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From Sensing Shape to Shaping Sense: A Dynamic Model of Absorptive Capacity and Selective Revealing

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Abstract

The concept of absorptive capacity is mainly agnostic to the iterative nature of knowledge production processes. We extend it to a dynamic model, in which firms can influence future spillovers they receive by selectively revealing knowledge today. We derive two strategies, signaling and steering, allowing firms to exhibit managerial agency to increase structural and content compatibility of external knowledge. We explicate potential goals, highlight boundary conditions, and discuss implications for innovation strategy and organization theory.

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ABSTRACT

The concept of absorptive capacity is mainly agnostic to the iterative nature of knowledge production processes. We extend it to a dynamic model, in which firms can influence future spillovers they receive by selectively revealing knowledge today. We derive two strategies, signaling and steering, allowing firms to exhibit managerial agency to increase structural and content compatibility of external knowledge. We explicate potential goals, highlight boundary conditions, and discuss implications for innovation strategy and organization theory.

Keywords: Absorptive capacity, knowledge, selective revealing, spillovers, innovation, induced isomorphism, learning.

The concept of absorptive capacity, originally defined as the firm's ability to recognize the value of externally produced spillovers, assimilate them, and apply them inside the firm (Cohen & Levinthal, 1990), is instrumental to our understanding of how firms can learn and benefit from knowledge produced by other parties in their environment. Absorptive capacity being a by-product of R&D, the concept provides an explanation to why firms would be willing to invest in R&D when faced with the risk of its results leaking to competitors, namely when the value of spillovers by others that can be absorbed by the focal firm is greater (Cohen & Levinthal, 1989, 1990). Investment in R&D, even when its benefits cannot fully be appropriated by the focal firm, are thus sensible when they improve the firm's ability to learn from its environment, and use this new knowledge to increase innovative performance and flexibility (Cohen & Levinthal, 1990; Todorova & Durisin, 2007; Zahra & George, 2002).

In a static perspective, the logical conclusion is thus to invest in R&D to be able to harness incoming spillovers, while, at the same time, taking appropriate measures to minimize the outflow of knowledge by the focal firm (Cassiman & Veugelers, 2002). However, recent empirical work by Yang et al. (2010) suggests that this conclusion may be different when assuming a dynamic perspective, in which the outputs of one firm's absorptive capacity process—new knowledge that is added to the firm's existing knowledge base—can in fact become the spillovers that others are trying to harness. Neither the original paper on absorptive capacity (Cohen & Levinthal, 1990), nor its two reconceptualizations (Todorova & Durisin, 2007; Zahra & George, 2002) or extensions (van den Bosch et al., 1999), nor critical reviews (Lane et al., 2006) or papers advocating the advancement of the concept (Volberda et al., 2010), address this point.

In conceptualizing such a dynamic model of absorptive capacity, we argue that, under certain circumstances, firms may actually *want to have some of their current knowledge* spill over

voluntarily to competitors through selective revealing (Harhoff et al., 2003; Henkel, 2006). We maintain that, as a consequence of the voluntary and strategic disclosure of knowledge, firms may be able to influence the value of knowledge spillovers they will receive from externals in the future. Namely, when externals adopt the revealed knowledge as an input to their respective absorptive capacity process, it will be taken in and contributed to their existing knowledge base. This, however, may lead to externals' subsequent knowledge and spillover production becoming more strongly aligned to that of the focal firm, both in its current structure and language as well as its future direction. As a result, the voluntary and involuntary spillovers these externals produce subsequently should require lower cost of absorption and promise higher strategic alignment for that firm that selectively revealed knowledge in the first place. Accordingly, we argue that firms may be able to induce the creation of higher-value spillovers in their environment by releasing some of their own knowledge voluntarily, and benefit from this by being able to more efficiently and effectively absorb future incoming spillovers.

We make three contributions to the literature in this article. First, we develop the aforementioned extension of absorptive capacity to make it a truly dynamic model of knowledge absorption, production, and learning. In doing so, we isolate the value determinants of incoming knowledge spillovers, namely their content compatibility to the focal firm's current problems and knowledge trajectory, and their structural compatibility to the firm's language and structure used for knowledge storage and production.

Second, we explicate the advantages of selective revealing, the purposeful and strategic disclosure of knowledge, in a dynamic model of absorptive capacity. In distinguishing whether firms release problem-related or solution-related knowledge to their environment, we derive two conscious strategies—*signaling* and *steering*—that describe how external spillover production may be deliberately endogenized through firm action. Specifically, we show how selective

revealing through signaling and steering allows firms to increase structural and content compatibility of future incoming knowledge spillovers. In addition, we demonstrate how firms can enact signaling and steering strategies to achieve four strategic goals: problem-solving, agenda-shaping, diffusion-enhancing, and trajectory defining. In doing so, we show how firms, through managerial agency, can be capable of shaping the knowledge environments in which they are embedded by strategically and purposefully revealing knowledge they hold themselves.

Finally, employing Teece's (1986) profiting from innovation framework, we explore external influences on and potential limits to endogenous spillover production. In doing so, we try to uncover boundary conditions to our arguments on the benefits of voluntary knowledge disclosure. In showing the impact of the appropriability regime, life cycle phase, and complementary assets, we provide some insight into the generalizability of our contribution. Finally, we further discuss how our argument relates to extant debates in innovation strategy and organization theory, and propose an agenda for future research into this subject.

DEVELOPING A DYNAMIC MODEL OF ABSORPTIVE CAPACITYY

A Meta-model of Absorptive Capacity

A firm's absorptive capacity (ACAP) represents its capability to profit from knowledge spillovers produced by other parties in its environment (Cohen & Levinthal, 1989; Todorova & Durisin, 2007; Zahra & George, 2002). Such incoming spillovers (Cassiman & Veugelers, 2002) are often a crucial ingredient to innovative success (Arora & Gambardella, 1990; Powell et al., 1996). They can offer firms access to new solutions to existing problems, new functions for existing products and services, as well as ideas for new products and services, thereby increasing the firm's innovative performance (Laursen & Salter, 2006).

Following Cohen and Levinthal's (1990) seminal article defining the concept, two reconceptualizations have been provided by Zahra and George, as well as Todorova and Durisin.

Zahra and George (2002) add the distinction of potential (PACAP) and realized absorptive capacity (RACAP). PACAP refers to the firm's ability to acquire and assimilate knowledge, symbolizing its ability to access and understand spillovers. RACAP stands for its ability to make use of these spillovers by transforming and exploiting them appropriately. Todorova and Durisin (2007), in addition to suggestion adjustments to the Zahra and George classification, point out the dynamicity and path dependency of ACAP. Building on Cohen and Levinthal's key argument of absorptive capacity being dependent on the existence of relevant prior knowledge, Todorova and Durisin close the feedback loop by making "new prior knowledge" an output of the ACAP process. Moreover, both Zahra and George as well as Todorova and Durisin suggest several moderators which, at different steps in the process, may impact the firm's ability to profit from knowledge spillovers, such as social integration mechanisms, power relationships, or certain activation triggers. Finally, all models predict that the ability to benefit from spillovers will increase the firm's competitive advantage through increases in flexibility, innovation, and performance—the higher the firm's level of ACAP, the more likely it will gain competitive advantage. We capture these three similar approaches to ACAP in an abstract model depicted in Figure 1, which will become the basis of our argumentation. This meta-model also captures many of the extensions and improvements proposed for the concept of ACAP (Lane et al., 2006; Volberda et al., 2010).

Insert Figure 1 about here

Determining the Value of External Knowledge: Structural and Content Compatibility

Keeping the moderators in Figure 1 constant, it is clear that the value of a knowledge spillover to a specific firm, that is, its potential net contribution to the firm's competitive advantage, is contingent on two factors. First, the maximum value of an external spillover is determined by whether or not it objectively addresses a need of the firm (Cohen & Levinthal,

1989; Lane & Lubatkin, 1998).[1] Termed "know-why" by Lane and Lubatkin (1998, p. 466), this need may be present or future, in that it may be represented by a problem the firm is currently unable to solve, or by a missing piece in the trajectory along which the firm's knowledge base, in particular its R&D, is supposed to develop (Cohen & Levinthal, 1990; Lane et al., 2006). Second, provided firms deem the spillover to be in accordance with their knowledge needs and trajectory, they can try to assimilate and translate it through their ACAP and exploit and recombine it to produce learning and innovation (Cohen & Levinthal, 1990; Kogut & Zander, 1992; Zahra & George, 2002),[2] at varying odds of success (Dyer & Singh, 1998; Lane & Lubatkin, 1998; van den Bosch et al., 1999; Zahra & George, 2002). We also know that firms can influence these odds by building, developing, and improving their ACAP through investments in R&D (Cohen & Levinthal, 1990; Todorova & Durisin, 2007), and into specific relationships (Lane & Lubatkin, 1998), in order to be able to access a wider range of sources of knowledge as well as improve their capabilities of extracting value from them.

Assume now that we also hold ACAP constant, making the value of the spillover for the firm completely contingent on the spillover itself. The value of the spillover will then be determined by two factors. First, as said earlier, this is the (objective) potential maximum benefit the spillover inherent in its *content compatibility* to the current problems and future needs of the firm (Cohen & Levinthal, 1989; Lane & Lubatkin, 1998). Second, the level of *structural compatibility* of the spillover with the firm's existing body of knowledge and the language used to describe it (Cohen & Levinthal, 1990; Dyer & Singh, 1998; Grant, 1996a; Lane & Lubatkin, 1998; Mowery et al., 1996) determines the cost of assimilation and translation. Higher structural compatibility to the firm's existing knowledge base will increase the efficiency of knowledge integration, as this

[1] This maximum benefit includes the value that can be generated through recombination of the focal spillover with internal knowledge and/or other spillovers (see Kogut & Zander, 1992; Lane et al., 2006).
[2] In fact, it should be through their ACAP that firms identify external knowledge as a being of compatible content and assimilate it accordingly, which corresponds to Zahra and George's (2002) idea of potential ACAP.

will provide common knowledge (Grant, 1996a, 1996b), common ground (Clark, 1996; Puranam et al., 2009), or common language (Weber & Camerer, 2003). Finally, structural compatibility may also be a prerequisite for the firm to understand the content compatibility of the spillover. Thus, only if some shared meaning and understanding are present to ensure structural compatibility will integration of external spillover be possible at all (Cohen & Levinthal, 1990; Grant, 1996b), as content compatibility cannot be judged otherwise (Zahra & George, 2002).[3]

Towards a Dynamic Model of Absorptive Capacity

Irrespective of the above value determinants, most extant literature conceptualizes spillovers as fully exogenous (see, e.g., Cassiman & Veugelers, 2002; Cohen & Levinthal, 1989, 1990; Dyer & Singh, 1998; Kogut & Zander, 1992; Lane & Lubatkin, 1998; Lane et al., 2006; Todorova & Durisin, 2007; van den Bosch et al., 1999; Volberda et al., 2010; Yang et al., 2010; Zahra & George, 2002).[4] In this view, the two contingencies of the value of external knowledge become limitations: structural and content compatibility of spillovers are static, and their value to the firm can only be increased by modifying elements internal to the firm, such as restructuring

[3] Whereas looking at the two dimensions of structural compatibility separately would clearly go beyond the scope of this paper, the following elaboration makes clear that their effects on spillover absorption should at least be highly correlated. First, *compatible language* is necessary for understanding to occur, which is especially relevant for highly abstract or scientific knowledge (Lane & Lubatkin, 1998). Here, members of epistemic communities (Holzner & Marx, 1979) or different firms (Weber & Camerer, 2003) might employ similar concepts, the meaning of which however may vary and can only be understood in its context (Zolo, 1989, p. 170). Consequently, when spillovers arrive in a "different language"—that is, no shared meaning (Grant, 1996a) exists—translation cost for such spillovers will increase, and the likelihood of them being successfully integrated by the focal firm drops (Grant, 1996a, 1996b; Weber & Camerer, 2003). Second, a *compatible structure* will ease the firm's assimilation of the external spillover, also resulting in a higher likelihood of the firm succeeding at its integration and exploitation. Similarity in the structure of technology portfolios between the focal firm and the source from which the spillover originates facilitates adoption of the spillover (Jaffe, 1986), and may help counter the problems of understanding described above (Grant, 1996a). As a consequence, an overlap in the knowledge space in which two firms are working leads to a higher likelihood of the spillover being used at all (Yang et al., 2010), a higher level of external knowledge being absorbed (Mowery et al., 1996), and, ultimately, higher innovative output for the firm absorbing the spillover (Yang et al., 2010).

[4] Whereas literature in economics exists that deals with the role of endogenous spillover production (Romer, 1990), the issues and mechanisms addressed there are substantially different from this paper. For example, they may be limited to specific collaboration and ownership structures, such as a research joint ventures in which development costs and outputs are jointly determined (Katsoulacos & Ulph, 1998; Katz, 1986). Consequently, they do not present the causal logic of why a single firm would try to endogenize spillover production by itself through *voluntary* spillovers as well as a description of how this may be achieved, the contributions of the present manuscript.

the firm's knowledge base, revising its knowledge trajectory, or increasing ACAP.

We argue that this static view of the ACAP process is due to the fact that the related literature usually looks at the occurrence of learning within a single firm at a specific point in time, thus missing the dynamicity and interaction that is fundamental to learning and the creation of new knowledge. We extend this view by introducing dynamic, inter-temporal considerations. In essence, we maintain that when firms absorb knowledge spillovers to make them usable for their own R&D efforts, these efforts themselves will produce spillovers to *other firms* which these can use for their R&D efforts, which will produce spillovers, and so on. Thus, when considering repeated flows of knowledge flows across the boundary of the firm over time, we see that new knowledge produced by the focal firm, through its R&D and ACAP, may become a predecessor of the spillovers it receives from its environment. This argument is summarized in Figure 2.[5]

Insert Figure 2 about here

To understand the implications of our argument, the mechanisms illustrated in Figure 2 need to be put in context of the literature of value generation from R&D and knowledge production. Figuratively, this would mean extending Figure 2 from the depicted two-firm case to an *'n'* actor case, where *n* different actors could subsequently build on each others' spillovers, and/or recombine multiple spillovers from different sources at the same time.

In this context, extant literature takes a predominantly negative view on the effect of firm knowledge leaking to the environment on the value of R&D of the focal firm. Most importantly, a large body of literature argues that the focal firm should either prevent such *involuntary*

[5] The situation illustrated in Figure 2 could for example depict the learning process in an alliance that the focal firm has entered. In a sequential process, each firm would take the relevant bits from an existing pool of knowledge held by the alliance partners, adapt and assimilate it (so as to be able to understand and use it), and add to that some private knowledge in accordance with the aims of the alliance. This updated knowledge is then contributed back to the pool, where the next party can pick it up to contribute, and the process is repeated until the goals of the partnering firms are reached or the alliance is dissolved (see, e.g., Powell et al., 1996). Similar processes of joint knowledge production, sharing, and learning will be ongoing in other modes of direct and purposeful collaboration by the firm, which could for example also involve customers, users, and suppliers (von Hippel, 1988).

knowledge spillovers to the environment altogether, or at least take steps so that eventual spillovers cannot be appropriated by other firms (Cassiman & Veugelers, 2002; Winter, 1987). The firm would ensure this through employment contracts (Williamson, 1985) and protection and appropriation mechanisms such as secrecy, patenting, or lead time (Cohen et al., 2000; Teece, 1986). The better the firm is able to protect the knowledge it produces by preventing involuntary spillovers to competitors and, thus, the higher excludability and inimitability will be, the more likely this knowledge will positively contribute to the firm's competitive advantage (Barney, 1991; Dierickx & Cool, 1989).

However, we argue that when looking at ACAP as a dynamic process, under certain circumstances, firms may be willing to create spillovers *voluntarily* and *purposefully*. Specifically, these firms will choose parts of their current knowledge and make it accessible to their environment, even free of charge, to foster learning, innovative performance, and, ultimately, competitive advantage (Harhoff et al., 2003; von Hippel & von Krogh, 2003). Such strategic behavior, termed 'selective revealing' (Henkel, 2006), rests on the assumption that voluntarily disclosing knowledge now will be beneficial to the firm in the short-term or long-term future. For example, an upstream firm may be willing to share some of the results of its R&D to increase downstream demand for related products (e.g., Harhoff, 1996). Similarly, firms might be willing to contribute upstream knowledge and IP to joint knowledge production efforts in order to attract more parties to join in quasi-collusive collaboration efforts, so as to ensure the firms' downstream competitiveness (Alexy & Reitzig, 2010)

SELECTIVE REVEALING IN A DYNAMIC MODEL OF ABSORPTIVE CAPACITY

The above examples indicate that selective revealing of knowledge by the focal firm can affect the knowledge production function of other actors. Since firms can determine what knowledge they want to reveal, they can determine which bits of their knowledge are provided to

externals' as potential input to their absorptive capacity processes, R&D, and similar knowledge production activities. Recalling the mechanism depicted in Figure 2, over time, these activities are likely to cause knowledge spillovers themselves, of which the focal firm might again profit.[6]

In this sense, by selectively revealing its own knowledge, the firm may be able to have an effect on the knowledge that is produced by others, and thereby induce others to produce higher-value knowledge spillovers. Specifically, the potential advantage of selective revealing would reside in inducing others' production of knowledge in such a way that its value to the focal firm increases. As discussed earlier, when holding all aspects related to ACAP that are internal to the firm constant, the value of incoming external knowledge depends on its content compatibility to the firms current problems and anticipated knowledge trajectory (their maximum value) and its structural compatibility to the firm's existing body of knowledge (absorption cost).Thus, selective revealing of knowledge by the focal firm will be advantageous if it can influence others' production of knowledge in such a way that they produce knowledge spillovers of higher structural or content compatibility.

To understand how selective revealing may impact the value of (subsequently) incoming knowledge, it is crucial to determinate the nature of the knowledge that is revealed by the firm. To do so, we follow von Hippel's (1988) established distinction of problem-related (or: need-related) vs. solution-related knowledge. Accordingly, we define *signaling* as the company purposefully leaking to its environment the current problems it is facing and/or the direction of the knowledge trajectory (including its gaps) along which it intends to move. We define *steering* as the focal firm voluntarily and strategically disclosing to its environment knowledge on how to solve a certain problem, as for example embodied in a patent, product, or product component

[6] See Yang et al. (2010) for a similar argument which, however, does not conceptualize spillovers by the focal firm as voluntary or strategic, but occurring by chance. Rather, they explicitly suggest that their "results should not be interpreted as a prescription for encouraging spillovers." (p. 386)

addressing a certain need or providing a certain function. Building on these definitions, in the following, we explicate how signaling and steering today may increase the structural and content compatibility of future incoming knowledge spillovers. Table 1 summarizes our argument.

Insert Table 1 about here

Selective Revealing Improving Content Compatibility of Future Knowledge Spillovers

Signaling. Signaling may have two direct effects on other actors in the focal firm's environment. Both effects build on the fact that problem-related knowledge directly embodies a need of the focal firm that others may be able to satisfy in a way that is also beneficial to them.

First, external actors may be encouraged to submit to the focal firm existing knowledge they have to help address the specific problem. Jeppesen and Lakhani's (2010) concept of broadcast search builds on the idea that, for many existing problems a firm may face, actors outside the firm have available to themselves private knowledge resulting from joint membership in multiple epistemic communities which they can apply to solve the problem at low cost. Literature on open source and user innovation illustrates how both firms and individuals may be willing to share for free such knowledge with the focal firm in the form of voluntary spillovers for a variety of reasons, including for example the pure fun and enjoyment of problem-solving (Lakhani & Wolf, 2005), status incentives (Jeppesen & Frederiksen, 2006), reciprocity (Bonaccorsi & Rossi, 2006; also see Westphal & Zajac, 1997), and, ultimately, downstream financial profit (Henkel, 2006).

Second, disclosed problem-related knowledge may act as a trigger for new development activity on the side of the external actors, as these now know that the problem, and thus demand for a solution, exists. For example, universities may launch research programs based on problem-related knowledge embedded in research calls made by commercial firms, a strategy widely employed in Silicon Valley (Alexy et al., 2009; MacCormack & Herman, 2004).

Taken together, these points indicate that the sharing of problem-related knowledge may

facilitate the development of problem solutions by others. Even when externals should not be willing to freely share their solutions with the focal firm as voluntary spillovers, at least the involuntary spillovers they produce will exhibit increased content compatibility with the current and future knowledge needs of the focal firm, as externals will still be aiming at the production of knowledge that is strongly related to the needs of the focal firm. Thus, once the dynamic nature of absorptive capacity is taken into account, signaling holds the potential to increase the value of future spillovers to the firm by improving their content compatibility.

> *Proposition 1a: In a dynamic model of absorptive capacity, selective revealing through signaling can increase the value of future knowledge spillovers to the focal firm. Specifically, signaling increases content compatibility by encouraging others to develop solutions to the firm's current and project future problems.*

Steering. Through steering, the focal firm has the option of making problem solutions, embodied for example in products, components, patents, or publications, available to external actors. In turn, the externals adopting the revealed knowledge may lead to them beginning to provide improvements, extensions, and complements to the spillover itself, and thus also to related knowledge that the firm has kept in-house. First, steering will allow others to increase functional compatibility of their products to that of the focal firm, or vice versa. This increased functional compatibility should precipitate both increased convergence toward the focal firm's knowledge trajectory as well as the generation of complements and second-generation innovation built on and around the revealed knowledge (Farrell & Gallini, 1988; Harhoff et al., 2003; Katz & Shapiro, 1985, 1986; Shepard, 1987). Second, as the fear of lock-in by a monopolistic supplier decreases through the release of the spillover in voluntary form (Farrell & Gallini, 1988; Shepard, 1987), higher levels of adoption of the knowledge, also among consumers, is more likely. Taken together, these two mechanisms indicate a strong potential for network externalities, which may ultimately result in other firms joining the focal firm's knowledge trajectory (Spencer, 2003). In any case, externals who adopt solution-related

knowledge disclosed by the focal firm will begin working on issues strongly related to that of the focal firm or increase their commitment to these areas of knowledge. As a result, both voluntary and involuntary spillovers these externals will produce should exhibit higher content compatibility to the current knowledge needs and intended knowledge path of the focal firm.

Taken together, steering, too, has the potential to impact on the maximum value of knowledge spillovers the focal firm receives from its environment by improving their content compatibility. We thus posit:

> *Proposition 1b: In a dynamic model of absorptive capacity, selective revealing through steering can increase the value of future knowledge spillovers to the focal firm. Specifically, steering increases content compatibility by attracting others to join the firm's knowledge trajectory.*

Selective Revealing Increasing Structural Compatibility of Future Knowledge Spillovers

Signaling. Any piece of problem-related knowledge revealed through signaling will embody the focal firm's structure and language of knowledge it has in the general area of the problem. In turn, externals that decide to adopt this spillover to work on the revealed problems will necessarily have to provide an *output* (to the focal firm) that is structurally compatible to the initially released problem. However, in order to be able to produce these structurally compatible outputs, the actual knowledge production process of the firm may have to be adjusted, which reduces the focal firm's adaptation cost of future spillovers produced by this external. At the very least, the external party trying to assimilate the spillover will have been in touch which the focal firm's language and structure, and thus needed to develop some translation capability, which should affect the external party similarly, albeit potentially less strongly.

> *Proposition 2a: In a dynamic model of absorptive capacity, selective revealing through signaling can decrease the cost of adaptation of future knowledge spillovers to the focal firm. Specifically, signaling may increase structural compatibility by facilitating output-driven adaptation of the structure and language of the knowledge base of others.*

Steering. Steering may lead to others adopting solution-related knowledge released by the

focal firm as *input* to their own R&D. Specifically, externals will try to absorb the revealed knowledge when it represents a cheaper replacement for or complement to their own R&D (Harhoff, 1996), which they will consequently try to assimilate, adapt, and exploit. However, in this absorption process, it is likely that the knowledge retains some of original character, that is, its language and structure. Through its own ACAP process, the external firm will familiarize itself with the original structure and language of the voluntary spillover and keep some of it as its own (Lane & Lubatkin, 1998), in particular when re-using the external knowledge with little to no modification (Fleming, 2001; Kogut & Zander, 1992) or when external knowledge is generally preferred to internal knowledge (Menon & Pfeffer, 2003). Due to the path-dependent nature of ACAP and learning (Cohen & Levinthal, 1989, 1990; Nelson & Winter, 1982; Todorova & Durisin, 2007), the adoption of the spillover by the external party may then lead to a perpetual assimilation in the structure of the output of the external party's ACAP process and potentially the process itself (van den Bosch et al., 1999). For example, it is well known that firms in alliance relationships, by adopting and extending each other's technologies, develop higher levels of overlap in the technologies they work on and increased similarity in their technology portfolios (Mowery et al., 1998), which in turn again eases adoption, extension, and exploitation (Dyer & Singh, 1998; Lane & Lubatkin, 1998; Mowery et al., 1996). Thus, provided they are adopted by externals, voluntary spillovers, too, might initiate an assimilation of language and structure of knowledge produced by these externals to that of the focal firm. Subsequently, the spillovers these externals produce can be harnessed more efficiently by the focal firm. Eventually, as shown by Yang et al. (2010), this increased structural compatibility will lead to a rise in the focal firm's ability to profit from incoming spillovers.

> *Proposition 2b: In a dynamic model of absorptive capacity, selective revealing through steering can decrease the cost of adaptation of future knowledge spillovers to the focal firm. Specifically, steering may increase structural compatibility by facilitating input-driven adaptation of the structure and language of the knowledge base of others.*

In addition, the release of either problem- or solution-related knowledge may also have indirect effects on externals and the structural compatibility of knowledge spillovers these produce. Specifically, firms may influence language and structure of spillovers by fostering the development and adoption of standards acting as norms governing knowledge production (Kogut & Zander, 1996). Once a sufficient number of actors has adopted a certain structure and language in a given knowledge domain, possibly culminating in the foundation of an epistemic community on its own (Holzner & Marx, 1979), it will be beneficial for other actors to converge to this format to facilitate common knowledge and efficient cooperation with its environment (Grant, 1996a, 1996b; Kogut & Zander, 1996). Ceteris paribus, the strategic provision of knowledge to others may increase the potential for standard-setting, and thus the establishment of norms about the structure and language of knowledge production, as for example articulated in a dominant design (Spencer, 2003). Ultimately, this form of standard-setting may cumulate in the focal firm being able to influence, and potentially even dominate, the structure of knowledge production across an entire industry, by transforming industry architecture (Gawer & Cusumano, 2002; West, 2003).

INCORPORATING SELECTIVE REVEALING IN FIRM STRATEGY

The preceding discussion has shown how selective revealing today may impact the value of spillovers the focal firm may subsequently receive. Specifically, through signaling and steering, firms may increase the structural and content compatibility of incoming knowledge. In the following, by looking at whether firms aim at achieving short-term or long-term benefits from employing these strategies, we explicate four strategic goals which firms may achieve by purposefully leaking knowledge to their environment: *problem-solving*, *agenda-setting*, *diffusion-enhancing*, and *trajectory-defining*. Table 2 summarizes our argument, Table 3 gives further details on the four strategic goals, also showing how they relate to extant literature. In

doing so, Table 3 makes clear that our dynamic logic, naturally, will more strongly apply to industries in which knowledge evolves along a cumulative path (e.g., Scotchmer, 1996).

Insert Tables 2 and 3 about here

Problem-solving and Agenda-shaping through Signaling

In signaling its current or future need to its environment, the firm is reducing the pre-existing information asymmetry about which knowledge it is looking for specifically, in turn encouraging external actors to modify their behavior accordingly (see Spence, 1973). Signaling thus provides a solution to the basic nested problem of establishing common ground ("I know that you know that I know that you know…" (Clark, 1996; Puranam et al., 2009)). The voluntary disclosure of a spillover is a clear signal of the intent to collaborate with externals, which is a non-trivial precursor of actual collaboration (Kogut & Zander, 1996), without mandating formalized or contractual collaboration to achieve the focal firm's goals (Spencer, 2003).

Problem-solving. As such, signaling may have an almost immediate impact on knowledge received for the firm's environment if it is used as a means to initiate *problem-solving* by externals. As named earlier, broadcast search may be an example for this strategy (Jeppesen & Lakhani, 2010). Here, the focal firm directly signals current problems it is unable to solve on its own to its environment in the hope to find external actors with related, yet sufficiently distinct knowledge, able to tackle the issue at hand. Clearly, this specific implementation of signaling is aimed at increasing the content compatibility, rather than the structural compatibility of incoming spillovers. However, as argued earlier, by working on a problem specified by the focal organization, the solution as well should bear elements of that firm's structure and language of knowledge production. Consequently, we posit:

Proposition 3a: Through signaling, a firm may quickly engage others in solving its current problems.

InnoCentive (Lakhani & Jeppesen, 2007) represents an illustrative example of how the

disclosure of current problems to third parties may lead to them providing solutions quickly. Here, firms, often after having tried to address an R&D issue for considerable time and with substantial resources, pass on problems to InnoCentive, acting as an intermediary that brings together the signaling party with a pool of several thousand potential solvers, consisting mainly of academics, industrial scientists, inventors, and hobbyists. Together with the original firm, InnoCentive creates a description of the problem that may appeal to wide areas of its solver pool. Because of the subject diversity of the pool, for a large share of the supposedly very difficult problems, a least one individual, often bridging adjacent areas of knowledge (Jeppesen & Lakhani, 2010), will have a solution for the problem readily at hand. While the firm will still have to pay a reward for accessing this solution, this type of signaling strategy will still very often be substantially less costly than insisting on finding a solution in-house, or forsaking a project altogether. In the same spirit, other firms, such as P&G (Huston & Sakkab, 2006), are listing on their website their current problems for everyone to see and contribute.[7]

Agenda-shaping. Regarding future knowledge needs of the organization, the signaling of problem-related knowledge may allow the focal firm to *shape the development agenda* in the technology areas in which it is active, so as to entice externals to coordinate around the production of solutions fitting to the focal firm's knowledge trajectory and its gaps. For example, regarding R&D, traditionally, future needs are addressed by integrating basic R&D into the firm, or contracting for it on the market for technology (Arora et al., 2001). However, these needs might also be communicated to the environment, for example through open research calls (Alexy et al., 2009) or idea jams (Bjelland & Wood, 2008). Even more basic, simply making the focus of R&D activity known to the public through the company website or official publications may spur the development of related activity and their submission to the firm from the firm's

[7] See www.pgconnectdevelop.com >> "Browse P&G's needs", last accessed December 12, 2010.

environment. Consequently, we state:

Proposition 3a: Through signaling, a firm may shape the development agenda around an evolving technology.

Agenda-shaping is for example incorporated in the so-called DARPA model, which has been executed successfully by the U.S. Department of Defense for decades, and which has also been transferred to several Silicon Valley companies, such as Intel (MacCormack & Herman, 2004) or HP (Alexy et al., 2009). For example, Intel would regularly design open research calls in nascent technology areas around its technology platforms. Whereas these calls are generally open to a wide audience (such as all university researchers), by restricting the specific problem to an area relevant to Intel, Intel achieves two direct benefits. First, they receive, for free, a large number of research proposal depicting both the current state-of-the-art of research in the problem area as well as the possible range of approaches to solving the problem. Second, Intel can hand pick and fund or hire those individuals whose suggestions they deem most economically or strategically viable to begin the joint exploration of identifying problem solutions.

Diffusion-enhancing and Trajectory-defining

Diffusion-enhancing. Steering, too, may have time-varying effects on its environment. From a short-term perspective, firms engage in steering to increase diffusion of their knowledge (also see Varian & Shapiro, 1999; von Hippel, 1988, 2005). For example, firms may release knowledge embodied in patents, products, or components, allowing other parties to adopt this knowledge quickly into their own knowledge production processes. As argued before the revealed knowledge might even be integrated unchanged by externals in industries which have layered architectures (Pisano & Teece, 2007) or in which modularity is prevalent (Baldwin & Clark, 2000). We thus posit:

Proposition 4a: Through steering, a firm may quickly enhance diffusion of its knowledge.

The advantages the focal firm may receive from such increased diffusion and alignment are

well-documented by the literature. Essentially, those externals that adopt the revealed solution-related knowledge will themselves begin to produce knowledge which has higher structural and content compatibility to the focal firm. However, since innovative activity (Scotchmer, 1996) and learning (Cohen & Levinthal, 1990; van den Bosch et al., 1999) are cumulative and path-dependent, adopting the released knowledge may permanently shift externals' technology trajectories to be more closely aligned to that of the focal firm. In turn, first, increased diffusion will enhance the value of other (knowledge) assets that the firm has *not* disclosed (Henkel, 2006) through network externalities. Second, other actors may be willing to share improvements and extensions to the revealed knowledge, independent of whether these are irrelevant (Allen, 1983) or relevant (Henkel, 2005; Nuvolari, 2004; Spencer, 2003) to competition, lowering development and maintenance costs of the focal firm. Eventually, the effects of steering may culminate in inducing norms of reciprocity and mutual non-enforcement of intellectual property rights (Alexy & Reitzig, 2010), and/or creating networks or ecosystems of knowledge production with the focal firm at the center (Varian & Shapiro, 1999).

Steering to enhance diffusion might be particularly appealing to a firm in control of technological platforms. This firm may open up part of the platform to induce others to adopt it. For example, IBM opened up the core of its Eclipse software development program to the public, including the source code of the software (West, 2003). Eclipse being open immediately increased its diffusion among individual end users, but also led to many commercial firms abandoning their own efforts at developing similar tools, instead focusing on adapting Eclipse to their respective needs. As many of these actors made their adaptations open to the public again at no cost, the functional scope of Eclipse and its functional compatibility with other platforms was extended substantially beyond IBM's initial contribution. This led to a further boost in diffusion, rendering Eclipse the de-facto standard software development tool on all platforms, including

those controlled by IBM's fiercest rivals Microsoft and Sun in which IBM previously had hardly been able to establish a foothold. In turn, IBM now had a bustling ecosystem around its platform producing upgrades and extensions to its program, and a substantially increased installed base to which it could sell complementary offerings.

Trajectory-defining. In a long-term perspective, steering is particularly useful to shape the development of newly-created or yet-uncertain knowledge trajectories. Here, by releasing solution-related knowledge, firms try to convince other industry stakeholders that their preferred technology trajectory is both viable and legitimate, and should be preferred over alternative solutions if these exist. By encouraging others to use the revealed knowledge, potentially even supporting them in doing so, the firm may be able to influence its environment to converge (or at least shift) towards the focal firm's preferred knowledge trajectory. As these externals' future path becomes more aligned to that of the focal firm, steering will increasingly allow the firm to impact how other industry stakeholders think about the evolution of the technology, guiding them towards the firm's preferred path. The more closely aligned externals become, the higher the structural and content compatibility of all knowledge they produce. Therefore, steering ultimately may enable the firm to influence or determine dominant design (Spencer, 2003), industry architecture (Gawer & Henderson, 2007), or even create entirely new institutional fields (Dodgson et al., 2007). Accordingly, we posit:

> *Proposition 4b: Through steering, a firm may define and establish (new) technology trajectories.*

For example, Spencer (2003) shows how the voluntary disclosure of basic knowledge via academic publishing in the flat-panel industry allowed firms to successfully influence industry standards and attract new entrants to the industry. She also found that firms sharing solution-related knowledge openly and globally achieved higher innovative performance. We argue that this is due to the fact that the strategic release of solution-related knowledge enticed existing

actors as well as new entrants to converge towards the focal firm's knowledge trajectory.

Relatedly, Dodgson, Gann, and Salter (2007) explicate how steering can help firms legitimize new technology trajectories by establishing institutional fields. They describe the case of the engineering consultancy ARUP, which had developed a novel technological solution to use elevators in case of fire emergencies. However, since established norms were strictly contradictory to this technological advancement, ARUP needed to convince all industry stakeholders of the viability of this technology. ARUP released solution-related knowledge to its competitors to increase the number of actors interested in establishing this field and strongly involved regulators in new building design. Ultimately, this strategy allowed them to create and legitimate the new field of 'fire engineering' in which they were known as the primary authority, since everyone was in accordance that it was ARUP's technology trajectory they had joined. Nevertheless, since ARUP was strategic about what specific knowledge they revealed, they continued to hold a commanding technological lead over all other parties.

BOUNDARY CONDITIONS OF SELECTIVE REVEALING STRATEGIES

Summarizing, we have so far developed a dynamic model of absorptive capacity, in which selective revealing allows the firm to influence the knowledge produced by others and its value to the focal firm. In particular, strategies of signaling and steering may increase the structural and content compatibility and, thus, the value of incoming spillovers, allowing firms to achieve the goals of problem-solving, agenda-shaping, diffusion-enhancing, and trajectory-defining.

While the preceding argumentation has shown that voluntary spillovers may pose a tremendous opportunity to firms, it is highly unlikely that selective revealing is universally beneficial to all firms in all competitive settings. Consequently, boundary conditions for our arguments need to be specified that indicate the circumstances under which engagement in selective revealing is more likely to be beneficial to companies.

Primarily, also with selective revealing, the firm needs to find a way to appropriate returns from learning and collaboration (Henkel, 2006; Pisano & Teece, 2007). To explore conditions that may limit or reinforce the value-creating potential of selective revealing, we will thus look at how the elements of Teece's (1986) profiting from innovation framework, which describes how a given appropriability regime, the life-cycle phase of a technology, and ownership of complementary assets, influence a firm's ability to benefit from its innovative activities. In turn, this discussion allows us to complete our dynamic model of ACAP, presented in Figure 3.

Insert Figure 3 about here

Appropriability Regime

Generally, the appropriability regime represents "environmental factors, excluding firm and market structure […]. The most important dimensions of such a regime are the nature of the technology, and the efficacy of legal mechanisms of protection." (Teece, 1986, p. 287) These two aspects have become well-known moderators in studies of ACAP, as they may affect the focal firm's ability to translate incoming knowledge into competitive advantage (Cohen & Levinthal, 1990; Zahra & George, 2002), as well as this knowledge becoming a spillover at all (i.e., leaking from another firm) (Todorova & Durisin, 2007).

Generally, the inability to protect in-house solution-related knowledge because of weak appropriability regimes may provide an incentive to disclose it voluntary instead (von Hippel & von Krogh, 2003). However, protection mechanisms will still apply to the disclosure of solution-related knowledge through steering even in weak appropriability regimes. For example, legal mechanisms may affect the structuring of knowledge to be released, as legal ownership over certain knowledge domains and their physical embodiments may mandate a changing the natural structure of to-be-released knowledge to ensure that other parties' ownership rights are not violated (Henkel & Baldwin, 2009). Also, the released knowledge might be protected by

intellectual property rights the firm itself holds, such as patents or copyright. In this case, granting royalty-free access (Farrell & Gallini, 1988; Shepard, 1987) or even forfeiting these rights entirely (Alexy & Reitzig, 2010) are options that the firm will need to consider to increase adoption and diffusion.

On the contrary, tight appropriability regimes may be supportive of firm efforts to engage in signaling. Specifically, the existence of clearly demarcated property boundaries is a necessary condition for the formation of exchanges between parties, which includes the exchange of knowledge (Arora et al., 2001). Thus, when a firm signals to its environment the existence of a knowledge problem, the existence of rights specifying ownership of a solution and what exactly it entails will facilitate the transfer of this solution to the focal firm. For example, InnoCentive problems include explicit descriptions about intellectual property ownership and transfer (Lakhani & Jeppesen, 2007), which is particularly important not to endanger patentability for (life) sciences problem solutions, where patents are of the highest value (Cohen et al., 2000). Similarly, undisputed patent rights over a technology may facilitate its swift acquisition or licensing (Alexy et al., 2009; Arora et al., 2001) once it has been identified as suitable solution to a problem disclosed via signaling. Taken together, we thus posit:

> *Proposition 5a: The prevalent appropriability regime will impact the firm's choice of free revealing strategies. Strong appropriability regimes will favor signaling strategies, whereas weak appropriability regimes will favor steering strategies.*

In addition, it is clear that a cognitive change regarding the role of intellectual property protection will need to occur if selective revealing is new to a firm. As for example argued by Alexy et al. (2009), in order for selective revealing strategies to succeed, the dominant mindset of internal agents to the protection of intellectual property and its strategic use needs to be modified. As such, the belief in the importance of legal appropriation mechanisms is likely to be an internal hurdle to the implementation of strategies embodying voluntary spillovers, in

particular when it comes to solution-related knowledge. We would not expect an equally-sized effect for signaling strategies, as those might not as often be considered to mandate the sharing of supposedly non-disclosable knowledge. We consequently posit:

> *Proposition 5b: The prevalent internal approach to the use of legal appropriation mechanisms will influence the use of strategic revealing. An internal focus on protection should decrease the firm's use of disclosure strategies, in particular of steering.*

In addition to protection mechanisms, the nature of the technology, such as its codifiability and tacitness (Winter, 1987) or stickyness (von Hippel, 1994) should influence the production of voluntary spillovers. First, firms might be hesitant to disclose tacit solution-related knowledge as it can be kept secret easily, thus promising high returns from excludability and inimitability (Teece, 1986; Winter, 1987). However, in case firms decide to disclose this knowledge nonetheless, they will need to make an effort to make this knowledge easily accessible to other parties in order to facilitate adoption. As a consequence, firms may either have to release additional contextual knowledge (which they might not have wanted to release) or invest into the provision of additional support, such as documentation or toolkits. While such efforts will create cost to the firm releasing the voluntary spillover, the potentially higher value of the released knowledge might in turn increase the likelihood of it being adopted by other parties.

Relatedly, certain attributes (in addition to its tacitness) can lead to knowledge being sticky, that is, difficult for the firm to actually express and articulate. Stickyness will thus affect how easy it is for the firm to describe its problem to outsiders (von Hippel, 1994) as well as share solution-related knowledge with them. In turn, stickyness will create additional cost for both signaling and steering efforts, whereas tacitness mainly affects steering. We can thus posit:

> *Proposition 5c: The nature of knowledge will influence the use of selective revealing strategies. The more tacit and sticky knowledge is, the less likely firm's will engage in selective revealing. Specifically, the tacitness and stickyness of knowledge will affect signaling and steering, and the stickyness knowledge will affect signaling.*

Life Cycle Phase

The life cycle phase in Teece's model refers to whether or not a dominant design exists. As the establishment of a dominant design and industry standards is one of the central goals of selective revealing strategies, it is clear that their impact is severely limited in case one exists already. Its non-existence should increase the likelihood that the focal firm may succeed in enforcing on external actors its own ideas of language, structure, problems, and trajectories through voluntary knowledge disclosure (Gawer & Henderson, 2007; Spencer, 2003). In contrast, the existence of such a standard[8] suggests that established categorizations for language and structure of knowledge production, and an accepted knowledge trajectory are already in place. The goal of defining a dominant design might thus be replaced by an attempt to adjust or modify it, potentially limiting the impact of voluntary disclosure strategies. However, the firm may instead decide to try to use selective revealing strategies to *break* the existing paradigm, in particular when the use of the current standard is costly to the focal firm as well as to other actors (Varian & Shapiro, 1999). The free nature of the revealed knowledge might entice other actors to use it instead of the current standard as an input to their own knowledge production functions, resulting in a dynamic mixed duopoly situation (Casadesus-Masanell & Ghemawat, 2006), or even the establishment of a single new standard (Varian & Shapiro, 1999). However, such a replacement of an existing, actively used standard should mandate that the revealed knowledge has to be of solution-related nature, suggesting that steering strategies will exhibit higher potential in situations where a dominant design exists. Summarizing, we posit:

> *Proposition 6: The existence of a dominant design will change the nature and goal of selective revealing strategies. Steering will be more suitable than signaling to replace existing dominant designs.*

Complementary Assets

Finally, those capabilities and assets required for the successful commercialization of an

[8] Teece also uses the terms standards (often in quotation marks), dominant design, and paradigm interchangeably.

innovation are called complementary assets. In particular when they are hard to replicate, ownership over such assets will result in the focal firm capturing a larger share of innovative rents (Teece, 1986). From the perspective of knowledge disclosure, ownership of complementary assets, which may also include related knowledge kept in-house, has a clear positive impact as potential losses from knowledge sharing are minimized (Fosfuri et al., 2008; Henkel, 2006). As argued earlier, steering in particular should lead to an increase in the value of complementary assets and the firm's ability to profit from them. For firms who hold complementary assets (i.e., large firms in particular), steering may allow them to commoditize layers of industry architecture and shift the nature of competition to the ownership of complementary assets. We thus posit:

> *Proposition 7: Ownership of complementary assets will positively affect firms' willingness to engage in strategies embodying knowledge disclosure and their ability to profit from them. Steering will be particularly valuable to large firms owning many complementary assets.*

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

In this paper, we have argued for an extension of the concept of absorptive capacity to expand its static view of exogenously given knowledge spillovers. Instead, we have developed a dynamic model of ACAP that accounts for the fact that the structural and content compatibility of incoming knowledge spillovers can be influenced, showing that firms can take purposeful action to manipulate the spillovers that other actors produce by selectively revealing knowledge themselves. When firms voluntarily disclose knowledge on their own and others adopt it as inputs to their knowledge production processes, both the outputs as well as the spillovers these externals produce will exhibit greater structural compatibility to the focal firm's existing body of knowledge, and greater content compatibility to the focal firm's problems and knowledge trajectory. We describe two strategies, namely signaling, the release of problem-related knowledge, and steering, the disclosure of solution-related knowledge, which firms can employ to attempt to shape externals' knowledge (and, thus, spillover) production and achieve four

strategic goals: problem-solving, agenda-shaping, diffusion-enhancing, and trajectory-defining. Finally, we have explored boundary conditions of our arguments by discussing the effects of the appropriability regime, life cycle phase, and complementary assets.

Our arguments formalize and extend a recent debate in the literature on ACAP that looks how outgoing spillovers might be beneficial to a firm (Yang et al., 2010). To this discussion, we contribute by conceptualizing the voluntary disclosure of knowledge as a conscious strategy aimed at shaping the spillovers others produce. We explicate the positive consequences of selective revealing, describe through which strategies they may be attained, formalize the goals that may be achieved, and reflect on how the choice and efficacy of selective revealing might in turn be influenced by contextual factors. Taken together, we expand the existing notion of ACAP to make it a truly dynamic concept of learning and knowledge production. The outputs of the focal firm's ACAP process—new knowledge—not only feed back into the focal firm's process itself (Todorova & Durisin, 2007), but may also be picked up by other actors in the firms environment. In turn, this will shape the outputs and spillovers these externals again produce, making them more valuable to the focal firm.

In addition, our model allows us to reinvigorate the link between ACAP, spillovers, and isomorphism mentioned by Lane and Lubatkin (1998), which has since disappeared from the literature. Specifically, the goal of signaling and steering is to influence external actors to adapt their language and structure of knowledge production as well as their knowledge trajectories to better match the focal firm. Thus, the focal organization is employing the strategies of signaling and steering to purposefully initiate isomorphic behavior by other actors. This *induced isomorphism* shares similarities with other forms of isomorphism (DiMaggio & Powell, 1983), in particular coercive isomorphism, which results from pressure or persuasion from environmental sources. Yet, the adoption of selectively revealed knowledge by external actors is not a coerced

decision, as its provision is not an "[invitation] to join in collusion" (DiMaggio & Powell, 1983, p. 150), but merely an open offer to external parties that those are free to reject. Nonetheless, the acceptance of this offer will mandate at least some isomorphic behavior. Induced isomorphism also shares aspects of mimetic isomorphism, as some externals will react positively to the focal firm's knowledge disclosures as they will reduce uncertainty. For example, disclosure of existing technologies and technology trajectories may serve as orientation to some parties that are grappling with related issues. Finally, the ultimate goal of induced isomorphism is to create normative pressures by establishing dominant standards and designs. Once enough firms have converged towards the focal firm's structure, language, problems, and trajectory, normative isomorphism may lead to the focal firm potentially emerging as the central organization in a larger knowledge network or ecosystem, and stimulating bandwagon effects that will strongly and primarily benefit the focal firm.

Furthermore, we think that our argument can also be informative to currently ongoing discussions in the literature on innovation strategy, two of which appear noteworthy. First, we would encourage future studies to formalize the ability to engage in selective revealing strategically as a dynamic capability (Teece et al., 1997). Clearly, being capable of using selective revealing to favorably influence the firm's competitive position is representative of an "ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments. (p. 516) " Second, the literature on open innovation and related phenomena often makes a distinction between outbound and inbound open innovation (see Dahlander & Gann, 2010 for a recent review). We would argue that, in many situations, this separation might also miss the dynamic processes that we have highlighted, particularly when outbound open innovation goes beyond a simple one-time sale of existing technologies but is strategic in nature. Echoing the findings of earlier studies in this field, our findings may also

mandate for different perspective of the management of intellectual property and R&D in firms (Alexy et al., 2009), as well as potentially even intellectual property policy (von Hippel, 2005; Yang et al., 2010).

At the same time, our study opens up several avenues for future research. First, regarding the value of incoming spillovers, the question of the relative importance of structural and content compatibility on their value for the firm is still unanswered. Similarly, empirical research should also look at, in closer detail as we have done, the relative effects of signaling and steering on the structural and content compatibility of incoming spillovers, as well as their ability to influence the knowledge production of others. Additionally, our argument raises a question about the right degree of influence firms may want to exert, as too similar an environment may not present the firm with sufficiently original knowledge spillovers. Moreover, researchers may want to look at questions of timing by explicating different levels of appropriateness of the strategies we have developed for varying points in the life cycle of a firm, industry, or technology (see, e.g., Westerman et al., 2006). Finally, future research may look at additional contextual factors that may influence the efficacy of strategies aimed at endogenizing spillovers. Candidates from the existing literature on ACAP may include organizational architecture, firm size, power relationships, and, more generally, industry architecture and geographic and cultural distance.

Irrespective of these potential further developments, we think that this paper has made a clear case for an extension of the concept of absorptive capacity to make it truly dynamic, allowing for the iterative flow of spillovers between firms. In so doing, our dynamic model of absorptive capacity highlights how firms may shape the spillovers they receive from others by purposefully leaking knowledge themselves. As this will, in turn, impact the value these incoming spillovers will have, such a dynamic view on absorptive capacity is crucial for our understanding how firms can benefit from harnessing knowledge generated beyond the boundary of the firm.

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FIGURES AND TABLES

FIGURE 1

Conceptual Model of Absorptive Capacity

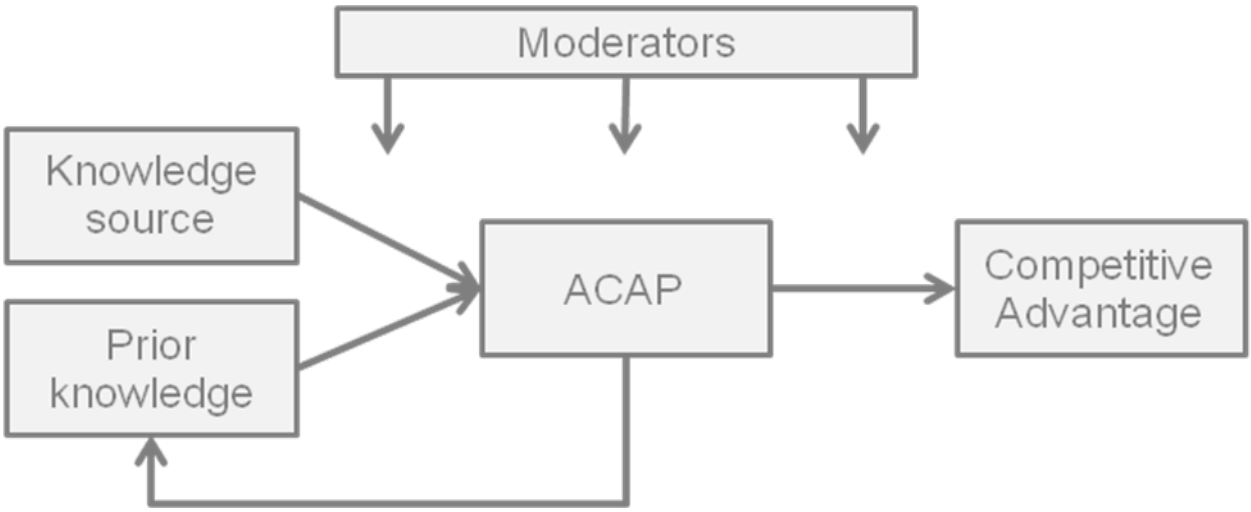

FIGURE 2

A Dynamic Two-firm Model of Absorptive Capacity and Spillover Production

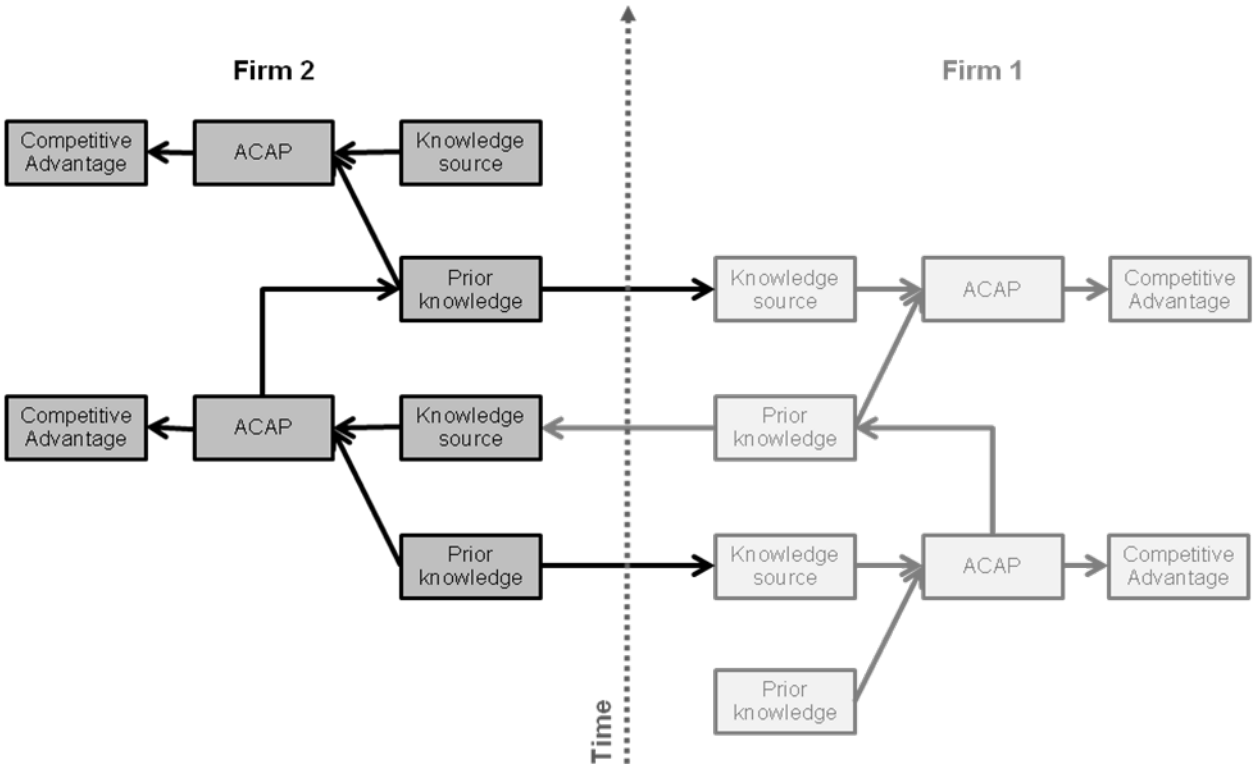

FIGURE 3

An Extended Model of Absorptive Capacity Incorporating Selective revealing Strategies

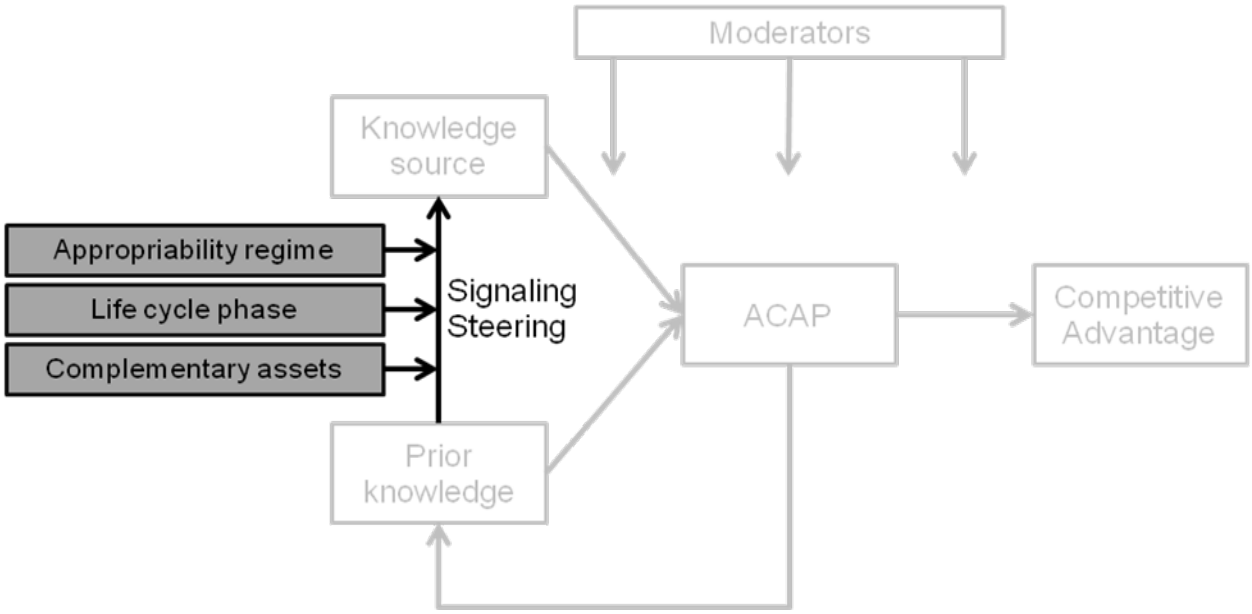

TABLE 1

Effects of Selective Revealing on the Focal Firm's Knowledge Environment

		Type of knowledge revealed	
		Problem-related signaling	*Solution-related steering*
Dimension of value impacted	*Content compatibility*	Facilitate development of solutions to firm's problems	Attract others to join the firm's knowledge trajectory
	Structural compatibility	Output-driven adaptation of structure and language	Input-driven adaptation of structure and language

TABLE 2

Intertemporal Effects of Selective Revealing Strategies

		Strategy	
		Problem-related signaling	*Solution-related steering*
Temporality of Goals	*Proximal goals*	Problem-solving (Broadcast search)	Diffusion-enhancing (Open source software)
	Distal goals	Agenda-shaping (Open research calls)	Trajectory-defining (Academic publishing)

Exemplar practices are given in parentheses.

TABLE 3

Achieving the Strategic Goals of Selective Revealing: Examples from Academic Literature

Goal	Definition	Studies	Contexts
Problem-solving	Encourage others to submit readily-available solutions to firm's existing problems	Huston & Sakkab, 2006; Jeppesen & Lakhani, 2010	Firms using InnoCentive*, consumer goods
Agenda-setting	Highlight firm's future demands so others can privately invest in and/or actively assist focal firm in developing solutions and complimentary offerings	Alexy et al., 2009; MacCormack & Herman, 2004	Defense industry, IT, pharma, consumer goods
Diffusion-enhancing	Facilitate wide adoption of revealed knowledge to increase value of complementary assets and likelihood of reciprocal behavior	Allen, 1983; Nuvolari, 2004; von Hippel, 1988, 2005; West, 2003	User innovation in all sectors, engineering, IT
Trajectory-defining	Build critical mass supporting firm's technology trajectory to attain buy-in from institutional environment	Dodgson et al. 2007; Spencer, 2007	Built environment, IT

* As Lakhani et al. (2007) explain, the problems posted on InnoCentive usually mainly stem from the life sciences, chemistry, or the applied sciences. Accordingly, the firms posting them would all be included in Scotchmer's (1996) definition of cumulative industries.