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Absorptive capacity at the individual level: an ambidexterity approach to external engagement

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Abstract

The ability of an individual to capture knowledge from outside the firm is a critical element in the development of an organization?s absorptive capacity. Despite the acknowledgement that individuals are central to absorptive capacity, researchers have tended to overlook the roles that individuals play in exploring, assimilating and exploiting external knowledge. By defining and measuring absorptive capacity at the individual level, we seek to enrich our understanding of how individuals learn from external knowledge and how such efforts shape the ability of an individual to contribute to their organization?s innovative efforts. We posit that knowledge assimilation plays a vital role in gaining from exploring and exploiting external knowledge. That is, we argue that individuals? performance to develop innovations not only

benefits from making efforts on a single dimension of absorptive capacity, but rather thrives when individuals combine efforts to explore, assimilate and exploit external knowledge. Using rich data from a large group of R&D scientists and their engagement with external sources of knowledge, we find support for our hypotheses.

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THE CRAFT OF OPENNESS:

ABSORPTIVE CAPACITY AT THE INDIVIDUAL LEVEL AND INNOVATION

Abstract - Despite the acknowledgement that individuals are central to absorptive capacity, researchers have tended to overlook the roles that individuals play in absorbing external knowledge. By probing absorptive capacity at the individual level, we seek to enrich our understanding of how individuals learn from external knowledge and how such efforts shape their ability to innovate. We argue that individuals gain a combinatorial advantage by engaging in multiple components of absorptive capacity. In particular, we theorize – and empirically substantiate - that knowledge assimilation plays a critical role in enabling individuals to gain from the use of external knowledge. Drawing upon rich data on R&D scientists, we find support for our hypotheses.

"The firm's absorptive capacity depends on the individuals who stand at the interface of either the firm and the external environment or at the interface between subunits within the firm."
(Cohen & Levinthal, 1990: 132)

In Cohen and Levinthal's (1990) seminal paper on absorptive capacity, individuals were seen to be at the frontlines of allowing organizations to learn from external sources of knowledge. Fundamentally, the absorptive capacity of a firm depends on the ability of its members to recognize valuable external knowledge in the environment, align it with existing organizational capabilities and promote its utilization within the organization. Subsequent research, however, has largely overlooked the role of individuals in developing, deploying, and maintaining a firm's absorptive capacity. Instead, research has focused mainly on the firm level, often using crude measures to approximate it. In a review of the literature on absorptive capacity, Volberda, Foss and Lyles (2010) come to the conclusion that individual-level antecedents are relatively neglected in the literature (see also Foss, Laursen, & Pedersen, 2011), although they constitute an essential building block of this concept in the field of organization research (Lane, Koka, & Pathak, 2006). As yet, we lack a clear understanding about the role that individuals play in effectively absorbing external knowledge.

Long before the development of the concept of absorptive capacity, the study of innovation had been concerned with how individuals, and subsequently their organizations, learn from external sources of knowledge. Indeed, Nelson and Winter (1977) described how R&D expenditures could be seen as an investment in search, arguing that most search efforts were 'local' in orientation in terms of their technological and organization scope. In this context, individuals and organizations tend to rely on internal knowledge, as such knowledge is accessible, safe and well aligned to the capabilities of the organization (March, 1991). Yet it is also clear that external knowledge itself may provide greater prospects for the combination and recombination of knowledge and therefore innovation (Fleming & Sorenson, 2004; Rosenkopf & Nerkar, 2001). The challenge, then, is how organizations can successfully encourage and enable its employees to absorb external knowledge.

At the core of our understanding of the role of individuals of learning from external sources is the work of Allen (1977), who demonstrated that some individuals inside the organization – what he called 'technological gatekeepers' – were critical to the use of external knowledge in the innovation process. Technological gatekeepers act as funnels of information from external to internal sources. Critically, Allen saw the role of the technological gatekeeper primarily as an information transfer role, whereby gatekeepers passed external information to internal colleagues. Although this work demonstrated the critical role of technological gatekeepers in bringing in and passing on external knowledge, it left much of

the internal processes of transforming and utilizing this knowledge unexplored. It is clear that other individuals - playing different roles - transform external knowledge into a format that is usable and exploitable by the organization (Harada, 2003).

Taken together, our understanding of the ways in which individuals harness, assimilate and utilize external knowledge to facilitate the innovation process remains incomplete. Although it is understood that external sources are important to the innovation processes (Laursen & Salter, 2006; Leiponen & Helfat, 2010), we still lack a clear understanding of the role of individuals in facilitating the development of an organization's absorptive capacity. Our current image of individual roles is tied to concepts about technological gatekeepers, and do not offer a complete picture of how individuals reshape and champion external knowledge to ensure its absorption by the wider organization. It remains an open question what roles individuals take in the process of absorbing knowledge into the organization, and how these different roles and efforts shape their ability to generate innovations for their organizations. Do individuals cover the full range of activities from the identification of external knowledge through its assimilation to its utilization, or do they rather take on specialized roles as 'identifiers', 'assimilators' or 'utilizers'? In addition, what are the performance implications for individuals wearing multiple 'hats' in the process of absorbing external knowledge? We still know very little about the potential synergetic effects of combining tasks across the various dimensions of absorptive capacity.

Therefore, this study focuses on the role of individuals in identifying, assimilating and utilizing external knowledge, addressing what Volberda et al. (2010) argue is a pressing need for our understanding of absorptive capacity. Using an inductive approach based on interviews with R&D scientists and a careful reading of the literature, we develop a definition of absorptive capacity at the individual level, illustrating the efforts individuals undertake to identify, assimilate and utilize external knowledge. This approach allows us to construct a new measurement scale of the individual-level components of absorptive capacity. In turn, we use a large-scale and detailed survey of R&D scientists and engineers in a large diversified multinational to explore the predictive validity of this new scale, examining how efforts of individuals to identify, assimilate, and utilize external knowledge individually contribute to their innovation performance. In addition, we examine the existence of potential synergetic effects of combining efforts of absorptive capacity along multiple dimensions.

Our study makes two contributions to our understanding of absorptive capacity. First, we unpack absorptive capacity at the individual-level, delineating the mechanisms that enable individuals' to successfully identify, assimilate and utilize of external knowledge. Most notably, we postulate that championing (Howell & Higgins, 1990) may be conceived as the individual-level derivative of the

utilization dimension of absorptive capacity as defined by Cohen and Levinthal (1990) and Lane and Lubatkin (1998). Second, we enrich understanding of the roles that individuals play in absorbing external knowledge and the performance implications for them in taking up these roles. We argue that individuals gain a combinatorial advantage by engaging in multiple components of absorptive capacity. While the existing literature at the organizational level gives little account of the middle component of assimilation, we maintain – and empirically substantiate - that this component critically shapes the value of the individuals' identification and utilization efforts.

THEORY AND HYPOTHESES

As Cohen and Levinthal (1990) state, the task of bringing in, processing and utilizing external knowledge in organizations falls to individuals. Staying close to the original logic of the organizational level concept as defined by Cohen and Levinthal (1990) and Lane and Lubatkin (1998), we define individual-level absorptive capacity as the level of effort that individuals undertake to identify external knowledge, assimilate it and utilize it to commercial ends. Although we acknowledge that organizational antecedents play a crucial role in determining absorptive capacity at the firm level, individual efforts constitute important building blocks of organizational absorptive capacity that have to date received limited scholarly attention (Foss et al., 2011; Volberda et al., 2010).

The identification and subsequent acquisition of external knowledge is generally agreed to be the first building block of absorptive capacity (Cohen & Levinthal, 1990; Lane et al., 2006; Zahra & George, 2002). Identifying potentially useful external knowledge is fundamentally a search process, requiring efforts from members of an organization to monitor, scan and explore the wider technological and market environment (Hambrick, 1982; Levinthal & March, 1981). Of course, such efforts are costly in terms of organizational resources, as individuals need to be given time and space to keep track of emerging developments, to monitor changing market demands and technological opportunities, and actively participate in external networks (Cockburn & Henderson, 1998; Katila & Ahuja, 2002; Laursen & Salter, 2006). Nor are efforts to identify external knowledge routine for all members of R&D departments. Despite current trends towards open models of innovations, many R&D scientists still rely predominantly on internal sources of knowledge, as transferring knowledge within the organization remains much easier than transferring it across organizations (Kogut & Zander, 1992). To help encourage engagement with external sources, some organizations assign individuals to the role of capturing external knowledge, such as dedicated knowledge scouts or gatekeepers (Allen & Cohen, 1969).

Although there are multiple ways in which a firm can sense developments in its environment and seize the relevant external knowledge from it, the task of monitoring the environment and recognizing valuable

opportunities eventually falls to individuals. Scientists and engineers in a typical R&D department are liable to actively searching the external environment for ideas, knowledge or technologies that may hold valuable opportunities for their home organization (Howell & Shea, 2001). They may actively study patent databases, attend scientific conferences and trade fairs or read technical literature in order to keep up-to-date with what happens in the world around them (Allen, 1977; Gibbons & Johnston, 1974). They may also be members of communities of practice (Brown & Duguid, 1991), engage in standard-setting platforms (Rosenkopf, Metiu, & George, 2001), and draw on their personal networks (Powell, Koput, & Smith-Doerr, 1996) to expose themselves to potentially valuable external knowledge. Moreover, individuals also play a key role in acquiring external knowledge in inter-organizational relationships (Nooteboom, 1999). In informal collaborations, such as projects with universities, it is likely to be individuals that initiate and manage the relationship with the external party (Dodgson, 1993). In formal collaborations, individuals will also need to stay alert for useful ideas and promising technologies arising from the collaboration.

There are two reasons why individuals that pro-actively search the external environment are more likely to generate innovations than those individuals that make lower levels of effort to search externally. Firstly, as research on entrepreneurial activity demonstrates, the alertness of individuals to opportunities is a critical part of their ability to generate new business concepts and products (Ardichvili, Cardozo, & Ray, 2003; Gaglio & Katz, 2001; Kirzner, 1973). Alert individuals aggressively look for useful ideas, often in unusual places. They monitor developments across a broad range of sources, as they are often looking for ideas that differ from the conventional logic of their industry or organization (Kaish & Gilad, 1991). They may also be seeking creative ways to bring together new ideas with existing knowledge. In the context of R&D, individuals who devote time and effort to actively scanning the external environment are likely to be in a better position to identify useful opportunities than their colleagues who make more modest efforts at external search and who instead rely on internal search. Secondly, the stronger the individual effort to actively search for external knowledge, the larger is their search space and the more likely they are to identify valuable external knowledge that may be combined with internal knowledge in a novel way (Fleming & Sorenson, 2001; Galunic & Rodan, 1998; Kogut & Zander, 1992). In contrast, individuals that make less on effort to search externally may tend toward proximal, domestic sources of knowledge, which could afford fewer opportunities for combinatorial novelty. Thus,

> *H1: Individuals' effort to identify external knowledge is positively associated with their innovative performance.*

The literature on absorptive capacity is divided on the number of dimensions the concept embodies, as some studies define separate assimilation and transformation phases, whereas others capture those in a single dimension. Despite this disagreement, all influential works in the field recognize the need for the assimilation, transformation or integration of external knowledge as a crucial step towards its application in novel products, processes or technologies (Cohen & Levinthal, 1990; Lane et al., 2006; Zahra & George, 2002). Fundamentally, any addition of new knowledge to a firm's knowledge base – be it emanating from internal or external sources – requires efforts of assimilation with a firm's existing expertise, skills and competencies. Indeed, the knowledge-based view of the firm (Grant, 1996a, b) places critical importance to knowledge integration, as this theory portrays the firm as the natural setting in which knowledge held by specialist individuals can be integrated and transferred at relatively low cost and low risk. Accordingly, individual members of an organization need to add their specialist expertise to the common pool of knowledge held by a firm, and therefore assimilation is required for successful accumulation of knowledge to happen.

The challenge of assimilating new knowledge to existing knowledge is exacerbated if it comes from an *external* source. In the first instance, external knowledge is likely to be incompatible with internal knowledge, as it is not formulated in the company's internal jargon and does not align with existing organizational categories (Lane & Lubatkin, 1998). Along those lines, Cohen and Levinthal (1990: 135) noted: "to integrate certain classes of complex and sophisticated technological knowledge successfully into the firm's activities, the firm requires an existing internal staff of technologists and scientists who are both competent in their fields and are familiar with the firm's idiosyncratic needs, organizational procedures, routines, complementary capabilities and extramural relationships". That is, external knowledge can rarely be directly mapped onto a firm's existing product groups, processes, and core technological competences. As a result, it is not always immediately apparent if and how external knowledge can bring value to a firm. Thus, it requires effort of individual 'assimilators' to connect additional knowledge to internal knowledge, and to find out how it may be recombined with what the organization already knows and can do. Moreover, rarely do external innovations come 'ready-made', nor can they be easily treated as 'plug-and-play' technologies that can quickly and easily be assimilated by the host organization. As Cohen and Levinthal (1990: 134) put it: "a critical component (…) for certain types of information, such as those associated with product and process innovation, is often firm-specific and therefore cannot be bought and quickly integrated into the firm". In other words, it is only when individuals make the effort to assimilate external knowledge with internal knowledge and processes that the potential of external knowledge can be realized and therefore translated into new products, process and services (Zahra & George, 2002).

To explore this assimilation process, we identify two main mechanisms of knowledge assimilation in which individuals are essential and which are directly related to their ability to generate useful innovations for their organizations. First, individual R&D scientists need to transform external knowledge to give it a 'local feel', grafting it with the organization's language and culture. This may involve transforming external ideas into the organization's categories, putting the idea into a format that can be reviewed and judged against other internal ideas in internal selection mechanisms, such as stage-gate processes (Cooper, 1990). One aspect of this transformation process is building an assessment of its market potential for the host organization, a role that only a person with deep knowledge of the organization's routines, expectations and capabilities will be able to perform. Moreover, individual R&D scientists may need to rework an externally developed prototype to demonstrate its technical feasibility. In addition, they may have to analyze and document the Intellectual Property related to an external invention and/or assess how the technology can be scaled up to be exploited in a large multinational. If any of these elements are missing, the external idea is likely to be rejected, as it would fail to meet the requirements of the internal selection process for new product or process developments.

Second, as a precursor to its subsequent application, external knowledge needs to be shared among colleagues and diffused across the wider organization (Hansen, 1999; Jansen, van den Bosch, & Volberda, 2005). This requires individuals to repackage and translate the original external knowledge in such ways that it can move across different boundaries within the firm (Dougherty, 1992). An important element of this transfer process is individuals' effort to engage their peers and try to enthuse them about the potential of the external knowledge. In many cases, external knowledge is by itself incompletely formed and therefore individuals will need to construct an appealing story about its value and merits that will convince others within the organization, often from different departments and functional areas, to further develop the idea. This 'story' will need to speak to the organization's internal logic - its history, its understanding of itself and its position in the market, and its ways of working (Lane & Lubatkin, 1998; Van de Ven, 1999). Given these two mechanisms, we argue that individuals who make greater efforts to assimilating external knowledge will be more successful in developing innovations for their organizations than those individuals who make lower levels of effort to assimilate external knowledge. Thus,

> *H2: Individuals' effort to assimilate the value of external knowledge is positively associated with their innovative performance.*

Once external knowledge has been assimilated to an organization's internal knowledge, it is ready to be applied in the development of new products, processes or technologies. While the literature on absorptive capacity implicitly describes the role of individuals in identifying and assimilating external knowledge, it

is largely silent on how individuals actually contribute to its application in new products, processes or technologies. We argue that champions of innovation (Howell & Higgins, 1990) play a crucial role in the utilization of external knowledge. Although knowledge may be assimilated by the firm, it still needs someone to advocate its application in innovative products or processes, to push it through internal assessments, and to overcome potential resistance of risk-averse managerial decision-makers (Andersson & Bateman, 2000). Although such championing behaviour is not specific for externally-generated inventions, selling an idea internally may be particularly necessary when the origins of the invention lay outside the firm, for example as a result of the Not-Invented-Here (NIH) syndrome (Katz & Allen, 1982).

Further, championing is of particular relevance for the utilization of external knowledge due to a lack of internal ownership of external ideas. An external idea may have no 'father' within the organization; i.e. an internal advocate that will work to prevent the invention ending up on the shelf. That is, the utilization of external knowledge requires someone who is passionate about the technology, can shepherd it through internal decision procedures, and can mould the views of senior management. Following the 'personality profile' that is portrayed in the championing literature, R&D scientists who pursue the utilization of external knowledge usually show a commitment to the external idea as if it was their own. They take risks to ensure the potential of external knowledge is realized (Howell & Higgins, 1990; Markham, 1998). Such efforts may require individuals to display a mixture of fervour, diligence and even guile. By undertaking such efforts, individuals can build momentum behind the idea, enabling the concept to migrate through different stages of internal selection to eventually reach the market or be implemented internally. Accordingly, those individuals who take up this role – actively pushing for the utilization of external knowledge – are likely to be more successful in generating innovations for their organization than individuals who adopt a more passive role towards the utilization of external knowledge. Thus,

> *H3: Individuals' effort to utilize external knowledge is positively associated with their innovative performance.*

We have argued that individuals' efforts to identify, assimilate and utilize external knowledge are positively associated with their innovation performance. However, the different roles that individuals take in this process have thus far been left unexamined. The literature on absorptive capacity has disregarded whether individuals contribute most strongly to their organization's absorptive capacity by taking on specialized roles as "identifiers", "assimilators" or "utilizers" or instead combine activities on multiple dimensions in order to contribute to absorbing external knowledge more effectively. As a result, it remains an open question what roles individuals take on in the process of absorbing knowledge into the

organization and how these different roles and efforts shape their ability to generate innovations for their organizations.

We argue that individuals gain a combinatorial advantage by engaging in multiple components of absorptive capacity. Staying close to the original logic in Cohen and Levinthal (1990), we surmise that knowledge assimilation plays a contingent role in how externally sourced knowledge is effectively recombined into innovative solutions (Kogut & Zander, 1992). The assimilation of external knowledge is, therefore, the 'glue' that adds the value to individuals' efforts to identify and utilize external knowledge. In other words, we suggest assimilation is a crucial building block for recombination, which may produce the most beneficial outcomes for innovation if it is combined with identification and utilization of external knowledge at the individual level.

There are strong reasons to suggest that individuals who combine the identification of external knowledge with its subsequent assimilation are likely to benefit from positive synergies. As stated in Hypothesis 1, active efforts to source external knowledge can help individuals to develop innovations. However, individuals will benefit more from their external search efforts, if they combine it with strong efforts to assimilate external knowledge. Synergy related to such 'identify-assimilate' combinations may come through two different mechanisms. First, high assimilation efforts may give a more targeted direction to an individual's external search activities, increasing the likelihood that external knowledge can be meaningfully applied to the development of innovations. Given the infinite size of the technological search space outside the organization's boundaries, individuals who can meaningfully reduce their search space when identifying external knowledge, will be more likely to spot opportunities that are valuable to the firm. Therefore, combining high levels of identification and assimilation may eventually lead to higher innovation performance. Second, even if identification and assimilation activities do not refer to the same piece of external knowledge, individuals who combine both activities in more general terms may still experience combinatorial advantages, as assimilation deepens the knowledge and awareness of what type of external knowledge the organization needs, helping individuals to develop a more refined filter when they actively scan the external environment for valuable knowledge.

In the same vein, individuals who combine efforts at the utilization of external knowledge with assimilation may also be able to gain synergetic benefits. Being involved in assimilation increases an individual's awareness of how external knowledge fits with the organization's existing capabilities and strategies. In turn, this helps an individual to build more compelling arguments on why the externally developed idea is worth further pursuing, enriching their story about the value of the idea to the organization. Second, champions involved in assimilation may tailor the assimilation process in such a

way that the chances of selling the externally generated idea to senior management at later stages of its development are increased. Indeed, champions are likely to develop tactics to mould the views of internal decision-makers and be capable of building coalitions of support to push an idea through internal stage-gate processes (Howell & Higgins, 1990). To ensure that the qualities of the idea itself are best suited for this process, individuals who combine the assimilation and utilization of external knowledge are able to shape the assimilation process in ways that will overcome barriers in the later utilization phase. Finally, involvement in the assimilation of external knowledge makes champions aware of the effort that was put into 'internalizing' external knowledge, which may increase their level of commitment and sense of ownership, which are both associated with successful championing behaviour.

In sum, we expect individuals who simultaneously wear multiple 'hats', combining the identification or utilization of external knowledge with its assimilation to outperform specialized 'identifiers', 'assimilators' or 'utilizers'. In other words, synergy across individuals' efforts to absorb external knowledge provides a premium on their ability to generate innovations. It is also true that some individuals may combine high levels of identification and utilization of external knowledge with low levels of assimilation. Even though we do not want to exclude the possibility that individuals gain from an 'identify-utilize' combination, we believe there is no strong *a priori* reason why individuals who combine these efforts would perform better than those who specialize in one dimension of absorptive capacity. Without the effort to assimilate the external knowledge, joining identification and utilization efforts are likely to produce knowledge of only limited value to the organization, as this knowledge will not fit internal requirements and categories. Thus,

> *H4a: Combining identification and assimilation in individuals' efforts to absorb external knowledge will be positively associated with their innovation performance.*
>
> *H4b: Combining assimilation and utilization in individuals' efforts to absorb external knowledge will be positively associated with their innovation performance.*

Individual R&D scientists may also show high levels of effort on all dimensions of absorptive capacity. We suggest that those individuals are able to benefit from greatest synergies across the complete knowledge absorption process, and as such may have the best chances to develop innovations. This is because these individuals simultaneously enjoy the synergetic effects of identify-assimilate and assimilate-utilize combinations. That is, individuals who combine strong efforts to identify and assimilate external knowledge and champion its internal use may be in the best position to steer their search activities towards knowledge with strong fit to the organization (i.e. easing assimilation), whilst at the

same time they may explicitly gear their assimilation activities in preparation for their dedicated championing efforts (i.e. easing utilization of external knowledge). Therefore, we posit:

> *H5: Combining identification, assimilation and utilization in individuals' effort to absorb external knowledge will be positively associated with their innovation performance.*

METHODS

Empirical setting

The research was undertaken in a large diversified multinational firm (which we will refer to as NEPTUNE) with global R&D efforts. The company operates a dual career ladder system in its R&D department that distinguishes between a management career ladder and a technical career ladder as individuals' progress up the organizational hierarchy. This study targeted all the members of the technical career ladder, which includes just over 600 senior scientists and engineers. These individuals play a leading role in product and process development, and have established track records in developing valuable innovations for the company.

Although its internal knowledge base is large and diverse, NEPTUNE actively encourages its R&D staff to harness ideas and expertise outside the company's boundaries. The company's scientists and engineers differ substantially in terms of job roles, but each individual is expected to attempt to source external expertise regardless of the specific objectives related to his or her job task. Despite the explicit orientation toward external knowledge, senior management believed the potential for external engagement was not fully realized. They suggested that too often their R&D staff tended to rely on local, in-house knowledge, as this knowledge was considered safe, easily understood and fit with existing categories. Indeed, this perceived attitude was later reflected in our interviews with R&D scientists, who often referred to external knowledge as 'second-best' after internal knowledge. In this context, our study was designed to provide insights into how technical leaders could become more effective in developing innovations through different forms of external engagement. In conducting this research, we worked closely with our industrial partner to better understand the role of external knowledge in R&D and to define the scope of the study.

Data collection

The data used in this study was collected in four stages. In the first stage, we conducted interviews with 22 scientists and engineers and two senior R&D managers. To ensure representativeness of our sample, we interviewed individuals from different business units, R&D sites, job functions and levels of seniority.

The interviews were intended to gain a broad understanding of the general context in which R&D is being undertaken and the specific role that external knowledge plays in this process. We paid particular attention to how these phenomena differ across job roles or business units. Further we attempted to acquire the company jargon and to understand the frame of reference of individuals in the technical career ladder. This approach allowed us to develop questions that were relevant and understandable across all job functions. We conducted the interviews following a protocol listing our main topics of interest, but we deliberately left the interviewees relatively free to steer the conversation towards issues they found of highest relevance within the setting of our study. We explicitly encouraged them to give concrete examples of their personal experiences with sourcing external knowledge and its subsequent application in new products, processes or technologies. All interview material was transcribed and coded using NVivo software to identify the main conceptual categories.

In the second stage, we designed a survey. To this end, we complemented the interview material with internal documents on NEPTUNE's R&D department, its dual career ladder system and its external engagement strategy. The questionnaire was piloted in a focus group of ten scientists and engineers in one of the company's major R&D sites. On the basis of feedback resulting from the piloting of the survey, we substantially adapted the questionnaire.

In the third stage, we administered the survey online to all senior members of the company's technical career ladder. Survey invitations were sent out by email in June 2010 with a cover letter from the company's Chief Technology Officer. On the company's request, the survey was made anonymous, as it was believed this would raise response rates, alleviate potential confidentiality concerns and also encourage respondents to answer honestly. After two reminders, a total of 408 surveys were returned, corresponding to a response rate of 67%. However, due to non-complete responses to some of the items used in this study, our final sample is reduced to 286 individuals. We checked for non-response bias by testing whether the distribution of the main individual's characteristics, such as gender, seniority, and location differ between the sample of respondents and non-respondents. There was no significant difference between these two groups in terms of these variables. We also investigated if there was a significant difference between early and late respondents with respect to other independent variables for which we do not have information on the entire population (Armstrong & Overton, 1977) and found no statistically significant differences.

As all the variables included in our analysis are self-reported and come from the same survey, there is the potential risk of common-method bias and single-respondent bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). We attempt to circumvent this problem by using self-reported managerial ratings as our

dependent variable. We believe that the anonymity of our survey and the additional choice given to respondents not to disclose this information reduced the tendency of respondents to answer in a biased manner (Podsakoff et al., 2003).

In the final stage of our study, we reported our analysis of the survey to senior members of the technical career ladder community and to the vice-president of the company's R&D department. These exchanges provided valuable feedback on the validity of our analysis and its implications for this organization.

Developing a scale for measuring individual-level absorptive capacity

To measure individual-level absorptive capacity, we developed new measurement scales, as we were unaware of any existing measurements of absorptive capacity at the individual level. To ensure our scales would lead to reliable and valid measurements of all dimensions of the concept, we followed a stepwise approach to formulate the items combining deductive and inductive methods (Hinkin, 1995).

First, we followed a deductive approach to define a protocol for the interviews that would gather information on the role of individuals in absorbing external knowledge. We started with reviewing the absorptive capacity literature (see also Volberda et al., 2010). We then created a list of the 'verbs' that described the active elements identified in the process of absorbing external knowledge in the most influential works on the topic, including most notably, the seminal work by Cohen and Levinthal (1990). Although this literature does not address the individual level in a systematic way, it widely discusses the potential role that individuals may play in recognizing, assimilating, and utilizing external knowledge. The identification and assimilation dimensions have a more evident individual component than the utilization dimension, where descriptions of the individual's role remain limited to 'creatively utilize' and 'effectively utilize'. Subsequently, we used this list of verbs to develop an interview protocol. In the interviews, we asked respondents about the efforts they make to stay aware of external developments; to access and integrate external knowledge; and to incorporate that knowledge in the development of innovations.

Second, we followed an inductive approach to generate scale items. Such an approach promotes high levels of content and face validity. We analysed and coded the interview material identifying the distinct efforts that individuals make when recognizing, assimilating and utilizing external knowledge. That is, we tagged small excerpts of interview material with in-vivo codes that described the practitioner terms – rather than their academic counterparts – for the activities individuals undertake to absorb external knowledge. Subsequently, we categorized the in-vivo codes into higher-order groups of similar activities and labelled them. To identify external knowledge individuals constantly monitor the environment, obtain

external knowledge through their personal professional networks, and consult patents, specialized magazines and the internet to stay up-to-date on market trends and emerging technologies. To assimilate external knowledge, scientists and engineers process external knowledge to better understand it, evaluate its importance against internal business needs, and try to excite their peers about it. They make explicit efforts to find out how it relates to the firm's ongoing expertise, and how it can be recombined with internal knowledge and technologies. Furthermore, they translate external knowledge into a form that is understandable to colleagues and actively share and transmit it to other parts of the organization. To utilize external knowledge individuals need to act as champions (Howell & Higgins, 1990), trying to overcome internal resistance and scepticism, and to gain support with management by showing personal commitment to the external idea and taking risks to ensure it is being acted upon. Thus, where the literature on absorptive capacity is relatively muted on the role of individuals in utilizing external knowledge, the interviews reveal that championing is a key component of this dimension of absorptive capacity at the individual-level. Table 1 summarizes ten different activities that emerged from the interviews, allocating them to three dimensions of absorptive capacity as defined by Lane and Lubatkin (1998). We do so mainly for representational reasons, as – at this stage of our study - we deliberately left the possibility open that the total set of items could conceal more than three factors and/or load in a different way than represented here. In particular, given that prior studies have not been consistent in identifying the dimensions of the absorptive capacity construct, we allowed for the assimilation dimension to exhibit separate 'diffuse' and 'integrate' components.

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In the third step, we formulated items for each of the ten activities that emerged from our inductive exercise, resulting in a total set of 19 items. In the formulation of our items, we explicitly used the terminology from the interview material to align with the respondents' frame of reference. The extreme right column in Table 1 displays (short versions of) the scale items and the middle column shows interview quotes that illustrate the activities related to them. Although not shown in Table 1, the survey instrument contained also negatively worded items to attenuate response pattern bias. In building our scales, we have also drawn items from existing scales for related constructs. In particular, we adapted the alertness scale developed within the entrepreneurship literature to capture the identification dimension of absorptive capacity (Busenitz, 1996; Cooper, Folta, & Woo, 1995; Kaish & Gilad, 1991; Kirzner, 1973). These scales have close affinity to the identification dimension of absorptive capacity as they attempt to capture the "capability of an individual to foreseeing the economic possibilities of opportunities when they come across them" (Kaish & Gilad, 1991: 48, italics in original). Further, we used the wording in the

work on championing by Howell and Higgins (1990) as inspiration for developing items to measure individuals' effort to utilize external knowledge.

Fourth, we pre-tested the construct validity of our measurement scales following a procedure suggested by Moore and Benbasat (1991). To this end, the survey items (i.e. across all intended underlying constructs) were printed on cards and shuffled randomly. Then, four 'judges' (PhD students in management, not working on organizational learning) were instructed to sort the items in groups, each consisting of four to six items, and label them. We then measured the extent to which the judges grouped individual items on the intended underlying constructs and assessed to what extent their labelling was similar to the names of the actual constructs. The exercise provided clues about the extent to which items pertaining to a single construct formed a coherent set (convergent validity) and the extent to which items referring to different constructs discriminated between them (discriminant validity). After substantial rewording of the items, we performed the same test using four different judges and found significant improvement on the extent to which items were allocated as intended. Following this exercise, we piloted the draft measurement scale in a focus group with ten scientists and engineers. We incorporated their feedback by making some further modifications to the wording of the items and removing items that did not apply to their job role. Items were measured on a 7-point Likert scale with anchor labels for each response option, as scales with high number of response options and the use of anchors throughout the scale tend to produce more reliable measurements (Weng, 2004).

Measures

Dependent variables. We measured individuals' innovative performance using the self-reported most recent *managerial rating*. Although the rating is a general indicator of workplace performance, several sources in NEPTUNE confirmed that the rating was assigned every year – with a forced distribution over the business units – by a committee of line managers based on an individual's ability – relative to peers – to produce innovations that generate value to the firm. Compared to innovation count variables, such as the number of patents or product innovations (see for example Tortoriello & Krackhardt, 2010), which are other conventional measures of individuals' innovation performance in management research, the managerial rating has the advantage of being applicable across all job functions, regardless of the type of innovation outcome expected from a given job role. Furthermore, although the rating is self-reported, it remains that the managerial rating is based on judgement by others rather than self-assessed, which helps circumvent problems of common-method bias (Podsakoff et al., 2003). To test the robustness of our findings regarding rating as a dependent variable, we repeated our analyses with two alternative rating-based variables, coding individuals as one if they had top-ratings 'at least once' or 'all the time' over the

last three years. The results obtained using these alternative performance variables are consistent with the findings reported in this study.

Independent variables. The independent variables of this study are the different dimensions of the absorptive capacity construct. To derive these dimensions, we conducted an exploratory factor analysis, adopting the principal component method. This method retains account for a maximal amount of variance of the original items (as opposed to the principal-factor method, where factors maximize common variance) and is often considered better when the underlying constructs are likely to be correlated. After removing two items that cross-loaded on two factors, the remaining 17 items loaded on three factors accounting for 80.5% of the variance among the original items. All factor loadings were above 0.4 with none of the items loading on multiple factors. In line with our theoretical framework, we labelled the three factors "Identify external knowledge" (α=0.66), "Assimilate external knowledge" (α=0.92) and "Utilize external knowledge" (α=0.75).

INSERT TABLE 2 HERE ###/

These variables measure the *effort* individual scientists and engineers put into identifying, assimilating and utilizing external knowledge and such levels of effort are unevenly distributed among our population of scientists and engineers. These stark differences in the level of effort the individuals undertook to absorb external knowledge reflects the choices individual R&D staff make about how to balance their attention between internal or external knowledge and, as we expected from our interviews, for many individuals, efforts to absorb external knowledge were relatively limited.

To assess the effects of synergy derived from combining efforts along multiple dimensions of individual-level absorptive capacity, we adopted a system-approach where we focus on co-occurrence of high levels of effort on the three different dimensions of absorptive capacity. That is, following He and Wong's (2004) study of organizational ambidexterity, we took the sample median to transform the scores on the three absorptive capacity factors into a series of mutually exclusive dummy variables. Through this procedure, we grouped individuals on the basis of the dimensions of absorptive capacity they combine in their work with above-median levels of effort. This produced groups of individuals, who either have below-median levels of effort on all dimensions of absorptive capacity (n=64), have above-median levels of effort on only one dimension (identifiers: n=31, assimilators: n=24, utilizers: n=28), individuals who focus on two dimensions (identify-assimilate: n= 23; assimilate-utilize: n=31; identify-utilize: n=21), or individuals who focus on all three (n=64). To test for the synergy from combining multiple activities on innovative performance, we included all the dummy variables using the set of individuals with 'below-median levels of effort on all categories' as reference category. Although this approach reduces the level

of granularity by transforming continuous variables into dummies, it is preferred to a model that includes two- and three-way interactions for two reasons. First, as Tanriverdi and Venkatraman (2005) point out, interaction terms are not suitable to test for synergies among more than two practices as the high correlations between main effects and the interaction terms limit the interpretability of the effects. Second, although the interpretation of three-way interaction terms is possible in OLS regressions, it remains exceedingly difficult in logistic regressions (Hoetker, 2007).

Control variables. We included several control variables to account for *both* an individual's characteristics and contextual features. First, intrinsically motivated individuals have been shown to outperform extrinsically motivated persons in creativity and innovation (e.g. Perry-Smith, 2006). *Intrinsic motivation* is measured on a 4-item scale adapted from Rynes, Gerhart and Minette (2004) (Cronbach's alpha=0.68). Second, we account for *grade*, which takes value 1 if the respondent has the highest or second highest grade, 0 otherwise. As ratings are relative to peers, scientists and engineers in higher grades are liable to build strong track records in generating innovations and therefore a high grade may reflect the past innovative capability of that individual. Third, we control for *tenure*, measured as the number of years an individual has worked for NEPTUNE, as more experienced individuals may be more able to win the support of their colleagues as they have built strong reputations and relationships on the basis of past efforts. Fourth, as research has shown that many women in scientific and technical careers often face a hostile and challenging work environment (Etzkowitz, Kemelgor, & Uzzi, 2000), we control for *gender*, where men represent the reference category. Fifth, scientists and engineers who perceive their work environment as supportive and stimulating tend to be more innovative than people with negative perceptions on the organization's innovation climate (Shalley, Gilson, & Blum, 2000). Therefore, we included a scale on the climate for innovation adapted from Siegel and Kaemmerer (1978) and Scott and Bruce (1994). From the original 22-items scale in Scott and Bruce (1994) that loaded on two factors, we selected 8 items from the factor *support for innovation* (α=0.86). Sixth, in our interviews, we noticed that the support of the manager of the R&D scientist was instrumental in helping that individual achieve high performance, as they provided access resources and support for the further development of innovative ideas. We therefore include a control variable measuring *managerial support* using a scale developed by Greenhaus, Parasuraman and Wormley (1990). We adapted this scale (including 7 items) to capture the relationship of the R&D scientist with their project manager (Cronbach's α= 0.94). Seventh, we control for the size of the market in which the innovation will ultimately be launched by including a dummy variable (*large market*) that takes the value of 1 if the respondent's R&D work relates to NEPTUNE's largest markets. Working in areas with large markets may increase visibility of the individual's innovations in the organization and potentially increase their chance to receive a high rating. Eighth, we

include a dummy variable indicating whether respondents work at NEPTUNE's *headquarters*. Those who work at the company's headquarters may be closer to where strategies are shaped and may have a better chance of influencing managerial decisions. Finally, the ability of individuals to generate innovations might be dependent on the type of job role they occupy and also on the department in which they operate. To account for this, we include a set of dummy variables related to *business units* and *job functions*.

RESULTS

We tested our hypotheses on the relationship between the three dimensions of absorptive capacity and managerial rating using a logit model. Due to the sensitive nature of our question on managerial rating, 87 respondents decided not to disclose this information. As a result, individuals with low managerial ratings were under-represented in our sample with respect to the distribution of ratings in the whole company. To account for this, we estimated our models using weights, which are equal to the number of 1-rated (0-rated) in our sample over the percentage of 1-rated (0-rated) in the population. In this way, we attribute additional weight to the group – the 0-rated – that is under-represented in our sample. It should be noted that the results obtained without using this weighting scheme are consistent with the ones reported here. The estimations are obtained clustering the errors by job functions. This allows for non-independence of the observations within each job function.

INSERT TABLE 3 HERE

Table 3 shows the descriptive statistics and the bivariate correlations of the variables included in the models. In our sample, 25% of individuals receive high managerial ratings; a similar proportion has high grades. On average, individuals have spent 20 years working for NEPTUNE. All three dimensions of absorptive capacity showed the expected positive association with rating. None of the correlations among independent variables are above 0.3, suggesting that multicollinearity is not a concern in our regressions.

INSERT TABLE 4 HERE

The results of our regressions are reported in Table 4. Model 1 is our baseline model, which only includes the control variables. These estimates indicate that individuals with high intrinsic motivation and strong managerial support were more likely to receive a high managerial rating. Also men are more likely than women to achieve a high rating. In Models 2-4, we add each of the variables capturing the different dimensions of an individual absorptive capacity separately, to test their influence on managerial rating. Model 2 shows the results for Hypothesis 1, which predicted that the more active efforts individuals make to identify external knowledge, the higher will be their innovative performance. This hypothesis is not supported. Model 3 adds the second dimension of absorptive capacity to the set of control variables:

assimilating external knowledge. As predicted by Hypothesis 2, the more individuals are engaged in assimilating external knowledge with existing internal knowledge, the more likely they are to achieve high innovative performance ($b = .438$, $p < .001$). In Model 4, we introduce the third dimension of absorptive capacity – utilizing external knowledge - and found that, as predicted in Hypothesis 3, the greater the level of effort of an individual in championing the use of externally source knowledge, the higher the chances of being highly innovative ($b=.268$, $p<0.001$). In Model 5, we include all three dimensions of absorptive capacity and found that assimilating external knowledge is still significant, but utilizing external knowledge is no longer significant. This suggests only weak support for Hypothesis 3.

Using the estimates from Model 5, we found that a one standard deviation increase in assimilating external knowledge increases the probability that an individual will receive a high rating by 4% (keeping all the other continuous independent variables at their means and the dummy variables at one if their mean value is greater than 0.5). Among all our variables, including control variables, the effort to assimilate external knowledge has the strongest effect in predicting performance. For example, an increase of one standard deviation in an individual's intrinsic motivation only leads to a 3% increase in the chances of obtaining a high rating.

INSERT TABLE 5 HERE

Table 5 reports the results of the regressions we estimated to test the effect of combining two or three dimensions of absorptive capacity. As Model 1 shows, individuals who combine multiple roles in absorbing external knowledge are more likely to achieve a high rating, which indicates support for Hypothesis 4. In particular, individuals who are identify-assimilators ($\beta=1.492$, $p=.000$, hypothesis 4a) and assimilate-utilizers ($\beta=0.699$, $p=.000$, hypothesis 4b) have higher likelihood of being rated highly by their managers than those who do not actively engage in absorbing external knowledge (our reference category). Notably, individuals who combine the identification and utilization activities without assimilation do not have an advantage relative to those individuals who do not actively absorb external knowledge. We also find strong support for Hypothesis 5, which predicted a performance premium those with high levels of effort on all three dimensions of absorptive capacity. The coefficient for the identification-assimilation-utilization combination is positive and highly significant ($\beta=0.941$, $p=.000$).

Although our empirical models include several variables capturing individual level characteristics that can affect their ability to be innovative, the estimates are likely to suffer from specification bias due to unobserved heterogeneity. To address this problem, we include the lagged values of managerial rating (rating in years prior to our study) to predict current managerial rating since one can assume that the same unobserved factors contribute to both current and past individual innovative performance. This permits us

greater confidence when inferring causal relationships between the different dimensions of absorptive capacity and innovative performance measured by managerial rating. One limitation of this approach is that the inclusion of the lagged dependent variable in our model can introduce autocorrelation in the error terms, which in turn can lead to inconsistent estimates (Greene, 2003: 266), although the downward bias of the standard errors due to serial correlation in the errors has been shown to be less pronounced when the correlation between current and past values of the dependent variable is low and is less severe in logit models than in ordinary least square models (Beck, Katz, & Tucker, 1998). Therefore, as a robustness test, we re-estimate our models including the managerial rating that an individual received two years prior to the survey as independent variable (the phi-correlation coefficient between current rating and the previous year rating is 74%, but only 34% for current rating and the rating two years earlier). When we ran our models with controls for the two different sets of past performance, the results are substantively the same as those reported above (not reported for reasons of space). When we control for past performance, only the effect of assimilate-utilize on current managerial rating disappears.

DISCUSSION

This paper seeks to contribute to a better understanding of how individuals absorb external knowledge and how the efforts of individuals shape their contribution to the innovative efforts of their organization. We began by unpacking the three dimensions of absorptive capacity at the individual-level, developing measures that reflected the efforts that individuals undertake to enable their organization to identify, assimilate and utilize external knowledge. This approach left us with three 'bundles' of individual effort – each corresponding to the phase of absorptive capacity previously identified in the literature (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998). In our analysis, we explored the impact of individuals' level of effort for each phase of absorptive capacity on their innovativeness. We expected that efforts in all three dimensions of absorptive capacity by themselves would be significantly related to an individual's ability to generate innovation. However, the results offered only limited support for this assumption. In the case of the identification of external knowledge, we found that individuals engaging in active search for external ideas were no more likely to receive higher ratings than their colleagues who search less actively externally. This result contradicts our expectations about the value of alertness to new opportunities for innovation. One possible interpretation of this result is that external search is in itself a difficult task, and therefore those individuals who rely on local, internal sources may as successful developing innovations as those to aggressively hunt externally. A further explanation for this non-result is that external search needs to be combined with other forms of absorptive capacity in order to be rendered effective, a point that we will explore below.

In the case of the second phase of absorptive capacity, assimilation of external knowledge, the results were much clearer. We found that the efforts of individuals to hone and graft external knowledge into the language and jargon of the firm are a powerful predictor of individual innovativeness. This result provides evidence for the importance of individuals in the process of knowledge integration, a concept at the core of the knowledge-based view of the firm (Grant, 1996b). It also speaks to the importance for individuals working in large firms to be able to transform and reshape external knowledge into a form that can be diffused within their organization. In this middle phase of absorptive capacity, external knowledge is transformed into a hybrid form that includes both internal and external components. This suggests that although it is common to treat external sources of knowledge in the innovation process explicitly as 'external', it is clear that individuals can modify these ideas, blending them with internal ideas. In other words, the source of knowledge itself may not determine its destiny within the organization; rather its value to the organization is likely to be dependent on the capacity of its members to transform this knowledge in a format that can be assimilated and integrated into what the organization already knows and can do. Fundamentally, it is what happens to make an idea conform to existing categories once it is 'brought into' the organization that helps to determine the response of the organization to the idea itself.

When we examined the third phase of absorptive capacity at the individual-level, we found only modest support for the importance for individual efforts to utilize external knowledge in terms of innovative outcomes. Although the variable was positive, it was not significant when we included the other two phases of absorptive capacity. Accordingly, it is clear that efforts to utilize external knowledge by themselves offer little advantage to individuals. This may be because such efforts come against internal resistance, and that, if other elements of the absorptive capacity process have not been undertaken by the same individual, the idea itself may face too great internal barriers to be acted upon.

In our analysis, we were careful to explore whether the combination of different forms of absorptive capacity had positive effects on an individual's innovative performance. At the core of this question is whether there are synergetic effects between different elements of individual's efforts to absorb external knowledge. Overall, we found clear evidence that combinatorial forms of absorptive capacity dimensions had the greatest effect on an individual's innovative performance. In the first instance, we looked at combining two elements of absorptive capacity and found that individuals who combine the identification and assimilation as well as those who combine the assimilation and utilization of external knowledge have the highest chances of receiving a high managerial rating. These results are consistent with the first stage of our analysis and suggest that assimilation provides the greatest effect on individual performance when it is combined with identification or utilization of external knowledge. Individuals who make large efforts to absorb external knowledge may have a more targeted direction in their external search activities.

At the same time, individuals who can reshape the external ideas to meet internal requirements and logics may be better able to overcome internal resistance in their pursuit to get external ideas utilized by the firm, and therefore help gain traction for these ideas against hostile or indifferent internal groups. By contrast, we found no evidence of synergetic effects between the identification and utilization of external knowledge by individuals. Efforts to absorb external knowledge that do not include knowledge assimilation do not bring many rewards.

In the final stage of analysis, we sought to understand whether the use of the three elements of absorptive capacity offers an advantage to individuals. The combination of all three forms of absorptive capacity has a strong impact on individuals' performance. This suggests that combining all three elements of absorptive capacity is an important strategy for individuals who seek to profit from external knowledge for themselves and their organizations. Focusing on just one element of these different phases increases the chances that external knowledge accessed by individuals will not be found, transformed and utilized by the organization. This finding is consistent with Cohen and Levinthal's (1990) suggestion that the absorption of external knowledge is not simply the product of the efforts of technological gatekeepers. Instead, it is the product of a wide range of efforts on the part of individuals to ensure that this knowledge is made useful for the organization and then put into practice.

Implications for managerial practice

The increasing importance that organizations have placed on their ability to be open to external sources of knowledge places new pressures on individuals. Many R&D staff are finding themselves coming under pressure to act as carriers of external ideas into and across the firm. This represents a significant change in the nature of the R&D process, as R&D staff on technical career paths has previously focused more on their ability to discover useful new ideas rather than their ability to acquire and integrate them (Mowery, 2009). In this context, our study speaks directly to the question of how an organization can best help prepare and reward its R&D staff for this new and broader external engagement role. First, we show that absorbing external knowledge involves three distinct bundles of effort. Organizations should balance their employees' efforts at learning from external knowledge across these different areas. For example, attempts to support the search for external ideas need to be balanced with efforts to enable external ideas to be assimilated and utilized. In many cases, organizations have given most attention to the search for these ideas in their open innovation initiatives, disregarding their assimilation and utilization within the organization.

Second, although technological gatekeepers may remain an important part of an organization's effort to find external ideas, it is also necessary to broaden 'the craft of openness' by investing managerial

resources and effort in the assimilation and utilization of these external ideas. Offering training for staff in overcoming internal barriers, and in learning how to transform external ideas into internal categories, may provide more benefits for the organization than simply increasing the scale of effort to find external ideas. Critically, organizations need to concentrate their managerial resources on the assimilation phase of absorptive capacity to ensure that their staff are adequately trained and supported to turn external ideas into attractive hybrids, which combine the novelty of the external idea with the requirements and categories of the internal innovation processes.

Finally, individuals whose role it is to engage external sources need to learn to play multiple roles in the process. External ideas will not necessarily find a suitable home unless they are honed and grafted to the organization itself. Moreover, once these ideas have been brought into the firm, they have to be aggressively and persuasively pushed internally. Our results suggest that it is hard to simply hand over innovative ideas between those individuals who search for ideas and those who assimilate and utilize them. We found that those individuals who received the highest performance ratings played all three roles, following external ideas through the entire cycle of the innovation process. This suggests that organizations need to develop incentive systems that reward individuals for all three stages of the process of absorbing external knowledge.

Implications for theory

There are two important implications for our understanding of absorptive capacity arising from this study. First, by exploring the ways in which individuals absorb external knowledge, we help ground the concept of absorptive capacity in a set of activities that capture distinct elements of individuals' efforts to identify, assimilate and utilize external knowledge. By bringing attention to these activities, we have sought to advance our understanding of the broad concept of absorptive capacity, developing more refined and empirically tractable mechanisms that capture individuals' efforts to absorb external knowledge. In doing so, we have attempted to fill a critical gap in our understanding of a central concept in organizational learning.

Second, this study has uncovered roles that individuals play in absorbing external knowledge and provided insights in productive combinations of different roles. We have expanded upon the notion of technological gatekeepers to capture distinct roles related to different stages of the knowledge absorption process. In particular, we have highlighted the critical importance of assimilation as the central, and yet often missing element, in shaping individuals' ability to learn from external sources. We argued and empirically substantiated that knowledge assimilation plays a contingent role in shaping the value of other phases of absorptive capacity. This points towards the need to give renewed attention to the knowledge

assimilation process within organizations, and how decisions and efforts in this stage shape the value of upstream search and downstream utilization efforts. The focus on the synergetic efforts of combining efforts across multiple phases of the knowledge absorption process also helps to enrich and extend our understanding of the value of having individuals take on multiple roles and how efforts in one area may complement efforts in other areas.

Limitations and future research

This study has relied on responses of individual scientists to a survey about their external search efforts and therefore is subject to several limitations. First, although we have information about objective performance measures, our measures themselves rely on the statements of individuals about their own performance. To be sure, we found that lower performers were less likely to declare their performance. Although we weighted the data to account for this bias in our response patterns, it is clear that more objective measures of performance from secondary sources would have been beneficial. That being said, our measures do have strong predictive validity and are consistent with the extant literature on the sources of individual-level innovativeness.

Second, our study relies on data from one organization and therefore it is unclear whether our results are based on the particular features of this organization. However, our interviews with different parts of this organization suggested that NEPTUNE's business groups operate fairly autonomously. Indeed, NEPTUNE is a large, complex firm with a wide range of different businesses. Although our survey was drawn from across all of its units and we controlled for differences in both the size of the market of the business unit and the business units themselves, we are unable to confirm whether our results would be similar in other large organizations.

Third, in a cross-sectional study of this type, it is difficult to rule out an endogenous variable that could explain both our measures of absorptive capacity and individual performance. Of course, we have included a wide range of individual-level variables and controlled for past performance, but we cannot exclude that there may be some unobserved heterogeneity that we have missed. Given these controls and tests, we believe that our results are not likely to be driven by unobserved heterogeneity, but, of course, without panel information and/or effective instruments, it is impossible to rule out completely other potential sources of endogeneity.

Lastly, in this study, we have focused on individuals and their roles in absorbing external knowledge. This approach helps to bring light to the role of individuals that stand at the interface between the organization and its external environment, but it does not provide insights into how organizational

antecedents of absorptive capacity may enhance or obstruct individuals' efforts to absorb external knowledge. A multi-level understanding of absorptive capacity could attempt to situate individual efforts within their teams, sub-units and divisions, helping to create a richer picture of how an organization builds its absorptive capacity (Volberda et al., 2010). However, such a research effort would require deep and rich information at each level and, at this stage in the empirical study of absorptive capacity, this remains a significant challenge.

The study of individual-level absorptive capacity can help to open a new window on how organizations learn from external sources of knowledge. Unfortunately, the research tradition that addressed this question, led by Allen and colleagues in the early 1970s, fell largely into abeyance. The recent call for the return of individuals to our understanding of organizational-level absorptive capacity provides a welcome opportunity to bring individuals back into this important area of organization learning. To help meet this challenge, this paper has sought to develop new measures to assess the roles of individuals in contributing to their organization's absorptive capacity, building on the fundamental insights of Cohen and Levinthal and others about how organizations learn. By examining the synergetic effects between different phases of absorptive capacity for individuals, we hope to spur future research on this powerful and yet often elusive concept.

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TABLE 1

An inductive approach to scale development: individual-level absorptive capacity

	Individual effort	Interview quotes	Measurement scale
Identify external knowledge	Monitor the environment	*"When I give training on this I say to folks, you know, do not begrudge the time that you spend reading whether patents or papers or whatever, because at some point you'll find value in it. It might take you ten years before you actually come across a problem where this is the solution."*	Keep track of emerging trends by reading scientific journals, patents, etc.
	Become aware of external technological opportunities	*"There is a new modelling technique actually that I've just piloted, which I had read about on the internet, from my literature search."* *"I do a lot of random searches on the internet to get linked to university portals around the world to see what's happening."*	Getting a sense of new developments by browsing the internet
	Aggressively seek out new opportunities	*"Now, I was sitting in the lobby in the hotel because I had to go to the airport and I was overhearing a conversation (...) He had a badge and it said professor in [academic discipline]. So, I talked to him (...). But it was just by chance, so it's basically having your radar screen on all the time."*	Obtain external knowledge through interaction with external partners
	Stay up-to-date on market developments	*"Being updated on what is going on in the world is important, so literature analysis, patent survey, all that stuff I do regularly, so I stay alert for what is around."* *"It's a bit more nebulous, you know, it's from knowing, from talking with people, knowing the state of the art."*	Reading magazines and newspapers every day to keep up-to-date on our markets
Assimilate external knowledge	Better understand external knowledge	*"I would try and see if there's a chance to make it work, playing with it [a supplier's technology] by myself in one way or another."* *"First of all I need to digest it [the external technology] myself and there's one tool we use a lot internally, which is [our knowledge sharing platform]."*	Process external knowledge to get a sense of its value and meaning
	Evaluate external knowledge against business needs	*"What are the benefits for using it [the external technology] either in terms of 'it's able to do something we couldn't do before', 'it's able to do a new transformation that allows us to maybe combine ingredients in a way that we couldn't do previously'?"*	Appraise the usefulness of external knowledge
		"So, it's, it's doing an overall assessment of the financial and technology benefits of the new process versus an existing process." *"[There are] some very strong [R&D managers] who I use on a regular basis, bouncing ideas off them, knowing that they will be able to look at an external idea from a more business-related standpoint rather than me looking at it from a more purely technical basis."*	Critically assess the value of external knowledge against business needs
	Excite peers about external knowledge	*"The first step is to assess the [external] opportunity with people I trust, just to get a feel of their passion meter, whether they feel the same excitement about the idea."* *"And within a couple of phone calls [with peers] you can get a feel for 'this is exciting' or, you know, 'people have told us this before' or 'we've tried it many times'."*	Excite colleagues about novel external technologies
	Recombine external knowledge with internal knowledge	*"We have the knowledge of our technologies, our customers. So we have to add a few different levels of filters as to how we look at an external technology."* *"We'll have a marriage of [internal and external] materials, when we're going to be presenting that [external technology] to influential people."*	Comprehend how external knowledge connects to ongoing internal R&D
		"Everything is about data. So once you can actually get data to show that the market likes that idea, then you actually have the hard and fast data to say this idea is a good one."	Analyse how external knowledge can be related to

		"[Then I do] a best-bet option analysis where you will look at a [new, external] technology versus your existing ones, and assess it for a whole range of things both from process ability, stability, cost, efficiency, likelihood of success."	business needs
	Make external knowledge intelligible into a form understandable to colleagues	*"It is a question of translating it into a language so that it means something in NEPTUNE"* *"I mean, you would tend to sort of NEPTUNE-ise the information a bit, I would say, you know, to make it work for people in NEPTUNE, some of the language that we would use."*	Translate external knowledge to ensure it is understood by colleagues
		"What you would know externally as a business plan, it covers several things (...) I work all of those things out before the management even sees anything." *"If you want [an external idea] to have an impact in the things that NEPTUNE wants to do, there has to be a step where you are able at least to condense things to actionable conclusions."*	Repackage external knowledge to make sure it gets attention internally
	Internally communicate, share and transmit external knowledge	*"So typically the way I would diffuse the information [external knowledge] would be (...) trying to sift it into a one-pager format [in our knowledge sharing system]."*	Diffuse external knowledge to other parts of organization
		"I start to whisper like 'hey, we got this technology. I'm still working with the supplier to figure it out but if it does this, would that be meaningful to you? What do you think the scepticism is going to be?' You've got to do a little bit of that legwork before you have the idea right."	Meet up with colleagues to discuss external knowledge
Utilize external knowledge	Overcoming internal resistance	*"And, I think my job is to put data on the table, which makes people think again and change the paradigm, that's one of my key roles."* *"And the next time the whole issue comes up, well, how can we address this market need? You take it off the shelf and you put it back on the table. So, often you'll find that an idea will take two or three times before you get any traction on it."*	Overcome resistance to guarantee the external idea is brought to fruition
	Strong commitment, effort and persistence to utilize external knowledge	*"The company's already got a fairly rigid mindset about what they want to do. Then, you would have a lot of translation work, I guess, to convince people to change tack based on external data."* *"And, I think, yes, you need to have a strong belief yourself; and you need to build up the necessary data to support it."*	Do almost anything to have my external knowledge taken up by the organization
	Take risks to utilize external knowledge	*"People can't argue with data, so before you go to any managers, before it gets any management exposure, you know, what we always try to do is get some, get some technical testing and some market data."* *"You have ideas, so if the senior manager says that's no good, he's more powerful than you. Therefore his decision is more powerful. If you then have some data, then it makes, it changes the whole power balance."*	Take risk to pursue adoption and capitalization of external knowledge
	Gain support and buy-in from management	*"So if you really believe in an idea, if this idea comes in, part of the skill of selling it is figuring out how to sell it."* *"It's only going to get legs if I can get, you know, it's all about influencing and getting some people who actually manage the business to buy into the idea. So you need someone who has a good opinion about you, someone who has good contacts, someone who will be a spokesperson for you."*	Make sure external knowledge is implemented even if the idea was not originally mine
		"We created a network of ambassadors in all the regions. And these people, they are so passionate about this and they're so willing to do that; they come up with the resources, manpower and money, to do the global research." *"You need to sell to him [a manager] against things which click with him; or what even clicks more with him is there's a market need which I can now meet, which was not me before. Sometimes you have to just create a story for them [managers] that convinces them, you almost show them how they can sell it on the market."*	Take action to make sure potential of external knowledge is realized

TABLE 2

Factor analysis of individual-level absorptive capacity items

	Factor 1	Factor 2	Factor 3	Mean	St.dev.	Min	Max
Identifying external knowledge (α=0.66)							
When interacting with others I always actively try to obtain information about emerging market needs or new technologies.	-0.02	0.21	**.67**	5.75	1.18	1	7
I read magazines and newspapers every day to keep up-to-date on our markets.	-0.05	0.02	**.84**	4.82	1.60	1	7
I frequently read scientific journals, trade publications or patents to keep track of emerging trends.	0.27	-0.12	**.65**	5.45	1.51	1	7
Assimilating external knowledge (α=0.92)							
I work hard to critically assess the potential value of external knowledge against our business needs.	**.75**	0.04	0.08	5.52	1.36	1	7
I am deeply involved in appraising the usefulness of external ideas.	**.80**	0.07	-0.04	5.00	1.61	1	7
I often analyse the way expertise of external contacts could be related to NEPTUNE's business needs.	**.77**	0.09	-0.02	4.90	1.61	1	7
I spend little time processing external knowledge to get a sense of how it might be meaningful for our business.	**.69**	-0.12	0.21	5.34	1.40	1	7
I strive to comprehend how external knowledge connects to NEPTUNE's ongoing research and development activity.	**.55**	0.04	0.17	5.47	1.33	1	7
I try to excite my colleagues about novel external ideas or technologies.	**.47**	0.27	0.18	5.75	1.16	2	7
I frequently meet up with colleagues to explain and discuss new knowledge I obtained externally.	**.65**	0.10	0.11	5.05	1.46	1	7
I perform a central role in diffusing externally sourced knowledge to other parts of NEPTUNE.	**.75**	0.17	-0.06	4.57	1.81	1	7
I take the time to "translate" external knowledge to ensure it is properly understood by my colleagues.	**.74**	0.13	0.00	5.36	1.31	1	7
I make an effort to "repackage" external knowledge to make sure it gets the attention it deserves.	**.69**	0.15	0.00	4.91	1.50	1	7
Utilizing external knowledge (α=0.75)							
When an external idea appeals to me, I work vigorously to make sure it is implemented, even if the idea was not originally mine.	0.08	**.58**	0.21	5.68	1.02	1	7
When new external ideas I believe in meet resistance within NEPTUNE, I put in a great deal of effort to guarantee the idea is brought to fruition.	0.12	**.78**	0.07	4.88	1.20	1	7
I would do almost anything to have my external ideas taken up by NEPTUNE.	-0.01	**.69**	0.02	3.76	1.47	1	7
I am willing to take action to make sure that the potential of external ideas I believe in will be realized.	0.16	**.77**	-0.10	5.50	1.04	1	7

Results obtained with principal-component factor analysis. Three factors with eigenvalue above 1 were retained, accounting for 59.2% of variance. After oblique rotation, the three factors account for 38.7%, 23.1% and 18.7% of the original variance among the items (together 80.5%). A Likelihood-ratio test shows the presented model is a significant improvement compared to a null-model where the items are assumed to be independent: $\chi^2 = 3353.51$; $p < 0.001$; $df = 136$.

TABLE 3

Descriptive statistics and bivariate correlations (N=286)

	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11
1 Managerial rating	0.25	0.43	0	1											
2 Identify external knowledge	-0.05	1.03	-4.42	1.77	0.06*										
3 Assimilate external knowledge	0.00	0.99	-3.21	1.74	0.15*	0.33*									
4 Utilize external knowledge	-0.02	0.98	-4.12	2.43	0.13*	0.24*	0.36*								
5 Intrinsic Motivation	-0.04	1.03	-4.42	1.64	0.14*	0.32*	0.26*	0.33							
6 Grade	0.23	0.42	0	1	0.01	0.15*	0.06*	0.15	0.13*						
7 Tenure	19.92	7.79	0	44	0.02	-0.05*	-0.19*	-0.12	-0.03	0.29*					
8 Gender	0.20	0.40	0	1	-0.07*	-0.08*	-0.13*	-0.10	0.03	-0.05*	0.05*				
9 Innovative Climate	0.04	0.95	-2.78	1.92	0.06*	0.04	-0.03	0.15	0.02	0.04	-0.04	-0.01			
10 Managerial support	-0.02	1.01	-3.50	1.08	0.14*	0.00	0.09	0.04*	0.03	0.01	-0.01	-0.01	0.36*		
11 Large Market	0.57	0.50	0	1	0.03	0.07*	-0.06	-0.05*	0.01	0.03	-0.13*	-0.14*	0.13*	0.09*	
12 Headquarters	0.63	0.48	0	1	0.00	-0.04	-0.02	-0.06	0.05*	0.21*	0.30*	0.01	-0.19	-0.03	-0.03

* $p < 0.05$.

TABLE 4

Multivariate regression models: managerial rating (dummy top rating) (N=286)

	1	2	3	4	5
Identify E K		0.05			-0.09
		(0.18)			(0.20)
Assimilate E K			0.44		0.42
			(0.16)**		(0.21)*
Utilize E K				0.268	0.16
				(0.092)**	(0.13)
Intrinsic Motivation	0.37	0.36	0.28	0.304	0.27
	(0.09)**	(0.11)**	(0.12)*	(0.087)**	(0.11)*
Grade	-0.19	-0.20	-0.29	-0.283	-0.33
	(0.22)	(0.19)	(0.24)	(0.236)	(0.21)
Tenure	0.01	0.01	0.02	0.015	0.02
	(0.01)	(0.01)	(0.01)	(0.010)	(0.01)*
Gender	-0.54	-0.53	-0.34	-0.45	-0.32
	(0.32) †	(0.36)	(0.34)	(0.369)	(0.39)
Innovation Climate	0.08	0.07	0.12	0.052	0.11
	(0.22)	(0.21)	(0.20)	(0.218)	(0.22)
Managerial Support	0.32	0.32	0.29	0.325	0.29
	(0.19) †	(0.19) †	(0.22)	(0.204)	(0.22)
Large Market	-0.06	-0.07	0.01	0.003	0.06
	(0.30)	(0.30)	(0.30)	(0.305)	(0.34)
Headquarters	-0.10	-0.09	-0.12	-0.079	-0.13
	(0.16)	(0.16)	(0.21)	(0.168)	(0.20)
Constant	-1.11	-1.11	-1.44	-1.28	-1.53
	(0.32)**	(0.29)**	(0.43)**	(0.30)**	(0.42)**
Log-likelihood	-124.25	-124.21	-121.71	-123.23	-121.27
Log-likelihood Ratio test (d.f.) [a]		0.07(1)	5.07(1)*	2.04(1) †	5.96(3) †

Logit estimations obtained using population weights
Robust standard errors for two-tailed tests clustered by job function
Business units and job functions included but not reported

† Significant at 10%; * significant at 5%; ** significant at 1%

[a] Compares Models 2,3,4, and 5 to Model 1;

TABLE 5

Multivariate regression model: Managerial ratings (N=286)

	Managerial Rating
Intrinsic Motivation	0.29
	(0.09)**
Grade	-0.29
	(0.23)
Tenure	0.02
	(0.01)
Gender	-0.47
	(0.39)
Innovation Climate	0.11
	(0.24)
Managerial Support	0.32
	(0.23)
Large Market	-0.02
	(0.31)
Headquarters	-0.05
	(0.22)
Focus on identifying EK	0.04
	(0.30)
Focus on assimilating EK	1.18
	(0.87)
Focus on utilizing EK	-0.02
	(0.47)
Identify and Assimilate EK	1.49
	(0.34)**
Identify and Utilize EK	0.13
	(0.50)
Assimilate and Utilize EK	0.70
	(0.22)**
Identify, Assimilate and Utilize EK	0.94
	(0.29)**
Constant	-1.83
	(0.52)**
Log-likelihood	-119.73

Logit estimations obtained using population weights
Robust standard errors for two-tailed tests clustered by job functions
Business units and job functions included but not reported

† Significant at 10%; * significant at 5%; ** significant at 1%