophisticated approaches (Deb and Trivedi 1997).

[3] The entropy measure is bounded between 0 and 1 with lower values indicating smaller separation between the segment identities as measured by the posterior probabilities.

[4] NEC(S) is shown to perform similar to Bozdogan's (1994) information theoretic measure—a measure that is more robust that CAIC or AIC since it is based on the properties of the information matrix—for mixtures of normal distributions. Hence although NEC(S) is not a general measure it is applicable here since we are using mixtures of normal distributions.

Results

The results of the full OLS and mixture regressions are presented in Table 3 with effect size estimates presented in Table 4. The effect size estimates are determined by computing the value of the estimated coefficient times the mean of the independent variable. This provides a more accurate picture of the contribution of that variable to the dependent variable and allows for aggregation so that direct, moderated and total effects can be distinguished more clearly.

Several things should be noted about this analysis and where it would differ from more standard approaches. The first important point is that there is no attempt to control for industry or firm level influences with respect to either the dependent or independent variables. The approach is to first apply the pure model from Figure 1 and then to seek to understand what determines segment membership at the second stage. This should be clear shortly.

Second, the choice of a three-segment solution is based on the improvement in the fit as measured by R^2 and NEC(S) even though the information criteria (CAIC and AIC) imply slightly less parsimony. Table 2 provides these statistics. The three-segment solution provided the clearest set of between segment distinctions although a two-segment solution might be viewed as also being a reasonable representation of the data except for the fact that it does not provide sufficient distinction between the segments (lowest entropy measure). Ultimately the choice of the three-segment solution was based on NEC(S), the entropy measure and the theoretical meaning of the results. Clearly larger segment solutions are neither parsimonious nor theoretically compelling when one looks at the segment sizes (some of which are small) and the structure of the models (which do not show greater distinctiveness in the added segments). Hence, the choice becomes one of between three or fewer segments. Therefore, we will discuss the one-, two- and three-segment solutions in the first instance.

Insert Table 2 Here

The most obvious piece of information in this analysis is that based on OLS estimation, there is only weak evidence that knowledge sourced from anywhere or absorptive capacity has a strong influence on performance. Although, each of the individual measures except for externally sourced knowledge is correlated with performance (see the Appendix 2 for a correlation matrix), the fit of the OLS model is quite poor—implying a 'relationship' but one subject to huge interfirm variance. The R^2 is low at 6 percent and all of this is driven by the intercept (see Table 3).

Insert Tables 3 & 4 Here

This is not improved upon when we attempt to examine separate parts of the model and deal with the issue of co-linearity in the data; again, the Appendix 2 shows that the variables in the model are strongly co-linear but also shows that the fit is very poor (this is seen in the R^2 computed for each bivariate correlation). Table 5 breaks down the OLS analysis in finer detail and although we can generate some significance for some of the independent variables two things need to be noted. First, and most critically, the R^2 can never improve and the fit of the model is not great. This combination of variables, considered so important by the literature explains little, if anything, about performance according to this analysis. Second, there is no clear pattern as to what might be the most appropriate model. At best, we can say that internal sourcing appears somewhat more important in determining marginal performance but we cannot say this with much confidence. In the end we would conclude from this analysis that it was possible only to accept hypotheses 1A, 1C, 2A and 2B based on direct comparisons of the correlations with performance. But when we apply mixture regressions we see a startlingly different pattern of results.

Insert Table 5 Here

The two-segment solution leads to an increase in R^2 to 53 percent and leads to the lowest AIC. Based on this solution we find that external sourcing and absorptive capacity explain almost all performance; it is just the combination that is different between the groups. Based on this information alone we would be forced to reject hypotheses 1A and 1C relating to internal knowledge sourcing and its interaction with external knowledge sourcing and hypothesis 4 dealing with whether or not a single model is appropriate. What the two-segment solution suggests is that a single model is probably correct (the significant variables imply this) but that the magnitudes of the coefficients in that model are subject to some differences. In other words performance is related to external sourcing and absorptive capacity with minor variation in the extent of the influence across firms. The comparatively low entropy measure (0.6515) and small value for NEC(S) (0.0465) indicates weak distinction between the groups as would be expected given the parameter estimates.

The most compelling picture comes from the three-segment solution where a more complex picture arises. There is an increase in R^2 to 83 percent although our information criteria indicate this model may be less parsimonious (both AIC and CAIC increase). Examination of the entropy measure (0.7805) signifies greater distinctiveness between the segments and the NEC(S) (0.1055) increases dramatically, indicating that the increase in discrimination between groups accounting for the reduced parsimony is best in this case. Segment 1 relies heavily on internal knowledge with some influence of external knowledge in conjunction with absorptive capacity (see Table 6). It has the highest overall performance (Performance = 4.45). Segment 2 relies almost exclusively on external knowledge, both directly and in conjunction with absorptive capacity. It is the poorest performing group (Performance = 1.80). Segment 3 is the most complex group with an intricate mixture of internal and external sources plus absorptive capacity driving performance. It is an intermediate performing group (Performance = 3.17). It should be pointed out that with this group the direct effects of knowledge sourcing are less relevant than the impact of absorptive capacity and internal and external sourcing in combination.

What we see from an analysis of these results is that all the hypotheses are supported when treated conditionally on the fact that they all need not apply to all firms.

Those unfamiliar with finite mixture regression might, at this point, argue that all we have done is estimated additional parameters in a complex way and hence generated more fit. This undervalues the insights that are revealed from the data and the fact that unobserved heterogeneity is by definition imperceptible ex ante. Hence, we must engage in ex post determination as to what determines segment membership. In other words, we want to know what is it about the difference between the estimated segments that is relevant but cannot do this until we have seen what the differences are that emerge from the data given the model structure we have proposed.

Hence, to get a more complete picture of these different segments we attempt to determine whether or not there are observable factors related to the likelihood of segment membership. Table 6 uses the three-segment solution and presents the means by group for a selected number of observable characteristics. Table 7 outlines multinomial logit (MNL) estimates relating to group membership. Segment membership was determined by the posterior probability of a firm being in that segment and each firm was assigned to that segment for which it had the maximum probability of being in.

Insert Tables 6 and 7 Here

Our first set of comparisons is based on a casual comparison of the means of the different segments (Table 6). As noted before, segment 2 is the worst performer and this is true even though it has the highest level of internal and external knowledge sourcing and absorptive capacity, although the two knowledge sources are not significantly different across the groups. This segment also has the fewest number of multinationals and the smallest number of employees. It is least likely to be involved in product development (in terms of the percentage of employees devoted to this) but more likely to be involved in research and manufacturing based on percentage of employees. It has the lowest level of marketing and sales intensity of any group. Segment 1, the best performer, is equal to segment 3 in terms of the number of multinationals and firm size. It is the second highest in research and development measured in dollar terms and equally high in research and product development (measured in number of employees). Both of these facts are related to this group's significantly higher innovation numbers. This also shows up in its higher numbers in terms of marketing and sales and services. Segment 3 is the second best performer and closer to segment 1 than segment 2 in terms of the number of multinationals, firm size product development and marketing and sales focus. It is the least likely to be involved in research and development in terms of employees but most heavily involved in product development.

Table 7 contains MNL estimates for the best subset of deterministic variables to predict segment membership (we have tested for all general blocks of deterministic variables – structural, staff distribution, knowledge environment and industry and Table 7 contains the best subsets of these variables). In all cases, the comparison in the MNL is against segment 3, the middle-performing group of firms.

Analysis 3 (in Table 7) is the most parsimonious model with the largest log likelihood (546.16) and with a segment prediction very similar to analysis 1 (on 53 percent). The three analyses show that the distribution of staff is less relevant when we include an innovation measure. What is most amazing about this analysis is that it shows that groups 1 and 2 differ from group 3 based on their greater likelihood of being a natural resources company, less innovation and greater system dependence. The impact of complexity disappears (although it is slightly correlated with system dependence). However, what distinguishes group 2 from groups 1 and 3 is the fact that they tend to be local rather than multinational organizations! If we look at where the misclassifications occur this evidence is reinforced. Segment 1 firms that are misclassified are misclassified wholly (100%) as segment 3 firms. Segment 3 firms when misclassified are almost wholly (98%) misclassified as segment 1 firms. When misclassifications of segment 2 firms occur, in 61% of the cases they are put into segment 1.

Discussion and Conclusion

We began this analysis with the simple task of asking whether internal and external knowledge sourcing had the same marginal impact on performance. In setting this agenda we wanted to go beyond simply stating the obvious; e.g., that both internal and external knowledge are important to firm performance or that absorptive capacity matters. Without accounting for unobserved firm heterogeneity it would have been impossible to discern the relative value of these two important sources of knowledge since they are so obviously related and standard empirical techniques in use in the literature would have been overwhelmed by this correlation. What we have shown is that the picture of knowledge sourcing and absorptive capacity is complex and needs sophisticated empirical techniques to get at even a simple understanding of what is going on. As we have revealed, there is enormous power in using latent class finite mixture regression as a way of understanding not just firm differences but discerning the different models that might apply. All too often we look for confirmation of our hypotheses—e.g., absorptive capacity is important, all knowledge sourcing is valuable—without paying attention to the fact that our models don't explain most of the variance in our data. As is shown here, there are patterns in the results that compel us to come up with more robust and parsimonious explanations of the phenomena we are investigating.

These techniques do not, however, determine for us the theoretical value of what we have uncovered. Nor do they necessarily provide immediate insight into why the results are the way they are. For example, we still cannot establish without more information why segment 2, with its high level of sourcing, is the weakest performing group. Perhaps this group represents failed attempts at change. For example, our measure of performance is a three year average but our measure of sourcing and absorptive capacity is contemporaneous. If these firms have performed poorly and are only now instituting knowledge programs that might explain the relationship. The fact that they are affected most by external sourcing is consistent with this logic; i.e., if they were performing poorly they might have less confidence in what they have available within the firm. It is also telling that the effect of this external sourcing is moderated by absorptive capacity but not by enough to counter the negative direct effect. Alternatively, maybe these are the firms that have reached the point of significant diminishing marginal returns on what they know, leading to greater reliance on outside sources. But what is very clear is that this group is not performing poorly because of the structural characteristics of their industry makeup or because it is lower on the variables of interest, the importance of the knowledge sources and absorptive capacity. The MNL analysis shows that segment 2 differs from segment 1, a significantly better performing group of firms, only on its level of multinationality. What we do know is that their poor performance is due to something more systemic.

What we can also say is that there may be less to our understanding of the relationship between knowledge intensive firms and performance than we would like to acknowledge. It has become something of a truism in the literature, as stated in our introduction, to assert that knowledge is one of the last remaining sources of sustainable competitive advantage. Yet we can show that there are groups of firms in the market (in our case approximately 17 percent) for whom this is clearly not the case at all. These firms deserve more in-depth study, as they may be critical to our understanding of the circumstances where access to certain types of knowledge pays. Again as evidenced from the MNL, one would have great difficulty in picking these firms out ex ante relying on public information only. A real value of latent class regression analysis is that it can identify who these firms are so that more in-depth analysis can address why they might not fit the 'norm'.

In examining segments 1 and 3 we find that internal sources of knowledge appear extremely important to performance. Both groups are evidence of this. Where they differ is in how they capitalize external knowledge. In the case of segment 1, external knowledge sourcing interacts with absorptive capacity. In the case of segment 3, external knowledge interacts with internal knowledge. Hence, while they are the two groups that are driving the overall relationship between the importance of internal knowledge sourcing and performance they do so in very different ways. Again, assuming a single model for all firms would have masked this effect.

The result shows that external knowledge in itself is rarely determining performance. If anything the direct effect of external knowledge is negative (true for all three segments). But, when moderated by either absorptive capacity (in segment 1) or internal knowledge (in segment 3) the value of external knowledge become positive. This indicates that external knowledge needs to be transformed and internalized which happens when combined with existing knowledge (absorptive capacity) or new internally generated knowledge in order to realize the full potential of the external knowledge.

This research is not without its limitations. There is the problem of co-linearity in our constructs that may be simply part-and-parcel of the problem we are studying. Unless we purposely sample firms with internal and external sourcing characteristics that allow for better distinctions between these groups we may never be able to understand the true distinction between knowledge sourced from inside the firm and that sourced outside. This is true of absorptive capacity as well. To attempt to account for this issue we also estimated some simpler models. Two models were used with the following independent variables: (1) the importance of internal knowledge, absorptive capacity, and the interaction between these two and (2) the importance of external knowledge, absorptive capacity, and the interaction between these two. These models under-performed our proposed specification in terms of fit and parsimony, but confirmed the basic conclusions, e.g., the general negative effect of external sources and the existence of three segments. To account for the fact that we may have mis-specified the interaction between the importance of internal and external knowledge sources, we estimated a model using a ratio of internal and external sourcing rather than a straight interaction. This implies that the balance of internal and external sourcing is important. This model also under-performed the one reported here.

From a methodological perspective, we need to remember that segment solutions in finite mixture regressions are condition upon the model structure being chosen. Hence, the hypotheses are joint tests of the appropriateness of the segment structure given the model structure. We have attempted to deal with this but it is possible that more complex structures may exist that we have not proposed and may imply different segment structures.

Finally, we should note that our results show that the poor performance of the OLS is not due to either co-linearity in the constructs or erroneous definitions of the constructs. Some might question our definition of absorptive capacity or the importance of internal and external knowledge sourcing. However, the finite mixture regressions do show that these measures explain a vast majority of the variance in the data and have consistent and compelling implications, albeit ones that do not match immediately to extant theory in an easy and simple way.

What we have shown is that firm heterogeneity not only exists but also can be categorized without reliance on ex ante speculation as to what determines heterogeneity. In doing so, we show that a singular view of the importance of different knowledge sources is not as clear as simple theory might imply. For example, simply because a firm has high levels of absorptive capacity or access to knowledge sources does not necessarily imply that they will realize the value of that knowledge (Zahra and George, 2002). As Soo et al. (2002) shows in a series of case studies many attempts to develop and utilize knowledge fail to meet expectations. What we have done is provide some insight into how we can model this complexity while still taking advantage of large-scale generalizable empirical survey research. However, to take this further we need a deeper understanding of the processes that led to these differences and we need to integrate this into the analysis so that we can determine the process by which such heterogeneity arises. For example, our analysis does indicate that contemporaneous industry and environment factors are not the only determinants of segment membership. What needs to be the subject of future work is formulating the dynamic structural antecedents to firm heterogeneity as well as the role that managerial decisions play in determining 'consistently' heterogeneous outcomes.

Appendix 1: Construct measures with the exact wording in questionnaire

Internal sources – Cronbach Alpha = 0.84

Please indicate the importance of internal staff (ie, colleagues in your own firm or business unit) as sources of information and/or know-how for the following activities (7-point Likert scale):

1. For the generation of new ideas
2. For product/service innovation
3. For product/service enhancements
4. For process innovations
5. For organizational innovations

External sources – Cronbach Alpha = 0.82

Please indicate the importance of external staff (ie, customers, suppliers, competitors, etc.) as sources of information and/or know-how for the following activities (7-point Likert scale):

1. For the generation of new ideas
2. For product/service innovation
3. For product/service enhancements
4. For process innovations
5. For organizational innovations

Organizational Absorptive Capacity – Cronbach Alpha = 0.89

To what extent does the organization have policies or procedures (formal or informal) that encourage employees to (7-point Likert scale):

1. Seek information from sources outside the organization?
2. Seek information from other departments or business units?
3. Seek information from the parent company (if applicable)?
4. Record or store the acquired information for future references?
5. Use the acquired information in their work?
6. Distribute the acquired information to fellow colleagues?
7. Participate in academic or industry conferences/seminars?
8. Constantly update their skills through training programs, workshops, self-learning etc.?
9. Keep themselves constantly updated with the latest technology or state of the art knowledge related to your organizational business?

Firm Performance – Cronbach Alpha = 0.83

Please indicate the category which you feel best estimates your business's performance over the last three years in comparison with competitors in your market (5-point scale going from lowest 20% to top 20%)

1. Return on investment (after tax
2. Market share (in your primary market)
3. Annual increase in total sales
4. Annual increase in total after tax profits

Appendix 2: Correlation Matrix of Constructs in the Model

	Performance	Internal Sources	External Sources	Organizational Absorptive Capacity
Performance	1.000			
Internal Sources	0.212*** (0.042)	1.000		
External Sources	0.057 (0.003)	0.243*** (0.059)	1.000	
Organizational AC	0.121** (0.015)	0.359*** (0.129)	0.336*** (0.113)	1.000

Note: Number in parentheses is the R^2 from a simple one-variable regression.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Figure 1: Model Structure, Hypothesized Effects and Measures

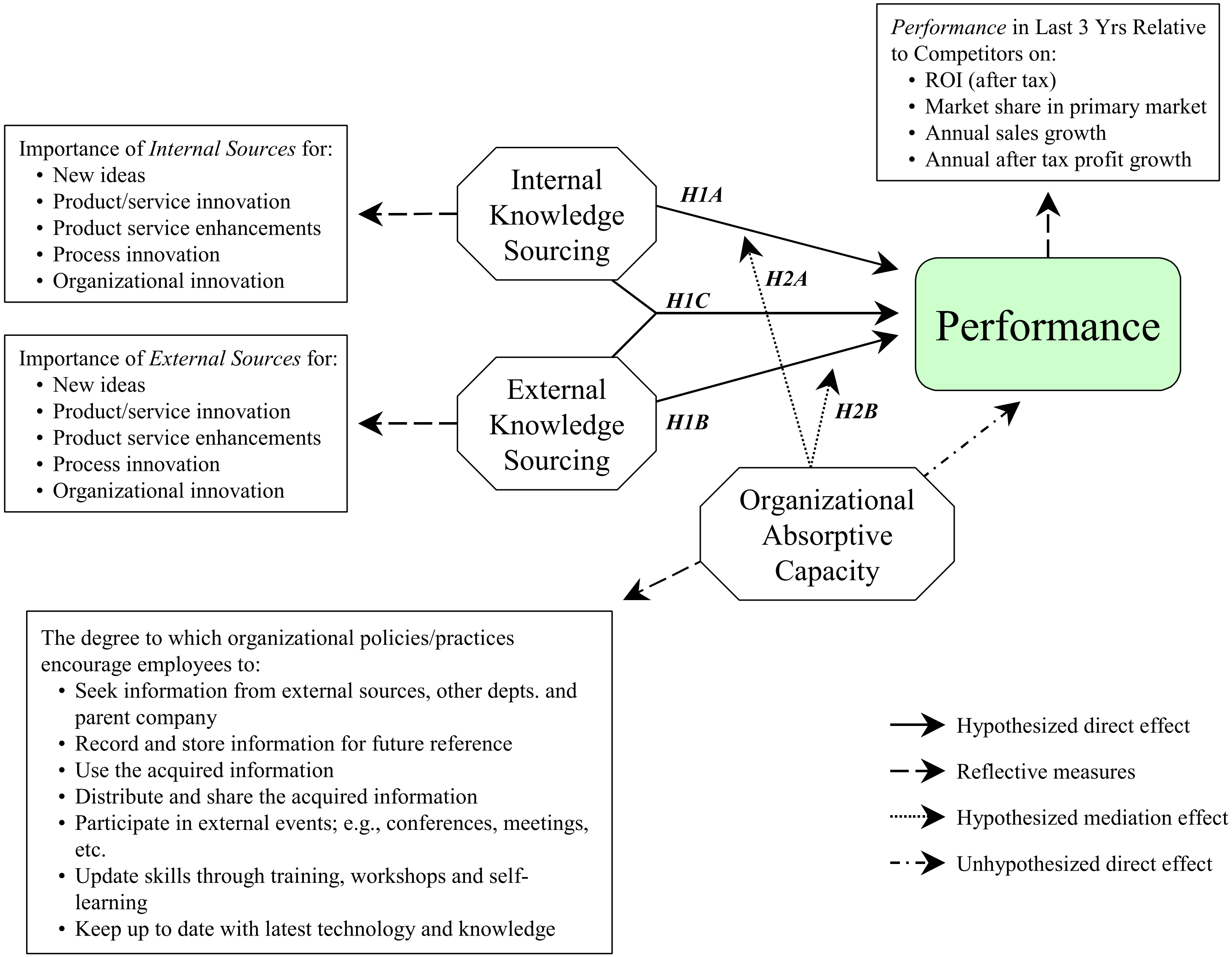

Table 1: Response Rates and Sample Characteristics

Industries included in the study	Per cent of total responses	Per cent response within industry
Metal mining	5	13
Oil and gas extraction	1	9
Petroleum refining	2	16
Chemicals and allied products	11	10
Primary metal industries	4	8
Machinery, except electrical	11	10
Electrical and electronic machinery	5	8
Transportation equipment	3	8
Measuring instruments	2	6
Banking	3	10
Credit agencies	3	8
Security and commodity brokers	2	5
Insurance	6	14
Business services	20	13
Health services	4	9
Legal services	5	10
Miscellaneous services	13	12
Total (percent)	100	

Table 2: Measures of Model Fit and Parsimony by Segment

	Number of Segments				
	1	2	3	4	5
Likelihood	–421.6	–407.6	–400.2	–372.92	–371.11
AIC	859.2	849.3	852.5	**815.86**	831.42
CAIC	**896.5**	928.6	939.51	979.18	1036.74
Entropy	—	0.6515	**0.7805**	0.7456	0.6902
NEC(S)	—	0.0465	**0.1055**	0.0153	0.0136
R^2	0.06	0.53	0.83	0.91	0.92
DF	8	15	23	31	39

Note: Minimum AIC, CAIC and maximum Entropy, NEC(S) are shown in bold.

Table 3: Model Estimates

		Two-Segment Solution		Three-Segment Solution		
	OLS	Segment 1	Segment 2	Segment 1	Segment 2	Segment 3
Intercept	2.80*	3.31***	3.93**	1.61	5.77***	4.70***
	(1.63)	(1.36)	(2.00)	(1.28)	(1.88)	(1.51)
Internal sources	0.28	0.33	–0.02	0.83***	–0.44	–0.61***
	(0.29)	(0.24)	(0.37)	(0.23)	(0.35)	(0.26)
External sources	–0.49	–0.60***	–0.67*	–0.12	–0.76***	–0.89***
	(0.30)	(0.24)	(0.39)	(0.23)	(0.36)	(0.28)
Organizational absorptive capacity	0.15	0.09	–0.12	–0.23	–0.48	1.09***
	(0.37)	(0.30)	(0.46)	(0.31)	(0.42)	(0.31)
External*absorptive capacity	0.06	0.08***	0.11*	0.13***	0.12*	–0.14***
	(0.05)	(0.04)	(0.07)	(0.03)	(0.05)	(0.04)
Internal*absorptive capacity	–0.07	–0.07	–0.07	–0.09*	0.01	–0.03
	(0.06)	(0.05)	(0.07)	(0.05)	(0.06)	(0.05)
Internal*External sources	0.04	0.04	0.06	–0.04	0.06	0.20***
	(0.05)	(0.04)	(0.07)	(0.04)	(0.06)	(0.05)
Class size of segment	1.00	0.74	0.26	0.42	0.18	0.40
Number of observations	289	72	217	118	49	122
Log likelihood	–421.6	–407.6			–400.2	
AIC	859.2	849.3			852.5	
CAIC	896.5	928.6			939.5	
Degrees of Freedom	8	15			23	
R–square	0.06	0.53			0.83	

Note: * p < 0.10, ** p < 0.05, *** p < 0.01

Table 4: Effect Sizes Associated with Model Estimates

		Two Segment Solution		Three Segment Solution		
	Segment 1	Segment 1	Segment 2	Segment 1	Segment 2	Segment 3
Direct effects:						
Intercept	**2.80**	**3.31**	**3.93**	1.61	**5.77**	**4.70**
Internal sources	1.60	1.83	–0.12	**4.65**	–2.46	**–3.41**
External sources	–2.32	**–2.82**	**–3.16**	–0.57	**–3.48**	**–4.19**
Organizational absorptive capacity	0.66	0.41	–0.55	–1.00	–2.25	**4.96**
Moderating effects:						
External*absorptive capacity	1.32	**1.78**	**2.41**	**2.82**	**2.60**	**–3.03**
Internal*absorptive capacity	–1.70	–1.69	–1.81	**–2.21**	0.25	–0.76
Internal*external sources	1.09	1.09	1.48	–0.94	1.52	**5.44**
Total effects:[a]						
Internal sources	0.99	1.23	–0.45	1.41	–0.69	1.14
External sources	0.09	0.05	0.73	1.20	0.60	–1.88
Organizational absorptive capacity	0.28	0.51	0.05	–0.46	0.59	0.97

Note: For direct and moderating effects, estimates based on significant coefficients from Table 3 are shown in bold.

[a] Includes all interaction effects, so some double counting will occur across sources and absorptive capacity.

Table 5: OLS Estimates of Variations of Basic Model

		Internal Sourcing		External Sourcing		Internal and External		
	Full Model	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 3
Intercept	2.80* (1.63)	2.08*** (0.34)	1.33 (1.35)	2.89*** (0.31)	4.34*** (0.89)	2.17*** (0.39)	3.39*** (1.26)	2.09*** (0.39)
Internal sources	0.28 (0.29)	0.21*** (0.06)	0.43 (0.24)	—	—	0.22*** (0.06)	0.01 (0.22)	0.21*** (0.08)
External sources	–0.49 (0.30)	—	—	0.02 (0.06)	–0.30 (0.19)	0.01 (0.05)	0.05 (0.05)	0.00 (0.01)
Organizational absorptive capacity	0.15 (0.37)	0.05 (0.06)	0.23 (0.32)	0.11* (0.06)	–0.24 (0.21)	—	—	0.05 (0.06)
External*absorptive capacity	0.06 (0.05)	—	—	—	0.08* (0.04)	—	—	—
Internal*absorptive capacity	–0.07 (0.06)	—	–0.03 (0.06)	—	—	—	—	—
Internal*External sources	0.04 (0.05)	—	—	—	—	—	–0.26 (0.27)	—
R–square	0.06	0.04	0.04	0.01	0.02	0.04	0.04	0.04

Note: * p < 0.10, ** p < 0.05, *** p < 0.01

Table 6: Group Differences and Similarities

	Segment 1	Segment 2	Segment 3	F-value
Variables in the model				
Performance [a]	4.45 (A)	1.80 (C)	3.17 (B)	424.90***
Internal sources [a]	5.52 (B)	5.82 (A)	5.58 (A,B)	1.45
External sources [a]	4.60 (B)	4.95 (A)	4.78 (A,B)	1.62
Absorptive capacity [a]	4.46 (B)	4.86 (A)	4.35 (B)	3.42**
Structural variables				
Multinationals (Percent of sample)	57 (A)	41 (B)	60 (A)	2.51*
Employees in business unit	445 (A)	333 (A)	416 (A)	0.21
Employees in organization	3,181 (A)	1,287 (A)	3,225 (A)	0.60
Service firms (Percent of sample)	62 (A)	52 (A)	52 (A)	1.32
Percentage staff devoted to the following activities [b]				
Basic research	2.14 (A,B)	2.80 (A)	1.41 (B)	2.25*
Product development	7.37 (A)	4.53 (A)	7.44 (A)	0.89
Manufacturing	19.06 (B)	28.59 (A)	24.09 (A,B)	1.67
Service delivery	40.13 (A)	34.05 (A)	37.72 (A)	0.58
Management	7.40 (B)	9.14 (A)	7.39 (B)	1.70
Marketing and sales	13.27 (A)	7.90 (B)	11.85 (A,B)	1.87
General administration	9.65 (B)	12.87 (A)	11.40 (A,B)	2.83*
Innovation measures				
Overall innovation index [a]	1.45 (A)	1.34 (B)	1.33 (B)	3.92**
New product prototypes	4.54 (A)	4.20 (A,B)	3.86 (B)	5.79***
New products – new to market	4.32 (A)	4.10 (A)	3.50 (B)	9.08***
New products – new to the firm	4.50 (A)	4.51 (A)	4.32 (A)	0.62
Significant modifications of products	4.76 (A)	4.27 (B)	4.40 (A,B)	2.23
Manufacturing techniques	4.16 (A)	4.46 (A)	4.14 (A)	0.62
Patents	4.57 (B)	4.57 (B)	4.39 (A)	2.97*
Research and development	8.03 (A)	6.39 (A)	8.23 (A)	0.32
Characteristics of knowledge environment				
Codifiability	4.94 (A)	4.98 (A)	4.86 (A)	0.13
Teachability	4.15 (A)	4.36 (A)	4.19 (A)	0.65
Complexity	5.22 (B)	5.51 (A)	5.14 (B)	2.13
System dependence	4.93 (A)	5.19 (A)	5.14 (A)	1.86
Observability	3.70 (A)	3.80 (A)	3.80 (A)	0.12
Individual performance (measured relative to competitors)				
Return on investment	4.41 (A)	2.00 (C)	3.13 (B)	110.73***
Market share	4.65 (A)	1.98 (C)	3.43 (B)	116.51***
Increase in sales	4.40 (A)	1.70 (C)	3.21 (B)	162.30***
Increase in profits	4.30 (A)	1.49 (C)	2.92 (B)	176.18***

Note: The letters in parentheses indicate which means are significantly different. For each variable those not different are indicated by the same letter—e.g., (A) in the case of codifiability. Those where a difference exists are indicated by a different letter—e.g., in the case of ROI all three groups are different and significant since three different letters are used. In situations where two letters are shown it indicates that this segment is not different from two other segments—e.g., in the case of internal sources of knowledge segment 3 is not different from segments 1 and 2 but segments 1 and 2 are different from one another.

[a] Denotes an aggregate measure

[b] Percentages do not add up to 100 percent due to overlap. For example, not all manufacturing firms would provide high levels of service and service firms high levels of manufacturing.*Note:* * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Multinomial Logistic Regressions on Segment Membership (Base = Segment 3)

	Analysis 1		Analysis 2		Analysis 3	
	Segment 1	Segment 2	Segment 1	Segment 2	Segment 1	Segment 2
Structural Variables						
Multinationals (Percent of sample)	0.150	–0.836**	0.186	–0.837**	0.132	–0.799**
	(0.289)	(0.402)	(0.291)	(0.398)	(0.277)	(0..374)
Staff Distribution by Activity						
Product development	–0.006	–0.035				
	(0.013)	(0.023)				
Service delivery	0.001	–0.008				
	(0.006)	(0.008)				
Marketing and sales	–0.001	–0.026	–0.005	–0.021		
	(0.011)	(0.019)	(0.009)	(0.017)		
Innovation: Overall innovation index			–0.962**	–0.807	–1.085***	–0.866*
			(0.409)	(0.555)	(0.350)	(0.515)
Knowledge Environment						
Complexity	–0.159	0.329	–0.152	0.252		
	(0.146)	(0.215)	(0.137)	(0.198)		
System dependence	0.311**	0.215	0.371**	0.297	0.318**	0.377**
	(0.154)	(0.202)	(0.155)	(0.200)	(0.145)	(0.196)
Industry Dummies						
Natural resources	1.455*	1.824**	1.357*	2.067**	1.326***	2.230***
	(0.823)	(0.917)	(0.802)	(0.877)	(0.800)	(0.848)
Business services	–0.193	–0.604				
	(0.422)	(0.710)				
Legal, health and other services	–0.363	–0.443				
	(0.379)	(0.534)				
–2 Log Likelihood	502.44		506.37		546.16	
McFadden's Pseudo R^2	0.067		0.066		0.051	
Percent correctly classified	53.20		50.60		52.90	