LOST IN A UNIVERSE OF MARKETS:

TOWARD A THEORY OF MARKET SCOPING FOR EARLY STAGE TECHNOLOGIES

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Abstract

This paper examines market scoping for early stage technologies, a fundamental yet underexplored marketing activity. Market scoping refers to managerial activities directed at the identification of market spaces for early stage technologies. Our discovery-oriented research aimed at theory development draws on an extensive, multi-year database of email trails and archival records detailing market scoping efforts for early stage technologies emerging from a global research university. Based on this longitudinal database, we provide an in-depth examination of managers' market space decisions and advance an initial theory of market scoping. We isolate managers' market scoping mindset—which manifests as market ambiguity avoidance or acceptance—as a key explanatory construct shaping market space decisions and outcomes. Market ambiguity avoidance results in managers' downstream orientation toward end-users; this mindset, counterintuitively, may lead to technology commercialization failure. In contrast, market ambiguity acceptance results in managers' upstream orientation; this mindset directs attention away from end-users, but helps uncover indirect paths to viable market spaces. This paper lays the groundwork for advancing marketing research in the context of early stage technology commercialization.

Keywords: early stage technology; innovation; new product development; technology commercialization; entrepreneurship; market ambiguity; market spaces

Introduction

The ability to commercialize early stage technologies emerging from research labs at universities, public research organizations, and high-tech firms is a critical feature of technological progress and economic growth (Chandy et al. 2006; Danneels 2007; Gruber et al. 2008). Early stage technologies face a unique, underexplored marketing challenge: they are associated with ambiguous market spaces. For example, Harvard scientists have recently developed *nanostructure meta-lenses* that can focus the entire visible spectrum of light with extremely high resolution (Khorasaninejad et al. 2016). Meta-lenses could revolutionize the design of many devices and can be linked to multiple market space options: smart phones, cameras, microscopes, and virtual reality applications. Although a patent application has been filed, the relevant market space for meta-lenses has yet to be identified. Jonathan Page, former director at Imperial Innovations, an influential technology investment firm, portrays the ambiguous market reality of early stage technologies as follows:

> Many [early stage] innovations are of a 'platform' nature. That is to say, they are not developed, linear fashion, into a specific product. Rather, they are innovations with a number of applications. It often takes a *long dialogue* with industry and with market researchers to reach the right application (WIPO 2011, p.18, emphasis added).

The identification of market spaces (i.e., technology-to-market linkages that present new product development opportunities) for early stage technologies is perhaps the most fundamental, but also most elusive marketing competence for managers and firms in technology industries (Danneels 2007; Gruber et al. 2013). Potential market spaces for early stage technologies can span multiple industries, offering varying prospects characterized by much uncertainty. Moreover, adverse market space decisions often result in significant resource misallocations and commercialization failure (Gruber et al. 2013; Gruber et al. 2008). Indeed, technology managers and industry collaborators face a dilemma: they must focus on a market space to move technology projects forward (Reid and de Brentani 2010), but retain flexibility by considering multiple market space options (O'Connor and Rice 2013).

The purpose of this paper is to unpack the "long dialogue" between managers and industry entities to shed light on market space identification processes for early stage technologies. We refer to these processes as *market scoping*. In line with similar research efforts in marketing focused on underexplored phenomena (e.g., Challagalla et al. 2014; Coviello and Joseph 2012; Ulaga and Reinartz 2011), we employ a discovery-oriented, theory-building approach to lay the conceptual groundwork for an important yet neglected substantive area in marketing (Yadav 2010). A key insight is that managers' downstream focus on end-users, while well intentioned, may result in an illusory sense of direction in situations of market ambiguity. Such a focus may create a false sense of progress, and may increase the risk of failure. In contrast, we find that managers' attention to upstream industry entities—away from end-users—can reveal new, indirect paths to markets and may improve the chances of success.

To put these insights in context, it is worth noting that the marketing literature places a strong emphasis on downstream, end-user phenomena. Though marketing has embraced technology and innovation management as important areas of study (e.g., Capon and Glazer 1987; Chandy et al. 2006; Yadav et al. 2007), the field is curiously silent about the early stage of technology evolution. Studies are rare that focus on phenomena associated with ambiguous market spaces where potential end-users may be unknown or difficult to identify. Scholars have directed attention to market learning processes in new product innovation (e.g., De Luca and Atuahene-Gima 2007), but these occur *after* relevant technology-to-market combinations have been established. As a result of the field's continued downstream focus, extant theory is conceptually at odds with the market reality of early stage technologies.

The innovation and entrepreneurship literatures have recognized the challenges that early stage technologies pose, but market scoping processes are not well-theorized. Prior research largely views market spaces as exogenously-given entities. As a result, prior

research neglects the role of managerial processes, and instead focuses on technological (Nerkar and Shane 2007), industry (Gambardella and Giarratana 2013), and firm characteristics (Fosfuri 2006). Pertinent research on boundary-spanning search (Rosenkopf and Nerkar 2001), networks of learning (Powell et al. 1996), and market opportunity formation (Gruber et al. 2013) assumes relevant search spaces, learning networks, and market knowledge to be identified, accessible, or available *ex ante*. Yet what managers actually do when search landscapes are vast and undefined, industry networks are weak or absent, and market knowledge is limited, is not well understood. Further, studying managerial processes that shape market spaces for early stage technologies is challenging because "researchers lack access to information about inventions […] prior to the initiation of the commercialization process" (Nerkar and Shane 2007, p.1156). In other words, it is difficult to obtain rich, real-time process data that reveal market space decisions that are made *before* technology commercialization attempts are initiated, *prior to* market-specific technology development.

We seek to address these gaps in prior research by: 1) developing an initial theoretical understanding of market scoping for early stage technologies; and 2) identifying the characteristics of effective and ineffective market scoping approaches. Our theory development effort is informed by insights obtained in the context of university technology transfer. This setting is a hotbed for early stage technologies that are partially codified, post-lab, and lack commercial validation. Hence, market ambiguity is endemic and effective market scoping is crucial for successful outcomes. Our overarching objective is to develop a theoretical framework that can lead to theory testing endeavors and identifies new research opportunities in marketing. We develop our discovery-oriented research based on an in-depth study of early stage technologies managed by the technology transfer office of a global research university. We assemble a unique longitudinal database of email trails and archival records, spanning several years, to develop granular insights into the focal phenomenon.

Email trails offer an unprecedented window into the nature of market scoping, narrated by major stakeholders involved in technology commercialization.

The conceptual framework that emerges from our discovery-oriented approach (see Figure 1) has the potential to open new avenues for marketing research in the context of early stage technology commercialization and, more broadly, in the field of marketing under uncertainty (e.g., Coviello and Joseph 2012; Moorman and Miner 1998; Read et al. 2009). Specifically, we make the following contributions to the literature. First, we establish the domain of the *market scoping* construct and contextualize it in the broader literature. Second, we introduce the concept of *market scoping mindset* which refers to managers' preferences regarding the resolution of market ambiguity. This mindset manifests as market ambiguity avoidance (i.e., preference for an early resolution of market ambiguity) or market ambiguity acceptance (i.e., preference for a gradual resolution of market ambiguity). Third, we show how market ambiguity avoidance and acceptance shape market space decisions and outcomes. Overall, our evidence and theorizing suggest that market ambiguity avoidance—although focused on end-users—is more likely to result in failure in the context of early stage technologies. In contrast, market ambiguity acceptance—even though it initially draws attention away from end-users—may ultimately help managers establish more viable market spaces. Our insights advance theory development in several areas, such as effectuation theory (Sarasvathy 2001), boundary-spanning search (Rosenkopf and Nerkar 2001), networks of learning (Powell et al. 1996), and market opportunity formation (Gruber et al. 2013).

This paper is structured as follows. We begin by describing the conceptual context of market scoping and our discovery-oriented theory development approach. Next, we develop our theory of market scoping along with a set of research propositions and discuss implications for research and practice. We end with an overview of key concepts and their operationalization and offer an agenda for future research on market scoping.

Conceptual Background of Market Scoping

Definitions: Early Stage Technologies, Market Spaces, and Market Ambiguity

Table 5 presents definitions of all concepts employed in our theory development effort. We introduce these definitions in various sections of the paper. In this section, we elaborate on an initial set of constructs to establish a theoretical backdrop for our subsequent discussions.

Early stage technologies represent nascent scientific and/or technical knowledge that is post-lab and partially codified. Such technologies are generally based on the identification of novel physical, mechanical, chemical, or biological principles that have been demonstrated in a laboratory setting (Arthur 2009). However, there is a lack of clarity about technology behaviors and attributes pertaining to potential commercial application settings (this corresponds with technology readiness level 4 as defined by NASA; see Mankins 1995).

This definition of early stage technologies has several implications. First, early stage technologies are typically pre-patent (i.e., a patent has not been filed or granted). Second, reflecting their scientific origins in labs, they usually present technology-push rather than market-pull innovations (Meyer-Krahmer and Schmoch 1998). Third, early stage technologies are fungible and transcend the boundaries of markets and industries (Gruber et al. 2008; Penrose 1959; Shane 2000). They can be altered and integrated with other technological knowledge to be transformed into market-specific technologies embodied in new products (Danneels 2007; Galunic and Rodan 1998).

Given early stage technologies' fungibility, managers have to identify relevant market spaces for them. We define *market space* as a set of technology-to-market linkages that present new product development opportunities for a focal early stage technology. A technology-to-market linkage refers to the combination of technological knowledge with information about market demand (Gruber et al. 2008). Successful technology-to-market linkages thus enable market-specific technology and product development. *Market ambiguity*

refers to the lack of clarity about the nature, number, and commercial viability of potential technology-to-market linkages. For example, scientists believe that nanostructure meta-lenses (mentioned earlier) may significantly impact the design of multiple devices. However, it is unclear how exactly meta-lenses could be applied to such devices, if there are other potential technology-to-market linkages, or if products developed for specific technology-to-market linkages will be profitable. Thus, market ambiguity can be distinguished from market uncertainty which refers to the difficulty of predicting specific outcomes, such as consumer demand, for a *given* technology-to-market combination (Santos and Eisenhardt 2009).

The Managerial Agency Research Gap

Market scoping refers to the set of managerial activities directed at the identification of the market space for a focal early stage technology. Market scoping can thus be viewed as part of the lengthy process that is involved in converting emerging technologies into commercialized new products (Chandy et al. 2006). Table 1 shows the different stages of this conversion process, including relevant variables and managerial activities discussed in the literature.

Prior research has examined factors that may explain the success of managers' technology commercialization efforts. This research suggests that the breadth and diversity of managers' technology and market knowledge raises their awareness of relevant technology commercialization opportunities (Gruber et al. 2013; Shane 2000). However, scholars have also argued that over-reliance on existing knowledge endowments may result in "familiarity traps" as managers may overlook opportunities outside their knowledge corridors (Ahuja and Lampert 2001). This ties in with the research on boundary-spanning search (e.g., Rosenkopf and Nerkar 2001). Such search patterns can push organizations beyond familiar knowledge domains and improve innovation outcomes. Another research stream focuses on networks of learning in technologically dynamic environments (e.g., Cohen and Levinthal 1990; Powell et al. 1996). This literature suggests that access to inter-organizational networks that offer

complementary technology assets facilitates the commercial exploitation of emerging technologies.

Despite these research efforts, a significant gap in the literature is the lack of attention to managerial agency in the identification of commercialization opportunities (see Table 1). Managerial agency, in this context, refers to managerial dispositions and preferences about how to engage with the external environment. Different manifestations of managerial agency orient managerial decision-making very differently (Cardinale 2018). The importance of managerial agency is acknowledged by the emerging realist perspective on commercial opportunities (Alvarez et al. 2013). This perspective suggests that market spaces are not exogenously given but co-created, shaped by the subjective preferences and resource inputs of the actors involved (Read et al. 2009; Sarasvathy 2001). However, research that provides satisfactory, fine-grained details about managerial agency is scant. As a result, the current understanding of managerial preferences and decisions related to the identification of market spaces for early stage technologies is limited. We now describe how this paper seeks to address this critically important research gap.

Discovery-Oriented, Theory Development Approach

This research is based on a discovery-oriented, multi-case study approach aimed at theory building (Eisenhardt 1989). Multiple cases permit a replication logic, with each case serving to confirm or disconfirm inferences drawn from others (Yin 2009). Our research follows theory development efforts in marketing that have focused on understudied phenomena (for recent examples, see Challagalla et al. 2014; Coviello and Joseph 2012; Ulaga and Reinartz 2011). The primary focus of such efforts is to develop a conceptualization which can spur subsequent theory testing efforts. Web Appendix A provides a detailed overview of our methodological approach and decisions.

Substantive Context

We chose university technology transfer as the context for our theory-building efforts. University labs are an important source of early stage technologies. The technologies that emerge from these labs are typically characterized by significant market ambiguity (Colyvas et al. 2002). Nevertheless, many universities and scientists are keen to commercialize their technological discoveries (Debackere and Veugelers 2005). We study early stage technologies emerging from one of the world's leading research universities (hereafter, University). The University is a recognized leader in the systematic commercialization of university technology. Since 1995, spinoff companies have attracted private investments worth more than $1.7 billion.

This substantive context, combined with our research protocol, minimizes inter-project variation in terms of: (a) differences in team quality; and (b) differences in technology quality and maturity (see Web Appendix B and C). First, all teams are staffed with a junior and a senior technology transfer manager, with expertise and experience in a pertinent technology field, while a member of the executive management team oversees project progress. This ensures a homogenous level of commercialization expertise across projects. Second, the focal technologies are at a pre-commercial and pre-patent stage when accepted by the technology transfer office and undergo a similar, rigorous selection process. The uniform application of this selection process increases the homogeneity of focal technologies' quality and maturity.

Selection of Early Stage Technologies

We used theoretical sampling to identify the focal technologies (Glaser and Strauss 1967). Case selection aimed to uncover the relevant spectrum of market scoping preferences, market space decisions, partnerships and external inputs, and market scoping outcomes. Exploratory interviews with technology transfer managers helped us identify 29 technology projects. By applying a set of selection criteria (see Web Appendix A), we arrived at our extended case sample of 12 technology projects. These projects were at a comparable (early) stage of

development, associated with an ambiguous market space, lacked formal industry ties, and received a similar level of marketing support (see Web Appendix C). At the same time, we ensured heterogeneity regarding certain project characteristics, such as the technology field, the route-to-market, and market scoping success. This variation enables a firmer grounding of the emerging theory (Harris and Sutton 1986). Based on this extended case sample, we first performed exploratory analyses to develop an initial understanding of the phenomenon. This was followed by an in-depth examination of the focal case sample: six technology projects that allowed us to reach theoretical saturation. Our approach adheres to the recommended sample size of four to ten cases for theory building (Eisenhardt 1989; for exemplars in marketing, see: Coviello and Joseph 2012; Gebhardt et al. 2006).

Assembling a Longitudinal Data Base

The lead author collected data on-site over a period of 20 months. He was provided with office space and University staff members were aware of his role as a researcher. He had complete access to project-level archival records and email data which revealed substantial details of managerial work at the University's technology transfer office. Formal and informal interviews helped triangulate our insights. Table 2 provides details of the various types of data for the six technology projects.

Archival and email records. We obtained access to complete archival records for the six focal technologies. In total, we collected 1,866 project documents (see Web Appendix A for details on the types of project documents). In addition, the University provided us with the complete email correspondence for the six technology projects involving all project stakeholders, including technology transfer managers, University inventors, consultants, investors, industry representatives, etc. In total, we used 12,602 email trails.

Using email records has several benefits. First, emails (with date and time stamps) provide a rich, real-time contextualization of archival data. Technology transfer managers,

inventors, and external stakeholders discuss market scoping preferences, decisions, and outcomes via email in real-time on a regular basis. Also, to keep team members informed, managers summarize important talking points and project decisions made in meetings and phone calls via email. Hence, emails provide a unique window into the focal phenomenon and help us overcome the data limitations of prior research. Second, emails minimize interviewer and interviewee biases. They validate the information from archival documents and rule out potential biases resulting from, for instance, retrospective biases, memory lapses, and impression management.

Formal and informal interviews. After studying the archival and email data, we conducted eight formal in-depth interviews with the six senior technology transfer managers responsible for the focal technologies. In addition, the lead author also conducted 45 informal interviews with a variety of staff members (see Table 2 for details).

Analytical Approach and Reliability of Extracted Insights

Analytical approach. Fine-grained case chronologies for the focal case sample formed the basis of data coding (see Web Appendix A for details). The unit of analysis throughout is the project team. We used the following coding procedures to develop our theoretical model (Strauss and Corbin 1998): 1) open coding to identify basic themes in market scoping preferences and decisions; 2) axial coding to integrate these basic themes into higher-order, theoretically distinct market scoping preference and decision categories; and 3) selective coding to identify the core explanatory construct: the market scoping mindset which manifests as market ambiguity avoidance or acceptance. Tables 3a and 3b illustrate our coding structure, including illustrative data excerpts for each code; these tables show how we derived distinct theoretical concepts from our data. Overall, our analytical approach is similar to that used by Santos and Eisenhardt (2009) who longitudinally tracked managerial decision-making through extensive archival data.

Reliability and validity. We checked the reliability and validity of our findings in several ways. First, we discussed our emerging findings, including labels and definitions, with the University's technology transfer managers in four one-hour meetings. We used their feedback to refine our emerging framework. Second, three independent judges verified the themes we identified in the email data (see Web Appendix A). The inter-judge reliability, calculated by the proportional reduction in loss method, was .85, well above the .7 threshold for exploratory research (Rust and Cooil 1994).

Finally, we conducted an exploratory computer-aided text analysis of email data based on our extended case sample (12 technology projects). This analysis helps triangulate and guide the overarching theme emerging from our in-depth examination of the focal case sample (6 technology projects): that managers' market scoping mindset shapes performance outcomes. Figure 2 depicts relative frequencies of the five most frequently used market-specific keywords. Out of the 12 projects, cases 1 and 5 (failures) display the strongest emphasis on target markets which suggests that the teams avoided market ambiguity. Cases 2 and 4 (successes) display the weakest emphasis on target markets which suggests that the teams were willing to accept market ambiguity. Cases 3 and 6 lie in between these two extremes (with mixed outcomes). These exploratory trends provide face validity regarding the potentially significant role played by the market scoping mindset.

The Nature of Market Scoping for Early Stage Technologies

Market scoping represents a set of managerial activities directed at the identification of the market space for a focal early stage technology. The identification of market spaces involves a variety of managerial preferences and decisions related to the search, assessment, and selection of potential market opportunities. Market scoping specifies the domain of the market space by identifying distinct technology-to-market linkages. External partners (e.g., consultants, investors, and corporate managers and researchers) provide critical inputs during

this process: end-user ideas, performance standards, technology benchmarks, testing facilities, technical know-how, funding, etc. Market scoping is thus an inherently collaborative activity, performed by project teams (technology transfer managers and inventors) together with external stakeholders. As such, market scoping is co-creational and effectual in nature (Alvarez et al. 2013; Sarasvathy 2001).

Prior research has typically focused on technology characteristics such as value, disruptiveness, and patent scope (e.g., Gambardella and Giarratana 2013; Nerkar and Shane 2007; Shane 2001) to explain commercialization success (see also Table 1). However, an early insight of our discovery-oriented research was that such characteristics may have limited explanatory power because they are only partially delineated in the context of early stage technologies. Indeed, our data suggest that market scoping efforts often facilitate a more complete understanding of an early stage technology and its potential. The statement below, made by a member of the executive management team of the technology transfer office, illustrates the important role of market space decisions[1]:

> What the value of a technology is cannot be answered until where it might be deployed is determined. Even so, often what looks like a great leap forward rapidly dwindles to incremental or worse upon a little development.

In subsequent sections, we present the insights from our discovery-oriented research. Figure 1 provides an overview of the derived theoretical model and identifies the key concepts: market scoping mindsets, market space decisions, and market scoping outcomes.

Market Scoping Mindsets

A key insight emerging from our discovery-oriented research is that managerial agency manifests as different market scoping preferences which subsequently shape market space decisions very differently. We refer to managers' preferences pertaining to the identification of market spaces for an early stage technology as the *market scoping mindset*. This mindset

[1] Given the global scope of our email database, a few words in quotes contained alternative spellings (e.g., British, American). For consistency, we use American spelling in the reported quotes.

reflects managers' priorities and attentional emphases when engaging with the external environment. A project team's mindset can thus be viewed as being comprised of the collective preferences of its constituent members. In all subsequent discussion, we use the project team as our unit of analysis.

As we started exploring the extensive email data, it became evident that there was considerable variance in terms of teams' preferences regarding, for example, the nature and breadth of the search landscape, the immediacy of the market space, and the desired form of value the technology may provide. Underlying this heterogeneity is a distinct set of market scoping preferences regarding the resolution of market ambiguity. Specifically, this mindset toward market ambiguity is based on three interrelated preferences regarding: 1) the speed of market ambiguity resolution; 2) the market (versus technology) specificity of external inputs; and 3) the type of partnerships. The mindset ranges between two extreme anchors shaped by the preferred speed of market ambiguity resolution: rapid or gradual resolution of market ambiguity. These anchors are closely associated with specific external input and partnership preferences—reflecting teams' attentional emphases. For expositional purposes, we label these anchors as market ambiguity avoidance and market ambiguity acceptance, respectively. Below, we discuss the distinctive managerial preferences associated with these anchors.

Market ambiguity avoidance. Under market ambiguity avoidance, teams prefer *a priori* market space representations that guide all market scoping activities. Specifically, this mindset is based on the following manifestations of market scoping preferences. First, teams prefer a rapid resolution of market ambiguity; that is, they prefer early market space clarity. The statement below, made by a project manager at the beginning of a technology project, demonstrates this preference for early market space clarity:

> *Project manager:* The initial markets include automotive applications (interior fittings), coatings (for material longevity), medical applications (compression stockings), and construction (strain indicators). Early contacts from >25 companies indicate a strong appetite for engagement in these markets and market scoping is now essential.

Second, to achieve early market space clarity, teams have a preference for market-specific inputs from the environment, such as end-use ideas, end-user benefits, and other market characteristics such as size and growth. The following email demonstrates a project manager's effort to gather market-specific information:

> *Project manager:* From this marketing study we are looking to define the following: 1) Establish a wide range of potential market applications. 2) Segment and prioritize the applications according to the total addressable market size, industry segmentation, barriers to entry/adoption and readiness of the technology for the application. 3) Establish realistic costs and market prices for the final product variants.

Third, teams prefer partnerships based on immediate market space interests to ensure early market space clarity. Such partnerships are typically driven by a "logic of consequences" (Heide and Wathne 2006; March and Olsen 1989): partners pursue a strictly utilitarian, payoff orientation. This logic is reflected in the following statement by a corporate manager:

> *Corporate manager:* I met [the inventor] at a conference today in Pittsburgh and was very impressed by the [technology] which he discussed in his presentation. We have a substantial business in the vaccine market and there is certainly some kind of fit here with the products which we already make and sell. We certainly have a lot of experience in making vaccine delivery systems which are cheap and effective, and which can be made reliably in quantities of hundreds of millions.

Market ambiguity acceptance. Under market ambiguity acceptance, teams prefer to discover the market space over time during the market scoping process. They are willing to delay the identification of specific market spaces and make an effort to avoid market space preconceptions. Specifically, this mindset is based on the following manifestations of market scoping preferences. First, teams prefer a slow and gradual resolution of market ambiguity. They leave market ambiguity unresolved and accept that the market space may have elements of indeterminacy. The following negative response by a project manager to a consultant's desire for early market space clarity illustrates this preference for a more gradual resolution of market ambiguity:

> *Consultant to project manager:* I would really like to get out there and explore the water filtration markets. I appreciate that you had not anticipated starting any market investigation, however, I am anxious that we should not miss the opportunity.

> *Project manager to inventor:* His enthusiasm is a good indicator – but I am a bit shy of proceeding as he describes […]. I'd prefer to hold off for a couple of months. I will write a suitable reply to slow him down a bit and keep all options open.

Second, teams prefer technology-specific (rather than market-specific) inputs to further explore the nature of the focal technology. For instance, in the following quote, a manager emphasizes the need for further technological inputs:

> *Project manager:* Do we know what are the processing properties of [the technology], e.g., processing temperatures, thermal and chemical stability, possible substrates, scaling-up problems, etc.? You need to know this before you can even start thinking about possible markets. […] you need to understand really well what your [technology] "can do" (rather than "may do").

Third, teams prefer partners who are interested in collaboration for the sake of technological learning. Such relationships are typically based on a "logic of appropriateness" (Heide and Wathne 2006; March and Olsen 1989): partners follow norms matched to the needs of a specific situation (e.g., market ambiguity in the case of early stage technologies). This logic is illustrated by the following email statement:

> *Corporate manager:* In fact I'm more interested in collaborating for interest in the journey and what we might learn together, rather than any particular end product. With respect to your [technology], an end product in itself is not particularly relevant to us since we don't make that kind of product; this would be for other companies.

Overarching proposition for theory development. A key insight that undergirds our proposed conceptualization relates to the market scoping mindset. Specifically, our data suggest that this mindset ranges between two extremes: market ambiguity avoidance (preferring early market space clarity) and acceptance (remaining open to a gradual resolution of market space clarity). The market scoping mindset appears to play a central role in shaping all subsequent activities aimed at securing external investment to enable technology commercialization. The causal explanatory role of the market scoping mindset is thus featured prominently in our proposed conceptualization, as shown in Figure 1. Accordingly, we advance the following proposition:

> P_1: The market scoping mindset for early stage technologies manifests as *market ambiguity avoidance* or *market ambiguity acceptance*. This mindset drives *market space decisions* which, in turn, impact *market scoping performance*.

The focal market scoping mindset is reminiscent of the concepts of "ambiguity intolerance", defined as individuals' perception of ambiguous situations as a threat (Budner 1962), and "need for closure", defined as individuals' desire for a firm answer to a question (Webster and Kruglanski 1994). Both concepts represent personality traits. The market scoping mindset, in contrast, refers to a set of specific managerial preferences pertaining to the phenomenon of market ambiguity. These preferences are likely shaped by prior professional experience, but personality traits may play a role too. Hence, ambiguity intolerance and need for closure may be potential antecedents of the mindset—an issue that we revisit in the discussion section.

Market Space Decisions

In the next sections, we use our discovery-oriented analysis to examine how teams' market scoping mindset shapes market space decisions. We focus on three major types of market space decisions that we found across all technology commercialization projects:

- First, to develop an early sense of orientation in an ambiguous market space, project teams perform *market space anchoring* activities. They seek to identify an initial set of market space options suggested by potential use situations or similar technologies, through search activities and by initiating industry contacts.

- Second, to assess the validity of the potential market space, project teams carry out *market space substantiation* activities. They seek to demonstrate technical feasibility, through tests and experiments, in order to develop technically robust market space options.

- Third, to formally establish the desired market space, project teams engage in *market space claiming* activities. They seek to formalize the nature and scope of the developed market space options. Specifically, they aim to formally secure the developed market space options for commercial exploitation by specifying "fields-of-use" in commercial agreements. Fields-of-use identify the areas of commercial exploitation assigned to external commercialization partners.

Below, we begin by showing how market ambiguity avoidance and acceptance influence market space anchoring, substantiation, and claiming, as well as performance outcomes. Table 4 summarizes these differences and the conceptual insights from our analysis. Tables 3a and 3b report illustrative data excerpts for the underling constructs. Our

analysis is also guided broadly by the trend depicted in Figure 2, which suggests that market ambiguity avoidance and acceptance may work very differently during technology commercialization efforts. We rely on data excerpts from cases at the two ends of the mindset continuum (cases 1, 2, 4 and 5) where the consequences of the mindset and its relationship to outcomes are more clearly revealed. We also use data from the two cases that lie in the middle (cases 3 and 6), at the threshold of project success and failure (see Figure 2).

How Market Ambiguity Avoidance Shapes Market Space Decisions and Outcomes

Downstream Market Space Anchoring

Market ambiguity avoidance is associated with the downstream anchoring of market spaces. This manifests in the following ways. Project teams seek to identify and specify distinct downstream end-use situations and scenarios. For instance, they employ application brainstorming workshops, online research, consultation of industry mentors, and other search activities to develop an initial list of potential end-use scenarios:

> *Project manager:* Regarding the list of industrial applications I rather haphazardly suggest the following: […] equipment used in the handling of gases, liquids, solid particulates or mixtures, such as in the food, chemicals and pharmaceuticals industries; […] glass, such as in windows, laboratory equipment, visors and screens; […] cooking utensils; […] water-borne machinery such as boats, surf-boards, submarines and oil platforms.

Teams seek to establish partnerships with downstream industry entities, such as end-users or manufacturers of end-user products. Such downstream partnerships offer market-specific inputs that help achieve the preferred early market space clarity. Specifically, they help clarify market needs and user benefits relative to distinct end-use scenarios:

> *Consultant:* We will use this market feedback to consolidate best ideas into the top 3 to 5 idea types. We will then identify organizations that represent good commercial examples of 'users' in these areas and begin the process of early stage enquiries. These discussions will not be under NDA (at this stage) and will be limited to 'here is our expected performance benefit, how attractive to you is that prospect?' We will not discuss technology.

Furthermore, partnerships with downstream industry entities help add further details to the potential end-use scenarios whereby teams increase the specificity of market space options:

> *Hospital physician:* I think [the device] would be particularly good for drugs provided in a sterile tray. You could have one for saline too, which is normally added to the tray separately in a way that I think is rather prone to introducing infection. As there are two different solutions on the tray (standard 10ml and loss of resistance), it would be possible to have custom made [devices].

Confirmatory Market Space Substantiation

Market ambiguity avoidance is associated with the confirmatory substantiation of market spaces. This manifests in the following ways. Project teams, together with downstream partners, seek to confirm (or disconfirm) the feasibility of the identified end-use scenarios. To this end, they develop samples and prototypes for technology tests and evaluations:

> *Project manager:* [We] awarded a Proof of Concept grant […]. Much of this money was spent on commissioning a new coating unit. This equipment […] would allow [the inventors] to produce samples in appropriate materials for particular applications, and to work with interested companies to assess the potential of [the technology].

Downstream partners articulate clear directions for technology tests and evaluations, in the form of user requirements and performance expectations. These are tailored to the identified end-use scenarios, guided by the needs of downstream partners:

> *Corporate manager:* The following are some thoughts on what prototypes would be useful to us:
> 1. Ideal size = ~10”x10”
> 2. Ideal thinness = 20um to 100um
> 3. Feel = less rubbery and more like polyethylene
> 4. Background (base film) = translucent, white, & black

The results of such technology tests and evaluations help teams confirm or disconfirm the feasibility of end-use scenarios, and thus narrow down the relevant market space:

> *Project manager:* We have learnt quite a lot about what [the technology] can and can’t be used for in the last few years since we filed the patent, so we should revise the applications listed in the marketing sheet. We found that it does not work where there is constant immersion in water. We don’t think it is robust enough for kitchen appliances. We don’t know about outdoor weathering, which would need a lot of engineering effort.

Closed-Ended Market Space Claiming

Market ambiguity avoidance is associated with the closed-ended claiming of market spaces. This manifests in the following ways. First, project teams, together with downstream partners,

try to establish clear-cut market boundaries by formalizing well-defined, end-use-specific fields-of-use in commercial agreements:

> *Project manager:* What areas are [company 1] interested in? If [company 2] focus on compression stockings, do we really want [company 1] covering medical textile applications as well?
> *Inventor:* I do not know precisely the areas of application [company 1] are interested in. They are global, so probably all medical textile applications.

Downstream partners provide direct access to specific end-user markets, and aim to incorporate the focal technology in end-user products. They may even aim to incorporate the technology in products that are already currently in the market:

> *Project manager:* [The company] have much experience in this field. I think that is why they have such specific ideas about how to move forward with the [technology]. [The company] currently have an existing product that is on the market that would utilize the [technology]. I feel that this company offers a solid opportunity for getting this technology into the marketplace for this field of use.

Teams seek to assign end-use-specific fields-of-use to several downstream industry entities to establish a clearly-defined, definite market space based on downstream markets:

> *Project manager:* I am very pleased to hear that you are interested in licensing [the technology] […]. I think the University would prefer to license the [technology] to several companies in their particular field of interest, as this is the best way of ensuring that the technology is developed to its full potential.

> *Proposition:* To summarize, market ambiguity avoidance strongly orients teams' decision-making toward downstream industry contexts where market-specific inputs and partnerships help resolve market ambiguity faster. Path dependencies then lock teams into a specific decision trajectory: They begin the market scoping process by identifying end-use-specific market space options. Teams then test the technology against user requirements and expectations, articulated by downstream industry entities, to confirm or disconfirm the feasibility of these market space options. Finally, teams seek direct access to clearly-defined end-user markets. Therefore, we offer the following proposition to guide empirical work:

> P2: When the market scoping mindset is characterized by market ambiguity avoidance, this leads to (a) *downstream* market space anchoring; (b) *confirmatory* market space substantiation; and (c) *closed-ended* market space claiming.

Impact of Market Ambiguity Avoidance on Market Scoping Performance

Market ambiguity avoidance is associated with unfavorable market scoping outcomes. When teams started by focusing on end-use scenarios and identifying potential downstream applications, market scoping efforts were not successful. Downstream industry entities, typically with an interest in a finished product that is ready for the market, apply highly stringent technology requirements, performance expectations, and IP standards—which the focal early stage technologies generally struggled to meet:

> *Corporate researcher:* The [material] will never be competitive compared to the major plastics materials used […]. It is a unique material which needs unique processing. It can neither be processed with the standard equipment at the standard speed nor can it ever be synthesized as cheap as polyethylene. […] I strongly advise that we keep our hands off. Customers from the construction industry are extremely inflexible and under extreme cost pressure.

Despite numerous attempts, teams struggled to establish specific end-user applications. Securing external technology investment was therefore time-consuming and associated with resource misallocations to unsuited market space options. In response to such failures, teams redirected their attention to alternative end-use scenarios, wasting further time and resources:

> *Project manager:* We're currently talking to potential customers about some applications we'd thought of originally, but I've been disappointed by our inability to find an application where the value of [the technology] could be sold directly to end-users. […] We're currently putting together a new proposal for some funded work by a company that manufactures compression stockings. They want some unique stretch material incorporated into their product, as [the inventor] has shown the [technology] may meet those requirements.

On those rare occasions that downstream firms decided to use the technology, the uncertainty that still surrounded the technology's value led to poor value appropriation on part of the inventors and the university, as the firms imposed unfavorable commercialization terms:

> *Project manager:* We may still get reimbursement for some of the patent expenses for the [technology] but that depends on [the company's] due diligence on the patents and if they think they are valuable enough to pay anything for.
> *Deputy director, technology transfer office:* Sorry to see that dinosaurs are still walking the earth - keep principled and explain to the academics why selling your first born is not a good way of building a family.

In the majority of events, market ambiguity avoidance was associated with the misidentification of suitable market space options and inefficient resource deployment:

> *Project manager:* Our reasons for abandoning [the technology] are: The patent does not properly cover the method we now use, so can be worked around. The added value for the applications where it will work is not great enough to generate high interest among potential users. We've learnt a lot over the last few years about applications where this technology will not work, so the number of possible applications is now fairly small. It's a shame that this conclusion has been reached after we got the […] patent granted.

Proposition: In summary, market ambiguity avoidance led to unfavorable commercial terms and teams failed to establish technology commercialization opportunities, despite investing significant time and resources into a variety of potential downstream market space options (see Table 4). Therefore, we advance the following proposition for empirical testing:

> P3: When market spaces for early stage technologies are determined by market ambiguity avoidance, this results in (a) *lower* value appropriability; (b) *fewer* commercialization opportunities; (c) *delayed* initial investment; and (d) *less* efficient market scoping resource allocation.

How Market Ambiguity Acceptance Shapes Market Space Decisions and Outcomes

Upstream Market Space Anchoring

Market ambiguity acceptance is associated with the upstream, rather than downstream, anchoring of market spaces. This manifests itself in several ways. Project teams seek to identify broad upstream technology regimes that may underlie specific downstream markets:

> *Project manager:* Semiconductors underlie very different industries, and are the most promising application area of our technology. In a sheet-like structure, the substrate has already attracted interest from leading energy companies. [The technology] could be a key component of semiconductor devices […] with potential applications in solar cells and LED displays.

Teams therefore seek partnerships with upstream industry entities, such as developers of similar or competing technological systems, characterized by high levels of technological sophistication regarding a focal technology regime. Such upstream partnerships offer technology-specific inputs that help explore the nature of the focal technology. Specifically, they possess relevant scientific and technological knowledge and provide technology benchmarks that help identify the most relevant technology features and capabilities:

> *Corporate researcher:* [The inventor] has developed a quite unique technology for membrane production. One of the nicest pieces of technology I have seen in a long time. It has wide ranging applications resulting from the very large surface area-volume ratio, controlled nano/micro pore size, the ability to make [surfaces] out of the polymer and then

> to fill the holes, wash the polymer out and get the "negative" version using a more stable material etc. etc. All of this makes the resultant [surfaces] very interesting.

Such partnerships thus help clarify the focal technology's contribution to the existing technological knowledge in an upstream context. Upstream industry entities are able to point out gaps in the technological knowledge an early stage technology can fill:

> *Corporate manager:* We are very interested in extending our IP around [carbonite substances] which are capable of storing and releasing large volumes of hydrogen, propane, etc. and show stable properties when cycled a number of times. This field would also include material structures for gas sequestration, particularly CO_2 which could be withdrawn from gas mixtures or the atmosphere.

Exploratory Market Space Substantiation

Market ambiguity acceptance is associated with exploratory, rather than confirmatory, substantiation of market spaces. Project teams, together with upstream partners, explore and improve the capabilities of the focal technology. Once they understand these better, they combine this knowledge with market information to derive market space options:

> *Project manager to investor:* Moving forward, as we get more information about the market segmentation […], and simultaneously get more information about the [technology's] technical performance […] – there's clearly going to be a significant piece of analytical work understanding whether the two overlap sufficiently to yield a realistic investable opportunity. But I guess that will be something for you and me to worry about.

Upstream partners provide complementary technological knowledge, technology benchmarks, and R&D capabilities that enable exploratory technological learning. Teams leverage these assets to explore the technology's potential capabilities:

> *Project manager:* The discussions we will have relates to the application of our technology to the expertise of [the company] in order that trials could be carried out using [the company's] equipment to produce optical fiber based [on the technology] with a view to exploring the potential for fiber-optic applications. […] In the longer term we hope that [the company] will license the technology to produce optical fiber for third party customers.

Upstream partners are typically experienced in identifying downstream applications for early stage technologies. Project teams leverage this competence to interpret the technical results from exploratory technology experiments, tests, and evaluations to derive potential end-use ideas for a focal technology:

> *Project manager:* Given the lab results then some of the potential applications we foresee include:
> 1) Identification of water contaminates and bacterial presence
> 2) Antifoams, defoamers and foam control agents
> 3) Water disinfectants and biocides

Open-Ended Market Space Claiming

Market ambiguity acceptance is associated with the open-ended, rather than closed-ended, claiming of market spaces. Project teams, together with upstream partners, define fields-of-use based on technology features and capabilities that transcend specific end-use scenarios:

> *Project manager to corporate manager:* What sort of field definition did you have in mind? Two options occurred to me: (a) a field defined by the type of material (b) a field defined by the use of the [technology]? My preference would probably be for version (a), a field defined by material […].
> *Project manager to inventor:* The idea is to use [the company] as the central point for ALL commercial activity related to your [technology]. I could imagine granting [the company] exclusive rights to make [products] out of any material. You could collaborate with [the company] to seek further applications of your technology.

Upstream partners, based on their technology assets, broad market access, and strategic intent (exploring novel application areas for their technological competences) are instrumental in creating technology platforms that may serve multiple downstream markets over time:

> *Corporate manager:* With ever increasing awareness of water quality, it is reasonable to believe that there are organizations that wish to show or prove that they are not causing water pollution. Examples: companies in sectors such as energy, agriculture, mining, etc. There will also be other markets – once the platform has been developed the applications are limited only to the availability of sensors. The potential market place is by no means limited to the […] and offers true business development opportunity across the globe.

In general, teams together with upstream partners and investors seek to formally establish an openly-defined, extendable market space for a focal early stage technology:

> *Investor:* We have to believe that the technology can be sufficiently good that it cannot only provide a better solution for existing markets, but also unlock additional markets or market value. Having a two-stage go-to-market strategy of generating revenues through semiconductors first while optimizing the technology to access the wider market value through (perhaps) simplification of the process system would be absolutely great […].

Proposition: To summarize, market ambiguity acceptance orients teams' decision-making toward upstream industry contexts where technology-specific inputs and partnerships help resolve market ambiguity gradually over time. Path dependencies then lock teams into a

specific decision trajectory: They initiate the market scoping process by identifying suitable technology regimes. Teams then leverage the technology assets of upstream partners to explore the technology's capabilities. Finally, they seek to establish an openly-defined market space that transcends specific end-use scenarios. Therefore, we advance the following proposition for empirical testing:

> P4: When the market scoping mindset is characterized by market ambiguity acceptance, this leads to (a) *upstream* market space anchoring; (b) *exploratory* market space substantiation; and (c) *open-ended* market space claiming.

Impact of Market Ambiguity Acceptance on Market Scoping Performance

Market ambiguity acceptance is associated with favorable outcomes. When teams did not initially focus on identifying end-use situations, this enabled successful market scoping outcomes. Investors appreciated the teams' focus on upstream technology regimes, rather than spreading attention across numerous downstream applications:

> *Investor:* I think investors have been stung many times by start-ups running out of money while they pursue too many things with the money available. The approach I would think might work best is to have the IP licensed in for semiconductors only (with sub-license rights) and contract the team for that work not precluding their ability to continue some research at the University on multiple applications.

Because the technology's value in terms of its advancement of knowledge in a specific technology regime has been clarified, teams were able to attract external investment for establishing technology platforms faster:

> *Investor:* The way to make the highest profits overall is to sit in the value-chain as a specialist […] intellectual property and materials supplier. As there is an industry out there producing the materials it seems counter-intuitive to replicate the established facilities and better to be a high margin specialist. […] what you end up doing is building a prototype and demonstration facility to convince licensees to sign up […].

Teams were able to ensure strong value appropriability by negotiating favorable terms in commercial agreements which allow for the exploitation of additional markets:

> *Project manager:* I have talked to [the CEO] about our discussion. He has suggested that we go for the arrangement that [the company] has 'first refusal' on any variation of [the technology] that [the inventor] believes may be worth developing. [The company] is to respond in a timely and appropriate manner. If [the company] does not wish to develop such a variant then [the University] can go ahead and talk to another company.

Upstream commercialization partners agreed to pursue multiple technology commercialization opportunities. Also, they aimed to create an innovation network of downstream market actors that would facilitate future technology adoption and diffusion:

> *Corporate R&D manager:* Whilst this development work is being conducted the [technology] would be utilized in 2-3 niche applications to raise its profile and prove its ability. […] The "case study" applications must be genuine problem cases with real opportunity in using as our flagship projects. In support of these high profile projects we would also actively develop a second tier of contacts. We believe that these would consist of a variety of contacts formed in the majority from specific industrial site applications who may still have an appetite […] despite the current economic climate.

Proposition: In summary, teams adopting market ambiguity acceptance managed to negotiate favorable commercial terms that allowed for strong value appropriability. They also attracted external investment for multiple technology commercialization opportunities based on relatively less time and resource investment (see Table 4). Therefore, we advance the following proposition for empirical testing:

> P5: When market spaces for early stage technologies are determined by market ambiguity acceptance, this results in: (a) *higher* value appropriability; (b) *more* commercialization opportunities; (c) *faster* initial investment; and (d) *more* efficient market scoping resource allocation.

Shifts in Market Scoping Mindsets

We found significant variation in how teams process and respond to unfavorable feedback regarding market scoping outcomes. Therefore, we explored whether (and why) any shift occurs in teams' market scoping mindsets in response to negative market information. Our data suggest that team dynamics—i.e., interaction patterns among team members including external third parties (e.g., Davis 2016)—play an important role. We illustrate our insights based on an exploratory examination of four teams that encountered unfavorable market information: cases 1 and 5 (no mindset shifts) and cases 3 and 6 (mindset shifts).

Cases 1 and 5: Mindset entrenchment. Teams managing these cases started with market ambiguity avoidance. Early in the project, they established *formalized boundary-spanning ties* that connected the teams with external experts. Specifically, teams forged close, long-term

relationships with industry consultants who had market-specific expertise. These consultants became an important part of the teams' market scoping process:

> *Project manager to inventor:* Yesterday [we] met [the consultants] – [they] wanted to talk to us about possible commercial mechanisms for taking the technology to market. They are particularly interested in some specific sectors (as you are probably aware). Their idea is that they can work jointly with us in the development of a specific application of their interest. They also think they have some blue-chip clients which are very likely to be interested in [the technology] and will be prepared to put some money in it.

The teams, along with the consultants, were eager to find attractive downstream market space options, yet their efforts typically resulted in disappointing outcomes. Despite unfavorable market feedback, the teams did not shift their market scoping mindset. Email communications suggest that they made external, market-related attributions for the unfavorable outcomes.

> *Project manager to inventor:* Spoke to [the corporate manager] yesterday. It is clear that […] there is no clear application in their minds that would merit any kind of investment on their part at this point in time. I don't hold out much hope at the moment for any real engagement from them. They are completely preoccupied with final stages of new product development for the CES next year, so are unlikely to have any interest in anything else until late 2011.

In cases 1 and 5, where external attributions were made, the consultants involved strongly influenced the direction of the projects. Given their market-specific interests, the consultants reinforced the teams' initial market scoping preferences, especially when they had to confront discouraging market information:

> *Project manager:* It is certainly interesting how small each opportunity is […] based on this market assessment. It may still be worthwhile setting up a company to license the technology […] so that companies can incorporate [the technology] into their existing production processes.
> *Consultant:* I believe our thinking may well be closely aligned! […] I think you are right – setting up the company, even as a shell, will provide a clean vehicle through which to pursue any specific licensing or development activities, and provide a foundation on which to build industry profile.

Furthermore, the consultants were instrumental in maintaining a continued attentional emphasis on downstream market space options, despite unfavorable market feedback:

> *Consultant to project manager:* A very good example of why it is important to qualify the real value of an opportunity: 200,000 [product units] per year equates to only 40 sq.m of the material. […] I would still suggest that a meeting with [the company] might be worthwhile since [the company] may also have higher volume applications.
> *Project manager to inventor:* I spoke to [the consultant], and I would like him to become involved in furthering commercial discussions [with the company].

Overall, the continued presence and inputs of the consultants involved in cases 1 and 5 fostered conformity and agreement among team members:

> *Inventor:* It's very clear that a food application of the [technology] would generate a huge amount of interest. And maybe some high profile food samples would be a key step in attracting the attention of brand owners in companies like Unilever.
> *Consultant:* I agree completely that it is the brand owners that need to get excited about this. […] I would certainly favor the approach of spending a little longer to make the samples better and have a higher level of certainty over our ability to deliver.
> *Project manager:* I entirely agree. I think success […] relies on the samples impressing [the companies].

This pattern of interactions shows that conformity within teams also shaped underlying market scoping preferences, which remained relatively homogeneous. This resulted in mindset entrenchment: a continued reinforcement of the existing market scoping mindset.

Cases 3 and 6: Mindset shift. Teams managing cases 3 and 6 also started with market ambiguity avoidance. Unlike cases 1 and 5, however, these teams established *flexible boundary-spanning ties* with several external experts: they cycled between different consultants, involved them on an ad hoc basis, depending on the specific issue at hand. The consultants provided teams with a broader spectrum of perspectives, and their inputs often conflicted with teams' assumptions and expectations for specific market space options:

> *Project manager to consultant:* As I mentioned I'm interested in an investigation of the disposal of [drug delivery devices]. […].
> *Consultant to project manager:* Please find the attached report. [The technology] could be disposed of in the clinical waste stream if rigid plastic containers were used (i.e. not plastic bags). These are obviously significantly more expensive than plastic bags.
> *Project manager to inventor:* Some disappointing news on the clinical disposal […].

In stark contrast with cases 1 and 5, the consultants—perhaps due to their less formalized roles and involvement in the projects—did not reinforce the teams' prevailing mindset. Rather, they presented teams with a broader set of new, alternative commercial perspectives:

> *Consultant to project manager:* Attached is a copy of the Interim Report […]. Our initial review of this [technology] has confirmed that we need an understanding of the supply chain since it is difficult to identify any definable group of end users. You will see that after a detailed analysis of [the technology] we have agreed […] that the testing should be focused on optical technologies. We anticipate that we will be able to find end users once we start working with organizations in the supply chain.

As teams realized their downstream efforts were largely ineffective, they began reflecting on their market scoping preferences and made internal attributions. They were open to the possibility that their initial preferences may have resulted in unfavorable outcomes:

> *Project manager:* I'm starting to think we are missing the mark with drug companies. […] I'm going to start digging more on who does the actual drug packaging. Although manufacturers do some of this, some recent conversations suggest that it may not be as much as we thought and they may not be the most receptive audience.

Overall, cases 3 and 6 were characterized by growing conflict and disagreement within teams. Team conflict was particularly pronounced in case 3, between managers and the inventor:

> *Inventor to senior manager*: I have serious concerns re the way [the lead project manager] is handling the [technology] project. […] We have opened up an exciting opportunity for [the technology] with an external company. We have ongoing dialogue with a number of other companies […]. [The project managers] are not prepared to accept the commercial views of myself. Every step in persuading [them] to make any move is an uphill battle.

Disagreements also focused on the underlying market scoping preferences. In case 3, the inventor strongly favored market ambiguity avoidance. The project manager, however, became more inclined toward market ambiguity acceptance as the project progressed. Opposing the preferences of the inventor, the project manager began preferring collaborations with potential upstream partners with access to multiple downstream markets:

> *Inventor:* [Optical companies] could bypass us completely by simply going to [the company] to buy [the technology]. We have no control over [the company] as to whom they supply and we therefore have no control over [optical applications]. I have difficulty seeing how [you] can license the technology to others if they can merely go to [the company] to purchase the stuff.
> *Project manager:* As I've said to you before, my priority is to give [the company] all the rights they need to make [the technology] a success […]. [My] feeling is that our highest priority over the next month is to nail down the level of interest from [the company], particularly as they are possible manufacturers […] for other customers.

Similarly, in case 6, a consultant connected the team with an upstream technology supplier. This shifted the team's attention away from the initially preferred downstream opportunities, spurring heated debates. One of the project managers was keen to collaborate with the upstream company, while the second project manager was more skeptical:

> *Project manager 1:* [The company] viewed [the technology] as an opportunity precisely because it could be offered widely to the pharma sector. I do not have the numbers but

> focusing on generics first and expanding to other drugs later may expand the market for [the technology] considerably.
> *Project manager 2:* Will everyone work with [the company]? You've suggested that they already work with all the major pharma so this may not be a problem but I'd prefer to hear a few examples. […] Having one partner roll out [the technology] rather than a half dozen is a lot easier from our perspective but only if the terms are right, they're capable and they're a good partner to work with […]. Otherwise we could be limiting the adoption of the technology.

Overall, the observed team dynamics in cases 3 and 6 were associated with increasing heterogeneity of market scoping preferences among team members. In both cases, senior managers overseeing the projects intervened and helped resolve team conflict:

> *Senior manager:* I did try and reinforce the message that working with [the company] to develop leads for applications is a wonderful thing. That since [the company] has rights to a more expensive material, even if [the company] ends up developing customers in a variety of fields, there are fields that may be interested in the lower tech/cost versions of the material so this is wonderful.

Eventually, in both cases, teams' mindsets shifted to market ambiguity acceptance. The mindset shift was successful for case 3, leading to a licensing deal. However, for case 6, the shift appears to have come too late. Despite the identification of new upstream opportunities, the technology transfer office decided to kill the project.

Proposition: Our data suggest that negative market feedback may not by itself result in a mindset shift. For mindset shifts to occur, team dynamics play critically important functions. We found that formalized, long-term boundary-spanning ties with a small number of external experts foster team conformity. Such conformity increases the likelihood of external attributions of unfavorable market feedback and reinforces homogenous market scoping preferences. The end result is mindset entrenchment. In contrast, flexible, informal boundary-spanning ties with a more diverse set of external experts facilitate debate and disagreements within teams. Such interactions increase the likelihood of internal attributions of unfavorable market information and growing heterogeneity of market scoping preferences. This facilitates mindset shifts. Collectively, these exploratory insights echo research regarding the influence of third-party linkages on agreement among group members (e. g., Davis 2016), as well as

research on team conflict and diversity (e.g., Jehn et al. 1999). Hence, we offer the following proposition to guide future research on mindset shifts:

> P6: A market scoping mindset shift is more likely to occur when team dynamics: (a) facilitate internal attributions regarding unfavorable market feedback; (b) facilitate greater heterogeneity in terms of team members' market scoping preferences; and (c) facilitate the enactment of diverging market scoping preferences. A shift from market ambiguity avoidance to acceptance increases the chances of market scoping success.

Discussion

A Model of Market Scoping for Early Stage Technologies

Figure 1 integrates insights that emerged during our discovery-oriented research process. Table 4 provides an overview of the conceptual properties of our key concepts. A key insight at the heart of this theory development effort is the significant explanatory role played by the market scoping mindset construct. Specifically, we find that this mindset ranges between two extremes: market ambiguity avoidance (preference for a rapid resolution of market ambiguity) or acceptance (preference for a gradual resolution of market ambiguity). The market scoping mindset plays a central role in shaping all subsequent decisions and outcomes. Its causal explanatory role is thus featured prominently in our conceptualization.

Market scoping mindset shapes three major market space decisions: anchoring, substantiation, and claiming. Market ambiguity avoidance orients decision-making toward downstream industry contexts that can help achieve rapid market space clarity. Partnerships with downstream entities offer the preferred market-specific inputs that guide further decision-making. These partnerships, in turn, create path-dependent decision trajectories focused on end-use scenarios, directed at the enactment of *a priori* market space representations. In contrast, market ambiguity acceptance orients decision-making toward upstream industry contexts. Here, partnerships with upstream entities offer the preferred technology-specific inputs that guide further decision-making, even though the immediate relevance of these inputs for potential market spaces may not be readily evident. These partnerships lead to path-dependent decision trajectories focused on technology capabilities,

facilitating the gradual discovery of market spaces. In the context of early stage technologies, it is the latter approach that eventually reveals promising paths to viable market spaces.

By directing close attention to managerial agency in technology commercialization, the proposed conceptualization advances the current state of marketing theory. We believe our work fills important conceptual gaps in the broader literature in innovation and technology commercialization, and urges practitioners to rethink their go-to-market heuristics.

Implications for Theory

The proposed conceptualization advances current theory development in the areas of innovation, technology management, and entrepreneurship. By focusing on managerial agency, we present specific details of managerial work involved in early stage technology commercialization. Prior literature has been largely silent about such details. In this regard, we would like to highlight three conceptual contributions. First, our findings enhance theory development in the context of boundary-spanning search (e.g., Rosenkopf and Nerkar 2001) and networks of learning (Cohen and Levinthal 1990; Powell et al. 1996). These literatures, while instructive, offer only limited insights when search spaces are expansive and undefined, and industry networks are yet to be established. Our findings show how managers' mindsets orient their search activities toward specific search anchors (i.e., downstream versus upstream market space anchors). These search anchors are associated with very different types of partnerships and industry networks. Hence, our findings explain *why* managers perform certain boundary-spanning search activities rather than others, and *why* they focus their attention on some networks of learning over others.

Second, we contribute to the further development of effectuation theory. Effectuation theory suggests that, in situations of uncertainty, new partnerships and contingencies are desirable because they extend the potential scope of decision-making (Read et al. 2009; Sarasvathy 2001). Our research offers a more nuanced understanding of the value of

partnerships and contingencies in the context of early stage technologies. Specifically, we find that partners seeking exploratory learning experiences are more likely to benefit the commercialization of early stage technologies; partners with market-specific interests may have limited value (and can even hinder commercialization efforts). We also find that certain events during the commercialization process—such as the identification of unexpected downstream use situations—can lead managers astray. Thus, our findings draw attention to a broader set of contingencies that operate in such contexts: when unexpected events may be beneficial, and when they may have a detrimental impact.

Third, we add an important caveat to the prevailing view that the successful formation of market opportunities depends primarily on innovators' market knowledge endowments (Gruber et al. 2013; Shane 2000). Direct market knowledge does indeed have advantages; however, it may also result in market space biases. As we show, the identification of viable market spaces can also occur indirectly via upstream interactions. Collaborations with upstream technology developers, although initially deflecting attention away from potential end-users, offer technology-specific inputs which may reveal indirect paths to end-users. This expanded view of knowledge endowments can serve as a useful guide for theory development regarding the formation of market opportunities for early stage technologies.

Finally, from a broader theoretical perspective, the proposed conceptualization adds a new perspective on how managers respond to situations of ambiguity in the wider context of innovation management and entrepreneurship. The prevailing view in prior research is rather narrow in that it assumes ambiguity to be undesirable, with managers generally seeking to reduce it (e.g., Lynn et al. 1996; Sommer et al. 2009). The notion of market ambiguity acceptance challenges and extends this perspective. It also connects this line of research with seminal work in social psychology related to individuals' ambiguity intolerance (Budner 1962) and need for closure (Webster and Kruglanski 1994). To develop a more

comprehensive understanding of how managers deal with ambiguity, researchers should consider these personality traits as important antecedents that shape distinct managerial preferences and, therefore, indirectly influence managerial decision-making and outcomes.

Implications for Practice

Look upstream, not just downstream. Managers are often drawn toward commercially attractive end-users and thus spend considerable time and effort looking downstream in technology commercialization contexts. Training programs designed to help practitioners frequently urge them to match technologies with downstream markets early on in the process. For example, the Association of University Technology Managers espouses a technology transfer roadmap that puts market needs at the forefront of decision-making (AUTM 2010). Potential upstream actors are, therefore, often overlooked as a result. Yet, as our work shows, developers of similar or competing technologies can offer a more realistic assessment of a technology's prospects, and may identify important deficits in a focal technology's capabilities. This could, in turn, help to steer further technology development in a more meaningful direction. The technology benchmarks these developers offer may provide a more fruitful avenue for making market space decisions.

Focus on the technology's evolution, not just its immediate user benefits. Well-articulated technology requirements and performance expectations, derived from market needs, offer clear directions for technology development. However, they can also create an illusory sense of certainty. We suggest that managers focus more attention on understanding the evolution of a focal technology's capabilities, and less on the current benefits these capabilities may offer to potential end-users. This would also require greater managerial attention to the external resource environment: managers need to leverage external assets to benefit the focal technology. They should try to understand what the environment has to offer, and identify avenues for potential collaboration with upstream industry entities.

Be agnostic, not dogmatic, about market spaces. This research suggests that a proactive focus on identifying market spaces early, while seemingly well-intentioned, can often lead to an inflexible stance about potential market opportunities. As a result, significant market scoping efforts continue to be directed at unsuitable market space options. This is often exacerbated by counterproductive relationships with industry consultants who reinforce such market scoping preferences, resulting in mindset entrenchment. Therefore, we suggest that organizations implement protocols, such as rotating partnerships with industry consultants, to facilitate diversity of commercial perspectives within teams.

Future Research Directions

Table 5 provides a detailed agenda for future research. Overall, our conceptualization can serve as a useful foundation for a productive research program on market scoping and early stage technologies.

Research opportunities to address the limitations of this research. This paper has some limitations that present opportunities for future research. First, as our research represents a first in-depth effort to understand market scoping, we adopted a discovery-oriented, theory-building approach. While theory testing was beyond the scope of this paper, Table 5 provides detailed guidance, in the form of suggested construct operationalization, for future research directed at theory testing. Such efforts could focus on the analysis of both qualitative and quantitative sources of data (e.g., company records, performance outcomes, and surveys). Although email data provide an unprecedented window into the focal phenomenon, researchers should also consider using other types of qualitative data that capture preferences and decisions in informal, face-to-face interactions.

Second, we examined the commercialization of early stage technologies at a large university's technology transfer office. This empirical setting, although substantively important, differs from more commercial settings in which market scoping may also occur.

Future research should therefore examine market scoping in such corporate settings. Researchers may wish to explore other aspects of the market scoping mindset (e.g., managers' preferences relating to the breadth of the search landscape) or discover additional market scoping preferences pertinent to corporate settings.

Third, the linkages between market scoping performance outcomes and eventual commercialization success were beyond the scope of this paper (see Figure 1). Future research should therefore examine the market scoping mindset's ultimate impact on traditional measures of marketing performance. Such research efforts will necessitate access to longitudinal data that provides team-level details regarding market scoping activities for specific technology projects and subsequent market-level performance data.

An expanded research program on market scoping for early stage technologies. The literature on managerial agency can continue to serve as a useful guide for further theory development. Specifically, pre-reflective aspects of managerial agency (Cardinale 2018) and the notion of "scripts" (Gioia and Poole 1984) merit future research attention. Pre-reflective aspects of managerial agency refer to internalized, deep-rooted managerial dispositions resulting from embeddedness in social structures (Cardinale 2018). Studying *pre-reflective aspects of market scoping* would help shed light on antecedent factors of the market scoping mindset, e.g., managers' prior professional experience and educational background. An exploration of these factors can also be conducted in conjunction with managers' personality traits such as ambiguity tolerance (Budner 1962) and need for closure (Webster and Kruglanski 1994). A related stream of research can focus on scripts—implicit schematic knowledge structures that specify behavior sequences for specific situations (Gioia and Poole 1984). Managers may enact *market scoping scripts* at different stages during early stage technology commercialization. Understanding how market scoping scripts are formed and enacted may further illuminate the formation of market space decision trajectories.

Future research endeavors can focus on a broad array of internal and external factors that may influence market scoping activities. We highlight several opportunities here and provide additional guidance in Table 5. First, to deepen our understanding of team dynamics and mindset shifts, future research should investigate the role of external stakeholders (e.g., consultants, investors, co-developers) in the market scoping process. Specifically, the institutional logics they bring to bear—related to, for example, secrecy, control, and time horizons—may influence the market scoping preferences of team members (Pahnke et al. 2015). Second, future research should consider potential "halo effects" (Sine et al. 2003) that may operate given the difficulty of assessing an early stage technology's prospects. For example, the prestige of individuals and organizations involved in the market scoping process may affect value perceptions and expectations of external parties, such as investors. Third, future research should study organizational factors that may moderate the proposed relationship between the market scoping mindset and market scoping success. For example, an organization's resource endowments may play an important role. In resource-rich organizational settings, the potential downsides of market ambiguity avoidance may be less severe because managers can invest more resources in technology development to alleviate the risks of technology adoption perceived by downstream industry entities.

By implementing the research agenda outlined above, we can advance our understanding of the unique marketing challenges that early stage technologies pose. The resulting research program would enable inventors, entrepreneurs, and managers to navigate ambiguous market spaces more effectively. Indeed, it would offer crucial guidance to them on how to commercialize early stage technologies successfully, despite being lost in a potentially vast universe of markets.

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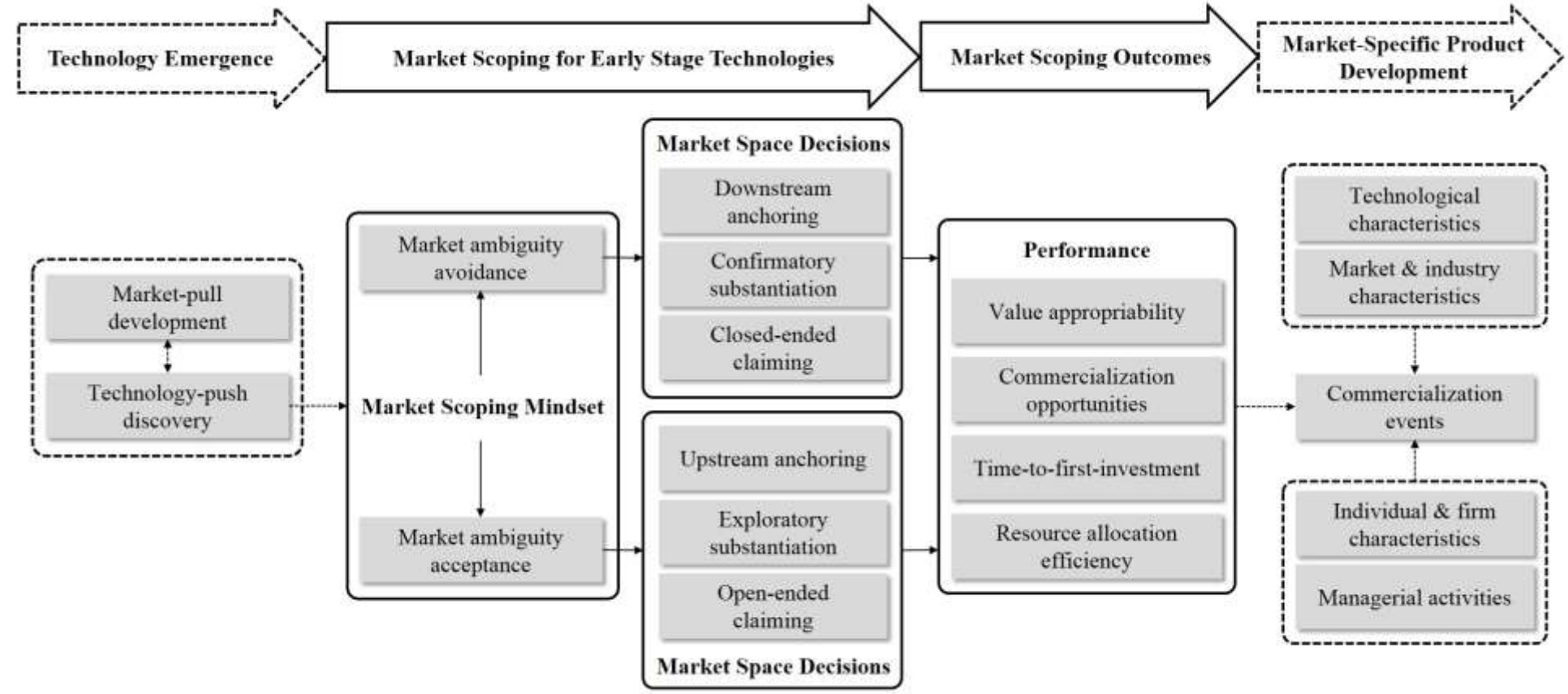
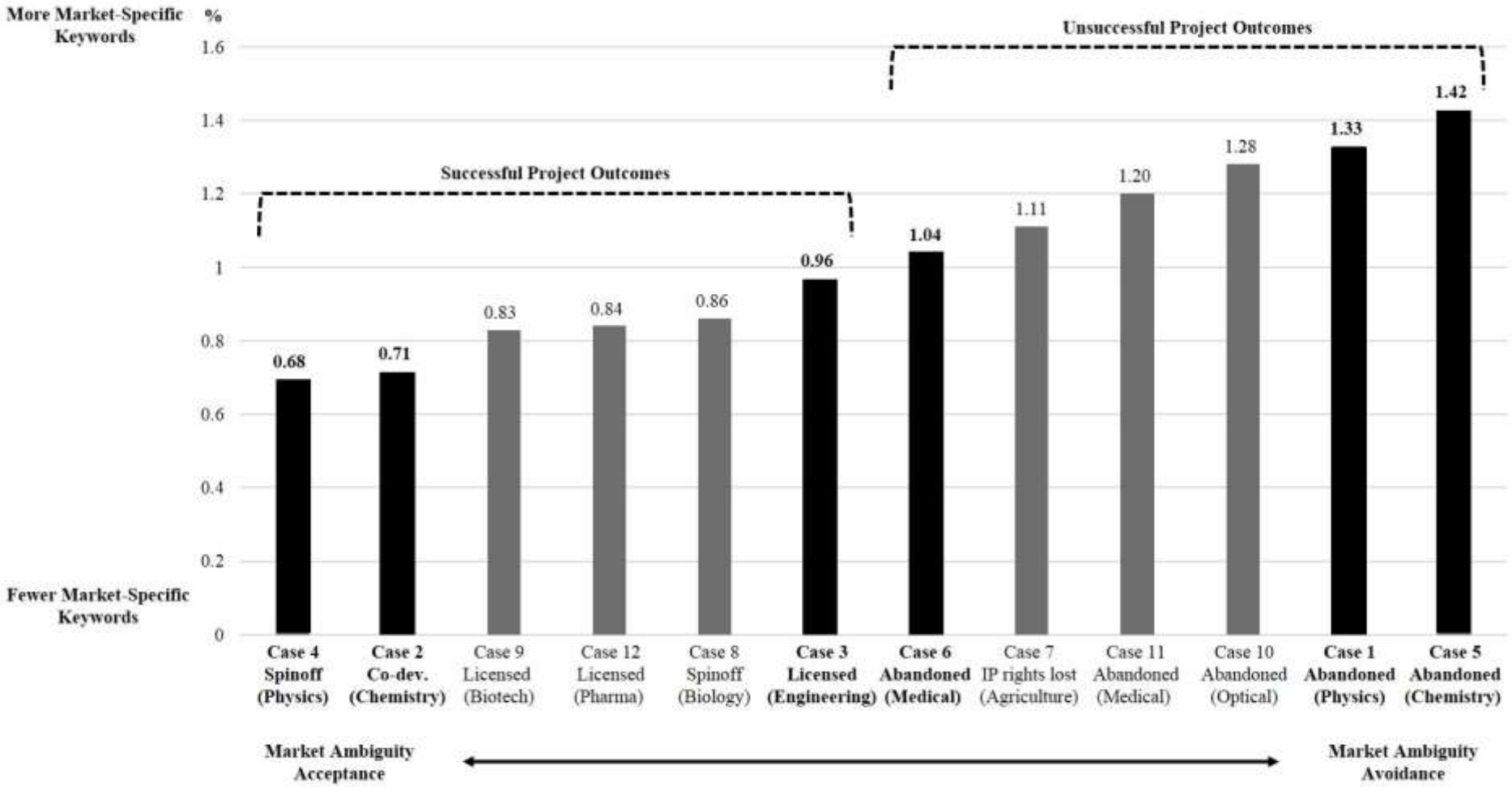
Figure 1: A Conceptual Model of Market Scoping for Early Stage Technologies



Note: The dashed boxes and arrows present constructs and relationships that are not explicitly theorized in this article. They are outside the scope of the proposed conceptualization. We depict them for nomological comprehensiveness and to illustrate links with extant theoretical work in this area.

Figure 2: Relative Frequency of Target-Market Keywords in Email Communications and Project Outcomes



Notes: (1) For each case, we identified the most frequently used keywords in email interactions which reflect case-specific target markets (e.g., "packaging", "biofuels", and "confection" which matched with the target markets we identified in our qualitative analysis). We then calculated weighted percentages of the frequencies of these keywords (including words with the same stem). We focused our analysis on the five most frequently used keywords per case; the sixth keyword's weighted frequency was negligible (weighted percentage of 0.05% or lower). These keyword frequencies indicate the attentional emphasis on target markets during market scoping. (2) For additional details, see Web Appendix A and D.

Table 1: Overview of the Literature on Converting Technologies into Innovations: Research & Marketing Competence Gap

	Technology Emergence	Market Scoping	Market-Specific Product Development	Innovation Diffusion
Technological Characteristics	▪ Technology-push discovery or market-pull development	▪ Technology fungibility ▪ Technology maturity ▪ Technology codification	▪ Technology originality ▪ Technology generality ▪ Technology complexity ▪ Technology value	▪ Technology radicalness ▪ Technology disruptiveness ▪ Innovativeness ▪ New product design
Market and Industry Characteristics	▪ R&D intensity ▪ Networks of learning	▪ Technology markets	▪ Patent effectiveness ▪ Patent scope ▪ Market heterogenity ▪ Opportunity riskiness ▪ Technology frames and dominant designs	▪ Market uncertainty ▪ Market dynamism ▪ Technical dynamism ▪ Market novelty
Individual and Firm Characteristics	▪ Entrepreneurial culture ▪ Absorptive capacity	▪ Prior knowledge ▪ Alertness	▪ Firm size ▪ Complementary assets	▪ User adoption criteria
Managerial Activities	▪ Exploratory search ▪ Fuzzy front-end management	**Research gap & marketing competence gap**	▪ Market experimentation ▪ Market learning ▪ Market visioning ▪ New product development process organisation	▪ Market driving behaviors ▪ Market priming ▪ Market pioneering ▪ User co-creation ▪ Market creation ▪ Boundary construction
Exemplary Studies	Etzkowitz (1998); March (1991); Rosenkopf and Nerkar (2001); Cohen and Levinthal (1990); Powell et al. (1996)	Danneels (2007); Shane (2000); Gruber et al. (2008); Kirzner (1997)	Lynn et al. (1996); Nerkar and Shane (2007); Dencker and Gruber (2015); De Luca and Atuahene-Gima (2007); Shane (2001)	Rogers (1976); O'Connor (1998); Humphreys (2010); Jaworski et al. (2000); Santos and Eisenhardt (2009)

Table 2: Case Data

Case #	Nature of Technology[1]	Project outcome	Email Trails	Archival Documents	In-depth Interviews	Informal interviews	Group meetings	Observation Time Frame
Case 1	Synthetic Material	Abandoned	3,834	488	2			06/2009 – 09/2013 (52 months)
Case 2	Sensor Technology	Co-development partnership	972	92	1			12/2009 – 09/2013 (46 months)
Case 3	Optical Filter Technology	Licensed	2,756	406	1			11/2003 – 11/2009 (73 months)
Case 4	Surface Preparation Technique	Spinoff company	2,633	314	1	45	4	05/2010 – 09/2013 (41 months)
Case 5	Chemical Substance	Abandoned	1,560	210	1			04/2005 – 09/2010 (78 months)
Case 6	Medical Device	Abandoned	847	356	2			07/2009 – 01/2013 (43 months)
		Σ	**12,602**	**1,866**	**8**	**45**	**4**	**333 months**

[1]The nature of the focal technologies has been disguised to prevent technology identification.
Note: This is an overview of the data for the focal case sample which we used to reach theoretical saturation. We identified the focal case sample from the extended case sample of 12 technology projects. For additional details, see Web Appendix A and D.

Table 3a: Coding Structure: Market Ambiguity Avoidance and Subsequent Decisions

1st Order Coding Categories and Representative Quotes	2nd Order Coding Categories
Preference for a rapid resolution of market ambiguity: ▪ "We discussed the benefits of identifying a well targeted, focused application that is of the right scale and value to be accessible to this technology fairly rapidly. I think that is the right approach for you." ▪ "I wonder if we could put together a tire inflation project where we try and develop a pressure sensor application for the [technology] … we had talked about this previously. It might be a good step to have a quick win." *Prioritizing market-specific inputs:* ▪ "[…] I think we should go full steam ahead on the study idea. It would be great to have some [industry] data on accuracy of drug dosage, reliablilty (failure rates), time to administer the drug etc." ▪ "There are a couple of areas we need to think about - The objective / scope and plan of the project […] – access market insights to determine most relevant applications (size / value, attractiveness of [the technology])." *Preference for partnerships based on immediate market interests:* ▪ "[The company] works with the major car manufacturers and as a starting point, I would like to gauge the interest that one of these potential customers might have in [the technology] as a precursor to developing a deeper dialogue." ▪ "[The company] appears in every way to be an ideal company to develop [the technology]. […] they have become interested in the vaccination market […] and they already have an internal development project […] and made the comment that our [technology] was simpler and better!"	Market ambiguity avoidance
Identifying downstream end-use situations: ▪ "[The consultant] identified a few opportunities which are worth further investigation. Perhaps the most promising one is the use of [the technology] to reduce lime-scale buildup in heating systems." ▪ "I mentioned the idea of using the [technology] to indicate correct inflation pressure of car tires. […] I also shared the idea of using the [technology] to indicate uneven wear of the tire surface." *Understanding relevant user benefits:* ▪ "I wonder if there is another way we should continue exploring how [the technology] might benefit [the company's] business. Beyond the use of [the technology] for anti-corrosion we can see real value in using [the technology] for material reinforcement in the construction sector." ▪ "The first half is aimed at […] gaining clarity of the benefits and status of the technology. [...] We will be focusing very much on its functional benefits rather than the underlying technology." *Increasing the specificity of identified use situations:* ▪ "In parallel we would like to put together a straw model of the potential market - how many groups, with what characteristics, in what hospitals." ▪ "I conducted some top level market research around a proposition in jewelry […] primarily for two reasons: possibility for early revenue generation and ability to charge a high-price."	Downstream market space anchoring
Understanding user requirements and expectations: ▪ "They have asked if it would be possible to treat a 40 cm length of ceramic membrane with an internal diameter of 1.5 mm and a pore size of 0.2 micron." ▪ "Please find below inputs from [the company]: 1) Overcost: 0.5 Euros max is the target. 2) Washing: 40°C (washing machine), no chlorine or softener. No tumble dryer. Final product will be certified for 30 washings." *Assessing the feasibility of use situations:* ▪ "The trial run demonstrated two minor issues. 1) The label looks like it can bend up but it probably isn't worth the risk of breaking it. 2) The pump doesn't fit air tight with the leur as an artifact of the vaccum moulding." ▪ "The good news is the [materials] retain their properties after a 30 deg C standard wash cycle (see second attached pic). The not so good news is they fell off the leggings, I think a little swelling occurs […]." *Narrowing down the relevant market space:* ▪ "You mentioned the test you performed on [the technology] produced interesting results. […] We had a long list of applications and have now narrowed it down, so we ended up with this short list: […]." ▪ "My view is that [external discussions] should focus on medical textiles and construction applications. These opportunities represent more direct opportunities than automotive and e-textile applications […]."	Confirmatory market space substantiation
Formalizing end-use-specific fields-of-use: ▪ "The only way that I can see moving forward is for us to be given an exclusive option 'in the field', for an anticipated exclusive license 'in the field' […], so that it is clear that we have been given unpolluted rights in the haematology diagnosis area, for the particular commercial areas stated." ▪ "If this approach is acceptable to [the potential licensee], would a Field restricted to "thrombosis prophylaxis" be sufficient for your needs?" *Establishing direct access to end-user markets:* ▪ "My hypothesis was that a technology such as yours could form the basis of a high margin, but initially low volume business selling high priced, visually stunning goods directly to the consumers." ▪ "I believe [the company] would be a useful partner both for manufacturing, and to get access to their customers in the automotive sector." *Establishing clearly-defined, definite market spaces:* ▪ "[I]t is not in our interests to have them having effective control in a too large field […]. [The company] has a position in fiber-optics and this is the field that we should restrict them to." ▪ "We now have several companies that are interested in [the technology], and, if appropriate, we would prefer to license this technology exclusively to each company in their particular field of interest."	Closed-ended market space claiming

Table 3b: Coding Structure: Market Ambiguity Acceptance and Subsequent Decisions

1st Order Coding Categories & Representative Quotes	2nd Order Coding Categories
Preference for a gradual resolution of market ambiguity: ▪ "We believe the development time necessary to bring [the technology] to market may be somewhat extended. […] However, we remain interested in exploring […] appropriate areas for commercial exploitation." ▪ "We discussed possible future developments. At the moment I am viewing this [technology] quite positively. […] However, it has to be said that although there are some exciting possibilities for the future, at the moment there is no guaranteed market […]." *Prioritizing technology-specific inputs:* ▪ "I have a number of issues that I would like to explore with you: What do you consider to be the main limitations of the technology […]? Are there any specific manufacturing issues associated with the various functional attributes of the [technology]? What do you see as the main competing technologies?" ▪ "Please keep the presentation short and focused on [the technology]. The idea was that they get a better feeling for the nature and capabilities of the technology and at the same time share more specific technical requirements […]." *Preference for partnerships based on technological learning:* ▪ "We have identified the possibility for an excellent joint project, which is actually more on the theory side: modelling how light is extracted from an emitting device using nanoimprint lithography. […] I feel that such a [project] would be 50% producing real results for [the company], and 50% pushing in new directions." ▪ "In view of the many possible applications […], we are very interested in taking discussions on this forward. [The inventor] mentioned that he could devise a research programme […] that could form the basis for commercial exploitation of the technology. We would be very interested in supporting such a programme."	Market ambiguity acceptance
Identifying upstream technology regimes: ▪ "[Similar technologies] have a recognized application in a broad range of technology fields. Specific examples where [the technology] can meet a technology need are in […] inorganic electrodes and metallized electrodes." ▪ "You will also meet with [a university professor] on Thursday […]. What it would be interesting to know from him would be how your invention will apply in semiconductors." *Identifying relevant technology benchmarks:* ▪ "As discussed a key first step is to characterize [the technology' properties] and benchmark them against other existing and established technologies." ▪ "I am happy to let you know that our team is really enthusiastic about your invention […]. They would like to have a feeling of how your invention compares with the current technological standards." *Clarifying technological contribution to existing technological knowledge:* ▪ "We showed [the corporate researcher] our images and he was astonished since he did not know of polymer based multilayers as we produce. This ties into your initial assessment of the unique layered quality." ▪ "There has been little technology centered on changing the plant to be easier to for the enzymes to break down and this is exactly where [the inventor's] technology fits."	Upstream market space anchoring
Leveraging external technology assets: ▪ "[The company] clearly has manufacturing skills and equipment relevant to us… extruding, wet chemistry, film thinning, laminating, rolling and surface treatment […]." ▪ "This [project] aims to bring together both key IP within the field, and the know-how of the partners, providing a strong base for exploitation of the technology." *Exploring technology capabilities:* ▪ "We are quite busy in the lab looking to demonstrate some properties of the [technology]; typically these go along the lines of replacement of the structures we create with others such as ceramics […]." ▪ "[The engineer] described how he had selected several substrate materials for their first trials and we talked in detail about their [tool] design. Yesterday's discussions were totally focused on technical aspects." *Opening up the relevant market space:* ▪ "Filling the scaffold [with a structural metal] creates a high surface area electrode. That high surface area could be used in dye-sensitized solar cells or in organic photovoltaics or even conventional solar cells." ▪ "If pilot tests prove to be efficient then [the technology] can be suitable for use in water pre-treatment applications."	Exploratory market space substantiation
Formalizing technology-specific fields-of-use: ▪ "I wonder if there is scope to claim a very wide patent in the region of "polyelectrolyte multilayers"? Or at least on "layer-by-layer deposition"?" ▪ "In particular could you think carefully about the Field. […] Presumably the field of interest to [the potential co-developer] is "electrochemical sensors". *Establishing technology platforms:* ▪ "We also would like to make every effort to move this forward because [the company] have indicated that success in the LED lighting field could lead to further development and licenses for other lighting fields. We feel that this is a platform license that could lead to other commercial opportunities." ▪ "Attached an outline summary for the business plan*:* It is estimated that the annual market for water filtration could be worth $4 billion by 2020 with numerous potential applications in various industries […]." *Establishing openly-defined, extendable market spaces:* ▪ "I think that we should say we are looking to licence ideally with a broad field to a single partner. […] I think an option structure may be worth exploring to expand the scope to all therapeutic areas […]. This avoids us being tied in from day 1 and should provide [the licensee] with enough security […]." ▪ "[The company] has 'first refusal' on any variation of the [technology] that [the inventor] believes may be worth developing. […] If [the company] do not wish to develop such a variant then [the inventor] can talk to another company."	Open-ended market space claiming

Table 4: Conceptual Properties of a Theory of Market Scoping for Early Stage Technologies

	Market Ambiguity Avoidance	Market Ambiguity Acceptance
Market Scoping Mindset	▪ Preference for a rapid resolution of market ambiguity ▪ Preference for market-specific external inputs ▪ Preference for partnerships based on immediate market interests	▪ Preference for a gradual resolution of market ambiguity ▪ Preference for technology-specific external inputs ▪ Preference for partnerships based on technological learning
Market Space Anchoring	**Downstream anchoring:** ▪ Identifying downstream end-use situations and scenarios ▪ Understanding relevant end-user needs and benefits ▪ Increasing the specificity of identified use situations	**Upstream anchoring:** ▪ Identifying upstream technology regimes underlying various downstream markets ▪ Identifying relevant technology benchmarks ▪ Clarifying contributions to existing technological knowledge
Market Space Substantiation	**Confirmatory substantiation:** ▪ Understanding user requirements and performance expectations ▪ Assessing the feasibility of identified end-use situations ▪ Narrowing down the relevant market space	**Exploratory substantiation:** ▪ Leveraging external technology assets and capabilities ▪ Exploring the focal technology's capabilities ▪ Opening up the relevant market space
Market Space Claiming	**Closed-ended claiming:** ▪ Formalizing narrow, end-use-specific fields-of-use ▪ Establishing direct access to end-user markets ▪ Establishing clearly-defined, definite market spaces	**Open-ended claiming:** ▪ Formalizing broad technology-specific fields-of-use that transcend end-use scenarios ▪ Establishing technology platforms that may serve multiple markets ▪ Establishing openly-defined, extendable market spaces
Market Scoping Performance Outcomes	▪ Lower value appropriability ▪ Fewer technology commercialization opportunities ▪ Delayed initial investment ▪ Less efficient resource allocation	▪ Higher value appropriability ▪ More technology commercialization opportunities ▪ Faster initial investment ▪ More efficient resource allocation

Table 5: Definitions of Key Concepts, Suggestions for Their Measurement, and Future Research Opportunities

Concept	Definition	Potential Operationalization	Potential Research Questions
Early Stage Technology	Nascent scientific and/or technical knowledge that is post-lab and partially codified	*Objective measurement:* ▪ Technology originated in a research lab ▪ Technology is not fully codified in a patent or paper ▪ Proof-of-concept is not established	What is the role of technological, organizational, and industry factors in driving the development early stage technologies?
Market Ambiguity	Lack of clarity about the number, nature, and commercial viability of technology-to-market linkages	*Subjective measurement:* ▪ Perceived plurality of technology-to-market linkages ▪ Perceived uncertainty regarding the nature and viability of technology-to-market linkages	What factors explain managers' perceived market ambiguity?
Market Space	Set of technology-to-market linkages that present new product development opportunities	*Objective measurement:* ▪ Field-of-use definitions in commercial agreements ▪ Field-of-use definitions in patent claims ▪ National/regional/divisional patent applications	What are effective configurations of market space options? What are the relationships between identified technology-to-market linkages?
Market Scoping	Set of managerial activities directed at the identification of the market space for a focal early stage technology	*Objective/subjective measurement:* Monetary/time investments into the search, assessment, and selection of technology-to-market linkages	What is the prevalence of market scoping in other organizational settings, such as corporate R&D and high-tech entrepreneurship?
Market Scoping Mindset	Preferences pertaining to the identification of potential market spaces (specifically, preferences regarding the resolution of market ambiguity)	*See below: market ambiguity avoidance and acceptance which represent endpoints of the market scoping mindset continuum*	What factors lead to market scoping mindset entrenchment in teams? How do market scoping preferences vary across organizational settings?
Market Ambiguity Avoidance	Preference for *a priori* market space representations that guide all market scoping activities	*Subjective measurement:* ▪ Preference for a rapid resolution of market ambiguity ▪ Preference for market-specific inputs ▪ Preference for partners with immediate market interests	What factors explain why managers adopt a certain market scoping mindset? What factors drive shifts in a prevailing market scoping mindset?
Market Ambiguity Acceptance	Preference for a gradual discovery of the market space over time	*Subjective measurement:* ▪ Preference for a gradual resolution of market ambiguity ▪ Preference for technology-specific inputs ▪ Preference for partners with an interest in technological learning	

Anchoring of Market Spaces	Managerial efforts to identify an initial set of market space options for further consideration	*Subjective measurement:* ▪ Focus on downstream end-use situations versus upstream technology regimes ▪ Focus on technology end-users versus technology developers	What factors influence the value of upstream opportunities? How do prior knowledge and social/organizational networks influence the identification of initial market space options?
Substantiation of Market Spaces	Managerial efforts to demonstrate the technical feasibility of a set of market space options	*Subjective measurement:* ▪ Focus on user requirements and expectations versus focus on accessible external technology assets ▪ Focus on confirmatory technology testing versus exploratory technological learning	How can firms enhance exploratory technological learning in order to derive meaningful market space options?
Claiming of Market Spaces	Managerial efforts to formalize the nature and scope of a set of market space options	*Subjective measurement:* ▪ Focus on end-use-specific versus technology-specific market space definitions ▪ Focus on closely-defined market spaces versus openly-defined market spaces	How can firms establish openly-defined market space options such that firms' rights are protected and access to multiple end-user markets is maximized?
Value Appropriability	Extent to which future profits from technology commercialization can be captured by technology owners	*Objective measurement:* ▪ Route-to-market (high: spinoff; medium: co-development; low: licensing) ▪ Agreed profit distributions (including royalties) ▪ Degree of exclusivity of commercial agreements	
Technology Commercialization Opportunities	Number of occasions when it becomes possible to commercially pursue a specific technology-to-market linkage through product development	*Objective measurement:* ▪ Number of licensing (or equivalent commercialization) agreements established ▪ Number of technology-to-market linkages receiving external investment for technology development	How are (pre-commercialization) market scoping performance measures related to final market performance measures? What steps can firms take to increase the diagnostic value of market scoping performance measures?
Time-to-First Investment	Time required to achieve first external investment for technology development after initiating market scoping	*Objective measurement:* Elapsed time from invention disclosure by inventor to first positive investment decision	
Market Scoping Resource Efficiency	Extent to which resources are used productively during the market scoping process	*Objective measurement:* ▪ Ratio between number of active/renewed agreements and number of expired/discontinued agreements ▪ Ratio between pursued and abandoned fields-of-use	