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Innovation Success in Context

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Abstract

Prior work suggests that intellectual capital plays a critical role in organizations' ability to succeed at innovation, that is, to create new and better products or services efficiently. However, little research has examined how intellectual capital translates into innovation success, and whether all forms of intellectual capital are needed for innovation success across industries. I hypothesize that intellectual capital affects innovation success through knowledge augmentation, and that the degree to which different forms of intellectual capital facilitate knowledge augmentation, and innovation success in turn, varies with industry dynamics. In a multi-industry study, I found support for my hypotheses: core forms of intellectual capital—human, organizational, and social—were positively associated with knowledge augmentation, which in turn was associated with innovation success, as indicated by innovation quality and efficiency. In a second study, deliberately conducted in an industry facing higher environmental dynamism than those in the first study—pharmaceuticals—I found that only human capital was positively linked to innovation quality and efficiency through knowledge augmentation. Organizational capital had no effect and social capital had a negative effect on innovation success in the pharmaceutical industry. I discuss theoretical and practical implications of the findings for innovation and knowledge use.

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Innovation:

The Roles of Intellectual Capital, Knowledge Augmentation and Environmental Dynamism

ABSTRACT

Prior work suggests that intellectual capital plays a critical role in organizations' ability to succeed at innovation, that is, to create new and better products or services efficiently. However, little research has examined how intellectual capital translates into innovation success, and whether all forms of intellectual capital are needed for innovation success across industries. I hypothesize that intellectual capital affects innovation success through knowledge augmentation, and that the degree to which different forms of intellectual capital facilitate knowledge augmentation, and innovation success in turn, varies with industry dynamics. In a multi-industry study, I found support for my hypotheses: core forms of intellectual capital—human, organizational, and social—were positively associated with knowledge augmentation, which in turn was associated with innovation success, as indicated by innovation quality and efficiency. In a second study, deliberately conducted in an industry facing higher environmental dynamism than those in the first study—pharmaceuticals—I found that only human capital was positively linked to innovation quality and efficiency through knowledge augmentation. Organizational capital had no effect and social capital had a negative effect on innovation success in the pharmaceutical industry. I discuss theoretical and practical implications of the findings for innovation and knowledge use.

INTRODUCTION

Management research has a long tradition of emphasizing the importance of innovation—creating new and better products or services efficiently—for organizational growth and survival (Van de Ven, 1986). In recent years, the emphasis has become even more pronounced as scholars and practitioners alike have observed that customers' escalating expectations, technological advancements, and global competition are all contributing to shortened lifecycles for existing offerings and consequently, a constant push for new products and services. This push has prompted much discussion and investigation of innovation.

One core finding from this burgeoning literature is that innovation success depends on an organization's intellectual capital (Pasher & Ronen, 2011; Stewart, 1997). Intellectual capital is defined as the sum of all knowledge possessed by firms (Nahapiet & Ghoshal, 1998), stored across three core repositories: human, organizational, and social. Human capital refers to the knowledge, skills, and abilities residing within individuals, resulting from their education, training, and experiences (Schultz, 1961). Organizational capital refers to the knowledge stored in institutional structures, both formal (e.g., manuals and systems) and informal (e.g., culture and attitudes) (Kang & Snell, 2009). Social capital refers to the knowledge embedded in relationships within and between organizations (Adler & Kwon, 2002). Studies suggest, in one way or another, that all three forms of intellectual capital are important for innovation. Some have found that each form has a direct effect on innovation (e.g., Lee, Swink, & Pandejpong, 2011; Menor, Kristal, & Rosenzweig, 2007), while others have found that the interaction of capitals contributes to success (Subramaniam & Youndt, 2005). Such findings have increasingly led to the belief that innovation requires all forms of intellectual capital (Pasher & Ronen, 2011; Stewart, 1997).

One key question that remains is: why is intellectual capital so important (Dean & Kretschmer, 2007)? Logically, the existence of stored knowledge is insufficient to produce an outcome. Stored knowledge is a resource, possibly the most important resource organizations possess (Grant, 1996). While possession of a resource can be important for signaling, power, or positioning, resources do not transform into valuable output without an effort to use them (Sirmon, Hitt, & Ireland, 2007). As such, it stands to reason that stored knowledge must be used and worked on to have an effect (Cook & Brown, 1999), particularly when the aspired outcome is innovative. Yet prior research has almost exclusively emphasized the intellectual capital-innovation link, without addressing how these repositories are used to contribute to innovation success.

A second question not addressed by prior work is whether and when all three forms of intellectual capital are required for innovation success in all contexts. Past research has found variable associations (sometimes independent effects, sometimes interactive effects) between forms of intellectual capital and innovation outcomes across studies. The variability suggests a contingent relationship (Donaldson, 2001), not currently included in models relating intellectual capital to innovation. Obtaining insights about when and how intellectual capital supports innovation success is important not only for advancing theory, but also for practice because organizations are increasingly challenged to continuously and rapidly innovate (Garud et al., 2013). As such they seek insight on the value of investing in forms of intellectual capital and understanding of this expensive and hard to maintain resource (Nahapiet & Ghoshal, 1998).

In this paper, I address both of these questions—the mechanism by which intellectual capital contributes to innovation success and the extent to which all forms of intellectual capital facilitate innovation success across industries. I develop hypotheses about the answers to these questions by drawing on past studies that have examined each form of capital as well as research on knowledge and learning processes, mindful that innovation is fundamentally the pursuit of new knowledge (Nonaka & Takeuchi, 1995). My review of past research leads me to consider knowledge augmentation—using knowledge to generate new ideas and skills that can serve as the basis for future action (Nag & Gioia, 2012)—as intervening between intellectual capital and innovation success. Examining this mechanism contributes to the innovation literature by clarifying how an important antecedent, intellectual capital, leads to innovation success.

I contribute further by addressing the generalizability of intellectual capital's effect on innovation success through knowledge augmentation across settings. Contextual specificity literature suggests contexts can possess unique attributes that influence the relationship between organizational antecedents and outcomes, causing relationships to differ (Beckman & Sinha, 2005; Rousseau & Fried, 2001). In this work, I explore industry-level environmental dynamism as a contextual factor, observing that innovation is a knowledge-driven process and the rate and discontinuity with which knowledge changes varies significantly between industries (Bourgeois & Eisenhardt, 1988; Dess & Beard, 1984). This analysis adds to the literature on intellectual capital and organizational knowledge more generally by showing that the importance of different knowledge repositories for innovation success depends on contextual dynamism.

I test my hypotheses using two studies. The first is a multi-industry study in which I examine the mediating hypotheses. The second is a study of one industry, pharmaceuticals, which I use to examine the contextual specificity of the relationship between forms of intellectual capital, knowledge augmentation, and innovation success, found in the first study. I selected this industry because it has been identified as distinctively dynamic (e.g., Hess & Rothaermel, 2011). The results lead me to a discussion of their implications for theory and practice. However, I begin with the theory and research that lead to my hypotheses.

THEORY & HYPOTHESES

Intellectual Capital, Knowledge Augmentation, and Innovation Success

Fundamentally, intellectual capital in its various forms is stored knowledge (Dean & Kretschmer, 2007). While possessing knowledge may bestow reputational benefit, it bestows little operational benefit as is; stored knowledge must be *used* to have an effect (Cook & Brown, 1999; Nag, Corley, & Gioia, 2007). Knowledge use occurs when knowledge is drawn upon for an activity. Unless the activity is identical with an activity performed in the past, which is not the case with an innovative activity, stored knowledge is not inherently valuable. Instead, intellectual capital's value should inhere in facilitating a way of knowledge use that supports innovation.

I contend that intellectual capital facilitates that kind of knowledge use. Specifically, it facilitates knowledge augmentation, defined as the using of knowledge to develop new ideas and skills that can serve as the basis for future action (Nag & Gioia, 2012). Knowledge augmentation involves reflecting and critiquing knowledge in ways that generate ideas that go beyond an application to a specific, immediate task. As a result of such reflection, organizations come to understand principles underlying problems. This deeper (augmented) understanding affords an enriched state of knowledge that allows organizations to enter into new areas of expertise and that serves as the basis for future action (Nag & Gioia, 2012). Thus, knowledge augmentation encompasses the concepts of knowledge transformation, recombination, and development, but is distinguished from them in that it aims to create *foundational* ideas and skills for *future use*.

The greater the knowledge embedded in the various forms of intellectual capital—human, organizational, and social capital—the more compelled and able the organization is to augment its knowledge because of the richness of each form of intellectual capital. Human capital is rich because it contains both tacit (typically complex and hard to access) and explicit knowledge, a virtue resulting from individuals' unique ability to absorb both types of knowledge (Ferdows, 2006; March, 1991). Organizational capital is rich because its knowledge has already been processed as a precursor to institutionalizing it so that it is comprehensible and usable (Daft & Weick, 1984). Social capital is rich because of the diversity of knowledge within it, which grows in proportion to the number of relationships and networks of relationships (Kang & Snell, 2009).

Rich knowledge, as present in intellectual capital, should foster an organization's desire and ability to augment its knowledge. Past research found that those with richer knowledge have a greater propensity for questioning existing knowledge due to emergent curiosity, a desire to reconcile conflicting knowledge, the presence of which often grows with the volume of stored knowledge, and ensuing decreased confidence in simply applying existing knowledge to new tasks (Kahneman, 2011). Additionally, those with richer knowledge are more inclined to seek an organizing scheme for their knowledge in order to make their knowledge manageable and useful. In a qualitative study of project teams at an international development agency Haas (2006), for instance, observed that when project teams possessed an abundance of rich knowledge, they felt greater pressure and took more steps to locate simple principles within their knowledge. Questioning and having such principles or schemes should improve organizations' ability to examine their knowledge in service of reconciling emerging conflicts and cataloging obtained insights for use in new contexts. Last, organizations with richer knowledge absorb more knowledge (Cohen & Levinthal, 1990). This suggests that they are more likely and better able to process knowledge, which is a prerequisite for developing the new understanding that serves as the basis of the new ideas and skills accorded with knowledge augmentation. Evidence to support the logic that organizations with greater intellectual capital engage in greater knowledge augmentation is found in the story of IDEO, which is regarded as a highly innovative design consultancy. This firm's success has been attributed to its use of its stored, rich knowledge from past projects in more than 40 industries to develop design principles for use in other settings (Hargadon & Sutton, 1997). Building from this example and outlined logic, I posit:

Hypothesis 1. Intellectual capital—human, organizational, and social capital—is positively associated with knowledge augmentation.

I propose that knowledge augmentation, in turn, contributes to innovation success along two pertinent dimensions: quality and efficiency (Haas & Hansen, 2005). High quality output (offerings valued by potential customers) tends to arise when organizations draw on diverse knowledge and concordant understanding of customers' problems (Lovelace, Shapiro, & Weingart, 2001). Nag and Gioia (2012) found in their qualitative study of the foundry industry that firms engaged in knowledge augmentation developed a collective understanding of specific problems, which led to increased ability to draw upon diverse expert knowledge relevant to developing new tools. They further observed that workers developed general insights beyond the specific problem that motivated their interactions. Having such insights is likely to facilitate the development of high quality output as it provides a more informed basis—in terms of ideas and skills—for the development of innovations that serve customer needs in different contexts.

Innovation should also occur more efficiently (satisfying or exceeding time and budget expectations) as a result of knowledge augmentation. Knowledge augmentation manifests in reexamination of and reflection upon knowledge as organizational members experiment with novel approaches to a problem (Nag & Gioia, 2012). Research has found that organizations that engage in cycles of action and reflection about routine tasks typically develop less time- and resource-intensive techniques for task completion due to learning (Lapré & Nembhard, 2010). I expect that such learning results in organizations developing skills that allow for faster and cheaper completion of innovative tasks as well, because experimenting with knowledge should provide feedback about what works well (Thomke, 1998). In addition to learning, another reason for efficiency gains from knowledge augmentation may be that this use creates a common understanding within organizations. Hult and colleagues (2004) found in a study of supply chains that firms which developed a common understanding of challenges achieved reductions in cycle time. I posit that such efficiency gains extend to innovation as well, because "innovation is a collective achievement" (Van de Ven, 1986: 591). Thus:

Hypothesis 2. Knowledge augmentation is positively associated with innovation success as indicated by innovation quality and innovation efficiency.

The preceding hypotheses (Hypothesis 1 and 2 together) lead me to argue that knowledge augmentation mediates the intellectual capital-innovation success link. As noted earlier, the stored knowledge in intellectual capital is likely insufficient to result in innovation success. Particularly, when intended for innovative purposes, it stands to reason that knowledge must be used in a way that changes and expands the range of possibilities beyond the original knowledge possessed. Past research suggests that applying knowledge as is produces more of the same, a consequence discussed under several labels, including inertia, rigidity (Leonard-Barton, 1992), or competency trap (March, 1991). Thus, I do not expect that simply having intellectual capital, although likely necessary, is sufficient for innovation success. For organizations to innovate, their stored knowledge must be made new. Knowledge augmentation, of and spurred by intellectual capital, provides newness. Hence, I hypothesize:

Hypothesis 3. Knowledge augmentation mediates between all forms of intellectual capital and innovation success as indicated by innovation quality and innovation efficiency.

The Moderating Role of Industry

I have argued that all forms of intellectual capital affect innovation quality and innovation efficiency through knowledge augmentation. It is, however, unlikely that all pathways (human, organizational, and social capitals to knowledge augmentation to innovation success) are equally relevant in all contexts for at least two reasons. First, each from of intellectual capital is inherently different by the nature of the structure and content of the knowledge embedded within it (Subramaniam & Youndt, 2005), and therefore may not be universally applicable. Second, patterns of association are often contingent on contextual attributes, a finding that has emerged out of contingency (Donaldson, 2001) and context specificity (Beckman & Sinha, 2005; Rousseau & Fried, 2001) research. Together, these observations suggest that the importance of each form of intellectual capital for knowledge augmentation and, in turn, innovation quality and innovation efficiency may differ based on context.

A key way in which contexts differ that is likely relevant when examining innovation, given that it is a knowledge-driven process, is in the dynamism of knowledge in the environment, and specifically the industry (Nonaka, 1994). Environmental dynamism refers to the rate and discontinuity of change in a given industry (Bakker & Knoben, 2014; Bourgeois & Eisenhardt, 1988; Dess & Beard, 1984). The rate of change is the pace at which knowledge changes. Discontinuity of change exists when a shift in knowledge renders existing knowledge obsolete (McCarthy, Lawrence, Wixted, & Gordon, 2010). I posit that variation in environmental dynamism manifests in differences in the extent to which each form of intellectual capital provides an advantage for knowledge augmentation and innovation success across industries.

I hypothesize that innovation success derived from knowledge augmentation in rapidly and discontinuously changing industries requires human capital more than organizational or social capital. I expect this because organizational capital (e.g., structures and systems) and social capital (e.g., norms of interactions and shared systems of meaning) do not change easily (Bourdieu, 1986; Kang & Snell, 2009; Walsh & Ungson, 1991). This is seen in the pharmaceutical industry, for example. Firms in this industry, with their ingrained drug development operations and collaborations based on chemical synthesis, were slow to incorporate biotechnology knowledge into their structured repositories. For at least 10 to 15 years, the repository for growing biotechnology knowledge was an "initial group of discoverers" (Zucker et al., 1998: 291). Such tendency for delay in the updating of organizational and social capital is especially an issue when knowledge grows fast. As the pace of knowledge growth increases, the relative knowledge quality of organizational and social capitals likely decreases because of the delay in adding new knowledge (Kang & Snell, 2009). In turn, these capitals' ability to serve as a relevant basis for knowledge augmentation depreciates, limiting their effect on innovation quality and efficiency. On the other hand, human capital retains and likely increases its value in the wake of rapidly changing knowledge because of humans' propensity to identify and integrate new knowledge as soon as it is presented (March, 1991). Their adaptability allows for timely growth in human capital, enabling it to be a more effective facilitator of knowledge augmentation and innovation quality and efficiency in settings with fast-evolving knowledge.

Human capital is also likely to increase in value relative to organizational and social capital because the effectiveness of the latter is additionally challenged by discontinuous change in knowledge. Discontinuity shifts prevailing industry knowledge in ways that often destroy organizations' competences (McCarthy et al., 2010; Tushman & Anderson, 1986). For example, Nokia's competences in producing mobile devices became irrelevant when Apple introduced its smartphone platform. The new competence of how to organize a system of innumerable application providers made Apple the clear market leader, despite Nokia's extensive device experience. Organizational capital is premised on distilling valuable experience and codifying the underlying competences. When discontinuous change occurs, the knowledge embedded in organizational capital becomes outdated and less relevant, constraining its capacity to foster knowledge augmentation and innovation success.

Social ties also have less benefit as a conduit of knowledge as knowledge becomes more difficult to understand (Sorenson, Rivkin, & Fleming, 2006), as is the case with discontinuously changing knowledge. Knowledge transmission within networks rarely occurs with perfect fidelity, requiring the receiving organization to reconstruct and/or complement parts of the original information. When the knowledge in question is unrelated to an organization's competences, as is likely in environments of discontinuous change, relying on the knowledge in social networks becomes particularly tenuous because the likelihood that the transmission is flawed increases as reconstruction or complementing more often fails. Organizations tend to apply their established competence, even in new situations (March, 1991). Doing so when knowledge is discontinuous means the "reconstructed" knowledge is likely flawed or irrelevant, and thus, large proportions of networks may absorb flawed or irrelevant knowledge. In contrast, individual humans are less likely to succumb to this error because more direct transmission allows less distortion during reconstruction. Furthermore, a virtue of human capital is its ability and preparedness to process and store divergent knowledge (Ferdows, 2006). Hence, my final hypothesis that highly dynamic industries dealing with rapid and discontinuous change benefit more from human capital.

Hypothesis 4. In highly dynamic industries, only human capital is related to innovation quality and innovation efficiency through knowledge augmentation.

METHODS

Research Settings

I collected survey data from two samples. To test Hypotheses 1 to 3, I used survey data from organizations operating in a broad set of industries (study 1). I considered industries where more than 45 percent of organizations engage in innovation to increase the likelihood that the posited relationships are of relevance to the sampled organizations. I obtained the relevant set of industries from past research by Castellacci (2008). Using a cross-industry sample further allowed me to examine my first three hypotheses *across* industries, in a generalizable setting.

To test the fourth hypothesis that the effect of forms of intellectual capital on knowledge augmentation and innovation success depends on industries' dynamism, I collected data from a second sample of pharmaceutical organizations (study 2). Past research (e.g., Hess & Rothaermel, 2011) has suggested the pharmaceutical industry is a distinctively dynamic industry. Consistent with this profile, the industry's R&D spending increased by 7 percent annually to more than $50 billion during the past decade (40% of global R&D spending by innovative companies), resulting in rapid knowledge change (Jaruzelski, Loehr, & Holman, 2012). Concurrently, the industry has experienced 30 percent erosion in market capitalization due to poor innovation performance (Tollman, Morieux, Murphy, & Schulze, 2011). Development failure rates approach 90 percent—an extreme compared to any other industry (Nature, 2007). This chasm between innovation spending and success suggests that the pace at which knowledge changes goes in hand with discontinuity, because otherwise new and presumably improved knowledge should predictably reduce failure rates. Given such environmental dynamism, the pharmaceutical industry was ideal for testing my hypothesis on the contextual specificity of the importance of forms of intellectual capital for knowledge augmentation and innovation success.

Samples and Data Collection

To study organizations in these two samples, I used a key informant approach (surveying one executive per firm), an approach routinely used in studies of intellectual capital (e.g., Youndt, Subramaniam, & Snell, 2004) and innovation (Poskela & Martinsuo, 2009). Recent meta–analytic correlations of subjective and archival measures have shown that key informants are particularly reliable in innovation settings (Homburg, Klarmann, Reimann, & Schilke, 2012). I identified potential informants using commercial databases in the U.K. and the U.S. Including both countries enlarged the pool of eligible informants without introducing undue country-related variation as these countries belong to the same cultural cluster and have similar innovation processes (Evanschitzky, Eisend, Calantone, & Jiang, 2012).

For sample 1, I invited 1172 executives to participate in the study via email. I sampled organizations in five industries: computer and electronics (20%), specialized machinery (29%), financial services (27%), telecommunications (12%), and knowledge-intensive services (12%). I received 187 complete survey responses (16 percent response rate), of which 32 had to be discarded due to 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 I 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 data from 155 informant-respondents, for an effective response rate of 13.2 percent, similar to the rate for other surveys of top executives and innovation processes (i.e., 10–15%) (Hambrick, Geletkanycz, & Fredrickson, 1993; Poskela & Martinsuo, 2009). Informants had a very high degree of strategic involvement (> 70% of respondents), leadership positions (> 85% in top management positions), and a high level of experience in their position (> 75% with tenure exceeding 20 years).

For sample 2, applying the same eligibility criteria to executives in the pharmaceutical industry, I invited 471 executives to participate in the survey via email. I received 66 complete responses; none had to be discarded. The effective response rate was 14.0 percent. Similar to sample 1, informants had a very high degree of strategic involvement, leadership positions, and a high level of experience in their position. In both samples, each informant provided information about one organization. Table 1 summarizes the samples.

Please insert Table 1 about here

Measures

I used multi-item survey scales with a seven-point Likert response format (1 = strongly disagree; 7 = strongly agree) to assess the constructs. To ascertain whether the scales captured the desired information and were psychometrically valid, I pilot-tested them with two groups prior to survey administration in my samples. First, I fielded the survey with 59 MBA students. I then modified the survey based on the pilot-test results to improve the reliability of the measures and tested the refined measures with 20 experts from industry and academia. Across measures, Cronbach's alpha (α), composite reliability (CR), and average variance extracted (AVE) indicated satisfactory reliability (α and CR > .70) and convergent validity (CR > AVE and AVE > .50), as well as discriminant validity (the square root of AVE of any two constructs exceeded the respective inter-construct correlation, shown in Table 2) (Hair, Black, Babin, & Anderson, 2010).

All survey measures and their psychometric properties are provided in Appendix A. Variance inflation factors (VIFs) indicated absence of multicollinearity (study 1 VIF range: 1.27-1.72; study 2 VIF range: 1.29-1.61).

Independent variables. I measured *human, organizational, and social capital* using Subramaniam and Youndt's (2005) scales. The measure of *human capital* consisted of five items and measured the overall skill, expertise, knowledge, intellect, and reputation of employees. The measure of *organizational capital* consisted of four items and assessed the extent to which the organization stored knowledge in routines and structures such as culture and databases. The measure of *social capital* consisted of five items and assessed the extent to which the organization can draw upon knowledge among and between networks of employees. Factor analysis supported the intended three-factor structure over alternatives, with all items except one item for organizational capital and social capital loading on the intended factor. The two exceptional items were eliminated from further analyses to improve the reliability of the scales (study 1: χ^2/ degrees of freedom = 1.40, comparative fit index [CFI] = .98, goodness-of-fit index [GFI] = .93, root mean square error of approximation [RMSEA] = .05; study 2: χ^2/ d.f. = 1.37, CFI = .97, GFI = .88, RMSEA = .07).

Dependent variables. I assessed knowledge augmentation and innovation success (quality and efficiency) using scales from Brettel et al. (2011). Knowledge augmentation has hitherto been examined qualitatively and described as the process of using knowledge to develop new ideas and skills that can serve as the basis for future action (Nag & Gioia, 2012). The concept, thus, differs from existing constructs like knowledge transformation, development, and recombination in that it aims to create foundations for *future use*. I therefore adapted a scale by Brettel et al. (2011) that assesses experiences and competences gained from R&D projects for other projects to assess *knowledge augmentation* with three items that asked the extent to which the innovation process enabled growth in ideas, expertise, and capabilities that might be leveraged in future endeavors. *Innovation quality* was measured using three items that assessed perceived value, quality, and marketability of the output resulting from the innovation process. *Innovation efficiency* was assessed using three items that captured success in meeting schedule and budget goals. Factor analysis supported a three-factor specification over alternative specifications (study 1: χ^2/ d.f. = 2.14, CFI = .98, GFI = .93, RMSEA = .08; study 2: χ^2/ d.f. = 1.38, CFI = .98, GFI = .91, RMSEA = .07).

I used subjective measures to assess innovation success in order to facilitate comparisons across organizations and industries. Prior studies have shown that subjective and objective performance indicators are highly correlated, supporting the validity of subjective measures (Dess & Robinson, 1984). I assessed the validity of using the subjective innovation success measures by comparing informants' assessment with objective data for 31 (15%) organizations in my samples (17 for study 1; 14 for study 2) for which informants voluntarily revealed their organization's identity. This proportion is in line with previous triangulation efforts in key informant studies (e.g., Gruber et al., 2010). Using the ThomsonOne database, I retrieved the sales growth rate for the year following my survey (2013), constructed a consensus forward sales growth estimate (to 2015), and obtained the return on invested capital (2013). These metrics have been used as innovation success indicators in prior work (e.g., Collins & Smith, 2006). Sales growth (φ = .36; $p < .05$) and future sales growth (φ = .42; $p < .05$) had strong correlations to my innovation quality measure, while return on invested capital was strongly correlated with my innovation efficiency measure (φ = .44; $p < .05$), supporting the validity of the measures.

Control variables. I selected control variables based on three criteria (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 size (number of employees) and age (in years), past performance (assessed by asking respondents to rank on a 1–5 scale both their organization's profits and sales growth compared to close competitors over the last three years), home country (0 = U.K. and 1 = U.S.), and industry type (study 1 only: 1 = service, 0 = manufacturing). These factors were selected because size may be associated with innovation as larger organizations may draw on a more extensive resource base, while small organizations may be more nimble (Subramaniam & Youndt, 2005). Age may influence the organization's ability to accumulate and embed knowledge in repositories over time (Walsh & Ungson, 1991), while past performance may be important because a positive trajectory frees resources for experimentation, which may improve innovation capabilities. Finally, home country and industry type were included because the innovation process may differ by country (Evanschitzky et al., 2012), as well as between services and manufacturing (relevant for Study 1) (Castellacci, 2008).

Last, I used Heavey et al.'s (2009) scale to assess environmental dynamism. The six-item scale assessed the degree to which an industry is characterized by rapid and discontinuous change. Confirmatory factor analysis suggested good model fit of the composite measure (study 1: χ^2/ d.f. = 2.04, CFI = .97, GFI = .97, RMSEA = .08; study 2: χ^2/ d.f. = 1.06, CFI = .99, GFI = .96, RMSEA = .03), which is consistent with previous studies (Heavey, Simsek, Roche, & Kelly, 2009; Nadkarni & Chen, 2014).

Analysis

I first examined the relationship between intellectual capital and my innovation success measures to replicate the capital-innovation relationship identified in prior work on which my research builds. I then tested Hypotheses 1 to 3 in models in which the effects of forms of intellectual capital on innovation quality and efficiency occur through knowledge augmentation (study 1). For both of these analyses, I used ordinary least squares regressions and SAS syntax presented in Hayes (2013) to formally test for mediation by computing indirect effects (*ab*) as the product of the regression coefficients of the three forms of intellectual capital on knowledge augmentation (a_i) and the regression coefficient of knowledge augmentation on my two innovation success measures, quality and efficiency (b_j). I, thus, computed six indirect effects. Confidence intervals (CIs) for the population value of the indirect effects were derived using Monte Carlo simulation. Past research shows that Monte Carlo CIs are especially robust to Type I error (claiming an indirect effect exists when it does not) (e.g., Fritz, Taylor, & MacKinnon, 2012) . Monte Carlo further mitigates power problems that arise when computing products of coefficient tests with traditional mediation tests (e.g., Sobel test) (Hayes, 2013).

I used the same analytical techniques employed in study 1 to test Hypothesis 4 (the effect of forms of intellectual capital on innovation success through knowledge augmentation is contingent on industry dynamism) using the data from my second study. As I selected the pharmaceutical industry for this study on the premise that it is distinguishably dynamic, the first step was to test this assumption. I used one-way analysis of variance (ANOVA) and planned comparisons to assess the environmental dynamism scores across industries included in study 1, followed by a comparison to the sample of pharmaceutical organizations in study 2. After confirming homogeneity of environmental dynamism among study 1 industries, and identifying a significant difference between these industries and the pharmaceutical industry, I proceeded to test Hypothesis 4.

I confirmed the validity of my mediation analyses by testing the assumption of homogeneity of the effect of knowledge augmentation on innovation success across values of intellectual capital to affirm that my antecedents did not interact with the mediator. I did not find evidence against the homogeneity assumption in my models ($p > 0.10$), which validated the approach (Hayes, 2013). I further tested the robustness of the Monte Carlo CIs by using different sizes of resamples and obtained consistent results. I report the results for indirect effects with 95% CIs from 2,000 samples. CIs that did not contain zero support mediation.

RESULTS

Table 2 reports the means, standard deviations, and correlations of all variables. Table 3 summarizes the results of my first study. Models 1 and 2 provide evidence that the intellectual capital-innovation success relationship that is the starting point for my research is confirmed in my sample with nuance. Model 1 shows that organizational capital ($\beta = .25$, $p < .01$) and social capital ($\beta = .26$, $p < .01$) were positively associated with quality, and Model 2 shows that human capital ($\beta = .41$, $p < .01$) and social capital ($\beta = .25$, $p < .05$) were related to efficiency.

Please insert Tables 2 and 3 about here

With respect to the hypotheses, Model 3 shows that all forms of intellectual capital—human ($\beta = .24$, $p < .05$), organizational ($\beta = .20$, $p < .05$), and social capital ($\beta = .21$, $p < .05$)—were positively associated with knowledge augmentation. Thus, Hypothesis 1, which predicted that intellectual capital is positively associated with knowledge augmentation, was supported. Hypothesis 2 was also supported, as knowledge augmentation was positively related to innovation quality (Model 4: $\beta = .72$, $p < .001$) and innovation efficiency (Model 5: $\beta = .40$, $p <$

.001), controlling for all forms of intellectual capital. Hypothesis 3 suggested that knowledge augmentation mediates the effect of all forms of intellectual capital on innovation quality and efficiency. As Table 4 shows, this hypothesis was supported, as the Monte Carlo 95% CIs around the indirect effects did not contain zero, signaling the significance of the mediation effect.

Please insert Table 4 about here

Hypothesis 4 predicted that the effect of forms of intellectual capital on the dependent variables is contingent on industry dynamism. One-way ANOVA, using industry type as classification variable, revealed a non-significant *F*-value for environmental dynamism ($p > .10$) among the study 1 industries, prompting my study of the pharmaceutical industry in order to exploit its distinctively dynamic profile. The planned comparison ($p < .05$) confirmed that the pharmaceutical industry faces greater environmental dynamism than the industries included in the first study.

Table 5, which reports the results of my analysis of the pharmaceutical industry (Study 2), further shows that the effect of the studied forms of intellectual capital on innovation success in this industry differed from that found in other industries (Study 1). Only human capital was positively related to innovation quality (model 1: $\beta = .53$, $p < .01$), efficiency (model 2: $\beta = .46$, $p < .05$), and knowledge augmentation (model 3: $\beta = .35$, $p < .05$). Knowledge augmentation was also positively associated with innovation quality (model 4: $\beta = .68$, $p < .001$) and efficiency (model 5: $\beta = .64$, $p < .001$). Unexpectedly, social capital negatively affected innovation quality (model 4: $\beta = -.22$, $p < .05$), controlling for knowledge augmentation. Monte Carlo CIs (shown in Table 6) confirmed that the indirect effects of human capital on innovation quality and efficiency through knowledge augmentation were significant. No mediation for other forms of intellectual capital was found. Thus, I find partial support for Hypothesis 5, as human capital was the only positive influence, but social capital also had a not hypothesized negative effect.

For completeness, given the lack of a positive effect for organizational and social capital, I examined possible interactions. I did not find interactions between human capital and other forms of intellectual capital on my outcomes. Across studies, the only control variable that was predictive was past performance ($p < .05$), which was related to knowledge augmentation, as well as innovation quality and efficiency. This is in line with previous studies that identified the importance of past performance for innovative outcomes (e.g., Jansen, Van Den Bosch, & Volberda, 2006).

Please insert Tables 5 and 6 about here

DISCUSSION

The purpose of this research was to advance understanding of how and when intellectual capital (in its various forms) is associated with innovation success. The theoretical analysis and empirical results provide insight on both topics that have implications for research and theory on innovation, intellectual capital, and knowledge in organizations more generally, as well as implications for management practice. In this section, I discuss the implications.

Implications for Theory on Innovation

Innovation scholars attest that innovation is often thought of as an outcome, owing to our incomplete understanding of the mechanisms that lead to innovation success (Garud et al., 2013). A recent meta-analysis on new product development studies, for example, concludes that the clarification of process success factors is a core gap in our theory and models of innovation (Evanschitzky et al., 2012). The little attention devoted to *how* intellectual capital transmits its effect on innovation success is a case in point. This is the first study to my knowledge that theoretically identifies and empirically confirms a mechanism by which an increasingly accepted antecedent (intellectual capital) is associated with two primary indicators of innovation success, innovation quality and efficiency. In sum, my results suggest that intellectual capital facilitates innovation success because it is associated with knowledge augmentation, which is associated with innovation success. I found these links in both of my studies, across industries in the multi-industry sample (study 1), as well as in the pharmaceutical industry (study 2).

In addition to identifying knowledge augmentation as a missing link in models of intellectual capital and innovation, this research also extends the nascent concept of knowledge augmentation (Nag & Gioia, 2012), in two ways. First, the developed arguments and results suggest that innovation success derived from knowledge augmentation can have an organizational-level antecedent (intellectual capital); the work by Nag and Gioia (2012) focused on attributes of individual executives as antecedents of knowledge augmentation. Second, my study motivates and quantitatively shows an association between knowledge augmentation and two innovation outcomes, and does so in a generalizable cross-industry setting as well as in a dynamic industry (pharmaceuticals). These findings extend their initial indication of knowledge augmentation's importance for novel outcomes, obtained via a post-hoc qualitative assessment in a single, relatively stable industry (the foundry industry). Despite these differences in studies, together, they lead to the conclusion that knowledge augmentation is important for achieving innovation. Given that knowledge augmentation is a form of knowledge use and there are other uses such as knowledge grafting—using knowledge from outside the organization to affect change within the organization (Nag et al., 2007)—a next logical step for research on innovation is to examine whether other types of knowledge use also play a role in innovation success, and the relative importance of different knowledge uses (in different contexts). Such research may shed further light on innovation as an organizational process, revealing mechanisms that lead to innovation.

As much as my results contribute to the understanding of the innovation process, they also advance research on innovation as an outcome. Existing models of innovation identify the two dimensions of innovation success studied here (Haas & Hansen, 2005). My results show that, while dimensions might emerge from the same intervening mechanism, the initial antecedents can differ. In my multi-industry sample, I found that human capital and social capital predict efficiency, while organizational capital and social capital predict quality. While these findings affirm the importance of social capital for innovation outcomes found in other multi-industry studies (e.g., Subramaniam & Youndt, 2005), they challenge the notion that the same antecedents/models are relevant for all innovation success metrics. And specifically for this research, they raise the question why organizational capital did not affect efficiency and why human capital did not affect quality in the multi-industry study. The latter finding is consistent with the idea that innovation quality improves with the incorporation of diverse knowledge. Yet research has shown (e.g., Dougherty, 1992) that individuals often develop 'thought worlds' that bound their capacity for contribution to specific knowledge domains. Such boundedness may impede the effect of human capital in collective tasks like innovation, unless the context benefits from specialization as, for instance, in the case of the pharmaceutical industry where R&D personnel is highly specialized to narrow therapeutic areas (Hess & Rothaermel, 2011).

With respect to organizational capital, the outcomes difference may reflect an emerging nuance in the organizational capital literature. Research has begun to discuss two different types of organizational capital: mechanistic and organic (Kang & Snell, 2009). Mechanistic capital such as scripted routines and rules is reasoned to reinforce efficient activity, but also to bias activities towards what proved useful in the past, which might hamper innovation (Subramaniam

& Youndt, 2005). Organic organizational capital, on the other hand, is loosely connected to precedent; it intends to provide high-level guidance for how to do business through autonomous organizational culture and work processes. This guidance is argued to engender greater flexibility and ability to absorb new knowledge, presumably improving innovation quality, while eroding some of the efficiency gains obtainable from standardization (Kang & Snell, 2009). This juxtaposition of forms of organizational capital offers a possible explanation for my finding that organizational capital is associated with quality but not efficiency: My measure, Subramaniam and Youndt's (2005) scale, may tap organic more than mechanistic organizational capital. Future research should examine the two forms of organizational capital as they relate to various innovation outcomes to compare their effect. It would also be informative to examine the interaction of these forms of organizational capital. It may be that combining them creates synergies with respect to innovation outcomes or tradeoffs.

Finally, my results suggest that models of innovation may need to be context, and particularly, industry specific as all forms of intellectual capital aided innovation success in the cross-industry sample, but only human capital helped innovation success in the distinctively dynamic pharmaceutical industry. Together, these results indicate that there is a need to include context in our models of innovation because it can be consequential. There have been several calls for more context-mindful, industry-specific research across scholarly fields from organizational behavior (Rousseau & Fried, 2001) to production and operations management (Beckman & Sinha, 2005). Yet, research has responded slowly perhaps because of a focus on generalizable research. Failure not to consider industry specific dynamics raises the risk of developing theory and practice recommendations that are incorrect for some.

The importance of considering context may not just be important for innovation. Reed and colleagues (2006) found that different forms of intellectual capital had different effects on financial performance in the commercial banking (only social capital important) versus personal banking industry (human, organizational, and social capital together were important). My results suggest that this industry contingency effect of intellectual capital extends to innovation. I thus complement and extend Subramaniam and Youndt's (2005: 452) finding that "each [capital] may influence an organization's innovative capabilities in different ways." I find that they not only influence in different ways but also differently in different industries.

Implications for Theory on Intellectual Capital and on Knowledge in Organizations

The identified contextual specificity of the intellectual capital-innovation success relationship does not just contribute to the innovation literature, but also to the literature on intellectual capital. My results suggest that forms of intellectual capital can have different effects between industries *and* also within an industry, in magnitude and direction. Prior research has highlighted the importance of human capital in the context of the pharmaceutical industry (e.g., Hess & Rothaermel, 2011; Tzabbar, 2009). My results affirm its importance, but also extend this finding by showing its greater effectiveness vis-à-vis organizational and social capital.

Surprisingly, it was not simply the case that social capital helped less than human capital. I found that social capital was negatively associated with innovation quality in this industry, controlling for knowledge augmentation. This negative effect is a departure from prior research in other settings that found positive associations between social capital and innovation outcomes (Moran, 2005; Powell, Koput, & Smith-Doerr, 1996; Subramaniam & Youndt, 2005). The departure may begin to shed light on conditions under which social capital may actually harm innovation quality. Given my focal industry's profile—highly dynamic—the conditions may include contexts characterized by rapid and discontinuous change. As argued earlier, social ties' importance for the transfer of information diminishes when knowledge becomes more difficult to understand (Sorenson et al., 2006). Analyzing individuals, psychologists have shown that knowledge transfer can even become negative if the knowledge possessed is perceived as related to a new problem, but the new problem is so fundamentally different that the knowledge cannot be, but is, applied (Gick & Holyoak, 1987). The present results suggest that the risk of negative knowledge transfer extends to networks of individuals (i.e., social capital), particularly when pursuing innovation quality under conditions of rapid and discontinuous change.

Beyond the contributions at the intersection of intellectual capital and innovation already noted, this study contributes to research and theory on knowledge in organizations more generally. The innovative possibilities that emerge from knowledge augmentation suggest that, although possessed knowledge (i.e., intellectual capital) creates an "information corridor" (Shane & Venkatraman, 2000: 222)—a seminal insight in the literature—such a corridor does not have to be a hindrance. The corridor may create the lens through which opportunities are recognized, but it is knowledge use (i.e., knowledge augmentation) within it that governs the quality of the output produced. My data provides initial evidence that this specific use of knowledge can lead to innovative rather than confining outcomes. This argument further lends credence to the emerging perspective in organizational theory that views knowledge not as a resource but as a resourceful practice (Cook & Brown, 1999; Nag et al., 2007).

Implications for Practice

The present results address an important managerial concern. As noted at the outset, organizations and their managers face increasing pressure to innovate successfully. Therefore, they seek insight on strategies they might use to innovate. My results imply that investing in all forms of intellectual capital is not the most effective approach for innovation success in all industries. Organizations and their managers are better served by identifying the capital(s) relevant (given knowledge dynamics) in their industry and investing accordingly.

My results for the pharmaceutical industry suggest organizations should selectively invest in human capital to increase their innovation success via knowledge augmentation. For firms in this industry, this insight about the importance of human capital relative to other forms of capital studied here is critical because many, if not most, have struggled to successfully innovate in the last decade. Markets have noticed. The top 20 firms alone lost $720 billion in market capitalization from 2000 to 2010 as investors lost confidence in their ability to bring innovative products to market efficiently (Tollman et al., 2011). My results suggest that part of the value erosion may result from insufficient investment in human capital and overreliance on social capital, which has a negative effect on innovation quality. The industry has eliminated 300,000 jobs over the past decade, which is equivalent to the size of the top three pharmaceutical firms (Herper, 2011). My results indicate that the industry may need to focus on developing its human capital and managing its social capital to minimize potential adverse effects of ties. Pharmaceutical firms may be served by focusing on staff selection, training, and rewards, which are effective strategies for human capital development (Becker & Huselid, 2006). In other industries, strategies for developing other forms of intellectual capital may be equally or more important.

Limitations

As with most research, my study has limitations. First, the data was cross-sectional. Thus, although the data shows that intellectual capital is associated with knowledge augmentation and innovation success in turn, I cannot confirm causal effects. Another variable correlated with my focal variables may explain the results. To limit this alternative explanation, I statistically controlled for six potential confounders across studies that previous research has deemed relevant in this research setting. I also entertained a post hoc assessment of knowledge augmentation preceding intellectual capital in affecting innovation success to examine an alternative, albeit less plausible process generating the data. Using the same analytical techniques, I did not find a significant indirect effect when testing all 12 possible pathways by which knowledge augmentation could transmit an effect on innovation success through intellectual capital across my studies. These statistical techniques do not establish a direction of causal flow, but do provide evidence against alternative explanations to my hypothesized effects (Hayes, 2013). Second, my sample only included organizations in the U.S. and U.K. and only those that satisfied the innovativeness thresholds. This sample leaves open the question of whether my results generalize to organizations in other cultural clusters and exhibiting different innovativeness, which provides an opportunity for future research. Third, although the survey response rate is similar to that of other innovation and key informant studies, the low rate raises the possibility that my results suffer from non-response bias. Scholars have acknowledged the difficulty of obtaining primary data on knowledge repositories and people embedded capabilities such as knowledge augmentation (e.g., Becker & Huselid, 2006; Subramaniam & Youndt, 2005). When I assessed non-response bias using two established procedures for assessment, I found no evidence for such bias. There was no significant difference in intellectual capital between early respondents and non-respondents, defined as participants who completed the first survey questions about intellectual capital but did not complete the entire survey. Additionally, a comparison of early and late respondents on all survey measures showed no significant difference ($p > 0.10$) (Armstrong & Overton, 1977). Another potential bias, common method bias, is raised by a fourth limitation: the reliance on a single informant per organization for all of my data. I conducted two post-hoc tests to assess the likelihood of such bias. The first, Harman's one-factor test, showed multiple factors with eigenvalues greater than 1 emerging (study 1: first factor 26.9 percent; study 2: first factor 29.9 percent), which is evidence that common method bias did not cause a single factor to explain the majority of the variance. The second test, including a common method factor into my model whose items included all of the six constructs' items (Podsakoff, MacKenzie, Jeong-Yeon, & Podsakoff, 2003), showed the ratio of substantive variance explained by the constructs to the variance explained by common method was over 70:1. Specifically, the average substantively explained variance of the items was .78 (study 1) and .76 (study 2), while method variance was .01 in each study. Although these tests do not eliminate the possibility of common method bias, they suggest that the results are not driven by such bias.

Conclusion

This study advances organizational theory by identifying knowledge augmentation as a mediator of the relationship between intellectual capital and innovation success in cross-industry settings. This study adds further nuance by being the first study, to my knowledge, to consider the environmental dynamism faced by particular industries as a contextual moderator. Taken together, the present results provide an enriched understanding of innovation success, showing that innovation success depends on three aspects of knowledge: where knowledge is embedded (forms of intellectual capital), how it is used (knowledge augmentation), and what the knowledge context is (industries' environmental dynamism).

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TABLE 1
Sample Characteristics

Study 1: Innovative industries	NAICS	Percent of sample
Manufacturing		
Computer and electronics	33	20%
Specialized machinery[a]	33	29%
Services		
Financial services	52	27%
Telecommunications	51	12%
Knowledge-intensive services[b]	54	12%

[a]Specialized equipment; medical, precision, optical instruments (Castellacci, 2008)

[b]Scientific services (e.g., health services); business services (e.g., consulting) (Castellacci, 2008)

Study 2: Pharmaceutical industry	NAICS	Percent of sample
Biopharma and chemicals	32	100%

Key informant status

Tenure (years)	Study 1	Study 2
>20	76%	85%
11-20	19%	12%
6-10	4%	2%
3-5	1%	1%
<3	0%	0%
Position		
Top management	87%	91%
Middle management	11%	8%
Line management	2%	1%
Non-management	0%	0%
Degree of strategic involvement		
Very high	71%	70%
High	15%	20%
Moderate	8%	5%
Low	6%	5%
Very low	0%	0%

Note: Industry classification adapted from Castellacci (2008)

NAICS (North American Industry Classification System)

NAICS mapped to European standard for UK firms (NACE)

TABLE 2
Means, Standard Deviations, and Correlations

Study 1 variables (N = 155)	**Mean**	**S.D.**	1	2	3	4	5	6	7	8	9	10
1. Human capital	5.52	0.96	.82									
2. Organizational capital	4.80	1.15	.30*	.77								
3. Social capital	5.11	1.22	.45*	.32*	.91							
4. Knowledge augmentation	5.11	1.19	.33*	.31*	.35*	.93						
5. Innovation quality	4.94	1.28	.31*	.36*	.35*	.64*	.93					
6. Innovation efficiency	4.73	1.35	.36*	.27*	.31*	.42*	.44*	.91				
7. Size	4.55	2.00	-.07	.01	-.11	-.07	-.05	-.01				
8. Age	4.10	1.34	-.02	.12	-.05	-.03	-.04	.04	.39*			
9. Past performance	8.65	2.30	.11	.24*	.13*	.24*	.22*	.24*	.13*	-.02		
10. Home country	0.52	0.50	-.21*	-.08	-.13	-.10	-.03	-.03	.13	-.07	.05	
11. Product/ service	0.39	0.49	-.12	.04	-.04	.02	.04	-.02	.08	.07	.08	.01
Study 2 variables (N = 66)	**Mean**	**S.D.**	1	2	3	4	5	6	7	8	9	10
1. Human capital	5.69	0.84	.84									
2. Organizational capital	5.04	1.06	.35*	.75								
3. Social capital	5.41	1.00	.46*	.38*	.89							
4. Knowledge augmentation	5.28	0.98	.39*	.30*	.45*	.90						
5. Innovation quality	5.20	0.97	.38*	.36*	.27*	.64*	.88					
6. Innovation efficiency	4.98	1.20	.39*	.28*	.38*	.47*	.43*	.91				
7. Size	4.64	2.03	-.15	-.04	-.20*	-.22*	-.23*	-.17				
8. Age	4.03	1.28	-.29*	-.08	-.23*	-.20*	-.23*	-.19	.46*			
9. Past performance	8.47	2.56	.10	.16	.16	.21*	.09	.09	.16	.16		
10. Home country	0.48	0.50	-.05	.03	.10	.03	.01	-.03	.05	-.06	.27*	

Note: Size is an eight-point scale (<50 to >10,000 employees); age is a six-point scale (<5 to >100 years); past performance is a ten point-scale (profit plus growth quintiles against competition)
* $p < .05$; Square root of average variance extracted (AVE) on diagonal where applicable

TABLE 3
Study 1: OLS Regressions of Intellectual Capital on Innovation Quality and Efficiency through Knowledge Augmentation

	Innovative Industries (N = 155)				
	Main Effects		**Mediation[a]**		
	1	2	3	4	5
Variables	**Quality**	**Efficiency**	**Knowledge Augmentation**	**Quality**	**Efficiency**
Control					
Size	-.05	-.03	-.07	-.01	.01
Age	-.02	.11	-.01	-.01	.11
Past performance	.09*	.13**	.09*	.02	.10*
Home country	.13	.23	.05	.09	.21
Product/ Service	.20	.05	.16	.09	-.01
Intellectual capital					
Human capital	.17	.41**	.24*	-.01	.32*
Organizational capital	.25**	.04	.20*	.11	-.03
Social capital	.26**	.25*	.21*	.11	.17
Knowledge augmentation				.72***	.40***
ΔR^2				.31	.09
R^2	.32	.33	.33	.63	.42
F	8.70***	9.12***	8.99***	27.54***	11.48***

[a]The causal steps strategy to testing mediation, popularized by Baron and Kenny, requires that the antecedent variable (intellectual capital, in this case) predicts the dependent variable (innovation success, in this case). However, advances in the understanding of mediation have led to the conclusion that this relationship is not necessary for mediation to occur. Rather than analyze the individual paths, a better test of mediation is to construct a confidence interval around the indirect effect (i.e., the product of as opposed to the individual paths linking antecedent to mediator and mediator to outcome) (Hayes, 2013)

* $p < .05$
** $p < .01$
*** $p < .001$

TABLE 4
Study 1: Monte Carlo Results for Indirect Effects and Supplementary Effect Sizes

Model	**Indirect Effect Size[a]**	**S.E.**	**Lower Limit 95% CI**	**Upper Limit 95% CI**
Innovation quality				
Human capital via knowledge augmentation on innovation quality	.18	.09	.02	.36
Organizational capital via knowledge augmentation on innovation quality	.14	.07	.02	.28
Social capital via knowledge augmentation on innovation quality	.15	.07	.02	.30
Innovation efficiency				
Human capital via knowledge augmentation on innovation efficiency	.10	.05	.01	.21
Organizational capital via knowledge augmentation on innovation efficiency	.08	.04	.01	.17
Social capital via knowledge augmentation on innovation efficiency	.08	.04	.02	.16

N = 155. Monte Carlo confidence intervals reported based on 2,000 samples

[a]Controlling for other forms of intellectual capital and regression covariates to mitigate potential confounding or distortion through epiphenomenal associations (for example, accounting for that mediation of the effect of intellectual capital on innovation success may occur through past performance which may be correlated with knowledge augmentation)

TABLE 5
Study 2: OLS Regressions of Intellectual Capital on Innovation Quality and Efficiency through Knowledge Augmentation

	Pharmaceutical Industry (N = 66)				
	Main Effects		**Mediation**		
	1	2	3	4	5
Variables	**Quality**	**Efficiency**	**Knowledge Augmentation**	**Quality**	**Efficiency**
Control					
Size	-.11	-.05	-.10	-.04	.01
Age	-.04	-.01	-.04	-.01	.02
Past performance	.05	.04	.08	-.01	-.01
Home country	-.03	-.15	.01	-.04	-.16
Intellectual capital					
Human capital	.53**	.46*	.35*	.29*	.24
Organizational capital	.21	.15	.10	.14	.08
Social capital	-.06	.23	.23	-.22*	.09
Knowledge augmentation				.68***	.64***
ΔR^2				.26	.15
R^2	.43	.35	.46	.69	.50
F	6.36***	4.46**	7.12***	15.82***	7.11***

* $p < .05$
** $p < .01$
*** $p < .001$

TABLE 6
Study 2: Monte Carlo Results for Indirect Effects and Supplementary Effect Sizes

Model	**Indirect Effect Size**[a]	**S.E.**	**Lower Limit 95% CI**	**Upper Limit 95% CI**
Innovation quality				
Human capital via knowledge augmentation on innovation quality	.24	.12	.04	.49
Organizational capital via knowledge augmentation on innovation quality	.07	.07	-.07	.23
Social capital via knowledge augmentation on innovation quality	.16	.09	-.02	.36
Innovation efficiency				
Human capital via knowledge augmentation on innovation efficiency	.23	.12	.03	.50
Organizational capital via knowledge augmentation on innovation efficiency	.07	.07	-.07	.22
Social capital via knowledge augmentation on innovation efficiency	.15	.09	-.03	.35

N = 66. Monte Carlo confidence intervals reported based on 2,000 samples
[a]Controlling for other forms of intellectual capital and regression covariates to mitigate potential confounding or distortion through epiphenomenal associations (for example, accounting for that mediation of the effect of intellectual capital on innovation success may occur through past performance which may be correlated with knowledge augmentation)

APPENDIX A
Survey Measures and Psychometric Properties

		Factor Loadings	
Human capital: Range '*strongly disagree*' to '*strongly agree*' (Subramaniam & Youndt, 2005)			
To what extent do you agree with the following items describing your organization's human capital:		Study 1	Study 2
HC1	Our employees are highly skilled	.82	.84
HC2	Our employees are widely considered the best in our industry	.79	.82
HC3	Our employees are creative and bright	.88	.86
HC4	Our employees are experts in their particular jobs and functions	.74	.82
HC5	Our employees develop new ideas and knowledge	.87	.85
	Cronbach's alpha (α)	.88	.89
	Composite reliability (CR)	.91	.92
	Average variance extracted (AVE)	.67	.70
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 organizational capital:			
OC1	Our organization uses patents and licenses as a way to store knowledge	-	-
OC2	Much of our organization's knowledge is contained in manuals, databases, etc.	.62	.60
OC3	Our organization's culture (stories, rituals) contains valuable ideas, ways of doing business, etc.	.83	.83
OC4	Our organization embeds much of its knowledge and information in structures, systems, and processes	.85	.80
	Cronbach's alpha (α)	.67	.64
	Composite reliability (CR)	.82	.79
	Average variance extracted (AVE)	.60	.56
Social capital: Range '*strongly disagree*' to '*strongly agree*' (Subramaniam & Youndt, 2005)			
To what extent do you agree with the following items describing your organization's social capital:			
SC1	Our employees are skilled at collaborating with each other to diagnose and solve problems	.87	.83
SC2	Our employees share information and learn from one another	.93	.92
SC3	Our employees interact and exchange ideas with people from different areas of the company	.92	.93
SC4	Our employees partner with customers, suppliers, alliance partners etc. to develop solutions	-	-
SC5	Our employees apply knowledge from one area of the company to problems and opportunities that arise in another	.90	.90
	Cronbach's alpha (α)	.93	.92
	Composite reliability (CR)	.95	.94
	Average variance extracted (AVE)	.82	.80
Knowledge augmentation: Range '*strongly disagree*' to '*strongly agree*' (adapted from Brettel *et al.*, 2011)			
The innovation process meets objectives and expectations in terms of the …			
KA1	Learnings and expertise that can be leveraged in future endeavors	.94	.89
KA2	Generation of new ideas as starting point of potential future endeavors	.91	.93
KA3	Enhancement of competencies and capabilities	.93	.88
	Cronbach's alpha (α)	.92	.88
	Composite reliability (CR)	.95	.93
	Average variance extracted (AVE)	.86	.81
Innovation quality: Range '*strongly disagree*' to '*strongly agree*' (adapted from Brettel *et al.*, 2011)			
The innovation process meets objectives and expectations in terms of the …			
Q1	Perceived value of the innovation output	.93	.93
Q2	Opportunities to market innovation output	.92	.90
Q3	Quality and performance of the innovation output	.94	.90
	Cronbach's alpha (α)	.92	.90
	Composite reliability (CR)	.95	.94
	Average variance extracted (AVE)	.87	.83
Innovation efficiency: Range '*strongly disagree*' to '*strongly agree*' (adapted from Brettel *et al.*, 2011)			
The innovation process meets objectives and expectations in terms of …			
E1	Meeting schedules	.92	.92
E2	Staying on budget	.87	.79
E3	Meeting operational and technical performance of the organizational expectations on innovation	.93	.91
	Cronbach's alpha (α)	.89	.85
	Composite reliability (CR)	.93	.91
	Average variance extracted (AVE)	.82	.77
Environmental dynamism: Range '*strongly disagree*' to '*strongly agree*' (Heavey *et al.*, 2009)			
Please indicate your agreement with the following statements. Our industry is characterized by:			
ED1	Major changes in the modes of production and/or service provision	.81	.69
ED2	A high rate of innovation	.85	.82
ED3	Profound changes in consumer/ business partner demographics	.72	.74
ED4	Frequent and profound changes in regulations	.54	.65
ED5	An increasing amount of spending on research and development	.79	.75
ED6	Frequent and profound changes in the number of competitors	.50	.71
	Cronbach's alpha (α)	.80	.82
	Composite reliability (CR)	.86	.87
	Average variance extracted (AVE)	.51	.53

(-) Item dropped as result of factor analysis