Design as an Isolating Mechanism for Capturing Value from Innovation: From Cloaks and Traps to Sabotage[1]

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ABSTRACT: How firms capture value from their innovations has long interested strategy and innovation scholars. Prior work has focused on legal, economic, and social mechanisms for isolating knowledge from imitation as crucial to this process. Our contribution extends this stream of research by identifying how design choices about the way knowledge is *manifested* (e.g., into routines, blueprints, prototypes, or products) can inhibit a counterparty's ability to imitate knowledge relating to a focal innovation. We derive six theoretically distinct types of knowledge manifestation that can be used for these ends, consider their impacts on the awareness, motivation, and capability of a counterparty seeking to imitate the focal knowledge, and organize them into a novel two-dimensional conceptual framework for comparison. By doing so, we add *design* mechanisms to the strategic toolbox of isolating mechanisms available for capturing value from innovation. This addition opens up a new channel through which organizational choice endogenously shapes appropriability regimes and introduces knowledge manifestations as an important unit of analysis for understanding innovation strategy.

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> "No one can walk out the gate of a steel plant or a refinery taking the economic value of the physical installation with him in his pocket, leaving a hollow shell behind. The same is not true of an R&D lab, since the pocket may contain an articulated statement of a simple item of knowledge whose value is substantially independent of the value of other knowledge that remains behind in the lab. And even though what is in the pocket may be only a copy of something that remains in the lab, it may suffice to make the original a hollow shell without economic value". (Winter, 1987: 173)

How firms capture value from their innovations has long interested strategy and innovation scholars (Ahuja, Lampert, & Novelli, 2013; Lieberman & Montgomery, 1988; Teece, 1986). Isolating mechanisms help firms capture value from innovation by restricting the mobility of knowledge required for effective imitation (Liebeskind, 1996; Rumelt, 1984), and prior work has identified a range of legal (Alcacer, Beukel, & Cassiman, 2017; Winter, 1987, 2000), economic (Liebeskind, 1996, 1997; Teece, 1986), and social isolating mechanisms (Fauchart & von Hippel, 2008; Jonsson & Regnér, 2009; Regnér, 2010).

Foundational work acknowledged design as a further potential isolating mechanism (Lieberman & Montgomery, 1988: 54; Winter, 1987: 174). For example, using an object-oriented programming language (e.g., Java; C++) enables a firm to reveal and demonstrate the "precise logic underlying an application" while keeping the source code required for easy imitation hidden (Gans & Stern, 2003: 339). This design choice makes it possible for a firm to inhibit counterparties from imitating the knowledge underlying the focal innovation and thus enhances their ability to capture value (Liebeskind, 1996). However, while theory has been developed to explain the antecedents of firms choosing to deploy such approaches (McGaughey, 2002), the nature of design choices and the causal pathways through which these choices could affect value capture remain untheorized. Omitting design as a potential isolating mechanism risks our theories of value capture being incomplete and difficult to test, and thus limits their usefulness for both future theory and practice.

The current paper responds to the challenge of theorizing design as a value capture mechanism. We begin by situating the notion of "design" as a distinctive class of isolating mechanism within the literature. Next, we theorize *what* is designed by drawing on studies of knowledge and imitation (Baldwin & Henkel, 2015; Hedlund, 1994; Zander & Kogut, 1995; McGaughey, 2002; Winter, 1987) to relax the traditional assumption that an innovation's knowledge characteristics are determined exogenously (e.g., Teece, 1986; Teece, Pisano, & Shuen, 1997; James et al., 2013), and consider the role of strategy in this generative process. We argue that firms can make strategic choices about how the knowledge underpinning a focal innovation is *manifested* (e.g., into a map, blueprint, routine, prototype, or product) and that these choices can help isolate knowledge from counterparty[2] efforts at imitation. We then proceed to draw on the recombinant view of innovation (Fleming, 2001; Nelson & Winter, 1982) to derive a typology of six conceptually distinct ways that the manifestation of knowledge can be manipulated by design. Finally, we use the competitive dynamics literature (for a review, see Chen & Miller, 2012) to theorize how design mechanisms might isolate knowledge from imitation and consider the associated costs and risks. Our theory is formalized as a set of propositions describing how each of the six design mechanisms affect the *awareness*, *motivation*, or *capability* of a counterparty seeking to imitate the focal knowledge.

The resulting theory contributes to the literature on innovation strategy by adding design mechanisms to existing explanations of how isolating mechanisms might inhibit knowledge mobility (Liebeskind, 1996), theorizing a new channel through which appropriability regimes might be endogenously shaped by actors (Ching, Gans, & Stern, 2019; Gans & Stern, 2017; Pisano, 2006), and drawing scholarly attention to a new unit of analysis for studying how firms capture value by isolating knowledge from imitation: the knowledge manifestation.

[2] Counterparties here and elsewhere in the paper include competing rival firms, as well as other parties that may attempt to imitate a firm's knowledge, for instance the firm's suppliers, customers, or firms operating in different geographical markets.

ISOLATING MECHANISMS FOR PROTECTING KNOWLEDGE FROM IMITATION

Building from Rumelt's (1984: 567) strategic theory of the firm, scholars have identified a wide range of isolating mechanisms capable of limiting "the *ex post* equilibration of rents among individual firms". Such isolating mechanisms prolong the period over which firms can capture value from their innovations in the form of Schumpeterian rents (Danneels, 2012; James et al., 2013; Roberts, 2001; Schumpeter, 1942). Here, we are interested in mechanisms that inhibit the involuntary transfer of knowledge about a focal innovation across firm boundaries (Winter, 1987), or its unsanctioned use (Liebeskind, 1996), thus enabling value to be captured by the original inventor. This is a challenging problem because knowledge is often revealed in use (e.g., through a product's design or observation of service fulfilment) and can be used by many people at the same time without diminishing its productive value for any one user. These two properties make a counterparty's attempts at imitation extremely difficult to detect and guard against (Liebeskind, 1996, Winter, 1987).

The literature has primarily focused on four specific isolating mechanisms for immobilizing knowledge: patents, secrecy, lead time and complementary assets (James et al., 2013). Design has occasionally been acknowledged by scholars as one such mechanism. Winter (1987: 174) explained that firms can change the way products are designed to inhibit the use of reverse engineering for imitation, and pointed to the practice of encasing integrated circuits in resin "that cannot be removed without destroying the device" as an example. Lieberman & Montgomery (1988: 54) made the point more generally when discussing how firms sustain first-mover advantages, noting that "designs that are deliberately difficult to reverse engineer" were an alternative to patents when seeking to inhibit imitators. However, much like the object-oriented code example in Gans & Stern (2003), existing research does not provide much guidance on how to position these observations within the broader literature on isolating

mechanisms. Without such positioning, it is easy to treat such instances as idiosyncratic curiosities rather than a distinctive, fundamentally important, and generalizable class of isolating mechanism.

As a first step towards developing our theory, we suggest that this insight can be effectively situated in existing literature by taking a step back and asking where the impetus to isolate comes from. At present, one can discern three "familial" groupings of mechanisms based on the source of leverage used to isolate the knowledge underpinning an innovation: 1) *Legal mechanisms* draw on institutionalized rules to regulate where, when, how, why, and by whom knowledge can be imitated. Examples include intellectual property rights (e.g. patents, copyright, trademark; trade secrets) (Winter, 2000) and non-compete agreements (Liebeskind, 1997); 2) *Economic mechanisms* draw on the principles of economic organization to inhibit imitation. Examples include investments in specialized complementary assets (Teece, 1986), incentive alignment (Liebeskind, 1996), lead time (Levin et al., 1987), and structural isolation (Liebeskind, 1997); and 3) *Social mechanisms* draw on sets of practices and norms within a community to inhibit imitation. Examples of these approaches can be seen in the use of norms and practices to protect recipes (Fauchart & von Hippel, 2008), clown personae (Fagundes & Perzanowski, 2018), the jokes of stand-up comics (Reilly, 2018) and new products (Jonsson & Regnér, 2009; Regnér, 2010) from imitation. The theory we build in this paper frames observations like that of Winter (1987), Lieberman and Montgomery (1988) and Gans and Stern (2003) as fitting within a fourth distinct familial grouping: 4) *design mechanisms*. As we will argue below, design mechanisms inhibit imitation by manipulating the articulation and codification of knowledge relating to a focal innovation (Winter, 1987). The impetus to isolate here comes from applying the principles of art and science, instead of law, economic organization, or social practices or norms. In the next section, we introduce the concept of a knowledge manifestation as a way of classifying the nature of design choices being made in the

innovation process before proceeding to theorize how these choices influence imitation and value capture.

KNOWLEDGE MANIFESTATIONS

The products, processes and services that firms invent to create and capture value are manifestations of what they know. Organizational knowledge is special in the sense that it is shared across people, and thus exists beyond one mind. This knowledge can be accumulated (e.g., writing computer code for a program; diagnostic stories that explain machine failure modes), disseminated (e.g., launching a product; sharing of best practices), and preserved (e.g., archiving a building's blueprints; incorporating stories of product success into organizational memory) for organizational ends. This transition from individual to organizational knowledge happens through a process of articulation (e.g., into stories; verbal design briefs; hypotheses) and then, often but not always, codification (e.g., into blueprints; prototypes; manuals) (Håkanson, 2007). We describe these outputs as manifestations in that they are embodiments of knowledge associated with a focal innovation.

A large literature has explored how different types of knowledge are created, used, integrated, and transferred within and between firms (e.g., Grant, 1996; Håkanson, 2007; Henderson & Clark, 1990; Kogut & Zander, 1992; Nonaka, 1994; Nonaka & von Krogh, 2009; Winter, 1987; for a recent review see Hadjimichael & Tsoukas, 2019). An important focus for much of this work has been the distinction between tacit knowledge that is used by individuals to perform actions but cannot be easily expressed by them (Polanyi, 1966) and explicit knowledge that is articulated into, for example, stories, drawings, and writings, making it "transmittable in formal, systematic language" (Nonaka, 1994: 16). Hadjimichael & Tsoukas' (2019) recent review of the literature on tacit knowledge shows that the majority of work on this topic is consistent with the main premise of the previous paragraph, namely, that knowledge becomes organizational through a process of individuals articulating their tacit knowledge into

more explicit forms that can more easily be drawn upon by other members of the organization, who may then proceed to internalize the knowledge back into a tacit form for effortless use in everyday action (Nonaka, 1994; Nonaka & von Krogh, 2009). From this perspective, the design mechanisms that we discuss below can be seen as pertaining to choices the organization makes about how to articulate the knowledge relating specifically to a focal innovation (i.e., not including the firm's general capabilities or "common knowledge" shared by the relevant community of practice (Håkanson, 2007; Zander & Kogut, 1995)) and share it among those involved in the process of researching, developing, and potentially commercializing that innovation.[3] Conceptualizing the creation of knowledge in this manner enables us to see that the replicability of knowledge might not be determined solely by its exogenous "inherent" nature (e.g., Teece, 1986), but instead be subject to a degree of choice (see, e.g., Winter, 1987).

To make this insight more tractable, we conceptualise knowledge and its manifestations, as 'recombinations' in the sense of Nelson & Winter (1982: 130) who argue that: "the creation of any sort of novelty in art, science, or practical life—consists to a substantial extent of a recombination of conceptual and physical materials that were previously in existence." Conceptualizing knowledge in this Schumpeterian manner has been central to understanding innovation (Freeman & Soete, 1997; Galunic & Rodan, 1998), and as thus provides a particularly useful abstraction for conceptualizing how privileged access to knowledge might be secured through the design choices one makes about its manifestation.

[3] As such choices must be made regardless of the mix of tacit hunch and explicit theory from which the initial idea for an innovation grew, we do not further pursue the tacit/explicit knowledge distinction in our theorizing below. Despite this, we recognise that the performance of some firms may depend on "superstar" employees whose tacit knowledge may not be articulable to any useful extent (e.g., the physical prowess and ability to read the game of members of a professional sports team) or on shared tacit knowledge that is developed through mutual experience without being articulated (e.g., Berman, Down, & Hill, 2002; Shamsie & Mannor, 2013). The extent to which such knowledge may be an important component of the knowledge relating to a focal innovation, the extent to which it can be articulated, and the ability of the organization vis-à-vis the individuals possessing this knowledge to capture value from it (see e.g., Lecuona & Reitzig, 2014), are interesting questions for future research. We are grateful to an anonymous reviewer for inspiring us to consider these important points.

A knowledge manifestation can be conceptualized as being made up of knowledge 'components' (Fleming, 2001). In keeping with the innovation literature on which we build, we assume that an inventor can "recombine any components within their purview" and thus that at "any point in technological evolution, any component is at risk of being recombined with any other component" (Fleming, 2001: 118-119). Empirically, there are a wide range of factors - ranging from social norms and networks, through to the technological modularity - that might shape whether two or more components are (re)combined (e.g. Nerkar & Paruchuri, 2005; Vakili & Kaplan, 2020). However, for the current paper, the foundational assumption is what we require to produce a useful typology. Henderson & Clark's (1990) classic description of a fan's components provides a prototypical example to illustrate the approach.[4] They explain that a fan can be understood as being made up of components including "the blade, the motor that drives it, the blade guard, the control system, and the mechanical housing" (Henderson & Clark, 1990: 11). As such, a fan can then be represented abstractly as five distinct knowledge components (a,b,c,d,e) as in Figure 1. We now proceed to consider how knowledge manifestations may be targeted by imitators and how design choices can inhibit their imitation.

-Insert Figure 1 here-

Knowledge Manifestations as Targets for Imitation

The intangibility of knowledge means that counterparties are likely to target their imitation attempts at its manifestation(s). For example, in a recent legal complaint[5] by Waymo, Uber Technologies is accused of illicitly accessing and utilizing manifestations of knowledge associated with self-driving car technology. The vector for these efforts is argued to be a group of senior Waymo employees who, before leaving Waymo for Uber, copied manifestations ranging from lists of specialized suppliers and Statements of Work, through to circuit board

[4] For a rich description of knowledge components and how their recombination drives innovation, see Fleming's (2002) paper on the invention of the thermal ink-jet printer at Hewlett-Packard.
[5] Waymo vs. Uber Technologies Inc, US Distinct Court, Northern District of California, San Francisco Division: Case 3:17-cv-00939.

design files and reports on the configuration and calibration of the firm's LiDAR sensors. Waymo says its suspicions of illicit imitation were confirmed in December 2016 when a key supplier inadvertently copied a Waymo employee on an email containing designs for Uber's new LiDAR circuit board. The similarities between both company's circuit boards was viewed by Waymo as evidence of Uber's illicit access to and imitation of the above knowledge manifestations.

Losing privileged access to such knowledge undermines a firm's ability to capture value from the associated innovation[6]. Targeted firms, do not, however, have to sit idly by and await these attempts, or hope for accidental emails alerting them to infringement. Instead, like map makers inserting fictitious entries (e.g., incorrectly named streets, non-existant towns) into manifestations of their knowledge (maps) to detect cases of illicit imitation (Nagaraj & Stern, 2020: 211), firms can proactively work to inhibit imitation by strategically manipulating how knowledge is manifested. Below, we first discuss the conceptual dimensions along which manifestations can be manipulated. We then build on insights from studies of competitive dynamics to develop propositions explaining how six theoretically distinct types of knowledge manifestation may act as isolating mechanisms by affecting the awareness, motivation, and capability of a counterparty seeking to imitate the focal knowledge.

The Design of Knowledge Manifestations

Firms can manipulate a knowledge manifestation by changing its structure and/or its content such that components are subtracted from or added to the whole, or (some) components are replaced with others. We theorize these changes as being enacted through design choices made along two conceptually distinct dimensions: 1) the completeness of the manifestation; and 2)

[6] For example, DuPont's process for producing titanium dioxide, which is key to making the color white and worth billions of dollars, gave it long-running quality and efficiency advantages over its rivals (Wilbur, 2016). Despite DuPont's efforts to protect its production process, the knowledge underpinning it - manifested in blueprints, sketches, and notes - was stolen and sold to key rivals attempting to imitate the process, thus undermining DuPont's ability to capture value from this innovation.

the extent to which the manifestation is modified. Taken together, these dimensions enable us to construct an exhaustive typology for classifying possible manifestation design choices (Figure 2). Each dimension is introduced in turn below and discussed in reference to how changes in design choices might manifest in the case of Figure 1's fan.

Firms make manifestation design choices by manifesting the knowledge at varying *levels of completeness*, ranging from *partial* manifestations, which represent only some of the components of the knowledge, to a *full* manifestation, representing all of the components of the knowledge, to an *augmented* manifestation, representing all of the components of the knowledge, plus component(s) that are extraneous. The completeness dimension, seen on the horizontal axis of Figure 2, reflects the extent to which the manifestation represents only an element of the focal knowledge, versus the manifestation being an independent and complete embodiment of the knowledge relating to a focal innovation (e.g., Winter, 1987). While not considered in prior work, the addition of extraneous components to the manifestation can be important in inhibiting knowledge imitation, as we discuss below.

The *top row* of Figure 2 illustrates how these varying levels of completeness might apply in the case of the fan example presented earlier. While the full manifestation is the same as in Figure 1, the partial manifestation consists of only three out of the five knowledge components (only the blade, the motor, and the control system, for example). The augmented manifestation, on the other hand, contains all of the knowledge components of the full manifestation, but also includes extraneous knowledge components *y* and *z*. These extraneous components are added for reasons of protection (e.g., the addition of an audio watermark to music, Natgunanathan, Xiang, Hua, Beliakov, & Yearwood, 2017) rather than functionality, aesthetics, or symbolism (Eisenman, 2013).

In addition to choosing the *level of completeness* at which the focal knowledge is manifested, the firm can choose whether the focal knowledge will be manifested with or without

modification. Modification is represented on the vertical axis of Figure 2 and entails change in the original manifestation's knowledge components, by way of substitution or transformation. Studies of competitive dynamics and innovation provide insight into why firms might choose to purposefully modify a knowledge manifestation: making inaccurate or misleading knowledge potentially accessible to counterparties can advantage the focal firm to the extent that it increases counterparty likelihood of expending time and effort pursuing suboptimal courses of action (e.g., Hannah, McCarthy, & Kietzmann, 2015; Hendricks & McAfee, 2006).

While the *top row* of Figure 2 presents illustrations of unmodified manifestations, the *bottom row* shows those with modification. Here, component *b* (the fan motor) has been replaced with component *x* (e.g., a different motor design), while component *c* (the blade guard), when part of the manifestation, is replaced with component *w* (e.g., an LED light array).

-Insert Figure 2 here-

DESIGNING KNOWLEDGE MANIFESTATIONS TO INHIBIT IMITATION

The above typology provides a systematic way of classifying and distinguishing between different ways of manipulating knowledge manifestations but does not enable us to theorize how these choices might affect a firm's ability to inhibit imitation. Without this step, our approach is descriptively useful, but lacks explanatory power concerning the likely effectiveness of a given strategy for capturing value. Therefore, to take this step, our next section first considers the antecedents of imitation identified in the rich literature on competitive dynamics before proceeding to draw from this work to theorize the mechanisms through which particular manifestation designs can reduce the imitability of the focal knowledge, while also discussing the main costs and risks of their development and use.

Competitive Dynamics and the Antecedents of Imitation

The Awareness, Motivation, and Capability (AMC) framework developed in the competitive dynamics literature (for a review, see Chen & Miller, 2012) argues that for a counterparty to

respond to a competitive action (e.g., new product introduction, MacMillan, McCaffery, & van Wijk, 1985) they must be *aware* of the action taking place and of its content, have sufficient belief in the benefits of responding to the action to be *motivated* to pursue a response, and possess the *capabilities* necessary to effectively execute the response. These considerations have been shown to influence the likelihood and speed of competitor imitation in prior work (e.g., Jonsson & Regnér, 2009; MacMillan et al., 1985) and enable us to theorize about whether a counterparty will engage in imitating a knowledge manifestation developed by the focal firm, and the level of counterparty capability required to be successful in this effort.

We argue that different knowledge manifestation designs - generated by manipulating a manifestation's completeness and modification - could shape counterparty *awareness* of the focal knowledge, the counterparty's *motivation* to pursue efforts to imitate this knowledge, and the level of counterparty *capability* required for successful imitation. The competitive dynamics literature has examined numerous drivers of AMC across four main units of analysis: the characteristics of the focal firm (e.g., Chen, Smith, & Grimm, 1992; Hambrick, Cho, & Chen, 1996; Semadeni & Anderson, 2010), the counterparty (e.g., Chen & Hambrick, 1995; Hambrick et al., 1996; Smith, Grimm, Gannon, & Chen, 1991), the focal-firm-counterparty dyad (Chen, 1996), and the action itself (e.g., Chen et al., 1992; Chen & Miller, 1994; Chen, Venkataraman, Black, & MacMillan, 2002; Guo, Yu, & Gimeno, 2017; MacMillan et al., 1985). As our focus is on how imitability can be affected by the design of knowledge manifestations, rather than by other factors pertaining to the focal firm, counterparty, or their dyadic relationship, we draw primarily on work that has explored how AMC is affected by characteristics of competitive actions. We will now introduce each element of the AMC framework and explain how each links design choices to imitation.

A counterparty's *awareness* of the focal firm's action has been argued to increase with that action's visibility, i.e., the extent to which information about the action and its content is

publicly available (Chen & Miller, 1994; Chen et al., 2002; MacMillan et al., 1985). Prior work has mostly operationalized visibility by measuring the amount of publicity accompanying the action (Chen & Miller, 1994; Chen et al., 2002), the extent to which a new product introduction is advertised (MacMillan et al., 1985), or the number of customers, markets, and competitors that the action affects (Chen et al., 1992; Lee, Smith, & Grimm, 2003). Recent work on the use of language in competition has shown that becoming aware of a counterparty's action requires not only noticing that the action has taken place but also interpreting its content and the intent behind it, and that the vagueness of the language used to explain competitive actions can affect their visibility by making actions more difficult for a counterparty to interpret (Guo et al., 2017). Building on the above, we will argue that particular knowledge manifestation design choices can also reduce visibility by concealing (some of) the focal knowledge from a counterparty, thus reducing counterparty *awareness* of its content and contributing towards protecting the focal knowledge from imitation by making it harder for a counterparty to identify what needs to be imitated (Amit & Schoemaker, 1993; also, cf. role of causal ambiguity in Barney, 1991; role of visibility in MacMillan et al., 1985).

Action characteristics that have been shown to affect a counterparty's *motivation* to respond include the action's perceived potential (i.e., its perceived commercial value and the extent to which it represents a competitive threat, Chen et al., 1992; Lee et al., 2003; MacMillan et al., 1985) and the extent to which this perceived potential is uncertain (Chen & MacMillan, 1992; Chen et al., 1992; Chen et al., 2002; Lee et al., 2003; Semadeni & Anderson, 2010). Furthermore, the extent to which the action signals the focal firm's commitment to defending any resulting advantage (e.g., through being costly to implement), has also been argued to reduce counterparty motivation to respond (Chen & MacMillan, 1992; Chen et al., 1992; Chen et al., 2002). In our theorizing below, we will argue that particular design choices can reduce a counterparty's motivation to imitate the focal knowledge through these mechanisms.

Finally, the key action characteristics affecting a counterparty's *capability* to effectively respond to a focal firm's action have been argued to be the extent to which implementing the action is likely to involve substantial time, investments, and disruption to existing ways of working for the counterparty (Smith et al., 1991; Chen et al., 1992; Chen & Miller, 1994; Chen et al., 2002; MacMillan et al, 1985). By considering how manifestation design choices will affect the costs of imitation for the counterparty, we will theorize the effects of these choices on the level of counterparty capability required for successful imitation.

Using design mechanisms to protect knowledge from imitation is also costly for the focal firm. First, additional time and resources are required to design, create, and put into use a particular manifestation. Second, a side-effect of using some of these knowledge manifestations is likely to be an increase in the difficulty of not only involuntary, but also intended knowledge transfer and collaboration (Liebeskind, 1996, 1997; Winter, 1987), potentially resulting in lower innovation performance (Wadhwa, Bodas Freitas, & Sarkar, 2017). As we will discuss below, the strategic use of some manifestation designs may also create risks for the firm's reputation. We now proceed to develop propositions regarding the benefits of each kind of manifestation design in terms of reducing the imitability of the focal knowledge, discuss their costs, and provide illustrative examples of their use.

The Benefits and Costs of Manifestation Designs

Table 1 provides an overview of how the different ways of manipulating knowledge manifestations described earlier affect a counterparty's awareness, motivation, and level of capability required for imitation. Following the same pattern as Figure 2, the first row of the table concerns unmodified manifestations of varying completeness and the second row corresponds to modified manifestations. The columns, on the other hand, capture the completeness of the manifestation, increasing from partial in the left column, to full in the central column, to augmented in the right column.

In our theory, firms deciding to reduce imitability through the design of a manifestation are assumed to be departing from a baseline of not doing so.[7] Following the earlier discussion of the process of organizational knowledge creation (Håkanson, 2007; Nonaka, 1994; Nonaka & von Krogh, 2009), we assume that, in practice, not actively designing manifestations to reduce imitability is likely to mean that a number of partial, unmodified manifestations are produced for different purposes by different parts of the firm in the process of researching and developing the focal knowledge. If this process leads to commercialization[8] without any design mechanisms being used to reduce imitability, we assume that the commercialized manifestation will be complete and unmodified, resulting in the AMC effects discussed in proposition 1.1 below. Furthermore, once a complete, unmodified manifestation has been made publicly available for purchase or use, we assume that any subsequent changes to its design are not likely to be effective in preventing imitation. Our reasoning here is that, once revealed, it will not be possible to recover the knowledge that counterparties could already have gained from the original, commercialized manifestation.

-Insert Table 1 here-

Complete, unmodified manifestation. Our starting point is that use of one or more of the proposed manifestation designs will in most cases be complementary to the use of legal, economic, and social isolating mechanisms discussed in prior work, with combinations of design and other isolating mechanisms providing greater levels of protection than the use of any particular isolating mechanism alone (Somaya, 2012). Indeed some of these design mechanisms require well-functioning legal, economic, or social isolating mechanisms if they

[7] This might be unintentional, or part of a broader "execution-focused strategy" (Ching et al., 2019; Gans & Stern, 2017).

[8] For the sake of brevity, we use "commercialize" here in its most general sense. It should be interpreted as referring to any good or service being made publicly available for purchase or use. This choice is consistent with other scholars working in this steam of literature (e.g., Teece, 2018).

are to have the desired effect. We begin with such a case by considering the likely effects and costs of revealing an unadulterated manifestation (Table 1, central cell, top row).

As a complete, unmodified manifestation reveals the unadulterated focal knowledge[9], the visibility of this knowledge and its content is increased, leading to greater counterparty awareness of it. Revealing the focal knowledge also affects counterparty motivation to imitate by allowing the counterparty to form a more accurate evaluation of its potential value, thus reducing uncertainty about whether or not imitation is likely to be worthwhile. Finally, the use of a complete, unmodified manifestation will reduce the level of counterparty capability required to successfully imitate the focal knowledge as the counterparty will not need to invest time and money into identifying all of its components.[10]

Proposition 1.1. Designing a complete, unmodified manifestation will increase counterparty awareness of the focal knowledge and their motivation to imitate it, while reducing the level of capability required for successful imitation.

The main costs of designing a complete, unmodified manifestation will be the costs of articulating the focal knowledge for inclusion in the manifestation. These costs include the time and resources invested in the development of an articulated knowledge manifestation (Zollo & Winter, 2002).

The above proposition argues that, on its own, use of a complete unmodified manifestation is likely to be counter-productive from the perspective of preventing imitation of the focal knowledge. However, when used in combination with well-functioning legal, economic, or social isolating mechanisms, i.e., those through which the focal firm or its relevant social community can recognise the firm's claim to knowledge ownership as legitimate and can

[9] As discussed earlier, by "focal knowledge", we mean the knowledge specifically relating to a focal innovation.
[10] In most cases these manifestations will be made public. However, even if this is not the case, holding the probability of the existence of the manifestation becoming known to a counterparty constant and comparing it to a baseline of no active manifestation design, creating a complete and unmodified manifestation will increase counterparty awareness of it and motivation to imitate it, while reducing the level of capability required for successful imitation.

successfully detect and sanction transgressions, use of such a manifestation can establish an enforceable claim to property rights. Despite raising counterparty awareness of the focal knowledge and reducing the level of capability required, this approach can inhibit the imitation of the target manifestation by signalling, through the focal firm's investment into the complementary legal, economic, or social isolating mechanism, their commitment to defending their ability to capture value from the focal knowledge, thus reducing counterparty motivation to imitate.[11]

Proposition 1.2. When used together with legal, economic, or social isolating mechanisms, designing a complete, unmodified manifestation will increase counterparty awareness of the focal knowledge, while reducing their motivation to imitate it and the level of capability required for successful imitation.

In addition to the cost of articulating the focal knowledge, when using a complete, unmodified manifestation together with legal, economic, or social isolating mechanisms, the focal firm will incur additional costs of codifying this knowledge to establish a legitimate claim to its ownership, with the costs of codification likely to be substantially beyond those of articulation alone (Zollo & Winter, 2002). The firm will also incur the costs of investing in the chosen legal, economic, and/or social isolating mechanisms, which will include both the direct costs of establishing the firm's claim to the focal knowledge (e.g., the costs of the patent application process), as well as the costs of detecting infringement and sanctioning such transgressions.

Ground staking of this kind is an important part of systems for establishing forms of legal intellectual property rights (e.g., patents, copyright), but is also used to create social claims to knowledge, such as with the publication of scientific articles by researchers, chefs' recipes

[11] In the rest of our proposition development, we discuss this and other contingencies only in two cases where no clear prediction can be made based on the AMC mechanisms alone.

(Fauchart & von Hippel, 2008), clown personae (Fagundes and Perzanowski, 2018), and the jokes of stand-up comics (Reilly, 2018).

Augmented, unmodified manifestation. As argued earlier in the "Knowledge Manifestations" section, legal, economic, or social isolating mechanisms are likely to be sufficiently effective for the ground staking approach to have the desired effect only in select cases (e.g., legal intellectual property rights in the medical instrument and pharmaceutical industries, Arora, Ceccagnoli, & Cohen (2008); see also Alcacer et al., (2017) and Leiponen & Byma (2009)). When this is not the case, extraneous components can be added to the manifestation (Table 1, top-right cell) in order to either assert a firm's claims to its knowledge in case of its unsanctioned replication by others or to obscure (some) knowledge components thus making them less intelligible or observable for potential counterparties. For simplicity of exposition, we will now consider these possibilities in reverse order.

Adding extraneous components to a manifestation serves to increase the complexity of the designed manifestation (Rivkin, 2000; Rivkin, 2001; Winter, 1987), making it harder for the counterparty to fully understand the manifestation and thus decreasing both the visibility of the focal knowledge as well as the counterparty's motivation to imitate it due to the resulting uncertainty about its potential value. However, because the unmodified components of the focal knowledge are present in the manifestation, it may also increase counterparty awareness and motivation, as argued in proposition 1.1. The balance of the above effects is likely to be determined by the extent to which the focal knowledge relates to a product versus a process and whether or not the knowledge manifestation in question is designed for commercialization. Products have greater observability in use than do processes (Teece, 1998; Winter, 1987), and making the manifestation available to customers will mean significant limitations on the extent to which its observability in use can be controlled by the originating firm due to counterparties being able to examine the manifestation at their leisure (Liebeskind, 1997; Teece, 1998). The

effect of this manifestation design on the level of counterparty capability required for successful imitation relative to the baseline case of a partial, unmodified manifestation, is equivocal as the benefits of the presence of all focal knowledge components as argued in proposition 1.1 are in this case accompanied by the costs of identifying and removing the extraneous components.

Proposition 2.1. When the focal knowledge relates to a process (rather than a product) and/or if the manifestation is not designed for commercialization, designing an augmented, unmodified manifestation will reduce counterparty awareness of the focal knowledge and their motivation to imitate it.

In addition to the cost of articulating the focal knowledge, additional costs of using this approach will be the costs of designing and adding the extraneous components to the complete, unmodified manifestation.

The use of "development mules" by automotive producers (e.g., Vellequette, 2015) provides a useful illustration of how such a strategy can be used to reduce counterparty awareness and motivation, and thus the probability of successful imitation for a non-commercialized product manifestation. Automotive firms road test new vehicle prototypes in order to validate engineering decisions made under less realistic experimental conditions.[12] However, because these tests must occur in public they expose the innovation to observation by counterparties and to potential attempts at imitation. In order to guard against this risk, additional materials (e.g., panels, tape and paint) are commonly fitted to the prototype's exterior to obscure its nature from observers, allowing it to be road tested with less risk that the knowledge manifested in the vehicle's bodywork design will be revealed. The additional knowledge component(s) in this case are extraneous in the sense that their only function is to protect the knowledge manifestation from imitation. The use of development mules is an example where the knowledge manifestation content itself is unchanged, but manipulation of

[12] Thanks to Paolo Aversa for a useful correspondence on this phenomena.

its structure through the addition of extraneous components creates a *cloaking* effect. A further example is the coating of integrated circuits in resin (Winter, 1987: 174).

If the focal firm not only adds extraneous components to a complete, unmodified manifestation but also makes an investment in legal, economic, or social isolating mechanisms, this will signal the focal firm's commitment to defending the focal knowledge from unsanctioned imitation and will thus reduce counterparty motivation to imitate it. Moreover, to the extent that the addition of extraneous components allows imitation to be proven and thus enables the focal firm to pursue sanctions against the imitator through the chosen isolating mechanism, the level of counterparty capability required for successful imitation will be increased due to the costs of identifying, and replicating or removing the extraneous components outweighing the benefits of the presence of all of the focal knowledge components.

Proposition 2.2. When used together with legal, economic, or social isolating mechanisms, designing an augmented, unmodified manifestation will reduce counterparty motivation to imitate the focal knowledge and increase the level of capability required for successful imitation.

In addition to the costs stated in discussing proposition 1.2, the additional cost of using this approach will be the cost of designing and adding the extraneous components to the complete, unmodified manifestation.

Such *tagging*, often using 'watermarks' or similar approaches, adds a marker to the manifestation that enables the firm to demonstrate that a counterparty is using/copying it illicitly. This approach is frequently used to establish ownership of intellectual property codified in text and images, with further examples including the previously-mentioned use of "trap streets" by map makers (Nagaraj and Stern, 2020), Artificial Intelligence models by firms (e.g., for digital watermarks used to protect deep neural networks, see Wang & Kerschbaum, 2019) and the addition of specific bacteria strains to genuine Swiss Emmentaler cheese that do

not change its texture, smell, or taste, but allow counterfeit Emmentaler to be identified if the bacteria's DNA marker is not present (Bosley, 2014).[13]

Partial, unmodified manifestation. Instead of using the complete manifestation or augmenting it by adding extraneous components, as discussed above, firms can design and use partial manifestations of the focal knowledge (Table 1, top-left cell). In contrast to our baseline case of not actively designing manifestations to reduce imitability and thus likely ending up with multiple partial manifestations created for different purposes, a strategically designed partial, unmodified manifestation can both reduce the imitability of the focal knowledge while also enabling voluntary knowledge transfer and collaboration (Alexy, George & Salter, 2013).

We assume that a designed partial, unmodified manifestation will contain only the component(s) of the focal knowledge required to enable collaboration and coordination in the development and/or production of that component(s) to take place. Therefore, it is less likely that valuable knowledge will be revealed to counterparties than in the baseline case when a partial manifestation is created without such considerations. As a result of this choice, a designed partial, unmodified manifestation will provide a counterparty with lower visibility of the focal knowledge, reducing counterparty awareness of it, while increasing uncertainty about the potential value of the focal knowledge, reducing counterparty motivation to imitate it. Finally, as a counterparty would have to expend time and resources identifying the knowledge components omitted from the partial manifestation, use of this approach also serves to increase the level of counterparty capability required for imitation to take place.

Proposition 3. Designing a partial, unmodified manifestation will reduce counterparty awareness of the focal knowledge and their motivation to imitate it, while increasing the level of capability required for successful imitation.

[13] We're grateful to Linus Dahlander for bringing this example to our attention.

We assume that effective component-level collaboration or coordination can take place only if the focal knowledge is sufficiently decomposable and if the focal firm invests in its effective modularization to ensure that the partial, unmodified manifestation will still be useful to collaborators (Baldwin & Henkel, 2015). Modularization is likely to be costly in terms of the time and resources required to redesign the focal knowledge components and the interfaces between them in order to create a functional modular design (Baldwin & Clark, 2000).

This practice of *careful coordination* has been documented when firms selectively reveal valuable knowledge to the market (e.g., Alexy et al., 2013; Henkel, Schöberl, & Alexy, 2014) and is commonly observed in supply chains involving parties based in countries with weak intellectual property rights enforcement (e.g., Henkel, Baldwin, & Shih, 2013; Zhao, 2006). For example, in such settings a firm may send designs for different components of its product to be built by different original equipment manufacturers but keep the assembly and quality assurance of the complete manifestation in-house to reduce the likelihood of any of the manufacturers introducing a rival product. Baldwin and Henkel (2015) explain that such approaches to "modularity-in-production" can be an effective way of inhibiting imitation and improving a firm's ability to capture value from innovation, whereas "modularity-in-use" may be less effective.

Partial, modified manifestation. Modification of a partial manifestation can provide the means to influence a counterparty's awareness, motivation, and level of capability required for imitation to the extent that it disrupts, confuses and complicates the interpretive process that underpins imitation efforts. A modified, partially complete, manifestation (Table 1, bottom-left cell) can obscure the true nature of the focal knowledge and act as a strategic feint (Hendricks & McAfee, 2006) that misdirects a counterparty's sense-making efforts. Such *feinting* refocuses a counterparty's imitation efforts on the wrong imitation target. As a result of the manifestation containing only some (if any) components of the focal knowledge, as well as some components

that have been modified, the visibility and thus counterparty awareness of the target manifestation is reduced. Counterparty estimates of the focal knowledge's value will also be more uncertain due to less of this knowledge being present in the manifestation and the modification of some of its components, reducing counterparty motivation to imitate. Finally, the level of counterparty capability required to mount a successful imitation attempt will increase due to the costs the counterparty would have to incur to not only identify the missing components of the target manifestation but also the time and resources wasted on imitating the modified components of the manifestation, and those spent on identifying and reversing the modifications made.

Proposition 4. Designing a partial, modified manifestation will reduce counterparty awareness of the focal knowledge and their motivation to imitate it, while increasing the level of capability required for successful imitation.

The costs of using this approach will be the time and resources spent on designing the modified components and creating a new manifestation with these modifications put in place, as well as the increased costs and difficulties of collaboration and coordination that will result from the need to ensure that those who need access to the manifestation for research, development, and/or commercialization purposes do not start using the modified manifestation instead of the original. This potential for confusion creates the risk that use of the modified, partial manifestation will affect not only the counterparties whom the firm suspects of aiming to imitate the focal knowledge (e.g., the firm's established commercial rivals) but also other counterparties (e.g., the firm's suppliers and customers), who may react unfavorably to the feint. If this does occur, the firm's reputation in the eyes of these untargeted counterparties may be tarnished, potentially affecting its ability to create and capture value in the future.

The use of partial, modified manifestations can be seen in cases such asa group of oil producers using fake surveys to mislead rival Standard Oil about their efforts to build the

world's first long-distance oil pipeline[14] (Hendricks & McAfee, 2006). By revealing that a pipeline was being planned but drawing Standard Oil's attention to locations that were, in fact, not going to be used for the pipeline, the producer group succeeded in preventing Standard Oil from blocking off the pipeline's intended route, and, once the Tidewater Pipeline was built, in breaking Standard Oil's regional oil transportation monopoly. Other examples include the UK's Ministry of Information telling the press during World War II that the success of British pilots in night-time aerial combat was due to their carrot-rich diet, thus hoping to keep attention away from on-board "Airborne Interception" radar technology, the true cause of the Royal Air Force's advantage (Smith, 2013). And also in the use of 'decoy patents' (Hounshell and Smith, 1988: 89-90; Langinier, 2005; McKelvey, 1996: 242), a tactic where firms file a patent for a technological component known to be less effective than the actual component used by the filing firm, to trigger a rival's investment in technology paths with limited promise. As our theorizing suggests, and the examples above illustrate, this type of manifestation is most likely to be useful if targeted at a specific counterparty that the firm has reason to believe is actively engaged in efforts to imitate its knowledge. Otherwise the costs and risks of this approach are likely to outweigh its benefits.

Complete, modified manifestation. The next design option we will consider is the use of a complete, modified manifestation (Table 1, central cell, bottom row). Compared to the baseline of not actively designing manifestations to reduce imitability, the effects of using a complete, modified manifestation on counterparty awareness of the focal knowledge and their motivation to imitate it are equivocal. On the one hand, modifying components of the target manifestation reduces the visibility of the focal knowledge and increases uncertainty about its value, as argued in proposition 4 above. On the other hand, the completeness of the

[14] The pipeline was an important innovation during this period. It was described as a "daring experiment" whose technological feasibility was so uncertainty that its completion was seen as "a major technological achievement, comparable to the Brooklyn Bridge four years later" (Yergin, 1991: 43).

manifestation increases the visibility of the focal knowledge by allowing the counterparty to understand what kinds of components the target manifestation consists of, even if (some of) these components have been modified in the designed manifestation, and thus also reduces the uncertainty about the value of the focal knowledge. Using this approach does, however, increase the level of counterparty capability required for successful imitation through the costs incurred in the process of identifying the modified components and reversing these modifications.

Proposition 5. Designing a complete, modified manifestation will increase the level of capability required for successful imitation.

In addition to the costs of using a partial, modified manifestation, the use of a compete, modified manifestation will also require the firm to incur the costs of articulating the knowledge components of the complete manifestation. While the knowledge being articulated in this case will be different to the case of the complete, unmodified manifestation due to the modifications made, this articulation process remains costly.

Obfuscation of this kind has a long history of usage in cryptography in the form of common cyphers, which can be used to encode information through, for example, character substitution. In recent decades, it has also become common practice in software development to use compilers to transform programming logic into uninterpretable but functional machine code, thus inhibit imitation via reverse engineering (Gans & Stern, 2003: 339). Interestingly, the same AMC effects and costs are at work in apparently quite different examples of sabotage of a potential counterparty's imitation efforts, including the leaking of faulty pipeline control software to the USSR by the CIA, leading to a pipeline explosion (Reed, 2005), and the apparently intentional errors in the blueprints that Charles Babbage created for his Difference Engine that seem to have been designed to foil suspected industrial espionage efforts (BBC, 2000). As the examples above illustrate, any reduction in imitability of the focal knowledge due to this design mechanism occurs not through changing the counterparty's awareness of the

knowledge or motivation to imitate it (as demonstrated in particular by the pipeline example and the significant efforts directed at cracking most common cyphers) but rather through increasing the costs of effective imitation for the counterparty.

Augmented, modified manifestation. The final design choice to consider is the use of an augmented manifestation with modifications (Table 1, bottom right cell). As we argue in the development of proposition 2.1, adding components to a complete manifestation increases its complexity, reducing counterparty awareness of the focal knowledge due to its lower visibility and their motivation to imitate it given the increased difficulties of estimating its value. The modifications made to the target manifestation as part of this approach also negatively affect counterparty awareness and motivation to imitate the focal knowledge, as argued for in the development of proposition 5. Furthermore, due to the manifestation being both augmented and modified, there are unlikely to be any counterveiling positive effects on counterparty awareness and motivation of the kind discussed in our arguments for propositions 2.1 and 5. As it has been modified, the manifestation will not contain all of the components of the complete target manifestation, and as it has been augmented it will not give the counterparty a clear understanding as to what kind of components the target manifestation consists of. The overall effect of using this approach is therefore to reduce counterparty awareness of the focal knowledge and their motivation to engage in an imitation attempt. Finally, the level of capability required for successful imitation will be increased due to the costs of identifying and removing both the augmentations and the modifications made to the target manifestation.

Proposition 6. Designing an augmented, modified manifestation will reduce counterparty awareness of the focal knowledge and their motivation to imitate it, while increasing the level of capability required for successful imitation.

In addition to the costs considered in the discussion of proposition 5, use of this approach would also require the focal firm to design the augmenting components and incorporate them into the manifestation.

Examples of this approach of *spiking* the target manifestation by modifying parts of it to interact with an augmented component are found in use by the majority of Digital Rights Management approaches, which add code to digital media to prevent it from being copied onto, or operating on, devices for which its use has not been sanctioned, and by software developers who add code to trial software that stops it functioning if a purchase is not made.[15] In contrast to the *tagging* approach previously discussed, *spiking* requires both the addition of extraneous components to the manifestation, as well as a modification to its functional components to alter their functionality if certain conditions are (not) met. While the above examples are of this approach applied to digital goods and services, its usability outside of software applications is increasingly feasible with the expanding possibilities of adding software layers to what were once purely hardware products (Porter & Heppelmann, 2014), with an example being John Deere tractors using software to restrict users' ability to repair their purchased equipment outside of an authorized service centre (Bloomberg, 2017). Whereas this case focuses on restricting customer behavior, the approach could similarly inhibit the ability of rivals to access, inspect and reverse engineer such products.

DISCUSSION

This paper has argued that the design choices firms make about the manifestation of knowledge underpinning a focal innovation shape its imitability and thus a firm's ability to capture value from this innovation. This influence on imitation flows from the way design choices influence the awareness, motivation, and required capability of counterparties who might seek to imitate

[15] Software "bombs" (including, time, logic and fork bombs) have a similar function. McGaughey, Liesch, & Poulson's (2000: 15-16) discussion of self-destructing industrial software is an example of a logic bomb being used to protect knowledge from imitation.

the focal innovation. These insights extend our understanding of the isolating mechanisms available for capturing value from innovation beyond the legal, economic, and social mechanisms considered in prior work (e.g., Fauchart & von Hippel, 2008; Jonsson & Regnér, 2009; Liebeskind, 1996, 1997; Regnér, 2010; Rumelt, 1984; Teece, 1986) and reveal a new causal channel for explaining the heterogeneity observed in firms' ability to protect their knowledge from imitation (Liebeskind: 1996). Instead of treating the replicability of knowledge as an environmental state exogenous to the strategy process (Teece, 1986; Teece et al., 1997; Teece, 2018), we theorize how it can be shaped endogenously by the design choices firms make. This shift in theory complements and extends important work being done to improve explanations of how firms capture value from innovation.

The literature on innovation strategy has increasingly recognized that the appropriability regime facing an innovation may be endogenously shaped by firm strategy (Ceccagnoli, 2009; Ching et al., 2019; Gans & Stern, 2017; Hall, Helmers, Rogers, & Sena, 2014; Pisano, 2006). Appropriability regimes were previously viewed as being exogenously determined by two environmental conditions: 1) inherent 'replicability' of the knowledge underpinning an innovation, and 2) the effectiveness of legal protections for intellectual property (Teece, 1986; Teece et al., 1997; Teece, 2018). Our contribution to the literature follows Pisano (2006) in challenging the assumptions about the exogeneity of environmental influences on appropriability. Whereas scholars such as Ceccagnoli (2009), Ching et al. (2019), and Gans & Stern (2017) have focused on firm choices between different legal and economic isolation mechanisms and how these shape appropriability for a given innovation, Pisano (2006) showed how firms can act strategically to influence the effectiveness of intellectural property protection more broadly, for instance by openly publishing patentable knowledge and thus weakening the appropriability regime facing upstream suppliers. Our theorizing endogenizes the other main environmental condition shaping an innovation's appropriability regime – the replicability of

knowledge – to advance theory. To do so, we build a typology to classify how the manifestation of knowledge can be shaped by the design choices firms make and draw on the Awareness-Motivation-Capability (AMC) framework to theorize how these choices endogenously influence knowledge imitability. We thus extend the innovation strategy literature by adding design mechanisms as an important class of tools that firms use to endogenously shape appropriability regimes.

The design mechanisms identified appear to be used commonly across disparate fields of application but have so far gone largely untheorized, despite having long been acknowledged as potential barriers to imitability in foundational papers on innovation strategy (e.g., Winter, 1987: 174; Lieberman & Montgomery, 1988: 54; Gans & Stern, 2003: 339). Beyond the importance of theorizing the nature and effects of these mechanisms in and of themselves, we see our paper as making three related contributions to the management literature.

Firstly, by theorizing the design choices associated with manifesting knowledge and linking this choice to the likelihood of imitation by a counterparty, we hope to broaden scholarly attention from theorizing the effects of *whether* knowledge associated with an innovation is articulated and codified, to considering *how* this is done and the implications it holds for value capture. Our paper provides a framework for pursuing these questions and a new causal logic for why a firm might be able to capture value using the "clever, unique" ways that they articulate and codify knowledge (Hedlund, 1994: 76). The scope for firms to get "clever" about this process has only expanded with the digitization of commerce and production (Shih, 2018), which has opened up new ways of articulating and codifying the knowledge underpinning an innovation (e.g., laser scanning; virtual reality; blockchain). Design mechanisms can be used to help isolate this knowledge from imitation and thus provide a new causal logic at the level of the innovation for heeding Håkanson's (2007: 80) call to resist the temptation of dismissing "codified knowledge as being (automatically) easily imitated, hence, unable to provide

competitive advantage and, hence, uninteresting.". Indeed, the arguments advanced herein suggest that choices about how to manifest knowledge are amongst the most interesting, enduring, and understudied by scholars of innovation strategy (Winter, 1987).

Secondly, our paper's typology provides a systematic way of collecting data about the use of design mechanisms for capturing value from innovation. It will now be easier to sample, parse, code, and analyze primary and secondary data. For example, surveys designed to collect primary data on managerial practice have played a central role in shaping our knowledge of isolating mechanisms (for a review, see Hall et al., 2014). Adding survey items about the design mechanisms theorized in this paper would help further expand our empirical knowledge of when and how firms capture value from innovation (James et al., 2013). The other main empirical route we see for expanding existing knowledge is through the secondary data stemming from litigation. This type of data reflects a clear choice to "leverage the firm's property rights for strategic gain" (Graham & Somaya, 2006: 15) and the litigation process requires the firm to reveal otherwise difficult to observe choices about the use of design mechanisms and how they are used to complement or substitute social, economic or legal isolating mechanisms. For example, in preparing to bring their case for copyright breach against the Automobile Association, the UK Ordinance Office's revealed their use of "trap streets" to buttress the copyright protection provided to their maps (see Clark, 2001). With global court records becoming increasingly digitized and accessible, litigation offers a useful new way of capturing rich secondary data on how firms deploy isolating mechanisms to capture value from innovation.

Thirdly, data on design mechanisms will mean that scholars can begin systematically studying if, when, and how these mechanisms might complement or substitute other types of isolating mechanisms. As Somaya (2012) explains, although tools like patents and secrecy have traditionally been treated as substitutes, in practice firms combine multiple isolating

mechanisms in an effort to optimize the value captured from a given innovation (e.g., Miric, Boudreau, & Jeppesen, 2019). This insight is particularly important for scholars seeking to identify a causal relationship between a given isolating mechanism and value captured. For example, a firm's ability to capture value from software through copyright protection (e.g., Teece, 1998: 57) should be fundamentally influenced by their use of complementary design mechanisms, such the "Tagging" seen in the use of digital watermarks to protect Deep Neural Networks (Wang & Kerschbaum, 2019) or "Spiking" seen in the deployment of self-destructing industrial software (McGaughey et al., 2000), and a combination of these approaches could be used to shape the trade-offs observed between the benefits of learning by revealing and risks of imitation (Contigiani, 2020). Similarly, firms might also be able to inhibit imitation of patented innovation by obscuring "enablement in a patent application" by deliberately increasing its complexity (Hall, Helmers, Rogers, & Sena, 2013: 606), which would imply that the causal effect originates from the combination of both legal and design mechanisms.

Failure to take *all* such combinations of plausible isolating mechanisms into account puts studies seeking to evaluate the effectiveness of a particular set of isolating mechanisms at risk of suffering from omitted variable bias, and making recommendations for management theory and practice that are based on a partial and inaccurate understanding of the strategies that firms use to capture value from innovation. For instance, the finding that using "design complexity" to protect knowledge does not seem to affect innovation performance either by itself or in combination with the level of extramural research and development (Wadhwa et al., 2017), might simply reflect the inability of a single "design complexity" measure to capture the use of different design mechanisms with differing effects on imitability (Wadhwa et al., 2017: 889). Similarly, the use of design mechanisms to prolong the period over which firms can capture value from their innovations through Schumpeterian rents may help to explain patterns in the persistence of firm profitability (Danneels, 2012; Roberts, 2001), which appear to be

inconsistent with predictions from a range of extant theories (Bennett, 2020). Our theorization of design mechanisms thus reveals a new channel through which omitted variable bias might occur and provides a framework for theorizing about, collecting data on, and interpreting the effects of this causal link.

Boundary Conditions for using Manifestation Design

The assumptions made in building our theory of design mechanisms suggest important boundary conditions to using the overarching approach. Our theory assumes that knowledge can be articulated and that components can be recombined (Fleming, 2001; Håkanson, 2007; Nelson & Winter, 1982). These assumptions are critical to our theory's propositions and suggest that areas of application where the knowledge underpinning an innovation is difficult to articulate and modularize would be less likely to find these mechanisms useful for inhibiting imitation. These are also the settings in which the risk of competitor imitation has long been viewed as being lowest (Winter, 1987) and so, taken together, investing in design mechanisms seems likely to be unappealing. However, it seems logical to expect that there will be a "grey zone" of cases situated along this continuum, where concern about competitor imitation is significant and success in capturing value from innovation requires a mix of codified and tacit knowledge, alongside modularization. In such cases, a firm might selectively reveal a codified component of knowledge in the form of a partial manifestation but be unable to articulate the rest of the manifestation. Our focus on articulable knowledge and assumption about the commercialization process[16] mean that our theory cannot at present speak to these cases.

Future Research

As with other isolating mechanisms (e.g., Somaya, 2012), there are likely to be tradeoffs between the benefits of using the different kinds of knowledge manifestations and the costs and risks involved. Our paper has made a first step in considering the likely tradeoffs between these

[16] See page 15.

costs, risks and benefits but did not theorize about the likely interplay between these effects on counterparty AMC and those that have been shown to operate at focal firm, counterparty, and dyadic levels (e.g., Chen, 1996; Chen & Hambrick, 1995; Chen et al., 1992; Hambrick et al., 1996; Smith et al., 1991). Future research should therefore consider how the effects of different knowledge manifestations may vary with heterogeneity in how counterparties identify and evaluate the actions of competitors, and in their resources and capabilities. For example, it may be the case that a given manifestation design appears more commercially promising or competitively threatening to counterparties in one industry compared to another, or that some manifestation designs could have a deterrent effect by signaling to certain counterparties that they do not possess the difficult-to-acquire capabilities required to imitate the focal knowledge.

The dynamic consequences of manifestation design choices have also not been considered. Here we suggest two important avenues for extending this analysis by considering how sequences of manifestation designs used by firms over time may affect the imitability of their knowledge, and the consequences of using design mechanisms for the organizational design of firms and its effects on knowledge creation within and beyond firm boundaries.

Manifestation design sequences. This paper has drawn on the AMC framework to theorize how choices regarding the design of a particular manifestation of the focal knowledge may affects its imitability. However, as discussed earlier, multiple knowledge manifestations are likely to be produced in the course of the innovative process, and furthermore, firms research, develop, and commercialize multiple different products, services and processes over time.

How might the effects of a particular manifestation design on counterparty awareness, motivation, and capability that we theorize in this paper be affected by the firm's repeated use of this and other design mechanisms over time? When would repeated use of these mechanisms establish a firm's commitment to protecting its innovations from imitation and so (further)

reduce counterparty motivation to engage in imitation attempts? And would this benefit outweigh the costs to the focal firm of developing a capability for designing manifestations with alterations that continue to be difficult for counterparties to identify and/or reverse? Genius Media's recently filed court case seeking $50 million in damages from Google for alleged misappropriation of song lyrics hinged on evidence from Genius' use of two different "tagging" designs over time and provides a useful illustration of such dynamics (McMillan, 2019). A promising avenue for future research to explore the above questions may be to draw on work in competitive dynamics that has studied the characteristics of firm action sequences and their effects (Ferrier, Smith, & Grimm, 1999; Ferrier, 2001; Miller & Chen, 1994, 1996). Recent theory that has linked sequence characteristics to the AMC framework in order to predict responses to sequences of competitive actions (Gao, Yu, & Cannella, 2017) may provide a useful foundation from which to build theory regarding the sustainability of design as an isolating mechanism over time, while also highlighting the possibility of counterparties responding to focal firm innovation in ways that go beyond imitation attempts targeting knowledge manifestations.

Studying the sequences of different manifestation designs firms use over time could also improve our understanding of whether the design mechanisms developed in this paper are complements or substitutes. We theorize that while some design mechanisms affect imitability primarily by reducing the likelihood of counterparty imitation attempts through the channel of reducing counterparty awareness of the focal knowledge and/or their motivation to imitate, the effect of others primarily flows through increasing the costs of imitation for a counterparty, thus raising the level of capability required for successful imitation and increasing the likelihood of unsuccessful imitation attempts. This distinction may have important value capture implications because imperfect imitation[17] has been theorized to enable imitators to sometimes outperform

[17] In our terminology, the counterparty engaging in an imitation effort that is unsuccessful in recreating the target manifestation, but still successful in imitating some component parts of it.

both innovators and perfect imitators (Posen, Lee, & Yi, 2013).[18] Indeed, using certain design mechanisms may unintentionally inspire a counterparty to pursue an innovation trajectory that, while of little value to the originating firm, may be valuable to the counterparty, given its resources and absorptive capacity.[19] Recent empirical work has shown that while imperfect imitation can indeed be a threat, its effects are contingent on a number of factors and that imperfect imitation can, in fact, reinforce the innovating firm's ability to capture value (Wang, Li, & Singh, 2018; Wang, Wu, Pechmann, & Wang, 2020). Future work should explore the implications of these contingencies for whether design mechanisms that affect imitability through one of the two channels discussed above are likely to be complements or substitutes in enabling value capture from innovation, and the implications of this for the sequence in which their use is most likely to be effective.

Organizational design and knowledge creation consequences. Different isolating mechanisms used to capture value from innovation require investments not just in their direct costs but also in altering the organizational design of the firm if they are to be effective. Patenting requires a balance between functional specialization and cross-functional involvement in the generation, protection, and utilization of intellectual property (Criscuolo, Alexy, Sharapov, & Salter, 2019; Reitzig & Puranam, 2009), and decisions to be made about the use of external parties in the process (for a review, see Somaya, 2012); efforts to keep knowledge secret require the firm to block off some channels of internal communication and interaction while funneling more of these activities through other channels (Costas & Grey, 2016; Liebeskind, 1997; Wadhwa et al., 2017); employee-focused economic isolating mechanisms require the design of incentives, jobs, and conduct rules to encourage employees

[18] We are grateful to an anonymous reviewer for making this important point.
[19] This argument is an extension of those proposed in Kogut & Zander (1992) and Zander & Kogut (1995). While the diffusion of manufacturing capabilities throughout an industry (through the mobility of key employees) has been found to increase the speed with which innovations are imitated (Zander & Kogut, 1995), heterogeneity in firm capabilities may lead to imitators developing the imitated manifestation in different ways, some of which may even become more valuable than perfect imitation would have been.

to stay loyal to the firm and/or reduce their opportunities to access and leak valuable knowledge (Baldwin and Henkel, 2015; Liebeskind, 1996, 1997; Wadhwa et al., 2017). Future research should explore the extent to which the strategic design of knowledge manifestations as proposed in this paper requires broader organizational design changes regarding who can access and influence the innovative process. Since managers will need to make decisions about which innovations to protect using these approaches and which design choices should be used to do this, future research should examine whether these changes are likely to increase the demands placed on boundedly-rational decision-makers to a detrimental extent, and whether and how organizational design can be used to manage these costs in large and complex organizations.

A further important consideration that is likely to be shaped by organizational design is the extent to which employees responsible for the strategic use of design mechanisms can leverage their mechanism knowledge into greater bargaining power vis-à-vis other stakeholders in the firm, and thus appropriate a greater share of the value created (Coff, 1999). While placing these responsibilities in the hands of a single employee seems likely to substantially increase her bargaining power, distributing these responsibilities among a number of employees in different units and/or locations could potentially counteract this effect (Coff, 1999). Doing so could also increase the costs to a rival firm of countering the use of design mechanisms by poaching the employees knowledgable about their effects and how these might be counteracted (Groysberg & Lee, 2009; Lazear, 1986).[20] Exploring whether and when the above conjectures hold would help inform the operationalization of design as an isolating mechanism and thus provides another promising future research opportunity.

Like most existing research on the topic, our theory and propositions currently focus on capturing value from a focal innovation, which the literature describes as the problem of primary appropriability. There is now growing interest in understanding "a firm's effectiveness

[20] We are grateful to an anonymous reviewer for suggesting these important insights.

in capturing a share of the future inventions spawned by its existing inventions", which Ahuja et al. (2013: 254) define as generative appropriability (e.g., Laursen, Moreira, Reichstein and Leone, 2017). Generative appropriability is beyond the scope of the current paper, but it is intuitive to expect that the use of designs mechanisms to capture value from a focal innovation, and the organizational design changes that might be required to effectively implement these approaches, might then have consequences for subsequent innovations.

For example, a firm might selectively reveal knowledge as part of a niche creation strategy (Alexy et al., 2013), which might then constrain their ability to use patents to capture value from follow-on innovations. On the other hand, to the extent that design mechanisms improve a firm's ability to capture value from a focal innovation, they should increase the incentive for developing follow-on innovations that build on this base (Teece, 1986). The overall effect is difficult to discern without further research. Five of the six mechanisms we outline involve modifying the manifestation or varying its level of completeness, actions which could be expected to reduce the mobility of knowledge across firm boundaries but also within the firm now and into the future, especially if combined with changes to organizational design. One could imagine a situation in which reduction in knowledge mobility reduces the cross-fertilization of knowledge within the firm, thus slowing or precluding the development of follow-on innovation (e.g., Wadhwa et al., 2017). Yet, our focus on counterparty imitation also sensitizes us to the prospect that reductions in the threat of imitation may have the opposite effect. The enhanced control of knowledge obtained through the use of design mechanisms might make it possible to involve a wider range of actors in the innovation process (e.g., suppliers, see Henkel, Baldwin and Shih, 2013; subsidiaries in countries with weak intellectual property rights protection, see Zhao, 2006) thus increasing the potential for follow-on innovation. Exploring how different design mechanisms and the organizational design choices

used to implement them affect both the imitability of knowledge relating to a focal innovation and value creation within and beyond firm boundaries is a crucial task for future research.

CONCLUSION

The ease of imitation is central to a firm's ability to capture value from innovation and, in competitive markets, is argued to determine the sustainability of competitive advantage (Teece, Pisano & Shuen 1997: 526). In this paper, we have built theory that offers a new explanation for how firms might achieve these outcomes. It is true that some of the mechanisms and examples discussed above arguably paint a malevolent, or at least cutthroat, view of the competitive dynamics that characterize organizational life. This is an aspect of the environment often assumed away by scholars in our field (MacAulay, Steen, & Kastelle, 2020). However, as we argue above, these conditions describe salient aspects of the competitive landscape facing managers and we believe that they deserve more scholarly attention (Alcacer, Beukel, & Cassiman, 2017; Flax, 1984; NBAR, 2017). Knowledge manifestations thus provide an essential new unit of analysis for expanding our understanding of innovation strategy to encompass long-used practices that are only becoming more important in today's increasingly digitalized and multinational business landscape. In doing so, we hope that our paper opens up new avenues of inquiry for scholars studying how firm strategy interacts with the art and science of design.

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Table 1: Using Manifestation Design to Inhibit the Imitability of Knowledge Relating to a Focal Innovation*

		Manifestation Completeness		
		Partial	Full	Augmented
Manifestation Modification	No	**Carefully Coordinating** - part of the target manifestation is revealed to facilitate collaboration. **AMC Implications:** Awareness & motivation reduced, capability required increased (P.3). **Costs:** Knowledge modularization. **Examples:** Distributed procurement and manufacturing; selective revealing.	**Ground Staking** – full target manifestation is revealed to establish claim (normative or legal) to property rights. **AMC Implications:** Awareness & motivation increased, capability required reduced (P.1.1). When used with legal/ economic/social isolating mechanism(s), awareness increased, motivation & capability required reduced (P.1.2). **Costs:** Knowledge articulation. When used with legal/ economic/social isolating mechanism(s), knowledge articulation, knowledge codification, investment in chosen legal/economic/ social isolating mechanism(s). **Examples:** Patenting; chefs publishing recipe books; scientific articles.	**Cloaking/Tagging** - extraneous component added to the full target manifestation for reasons of protection rather than functionality or aesthetics. Used to facilitate assertion of property rights (tagging) or to hide part of the manifestation from observation (cloaking). **AMC Implications:** When focal knowledge relates to a process and/or is not designed for commercialization, awareness and motivation reduced (P.2.1). When used with legal/ economic/social isolating mechanism(s), motivation reduced and capability required increased (P.2.2). **Costs:** Knowledge articulation, extraneous component design and implementation. When used with legal/ economic/social isolating mechanism(s), knowledge articulation, knowledge codification, augmenting component design and implementation, investment in chosen legal/ economic/social isolating mechanism(s). **Examples:** Watermarks; Trap Streets; DNA markers; Development Mules.

* Proposition numbers parenthesized (e.g., P.1.1 corresponds to proposition 1.1).

Table 1 (cont.): Using Manifestation Design to Inhibit Imitability of Knowledge Relating to a Focal Innovation*

		Manifestation Completeness		
		Partial	Full	Augmented
Manifestation Modification	Yes	**Feinting** – a partial manifestation is modified to disrupt and misdirect rival's sense-making and trigger a suboptimal search path. **AMC Implications:** Awareness & motivation reduced, capability required increased (P.4). **Costs:** Modification design and implementation, increased coordination and collaboration costs, reputational risks. **Examples:** Fake surveys undertaken to distract Standard Oil from building of Tidewater pipeline; stories about carrots as secret to British night-time aerial success to re-direct attention away from development of radar in World War II**;** decoy patents.	**Obfuscating** – a full manifestation is modified to disrupt and/or damage rival's imitation efforts. **AMC Implications:** Capability required increased (P.5). **Costs:** Modification design and implementation, knowledge articulation, increased coordination and collaboration costs, reputational risks. **Examples:** Leaking of faulty pipeline control software to USSR by CIA; Babbage difference engine; common cyphers; use of software compilers.	**Spiking** – an augmented manifestation is modified to prevent unsanctioned replication and usage **AMC Implications:** Awareness & motivation reduced, capability required increased (P.6). **Costs:** Modification design and implementation, augmenting component design and implementation, knowledge articulation, increased coordination and collaboration costs, reputational risks. **Examples:** Digital Rights Management; trial software.

* Proposition numbers parenthesized (e.g., P.4 corresponds to proposition 4).

FIGURE 1

Abstraction: A Fan's Knowledge Components

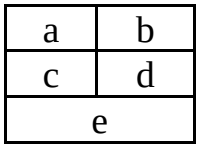
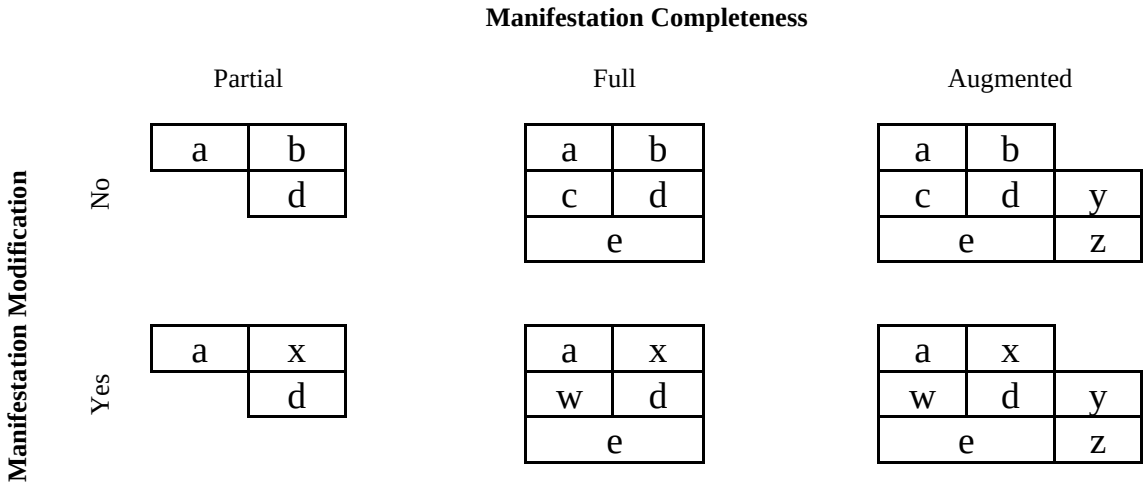


FIGURE 2

Knowledge Manifestations: A Fan's Knowledge Components Can Vary in Completeness and Modification



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