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HYBRID VIGOR: SECURING VENTURE CAPITAL BY SPANNING CATEGORIES IN NANOTECHNOLOGY

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This study develops and tests a set of novel theoretical predictions about the conditions under which category spanning is rewarded by external audiences. To do this, we revisit the assumption that comprehensible organizational identities are associated with individual categories. Drawing on insights from cognitive psychology, we suggest that category spanning does not necessarily lead to confusion, but, rather, to interpretations that rely on a "header–modifier" structure where one category anchors cognition but is modified by features of the other. Audiences may have clear understandings about how categories fit together and cognate schema for evaluating firms that hybridize by spanning between them. An empirical examination of venture capital in the carbon nanotechnology industry supports our approach: start-ups were rewarded or punished for hybridization contingent on how they mixed "science" and "technology" in their patents, top management team, and collaborations. As such, we show that the category a firm starts in, how it hybridizes, and the degree to which this affects core versus peripheral identity markers may all affect how it is perceived.

Over the past 15 years, organization scholars have become increasingly interested in the role of categories within fields and markets (Vergne & Wry, 2014). A major contribution has been to show that organizations that hybridize via mixing elements of multiple categories tend to be overlooked or devalued: a phenomenon known as the "categorical imperative" (Zuckerman, 1999). An explanation for this finding is that categories convey a coherent collective identity for a group of firms (but, see Wry, Lounsbury, & Glynn, 2011). If a firm hybridizes, this is presumed to dilute a clear category-focused identity, resulting in confusion about what "type" it is, where its core expertise lays, and how it should be valued (Durand, Rao, & Monin, 2007; Greenwood, Raynard, Kodeih, Micelotta, & Lounsbury, 2011; Hsu, 2006; Hsu & Hannan, 2005; Zuckerman & Kim, 2003).

However, the argument that category focus is required for a firm to be positively viewed encounters difficulty when explaining how hybridization might elicit positive reactions. This is a significant limitation, given evidence that audiences reward some instances of hybridization and many organizations actively hybridize. Microfinance institutions blend features of "banks" and "development agencies" (Battilana & Dorado, 2010); yacht-makers may integrate features of "design firms" and "naval yards" (Delbridge & Edwards, 2008); and it is common for start-ups in high-technology industries to bridge "science" and "technology" (Zucker, Darby, & Brewer, 1998). While studies of the categorical imperative suggest that category spanning is rare and hard to interpret—and this is certainly true in some cases—these examples highlight contexts where it is more accepted and potentially rewarded. We advocate for more symmetrical theorization in order to better account for positive and negative reactions to hybridization.

To do this, we draw on the composite concepts literature in cognitive psychology (Cohen & Mur-

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phy, 1984; Hampton, 1988). Adapting insights from this research, we develop an approach that departs from the categorical imperative in three ways that are germane for understanding how audiences perceive hybridizing firms: (1) the locus of cognition, (2) the role of categories in evaluation, and (3) the relationship between category spanning and identity. In this regard, a composite concepts approach locates cognition in category combinations. The central insight is that audiences can perceive categories as distinct, yet still see how they relate to one another (Murphy & Medin, 1985). When such understandings are widely shared, this may have important implications for how we conceive of the relationship between categories, identities, and evaluation. Unlike the categorical imperative, where hybridity is linked to identity dilution, we suggest that hybridization results in a composite identity that may be positively or negatively viewed, based on an audience's understanding about how the mixed categories fit together.

Studies suggest that combinations are interpreted according to an asymmetrical structure in which one category (the header) anchors perceptions, but is modified by features of the other category (the modifier) (Cohen & Murphy, 1984; Hampton, 1988); for example, a "boat-house" is a type of house that is modified by features of the boat category. Applied to organizations, the implication is that it is important to distinguish between hybridization that affects core versus peripheral identity markers, because these may affect the header and modifier category, respectively, that are conveyed in its composite identity. Hybridizing central features associated with a firm's category of origin may result in a new header being used to interpret the firm and its other attributes. However, hybridizing peripheral areas will likely be interpreted as modifications to a firm's more central attributes.

We develop and test our composite concepts approach in an empirical study of venture capital investments among start-up firms in the carbon nanotube (CNT) industry between 1994 and 2005. While hypotheses are framed in reference to the CNT industry, we believe they are generally applicable to hybridizing firms, especially under conditions where some types of category mixing are acceptable and rewarded. We chose the CNT industry as our setting for three reasons. First, in a previous study, the first two authors observed that some firms with patents in areas dominated by prominent scientists and in areas dominated by large firms received venture funding (Wry & Lounsbury, 2013). We were intrigued and wanted to better understand the positive outcomes of category spanning. Second, there is evidence that "science" and "technology" are relevant categories for venture capitalists (VCs) when they evaluate CNT firms (Waitz & Bokhari, 2003). Third, inter-category relationships are most likely to be evident and understood when hybridization is frequently observed (Murphy, 1988). Thus, while many studies have focused on contexts where category spanning is rare (Zuckerman & Kim, 2003: 29–30), it is common among CNT start-ups and an asset for our analysis.

Hypotheses focus on the relationship between hybridization and the likelihood of securing venture capital. We distinguish between start-ups that originate in science (e.g., spinouts from academic labs) and those that originate in technology (e.g., firms created by high-technology entrepreneurs).[1] We identify multiple ways that firms can span these categories—through product focus, top management team composition, and collaborations—that are relevant to VCs and reflect core versus peripheral identity markers (Eisenhardt & Schoonhoven, 1990; Higgins & Gulati, 2003).

As with other studies that develop context-specific hypotheses (e.g., Durand et al., 2007), we conducted interviews to gain a deeper understanding of our industry context. Discussions with VCs indicated that, in the parlance of composite concepts theory, they valorize category combinations where technology is the header category and science is the modifier. Thus, we predict that science start-ups will benefit by hybridizing core features with technology category features, while technology start-ups will be overlooked if they alter core elements to be perceived as more science-like. By contrast, we predict that hybridizing more peripheral areas will benefit technology start-ups, but not science start-ups. We find strong support for our arguments as well as the utility of a composite concepts approach.

Our study makes three primary contributions. First, we build new theory about category spanning. By locating meaning in category combinations, we dispute the notion that clear identities are associated with single-category focus (Hsu, 2006; Hsu & Hannan, 2005; Hsu, Hannan, & Kocak, 2009; Zuckerman & Kim, 2003). Second, we highlight the

[1] A detailed account of how we made this distinction is provided in the Methods section, below.

importance of considering not only the degree to which a firm fits in a focal category, but also the influence of other-category features in evaluative judgments. Third, we suggest that spanning may be viewed positively or negatively, and show how this is intertwined with the category in which a firm starts before it hybridizes. Applied to start-ups, our findings also extend research on how categories and identities affect entrepreneurial resource acquisition (Lounsbury & Glynn, 2001; Navis & Glynn, 2011; Wry & Lounsbury, 2013; Zhao, Ishihara, & Lounsbury, 2013).

The paper proceeds as follows. We start by discussing the categorical imperative and then contrast it with a composite concepts approach. After this, we develop our hypotheses based on different types of hybridization among start-ups in the CNT industry. Given the context-specific nature of our hypotheses, we provide some discussion to introduce our setting and the nature of "science" and "technology" as categories that are relevant in VC investment decisions. Next, we discuss our analytic method and results, as well as a series of robustness checks that support our findings. We conclude by elaborating the implications of our study for research on categories, hybridization, and entrepreneurial resource acquisition.

THEORY AND HYPOTHESES

Over the past decade, organization theorists have become increasingly interested in categories and their organizational effects. A foundational assumption in this work is that categories enable complex fields and markets to function smoothly by segmenting organizations into groups that share features that distinguish them from members of other categories (Hsu & Hannan, 2005; Lounsbury & Rao, 2004; Zuckerman, 1999). Audiences are thought to associate these defining features with a collective identity for category members, and this allows them to quickly identify commensurate firms and apply relevant evaluation criteria (Hsu & Hannan, 2005). As such, the categorical imperative adopts an audience-centric view where categories mediate perceptions by furnishing understandings about the attributes and behaviors that are expected of particular "types" of organizations (Hannan, 2010). There is a consistent finding that firms that mix elements of multiple categories are devalued because it is unclear where they fit within a field, what types of expertise they have, or how they should be evaluated. The existence of this *categorical imperative* was revealed by Zuckerman (1999), who showed that securities analysts were inattentive to firms that operated in multiple product market categories, resulting in stock price devaluations. Other research has shown that hybridization may result in poor evaluations (Phillips & Zuckerman, 2001; Rao, Monin, & Durand, 2005), legitimacy challenges (Greenwood, Suddaby, & Hinings, 2002), and organizational failure (Carroll & Swaminathan, 2000).

Recently, attention has begun to shift from illustrating the categorical imperative to identifying factors that moderate its functioning. To this end, studies have shown that the penalties for spanning are attenuated when categories have low contrast and the identities associated with each are nebulous. This may happen when a category system is emergent or in flux (Ruef & Patterson, 2009), or when categories blend together because actors routinely integrate features from one into another (Hsu, Negro, & Perretti, 2012). Spanning between distinct, but similar, categories may also temper the loss of focus associated with the categorical imperative (Wry & Lounsbury, 2013). It has also been noted that firms can benefit from hybridization when they engage in less category spanning than others (Durand et al., 2007), or when they want to dilute a stigmatized identity (Vergne, 2012). While these studies have advanced our understanding of category effects, questions remain about the conditions under which hybridization is embraced and positively viewed (but, see Pontikes, 2012).

A Composite Concepts Approach

In order to better account for both positive and negative reactions to hybridization, we challenge two assumptions associated with the categorical imperative: (1) comprehensible identities are fixed in individual categories and (2) category spanning dilutes an organization's identity. While these are surely true in some cases, they overlook the possibility that categories can be related in ways that go beyond the blurring of their boundaries where the essence of the original categories is eroded. We develop an alternate approach, based on composite concept cognition, where category combinations, as opposed to individual categories, are the focal unit of analysis (Cohen & Murphy, 1984; Hampton, 1988; Murphy, 1988; Murphy & Medin, 1985; see also Cornelissen & Durand, 2012). This approach adopts a different set of assumptions than the categorical imperative, and may thus offer unique insight into how hybridization is perceived.

The locus of cognition. The theory of composite concepts has been developed in cognitive psychology to account for how individuals perceive of combinations. Like the categorical imperative, this perspective recognizes that individual categories play a key role in cognitive processes. However, the focus is on understanding how individuals make sense of category combinations as composite entities, eschewing the assumption that category mixing causes problematic uncertainty or ambiguity (Cohen & Murphy, 1984; Murphy & Medin, 1985).

Notably, this research suggests that categories may be combined in different ways and that this affects how the composite is perceived. In particular, the comprehension of mixed entities relies on an asymmetrical structure where one category anchors perceptions and the other acts to modify it (Hampton, 1988; Murphy, 1988). It is vital to understand which category is which, because this can shape perceptions in fairly dramatic ways. For example, "cat" and "house" can be combined to connote a domestic animal or a house of ill repute, depending on which is the header and which is the modifier. Illustrating this in an organizationally relevant context, Park, Jun, and Shocker (1996) showed that a hypothetical cake mix co-branded by Godiva and Slim-Fast was perceived differently depending on which was the header in the composite. Varying the product name (Godiva Chocolate Cake Mix by Slim-Fast *versus* Slim-Fast Chocolate Cake Mix by Godiva) resulted in different evaluations. When Godiva was the header (the first example), consumers assumed more calories and richer flavor. When Slim-Fast was the header (the second example), consumers assumed that the product was healthier, but not as tasty.

Categories and evaluation. By locating cognition in category combinations, our approach also challenges the assumption that organizations are necessarily evaluated against a backdrop of individual categories. Indeed, studies have shown that audiences can arrive at conclusions about whether a composite is sensible or not based on their knowledge of particular categories and how their features fit together (Cohen & Murphy, 1984; Murphy & Medin, 1985). As such, the perception of composites is closely related to an audience's conception of the relationship between specific categories (Kennedy & Fiss, 2013). Reflecting this, studies have shown that cognitive processing takes longer when actors encounter new combinations, or when knowledge of the combined categories does not support a coherent composite (Liu, 2008; Rips, 1995). This again implies that directionality is important for determining if the combination of two categories is seen as sensible or not. To wit, most people understand that an "ocean wave" is a type of wave, but may have difficulty making sense of a "wave ocean" (Hampton, 1988).

Moreover, audiences may have schema that allow them to evaluate good versus bad instances of a composite. For example, most people understand what an "apartment dog" is based on their knowledge of dogs, apartments, and how the two interact. Thus, while any dog can, theoretically, live in an apartment, a contextualized understanding of the two categories creates expectations about the features—such as being small, quiet, and well behaved—that provide a foundation for evaluating the composite (see Murphy, 1988). While this insight has not been integrated into the organizational literature, marketing studies point to its relevance. Research has shown that consumer's judgments of brand extensions and co-branded products reflect their knowledge of brand attributes and the degree to which their integration is seen as adding or subtracting value (Park et al., 1996; Geylani, Inman, & Hofstede, 2008). Thus, there is evidence that, while hybridizing firms may be overlooked or devalued if audiences have trouble understanding how the features of the combined categories fit together, they may be favorably perceived if they move toward a mix that accords with audience schemas.

Mixing and organizational identity. Applied to organizations, a composite concepts approach suggests that it is important to consider the structure of the identity that is conveyed by a hybridizing organization; in particular, which category is the header, which is the modifier, and what is implied through their combination. As such, we argue that the direction of hybridization, and the degree to which core versus peripheral identity markers are affected, may affect how a firm is perceived. This approach requires closer engagement with the macro-organizational identity literature than is evident in research on the categorical imperative, where all forms of hybridization are considered equivalent. Identity scholars have argued that the institutional environment provides a variety of identity elements that an organization can mix in various ways (Glynn, 2008; Lounsbury & Glynn, 2001; Navis & Glynn, 2011). An organization's identity may thus comprise multiple attributes of varying importance (Gioia, Schultz, & Corley, 2000), and this stratification is likely to be most evident in hybrid organizations (Battilana & Dorado, 2010; Pache & Santos, 2010). Studies in cognitive psychology show that prominent features have strong cue validity, thus affecting the header category that is applied to an entity (Rosch, 1975; Rosch & Lloyd, 1978). Accordingly, we expect that hybridizing prominent features—core identity markers associated with a firm's category of origin—will affect perceptions differently than hybridizing peripheral features because of the effects that this has on the header–modifier structure conveyed by its identity. Since this is a dynamic process, it also implies that the category in which a firm starts will affect how different types of hybridization moves are perceived.

For example, Rindova, Dalpiaz, and Ravasi (2011) showed that Alessi's "artistic" household appliances elicited very different consumer reactions depending on whether the organization's primary identity was as a design or a manufacturing firm. When the manufacturing identity was primary, attempts to integrate artistic features into an appliance were viewed as interfering with its utilitarian functions and sales were slow. However, when the company shifted to position itself as a design firm, employing high-profile artists to design products, these were perceived as objects of art to be appreciated for their aesthetic qualities and sales were brisk. Delbridge and Edwards (2008) also showed that, while all super-yacht builds require collaboration between designers and naval architects, a number of firms took steps to integrate the two. When architecture was more prominent, firms appealed to cost-focused clients, while design-focused firms appealed to those who were concerned with aesthetics. Microfinance institutions may also adopt identities where revenue generation supports development goals, or where development goals support profit-making. However, for commercial funders, the latter is viewed as a much more desirable mix (Frank, 2008).

In the context of hybridization, we also argue that the cognitive processes implied by the composite concepts approach may work through audience attention and interpretation (Gioia & Thomas, 1996; Ocasio, 1997; Weick, 1995), rather than the objective measures of category focus that are used in most existing studies (see Hannan, 2010). In this regard, we draw on evidence that sensemaking is activated when individuals "notice" events in their environment and "bracket" them for closer attention (Weber & Glynn, 2006). At this stage, there are many ways that an event may be interpreted. To adjudicate, actors draw on previous experience and mental models to "select" the interpretation that they believe best fits the particular circumstance (Weick, 1995). Based on this, we expect that even a few changes to an organization's identity may be sufficient to cause audiences to question "what's going on here" and trigger sensemaking, so long as the changes are noticed. Thus, while early interpretations will likely be reinforced if a firm continues to hybridize, we do not see this as a pre-condition for the dynamics we're theorizing.

Empirical Context and Hypotheses

We test the utility of a composite concepts approach with hypotheses about hybridization and venture capital investment in the CNT industry between 1994 and 2005. CNTs are very small, strong, and light structures with a number of novel properties for electrical, thermal, and light emission (Meyyappan, 2005). Their history can be traced to the discovery of carbon (C60)—a new carbon allotrope—in 1985 by a Rice University research team that was subsequently rewarded with the Nobel Prize (Berube, 2006). CNTs are a tubular derivative of C60, the discovery of which is credited to Iijima (1991). Potential commercial uses are wide ranging and include new kinds of diodes, materials, transistors, sensors, flat panel displays, and emission arrays. Patenting began soon after Iijima illustrated CNT synthesis, and the first CNT start-up firms emerged in the early 1990s: overall, 62 start-ups were active between 1993 and 2005.

Start-ups tended to follow the well-established demarcation of "science" and "technology" as categories that are associated with different identities, interests, and practices (Dasgupta & David, 1994; Zucker et al., 1998). In this regard, science is linked with research in foundational disciplines such as biology, chemistry, and physics, where the primary aim is to advance understanding of the natural world. By comparison, technology is associated with applied research oriented toward solving real-world problems (Petroski, 2010). Moreover, there is an assumed relationship between these categories where basic science discoveries provide the foundation for the development of technological product applications. Thus, while there are a number of challenges associated with their integration, science and technology are generally perceived to be distinct, but interlinked, categories (Nelson, 1986; Rosenberg & Nelson, 1994).

Extending this, studies have shown how the distinction between science and technology may translate into start-up activity. Start-ups are more or less tied to the academic community and are variously dedicated to commercializing broad scientific discoveries versus specific products (Maurer & Ebers, 2006; Meyer, 2000; Zucker & Darby, 2008). Reflecting this, CNT firms were split fairly evenly between those launched by scientific researchers to commercialize basic science discoveries (henceforth, "science" start-ups) versus those founded by more commercially oriented actors with a focus on product applications (henceforth "technology" start-ups).[2]

As with other studies that develop context-specific hypotheses (e.g., Durand et al., 2007), we consulted archival materials and conducted interviews to gain insights into how our focal audience, VCs, perceived hybridization moves.[3] Our goals were to affirm that science and technology are categories that VCs use to analyze CNT start-ups, and to ascertain how these categories are perceived. Starting with a specialist in nanotechnology intellectual property evaluation, we used a snowball approach (Biernacki & Waldorf, 1981) to identify eight interviewees: five partners in VC funds that invest in nanotech and three intellectual property specialists. We conducted 13 interviews, speaking to the VC partners twice, lasting between 20 minutes and 1 hour. Topics included coverage areas, due diligence, evaluative criteria, and perceptions of science and technology, as well as how these should or should not be mixed.

Overall, respondents mirrored the popular perception that science and technology are distinct, but related, categories. There was also a general consensus that these categories apply to CNT start-ups and play an important part in their evaluation. For instance, when asked about their evaluative criteria, interviewees routinely distinguished between patents based on scientific discoveries versus those built on more applied efforts. According to two interviewees:

> [Basic] science patents tend to be for really broad platform technologies [like producing nanotubes or related materials] which are tough to value . . . firms really need to illustrate the feasibility of their IP [intellectual property] for specific products.

> A firm needs to emphasize product applications and the market side of things . . . science is great, but we invest in technologies as an enabler to solve problems in specific markets.

VCs also lumped together founders and other executives with science versus technology backgrounds. For John Glushik—a general partner at Durham Venture Capital—this meant looking for teams with engineering expertise, and, particularly, demonstrated capabilities in using this to develop saleable consumer products (Vinlaun, 2012; and see also Jurvetson & Waters, 2005; Waitz & Bokhari, 2003). Likewise, one of our interviewees reported a negative perception of firms with management teams that were dominated by university scientists:

> Big scientific breakthroughs are the most likely to get support from [university] transfer offices. These inventors don't have the expertise to evaluate commercial possibilities though . . . These firms get founded too early and don't have [type of] people who know what types of technologies to actually develop with what they've got.

Yet, despite the apparent preference for technology focus when evaluating start-ups, VCs also stressed that science enables technological advance and that firms that mix science and technology are attractive investment targets—but only when the former is viewed as "pushing" the latter. All eight interviewees shared this view. Two, in particular, noted:

> I love companies that have downstream [product-focused] IP that validates fundamental process and material patents . . . it shows me that they're getting serious and thinking about how they're going to impact the big market that their discovery relates to.

> Science moving to technology makes firms attractive . . . it hits the boxes that the VCs want you to tick . . . you need to demonstrate the feasibility of science for market applications.

In sum, mirroring the general perception that science provides an input for technological development (Nelson, 1986; Rosenberg & Nelson, 1994), VCs seem to value different kinds of hybrids the most, and value pure science start-ups least. However, this should not be interpreted as the science

[2] See the Methods section for a full discussion of how we determined the science versus technology focus of the firms in our sample.

[3] As with these studies, the purpose of our interviews was to add context and help to illustrate key arguments. They should not be interpreted as contributing to a mixed-method study.

category being viewed as illegitimate. To wit, Nanotech VC reported an "interest in any nanotechnology that is novel, scalable, and cost effective" (Nanotech VC, 2011), and pure science start-ups—such as Epion Corp. and Carbon Nanotechnologies, Inc.—received funding. A handful of pure technology start-ups also received money. Still, the majority of deals were for hybridized firms. Category mixing was routine and science and technology start-ups hybridized at similar rates. Thus, we apply a composite concepts approach and predict that the investment prospects for both science and technology start-ups is related to the degree that they hybridize in ways that bring them closer or further away from the audience's ideal investment prospect.

Our hypotheses focus on three potential areas where CNT start-ups might mix science and technology as they move away from a position within a recognized founding category: (1) products, (2) top management team, and (3) collaborations.[4] Archival sources and our interview data suggest that each of these affect VC investment decisions (Eisenhardt & Schoonhoven, 1990; Higgins & Gulati, 2003). They are also variously prominent as identity markers. Perceptions of a firm are closely associated with its product offerings (Navis & Glynn, 2011) as well as the identities of its founder(s) and top managers (Rodrigues & Child, 2008). By comparison, collaborations are more peripheral identity markers (Jones & Volpe, 2011; Lawrence, Hardy, & Phillips, 2002).

Product hybridization. For high-technology start-ups, patents are generally considered a reflection of product development focus (Baum & Silverman, 2004). This is very germane to nanotechnology, where many products require years of development (Lux Research, 2006). For our study, it is useful to note that some patents rely on basic science expertise and others on technological know-how (Zucker & Darby, 2008). This indicates the degree to which a firm is focused on science or technology, as well as when it hybridizes by patenting outside of its home category. We expect that hybridization via patenting will affect science and technology start-ups differently because hybridizing a core identity marker may create a new lens for interpreting previous patents as well as more peripheral identity markers (Murphy, 1988).

When a VC notices a science start-up beginning to secure technology patents, this could potentially be interpreted in a variety of ways. However, in selecting a plausible account, VCs will likely rely on their understandings about how science and technology are related, as well as previous observations of firms that made such moves (Weick, 1995). Given the directionality of the imputed relationship between science and technology, we expect that it will be positively viewed (Jurvetson & Waters, 2005; Waitz & Bokhari, 2003). Indeed, we suspect that VCs will use technology as the header category for interpreting such firms and their overall identity. Consequentially, a firm may be interpreted as becoming more technology focused and taking steps to translate its basic science patents and expertise into applied products.

However, VC interviews suggested that product-level hybridization that moves "backwards" toward science is negatively viewed. When VCs notice a technology start-up hybridizing in this way, it may be interpreted as going against the usual ordering of science and technology. To the extent that such moves put these categories out of order, they may shift the header–modifier structure so that a firm's technological expertise and patents are interpreted through its science patents, even if these are only a small portion of its overall portfolio (Gioia & Thomas, 1996; Weick, 1995). Observing a technology firm take out science patents may cue memories of firms that made such moves because they lacked the scientific base to develop their products, or that began platform technology development that was disconnected from earlier product development (Lux Research, 2006). In either case, the firm may be viewed as becoming science focused and misaligned with expectations about how science and technology go together in the normal course of product development (Dasgupta & David, 1994). Thus, we predict:

> *Hypothesis 1. Science start-ups that hybridize their product offerings by securing technology patents will be more likely to receive venture capital funding.*

> *Hypothesis 2. Technology start-ups that hybridize their product offerings by securing ba-*

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[4] Since our theoretical focus is to explore the sources and consequences of hybridization, our empirical analysis of start-ups starts with an assessment of whether a newly created firm is initially anchored in the science or technology category. While hypothetically possible, no start-ups in our study were created as hybrids. Details of how we determined the starting category for start-ups is provided in the section below on data and methods.

sic science patents will be less likely to receive venture capital funding.

Top management team hybridization. In addition to hybridizing at the product level, a start-up may also span between science and technology by altering the composition of its top management team (TMT). Studies have illustrated the link between founder(s) and top managers and a firm's identity (Baron, Hannan, & Burton, 2001; Navis & Glynn, 2011; Rodrigues & Child, 2008). Indeed, Fauchart and Gruber (2011) showed that, within a single industry, start-ups prioritized different goals and self-identified as different types of firms based on the management team's background in business, community, or social welfare. Top managers thus directly signal their organization's identity and provide a link to other key markers such as product focus. VCs pay close attention to a start-up's management team and functional expertise when making investment decisions (Baum & Silverman, 2004; Eisenhardt & Schoonhoven, 1990).

While studies, to date, have focused primarily on the diversity of experience among a firm's managers (Eisenhardt & Schoonhoven, 1990), or the completeness of its team with regard to business functions (Beckman & Burton, 2008), we suggest that expertise in scientific research versus technology commercialization is also an important consideration for firms operating at the techno-scientific frontier, such as in the CNT industry. Indeed, our data suggest that newly created start-ups with basic science patents tended to have scientific founders, whereas technology start-ups were more likely to have founders with product engineering expertise. Given that TMTs provide a strong signal of a firm's identity and strategic focus, we anticipate that category mixing at this level will have implications similar to product hybridization.

For science start-ups, we predict that adding executives with a background in technology commercialization will be positively viewed, because it may suggest to VCs that the firm is serious about transforming its discoveries into commercial products and is adding expertise that is relevant for this type of shift. Thus, VCs may use technology as the header for evaluating the firm's category spanning, fitting with expectations for desirable hybridity. However, we expect that cognate moves made by technology start-ups will be negatively viewed. Although it may be desirable for such firms to access to scientific expertise (Zucker et al., 1998), adding scientists to the TMT may be read as a shift toward a more basic science orientation because of the high cue validity associated with such moves. As with product hybridization, VCs may have difficulty understanding a firm's technology focus if science becomes the header for perceiving its category spanning. As such, we predict:

Hypothesis 3. Science start-ups that hybridize their top management team by hiring executives with technology commercialization expertise will be more likely to receive venture capital funding.

Hypothesis 4. Technology start-ups that hybridize their top management team by hiring executives with basic science expertise will be less likely to receive venture capital funding.

Collaboration hybridization. While product and management team hybridization affect fairly central identity markers, collaborations are more likely viewed as peripheral activities relative to the core of an organization's identity (Jones & Volpe, 2011; Lawrence et al., 2002). Based on this, we expect that spanning categories through collaboration will not enhance VC evaluations of science start-ups. In such situations, "technology" is more likely to be perceived as the modifier category interpreted through the lens of a "science" header category (Hampton, 1988; Murphy, 1988). In the best-case scenario, collaborations may be viewed as technology modifying how a firm's science focus is perceived, resulting in perceptions that it is working to commercialize general-purpose scientific patents (Maurer & Ebers, 2006). In nanotechnology, however, this is unlikely to make a firm more attractive to investors, since it does not bring it closer to the investment ideal where science modifies technology. Indeed, VCs may view this type of hybridization as going against their investment ideal, downgrading their evaluations of such firms (Anderson, 2011; Jurvetson & Waters, 2005).

By comparison, we expect cross-category collaborations to benefit technology start-ups. Such moves are likely to evoke perceptions where science is the modifier category, as compared to when it affects more central features of the organization. When this happens, a firm may be interpreted as being focused on technology as the header category anchoring VC perceptions, but with access to the types of expertise needed to capitalize on relevant basic science developments (Powell, White, Koput, & Owen-Smith, 2005). Thus, while hybridizing core identity features may result in a technology start-up being less favorably viewed, we expect that this will be reversed when it hybridizes peripheral identity features. As such, we predict:

Hypothesis 5. Science start-ups that hybridize by collaborating with actors that possess technology commercialization expertise will be less likely to receive venture capital funding.

Hypothesis 6. Technology start-ups that hybridize by collaborating with actors that possess basic science expertise will be more likely to receive venture capital funding.

DATA AND METHODS

Our analysis is based on the population of CNT start-ups from 1993 to 2004, inclusive. To identify these firms, we started by gathering information about all CNT patents issued by the United States Patent and Trademark Office (USPTO) using the StarTechZD database, a comprehensive storehouse of nanotechnology patents, grants, and publications supported by the U.S. National Science Foundation (Zucker & Darby, 2008). To identify CNT patents from this larger set, we did a keyword search for "nanotube" and related terms gleaned from CNT research compendia (Meyyappan, 2005). A PhD student with nanotube expertise reviewed each patent to check for false positives where a patent mentioned one of our keywords, but was not primarily related to CNTs. Six patents were eliminated, leaving us with an analysis set of 1,128. From this, we created an inventory of organizational patent assignees. After removing university and corporate patents, we cross-referenced remaining names against a list of start-ups compiled from the Lux Nanotechnology Report (2006), the Nanotube Site (Tomanek, 2009), and UnderstandingNano.com (Boysen, 2009). This yielded 62 start-ups; the first emerging in 1991.[5] There was very little start-up activity until 1993, however, so this is the first year for our independent variables. VC investment is from Zephyr—a venture capital database covering our analysis window—and is lagged one year, so that analysis runs from 1994 to 2005.

We gathered information on each firm from a number of sources. Using StarTechZD, we searched for each firm's academic publications and government grants. Also, to ensure that patent data for each firm was comprehensive, we searched the USPTO database directly for patents that were applied for in our analysis period but granted later and thus not in the StarTechZD data (which ends in 2004). We also compiled a database of the historical website pages for each firm using the WayBack-Machine Internet archive (archive.org, 2012). This produced approximately 15,000 web pages covering 60 start-ups. While many firms updated their websites frequently, offering a granular look into their historical development, we sought alternate data sources for firms that did not have archived pages or that updated their sites infrequently (>1 year between updates). Using Google, the Bloomberg database, LexisNexis, as well as our ties to CNT scientists and investors, we identified and interviewed the founders of 24 of these firms. Interviews were by phone or Skype and lasted between 20 minutes and 1 hour. We could not find data for four firms; we dropped them from our sample, leaving a final analysis set of 58 firms.

Science versus Technology Start-ups

To distinguish between "science" and "technology" start-ups, we looked at each firm's initial patent focus and the functional background of its founder(s). In this context, it is important to note that the distinction between basic science and technological development translates into the aims of different types of start-ups. Although some degree of engineering is required in the course of most product development, patents may variously draw on scientific versus technological expertise and focus on general versus focused applications (Meyer, 2000; Powell et al., 2005; Zucker et al., 1998; Zucker & Darby, 2008). Similarly, while all start-ups will generally share a focus on product commercialization, a founder's background in basic versus applied research may affect a firm's focus. For example, Maurer and Ebers (2006) found that many German biotechnology firms that were founded by university scientists focused on basic research as a result of their strong ties to the scientific community.

Patent analysis is based on science area categorizations from StarTechZD. Examining the previous patents and publications that a focal patent references, StarTechZD discerns the degree to which it

[5] It is worth noting, however, that Hyperion Catalysis claims to have synthesized multiwall CNTs in 1983. However, because the discovery of CNTs is officially attributed to Iijima in 1991, this is when the clock starts on our analysis (though Hyperion is still in our dataset).

builds on knowledge from biology; chemistry and medicine; computing and information technology; semiconductors; circuits and superconductors; other sciences; or other engineering (Zucker & Darby, 2008). We coded patents rooted in "biology," "chemistry and medicine," and "other sciences" as science patents and the others as "technology" patents.[6]

To code founder backgrounds, we relied on our interviews and website archive data. Founders with a PhD in biology, chemistry, physics, or cognate disciplines were considered to have "science expertise," while those with an engineering background or who had experience in technology commercialization through their work with an extant firm, another start-up, or a VC fund were classified as having "technology expertise." As expected, there was a high correlation between founder background and a firm's initial patents. Still, there were two instances where these diverged, as well as four cases where firms had mixed founding teams. To determine how to classify these firms, we consulted website archives (or a firm's founder) to see how they presented themselves. Firms that reported developing general-purpose technologies—such as developing CNTs or CNT-enabled materials for use in multiple applications—were considered science start-ups, while those developing specific products were classified technology start-ups. In each case, this aligned with the firm's patent focus. Still, to ensure that this didn't introduce bias into our results, we ran unreported models with these firms excluded: results were very similar to those reported. In sum, we found 27 science and 31 technology start-ups; Figures 1 and 2 show the historical breakdown between them and the extent of hybridization over time.

[6] Not all patents accord neatly with a single area in the StarTechZD analysis. In cases where a patent draws on diverse expertise, StarTechZD reports the proportion that is related to each area. While this was not an issue for more than 90% of the patents in our sample, 16 were focused 70–99% on science or technology and 10 were focused between 50–69%. We dealt with this in three ways. First, we ran models excluding these patents. Second, we excluded patents that were split evenly between science and technology. Third, we excluded patents with >70% focus. While all three yielded similar results, we opted for the third in reported models because these patents were substantially based on either science or technology.

Variable Definitions

Dependent variable. Our dependent variable is venture capital investment, coded as a binary variable set to 1 in the year(s) that a firm received funding. We used a dummy variable for two reasons. First, details about investment size were available from Zephyr, but not for all deals and not always with terms disclosed. As such, similarly sized investments may reflect substantially different valuations. Second, firms may seek different levels of investment, meaning that variation in deal amounts may not be a good indicator of a firm's success in attracting capital. A dummy variable is a conservative way to handle this lack of consistent information. There were 68 VC deals worth over $250 million in our analysis period.

Independent variables. Our first independent variable is hybridization via patenting. We measured this in two ways: a yearly count of a firm's out-of-category patents as well as a cumulative measure to help account for the process effects of hybridization (Barnett & Carroll, 1995). Variables are based on patent application dates, per convention (Hall, Jaffe, & Trajtenberg, 2001). To assess hybridity at the top management level, we used website archives and interview data to create an inventory of hires at the top two levels of a firm's management hierarchy. Individuals with a PhD in a basic science discipline were coded as "science hires," while those from engineering schools, other start-ups, or extant firms were coded as "technology hires." We excluded chief financial officers because the position is relevant to all start-ups and was uniformly filled by a chartered professional accountant (or equivalent). We test Hypothesis 3 and Hypothesis 4 with yearly and cumulative counts.

We also measured category spanning through collaboration with yearly and cumulative measures. To create these variables, we began by making an inventory of organization assignees and inventors listed on each firm's patents (when multiple organizations were listed), as well as the individual inventor names. To determine the functional background of each inventor, we cross-matched this list against a database of the approximately 3,500 researchers listed with their affiliations in the CNT publications archived by StarTechZD. For the handful of inventors who did not appear in this dataset, we did manual searches for each in the Web of Science, ProQuest Dissertation, and USPTO databases to identify ad-

FIGURE 1
Cumulative Yearly Science Start-ups and Types of Hybridity

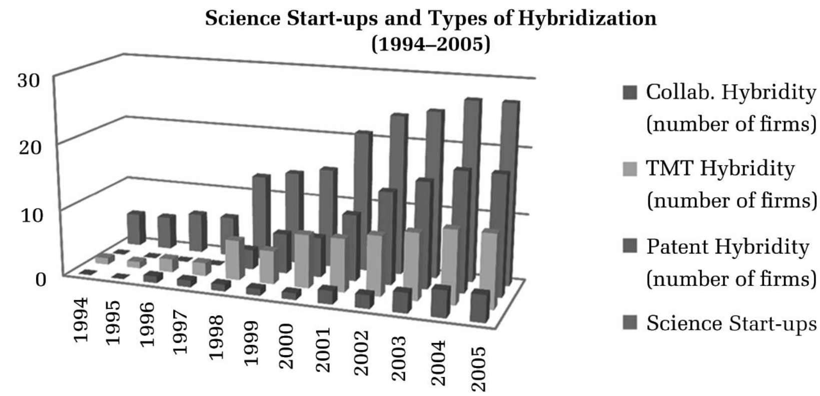
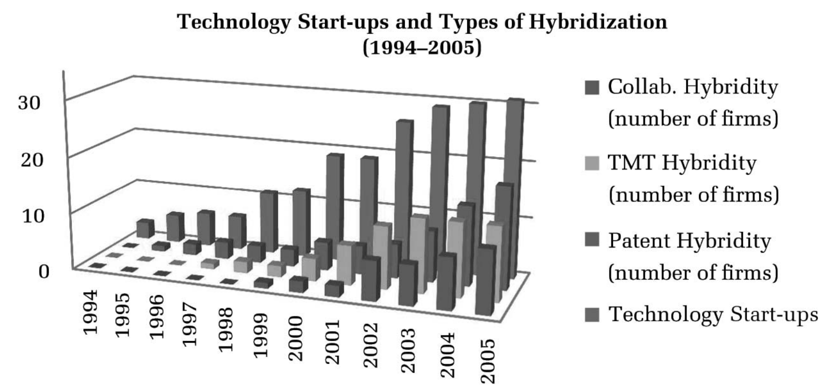


FIGURE 2
Cumulative Yearly Technology Start-ups and Types of Hybridity



ditional publications, dissertations, or patents with clues about their background. We used the same basic technique to identify collaborations from a firm's academic publications and rounded out our data with the collaborations listed on a firm's website or reported during founder interviews.

Control variables. We included a number of control variables that reflect the availability of venture capital and a firm's ability to access it. We controlled for temporal variation in the supply of venture capital with a dummy variable set to "1" after the U.S. National Nanotechnology Initiative (NNI) passed in 2001. The NNI allocated over $1 billion per year for nanotechnology funding, and there is evidence that this was accompanied by an increase in VC investment (Lux Research, 2006). Martens, Jennings, and Jennings (2007) used a similar period effect dummy to control for market structure shifts in dot.com versus dot.bomb initial public offerings.

At the firm level, we controlled for potential life-course effects with variables for its emergence (when it applied for its first CNT patent) and age (in years). Firms that target different market niches may also have different appeal to VCs. We controlled for this with dummy variables that track a firm's focus in nano-tools, materials, optics, energy, electronics, or health care (Lux Research, 2006). Given evidence that firms with more patents may be perceived as innovative, and thus more attractive to VCs, we controlled for the overall number of patents held by a firm, as well as the importance of a firm's patents, which is, by convention, measured as the number of times that these are cited by other patents (Baum & Silverman, 2004; Martens et al., 2007). Also, studies have shown that firms that are led by high-profile individuals may be viewed more favorably (Hayward, Rindova, & Pollock, 2004), and this may be particularly pronounced in techno-scientific industries (Zucker et al., 1998). Following

Zucker et al. (1998), we controlled for "star" founder, defined as those with 1,000+ citations to their scholarly articles. We also controlled for TMT size as a proxy for a firm's human capital, which some authors have linked to investment (Baum & Silverman, 2004; Beckman & Burton, 2008).

Finally, we controlled for two types of previous investment. Firms that have received venture capital are generally more likely to receive follow-on investment (Gompers & Lerner, 2004). Thus, we included a dummy variable tracking previous VC investment. Many CNT firms also receive government grants (Berube, 2006). We included a dummy variable tracking whether or not a firm had received grant money to control for the potential effect that this may have on subsequent VC funding. Table 1 shows a full breakdown of our variables and sources.

Relationship to earlier research. In a previous study, the first two authors examined how technology focus, as reflected in USPTO patent classes, affected VC investment in CNT start-ups (Wry & Lounsbury, 2013). Contra our theoretical prediction, some firms with patents in classes dominated by star scientists as well as in classes dominated by large corporations were funded. The current paper shares a dependent variable with this work and was motivated in part by this finding. Controls for a firm's patents, patent citations, founder status, market focus, and previous investment were used in both studies. Since our previous study had a different theoretical focus on patent classes, the current paper on science–technology hybridization required novel conceptualization of, and data for, all independent variables as well as additional controls.

Analytic Method

We modeled the effect of hybridization on VC investment using probit models with a maximum likelihood estimation procedure. This is common for binary response models, such as ours, where the dependent variable can take only two values. Per

TABLE 1
Variable Descriptions

Variables	*M*	*SD*	Min.	Max.	Source
1. VC investment	.123	.329	0	1	Zephyr
2. Science start-up	.502	.501	0	1	StarTechZD/WayBackMachine
3. Technology start-up	.564	.497	0	1	StarTechZD/WayBackMachine
4. Nano-tools	.118	.322	0	1	Lux Research
5. Materials	.443	.399	0	1	Lux Research
6. Optics	.114	.319	0	1	Lux Research
7. Energy	.106	.308	0	1	Lux Research
8. Electronics	.127	.333	0	1	Lux Research
9. Health	.151	.359	0	1	Lux Research
10. Post NNI	.578	.495	0	1	U.S. Government
11. New firm	.156	.364	0	1	StarTechZD
12. Firm age	4.38	2.85	0	12	StarTechZD
13. Star founder	.207	.406	0	1	StarTechZD/Web of Science
14. TMT size	4.08	1.22	1	6	WayBackMachine/interviews
15. Patents, overall	5.08	2.38	1	47	StarTechZD/USPTO
16. Patent citations	11.67	34.15	0	247	USPTO
17. Previous grants	.193	.395	0	1	StarTechZD
18. Previous venture capital	.122	.329	0	1	Zephyr
19. Tech. patents, year	1.62	2.80	0	19	StarTechZD
20. Tech. patents, overall	4.01	6.96	0	47	StarTechZD
21. Science patents, year	.692	1.66	0	13	StarTechZD
22. Science patents, overall	2.13	4.74	0	23	StarTechZD
23. Tech. TMT, year	.223	.657	0	3	WayBackMachine/interviews
24. Tech. TMT, overall	1.88	1.35	0	6	WayBackMachine/interviews
25. Science TMT, year	.073	.343	0	3	WayBackMachine/interviews
26. Science TMT, overall	1.32	1.22	0	5	WayBackMachine/interviews
27. Tech. collabs., year	.084	.357	0	3	WayBackMachine/interviews
28. Tech. collabs., overall	.360	1.14	0	7	WayBackMachine/interviews
29. Science collabs., year	.418	1.62	0	5	WayBackMachine/interviews
30. Science collabs., overall	1.50	4.37	0	12	WayBackMachine/interviews

earlier studies of hybridization, we used a random effects specification to address the non-independence of observations within firms. This approach splits the residual of each observation into firm-specific and "usual" components, allowing for firm-level variation across years (Durand et al., 2007: 464). Model estimation was with STATA 12, using the "xtprobit" command.

Matching our hypotheses, we analyzed science and technology start-ups separately. In addition to differences between these firms with respect to their initial patent focus and founder backgrounds, unreported pooled models show that firms that are founded as technology start-ups are significantly more likely to attract VC investment ($p < .01$). This is consistent with VC interviews that valorized technology as the header category. Firms entered our dataset when they applied for their first patent and exited if they were acquired or filed for bankruptcy (per Zephyr). Data is by firm-year with 180 observations for science start-ups and 202 for technology start-ups. Independent and control variables are lagged one year and updated yearly. We also contextualized our findings with qualitative data. Specifically, we re-interviewed five VC partners to whom we had talked earlier, presenting them with hypothetical situations matching our hypotheses and asking for their reactions. Discussions were by Skype and lasted between 30 and 45 minutes. Excerpts are presented via quotes that lend further support to our core findings.

Main Results

Table 2 presents variable correlations and shows there are no collinearity problems. Tables 3 and 4 report our empirical analysis: Table 3 is for science start-ups and Table 4 is for technology start-ups. Model 1 is the baseline with just controls, Models 2–10 add hypothesized variables, and Model 11

TABLE 2a
Variable Correlations

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. VC investment											
2. Science start-up	−.070 5										
3. Tech. start-up	.072	−1.00									
4. Nano-tools	−.103	.053	−.121 .026								
5. Materials	−.100	−.131	.026	−.393							
6. Optics	.221	.135	−.200	−.236	−.369						
7. Energy	−.019	.089	.302	−.173	−.082	−.162					
8. Electronics	.069	−.066	.021	−.170	−.266	−.089	−.117				
9. Health	−.063	−.150	.115	−.132	−.205	−.123	−.090	−.089			
10. Post NNI	.079	−.057	.037	−.080	.039	−.009	−.073	.104	−.030		
11. New firm	.003	−.078	.006	−.043	.012	.017	−.024	.056	−.019	−.208	
12. Firm age	.024	.039	−.035	.127	−.024	−.077	.020	−.082	.052	.323	−.512
13. Star founder	.079	.246	.017	−.256	.154	−.187	.362	.008	−.133	.087	.027
14. TMT size	.161	.056	.165	−.257	−.019	.057	.007	.251	−.081	.124	−.071
15. Patents, overall	.103	−.003	.079	−.219	.255	−.082	.135	−.009	−.117	.260	−.264
16. Patent cites	.024	.075	−.100	−.132	.331	−.134	−.072	−.077	−.080	.191	−.096
17. Prev. grants	.012	.033	−.099	.285	.041	−.193	−.168	−.073	−.013	.059	−.132
18. Previous VC	.033	−.083	.090	−.119	.022	.263	−.038	−.010	−.120	.256	−.177
19. Tech. patents, year	.288	.009	.070	−.101	−.151	.245	.089	.056	−.131	−.041	−.087
20. Tech. patents, overall	.287	.065	.062	−.151	−.154	.372	.177	−.102	−.148	.235	−.262
21. Science patents, year	−.033	.088	−.064	−.134	.075	.118	−.013	−.075	−.054	−.001	−.045
22. Science patents, overall	.061	.261	−.009	−.181	.111	.122	.026	−.113	−.066	.118	−.167
23. Tech. TMT, year	.106	.092	−.070	−.043	−.135	.215	−.007	−.032	.015	−.011	−.088
24. Tech. TMT, overall	.316	−.068	.126	.001	−.280	.266	.036	−.101	.158	.175	−.215
25. Science TMT, year	.070	−.066	.038	−.005	−.048	.069	−.070	−.018	.077	−.017	−.091
26. Science TMT, overall	.075	.177	−.201	−.133	.056	.059	−.173	.015	.052	.185	−.014
27. Tech. collabs., year	.103	−.080	.064	−.059	.042	.093	−.056	−.028	−.062	−.021	−.037
28. Tech. collabs., overall	.143	−.117	.090	−.159	.071	.061	−.085	.135	−.083	.127	−.076
29. Science collabs., year	.118	.023	−.058	−.061	.121	−.019	−.089	−.003	−.033	.116	−.016
30. Science collabs., overall	.074	.074	−.121	−.089	.184	−.024	−.118	−.032	−.043	.197	−.109

TABLE 2b
(continued)

	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
13. Star founder	−.108										
14. TMT size	.005	.261									
15. Patents, overall	.365	.233	.181								
16. Patent cites	.176	.291	.321	.578							
17. Prev. grants	.224	−.145	−.146	.010	−.096						
18. Previous VC	.215	.022	.095	.301	.200	−.018					
19. Tech. patents, year	−.052	.055	.146	.319	.037	−.075	.067				
20. Tech. patents, overall	.408	.044	.207	.545	.186	−.101	.435	.499			
21. Science patents, year	.025	.032	.174	.157	.140	−.050	.054	.330	.251		
22. Science patents, overall	.287	.009	.234	.370	.339	−.046	.102	.150	.508	.580	
23. Tech. TMT, year	−.058	.079	.125	−.006	.023	.017	.182	.235	.226	.188	.054
24. Tech. TMT, overall	.252	−.039	.573	.196	−.025	.226	.313	.266	.475	.007	.078
25. Science TMT, year	−.083	.093	.103	.007	.084	−.042	−.011	.201	.031	.044	−.021
26. Science TMT, overall	−.135	.340	.364	.032	.202	.039	.096	.007	−.018	.150	.062
27. Tech. collabs., year	.045	.035	.067	−.014	−.008	−.075	.079	.082	.102	.109	.056
28. Tech. collabs., overall	.121	.032	.090	.222	.056	−.142	.160	.260	.269	.088	.143
29. Science collabs., year	−.062	.162	.115	.051	.205	−.013	.109	.100	.036	.175	.041
30. Science collabs., overall	.062	.242	.161	.235	.331	−.010	.307	.047	.097	.272	.191

TABLE 2c
(continued)

	23.	24.	25.	26.	27.	28.	29.
24. Tech. TMT, overall	.355						
25. Science TMT, year	.226	.109					
26. Science TMT, overall	.105	−.122	.271				
27. Tech. collabs., year	.063	−.038	−.027	.118			
28. Tech. collabs., overall	.012	−.052	−.053	.051	.463		
29. Science collabs., year	.064	.034	.312	.241	.132	.104	
30. Science collabs., overall	.068	−.011	.140	.286	.182	.240	.609

is the full model with cumulative measures for all hypothesized covariates.

Hypotheses 1 and 2 argue that science start-ups will benefit from category spanning through patenting, while the same type of hybridization will have negative effects for technology start-ups. We find considerable support for these hypotheses. Table 3, Model 2, shows that a science start-up's technology patents per year are a strong predictor of VC funding. This effect remains strong when testing cumulative technology patents, and when we control for cumulative science patents (Models 3–4). Looking at technology start-ups, Table 4, Model 2, shows a strong and significant negative coefficient for yearly science patents. Model 3 tests the effect of cumulative science patenting and Model 4 adds a firm's overall technology patents: science patents have the expected negative effect in both models.

When we asked VCs about this type of hybridization, responses were typically pointed and matched our argument that hybridizing via patenting is positively viewed when read through a technology lens, but not when science is used as the header category. According to two VCs:

> *If* a firm can make the link between platform patents and specific products, I'll be interested. Downstream [product] patents show me that a firm is moving in the right direction . . . it validates the foundational IP and can be a pretty compelling package when everything is put together.

> Going back upstream [from technology to science] happens, but it's a really risky move. What am I supposed to make of all that product IP? Doing science is slow and expensive . . . why are they doing it if they want to make end-stage products? Now you've got to scale up the science, you've got to work on the product, and the overall impression is that the product is getting sacrificed while they work on the basic stuff.

TABLE 3
Random Effects Probit Regressions of Venture Capital Investments: Science Start-ups, 1994–2005

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Post NNI	−.881*	−1.097	−1.54**	−1.87***	−.849*	−.855	−.915	−.883*	−.881*	−.968*	−1.33**
	(.486)	(.710)	(.665)	(.642)	(.502)	(.641)	(.632)	(.488)	(.485)	(.493)	(.674)
New firm	.885*	3.25***	2.14**	2.02**	1.08**	1.48*	1.44*	.884*	.881*	.749	2.19**
	(.502)	(1.19)	(1.02)	(.929)	(.541)	(.767)	(.747)	(.503)	(.502)	(.524)	(1.04)
Firm age	.156	.486***	.171	.129	.185	.236*	.248*	.165*	.165*	.221**	.070
	(.086)	(.171)	(.134)	(.146)	(.089)	(.139)	(.140)	(.086)	(.086)	(.095)	(.216)
Star founder	−.161	−.408	.934	.484	−.147	.228	.332	−.163	−.167	−.212	.478
	(.395)	(.456)	(.627)	(.534)	(.378)	(.503)	(.487)	(.398)	(.397)	(.414)	(.665)
TMT size	.125	.294	.933*	.739*	.093	.165		.052	.057	−.073	
	(.195)	(.266)	(.494)	(.391)	(.208)	(.355)		(.204)	(.207)	(.225)	
Patents overall	.066	.149**	−.131		.075	−.042	−.049	.065	.067	.073	
	(.048)	(.072)	(.092)		(.052)	(.072)	(.072)	(.048)	(.049)	(.051)	
Patent citations	.002	−.005	.019	.006	−.001	−.003	−.003	.002	.001	−.001	.001
	(.008)	(.009)	(.015)	(.009)	(.008)	(.011)	(.011)	(.008)	(.008)	(.009)	(.015)
Previous grants	.161	−.703	.212	.161	.107	−.947	−.973	.158	.136	.167	−.903
	(.668)	(1.22)	(1.78)	(1.37)	(.699)	(1.39)	(1.32)	(.672)	(.445)	(.712)	(1.98)
Previous VC	.332	−1.13	−.538	−.520	−.538	−.519	−.504	.334	.335	.294	−.800
	(.448)	(.827)	(.573)	(.568)	(.511)	(.589)	(.578)	(.447)	(.445)	(.455)	(.652)
Hypothesis 1											
Tech. patents, year		.380***									
		(.104)									
Tech. patents, overall			.159***	.136***							.083**
			(.047)	(.040)							(.050)
Science patents, overall				−.005							−.013
				(.017)							(.020)
Hypothesis 3											
Tech. TMT, year					.260*						
					(.170)						
Tech. TMT, overall						1.11***	1.09***				.766**
						(.308)	(.288)				(.348)
Science TMT, overall							.115				−.071
							(.320)				(.433)
Hypothesis 5											
Tech. collabs., year								−.017			
								(.539)			
Tech. collabs., overall									−.043	.040	.247
									(.264)	(.188)	(.482)
Science collabs., overall										−.307*	−.084
										(.180)	(.291)
Constant	−2.11**	−6.66***	−8.59***	−7.33***	−2.57**	−5.55***	−4.88***	−2.11**	−2.14**	−1.67	−7.44**
	(1.06)	(2.25)	(3.16)	(2.51)	(1.14)	(2.27)	(1.16)	(1.07)	(1.08)	(1.12)	(3.09)
Firm random effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Market focus dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	180	180	180	180	180	180	180	180	180	180	180
Log likelihood	−51.47	−38.51	−36.39	−37.46	−50.36	−35.32	−35.37	−51.47	−51.46	−49.14	−33.14
Wald χ^2	10.72	16.31	20.35	19.35	11.68	15.71	16.86	10.73	10.76	12.39	17.04

Note: Standard errors in parentheses. One-tailed tests for directional constructs and two-tailed tests for controls.
* $p < 0.10$
** $p < 0.05$
*** $p < 0.01$

Hypotheses 3 and 4 predict that TMT hybridization will be positively perceived for science start-ups, but not for technology start-ups. Table 3, Model 5, shows modest support for Hypothesis 3 when testing the influence of yearly technology hires among science start-ups ($p < .10$). This is not surprising, however, considering that this is a relatively rare event. When overall technology hires are considered, the effect strengthens and remains strong when the number of science managers in a firm's upper echelon is included, thus supporting Hypothesis 3. In contrast, results do not support Hypothesis 4; that is, that science hires are detrimental for technology firms. Although the effect of yearly science hires is in the expected negative direction, none of the coefficients for management hybridization in Table 4, Models 5–7, are significant. Again, VC interviews helped us to better understanding these findings, particularly the nonresult for TMT hybridization among technology start-ups. According to two interviewees:

> A firm with basic platform type stuff will really benefit from hiring someone with some solid tech expertise. It shows me that they're starting to think about what they're actually going to do with this stuff . . . you need to have those chops on the team, either directly [when developing product

TABLE 4
Random Effects Probit Regressions of Venture Capital Investments: Technology Start-ups, 1994–2005

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Post NNI	.669	.216	.265	.295	.355	.355	.153	.405	.298	.291	.209
	(.476)	(.342)	(.343)	(.353)	(.330)	(.330)	(.348)	(.363)	(.335)	(.336)	(.395)
New firm	.088	−.074	.118	.186	.058	.096	.225	.090	.040	.047	.325
	(.433)	(.446)	(.443)	(.451)	(.443)	(.437)	(.445)	(.479)	(.439)	(.439)	(.489)
Firm age	−.082	−.096	−.031	−.061	−.094	−.093	−.059	−.106	−.132	−.129	.011
	(.078)	(.076)	(.080)	(.086)	(.077)	(.076)	(.079)	(.098)	(.088)	(.088)	(.103)
Star founder	.392	.358	.218	.201	.376	.291	.312	.121	.144	.118	.513
	(.417)	(.423)	(.425)	(.434)	(.419)	(.511)	(.505)	(.456)	(.423)	(.429)	(.632)
TMT size	.201*	.309**	.298**	.352**	.201*	.174		.012	.101	.084	
	(.120)	(.131)	(.136)	(.145)	(.121)	(.161)		(.139)	(.129)	(.133)	
Patents, overall	.042	.065**	.038		.037	.037	.031	.047	.035	.041	
	(.029)	(.031)	(.029)		(.028)	(.028)	(.029)	(.032)	(.029)	(.032)	
Patent citations	.002	.004	.011	.025**	.002	.002	.005	.003	.004	.004	.047***
	(.005)	(.005)	(.008)	(.010)	(.005)	(.005)	(.004)	(.005)	(.005)	(.005)	(.014)
Previous grants	.158	.002	.152	.173	.142	.152	.124	.175	.227	.165	.228
	(.370)	(.393)	(.374)	(.377)	(.376)	(.374)	(.409)	(.420)	(.380)	(.401)	(.441)
Previous VC	.723**	.691*	.650*	.482	.661*	.683*	.540	.538	.372	.382	.300
	(.361)	(.355)	(.352)	(.370)	(.359)	(.355)	(.369)	(.389)	(.388)	(.388)	(.422)
Hypothesis 2											
Science patents, year		−.471**									
		(.226)									
Science patents, overall			−.089*	−.219***							−.324***
			(.054)	(.086)							(.110)
Tech. patents, overall				.070**							.013
				(.030)							(.034)
Hypothesis 4											
Science TMT, year					−.090						
					(.331)						
Science TMT, overall						.037	.129				.097
						(.193)	(.145)				(.178)
Tech. TMT, overall							.272*				.154
							(.148)				(.168)
Hypothesis 6											
Science collabs., year								.711***			
								(.164)			
Science collabs., overall									.128***	.143***	.282***
									(.053)	(.061)	(.099)
Tech. collabs., overall										−.059	.028
										(.116)	(.125)
Constant	−1.60**	−1.75***	−1.91***	−2.38***	−1.59**	−1.57**	−1.68*	−1.35*	−1.25*	−1.18*	−1.36**
	(.661)	(.674)	(.698)	(.777)	(.662)	(.648)	(.610)	(.729)	(.695)	(.710)	(.690)
Firm random effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Market focus dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	202	202	202	202	202	202	202	202	202	202	202
Log likelihood	−57.07	−54.02	−56.03	−53.45	−57.50	−57.52	−56.40	−46.23	−54.43	−54.30	−48.51
Wald χ^2	27.95	30.79	28.73	29.01	27.53	27.52	29.42	38.16	31.14	31.31	33.76

Note: Standard errors in parentheses. One-tailed tests for directional constructs and two-tailed tests for controls.
* $p < 0.10$
** $p < 0.05$
*** $p < 0.01$

applications] or by anticipating that they will be necessary.

> I want to see scientific credibility, so I don't have any problem with a firm bringing in some university types to round out the team . . . as long as they keep their focus on the original mission . . . if they start working on science stuff, I'd get very nervous about putting my money in a firm like that.

Our last set of hypotheses focused on hybridization that affected more peripheral aspects of identity. We argued that hybridizing through collaborations will benefit technology start-ups—befitting the investment ideal of VC funders—whereas this will not help science start-ups attract funding. We fail to support Hypothesis 5. Table 3, Models 8–10, shows that cross-category collaborations have no effect on the likelihood of science start-ups attracting venture capital. While not consistent with our hypothesis, a possible explanation is that hybridization of such peripheral features may have low cue validity and simply go unnoticed when audiences aren't sensitized to look for them (Ocasio, 1997; Weick, 1995). By comparison, VCs may be highly attentive to desirable forms of hybridization, even when it involves a firm's peripheral features. Reflecting this, we find strong support for Hypothesis 6. Table 4, Model 8, shows that technology start-ups that have more yearly cross-category collaborations are significantly more likely to be funded. And, as Models 9 and 10 show, this effect also applies when cumulative scientific collaborations and a firm's overall collaborations are accounted for. Interviews with VCs added texture to these findings on hybridization via collaboration. According to three:

> Many big companies have stopped doing core R&D because there are no returns from it. They outsource it to labs, scientists, and [science] start-ups. That's what I want to see in a firm. Clear focus, but a pipeline to the basic scientific knowledge that they need to stay on the cutting edge.
>
> Okay, so a firm starts working with business partners or taking out [joint] IP with engineers. So what? Maybe they're trying to make the platform technology happen, but that's not really the kind of thing that gets me excited.
>
> If I'm looking at two firms with [scientific] platform IP, I'll pick the one with business collaborators; says there's a ready-made customer. Still, that's not what I'm really interested in. I want a firm to focus on a big and clear market.

Robustness Checks

We conducted a series of robustness checks, both to help rule out alternate explanations and to bolster our findings. First, while the use of random effect probit models is consistent with previous studies of hybridization (Durand et al., 2007), there are other ways to model our data. Given our interest in the temporal effects of hybridization, we used two additional approaches—exponential hazard rate models and fixed effect logistic regression—that more directly isolate the effect of changes in our hypothesized variables over time within firms. The pattern of results was similar to our reported findings for both sets of models. Notably, however, the effect for TMT hybridization among technology start-ups was negative and significant in fixed effects logit models, thus lending some support to Hypothesis 4. We urge caution when interpreting this result, though, because the fixed effect model excludes firms that did not receive funding and thus have no variation on the dependent variable. The resulting decline in statistical power also led to weaker results in the full models for both science and technology start-ups.

A second potential issue is feedback effects between investment and hybridization. To investigate, we used a single rotated principal component of cumulative hybridization of patents, management, and collaborations, as well as all controls to determine whether hybridization was sensitive to investment: it was. Our reported models partially address this by accounting for prior investment and industry trends as well as both cumulative and yearly hybridization. To further guard against reverse causality, we also ran supplementary models where firms left our dataset after their first VC investment round. Results were very similar to reported findings.

Next, we tested additional controls that may be relevant to VC investment. For potential regional effects (Romanelli & Khessina, 2005), we used a dummy variable set to "1" for firms that were founded in Boston, Houston, and Silicon Valley—regions with the most nanotechnology start-up activity (Berube, 2006; Wry, Greenwood, Jennings, & Lounsbury, 2010). We also included a dummy variable tracking whether a firm was a corporate or university transfer office spinout (Owen-Smith & Powell, 2003). While these controls were not significant in our previous study (Wry & Lounsbury, 2013), we wanted to ensure this held up under the current analysis. Also, while the post-NNI period is associated with increased nanotechnology funding (Lux Research, 2006), we tested two alternate variables—the overall number of VC investments and average deal size per year in the United States, as reported by Zephyr—that reflect the more general investment climate. None of these variables were significant, so we did not retain them in our main models.

In addition, our "technology" variables for top management and collaborations comprise research engineers as well as managers with commercialization experience. Given that TMT hybridization strongly predicted VC funding for science start-ups and we failed to support the predicted outcome for collaboration hybridization among these firms, we decided to look for more nuance by decomposing these variables. We coded TMT hires as "engineering" when an actor's previous affiliation was with a research institution and "commercialization" when their previous affiliation was with an existing firm, another start-up, or a VC fund. Collaborations with engineers who held academic affiliations were coded "engineering" and collaborations with other firms were coded as "commercialization." Unfortunately, the number of observations for the decomposed variables was too small to return meaningful results in the collaboration models. However, the effects for both engineering and commercialization hires matched our reported results. Thus, consistent with our hypothesis, we are confident that managers with engineering or commercialization experience make a science start-up more attractive to VCs.

We are also sensitive to the possibility that the status of a firm's affiliations may affect its attractiveness to investors (Higgins & Gulati, 2003). Our collaboration models may thus reflect status affiliations rather than identity perceptions. To check this, we created variables to track the status of collaborators. We considered firms with >$500m in annual sales (from Compustat) and scientists with >1,000 citations to their scholarly articles to be high-status collaborators. Neither cumulative nor yearly measures of these variables were significant predictors of funding.

Finally, while there are concerns with using a continuous variable to measure investment, we created an ordinal variable to provide coarse insight into the effect of hybridization on deal size. Coding was as follows: no investment = "0"; some investment but of a small or unknown amount = "1"; large investment (>10 million U.S. dollars) = "2." We modeled this using ordered probit regression with time trends (Allison, 1995). Results were consistent with our reported models: for patent hybridization, science start-ups were more likely to receive large investments, and technology start-ups were less likely to receive any money; TMT hybridity led to larger deals for science start-ups, but had no effect on technology start-ups; collaboration hybridization led to larger investments in technology start-ups, but had no effect for science start-ups.

DISCUSSION AND CONCLUSIONS

In this paper, we focused on identifying conditions under which hybridization is rewarded or punished by external audiences. Departing from arguments rooted in the categorical imperative, we drew on cognitive psychology research, which focuses directly on how audiences understand combined entities (Cohen & Murphy, 1984; Murphy & Medin, 1985). This work suggests that individuals may view categories as distinct, yet still perceive meaningful linkages among them. Thus, while a clear categorical identity may be favorably viewed, this does not necessarily mean that hybrids are difficult to understand or value. Beyond this, a composite is more than the sum of its parts; comprehension relies on a header–modifier structure in which one category anchors perceptions and is modified by features of the other (Cohen & Murphy, 1984; Hampton, 1988). Adapting this to organizations, we argued that it is important to attend to the manifold ways that categories can be bridged, whether these affect a firm's central or peripheral identity markers, and the degree to which different types of spanning accord with audience understandings about how categories fit together. We thus suggest that hybridization is not just a matter of degree (Hannan, 2010), but a matter of degree across multiple dimensions that variously affect audience perceptions. Unlike previous studies of hybridization (Durand et al., 2007; Rao et al., 2005), we also highlighted the importance of attending to the category in which a firm starts, as this may affect whether different hybridization processes are viewed positively or negatively.

A detailed examination of start-ups in the CNT industry supported our approach. Based on archival sources and interviews, we found that investors valued different types of science–technology hybrids most and firms with a pure science focus least. While some firms with a strong focus in either category received funding, the majority of deals were for those that hybridized in specific ways. For science start-ups, this was when core identity markers were hybridized; similar moves by technology start-ups were negatively viewed. The opposite was true when these firms hybridized more peripheral identity features. VC interviews supported our supposition that this was due to "science" or "technology" being invoked as the header to interpret what was happening to a firm's identity as it hybridized. Our findings contribute to the literatures on categorization, hybridization, and entrepreneurial resource acquisition.

Contributions to the Study of Categories

Our approach revisits the argument that categories affect commensuration and evaluation within fields by segmenting participants into clear and distinctive groups (e.g., Hsu & Hannan, 2005; Zuckerman, 1999). While there is a general recognition that firms can unproblematically stake out unique identities within a category, the linked assumption is that category spanning is difficult to understand (Hsu, 2006; Hsu & Hannan, 2005; Hsu et al., 2009; Whetten, 2006; Zuckerman & Kim, 2003). While this undoubtedly applies in many cases, we believe it has also contributed to a theoretical blind spot related to the interpretation and evaluation of category spanning. Indeed, by fixing sensible identities in specific categories, efforts to relax the categorical imperative have largely been limited to showing that penalties for hybridization are attenuated when categories and identities become unmoored from one another because a category system is in flux (Ruef & Patterson, 2009) or because categories lose contrast (Rao et al., 2005).

In comparison, we direct attention to the potential for audiences to perceive meaningful relationships among categories and, thus, sensible (and even valued) identities for category spanners. While it is important not to make assumptions about audience perceptions of inter-category linkages ex ante, our results show that, when such understandings exist, they may significantly affect how hybridizing organizations are perceived. As such, we highlight the value in studying the broader sets of potential relationships that may exist among categories, rather than simply locating them on a continuum ranging from "clear and distinct" to "fuzzily bounded" (Hannan, 2010; Hsu et al., 2012; Pontikes, 2012; Rao et al., 2005). Given the recent emphasis on audiences in the categories literature, this is a natural extension. This approach also has the potential to sensitize scholars to look for schemas that might otherwise be missed, and thus helps to enrich understanding about the dynamics of audiences, categories, and organizations.

Contributions to the Study of Hybridizing Organizations

Our approach has a number of implications for the conceptualization and study of organizational hybridization. In particular, we offer an alternate conceptualization of category spanning that draws on a rich tradition of cognitive psychology research. In doing so, we suggest that it is important to develop theory that can account for the full range of reactions that hybrid organizations might elicit. An implication of this shift is to highlight the importance of considering not only the degree to which a firm fits in a focal category, but also the role of its other category features in shaping evaluative judgments. As such, the category in which a firm starts, the way that it hybridizes, and the extent to which this affects core versus peripheral identity markers may all affect how it is perceived.

In this context, a contribution of our study is to highlight the role of directionality in hybridization and the effect that this may have on audience evaluations. While past studies have tended to be agnostic about the category in which a firm starts, or how it moves through categories (Durand et al., 2007; Phillips & Zuckerman, 2001), a firm's hybridization trajectory is central to a composite concepts approach. Because cognition relies on a header–modifier structure, it is dangerous to assume that firms that start in different categories—and are, thus, likely to be evaluated with different header categories—will be viewed similarly when they mix the same categories. Indeed, our results show that directionality can have a significant impact on how a hybridizing firm is perceived. A natural extension would be to examine how firms that start in the same category are perceived when they hybridize in different directions. For instance, products might share a 90% focus in the "water" category, but elicit very different responses if the remaining 10% comprises juice, scotch, or vinegar. And, while we focused on hybridization as a process, future work should examine the implications of a composite concepts approach for the study of born-hybrids, such as social enterprises that mix social and financial aims by their nature (Battilana & Dorado, 2010; Besharov & Smith, 2014; Dacin, Dacin, & Tracey, 2011).

Along these lines, it would be useful to expand research on category spanning to explore how the perceptions and evaluations of varied audiences may hinge on the ability of firms to manage the institutional complexity associated with hybridization. Scholars have begun to focus on how organizations navigate contexts comprising institutional logics that generate competing pressures and demands on organizational leaders; what Greenwood, Díaz, Li, and Lorente (2010) have labeled "institutional complexity." While various intra-organizational processes by which this complexity is managed have been documented (Battilana & Dorado, 2010; Glynn & Rafaelli, 2013; Lounsbury & Boxenbaum, 2013), there has been scant research to date connecting this to audience reactions (but, see Glynn & Lounsbury, 2005; Wry, Cobb, & Aldrich, 2013).

Indeed, there is evidence, in some industries, that audiences value different types of hybridity, suggesting that category mixing may involve strategic trade-offs (e.g., Frank, 2008). Future research should also examine how forces for and against hybridization affect a firm's decision to hybridize, as well as the institutional- and firm-level factors that moderate such decisions (Wry et al., 2013). This may yield novel insights into why firms hybridize in the first place—a key but undertheorized question in the categories literature (Vergne & Wry, 2014). Since we would expect to see much more category spanning and organizational hybridization under conditions of high institutional complexity, further research is required to understand how categorization is shaped by institutional logics (Thornton, Ocasio, & Lounsbury, 2012).

Contributions to the Study of Entrepreneurial Resource Acquisition

Given the challenges that newness creates for start-ups (Stinchcombe, 1965), considerable effort has been expended to understand the factors that help ventures acquire resources such as financial capital (e.g., Cooper, Gimeno-Gascon, & Woo, 1994; Martens et al., 2007; Zott & Huy, 2007). Studies of "cultural entrepreneurship" have emphasized the role of organizational identity—particularly as it intersects the categories literature—in this process (Lounsbury & Glynn, 2001; Navis & Glynn, 2011; Wry et al., 2011; Zhao et al., 2013). Per the categorical imperative, this work assumes that it is important for start-ups to convey an identity that conforms to a recognized collective identity category, or to engage in efforts to establish a new category around the firm's unique attributes (Aldrich & Fiol, 1994; Kennedy, 2008; Navis & Glynn, 2010). Our approach suggests, however, that strategic hybridization may be advantageous in some contexts. To the extent that an entrepreneur understands the category dynamics of his or her industry and the types of identities that are conveyed by different types of hybridity, such moves may become a source of positive differentiation. Here, our study points to the utility of reviving earlier work that focused on categories and managerial cognition (Porac & Thomas, 1990). While this stream has dwindled with the ascent of the categorical imperative (Durand & Paolella, 2013; Kennedy & Fiss, 2013; Vergne & Wry, 2014), it may be fruitful to examine managerial and external audience category perceptions, the influence of each on organizational action, and the factors that bring these more or less into alignment.

Managerial Implications

For managers, our study offers practical advice about the importance of categories and conveyed organizational identity. Indeed, results show that, even in industries where hybridization is positively viewed, the allocation of rewards and punishments is not symmetrical. Despite the fact that science and technology start-ups mixed the same two categories, the former was rewarded for this while the latter was punished. However, more peripheral hybridization was advantageous for technology firms. As such, managers need to be aware of the implications of directionality in hybridization as well as the varying level of cue validity that is associated with different decisions. Both may have consequential implications for how a firm is perceived. Thus, attending of the external environment, and the interests of the audiences it comprises, may position a firm to capitalize on hybridity. As such, there may be opportunities for firms to cultivate "optimally distinctive" identities that cross multiple categories as a source of positive distinction (Deephouse, 1999).

Limitations

Despite the strength of our findings, there are limitations to our analysis. Although evidence suggests that the three types of hybridization we focus on are relevant to VCs, they are not exhaustive. For instance, a start-up may span between science and technology through non-managerial hiring, acquisitions, or a variety of other means. Science startups may also hire engineers in the course of developing platform technologies and firms may distribute their social capital among employees, giving rise to collaborations that are hard to observe with organizational-level measures (Maurer & Ebers, 2006). While these factors are arguably less visible than the variables used in our analysis—and thus less likely to affect external perceptions—they may have important implications for a firm. Thus, a limitation of our study is the inability to account for internal competencies that may affect a firm's efficacy and efficiency in ways that make it more or less attractive to investors.

We also note that managers may be able to shape VC perceptions by contextualizing hybridity within a broader narrative (Martens et al., 2007). Indeed, studies have shown that a firm's image is significantly mediated through managerial intervention (Corley & Gioia, 2004; Gioia et al., 2000). This limitation is blunted somewhat in studies of venture capital because investment decisions follow intensive scrutiny of an organization. Still, future research should investigate this directly. Also, our findings accorded with the sense-making literature, but we did not examine the dynamic processes associated with these judgments (Weber &

Glynn, 2006). Results should be interpreted with this data limitation in mind. We also note that, while results were consistent with a composite concepts approach, we did not directly examine the cognitive processes associated with these effects. VC interviews offered some insight, but future studies should investigate the underlying micro-processes in more detail.

In addition, while we focused on the effects of hybridization at different levels of a firm's identity, we recognize that these may jointly shape audience perceptions. It is also possible that hybridity may encompass more than the two categories that we focused on here. Scholars should embrace this complexity and examine how audiences react to different category configurations, as well as the interaction between temporal and composite hybridity. Also, while we developed a new approach, this involved accepting a number of ontological assumptions about categories and their consequences. There is evidence to support these assumptions, but also studies that suggest that not all categories function in the same way. For instance, some are organized into nested hierarchies, and categories at different levels may have different effects (Rosch & Lloyd, 1978). Future studies should examine how combinations of categories that are more or less similar, and that sit at different hierarchal levels, are perceived (Vergne & Wry, 2014).

Conclusion

In sum, our paper developed a novel approach for studying organizational hybridization. In doing so, we contribute to a more symmetrical theorization of categories and category effects that recognizes combinations themselves as a valuable unit of analysis, rather than according priority to individual categories. We thus offer insight into the conditions under which category spanning is both rewarded and punished while inviting further research at the intersection of organization theory and cognitive psychology.

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