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In Search of Precision in Absorptive Capacity Research: A Synthesis of the Literature and Consolidation of Findings

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This paper addresses two fundamental problems in the absorptive capacity (AC) literature: conceptual ambiguity on what AC is and a lack of synthesized empirical findings showing how AC matters for firm outcomes. We take a two-pronged approach to address these problems: (1) conceptual distillation of the literature to discern the core AC dimensions, outcomes, and contingent external knowledge conditions and (2) meta-analysis of the empirical literature to synthesize the findings. For conceptual distillation, we identify three dimensions of AC: absorptive effort (i.e., the knowledge-building investments made by a firm), absorptive knowledge base (i.e., the current knowledge stock of a firm), and absorptive process (i.e., a firm's internal procedures and practices related to knowledge diffusion). We develop these dimensions by explicating their theoretical roots, functions, mechanisms, and corresponding measures. Leveraging the conceptual distillation, we conduct meta-analyses of the empirical literature and synthesize key

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findings. We find that AC has a significant positive effect on firm outcomes and that the most commonly used dimension, absorptive effort, has the lowest mean effect size. We also find that knowledge acquisition and innovation generation fully mediate the effect of absorptive knowledge base but partially mediate the effects of absorptive effort and absorptive process on firm performance. Furthermore, AC's effects on firm outcomes vary across external knowledge contingencies. Overall, this paper provides a strong theoretical and empirical basis to advance a dimensional approach in AC research and thereby facilitates a more rigorous research necessary for cumulative knowledge development on this important topic.

Keywords: *absorptive capacity; meta-analysis; innovation*

Absorptive capacity (AC) is a widely studied concept in management, and it is defined as a firm's ability to "recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990: 128). Multiple attempts to clarify, review, and at times redefine AC (Lane, Koka, & Pathak, 2006; Volberda, Foss, & Lyles, 2010; Zahra & George, 2002) suggest the importance of the concept and the persistence of some fundamental issues. Our analysis of the literature shows that two key problems have hampered research progress on this topic: ambiguity on what AC is and a lack of clarity on the effect of AC on firm outcomes. These interrelated problems have led to fragmented and shallow theorizing and less rigorous empirical research that have in turn inhibited cumulative knowledge development on AC.

The ambiguity problem refers to the widespread confusion regarding the "meaning and nature" of AC (Volberda et al., 2010: 943) and the construct's reification (Lane et al., 2006). This problem also threatens the validity of existing studies. While several scholars have noted the multifaceted nature of AC (e.g., Lewin, Massini, & Peeters, 2011) and explicated some dimensions (e.g., Carlo, Lyytinen, & Rose, 2012; Liao, Welsch, & Stoica, 2003; Srivastava, Gnyawali, & Hatfield, 2015), researchers continue to use it as a general purpose construct. This use is due in part to the lack of a systematic theoretical exposition of key dimensions and a clear articulation of how empirical measures map onto the dimensions. The effect problem arises in the absence of meta-analytic studies that can show the overall effect of AC on firm outcomes and identify conditions where the effects vary. The problem is exacerbated by two additional issues: first, the use of the same measures as indicators (e.g., de Faria, Lima, & Santos, 2010) and outcomes (e.g., Arbussà & Coenders, 2007) of AC, such as research and development (R&D) investments; and second, inconsistent empirical findings, with studies showing positive (Dushnitsky & Lenox, 2005), negative (Bierly, Damanpour, & Santoro, 2009), and nonsignificant (Mowery, Oxley, & Silverman, 1996) effects of AC on firm outcomes. It is unclear if such inconsistent results are driven by a mismatch between the conceptualization of AC and its measures, by the inconsistent use of measures, or something else. These problems raise concerns about the construct validity of AC.

Since the ambiguity and effect problems are interrelated, we take a two-pronged approach to address them—a conceptual distillation and an empirical synthesis. Using this approach, we go beyond the prior reviews that are only conceptual. For conceptual distillation, we start by analyzing the seminal works of Cohen and Levinthal (1989, 1990, 1994) and the subsequent literature that explains the multidimensional nature of AC (e.g., Carlo et al.,

2012; Lane & Lubatkin, 1998). On the basis of the analysis, we identify and articulate three distinct dimensions of AC: absorptive effort (i.e., the knowledge-building investments made by a firm), absorptive knowledge base (i.e., the current knowledge stock of a firm), and absorptive process (i.e., a firm's procedures and practices related to internal knowledge diffusion). We articulate their unique characteristics, underlying mechanisms, and corresponding measures.

Furthermore, we bring back the core of AC that was stressed in its conceptualization (Cohen & Levinthal, 1990); that is, the extent of benefits from AC depends on the characteristics of external knowledge as well as how and from whom the external knowledge is being accessed. Accordingly, we identify and articulate three important aspects of external knowledge contingencies—knowledge type ("what"), governance mode used for accessing external knowledge ("how"), and learning source ("from whom")—and we explicate their roles in modifying the AC-outcomes relationships.

Our conceptual distillation provides a basis for a systematic meta-analysis that helps to understand the overall effect of AC and its distinct dimensions on the firm outcomes, as well as how such effects may vary across different external knowledge conditions. The results based on our meta-analysis show that among the three AC dimensions, absorptive effort is most widely used, but it generates the lowest mean effect size estimates. Among the three outcomes of AC—knowledge acquisition, innovation generation, and firm performance (see Outcomes of AC section) —the effects of AC dimensions are lowest on firm performance. Furthermore, knowledge acquisition and innovation generation fully mediate the effect of absorptive knowledge base but partially mediate the effects of absorptive effort and absorptive process on firm performance. Among different external knowledge contingencies, AC has higher effect sizes in vertical relationships and lower effect sizes in contexts of mergers and acquisitions (M&A). Meta-analysis thus complements our conceptual distillation by identifying empirical patterns and by providing cumulative empirical evidence about the dimensions of AC and their unique roles.

Our study contributes to the literature in three important ways. First, our distillation of the literature and illumination of core AC dimensions provide conceptual clarity and coherence to the AC construct, which in turn contribute to the development of a clearer and stronger theory of AC. We provide guidelines on how future researchers could (1) build on our conceptualization of the dimensions in developing more fine-grained theoretical arguments, (2) use corresponding empirical measures that fit with the dimensions, and (3) dig deeper into the unique effects of each dimension. Second, our consolidation of empirical findings and identification of key patterns in the AC-outcome relationships provide cumulative empirical evidence on the role of AC on firm outcomes. The specific meta-analytic findings, in combination with our theoretical exposition of the dimensions and associated measures, thus pave the way for a dimensional approach to future theorizing and empirical studies on AC. Third, our articulation of key external knowledge contingencies and corresponding empirical findings helps to address the reification problem stressed by Lane and colleagues (2006) by explicitly considering these contingencies in future research. We believe that our paper (1) provides the necessary theoretical precision to advance a multidimensional approach to AC, (2) enables researchers to match their measures with the theory, and (3) consequently improves precision in AC research both theoretically and empirically.

Conceptual Synthesis and Development

The rapid growth of the AC literature has been accompanied by widespread confusion on what AC is. Much of the literature provides rather fragmented theoretical arguments on AC and its role, and many empirical measures are used without a clear correspondence with the construct or its underlying mechanisms. This ambiguity problem has been underscored by prior researchers (Volberda et al., 2010) with a warning that the reification of the construct has stifled research progress on AC (Lane et al., 2006). Furthermore, although scholars have underscored the multidimensional nature of AC (e.g., Zahra & George, 2002), many researchers continue to use it as a general purpose construct, thus aggravating the ambiguity problem.

We address the ambiguity problem by distilling key conceptual insights from the existing literature and leveraging these insights to theoretically develop AC's dimensions, thus providing conceptual clarity and coherence to the AC construct. In terms of the scope of our conceptual review, we focus on the works of Cohen and Levinthal (1989, 1990, 1994), review articles published in top-tier journals (Lane et al., 2006; Lewin et al., 2011; Todorova & Durisin, 2007; Volberda et al., 2010; Zahra & George, 2002), and other articles published in top-tier journals that stressed the multifaceted nature of AC and contributed toward its theoretical development (e.g., Carlo et al., 2012; L. Kim, 1998; Lane & Lubatkin, 1998; Liao et al., 2003; Matusik & Heeley, 2005; Reus, Ranft, Lamont, & Adams, 2009).

Lane and Lubatkin (1998) were one of the first to note that AC is a multidimensional construct. They identified the ability to recognize and value external knowledge, assimilate new knowledge, and commercialize new knowledge as AC dimensions. Lane and colleagues (2006) reemphasized these dimensions. L. Kim (1998) highlighted prior knowledge base (stock) and intensity of effort (flow) as two AC dimensions. Zahra and George (2002) reconceptualized AC as a "dynamic capability" and modified Cohen and Levinthal's (1990) model by decomposing AC into "potential AC" and "realized AC" dimensions. They split each into two subdimensions: "potential AC" (acquisition and assimilation) and "realized AC" (transformation and exploitation). While Zahra and George (2002) wrote one of the most influential works in the AC literature, their paper contributed to some of the conceptual ambiguity. For example, Todorova and Durisin (2007) criticized Zahra and George, stressing the need to include "recognizing the value" of external knowledge, which the latter authors left out. As Liao and colleagues (2003) noted, the "realized absorptive capacity" dimension created a problem of tautology, as it overlapped with the outcomes that AC was supposed to predict.

Lewin and colleagues (2011) emphasized the importance of routines and processes, conceptualizing AC as organizational metaroutines and proposing internal and external metaroutines as two dimensions of AC. Carlo and colleagues (2012) identified knowledge base and routines as two dimensions of AC in distinguishing between "what a firm knows" and "what a firm does," and they grouped knowledge search and knowledge dissemination as two dimensions within their "routines" dimension. Matusik and Heeley (2005) included attributes of knowledge base and structures and routines for knowledge transfer within their collective (firm-level) AC dimension, while adding linkages with external environment and individual absorptive abilities as two additional AC dimensions. Reus and colleagues (2009) identified external knowledge acquisition and intraorganizational knowledge transfer as two distinct knowledge-based capabilities related to AC. Despite such attempts underscoring the multidimensional nature of AC, scholars continue to use it as an umbrella concept with little

attention to its dimensions (Volberda et al., 2010). This is in part due to the lack of clear theoretical exposition of the AC dimensions, which is what we intend to provide next.

Dimensions of AC

An important commonality that we observed in the prior literature is the scholars' recognition of three core functions of AC: first, searching and identifying valuable external knowledge (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Todorova & Durisin, 2007), or what we refer to as performing the function of a *radar*; second, understanding, exploiting, and transforming external knowledge (Carlo et al., 2012; Matusik & Heeley, 2005; Zahra & George, 2002), which we suggest are the functions analogous to the function of a *processor*; and third, converting the acquired individual-level knowledge to organizational-level knowledge by sharing and diffusing it (Cohen & Levinthal, 1990; Lewin et al., 2011; Liao et al., 2003; Matusik & Heeley, 2005; Reus et al., 2009), or what we refer to as performing the function of a *converter and transmitter*. Collectively, the literature has recognized that these three functions—*radar, processor*, and *converter and transmitter*—are at the core of AC.

By distilling the prior theoretical and empirical AC literature, we identify three distinct dimensions of AC and explain how these dimensions uniquely help in performing the core functions of AC. We label these dimensions *absorptive effort, absorptive knowledge base*, and *absorptive process*. Absorptive effort concerns a firm's knowledge-building investments that enable a firm in searching, identifying, and acquiring external knowledge—primarily performing the *radar* function. Absorptive knowledge base concerns a firm's accumulated stock of knowledge that helps to understand, recombine, and transform external knowledge—primarily performing the *processor* function. Absorptive process concerns a firm's internal procedures and practices that facilitate in sharing and internal diffusion of external knowledge—primarily performing the *converter and transmitter* function. Thus, these dimensions together perform the three core functions of AC—radar, processor, and converter and transmitter; however, no single dimension is equipped to perform all three functions very well. We systematically develop these AC dimensions by articulating their unique characteristics, theoretical roots, and associated empirical measures. Table 1 provides a conceptual summary of the dimensions, and Table 2 maps the measures to the dimensions.

Absorptive effort. As noted, absorptive effort refers to the knowledge-building investments made by a firm that facilitate searching, identifying, and acquiring external knowledge. Knowledge-building investments can be in the form of financial, human, and other resources. We use the label "effort" in line with the original point made by Cohen and Levinthal (1990: 131, 150), who argued that "intensity of effort is critical" and, to develop AC, "the firm must dedicate effort." In their subsequent study, Cohen and Levinthal (1994) again stressed that for firms to use accessible external knowledge, they first need to spend time and devote energy to developing internal expertise. In multiple papers, Cohen and Levinthal (1989, 1990, 1994) emphasized that firms invest in R&D not only to generate knowledge internally but also to enhance their ability to leverage knowledge external to them. Cohen and Levinthal (1990) used the label AC for the second role of R&D investments.

The deeper theoretical roots of the absorptive effort dimension can be traced back to the knowledge externality and spillover literature (Griliches, 1979; Jaffe, 1986). Two core findings from this literature stream include that R&D investments made by other firms increase the

Table 1
Nature and Characteristics of AC Dimensions and Their Theoretical Development

	Absorptive Effort	Absorptive Knowledge Base	Absorptive Process
Definition	Knowledge-building investments made by a firm	Current knowledge stock of a firm	Internal procedures and practices related to knowledge diffusion
Functional role	*Primary*: Radar—search, identify, acquire *Secondary*: Processor—understand, combine, transform	*Primary*: Processor—understand, combine, transform *Secondary*: Radar—search, identify, acquire	*Primary*: Converter and transmitter—create organizational level knowledge and share and diffuse it *Secondary*: Radar and processor—search, identify, acquire, understand, combine, transform
Primary mechanisms	• Development and use of knowledge search routines—scanning and sensing • Boundary-spanning learning • Direct interface with external knowledge	• Development and use of knowledge-processing routines • Learning through direct experimentation and experience	• Development and use of knowledge-sharing rules, norms, and procedures • Interactive learning
Secondary mechanisms	• Development of knowledge-processing routines • Development of knowledge base	• Influencing the nature and direction of search • Interface with external knowledge through interpretation, evaluation, validation	• Development of knowledge search routines and knowledge-processing routines • Interface with external knowledge through individuals who are part of internal routines but engage with external environment
Nature of AC dimension	Developmental and forward looking	Cumulative and path dependent	Structured and adaptive
Theoretical foundation	Knowledge externalities and spillover (Griliches, 1979; Jaffe, 1986): • Evidence of knowledge spillover: the R&D productivity of firms increases with the R&D expenditure of its neighbors • Firms increase their R&D effort in the presence of knowledge spillover opportunities	Associative learning and problem solving (Ellis, 1965): • Learning occurs when new knowledge is related to prior knowledge • Firm knowledge base development is cumulative and path dependent	Knowledge integration and information processing (Daft & Weick, 1984; Huber, 1991): • Knowledge resides within individuals, and individual knowledge needs to be shared, integrated, or converted to become organizational • The information processing involves acquiring, distributing, or interpreting information
Characterization from Cohen and Levinthal (1990: 128, 132, 138)	"R&D not only generates new knowledge but also contributes to the firm's absorptive capacity"	"[AC] is largely a function of the firm's level of prior related knowledge"	"The structure of communication . . . and . . . the character and distribution of expertise" are "aspects of AC that are distinctly organizational"
Subsequent building from the original idea	L. Kim (1998); Lewin, Massini, & Peeters (2011)	Lane and Lubatkin (1998); Carlo, Lyytinen, & Rose (2012); Srivastava, Gnyawali, & Hatfield (2015)	Lane and Lubatkin (1998); Zahra and George (2002); Matusik and Heeley (2005); Lewin et al. (2011); Carlo et al. (2012)

Note: AC = absorptive capacity; R&D = research and development.

Table 2
Three Dimensions of AC and the Measures Used

Dimension of AC	Measures used in the literature
Absorptive effort	Financial investment in R&D • R&D expenditure (Dushnitsky & Lenox, 2005; Nambisan, 2013) • R&D intensity as R&D expenditure divided by total sales (Estrada, de la Fuente, & Martín-Cruz, 2010) • Firm's expenditures on R&D activities and training programs divided by its total number of employees (K. H. Tsai, 2009) • Dummy variable indicating if the firm has an internal R&D department (Pinto, Fernandez-Esquinas, & Uyarra, 2015), if the firm engages in R&D activities (de Faria, Lima, & Santos, 2010) Commitment for technology development • Number of R&D employees (Huang, Lin, Wu, & Yu, 2015) • Percentage of R&D employees among the total number of employees (Estrada et al., 2010) • Percentage of firm employees with a master's degree or PhD (Xia & Roper, 2008) • Survey items asking the percentage of employees with information on up-to-date technical practices and skills (Matusik & Heeley, 2005) • The commitment and concern of the management of the company toward R&D (Expósito-Langa, Molina-Morales, & Tomás-Miquel, 2015)
Absorptive knowledge base	Patent-based measures • Patent stock: total number of patents (Dushnitsky & Lenox, 2005; Nooteboom, Van Haverbeke, Duysters, Gilsing, & van den Oord, 2007) • If the firm has filed patents (Pinto, Fernandez-Esquinas, & Uyarra, 2015) • Quality of a firm's technology portfolio: a count of the citations received by a firm's patents from subsequent patents (C. S. Kim & Inkpen, 2005) Non-patent-based measures • Number of scientific papers published by firm employees (Kang, 2012) • Number of prior product innovations (Estrada et al., 2010), if the company has introduced any innovations in a certain period (Pinto et al., 2015) • Survey items directly asking employees to evaluate the existing knowledge or competence of the firm (Kumi, 2013)
Absorptive process	Survey items asking about knowledge-sharing practices • "We adopted an excellent information infrastructure for employees to share information and knowledge" (Zhao & Anand, 2009: 973) • We have a "common style of communicating about technical issues" (Matusik & Heeley, 2005: 559) Survey items asking about knowledge dissemination practices • New external knowledge is "disseminated at all levels in the organization" (Liao, Welsch, & Stoica, 2003: 72) Survey items asking about overall learning practices • "We periodically organize special meetings with customers or third parties to acquire new knowledge" (Jansen, Van Den Bosch, & Volberda, 2005: 1014) • "We collect industry information through informal means (e.g., lunch with industry friends, talks with trade partners)" (Jansen et al., 2005: 1014)
Others	• Acquirer size (Li, Li, & Wang, 2016) • Technological overlap or distance (Bierly, Damanpour, & Santoro, 2009; Dushnitsky & Lenox, 2005; Sears & Hoetker, 2014) • Mathematical estimations of the efficiency of absorbing know-how with econometric models (Xiong & Bharadwaj, 2011)

Note: AC = absorptive capacity; R&D = research and development.

pool of technological opportunities (Griliches, 1979) and that R&D productivity of a firm increases with R&D investments made by other firms (Jaffe, 1986). Several studies demonstrated that firms realize greater returns from their R&D investments in the presence of knowledge spillovers (Levin, 1988). In addition, firms may even increase their own R&D investments when R&D investments made by other firms increase (Cohen & Levinthal, 1990). Overall, this literature stream provided the building blocks for the development of the AC literature in general and the absorptive effort dimension in particular.

Absorptive effort functions as a "radar"—it enables a firm to detect and spot important external knowledge developments and receive knowledge that is relevant and valuable. AC is fundamentally about learning (Cohen & Levinthal, 1989), and motivation and willingness to learn are central to learning. By infusing new energy, efforts in the form of new knowledge-building investments increase a firm's willingness and motivation to learn (Srivastava et al., 2015). Knowledge-building investments contribute to the development of external knowledge search routines, which is the primary mechanism through which the absorptive effort dimension comes into play. Through systematic and repeated use, these external knowledge search routines become more effective in helping a firm scan the external environment and identify valuable learning opportunities (Zahra & George, 2002). Compared with the other dimensions, the absorptive effort dimension provides the most direct interface with external knowledge sources. Absorptive efforts could span organizational and technological boundaries. Accordingly, greater absorptive efforts help firms to notice new external knowledge developments more quickly, assess their relevance or value, and then bring that knowledge to the firm.

Absorptive effort is forward-looking as Cohen and Levinthal (1994) stressed: investments in R&D not only help exploit new technological developments but also help *envision the emergence* of new technologies. Current knowledge-building investments contribute to the development of knowledge processing routines, which in turn lead to the development of future capabilities (Mowery et al., 1996). Those capabilities would help in understanding, combining, and transforming external knowledge, thus also performing the *processor* function. Since these effects occur through the formation of future capabilities in subsequent periods, we consider the processor function a secondary function of absorptive effort.

We note that downsides are also associated with absorptive effort. When making knowledge investments, firms incur opportunity costs by forgoing other investment options, such as increasing production capacity (Reus et al., 2009). These opportunity costs can be particularly high for firms operating in less complex and dynamic environments (Reus et al., 2009). In addition, such investments are often made under uncertainty, as noted by Cohen and Levinthal (1994: 229): "AC represents a bet on a field of technology or science." However, there is little certainty that such bets will be successful.

As summarized in Table 2, two sets of measures are generally used to capture absorptive effort: financial investment in R&D and other commitments for technology development. Financial investment in R&D has been often operationalized as R&D intensity (Estrada, de la Fuente, & Martin-Cruz, 2010), the most commonly used measure of absorptive effort. Other commonly used empirical measures of commitments for technology development include having a large number of R&D employees (Huang, Lin, Wu, & Yu, 2015), a higher percentage of people with technological expertise (Estrada et al., 2010) and skills (Matusik & Heeley, 2005), and a broader resource commitment by the management toward R&D (Expósito-Langa, Molina-Morales, & Tomás-Miquel, 2015).

Absorptive knowledge base. Absorptive knowledge base refers to the accumulated stock of knowledge held by the firm that facilitates understanding, recombining, and transforming external knowledge. Cohen and Levinthal (1989: 570) emphasized this dimension, noting that the "stock of prior knowledge . . . constitutes the firm's absorptive capacity." Furthermore, Cohen and Levinthal (1990: 138) argued that AC is largely a function of prior related knowledge and that "a firm without a prior technological knowledge base in a particular field may not be able to acquire one readily." These characteristics make the absorptive knowledge base dimension cumulative and path dependent.

The theoretical foundation of the absorptive knowledge base dimension can be traced to the associative learning and problem-solving literature at the individual level (Chiesi, Spilich, & Voss, 1979; Ellis, 1965; Gagne, 1962). Prior knowledge is important because learning is associative; that is, existing knowledge provides opportunities to develop associative linkages with the new knowledge. For individual-level learning, Gagne (1962) emphasized the importance of having lower-order capabilities in learning higher-order capabilities. White (1972: 97) examined the core arguments of Gagne's learning hierarchy theory "that any piece of knowledge can only be acquired by people who possess certain prerequisite pieces of knowledge, which have their own prerequisites in turn" and found support for learning of higher-order "intellectual skills." Further experimental work on the theory also showed that prior knowledge within a domain facilitates learning new knowledge from that domain (Chiesi et al., 1979). Cohen and Levinthal (1990) brought these insights from individual-level learning to organizational-level learning, laying the foundation for the absorptive knowledge base dimension of AC.

Absorptive knowledge base functions primarily as a "processor" by helping a firm to understand external knowledge, assess its relevance and utility, combine the external and internal knowledge, and use the knowledge to find novel solutions to problems. This dimension captures the "stock" aspect of AC. The knowledge-processing routines that underlie the development of this "stock" provide the primary mechanism through which recombination and transformation of external knowledge occur (Zahra & George, 2002). A firm's current knowledge base provides the basis for identifying ways of combining external and internal knowledge. A firm with diverse internal knowledge would more likely make novel associations and linkages with external knowledge (Cohen & Levinthal, 1990).

We also note that in its secondary role, absorptive knowledge base can partly serve the radar function by helping the firm detect new external knowledge developments, particularly when the external knowledge is related to the firm. Firms are more likely to notice and acquire external knowledge when the knowledge is familiar to them (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998). When external knowledge, however, is unfamiliar or unrelated to the firm's existing knowledge base, there is a risk of absorptive knowledge orienting the radar away from the unfamiliar external knowledge and toward more familiar external knowledge. Cohen and Levinthal (1990: 133) noted this particular downside of absorptive knowledge base: "any particular body of expertise could become sufficiently overlapping and specialized that it impedes the incorporation of outside knowledge and results in the pathology of the not-invented-here (NIH) syndrome."

The path-dependent and cumulative nature of absorptive knowledge base makes this dimension more oriented toward the past than the future. As a firm accumulates strong capabilities in certain technological areas, it will become increasingly difficult for the firm to modify its technological path and acquire knowledge from alternative areas (Reus et al.,

2009). A strong absorptive knowledge base may also reduce a firm's overall willingness to search for external knowledge because internal knowledge strength could make the firm complacent, develop a dismissive attitude toward external knowledge, and fall into "competency traps" (Ahuja & Lampert, 2001; Srivastava & Gnyawali, 2011). A stronger absorptive knowledge base can also cause knowledge leakage concerns, thus further reducing the willingness to reach out to external knowledge sources (Srivastava et al., 2015).

Empirical research related to the knowledge base dimension of AC has largely focused on technological knowledge (e.g., C. S. Kim & Inkpen, 2005). Some of the commonly used indicators, as shown in Table 2, include the stock or number of patents or unique patents (Dushnitsky & Lenox, 2005; Nooteboom, Van Haverbeke, Duysters, Gilsing, & van den Oord, 2007; Srivastava et al., 2015), share of a firm's patents within the industry (Srivastava et al., 2015), and patent citations (C. S. Kim & Inkpen, 2005). Measures used by prior research that are not patent based include the number of scientific publications (Kang, 2012) and the number of prior product innovations (Estrada et al., 2010). Researchers have also used survey instruments to examine whether the organization has the technical competence to absorb new knowledge (Kumi, 2013).

Absorptive process. Absorptive process refers to the internal procedures and practices that facilitate the sharing and diffusion of external knowledge inside the organization. Cohen and Levinthal (1990) stressed that an organization's AC depends on links across a mosaic of individual capabilities and suggested that knowledge-sharing procedures enable the creation of linkages across the knowledge of multiple individuals, thereby facilitating knowledge diffusion. More recently, Volberda and colleagues (2010: 937) underscored the importance of the process dimension and urged researchers to examine "various internal mechanisms . . . such as the structure of communication and the character of distribution of expertise and knowledge inside the organization."

We can trace the theoretical foundation of the absorptive process dimension of AC to the literature on information processing (Daft & Weick, 1984; Huber, 1991) and knowledge integration (Grant, 1996; Nonaka, 1994). Core insights emerging from these literature streams are that information processing involves acquiring, distributing, or interpreting information and that the knowledge held by individuals needs to be shared, integrated, or converted to become organizational (Crossan, Lane, & White, 1999). Knowledge transfer between units is fraught with difficulties (Szulanski, 1996); however, the presence of knowledge-sharing practices and routines help in overcoming some difficulties.

Absorptive process primarily functions as a "converter" and a "transmitter." As illustrated in Table 1, the absorptive process institutes mechanisms for gathering information from individuals, converting the multiple pieces of information into organizational knowledge, and sharing and diffusing that knowledge. The nature of learning through absorptive process is more interactive. Practices such as cross-functional integration, socialization, and job rotation can help develop a shared body of knowledge and identify multiple applications of that knowledge (Jansen, Van Den Bosch, & Volberda, 2005). Knowledge dissemination and diffusion processes facilitate the transmission of relevant knowledge to various units and entities within the organization. Absorptive process also plays an important role in storing and retrieving organizational knowledge (Jansen et al., 2005). Through the development of practices for knowledge search (e.g., employees regularly visiting other firms) and processing (e.g., regular meetings for analyzing market information; Jansen et al., 2005), absorptive

process also performs a secondary function as a radar and as a processor. Individual employees who are part of intraorganization knowledge-sharing routines but have direct interactions with the external environment can help bring in new knowledge directly from the external knowledge sources and help combine such knowledge with the internal knowledge.

The absorptive process dimension also has some limitations. If the knowledge being shared and transferred is not useful or novel, the routines and procedures in place will be a waste of organizational resources. Too many procedures for knowledge search and sharing can make organizational members feel obligated to go through these processes, but the information that they obtain is often redundant. Even when the knowledge being shared is novel, frequent dissemination and diffusion practices can create an information overload (Hansen & Haas, 2001).

Researchers studying the process dimension have generally measured it through surveys. Expressed rules, heuristics, norms, and practices are noted as observable indicators of processes (Lewin et al., 2011). Jansen and colleagues (2005) and subsequent studies building on that study (e.g., Chang, Gong, & Peng, 2012) examined meetings and interactions among units, sharing of practices across units, and similar processes of developing shared knowledge in an organization. They examined practices such as conducting market searches, having regular meetings to discuss the impact of new market trends, and examining others' patents and industry magazines (Jansen et al., 2005). Others captured processes related to external knowledge acquisition (e.g., meetings and interactions with clients and competitors) and intrafirm knowledge dissemination (Liao et al., 2003). Still others examined practices related to sharing information and knowledge (e.g., Zhao & Anand, 2009) and structures and routines for knowledge transfer (Matusik & Heeley, 2005).

In summary, we make three important observations based on our analysis of the literature. First, the three dimensions are distinct from one another, while they overlap somewhat in terms of the functions they perform. Using principal component factor analysis of the empirical measures, we find that the unique contributions of absorptive effort, absorptive knowledge base, and absorptive process to the common factor AC are 0.53, 0.46, and 0.71, respectively, clearly indicating the uniqueness and shared nature of the three dimensions. Second, these dimensions build on one another. Finally, we want to note that although the three dimensions encompass most of the AC measures used in our sample, some of the measures used in a few studies (labeled "others" in Table 2) do not fit in these dimensions. Additionally, 8% of our sampled studies used dyad-level measures, such as technological similarity or distance (Bierly et al., 2009) or overlap of practices between firms (Lane & Lubatkin, 1998). We did not consider these representing another unique dimension of AC (dyad AC), because they still use the absorptive knowledge base or the absorptive process logic at the dyad level.

Outcomes of AC

In our review, we find that >50 outcome measures have been used in empirical AC research. The AC outcome measures include knowledge transfer (Reiche, 2011), knowledge received (Chang et al., 2012), generation of patents (Rothaermel & Alexandre, 2009), products (Nambisan, 2013), processes (Carlo et al., 2012), and firm profitability—for example, return on assets (Bergh & Lim, 2008), return on equity (Luan & Tang, 2007), and return on investment (Chang et al., 2012). As shown in Appendix A (see online supplement), we grouped these outcomes into three main categories: knowledge acquisition, innovation

generation, and firm performance. These three key outcome categories, as noted by prior literature (e.g., Volberda et al., 2010), encompass 81% of the outcome measures in our sample. Examples of other types of outcomes examined include level of product diversification (Wang, Ning, & Chen, 2014), strategic variety (Larrañeta, Zahra, & González, 2012), and R&D outsourcing intensity (Spithoven & Teirlinck, 2015). Because the volume of empirical research on these outcomes is small, we included them in the "others" category.

Knowledge acquisition. Knowledge acquisition refers to the scientific, technological, organizational, or general knowledge (Lane et al., 2006) acquired by a firm from outside. Examples of knowledge acquisition include gaining new knowledge from other firms (e.g., Lane & Lubatkin, 1998) and from different units of an organization (e.g., W. Tsai, 2001). Empirical measures of knowledge acquisition include the rate of external learning (Schildt, Keil, & Maula, 2012), knowledge transfer (Reiche, 2011), and improvement in the firm's stock of knowledge (Zhao & Anand, 2009). Studies often used survey items asking about the amount of knowledge received (Chang et al., 2012), the rate of knowledge transfer (Reiche, 2011), and improvements in the stock of knowledge (Zhao & Anand, 2009).

Innovation generation. Innovation generation refers to the development of new intellectual properties, new products or processes, and new services by utilizing external knowledge (Lane et al., 2006). Whereas the knowledge output of AC is knowledge acquisition, the commercial output of AC is innovation generation (Lane et al., 2006). Cohen and Levinthal (1990: 129) argued that AC "is crucial to a firm's innovative capability." Building on this idea, subsequent studies examined AC's impact on the quantity, quality, and novelty of innovation (Makri, Hitt, & Lane, 2010), explorative and exploitative innovation (Bierly et al., 2009; Nambisan, 2013), different types of service and process innovations (Carlo et al., 2012), and speed of innovation (Fabrizio, 2009).

Empirical measures used to capture innovation generation are usually based on patents, new products, and survey questions. Patent-based measures include total number of patents (Rothaermel & Alexandre, 2009) and exploitative and explorative patents generated (Nooteboom et al., 2007). New product-based measures include number of new products and services (Nambisan, 2013), the adoption of new knowledge in software development (Carlo et al., 2012), and "innovation achieved rate" (W. Tsai, 2001). Some studies used survey items asking respondents to rate the company's new product development program (Ferreras-Méndez, Newell, Fernández-Mesa, & Alegre, 2015) and new features of products as compared with those of competitors (Lawson, Tyler, & Potter, 2015).

Firm performance. Firm performance, as such, was not an outcome suggested by Cohen and Levinthal (1990), but many subsequent studies argued that since AC has significant effects on learning and innovation and since learning and innovation are important predictors of firm performance, AC should also influence the bottom-line performance (e.g., Chang et al., 2012; Lane et al., 2006). Measures of firm performance studied in the AC literature include sales growth (Patel, Kohtamäki, Parida, & Wincent, 2015); financial profitability, such as return on assets (Bergh & Lim, 2008), return on equity (Rothaermel & Alexandre, 2009), and return on investment (Chang et al., 2012); and market performance, for example, cumulative abnormal returns (Sears & Hoetker, 2014) and initial public offering valuation (Xiong & Bharadwaj, 2011).

We want to highlight two issues here that typically arise during the operationalization of AC and outcomes of AC and that have important implications. One critical issue that we observe is related to the misalignment between the conceptualization and the operationalization of AC. For example, studies have used R&D intensity as a measure of absorptive knowledge base or technological capability (e.g., Bierly et al., 2009; Cohen & Levinthal, 1990). Mowery and colleagues (1996), among others, have correctly noted that R&D intensity is not a measure of either knowledge base or technological capability. This misalignment issue that is frequently observed in the AC literature contributes to the effect problem that we noted earlier. The other critical issue that we observe is that the same measures were used at times for AC and at other times for AC outcomes. For example, acquisition and exploitation (Zahra & George, 2002) were sometimes considered parts of AC, absorptive process (Jansen et al., 2005), and outcomes of AC (Bierly et al., 2009; Nambisan, 2013). Such inconsistent use of measures heightens the effect problem. We emphasize that the processes and routines for bringing in and exploiting knowledge are elements of AC dimensions but that the acquired knowledge and the generated innovation are outcomes of AC.

Potential Moderators of the AC-Outcome Relationship

Since AC is essentially about accessing, acquiring, and learning from external knowledge, the relationship between AC and outcomes is contingent on conditions associated with external knowledge (Volberda et al., 2010). Drawing on the prior literature, we identify three important conditions: the *governance mode* through which external knowledge is sourced ("how"; e.g., Sears & Hoetker, 2014), the *source* of external knowledge ("from whom"; e.g., Xiong & Bharadwaj, 2011), and the *type* of knowledge being accessed ("what"; e.g., Winkelbach & Walter, 2015). In what follows, we discuss how these conditions influence AC-outcomes relationships.

Governance mode. Governance mode refers to the structural arrangements connecting a focal firm with an external knowledge source, thus indicating *how* the firm is connected with the source (Williamson, 1975). The structural arrangements vary in the extent to which the firm has ownership and control over them, and they offer alternative ways to connect with a given external knowledge source. The choice of governance mode can range from arm's-length market transactions, with no ownership and control, to fully integrated hierarchical arrangements with full ownership and control (Williamson, 1975). We identify the following as key governance modes based on their prevalence in the empirical AC literature that factors the role of external knowledge: market transactions (contracts, market purchases, licensing), informal networks (social networks among firms' top management teams or informal interactions among firms due to their co-location), strategic alliances (formalized firm-to-firm voluntary agreements, joint ventures, and corporate venture capital investments), M&As, and intrafirm relationships (e.g., between subsidiaries and parent firms).

Due to varying ownership and control, governance modes differ in the richness of the interaction that they offer and coordination costs that they involve with a given external knowledge source. These conditions are likely to influence the effectiveness of a firm's AC. Compared with the market-based modes, hierarchical governance modes, such as alliances, M&As, and intraorganization modes (from subsidiaries to parents), offer opportunities for

richer interactions and superior access to external knowledge sources, which in turn increase potential knowledge flow. However, richer interactions also incur more coordination costs—especially in the case of M&As. During an M&A process, the integration of two previously disparate entities often destabilizes existing knowledge routines and power structures, creates disruptions, and causes conflicts due to differences in organizational routines (e.g., Reus, Lamont, & Ellis, 2016). These increased coordination and integration costs may offset the potential benefits of increased interactions, causing AC to have even lower effects in M&A contexts. Informal network, which is in the middle of the governance mode continuum, may help balance the trade-off between interaction and coordination and thus provide more potential for richer communication with less coordination costs.

Learning source. Learning source refers to the external knowledge–possessing entity—*from whom* the firm attempts to learn and acquire knowledge. Learning sources and governance modes are rather independent of each other: Firms can use the same governance mode (e.g., alliance) to learn from different learning sources (e.g., suppliers vs. competitors), or they can use different governance modes (e.g., contract vs. alliance) to learn from similar learning sources (e.g., suppliers). We focus on four commonly studied learning sources in this study: vertical (e.g., customers, suppliers), horizontal (e.g., competitors), universities (and government R&D organizations), and intraorganizational. The learning sources differ in two important ways: the kind of knowledge that they offer and the extent to which they influence the collaborative intention and fear of imitation between the firm and source (Hamel, 1991).

First, learning sources differ in the nature of knowledge that they offer. For instance, universities provide scientific knowledge (Mindruta, 2013) that can be applied in the development of technologies, but vertical sources provide market knowledge (Berkhout, Hartmann, & Trott, 2010). It is likely that market knowledge will be more actionable and therefore may more directly influence performance, but scientific knowledge involves higher levels of uncertainty, is less actionable, and therefore may take longer to show performance benefits. Therefore, we expect that the effect of AC on outcomes would be stronger in vertical learning sources than in university (and government R&D organizations) learning sources.

Second, firms are more likely to collaborate than compete with vertical sources, but the opposite is likely to be the case with horizontal sources. Even when firms collaborate with horizontal sources, the fear of knowledge misappropriation (Lavie, 2007) and the potential impact of misappropriation are much higher in such cases. These differences suggest that knowledge from vertical learning sources (e.g., suppliers and customers) can be accessed more easily than from horizontal learning sources (e.g., competitors; Ferreras-Méndez et al., 2015).

Knowledge type. Knowledge type refers to the nature of knowledge intended to be transferred from the external knowledge source. Much of the literature has made the distinction between technological and nontechnological knowledge. We argue that the ease of knowledge transfer will be lower for technological knowledge because it is often more complex, uncertain, and less actionable than nontechnological knowledge. The assimilation and integration of technological knowledge require more organizational resources (Winkelbach & Walter, 2015), thus reducing the efficiency of knowledge absorption. In addition, technological knowledge is more likely to be firm specific. Nontechnological knowledge, such as management, organizational, and marketing knowledge, is often transferable across organizations, but the transferability of a technology is often limited.

Having articulated the three dimensions of AC and their unique features, key outcomes of AC, and potential moderators of the AC-outcomes relationship, we now address the following four research questions through meta-analysis: (1) To what extent do the three AC dimensions—absorptive effort, absorptive knowledge base, and absorptive process—vary in their effect on overall firm outcomes? (2) To what extent does the effect of overall AC differ across the three firm outcomes—knowledge acquisition, innovation generation, and firm performance? (3) To what extent do the effects of the three dimensions of AC—absorptive effort, absorptive knowledge base, and absorptive process—vary across the three firm outcomes—knowledge acquisition, innovation generation, and firm performance? (4) To what extent do the effects of three contingencies related to external knowledge—governance mode, learning source, and knowledge type—influence the effect of AC on firm outcomes?

Meta-Analysis

Meta-analysis is particularly appropriate to answer these research questions. It also complements our conceptual distillation, which provides a basis for designing and conducting the meta-analysis. We first compare the strength of effects based on different methodological and theoretical choices made in the predictor and the outcome variables. We then focus on unpacking the effect of different contingent conditions. Finally, we parse the direct and indirect effects of the various variables examined.

Sample

To construct our sample for the meta-analysis, we used the following three-step procedure that describes our literature search scope. First, we searched for studies published between 1990—the year that Cohen and Levinthal's work was published—and June 2016 with the term "absorptive capacity" appearing in the title, abstract, or author-specified keywords via the EBSCO Business Source Complete database. Second, to maintain quality, we restricted the sample to studies published in the journals included in the Institute for Science Information's Web of Knowledge Journal Citation Report (2013). Third, to ensure that the latest key publications are included in our sample, we also searched for articles published between 1990 and June 2016 in eight top-tier journals via their websites: *Academy of Management Journal, Administrative Science Quarterly, Journal of International Business Studies, Journal of Management, Journal of Management Studies, Management Science, Organization Science*, and *Strategic Management Journal*. Overall, we identified 741 studies using the literature search procedures described.

We used the following selection criteria to construct our sample for the meta-analysis: (1) The study must be an empirical study, and AC must be included in its empirical test. (2) The study must report the sample size and the pairwise correlation between its AC measures and dependent variables. (3) AC and the dependent variable of the study must be tested at the organizational level. (4) The study must not have used the same sample used by a prior published study included in the current sample (Arthur, Bennett, & Huffcutt, 2001). Using these four selection criteria, we built our sample, which consisted of 193 empirical studies with 430 reported bivariate correlations and 2,246,500 sampled observations. For a list of primary studies included in our sample, see Appendix B (see online supplement).

Data-Coding Procedures

Following the procedures recommended by Lipsey and Wilson (2001), we first developed a coding protocol to extract information from the studies. From each study, we recorded the reported bivariate correlation (*r*) between AC measures and the dependent variables, the sample size, and statistical artifacts such as measurement reliability. We also recorded the reported regression coefficients between AC measures and the dependent variables, as well as the standard errors of the regression coefficients to use them in our robustness check models.

For each bivariate correlation, we coded the AC dimension used in the empirical measure (see Table 2 for details), the outcome examined (see Appendix A for details), and the corresponding governance mode (market transaction, informal network, alliances or corporate venture capital, M&A, internal, unspecified—if governance mode was not apparent or multiple governance modes were examined in the study), learning source (horizontal [i.e., competitors or start-ups], vertical [i.e., customers or suppliers], universities and research organizations, intraorganizations, or source unknown—if the learning source was not apparent or multiple learning sources were examined in the study), and knowledge type (technological or nontechnological) examined in the primary studies. Finally, we collected information on the study methodology (whether the study used panel or cross-sectional data and whether it used surveys to measure either AC or its dependent variable). Two coauthors coded a subsample of randomly selected papers independently and had an overall intercoder agreement of 96.92%. They resolved disagreements on items involving subjective assessment in coding (e.g., AC dimension, learning source, and governance mode) through discussion and further refined the coding protocol. After the two authors achieved 100% consistency on another randomly drawn sample, one coauthor then coded the rest of the sample.

Meta-Analysis Procedures

We used three meta-analytic procedures to answer our research questions in a robust manner. We first used random effect Hedges-Olkin-type meta-analysis (HOMA; Hedges & Olkin, 1985) to calculate and compare the mean effect sizes for AC dimensions, AC outcomes, and AC dimension–AC outcome combinations. We then used meta-analytic regression analysis (MARA) to test the moderating effects of governance modes, learning sources, and knowledge types. Furthermore, we used meta-analytic structural equation modeling (MASEM) to examine the direct effects and indirect effects of AC dimensions on firm performance and to conduct mediation tests. We followed established guidelines for performing these analyses (e.g., Drees & Heugens, 2013). In what follows, we provide further details of these analytical procedures.

HOMA procedure. We used Pearson product-moment correlation (*r*) as the input to estimate mean effect sizes, as it is more commonly used in management meta-analysis studies (Geyskens, Krishnan, Steenkamp, & Cunha, 2009). When a study operationalized the same measure in multiple ways (e.g., operationalized R&D intensity in the past 1, 3, and 5 years) or reported multiple correlations from different components of survey items, we averaged the multiple correlations into a single composite to adjust for the nonindependence of effect sizes

(Connelly, Crook, Combs, Ketchen, & Aguinis, 2015). For additional details of the procedure that we followed, see Appendix C (see online supplement).

MARA procedures. We used MARA to test the moderating effects of the three external knowledge–related contingencies (learning source, governance mode, and knowledge type). We note that in our MARA analysis, the dependent variable is the corrected Pearson product-moment correlation (r_c) between AC and the study outcome variables. We used dummy variables to control for study methodologies in terms of whether the study used panel or cross-sectional data and whether it used survey methods to measure either AC or the dependent variable. We also controlled for the sample size used in the study. Subsequently, we included *AC dimensions* (absorptive effort, absorptive knowledge base, absorptive process), *AC outcomes* (knowledge acquisition, innovation generation, firm performance), *learning sources* (vertical, horizontal, university, intraorganization, and source unknown), *governance modes* (market transaction, informal network, alliance, M&A, internal, and mode unknown), and *knowledge types* (technological vs. nontechnological) as dummy variables to test their moderation effects. We weighted the effect sizes by their inverse variance weight and used a random effects generalized least squares regression procedure that factors dependencies in effect sizes and gives more precise parameter estimates (Geyskens et al., 2009).

MASEM procedures. We conducted the MASEM analysis in two stages (van Essen, Otten, & Carberry, 2015) to examine the direct and indirect effects of AC dimensions on firm performance and conduct mediation analysis. In the first stage, we conducted 15 separate HOMA analyses, using the bivariate correlation reported in our sample studies to compute the mean correlations among the three AC dimensions and the three outcome variables. We used these correlations to build the correlation matrix (Appendix D, see online supplement). In the second stage, we used this matrix as an input to apply maximum likelihood structural equation modeling procedure (van Essen et al., 2015). We used the harmonic mean of the number of observations used in primary studies as our MASEM sample size following the recommendations from Bergh et al. (2016).

Results

Effect of Overall AC

We first discuss the overall effect of AC on overall outcomes. Table 3 reports the results from the HOMA with Pearson product-moment correlations. As shown in Table 3, the mean effect size ($r_{\bar{c}}$) of 0.32 with a low standard error (0.02) and a small confidence interval (0.28 to 0.36) indicates a positive and significant effect of overall AC on overall firm outcomes.

AC Dimensions and Overall Firm Outcome

Research Question 1 asks to what extent the three AC dimensions vary in their effect on overall firm outcomes. As shown in Table 3, *absorptive effort* is the most commonly used AC dimension. Among the three AC dimensions, *absorptive process* yields the highest mean effect size. Its mean effect size ($r_{\bar{c}} = 0.47$) is significantly greater (z test for difference [0.27]: $p = .000$) than the mean effect size of *absorptive effort* ($r_{\bar{c}} = 0.20$) but not significantly

Table 3
Results of Hedges and Olkin-Type Meta-Analysis With Pearson Product-Moment Correlation

	Studies, n	K	Total sample size, N	$r_{\bar{c}}$ (p)	z	$SE_{r_{\bar{c}}}$	95% CI		Q
Overall relationship	193	430	2,246,500	0.32 (.000)	17.82	0.02	0.28	0.36	280,346.08
Dimensions of AC									
Absorptive effort	73	132	1,084,146	0.20 (.000)	14.76	0.01	0.18	0.23	17,732.39
Absorptive knowledge base	46	87	68,924	0.44 (.001)	3.20	0.15	0.15	0.73	99,485.14
Absorptive process	54	94	22,138	0.47 (.000)	15.91	0.03	0.41	0.53	2,033.10
Other AC dimensions	62	117	1,071,292	0.20 (.000)	12.60	0.02	0.17	0.23	19,496.02
Outcomes of AC									
Knowledge acquisition	31	55	18,272	0.32 (.000)	8.95	0.04	0.25	0.39	1,181.07
Innovation generation	88	178	1,045,880	0.38 (.000)	9.90	0.04	0.30	0.46	216,122.92
Firm performance	68	116	474,053	0.27 (.000)	14.02	0.02	0.23	0.31	6,441.82
Other outcomes	43	81	708,295	0.23 (.000)	14.23	0.02	0.20	0.26	8,748.93
Dimensions → outcomes									
Absorptive effort → knowledge acquisition	6	8	2,231	0.32 (.002)	3.17	0.11	0.12	0.53	143.65
Absorptive effort → innovation generation	38	57	912,379	0.21 (.000)	10.21	0.02	0.17	0.25	12,298.72
Absorptive effort → firm performance	21	31	35,649	0.20 (.000)	4.94	0.04	0.12	0.29	1,031.45
Absorptive knowledge base → knowledge acquisition	7	9	6,837	0.27 (.009)	2.60	0.11	0.06	0.48	371.88
Absorptive knowledge base → innovation generation	20	36	41,037	0.65 (.000)	3.57	0.21	0.23	0.99	26,660.43
Absorptive knowledge base → firm performance	17	27	8,923	0.25 (.000)	6.77	0.04	0.18	0.33	289.35
Absorptive process → knowledge acquisition	13	16	2,898	0.47 (.000)	11.00	0.05	0.38	0.56	85.65
Absorptive process → innovation generation	22	30	7,401	0.53 (.000)	10.32	0.06	0.42	0.65	686.49
Absorptive process → firm performance	26	35	8,955	0.43 (.000)	8.41	0.05	0.32	0.53	858.61

Note: K = number of effect sizes; $r_{\bar{c}}$ = mean effect size for measurement error–corrected correlations; $SE_{r_{\bar{c}}}$ = standard error of $r_{\bar{c}}$; CI = confidence interval; Q = Cochran's homogeneity test (all Q values are significant at $p = .000$); AC = absorptive capacity.

greater (z test for difference [0.03]: $p = .420$) than the mean effect size of *absorptive knowledge base* ($r_{\bar{c}} = 0.44$). Furthermore, the mean effect size of *absorptive knowledge base* is significantly greater (z test for difference [0.24]: $p = .057$) than the mean effect size of *absorptive effort*. Therefore, although *absorptive effort* is the most commonly used AC dimension, it has the lowest mean effect size.

One explanation for the highest effect size of *absorptive process* could be that this dimension is about current organizational practices, especially those that emphasize the conversion of individual knowledge to organizational knowledge. In contrast, *absorptive effort* focuses on knowledge-building endeavors that are more future oriented, so it may take some time before all benefits become apparent. *Absorptive knowledge base* is built on foundations that are more past oriented, and it has greater path dependency, which is helpful when external knowledge is related but less so when external knowledge is unrelated. One alternative explanation is that studies that measure *absorptive process* are all survey based, and they may capture more aspects of AC with their measurement instruments than simply the learning process aspect.

Overall AC and Firm Outcomes

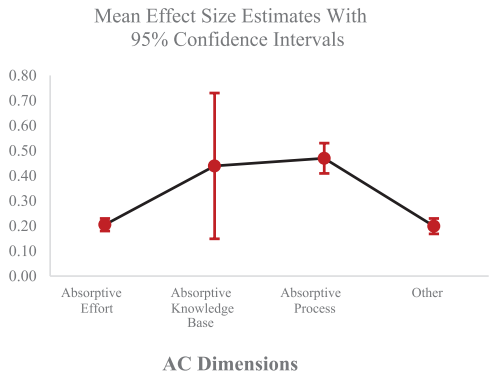
Research Question 2 focuses on AC outcomes. Among the various firm outcomes examined, *innovation generation* is the most frequently examined outcome in our sample. As shown in Table 3, the effect of AC is the highest on *innovation generation* ($r_{\bar{c}} = 0.38$) and is the lowest on *firm performance* ($r_{\bar{c}} = 0.27$). Its effect on *innovation generation* is greater than its effect (z test for difference [0.06]: $p = .128$) on *knowledge acquisition* ($r_{\bar{c}} = 0.32$) or its effect on *firm performance* (z test for difference [0.11]: $p = .008$). Furthermore, its effect on *knowledge acquisition* is greater (z test for difference [0.05]: $p = .132$) than its effect on *firm performance*.

AC Dimensions × Firm Outcomes

To answer Research Question 3, we next examined the differential effects of AC dimensions on AC outcomes. As shown in Table 3, we find that all three AC dimensions have the smallest effect sizes when predicting *firm performance.* In addition, we find that *absorptive effort* has a greater effect size (z test for difference [0.11]: $p = .153$) when predicting *knowledge acquisition* ($r_{\bar{c}} = 0.32$) than when predicting *innovation generation* ($r_{\bar{c}} = 0.21$), while *absorptive knowledge base* has a greater effect size (z test for difference [0.38]: $p = .056$) when predicting *innovation generation* ($r_{\bar{c}} = 0.65$) than when predicting *knowledge acquisition* ($r_{\bar{c}} = 0.27$). *Absorptive process* has similar effect sizes when predicting *innovation generation* ($r_{\bar{c}} = 0.53$) and *knowledge acquisition* ($r_{\bar{c}} = 0.47$; z test for difference [0.06]: $p = .197$). While comparing all AC dimension–AC outcome pairs, we find that *absorptive knowledge base–innovation generation* pair has the largest effect size ($r_{\bar{c}} = 0.65$). Figures 1-3 show a comparison of mean effect sizes based on different AC dimensions (Figure 1), outcomes (Figure 2), and dimensions-outcomes combinations (Figure 3).

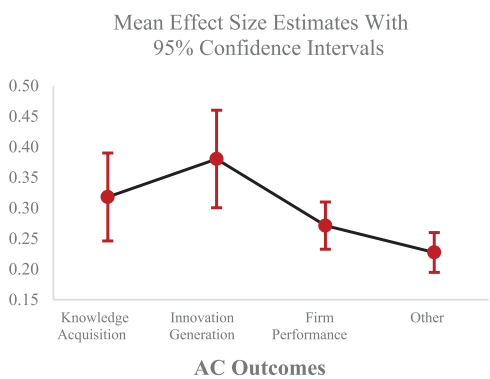
One explanation for the finding that *absorptive effort* is more strongly associated with *knowledge acquisition* but *absorptive knowledge base* is more strongly associated with

Figure 1
Effect Size Comparison Based on AC Dimensions



Note: AC = absorptive capacity.

Figure 2
Effect Size Comparison Based on AC Outcomes

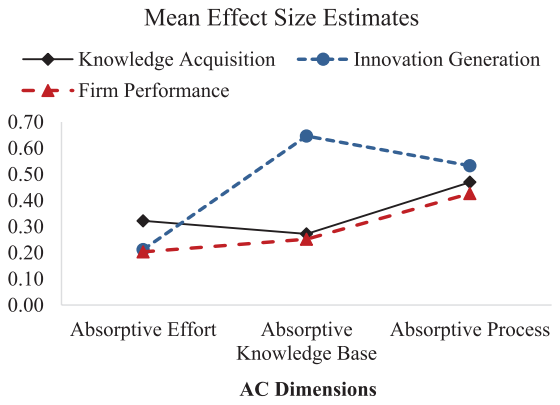


Note: AC = absorptive capacity.

innovation generation could be that for knowledge acquisition, the need for a more open mind-set and the motivation and eagerness to search for new external knowledge assume greater importance, but in innovation generation, the role of ability to transform and exploit external knowledge assumes greater importance. Prior research (Ahuja & Lampert, 2001; Srivastava & Gnyawali, 2011) suggests that firms with a stronger knowledge base exhibit greater resistance to external knowledge, particularly knowledge that is distant to them, whereas firms making greater technological efforts exhibit more willingness to search and learn new external knowledge.

Since *knowledge acquisition* and *innovation generation* together indicate the value creation effects of AC and *firm performance* indicates the value capture effects of AC, it is

Figure 3
Effect Size Comparison Based on AC Dimensions and Outcomes



Note: AC = absorptive capacity.

possible that value creation effects precede value capture effects, which may explain why AC dimensions have the lowest effects on *firm performance*. Accordingly, we further examined whether the effects of the three AC dimensions on *firm performance* were mediated through *knowledge acquisition* and *innovation generation.* We used the MASEM procedure to conduct this mediation analysis. As shown in Table 4, we find that 61.54% of the total effect of *absorptive effort* and 53.85% of the total effect of *absorptive process* on *firm performance* are mediated through *knowledge acquisition* and *innovation generation*. In contrast, the effect of *absorptive knowledge base* on *firm performance* is fully mediated through *knowledge acquisition* and *innovation generation*. One explanation for this finding could be that *absorptive knowledge base* itself does not play a direct role in the production function, so benefiting from it requires that it first be utilized in value-creating activities. Figure 4 depicts the results of MASEM analysis.

Moderators in the AC-Firm Outcome Relationship

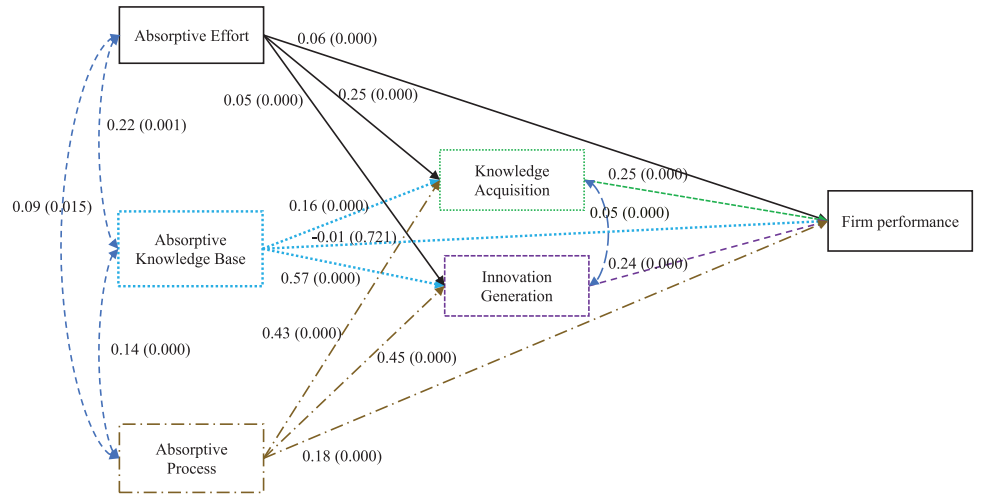
We used the MARA procedure to answer Research Question 4, which asks to what extent the effects of AC differ by governance modes, learning sources, and knowledge types. Table 5 shows the results of the moderation tests. In terms of *governance mode*, the coefficient of *M&A* (base mode: *unspecified*) is negative and significant (Table 5: Model 4, $\beta = -0.17$, $p = .002$). In comparison with the other modes, we find that the coefficient of *M&A* is also significantly lower than the coefficients of *alliance* ($\beta = -0.04$, $p = .024$) and *informal network* ($\beta = 0.04$, $p = .002$). Since M&A and alliance are often considered alternative governance modes, this finding is particularly interesting. Although M&A provide greater ownership and control, the process of M&A often disrupts organizational routines; therefore, this finding is consistent with our expectations. In addition, we find that the coefficient of *market transaction* is negative (Model 4, $\beta = -0.06$) and significant at $p = .086$ (base mode: *unspecified*). The coefficient of *market transaction* is also signifi-

Table 4
Meta-Analytic Structural Equation Modeling Results

	Model 1: Direct effects				Model 2: Indirect effects				Model 3: Total effects					
	Coef	*SE*	*p*	*z*	Coef	*SE*	*p*	*z*	Coef	*SE*	*p*	*z*	Indirect effects,[a] %	R^2
Knowledge acquisition														.32
Absorptive effort	0.25	.01	.000	21.55					0.25	.01	.000	21.55		
Absorptive knowledge base	0.16	.01	.000	13.73					0.16	.01	.000	13.73		
Absorptive process	0.43	.01	.000	37.23					0.43	.01	.000	37.23		
Innovation generation														.62
Absorptive effort	0.05	.01	.000	5.65					0.05	.01	.000	5.65		
Absorptive knowledge base	0.57	.01	.000	65.71					0.57	.01	.000	65.71		
Absorptive process	0.45	.01	.000	52.58					0.45	.01	.000	52.58		
Firm performance														.31
Knowledge acquisition	0.25	.01	.000	18.13					0.25	.01	.000	18.13		
Innovation generation	0.24	.02	.000	12.56					0.24	.02	.000	12.56		
Absorptive effort	0.06	.01	.000	4.67	0.08	.01	.000	14.57	0.13	.01	.000	10.74	61.54	
Absorptive knowledge base	−0.01	.02	.721	−0.36	0.18	.01	.000	15.42	0.17	.01	.000	13.71	100.00	
Absorptive process	0.18	.02	.000	11.68	0.21	.01	.000	20.40	0.39	.01	.000	32.21	53.85	
Observations	5,267													
Overall model R^2	0.70													
RMSEA	0.00													
CFI	1.00													
Likelihood ratio test														
Baseline vs. saturated	9,180.70													
Model vs. saturated	0.00													

Note: coef = coefficient; RMSEA = root mean square error of approximation; CFI = comparative fit index.
[a]As a proportion of total effects.

Figure 4
Meta-Analytic Structural Equation Modeling Results



cantly lower than the coefficients of *informal network* (β = 0.04, p = .009) and *alliance* (β = –0.04, p = .089). This finding highlights the challenges of having rich interactions and knowledge exchange in most market transactions. The effect size of the *informal network* mode is significantly greater than the effect sizes of *M&A* and *market transaction*, as noted, although it is not significantly different (p = .340) from the effect size of *unspecified* mode. Last, we did not find any significant differences among *M&A, internal*, and *market transactions* governance modes.

Next, we compared the effect sizes of different learning sources. The effect size of *vertical* learning source is positive and significant (Table 5: Model 5, β = 0.16; p = .000) and is the highest. Furthermore, in comparison with the base learning source *unspecified*, the effect size of *university* (Model 5, β = –0.11, p = .031) is negative and significant, and the effect size of *horizontal* (Model 5, β = –0.05, p = .135) is negative but not significant. Both effect sizes do not differ significantly from the effect size of *intraorganizational* learning source. This finding that horizontal sources have lower effect sizes than vertical learning sources is consistent with our expectations, as the extent of cooperation and coordination with horizontal sources is usually lower than with vertical sources due to the presence of greater competitive tension in the horizontal relationships.

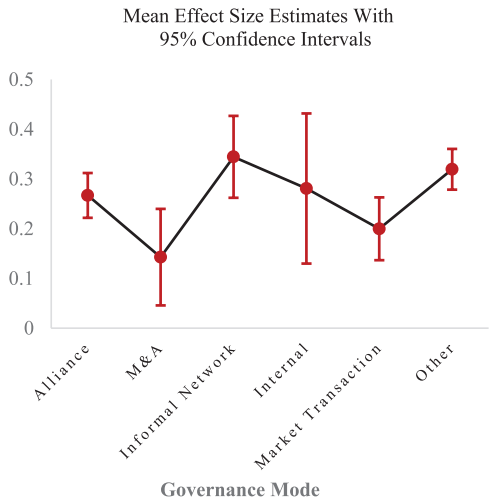
Finally, we examined how the effects of AC differ according to the knowledge type. The results show that the coefficient of *technological knowledge* is negative and significant (Table 5: Model 6, β = –0.07, p = .004). This finding shows that in comparison with nontechnological knowledge, absorbing technological knowledge is more challenging, as it probably involves a greater level of complexity and uncertainty. Figures 5-7 illustrate the comparison among different governance modes (Figure 5) and learning sources (Figure 6) and between knowledge types (Figure 7).

Table 5
Meta-Analytic Regression Analysis Results

	Model 1: Controls				Model 2: AC dimensions				Model 3: AC outcomes				Model 4: Governance mode				Model 5: Learning source				Model 6: Knowledge type			
Variables	Coef	*SE*	*p*	*z*	Coef	*SE*	*p*	*z*	Coef	*SE*	*p*	*z*	Coef	*SE*	*p*	*z*	Coef	*SE*	*p*	*z*	Coef	*SE*	*p*	*z*
Methodological and study artifacts																								
Panel data	−0.10	.04	.007	−2.68	−0.09	.03	.007	−2.72	−0.10	.03	.002	−3.04	−0.13	.04	.000	−3.55	−0.10	.03	.006	−2.76	−0.09	.03	.006	−2.73
IV or DV survey measure	0.18	.03	.000	6.39	0.13	.03	.000	4.40	0.13	.03	.000	4.18	0.08	.03	.011	2.56	0.06	.03	.055	1.92	0.05	.03	.157	1.42
Sample size	−0.00	.00	.404	−0.83	−0.00	.00	.708	−0.37	−0.00	.00	.789	−0.27	0.00	.00	.865	0.17	−0.00	.00	.935	−0.08	−0.00	.00	.636	−0.47
AC dimension (base: other AC dimensions)																								
Absorptive effort					0.04	.03	.153	1.43	0.05	.03	.078	1.76	0.02	.03	.588	0.54	0.02	.03	.443	0.77	0.03	.03	.293	1.05
Absorptive knowledge base					0.15	.03	.000	4.21	0.16	.03	.000	4.60	0.13	.04	.000	3.60	0.12	.03	.000	3.60	0.13	.03	.000	3.73
Absorptive process					0.17	.04	.000	4.61	0.19	.04	.000	5.16	0.16	.04	.000	4.41	0.15	.04	.000	4.07	0.15	.04	.000	4.33
AC outcomes (base: other AC outcomes)																								
Knowledge acquisition									0.05	.04	.215	1.24	0.05	.04	.222	1.22	0.04	.04	.333	0.97	0.04	.04	.373	0.89
Innovation generation									0.10	.03	.002	3.17	0.09	.03	.003	2.93	0.10	.03	.001	3.31	0.10	.03	.001	3.39
Firm performance									−0.01	.04	.880	−0.15	−0.01	.03	.839	−0.20	−0.01	.03	.820	−0.23	−0.02	.03	.539	−0.61
Governance mode (base: mode unspecified)																								
Alliance													−0.04	.03	.193	−1.30	−0.06	.03	.085	−1.72	−0.05	.03	.115	−1.58
M&A													−0.17	.06	.002	−3.08	−0.19	.05	.001	−3.41	−0.18	.05	.001	−3.27
Informal network													0.04	.04	.340	0.95	0.05	.04	.231	1.20	0.02	.04	.579	0.56
Internal													−0.03	.05	.573	−0.56	−0.06	.09	.482	−0.70	−0.04	.09	.653	−0.45
Market transaction													−0.06	.04	.086	−1.72	−0.13	.04	.001	−3.47	−0.12	.04	.002	−3.08
Learning source (base: source unspecified)																								
Vertical																	0.16	.04	.000	4.00	0.14	.04	.000	3.56
Horizontal																	−0.05	.04	.135	−1.50	−0.05	.04	.211	−1.25
Intraorganization																	0.04	.07	.630	0.48	−0.00	.07	.975	−0.03
University																	−0.11	.05	.031	−2.16	−0.09	.05	.097	−1.66
Knowledge type (base: nontechnological knowledge)																								
Technological knowledge																					−0.07	.03	.004	−2.88
Constant	0.18	.03	.000	7.32	0.13	.03	.000	4.30	0.08	.04	.037	2.08	0.17	.05	.001	3.47	0.18	.05	.000	3.78	0.24	.05	.000	4.58
Observations	430				430				430				430				430				430			
Log likelihood	−17				−3				6				12				25				29			
Wald's χ^2	90				126				149				166				203				215			

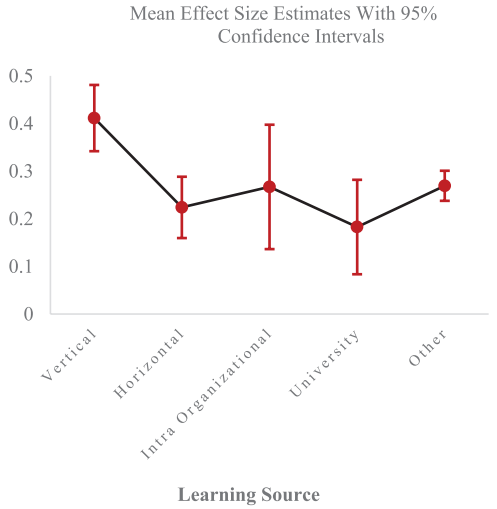
Note: AC = absorptive capacity; coef = coefficient; IV = independent variable; DV = dependent variable; M&A = mergers and acquisitions.

Figure 5
Mean Effect Size Comparison Based on Governance Modes



Note: M&A = mergers and acquisitions.

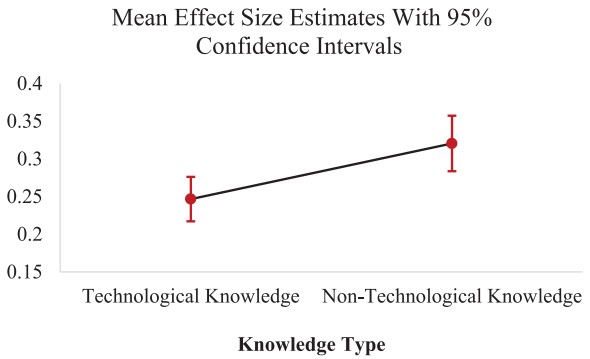
Figure 6
Mean Effect Size Comparison Based on Learning Sources



Robustness Checks

To ensure the robustness of our findings, we conducted the following additional analyses. First, to adjust for influences from potential outliers, we used the sample-adjusted meta-analytic deviancy statistic method (Beal, Corey, & Dunlap, 2002). We identified 13 outliers

Figure 7
Mean Effect Size Comparison Based on Knowledge Type



and conducted HOMA using the reduced sample. We report these results in Appendix E (see online supplement). These results are largely consistent with our primary results; the only notable change is that the effects of AC on knowledge acquisition and innovation generation become similar ($r_{\bar{c}} = 0.32$ and $r_{\bar{c}} = 0.33$, respectively). Second, as an alternative to bivariate correlations, we used the partial correlation coefficient ($r_{xy.z}$), which factors the effects of other variables in the model (van Essen et al., 2015). We computed $r_{xy.z}$ following the approach used by Carney, Gedajlovic, Heugens, Van Essen, and Van Oosterhout (2011). Because of missing information on *t* statistics and degrees of freedom, the sample size was reduced to 109 studies and 193 coefficients. In Appendix F (see online supplement), we report the results of HOMA using the sample based on partial correlation coefficients. According to these results, the sign and pattern of the effect sizes remain largely consistent with our primary results, but the magnitude of the effect sizes decreases. In addition, the effect of AC on *knowledge acquisition* ($r_{\bar{c}} = 0.08$, $p = .004$) becomes lower than its effect on *firm performance* ($r_{\bar{c}} = 0.14$, $p = .000$), and the effect size for the *absorptive effort–knowledge acquisition* pair ($r_{\bar{c}} = -0.04$, $p = .189$) becomes negative and lower than the effect size of the *absorptive effort–innovation generation* pair ($r_{\bar{c}} = 0.14$, $p = .000$). The limited number of studies that examine these relationships could be a key reason for the inconsistent results.

Third, to overcome the limitation of using EBSCO Business Source Complete as a single search engine, we further duplicated our literature search process and used the same selection criteria using the ABI/INFORM Collection database and found 19 additional papers that did not show up in the EBSCO search results. In Appendix G (see online supplement), we report the results that are based on the sample that includes these additional studies. These results remain largely consistent with our primary analysis. Last, to ensure that our results are not biased by the publication status, we also obtained unpublished studies and working papers by searching doctoral dissertations and the Academy of Management conference proceedings. We added 26 unpublished studies to our sample and report HOMA results in Appendix H (see online supplement). These findings are largely consistent with our primary findings.

Discussion and Implications for Future Research

The rapid growth of research on AC underscores the increasing importance of the concept. Our review of the literature, however, shows that the rapid growth has led to two fundamental problems: the *ambiguity problem* and the *effect problem*. The ambiguity problem is evident from the confusion regarding the meaning and nature of AC, as well as the persistent use of AC as a general purpose umbrella concept despite calls to view it as a multidimensional construct. The effect problem resulted from the lack of explicit attempts to systematically assess the extent to which AC matters, and the problem is exacerbated by the inconsistent findings on the effect of AC on firm outcomes and by the use of same measures for different things. These two problems are interrelated: conceptual ambiguity with loose theorizing and the use of a variety of measures without a thoughtful connection to the theory have inhibited deep empirical investigation, and the lack of meta-analytic synthesis of empirical findings begs the theoretical question of whether and in what ways AC matters for firm outcomes. More broadly, these problems have raised construct validity concerns, inhibited the development of cumulative knowledge, and hampered rigor in conceptual and empirical research. This paper was motivated by these fundamental problems.

Our review is different from prior reviews in two important ways. First, in contrast to prior reviews that were primarily conceptual, we took a two-pronged approach—conceptual distillation and empirical synthesis—to address the two interrelated problems. Second, we distilled and consolidated current theoretical insights on the multidimensional nature of AC and explicated the underlying dimensions, including their theoretical roots, functions, and mechanisms. More important, we established correspondence between the theoretical dimensions and empirical measures, assessed the empirical state of the literature, and synthesized key findings. Overall, our paper provides a strong basis for future research with greater conceptual and empirical precision.

Contributions

We articulate a few core contributions before discussing research implications stemming from this paper. First, this paper provides a much-needed clarity to the conceptualization of AC. Our conceptual discussion clearly lays out (as summarized in Table 1) the functional role as well as the primary and secondary mechanisms of each dimension. This articulation helps to understand why we observe differential effects of AC on different outcomes. Our theoretical grounding of each mechanism, by illustrating the foundational literature and how subsequent research has contributed to the development of each dimension, provides a basis for further theoretical exposition of the dimensions in future research. Our articulation of the three dimensions and their unique features, as well as our mapping the measures to these dimensions, helps to increase the correspondence between theory and measures of AC.

Second, our meta-analytic synthesis of empirical findings and the patterns in those findings show that AC does indeed matter for firm outcomes, and the extent to which it matters depends on the dimension of AC and the outcomes examined. The results from the factor analysis, coupled with the theoretical insights about unique nature and role of each dimension, underscore the need to take a dimensional approach to empirical research. Future researchers can use our findings as a starting point to further articulate the role of each dimension and empirically examine its effects. Stronger effects of AC dimensions on

knowledge acquisition and innovation generation than on firm performance indicate a possible distinction between value creation and value capture effects of AC. Future empirical research examining the specific dimensions and their effects could dig deeper into these distinctions.

Third, our articulation of the key contingency conditions brings to the fore the original conceptualization of AC as an ability to leverage external knowledge, which is often neglected in the empirical literature. We identified and explained key contingencies of governance mode, learning source, and knowledge type. Our findings do indicate that AC's effects on firm outcomes vary across these contingencies and suggest the importance of examining external knowledge contingencies in future research. We believe that our theoretical exposition of the key dimensions and their roles, coupled with the meta-analytic synthesis of the effects of AC, provides a strong foundation for more precise theorizing and empirical research, which in turn will help develop cumulative knowledge on AC.

Implications for Future Research

We briefly explain how insights from this paper contribute to theoretical and empirical precision in future AC research in four key ways: taking a multidimensional approach to AC, matching conceptualizations and measures of AC, exploring AC mechanisms, and examining external knowledge contingencies. We have articulated three distinct dimensions of AC: absorptive effort, absorptive knowledge base, and absorptive process. We have explicated how each dimension, though a part of the broader construct of AC, is theoretically distinct from the other two, and we have empirically demonstrated how the effectiveness of each dimension varies across firm outcomes. Accordingly, we underscore the importance of taking a multidimensional approach to AC, and we provide the theoretical and empirical bases for doing so. Recognizing the conceptual and empirical distinctions among the three AC dimensions will be helpful in improving the precision in theory building and answering some of the fundamental questions regarding how, why, when, and to what extent AC matters. A full-scale multidimensional empirical study, however, could be challenging. Future research that focuses on one or two dimensions of AC can still provide richness by explicitly recognizing the trade-offs involved and then digging deeper into the unique nature and role of the dimension examined.

The effect problem arising from the weak correspondence between theorizing and the empirical measures, as evidenced by the use of the same measures as antecedents and outcomes of AC, and the use of diverse measures without a clear connection with the theory has hampered research progress. We addressed this effect problem by specifying measures (Table 2) that correspond to the different dimensions of AC. The choice of AC measure should be driven by the theoretical specification. We emphasize that operationalizing AC using measures in a consistent manner will be critical in developing a coherent body of knowledge. Furthermore, it is important to address the issue of measurement error. We found that the average corrected effect size was 0.23 when independent variables were measured with the survey method but that the average corrected effect size increased to 0.39 when dependent variables were also measured with the survey method. Similarly, when only independent variables were measured through patents, the average corrected effect size was 0.07, but when dependent variables were also measured with patents, the average corrected effect size increased to 0.40. Such errors can contribute to misleading results.

AC studies often pay little attention to the mechanisms through which the effects of AC occur. Knowing how and why an effect occurs is fundamental to understanding a phenomenon. For improving theoretical precision, it is important for future research to specify the AC mechanisms connecting AC with the outcome variables. In addition, theoretical explanations cannot be realized without subjecting the mechanisms themselves to empirical tests. Accordingly, we highlight a wonderful opportunity to develop an *AC mechanism–focused research stream*. An important line of inquiry within this stream can focus on developing more relevant, reliable, and precise measures for AC mechanisms and subject those mechanisms to empirical tests. Another line of inquiry can focus on examining how those mechanisms connect AC dimensions to firm-level value-creating and value-capturing outcomes.

The theory of AC is fundamentally about moderation: The presence of AC affects the extent to which a firm can leverage external knowledge. However, many AC studies did not explicitly consider the role of external knowledge conditions. This problem worsens when AC is viewed as a strategic asset "that enhances the performance effects of firm capabilities" (Patel, Terjesen, & Li, 2012: 204) or as a dynamic capability that can modify other organizational capabilities. We note that this line of argument draws from the resource-based view rather than AC, ignores the core of AC as a potential enabler of external learning, and contributes to the persistence of the ambiguity problem noted earlier. A key difference between the theory of AC and the theory of the resource-based view lies in the specification of external knowledge–oriented learning. The three important aspects of external knowledge—*learning source, governance mode*, and *knowledge type*—that we explicate bring back external knowledge contingencies to the core framework of AC and open up opportunities to develop an *external knowledge–focused research stream*. Opportunities exist for rich theoretical development and empirical research by simultaneously considering the impact of different AC dimensions and their theorized mechanisms with external knowledge conditions. The explicit attempt to capture external knowledge conditions, their interactions with AC dimensions, and how such interactions influence firm outcomes would help develop a richer theory of AC.

In conclusion, this paper set out to address the twin problems of conceptual ambiguity and lack of cumulative evidence on the effect of AC on firm outcomes. We addressed the ambiguity problem by systematically distilling the literature, by explicating the key dimensions of AC and corresponding measures, and thereby showing how a multidimensional approach would increase theoretical and empirical precision. We addressed the effect problem by synthesizing the empirical findings using meta-analytic techniques, by showing that AC matters positively for firm outcomes, and by showing differential effects of AC dimensions on different firm outcomes. We believe that this paper provides deeper conceptual insights about the multidimensional nature of AC, paves the way for a dimensional approach to theorizing and empirical research, and thereby facilitates more rigorous research that will allow for cumulative knowledge development on this important topic.

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