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Innovating In Health Care: The Contextual Specificity Of Capital

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ABSTRACT

Prior research suggests that innovation process effectiveness (IPE) – the degree to which an organization proficiently coordinates resources and activities for innovation – is a key contributor to organizational innovativeness, and ultimately organizational success. Despite the pivotal role of IPE, little research has focused on the factors that facilitate IPE. I propose that IPE depends on organizations' ability to access needed knowledge. Specifically, I hypothesize that IPE is related to organizational access to human capital (i.e., knowledge embedded in workers) and organizational capital (i.e., knowledge embedded in structures), with the relative impact of each capital differing between health care and other innovative industries due to industry-based differences in knowledge properties. My study of 221 organizations confirmed that access to capital predicts IPE, with the relevant capital differing by industry. In the health care industry, only human capital was positively associated with IPE, as measured by its three indicators: combinative capability, process efficiency, and output quality. In contrast, in other innovative industries, both human capital and organizational capital were associated with IPE. In these non-health care industries, access to both capitals predicted combinative capability and efficiency, both of which mediated the relationship between access to capital and output quality. Only combinative capability mediated the relationship between human capital and output quality in health care. These results suggest that access to knowledge resources plays a significant role in IPE, but the impact of particular resources is context-specific.

Key words: Knowledge repositories, innovation process effectiveness, contextual specificity, health care

ACKNOWLEDGMENTS

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1. INTRODUCTION

Organizations across industries rely on innovation as a source of growth, cost reduction, and quality improvement (Teece 2007). A robust literature covering more than 200 studies suggests that innovation success depends on the effectiveness of organizations' innovation process, that is, how proficiently organizations coordinate their resources and activities for idea development and implementation (Evanschitzky et al. 2012). Despite the importance of innovation process effectiveness (IPE) for innovation and organizational success, the factors that foster IPE have received little attention, leaving managers with limited guidance about how to improve IPE and leaving ambiguity in the organizational literature about a key contributor to innovation. Recognizing this gap, scholars have issued calls for theoretical development and empirical investigation of IPE (Lee et al. 2011).

This thesis seeks to answer the calls and investigates the role of knowledge resources in IPE. Specifically, I examine the effect on IPE of knowledge repositories within organizations. I focus on knowledge repositories because research indicates that creative enterprises such as innovation hinge on the integration and application of knowledge (Subramaniam and Youndt 2005). Building from this observation, I presume that access to relevant knowledge is a preceding necessity. Stored within knowledge repositories is knowledge about past and current organizational practices, their outcomes, and new ideas for improving performance (Walsh and Ungson 1991). In this work, I focus on the effect of access to two core knowledge repositories (Argote and Miron-Spektor 2011): organizational members (human capital) and organizational tasks, structures, tools, and routines (organizational capital). I focus on these two, as opposed to an extended suite of knowledge repositories, because they are subject to management intervention and I hope to inform industry practices in addition to theory.

There are several features of this research that are notable. First, it provides insight on how knowledge repositories relate to the innovation *process*. Prior work has emphasized the relationship between knowledge repositories and innovation *outcomes* (e.g., Ahuja (2000); Subramaniam and Venkatraman (2001)), without directly addressing the process by which knowledge repositories are related to outcomes. Second, this research provides a nuanced understanding of IPE as it examines the relationship between knowledge repositories and each of the criteria by which performance with respect to IPE is judged: increased combinative capability, process efficiency, and output quality (Brettel et al. 2012). Although prior work identified these criteria, it has not considered them individually nor potential relationships between them, which this work does. Last, but not least, this work addresses the question of whether the effect of access to knowledge repositories varies in industries with different features by comparing the effects in health care versus other innovative industries, using data from 221 organizations in the United States (US) and the United Kingdom (UK).

I separately examine health care because both scholars and practitioners have argued that health care is fundamentally different from other industries because it focuses on human life (and death) and must contend with the extreme form of challenges faced by other industries (e.g., customer/patient variability, knowledge intensity, etc.) (McCreary 2010; Ramanujam and Rousseau 2006). Additionally, I was compelled to examine IPE in health care separately because, although there are some organizations within health care that are heralded for their IPE (e.g., Gilead Sciences (Lubkeman 2010), Kaiser Permanente (McCreary 2010)), many, if not most, struggle with IPE. The top 20 pharmaceutical firms alone lost 30% of their market capitalization ($720 billion) from 2000 to 2010 as investors lost confidence in their competency to bring innovative products efficiently to market (Tollman et al. 2011). The difficulty with IPE

is not limited to pharmaceutical firms. The health care delivery sector (i.e., hospitals, medical groups, etc.) has also struggled with process-rooted challenges, like innovation implementation failures, which have resulted in less than expected quality improvement from innovation adoption (Nembhard et al. 2009). This is of particular concern because quality problems are widespread, resulting in nearly 100,000 preventable deaths annually in the US alone (Institute of Medicine 1999). Through this thesis, I aim to provide theoretically-derived, empirically-evaluated insight on contributors to IPE in health care versus other industries. The results show there are differences between industries.

2. ACCESS TO KNOWLEDGE REPOSITORIES AS A FACILITATOR OF IPE

2.1. Access to Human Capital as a Facilitator of IPE across Industries

According to scholars (e.g., Brettel et al. (2012)), IPE exists when the innovation process results in increased combinative capability, process efficiency, and high quality output. Combinative capability is the ability to generate new applications and concepts from existing knowledge. Efficiency exists when the organization's time to project completion and realized budget satisfies or exceeds expectations. A high quality output from an innovation process is an idea that is valued by potential customers. Reflecting these three criteria, IPE captures how proficiently an organization coordinates its activities in support of innovation creation, irrespective of whether the benefits of the innovation are realized. Thus, it differs from innovation effectiveness, which assesses the realization of the intended benefits of a given innovation (Klein et al. 2001).

I contend that the availability of human capital (Schultz 1961; Subramaniam and Youndt 2005) – the knowledge, skills, and abilities residing within an organization's workers – plays a significant role in facilitating all aspects of IPE. Workers have a unique capacity to interpret, evaluate, integrate, and create knowledge (March 1991). Furthermore, they are able to absorb

explicit as well as tacit and complex knowledge (Ferdows 2006). These abilities, rooted in

human cognition (Kang et al. 2007), make it likely that access to human capital facilitates

organizations' combinative capability. Combinative capability, as noted above, is manifest in the

creation of new applications from existing knowledge. Cohen and Levinthal (1990) showed that

the ability to recognize the potential value of knowledge, which is necessary for developing new

applications, depends on the knowledge's relationship to other knowledge already possessed.

When workers possess related knowledge, they are better able to absorb and integrate

knowledge, and presumably to combine it for new applications in future endeavors. Thus, the

greater knowledge and expertise embedded in workers, the greater combinative capability of the

organization should be. I expect this partly to be due to cognitive facility and partly due to the

richness in information sharing that occurs when greater worker expertise exists (Lee et al 2011).

Collins and Smith (2006) found that organizations that strategically chose their HR practices in

order to have access to talented workers had staff that engaged in greater knowledge exchange

and combination that led to valued products. Thus, I reason that human capital supports

combinative capability.

Human capital should also improve efficiency. Because information sharing quality is

higher when human capital exists, I expect that knowledge is processed more efficiently.

Efficiency is also likely to be greater because human capital enables rapid learning. Research on

learning curves has found that organizational production accelerates as worker experience grows

(Lapré and Nembhard 2010). This suggests increased efficiency due to learning by and

embedded in workers. According to learning theory, the knowledge and skill that workers

acquire as they perform their tasks automatically results in their development of more efficient

techniques for task completion. The notion of efficiency derived from learning embedded in

workers is based on studies of routine tasks, but should extend to innovative tasks as well as, which also require deliberate learning via experimentation (Thomke 1998), likely spurring more efficient processes.

Both process efficiency and combinative capability derived from human capital should increase the likelihood of a high quality output i.e., an idea that is valued by potential customers. Prior research suggests that most new ideas arise from the combination of existing principles or products (Smith et al. 2005). For example, the iPhone, a valued innovation in communications, was created when engineers at Apple combined the technology of more than 200 components suppliers with innumerable independent application providers (Reeves and Bernhardt 2011), suggesting the combinative capability of an organization can contribute to high quality output. The savvy integration of new knowledge in particular, which combinative capability enables, may help organizations to remain current and better positioned to formulate new ideas that respond to evolving customer needs or desires (Teece 2007).

Expertise in process efficiency is also likely to foster high quality output. Pursuit of efficiency imposes an internal discipline for achieving goals subject to time and resource constraints. Such discipline induces an iterative decision process about what ideas hold the greatest potential value (Cooper et al. 1999), increasing the likelihood of selecting the best ideas and thus creating higher quality output. Extending from my propositions that both efficiency and combinative capability contribute to high quality output and that human capital enables efficiency and combinative capability, I further contend that the effect of human capital on output quality is mediated by combinative capability and efficiency. Summarizing, I posit:

Hypothesis 1. *Human capital is positively associated with (1a) combinative capability and (1b) efficiency, both of which mediate the relationship between human capital and (1c) output quality.*

2.2. Access to Organizational Capital as a Facilitator of IPE across Industries

Organizational capital is the institutionalized knowledge and codified experience residing in routines, tools, patents, licenses, databases, and systems (Youndt et al. 2004). I hypothesize that this form of capital is also positively associated with the elements of IPE, albeit for different reasons compared to human capital. Organizational capital likely enhances an organization's combinative capability by facilitating knowledge use (Cook and Brown 1999). Knowledge embedded in organizational capital has already been converted from tacit to explicit. The explicitness reduces causal ambiguity, thus, improving the comprehensibility of knowledge (Szulanski 1996) and ability to use it in future endeavors. Nonaka and Takeuchi (1995) found that, only upon understanding how a master baker kneads dough, codifying the motion as "twisting stretch" (p.105), was a design team able to create a superior kneading mechanism for bread-making machines. In its design, the team combined various existing kneading processes. Building on this finding, I propose that greater clarity of knowledge, which organizational capital facilitates, increases the ability to use and combine knowledge to create new applications. Likewise, the frame of reference provided by organizational capital should help with the evaluation of new against existing knowledge, thereby calibrating what information may be effectively combined in future endeavors (Kang and Snell 2009).

Organizational capital may also improve efficiency by virtue of providing easy to locate knowledge that is legitimized and instructive. The ease reduces the need for search, which increases efficiency. The fact that information stored in this repository has been legitimized and formulated in such a way as to be instructive (Brown and Duguid 1991) also means that the organization and its workers need not dedicate as much time to distilling and interpreting knowledge during the innovation process as would be required for knowledge that had yet to be

codified. This promotes efficiency during the innovation process. Furthermore, having organizational capital may provide a benchmark for the setting of reasonable timelines and budgets, making achievement of them possible. Given my hypothesis that organizational capital is positively associated with efficiency and combinative capability, both of which I contend contribute to higher quality output as argued above, I propose that:

Hypothesis 2. *Organizational capital is positively associated with (2a) combinative capability and (2b) efficiency, both of which mediate the relationship between organizational capital and (2c) output quality.*

2.3. Relative Impact of Human and Organizational Capital on IPE in different Industries

Scholars and practitioners have argued that industries can possess unique attributes that influence the relationship between organizational characteristics and outcomes, causing relationships to differ across contexts, an occurrence referred to as "contextual specificity" (Beckman and Sinha 2005; Rousseau and Fried 2001). I contend that contextual specificity exists for the relationship between organizational access to knowledge repositories and IPE. In particular, I hypothesize that the impact of human and organizational capital differs for health care versus other industries due to differences in the knowledge utilized in health care.

The health care industry consists of organizations that are broadly classified into two groups: health care delivery providers (hospitals, medical groups, etc.) and suppliers of health-related technology (pharmaceutical corporations, biotechnology firms, etc.) (Burns 2005). The former provides preventative care and treatment to patients, while the latter supplies the technologies (e.g., drugs, diagnostic tests, etc.) used by the former to care for patients. In this thesis, I compare health care providers and suppliers with organizations in other innovative

industries such as electronics and network infrastructure.

A key observation from prior research is that organizations and industries can vary in the types of knowledge upon which they draw and utilize (Cardinal 2001), an observation that is exemplified in the comparison of the health care industry to others. The rate of knowledge growth in health care is especially rapid, as indicated by the addition of over 700,000 new references to Medline per year (the bibliographic database for biomedical articles) (NIH 2012). Also reflecting its knowledge intensity, suppliers of health technology regularly dominate R&D investment rankings, accounting for 40% of global R&D expenditure by innovative corporations contributing to a high knowledge production function (Jaruzelski et al. 2012). This pace of knowledge growth places the health care industry at the extreme relative to other industries.

The nature of knowledge that dominates the industry also differentiates it from others. Scholars have observed that knowledge in health care has a significant tacit component (Berta and Baker 2004), not easily codified. Hence the emphasis on site visits to high-performing health care delivery providers to observe what is important for clinical excellence. Suppliers particularly grapple with tacit knowledge during product development. Identification of target molecules from myriad compounds is subject to irreducible uncertainty. Molecules are part of unique cellular mechanisms and even leading scientists may only have a partial understanding of molecule interaction in a given mechanism (Pisano 1996). As a result, drug development failure rates approach 90%, an extreme compared to other industries (Nature 2007).

The health care industry additionally wrestles with a high degree of specialization. Due to the volume of knowledge, health professionals have become increasingly specialized such that each now brings only a portion of the knowledge needed to effectively care for patients. The average patient in a hospital now receives care from more than 20 professionals (different types

of physicians, nurses, etc.) who must integrate their expertise to provide high-quality care (Bohmer and Knoop 2007). The increasing volume of knowledge, especially through the advent of biotechnology, has also caused suppliers to specialize (Nicholls-Nixon and Woo 2003). Specialized knowledge manifests in form of organizations focusing on specific therapeutic areas (e.g., biotechnology firms like Gilead Science on antiretroviral drugs) and on specific functions (e.g., contract research organizations like Covance on antibody development). Specialization has developed to a degree that contractual R&D partnerships are twice as prevalent in the pharmaceutical industry compared to any other industry (Hagedoorn 2002).

Because of the industry's knowledge properties – rapidly changing, highly tacit, and greatly specialized – I assert that human capital is more influential on IPE than organizational capital in health care. I expect this because organizational capital outdates more easily in environments with rapidly changing knowledge. The knowledge embedded in this repository becomes less relevant more quickly and there tends to be a delay in adding new knowledge to this repository especially when knowledge grows fast (Kang and Snell 2009). Thus, as the pace of knowledge increases, organizational capital's ability to provide an effective frame of reference for the calibration of what information to combine and what efficiency goals to set diminishes, limiting its value for combinative capability and efficiency promotion. On the other hand, human capital retains and likely increases its value in the wake of fast-changing knowledge because of workers' inherent ability to begin interpreting and integrating knowledge as soon as it is presented (March 1991). Their skill should make human capital a more effective facilitator of IPE than organizational capital in the rapidly evolving health care industry.

Human capital further increases in value relative to organizational capital when the prevalence of tacit knowledge is considered. The increased incompleteness of the latter, which

does not readily store tacit knowledge, constrains its capacity to serve as a foundation for IPE when tacit knowledge is high. Consistent with this logic, in a review of over 400 pharmaceutical R&D projects, Hoang and Rothaermel (2010) found that performance of in-licensed projects was negative unless the licensee employed scientists with related drug development experience. In other words, firms failed to progress with the innovation process unless they drew upon human capital to process the tacit knowledge not embedded in the license. Hence, my theory that an industry high in tacit knowledge, like health care, benefits more from human capital.

The high knowledge specialization in health care lastly means that highly fragmented knowledge often needs to be integrated for task completion, whether it is a routine task or innovative task. The imperative for integration is reflected in recent innovations, which increasingly rely on reciprocal rather than sequential interactions between health professionals and scientists (Bohmer 2009). While all innovative organizations face the challenge of integrating knowledge, this challenge is magnified in health care by the volume of knowledge and specialization. Given that the integration of knowledge is conditional upon knowledge already possessed (Cohen and Levinthal 1990), and since skilled workers should possess more current and complete knowledge given the pace and tacitness of knowledge in health care, I expect human capital to play a more pivotal role in IPE rather than organizational capital:

Hypothesis 3. *In health care, human capital is more strongly associated with IPE – combinative capability (3a), efficiency (3b), and (3c) output quality – than organizational capital.*

3. RESEARCH METHODOLOGY

3.1. Sample and Data Collection

To empirically examine the relationship between the access to different knowledge repositories and IPE, I used survey data from a sample of organizations in a broad set of industries. To be

included in my sample, organizations had to satisfy two criteria. First, given our interest in innovative industries, organizations had to operate in innovative industries, indicated by greater than 45 percent of the industry engaged in innovation activity (Castellacci 2008). Second, organizations had to have more than 50 employees because I sought to include organizations large enough for knowledge repositories to potentially serve a useful function (e.g., Bhattacharya et al. (2005)). Applying these criteria, relevant organizations operated in five industries: health care, computer/electronics manufacturing, specialized machinery manufacturing, network infrastructure services, and knowledge-intensive services.

To study organizations in these industries, I used an approach routinely used in studies of knowledge repositories (e.g., Subramaniam and Youndt (2005)) and innovation processes (e.g., Poskela and Martinsuo (2009)): the key informant approach, surveying one executive (C–level executives, Presidents, and Directors) per firm. Recent meta–analytic correlations of subjective and archival measures showed that key informants are highly reliable in innovation-intensive settings (Homburg et al. 2012). I identified potential informants using commercial databases in the UK and the US. Since these countries belong to the same cultural cluster (Ronen and Shenkar 1985) and exhibit similarity in terms of IPE (Evanschitzky et al. 2012), this sampling strategy was applied to enlarge the pool of eligible key informants.

I invited 4,196 executives in the UK and US (1,922 UK; 2,274 US) to participate in the study via email in January 2012. Of the invitations sent, 2,479 were returned due to wrong email address and 74 were returned because the respondent left the company or replied as out of office. The remaining invitations (1,643) were not automatically returned, suggesting that they were received by the intended recipient. I received 253 survey responses, of which 32 had to be discarded due to missing data and/or respondent disqualification because of insufficient evidence

of key informant status. According to prior research (Homburg et al. 2012), an executive-level informant should hold a management position and/or have a high degree of involvement in strategic decision-making, which was determined based on responses to (a) "Please mark the answer that matches your job description best" (top, middle, line, or non-management) and (b) "Please indicate your level of involvement in corporate strategic activities" (5-point Likert scale: very high to very low involvement). I excluded all respondents not part of management, and discarded responses when informants indicated middle/ line management and low to very low involvement in strategic activities.

After disqualifications, I retained the data from 221 informant-respondents, for an effective response rate of 13.5%, similar to the rate for other surveys of top executives (i.e.,10–12% (Hambrick et al. 1993)) and innovation processes (i.e., 15% (Poskela and Martinsuo 2009)). Informants had a very high degree of strategic involvement ($\geq$ 70% of respondents), leadership positions (> 85% in top management positions), and a high level of experience in their position ($\geq$ 90% with tenure exceeding 10 years). All organizations satisfied the 50–employee minimum criterion except for nine that reported fewer than 50 employees. Since these organizations initially satisfied the inclusion criterion per their database record and reported greater than 40 employees in our survey, I retain them in my sample. Table 1 summarizes the respondent demographics, with each of the 221 informants providing information about one organization.

Please insert Table 1 about here

3.2. Measures

Generalizable multi-item survey scales with seven-point Likert response format were used. To ascertain whether the measures captured the desired information and were psychometrically valid, I pilot-tested them with two groups prior to survey administration in my sample. First, I

fielded the survey with 59 MBA students. I then modified the survey based on the pilot-test

results to improve the distinctiveness of the IPE dimensions and tested the refined measures with

20 experts from industry and academia. For all measures (Appendix A), Cronbach's alpha (α),

composite reliability (CR), and average variance extracted (AVE) indicated satisfactory

reliability, convergent validity, and discriminant validity, based on recommended thresholds of

0.7 for α and CR , and 0.5 for AVE (Hair et al. 2012).

Knowledge repositories. I measured human capital and organizational capital using

Subramaniam and Youndt's (2005) scales. I conducted a principal components factor analysis

with varimax rotation and found support for the intended two-factor structure, with all but one

item loading on its intended factor and both factors exhibiting eigenvalues greater than one. The

one exceptional item was eliminated from the analyses. Confirmatory factor analysis (CFA)

supported the two-factor specification (χ^2/ degrees of freedom = 2.41, comparative fit index

[CFI] = 0.94, incremental fit index [IFI] = 0.94, goodness-of-fit index [GFI] = 0.93). The first

factor, indicating *human capital,* consisted of five items and measured the overall skill, expertise,

and knowledge of employees (α = 0.89; CR = 0.92; AVE = 0.69). The second factor, indicating

organizational capital, consisted of three items and assessed the extent to which the organization

stored knowledge in structures such as databases and manuals (α = 0.60; CR = 0.79; AVE =

0.55). Although this measure of organizational capital did not exceed the conventional threshold

of 0.70 for α, it had a composite reliability of 0.79, which some regard as a more appropriate

indicator of reliability because composite reliability provides a better assessment of internal

consistency (Bagozzi and Youjae 1988; Hair et al. 2012)

Innovation process effectiveness. My measures of the three dimensions of IPE were

adapted from Brettel et al. (2012). The first dimension, *combinative capability*, was assessed

using three items that asked the extent to which the innovation process enabled growth in expertise, capabilities, and ideas that might be applied (combined) in future endeavors ($\alpha = 0.91$; CR = 0.94; AVE = 0.84). The second dimension, *process efficiency*, was assessed using three items that captured success in meeting schedule and budget goals ($\alpha = 0.87$; CR = 0.92; AVE = 0.80). Last, *output quality* was measured using three items that assessed perceived value, quality, and marketability of innovative ideas ($\alpha = 0.92$; CR = 0.95; AVE = 0.86). A principal components factor analysis of all survey items using a varimax rotation confirmed the three factors, with all items loading on their intended factor and all factors exhibiting eigenvalues greater than one. CFA supported the three-factor specification (χ^2/ degrees of freedom = 1.82, CFI = 0.98, IFI = 0.98, GFI = 0.94).

Control variables. I selected control variables based on three criteria recommended by (Becker 2005): (i) theory suggests that the variable might be correlated with the dependent variable, (ii) the variable might be correlated with a hypothesized independent variable, and (iii) the variable is not integral to the specified model, but theoretically important. Based on these criteria, I included organizational age (in years), R&D emphasis (measured by a seven-point Likert scale survey item asking respondents to indicate their level of agreement with this statement: "We put strong emphasis on R&D, innovation, and technological leadership"), prior performance (assessed by asking respondents to rank on a 1-5 scale their organization's performance compared to close competitors over the last three years in terms of profit level and market share), industry type (0 = manufacturing and 1 = service), and home country (0 = UK and 1 = US) . These factors were selected because organizational age may influence the organization's ability to accumulate and embed knowledge in repositories over time (Walsh and Ungson 1991), while a firm's general emphasis on R&D could affect the effort to build

knowledge repositories that foster IPE (Subramaniam and Youndt 2005). Moreover, prior

performance may be important because a positive trajectory frees resources for experimentation,

which may improve innovation capabilities (Hill and Rothaermel 2003). Finally, industry type

and home country were included because the innovation process in services may differ from that

in manufacturing, or may differ by organizations' home country (Castellacci 2008).

3.3. Analytic Methods

I examined the proposed relationships with the organization as the unit of analysis and using

structural equation models (SEM). Structural equation modeling allowed examining how one

knowledge repository impacts output quality, accounting for potential mediation through

combinative capability and efficiency, while holding the relationships between the other

knowledge repository and the elements of IPE constant. I used partial least squares (PLS) models

because such models are more appropriate than maximum likelihood covariance–based

techniques when the sample includes less than 250 observations and the data are not normal

(Reinartz et al. 2009). My data fit both of these criteria. The full sample included 221

organizations and the subsamples for our cross-industry analysis were necessarily smaller (N=73

health care organizations and N=148 organizations in other innovative industries). Additionally,

the null hypothesis of data normality was rejected at the 1 percent level of significance for all

indicators using a Shapiro–Wilk test. Kolmogorov–Smirnov tests confirmed these results. For

data with these attributes, PLS SEM, which does not require any distributional assumptions,

overcomes model identification issues and provides more reliable statistical results (Gefen et al.

2011). Therefore, I used this variance-based SEM technique for my analyses, which were carried

out with Smart PLS Version: 2.0.M3.

      I complemented the SEMs with additional mediation analysis that allowed assessing the

strengths of a particular mediation effect and comparing the effects of multiple mediators in a single model, applying Preacher and Hayes' (2008) procedure. To ensure that this additional analysis is based on the same data as the SEMs, I imported the standardized latent variables of my SEMs into SAS 9.3 prior to applying Preacher and Hayes' procedure. Given my non-normal data I used a nonparametric bootstrapping approach for this additional mediation analysis, interpreting the 95% bias corrected confidence intervals emerging from 1,000 bootstrap samples.

4. RESULTS

4.1. Evaluation of Measurement Models

To assess the appropriateness of my PLS models, I followed Gefen et al. (2011) in calculating three metrics. First, I calculated the coefficient of determination R^2, which indicates the explanatory power of models. The R^2 values exceeded the threshold value of 0.19 for satisfactory power (0.207–0.649 for health care, 0.267–0.665 for non-health care, and 0.256–0.649 for the full sample) (Hair et al. 2012). Second, I estimated the Stone–Geisser–Criterion Q^2 using a blindfolding procedure with omission distance of five. The Q^2 values all exceeded zero (health care: 0.133–0.495; non-health care: 0.194–0.533; full sample: 0.180–0.529), suggesting that my models predict the latent variables well. Third, I computed the variance inflation factors (VIF) to examine multicollinearity among independent variables. The VIFs were less than 2 (health care: 1.289–1.880; non-health care: 1.294–1.623; full sample: 1.277–1.663), hence much smaller than the threshold of 10 (Gefen et al. 2011). Last, to ensure that model fit was comparable across all models, I calculated models' goodness-of-fit (GoF) as the geometric mean of the average communalities and the models' average R^2 values (Hair et al. 2012). The GoF values were 0.514 for health care, 0.545 for non-health care, and 0.535 for the full sample, suggesting comparability. Thus, summarizing across indicators, my models provided valid, reliable results.

4.2. Results of Models Examining the Capital-IPE Relationship

Table 2 reports the means, standard deviations, and correlations of all variables. Table 3 presents the results of my structural equation models, examining the hypothesized relationships for health care (model 1), other innovative industries (model 2), and the full sample (model 3). Across models, human capital was positively and significantly associated with the first two indicators of IPE, combinative capability and efficiency, supporting Hypothesis 1a and 1b. Results for output quality and relationships between all variables, however, differed across models, that is, between industries. In the health care industry (model 1), only combinative capability was associated with output quality; it mediated the relationship between human capital and output quality. No direct or mediating effect of efficiency was found. Therefore, Hypothesis 1c is only partially supported in the health care industry. In contrast, in other industries (model 2), both combinative capability and efficiency were associated with output quality and mediated the relationship between human capital and output quality. These results support Hypothesis 1c in non-health care industries. Results of the all-industries model (not differentiating health care from other industries, model 3) mirrored those for the non-health model (model 2), which contained two-thirds of the sample.

Please insert Tables 2 and 3 about here

The results with respect to organizational capital also show significant differences between health care and other industries. This knowledge repository was not significantly associated with any element of IPE in the health care industry, but was positively associated with combinative capability and efficiency in other industries, providing support for Hypotheses 2a and 2b in the non-health care industries but not in the health care industry. I also find support for Hypothesis 2c in non-health care industries. Both combinative capability and efficiency were positively related to output quality, mediating the relationship between organizational capital and

output quality. Again, results of the all-industries model (model 3) mirrored those for model 2. No mediating relationship was found in the health care industry as organizational capital had no relationship to any element of IPE. Given the absence of an effect for organizational capital and a positive effect of human capital in the health care industry, Hypothesis 3 was supported; human capital did have a stronger relationship to IPE than organizational capital in this industry.

As shown in Table 4, the mediation tests confirmed my SEM results and provided further clarity about the effects. In the health care industry, the relationship between human capital and output quality was only mediated by combinative capability (BCB $CI_{95\%}$= 0.001-0.489). Efficiency did not mediate ($CI_{95\%}$ = -0.023-0.234) and no effect of organizational capital on IPE was found. In other industries, however, both combinative capability and efficiency mediated between human capital and output quality ($CI_{95\%}$ = 0.082-0.362 and $CI_{95\%}$ = 0.012-0.209, respectively) and between organizational capital and output quality ($CI_{95\%}$ = 0.109-0.296 and $CI_{95\%}$ = 0.013- 0.154, respectively). Contrast tests showed both variables to be equally strong mediators of the human capital-output quality relationship ($CI_{95\%Contrast}$ = -0.010-0.310), and combinative capability to be a significantly stronger mediator of the organizational capital-output quality relationship than efficiency ($CI_{95\%Contrast}$ = 0.019-0.258). Across all models, the control variables of firm age, R&D emphasis, past performance, industry type, and home country were not significant ($p > 0.10$).

Please insert Table 4 about here

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5. DISCUSSION

The purpose of this research was to advance the understanding of IPE, an important yet little understood determinant of successful innovation. I proposed and my results confirmed that organizations' access to knowledge repositories plays a key role in contributing to greater IPE.

Recent research has highlighted the importance of knowledge repositories for organizational effectiveness and innovation outcomes (Menor et al. 2007), but the connection to IPE had not been proposed and investigated. My results show not only which knowledge repositories (i.e., human and/or organizational capital) are significant for IPE in different industries but also the pathway by which individual repositories affect each element of IPE and the relationship between elements (combinative capability, process efficiency, and output quality).

In sum, my results suggest that human capital affects output quality through combinative capability in the health care industry, while human and organizational capital affect output quality through two pathways – combinative capability and efficiency – in other innovative industries. I also found that human capital in the health care industry ($R^2 = 0.656$) has a similar magnitude of effect on output quality as the combination of human and organizational capital in other industries ($R^2 = 0.664$). These findings reinforce the importance of human capital in health care and also indicate that human capital is necessary but not sufficient for IPE in other innovative industries. Organizational capital may also be needed in other innovative industries because external, collective repositories are not as dominant in other industries. In health care, such external repositories play a central role. For example, on the health care delivery side, professional associations and government databases exist for this purpose, while on the health care supplier side, knowledge, particularly about the innovation process, is highly informed and regulated by government agencies. Thus, individuals in health care first and foremost carry professional-based knowledge (e.g., knowledge of surgical procedures) (Huckman and Pisano 2006). In other industries workers often carry as much organization-based knowledge (e.g., knowledge of development processes), hence the documented loss of organizations' capabilities when workers depart and recommendations to invest in organizational capital to prevent erosion

of organizational knowledge (Huber 1991).

Although I predicted the effect of organizational capital to be weaker in health care due to industry-related knowledge properties, the insignificant effect was surprising. Despite this result, I caution against assuming that access to this repository is not beneficial for IPE in health care. Recent research shows that checklists, a form of organizational capital, can be helpful for the implementation of innovations but also suggests that gains from their use depends on professional support for this tool (Gawande 2010) . Likewise, the effectiveness of organizational capital on IPE in health care may depend on other factors such as the perceived quality of the repository's contents or unit culture. Future research should examine whether such factors moderate the effect of organizational capital on IPE in health care.

The other surprising finding was that the relationship between IPE dimensions also differed in the health care industry. Efficiency did not predict perceived output quality in this industry, as it did in other innovative industries. The disconnect in health care suggests the need for revision in the conceptualization of IPE. My hypotheses had implicitly suggested two stages of IPE with combinative capability and efficiency in the first stage, resulting in output quality in the second stage. While results for non-health care industries support that conceptualization, results for the health care industry indicate an alternative formulation with two elements of effectiveness in the second stage i.e., efficiency and output quality, with the latter resulting from combinative capability in the first stage. That efficiency is not a consideration in valuation of output quality may reflect that the innovation timeline is heavily regulated for suppliers limiting their influence on efficiency, and may also reflect that a process that results in life-saving output is valued even if inefficient. Thus, the two dimensions of IPE can be unrelated in health care.

The goal of this research was to offer insight on IPE, but it also adds to research on

knowledge repositories, specifically to research that considers the effects of individual repositories as opposed to repositories as a whole (e.g., Menor et al. (2007)). Thus far, studies of individual repositories have shown that different repositories can affect different outcomes and affect the same outcome differently. For example, Subramaniam and Youndt (2005) showed that organizational capital positively influences incremental innovative capability, while human capital negatively influences radical innovative capability in the absence of countervailing forces. This work extends this research by showing that different repositories can not only affect the same outcome through different processes but also have varying effects across industries.

Taken together, my results also inform the debate about whether health care is different. In many respects health care mirrors other industries. For example, it relies on knowledge workers similar to other professional service or scientific manufacturing industries; it has a professional hierarchy like many labor-intensive ones; and it faces cost-cutting pressures like most industries. Nevertheless, my IPE findings indicate that health care differs from other innovative industries. From a research and theory development standpoint, this difference is significant. It affirms the importance of considering contextual specificity. There have been several calls for more context-mindful, industry-specific research across scholarly fields from organizational behavior (Tamuz and Thomas 2006) to production and operations management (Beckman and Sinha 2005). Yet, research has responded slowly perhaps because of a focus on generalizable research. My results suggest the importance of industry studies to advance understanding of dynamics within industries and to be helpful to specific industries. Failure not to consider industry-specific dynamics raises the risk of developing theory and recommendations that are incorrect for some.

This thesis' results imply that investing in all knowledge repositories is not the most

effective approach for optimizing IPE in all industries. Organizations and their managers are better served by identifying repositories specifically linked to IPE in their industry and selectively investing in them. Based on my results, managers in health care should invest in human capital to increase their organization's IPE, while managers in other innovative industries should focus on developing human and organizational capital. Prior work suggests that employee selection, training, and rewards are effective tools that managers can use to develop human capital (Huselid and Becker 2011), whereas investments in information technology can enhance organizational capital (Poston and Speier 2005). Whether there are other tools that are particularly effective for developing each form of capital remains a question to be explored. Additionally, for industries that require both human and organizational capital, there remains a question about how to effectively combine tools to foster the development of these important knowledge repositories. For all organizations, my results point to the importance of tools supporting human capital and thus worker development. To realize the benefits of that investment, organizations must attend as much to retention and development of skilled workers as to their recruitment. Retention has been a challenge for managers in health care delivery (Waldman et al. 2004), an environment where quality and safety are paramount and turnover has especially negative consequences, as a recent meta-analysis showed (Hancock et al. 2013). Health care suppliers have also cut 300,000 jobs over the past ten years, equivalent to the size of the top three firms in the industry (Herper 2011). My results imply that there is value in managers' continued pursuit of retaining and developing skilled workers.

As with most research, this study has limitations. First, the cross-sectional nature of my data prevents me from concluding that access to knowledge repositories determines IPE; another variable correlated with both access to knowledge repositories and IPE may explain my results.

Second, my sample only included organizations in the US and UK and only those that satisfied my size and innovativeness thresholds. The limited sample leaves open the question of whether the presented results generalize to organizations in other cultural clusters and with different sizes and innovativeness. Third, although my survey response rate is similar to that of other innovation and key informant studies, the low rate raises the possibility that my results reflect non-response bias. However, when I assessed this bias using Armstrong and Overton's (1977) procedure of comparing early and late respondents, I found no significant difference minimizing concerns about non-response bias. Fourth, I collected data regarding knowledge repositories and IPE from a single key informant, which raises the possibility of common method bias. I conducted two post-hoc tests to assess the likelihood of such bias. The first, Harman's one-factor test, showed multiple factors emerging in factor analysis and none were dominant. The second test, including a common method factor into my model (Podsakoff et al. 2003), showed that method-based variance was 0.01, miniscule compared to variance explained by the constructs of 0.75. While these tests do not eliminate the possibility of common method bias, they provide evidence that my results are not driven by such bias. Last, the relatively small health care sample (N=73) might raise questions about whether the non-significant results for organizational capital might be due to statistical limitations. Given that I found significant results for human capital in this small sample, statistical limitations do not seem to have prevented detection of significant effects and true differences for health care.

A next step for research is to investigate the role that other knowledge repositories such as social capital – knowledge embedded within and utilized by interactions among individuals – may play for IPE in health care and other industries. I chose to focus on human and organizational capital because they are widely accepted as fundamental repositories and

managers readily exercise influence over them.

In conclusion, this thesis provides evidence for the importance of knowledge repositories for IPE and documents the contextual specificity of this relationship. This insight is a step in the direction of better understanding the relationship between knowledge and innovation and showing the impact of industry effects. Based on my findings, researchers may be well-served by incorporating industry-specific dynamics into their theorizing. Unless potential variance across industries is taken into consideration, wholehearted recommendations based on aggregate results may be misdirected because of the risk associated with investing in knowledge processes and its demanding resource requirements. I hope that this study inspires more research that is conscious of industry dynamics and their role in innovation and other knowledge-based processes.

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Table 1 Response Demographics

Industry type	NAICS affiliation	UK	US		Respondent profile		UK	US
Health care					**Tenure (years)**		**UK**	**US**
Suppliers: Pharma/ Chemicals; Medical instruments	325/ 339	29%	22%		>20		63%	91%
Delivery: Health care organizations (e.g. hospitals)	54, 62	8%	7%		11-20y		27%	6%
					6-10y		4%	2%
Other innovative industries					3-5y		4%	0%
Computer/ Electronic	334-335	15%	10%		<3y		2%	1%
Specialized machinery	31, 33	12%	11%					
Financial services[a]	52	18%	32%		**Position**		**UK**	**US**
Telecommunications[a]	51	8%	14%		Top management		88%	89%
Professional services[b]	54	4%	1%		Middle managemt		10%	9%
Scientific services[b]	54	6%	3%		Line management		2%	2%

Firm size (number of employees)		**UK**	**US**		**Degree of strategic involvement**		**UK**	**US**
10-49		4%	5%		Very high		72%	70%
50-99		15%	17%		High		14%	19%
100-249		14%	23%		Moderate		7%	6%
250-999		27%	19%		Low		7%	3%
1000-2499		10%	13%		Very low		0%	2%
2500-9999		15%	7%		UK (N=114); US (N=107)			
>10000		15%	16%					

UK (N=110); US (N=100): Excluding private equity firms who reported employees based on firm portfolio

Note: Innovative industry classification adapted from Castellacci (2008)

[a] Network-infrastructure services; [b] Knowledge-intensive services

NAICS (North American Industry Classification Systems), mapped to NACE for UK firms (NACE is the statistical classification of economic activities in the European community)

<div align="center">**Table 2 Correlations, Means, and Standard Deviations**</div>

Latent variable	1.	2.	3.	4.	5.
1. Human capital (HC)	**1.00**	0.37**	0.46***	0.43***	0.54***
2. Organizational capital (OC)	0.29*	**1.00**	0.25*	0.25*	0.25*
3. Combinative capability (CC)	0.42***	0.39***	**1.00**	0.62***	0.76***
4. Process efficiency (PE)	0.44***	0.39***	0.54***	**1.00**	0.58***
5. Output quality (OQ)	0.39***	0.41***	0.78***	0.57***	**1.00**

Notes: Pearson correlation; Health care sample above the diagonal; Non-health care sample below the diagonal
*** Significance at $p < 0.001$; ** $p < 0.01$; * $p < 0.05$ (two-tailed)

Health care (N=73)					
Mean	5.69	5.01	5.31	4.95	5.19
Standard deviation	0.92	1.08	0.95	1.16	0.94

Non-health care (N=148)					
Mean	5.50	4.16	5.09	4.75	4.93
Standard deviation	0.94	1.30	1.18	1.34	1.28

Table 3 Path Estimates, R^2

Model	1. Health care Path coefficients	2. Non-health care Path coefficients	3. Full sample Path coefficients
Path			
Human capital → Combinative capability	0.415**	0.323***	0.342***
Human capital → Process efficiency	0.387*	0.359***	0.364***
Human capital → Output quality	0.216*	0.003	0.055
Organizational capital → Combinative capability	0.119	0.311***	0.266***
Organizational capital → Process efficiency	0.129	0.280***	0.243***
Organizational capital → Output quality	0.001	0.061	0.079
Combinative capability → Ouput quality	0.584***	0.577***	0.594***
Process efficiency → Ouput quality	0.208	0.210*	0.186**
R^2 Combinative capability	0.232	0.267	0.256
R^2 Process efficiency	0.213	0.273	0.256
R^2 Ouput quality	0.656	0.664	0.649

Notes: Controlling for (1) firm age, (2) innovation emphasis, (3) past performance, (4) industry type, (5) home country; (all not statistically significant, $p > 0.10$)

*** Significance at $p < 0.001$; ** $p < 0.01$; * $p < 0.05$. Health care sample (N = 73); Non-health care sample (N = 148); Full sample (N = 221)

Table 4. Mediation analysis of the effect of knowledge repositories on innovation process output quality through combinative capability and efficiency

Antecedents	Mediators	Health care–IPE output quality			Non–health care–IPE output quality		
		Point Estimate	95% CI (PB)	95% CI (BCB)	Point Estimate	95% CI (PB)	95% CI (BCB)
Human Capital (HC)	Combinative Capability (CC)	0.237*	[0.054;0.557]	[0.001;0.489]	0.203*	[0.067;0.338]	[0.082;0.362]
	Efficiency (EF)	0.058	[-0.027;0.221]	[-0.023;0.234]	0.074*	[0.004;0.185]	[0.012;0.209]
	Total Indirect Effect (CC+EF)	0.295	[0.086;0.644]	[-0.034;0.564]	0.277*	[0.134;0.432]	[0.135;0.435]
	Contrast (CC-EF)	0.180	[-0.013;0.526]	[-0.066;0.490]	0.129	[-0.034;0.285]	[-0.010;0.310]
Organizational Capital (OC)	Combinative Capability (CC)	0.054	[-0.106;0.211]	[-0.095;0.230]	0.194*	[0.106;0.288]	[0.109;0.296]
	Efficiency (EF)	0.020	[-0.023;0.081]	[-0.005;0.119]	0.057*	[0.006;0.130]	[0.013;0.154]
	Total Indirect Effect (CC+EF)	0.074	[-0.115;0.253]	[-0.097;0.278]	0.251*	[0.147;0.367]	[0.158;0.379]
	Contrast (CC-EF)	0.034	[-0.113;0.193]	[-0.095;0.214]	0.137*	[0.020;0.258]	[0.019;0.258]

Notes: * Significance at $p < 0.05$; CI (Confidence Interval); PB (Percentile Bootstrap); BCB (Bias-Corrected Bootstrap)
Health care sample (N = 73); Non-health care sample (N = 148)

Appendix A: Survey measures with psychometric properties

Human capital: Range 'strongly disagree' to 'strongly agree' (Subramaniam & Youndt 2005) — Factor Loadings

To what extent do you agree with the following items describing your organization's human capital:

		Factor Loadings
HC1	Our employees are highly skilled	0.83
HC2	Our employees are widely considered the best in our industry	0.81
HC3	Our employees are creative and bright	0.87
HC4	Our employees are experts in their particular jobs and functions	0.76
HC5	Our employees develop new ideas and knowledge	0.86
	Cronbach's alpha (α)	0.89
	Composite reliability (CR)	0.92
	Average variance extracted (AVE)	0.69
	Square root (AVE)	0.83

Organizational capital: Range 'strongly disagree' to 'strongly agree' (Subramaniam & Youndt 2005)

To what extent do you agree with the following items describing your organization's organization capital:

OC1	Our organization uses patents and licenses as a way to store knowledge	0.66
OC2	Much of our organization's knowledge is contained in manuals, databases, etc.	0.80
OC3	Our organization's culture (stories, rituals) contains valuable ideas, ways of doing business, etc.	-
OC4	Our organization embeds much of its knowledge and information in structures, systems, and processes	0.76
	Cronbach's alpha (α)	0.60
	Composite reliability (CR)	0.79
	Average variance extracted (AVE)	0.55
	Square root (AVE)	0.74

Combinative capability: Range 'strongly disagree' to 'strongly agree' (adapted from Brettel et al. 2012)

The innovation process meets objectives and expectations in terms of the …

CC1	Learnings and expertise that can be leveraged in future endeavors	0.93
CC2	Generation of new ideas as starting point of potential future endeavors	0.91
CC3	Enhancement of competencies and capabilities	0.92
	Cronbach's alpha (α)	0.91
	Composite reliability (CR)	0.94
	Average variance extracted (AVE)	0.84
	Square root (AVE)	0.92

Process efficiency: Range 'strongly disagree' to 'strongly agree' (adapted from Brettel et al. 2012)

The innovation process meets objectives and expectations in terms of …

PE1	Meeting schedules	0.92
PE2	Staying on budget	0.84
PE3	Meeting operational and technical performance of the organizational expectations on innovation	0.92
	Cronbach's alpha (α)	0.87
	Composite reliability (CR)	0.92
	Average variance extracted (AVE)	0.80
	Square root (AVE)	0.89

Output quality: Range 'strongly disagree' to 'strongly agree' (adapted from Brettel et al. 2012)

The innovation process meets objectives and expectations in terms of the …

OQ1	Perceived value of the innovation output	0.93
OQ2	Opportunities to market innovation output	0.92
OQ3	Quality and performance of the innovation output	0.93
	Cronbach's alpha (α)	0.92
	Composite reliability (CR)	0.95
	Average variance extracted (AVE)	0.86
	Square root (AVE)	0.93

(-) Item dropped as result of principal components factor analysis