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Where Does Innovation Start: With Customers, Users, or Inventors?

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Report Summary

Innovations are vital for business health, survival, and success. All innovations start with an idea. Understanding the origin of ideas for innovations is critical to firms that are striving to come up with the next big idea before competitors do. This study seeks to understand the origins of innovative ideas. In particular, to what extent do ideas originate with the customer, inventor, or user? What role does technology play in the origin of ideas?

Stav Rosenzweig, Gerard Tellis, and David Mazursky offer a framework with three agents – customer, inventor, and user – and three technologies – novel, imitative, and exaptive – that affect the origin of ideas for innovations. Using the historical method, they collect data on and analyze 180 innovations, commercialized between 1900 and 1999, and recreate their early history, especially during the stage of ideation. The historical approach enables a longitudinal perspective that is missing in innovation studies.

The study yields three main findings, the first two of which run contrary to prevalent thinking in the marketing literature. First, inventors play a significantly bigger role than customers in the origin of ideas for innovations. Second, benefits of the innovation to customers increase as the role of customers in the origin of the idea decreases. Third, superior benefits also increase as the role of exaptive technology increases.

These findings provide important managerial implications. First, managers can learn which agent and which technology in the origin of the idea contribute to superior benefits of the innovation and allocate their resources accordingly. Second, managers can identify novel technology solutions for their firm's internal problems, and convert those to serve external customers. Third, exaptive technology seems to possess an unfulfilled potential for firms' managers seeking ideas for innovation: in their quest for ideas for new ideas, managers should actively rethink how their technology can serve customers in domains different than the ones they currently serve. Managers should also canvass other product domains and identify plausible technology shifts to their own product domain.

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Introduction

Innovations are vital for business health, survival, and success. All innovations start with an idea. In this study we examine the origin of ideas for innovations. By origin of the idea, we refer to the main event that immediately preceded and triggered the idea for the innovation. Firms have a compelling need to understand the origin of ideas for two reasons. First, ideation is a critical first step in innovation. If managers have erroneous beliefs regarding the origin of the idea, they might make wrong decisions about this first step and jeopardize the entire innovation effort (Hauser, Tellis, and Griffin 2006). Second, firms spend a great deal on research and development. Much of this money is spent on developing a few ideas from screenings of a large pool of ideas. Generating a large number of high quality ideas is important for the success of the process because the starting ideas determine the sample from which winners arise (Franke, Poetz, and Schreier 2014; Girotra, Terwiesch, and Ulrich 2010; Hargadon and Sutton 2000; Kornish and Ulrich 2011; Singh and Fleming 2010). For these two reasons, understanding the origin of ideas that led to innovations in the past can help managers initiate innovations in the present.

Despite the importance of the origin of the idea, a review of research shows that studies on ideation represent only 5% of product development studies and that their number is decreasing (Page and Schirr 2008). This limited scholarly attention stands in contrast to the expressed need to better understand and manage the early stages in the innovation process (Barczak, Griffin, and Kahn 2009; Henard and Szymanski 2001; Soukhoroukova, Spann, and Skiera 2012).

We posit that the past behavior of firms and innovators and the past evolution of technologies provide a mine of information about the origin of innovation. Accordingly, this study will sample 180 notable innovations from the past and recreate their early history, especially during the stage of ideation. To do so, the study will follow the principles of the historical method (Golder 2000). This historical method has proved productive and has revealed some profound insights about market pioneering, firm incumbency and entry, and technological evolution (Agarwal and Bayus 2002; Golder and Tellis 1993; Chandy and Tellis 2000; Sood and Tellis 2005). The historical approach enables a longitudinal perspective that is missing in innovation studies (Montoya-Weiss and Calantone 1994; Page and Schirr 2008). It also enables looking at how innovations are *actually developed*, rather than merely how they *should be developed* (e.g., Narver, Slater, and MacLachlan 2004). The Method section provides details of this approach.

This study seeks to address the following questions. What is the origin of the idea for innovations? In particular, to what extent do ideas originate with the customer, inventor, or user? What role does technology play in the origin of ideas? The literature contains limited research and diverging recommendations on these issues. To answer the research questions, we study the detailed history of the origin of the idea of 180 innovations commercialized in the U.S. market between 1900 and 1999. The next three sections describe the theory, method, and results of the study. The final section discusses the findings.

Theory

This section presents the conceptual framework and hypotheses to be tested.

Conceptual framework

The literature discusses the origin of the idea for innovations in two primary dimensions. First, the literature discusses the human factor as the initiator of an innovation. The marketing literature focusses primarily on customers (e.g., Griffin and Hauser 1993; Slater and Narver 1999). Innovation and strategy literature tends to focus primarily on inventors acting in firms such as R&D personnel (e.g., Christensen and Bower 1996) and on users (e.g., von Hippel, de Jong, and Flowers 2012). Second, some literature discusses technology as a source for innovation (e.g., Utterback and Abernathy 1975; Sood and Tellis 2005).

Some of the literature examines both types of innovation sources in a single framework. For example, Utterback and Abernathy (1975) suggest that whereas customers stimulate innovation when a firm begins product development, technology initiates innovation later on in a firm’s product and process development. That is, the contribution of the human agent and technology to the idea of the innovation is consecutive. We contribute to this literature by treating customers, users, inventors and technology in a single theoretical framework.

We suggest a framework based on two dimensions for the origin of the idea. The first dimension is the agent. The agent can be an inventor, a customer, or a user. We define inventors as individuals who develop an innovation for the purpose of profiting from it. We define customers as individuals who constitute the target market of the innovation and *have someone else create the innovation for them*, that is, an inventor. We define users as individuals who develop an innovation for the primary purpose of using it themselves (e.g., Shah and Tripsas 2007; von Hippel 2005; von Hippel, de Jong, and Flowers 2012). Thus, users differ from 1) inventors who develop innovations for the purpose of profit and 2) customers who express their unmet needs to inventors. In contrast, users take the initiative and develop innovations themselves for themselves rather than request a third party to develop the innovation. By these definitions, the terms inventor, customer, and user are mutually exclusive yet collectively exhaustive for the role of agents in the ideation of the innovation. Still, our measurement allows for multiple contributions to the idea of the innovation. After ideation, the subsequent development of an innovation involves dynamic interactions among agents (Read et al. 2009). Some of these interactions may be critical to the ultimate success of the innovation. Whereas this process of the development of an innovation is complex, the current study focuses on only the origin of the idea, because ideation plays such a critically important role in the start of innovation.

Ideas originating with customers are central to marketing thought (e.g., Gatignon and Xuereb 1997; Griffin and Hauser 1993; Kohli and Jaworski 1990). The role of the inventor is widely researched in the innovation literature but not as widely researched in other literatures. The role of user is extensively studied by von Hippel and his colleagues.

The second dimension in the origin of idea is the technology. Prior research addressing technology issues primarily tends to dichotomize technologies (Garcia and Calantone 2002). For example, Utterback and Abernathy (1975) discuss new vs. existing technologies and Tushman and Anderson (1986) address incremental technological improvements vs. technological discontinuities. However, Garcia and Calantone’s (2002) review of technology typology presents the dichotomizing typology of radical vs. incremental technology as the most frequent in the literature (e.g., Chandy and Tellis 1998; Henderson and Clark 1990). Similar to Henderson and Clark, who treat technologies based on their design-oriented perspective of innovation (1990, p. 11), our perspective is origins-oriented.

We identify in the literature three such origins-oriented technology types that could affect the origin of an idea: novel, imitative, or exaptive. These three types are distinct. Yet, one, two, or all three of them could affect the origin of a single idea: a) a novel technology is one the inventor thinks about and develops exclusively for the purpose of the focal innovation; b) an imitative technology is one that is copied from an existing product in the same market; and c) an exaptive technology is one that originates in a completely different market but is adapted to the focal market.

The dichotomy of incremental/existing/imitative technology vs. radical/new/novel technology has been widely discussed in the innovation, marketing, management, and entrepreneurship literature (e.g., Henard and Szymanski 2001; Narver, Slater, and MacLachlan 2004; Utterback and Abernathy 1975). On the other hand, exaptive technologies have only been sporadically noted in previous literature (e.g., Fleming 2001; Hargadon 2002; Sood and Tellis 2005). In this paper, we discuss it in detail and differentiate it from novel or imitative technologies.

We choose the agent and technology as the focus of this study because these are the single most discussed elements in the new product and innovation literatures. Specifically, a number of central studies focus on aspects of agents and technology (e.g., Chandy and Tellis 1998; Christensen and Bower 1996; Singh and Fleming 2010; Sood and Tellis 2005; Von Hippel 1976). Still, to the best of our knowledge, this is a first attempt to analyze the origin of the idea in a single framework with three alternative agents and three alternative technology types.

The role of the agent – the customer. The literature on innovation discusses the customer as an agent of innovation ideas quite often (e.g., Griffin and Hauser 1993; Slater and Narver 1999; Urban and Hauser 2004). Consider the following example.

In 1902, Sackett-Wilhelms Lithographing and Publishing Co. of Brooklyn, New York, expressed to Buffalo Forge Company the need to treat the temperature and humidity so color printing would be stable. In response, Willis Carrier, an engineer at Buffalo Forge Company, invented a machine that controlled the temperature and humidity. He called it “apparatus for treating air” though it subsequently became known as the air-conditioner. The air-conditioner significantly improved the prior primitive cooling technology, and in addition, it enabled controlling humidity and cleanliness of air. This is an example of an innovation where the role of the customer in the origin of the idea is substantial because an explicitly expressed customer demand triggered the idea for the innovation.

This situation, where the customer faces a problem and asks someone else to solve the problem, differs from a situation where the agent solves the problem, as in the two types we discuss next.

The role of the agent – the inventor. The literature on management extensively discusses the role of the inventor. Notably, the role of the inventor is implied but not as widely discussed in the literature in marketing. Consider the following example.

During the late 1940s and 1950s, General Electric invested in developing heat lamps, envisaging customers would buy such lamps. Any prior attempts to develop heat lamps ended in the blackening of the bulb, eliminating the lamp's effectiveness. Elmer Fridrich was a member of the team of inventors of GE. Based on his experience, learning, and technological knowledge, Fridrich was able to solve problems that previous developers faced. He added iodine to a lamp containing halogen, and the chemical outcome prevented the blackening of the bulb. After refining the halogen lamp, GE patented the halogen lamp based on Fridrich's innovation and launched the new product.

Innovation ideas in which the role of the inventor is substantial emerge from neither customer request nor personal need. Rather, based on knowledge of the market and of technology (Singh and Fleming 2010), an inventor realizes that she or he can develop a new product primarily for commercial profit rather than personal use. Differing from the customer, the inventor comes up with an idea to solve a customers' problem based on his or her knowledge of technology. The halogen lamp is an example of such an idea.

The role of the agent – the user. In some cases the knowledge of the innovator stems directly from the fact that the innovator is a current user of substitute products. User innovation has been discussed in the literature primarily — but not exclusively—by von Hippel and colleagues (e.g., von Hippel 1986; von Hippel, de Jong, and Flowers 2012). Consider the following example.

Until the beginning of the 20th century, women's undergarments typically included corsets. In 1910 Mary Phelps Jacob put on her corset as she was preparing to attend an event. As she tried her dress on, the whalebones of her corset were showing from under her gown. Unhappy with the result, she took a ribbon and two handkerchiefs and sowed them together into a simple bra. The new undergarment stimulated the interest of her friends who asked her to make them one. When a stranger offered her money for the garment she realized the potential and started her own business. In 1914 she patented her Brassiere (US patent number 1115674), which became one of the earliest modern bras.

Differing from an inventor, the user personally faces a problem and comes up with an idea to solve the problem based on his or her user experience. The innovation is initially intended for self-use. The user can later further develop or commercialize the innovation hoping that it fulfills an unexpressed need of other customers.

Note that by the above definitions, ideas can originate from customers, inventors, users, or—in many cases— a combination of all three.

The role of technology. The technology that underlies an idea for an innovation can be novel, imitative, or exaptive. The literature focuses on novel or imitative technology, but hardly on exaptive technology. In what follows, we provide explanations and examples for novel, imitative, and exaptive technologies in the origin of the idea. We begin by discussing novel technology.

Firms can use sophisticated technologies in developing their innovations (Gatignon and Xuereb 1997). A firm that increases its technological focus enhances its development of novel technology (Kim, Im, and Slater 2013). We define an idea based on a novel technology as one for which the technology does not yet exist and the inventor thinks about it exclusively for the purpose of the focal innovation. Consider the following example.

During the early 1920s Richard Drew was working at a small firm called 3M that was manufacturing sandpaper. He visited auto shops when testing one of the firm's sand paper brands. During his visits he noticed that car painters found it difficult to keep the edges between two colors—the then popular color design for cars—clear and accurate. The painters used sheets of paper and a strong adhesive that damaged the painted color upon removal. Drew believed that he could use 3M's lab to develop an innovation that would solve the problem. In 1925 he developed a wide paper tape with an adhesive along its edges that was sensitive to pressure but gentle; he subsequently developed an improved version of a tape completely covered with the adhesive on one side. 3M branded this innovation Masking Tape. The technology underlying Masking Tape was novel: the paper tape coated with a gentle adhesive substantially differed from the cumbersome combination auto painters used. The inventor formulated a new technology and subsequently developed it for the sole purpose of his idea for innovation.

The literature on innovation also discusses imitative technology quite often. Imitative technology means basing a new product idea on existing products or technologies. Imitation encompasses a wide array of possibilities of duplication (Zander and Kogut 1995). It can range between a “me too” exact copy and minor duplication of product components. The literature addresses imitative technology primarily as imitation of competitors (e.g., Ethiraj, Levinthal, and Roy 2008; Zander and Kogut 1995). However, a firm bases an idea on imitative technology also when it targets its own customers with an idea that is some modification of its own prior products (Cattani 2005). Consider the following example.

In 1959 Mattel launched Barbie. Mattel based the idea for Barbie on the German Lilli doll. Like Lilli, Barbie had a then-unique adult woman body made of plastic, fashionable miniature clothes, a uniquely attached styled hair, and a painted face. Thus, the idea for the Barbie doll was primarily imitative: in terms of technology it was quite similar to other dolls and in terms of design it was quite similar to its predecessor, Lilli. Barbie is an example of imitative technology as the idea underlying it mimicked both technology and design of an existing product from the same product domain.

In many cases, scholars refer to innovations that are largely based on ideas originating with novel technologies as radical innovations and to innovations that are largely based on ideas originating with imitative technologies as incremental innovations (e.g., Chandy and Tellis 1998; see also Garcia and Calantone 2002). However, while reviewing the literature, one comes across yet another less discussed type: exaptive technology.

Exaptation is a term that social scientists adopted from the discipline of evolutionary biology (Dew et al. 2008; Gould and Vrba 1982; Villani et al. 2007). Exaptation is a trait originally designed to perform one function, which is adapted and used for a completely different function. In the context of technology, exaptation is adapting a technology from one established product domain to a new product domain (Dew et al. 2008; 2011). Consider the following example.

During the second half of the 19th century, the Corning Glass Works company produced lantern globes for lighting railroads. At the beginning of the 20th century the company developed a type of glass which could endure extreme temperatures. It was developed to reduce breakage of railroad lanterns due to weather conditions. A few years later the company realized that the same technology could serve a new market: the technology could be used as cookware. Unlike the cookware used at the time, which was made of metal or clay, a new glass cookware would be clear and easy to clean. The company developed Pyrex and launched it in 1915. The technology underlying the idea for Pyrex is primarily exaptive.

One can examine exaptation from two different perspectives: the perspective of the original product domain and the perspective of the new product domain. For the original product domain, the shift in technology is quite small. Hence the change is evolutionary, not revolutionary. For the new product domain, the new technology is quite different from the existing technology. Hence, the change is revolutionary and consists of a considerable leap in technology. The case of Pyrex illustrates this difference in perspective. Developing a heat resistant glass was an evolutionary step in the lantern-glass domain. However, for cookware, the shift from metal or clay cookware into an easy-to-see and easy-to-clean glass was revolutionary. Thus, an idea originating with exaptive technology generates a break in the linear evolution of the new product domain. Interestingly, there are a number of innovations that were initially unsuccessful but generated ideas that ended up being important innovations in entirely different domains. Examples are the phonograph, which was an idea originating from a dictating machine and LCD flat screens that were an idea originating from car safety windshields (Cattani 2006; Diamond 1997).

Differentiating exaptation. The innovation literature has addressed innovative processes somewhat similar to exaptation, such as recombination, brokering, analogous markets, and effectuation. Recombination relates to a conflation of existing components in new ways, where the inventor takes existing components form either different or same domains (Fleming 2001). Similarly, brokering relates to inventors recombining technologies they are experienced with in new ways (Hargadon 2002; Hargadon and Sutton 1997). In both recombination and brokering, the inventor may use components for the same purpose and in the same manner they were previously used. For example, Ford's mass production was a conflation of four previously well-developed technologies already used in car manufacturing into a single production line—interchangeable parts, electric motor, flow production, and assembly line (Hargadon 2002). This concept is considerably different from taking a car safety windshield out of the car and adapting it to TV screens, which is an exaptive process (Cattani 2006). Moreover, brokering studies discuss the idea of brokering from the agent's point of view, emphasizing networks and individual interactions (e.g., Hargadon and Bechky 2006; Hargadon and Sutton 2000), while exaptation focuses on technological aspects. The focus on the agent is also evident in a recent study on analogous markets (Franke, Poetz, and Schreier 2014). Whereas transferring solutions from analogous markets requires a base of analogy between the analogous and the target market, such as an analogous problem that requires solving, exaptation does not necessitate any analogy. Similarly, recombination usually takes place between proximal components (Fleming 2001), and therefore is quite different from the adaptation from an entirely different domain that occurs in exaptation. Effectuation theory indirectly addresses the agent's point of view, where the inventor works with what is currently at hand (Read et al. 2009; Sarasvathy 2001). Exaptation is more specific than recombination, brokering, and effectuation. It refers to taking a specific technology out of its own domain and adapting it into a new use (adaptation) *and* in an entirely different domain. Thus, we complement recombination, brokering, and effectuation theories and studies by 1) focusing on the technology—rather than on agents, and 2) addressing the specific aspect of adaptation of technology into a new domain that has been largely neglected in prior studies.

Hypotheses

This section presents our theoretical model and develops hypotheses about 1) the origin of ideas, 2) benefit of the innovation, and 3) role of exaptive technologies. We depict our theoretical model in Figure 1. The model expresses the role agents and technology play in ideation that leads to innovations' benefits. We find that the literature is sharply divided, leading to rival hypotheses about the first two issues above: 1) whether ideas for innovations come primarily from the customer or the inventor; and 2) whether benefits of the innovation increase with greater customer, inventor, or user contribution.

The customer as an agent: the primacy and contribution of the customer in the origin of the idea

The literature in marketing versus that in innovation and strategy suggests rival hypotheses about the role of customer in the origin of the idea and the benefit of an innovation. We first discuss the hypotheses emerging from the marketing literature and then those from the innovation and strategy literature.

Marketing thought focuses on customers and their wants and needs. Because customers are the ones to use and benefit from innovations, marketing thought emphasizes a customer orientation (Kotler and Keller 2012). Moreover, for developing innovations, starting with the customer is a fundamental tenet in the marketing literature (Dahan and Hauser 2002; Griffin and Hauser 1993; Liechty, Ramaswamy, and Cohen 2001; Slater and Narver 1998). In particular, two formal streams of research have arisen around customer focus: Market Orientation and Voice of the Customer. The theory of Market Orientation suggests that a productive path to ideation is contacting customers in search for their needs. This approach advocates that firms should develop innovations in response to customers' explicit requests and suggestions. At the same time, firms should also search for latent customer needs through in-depth research into customers' thoughts and behavior (e.g., Narver, Slater, and MacLachlan 2004; Slater and Narver 1999). Such close contact with the customer, in search of both explicit and latent needs, leads to innovations that provide benefits over existing products (Grinstein 2008; Urban and Hauser 2004).

The theory on Voice of the Customer has a similar emphasis on the customer as a source of ideas for innovations (Griffin and Hauser 1993). The authors advocate contacting customers, asking them to articulate their wants, prioritizing their wants, and organizing them into a hierarchy. Such deep customer contact should then constitute a rich set of ideas for innovations that satisfy customer wants. Here too the role of the customer in the origin of the idea is substantial and fundamental.

Market Orientation and the Voice of the Customer are widely known and quite established theories in the marketing literature and innovation practice. They build on early ideas (e.g., Utterback and Abernathy 1975). These concepts share a number of characteristics. They suggest that the substantial role in the origin of ideas should be of customers; not of inventors.

Ideas should originate either from customers' explicit requests or from interacting with them and inferring future wants. Inventors clearly play a role in developing innovations but it is subsequent to sourcing ideas for innovations from customers. Basic to these theories is the premise that the idea that leads to an innovation should originate from customers. Only subsequently do the inventors develop solutions designed to comply with customers' current or future wants. The implication is that such a sequence leads to innovations that provide superior benefits to customers. In summary, marketing thought suggest that:

HYPOTHESIS 1_0. The role of customers in the origin of ideas is greater than the role of inventors;

HYPOTHESIS 2_0. The benefits of an innovation over existing products increase as the role of the customer in the origin of the idea increases.

In sharp contrast to this emphasis on the customer in marketing, literature on innovation and strategy suggests that a focus on the customer may be detrimental to innovation and should be limited. In particular, the theory of Disruptive Technologies advocates that established firms may fail to remain leaders of their markets because they listen to their current customers too carefully. In many cases, current customers do not appreciate emerging radical technologies because these technologies do not meet current customers' needs early on. Contact with their customers drives firms to focus on sustaining technologies with limited superior benefits over existing technologies. A focus on customers may lead a firm to miss the next big technological change on the horizon and cause it to be disrupted (e.g., Christensen 1997; Christensen and Bower 1996).

Likewise, some scholars discourage contacting customers for ideation because customers are unable to envisage radical technological changes. Customers may also be unable to foresee the benefits they can obtain from future innovations (e.g., Bennet and Cooper 1979; Frosch 1996). Accordingly, popular business literature suggests that firms should "ignore the customer" in order to avoid "safe and bland" innovation ideas (e.g., Martin 1995). Still other authors have argued that technological change is too rapid and technical for customers to visualize what is possible in the future and how technologies could satisfy latent needs (Sood and Tellis 2005). So customers can not even articulate the wants that could be satisfied by future technology. This line of reasoning suggests that inventors' knowledge shapes customer wants rather than the other way around as proposed by marketing though and theory.

These arguments suggest that managers should trust neither current customers nor customers in general for ideas for innovations but instead rely on inventors. Moreover, if an innovation is to provide superior benefits over existing products, the role of the customer in the origin of the idea should be limited. Contrary to the philosophical emphasis on customers in marketing thought, these arguments lead to the following rival hypotheses:

HYPOTHESIS 1_a. The role of inventors in the origin of ideas is greater than the role of customers;

HYPOTHESIS 2_a. The benefits of an innovation over existing products increase as the role of the customer in the origin of the idea decreases.

The dimension of technology: the contribution of exaptation

The literature on innovation offers specific actions for generating ideas for innovations that provide customers with superior benefits over existing products. Such actions could be a recombination of existing components or technologies in new ways (Fleming 2001; Hargadon 2002) or connecting "seemingly unrelated questions, problems, or ideas from different fields" (Dyer, Gregersen, and Christensen 2009, p. 63). Adapting technologies in one product domain to customer needs in another product domain is the essence of exaptation. Ideas for innovations based on exaptation can provide customers with superior benefits for two reasons. First, technologies developed and advanced within a particular market for a particular customer typically reach a limit of technological progress (Foster 1986). Ultimately, maturity in technological evolution sets in. In this context, taking a technology developed for another product and using it in a new product domain can result in cross-fertilization, new solutions, and new benefits to customers in the new product domain (Foster 1986). Likewise, taking an idea from its original context and using it in a different one can result in creative solutions (Franke, Poetz, and Schreier 2014; Goldenberg, Mazursky, and Solomon 1999a). Second, the benefits of an innovation to customers entail the sum of the innovation's relative advantage minus the risks associated with its adoption (Moreau, Lehmann, and Markman 2001). The literature has largely overlooked the meaningful benefit of exaptive technology in terms of reduced risk. Novel technologies can be risky because they can perform poorly or cause damage (McNally, Cavusgil, and Calantone 2010; Moreau, Lehmann, and Markman 2001; Ram and Sheth 1989). Conversely, the risk with exaptive technology is limited because the technology has already proved functional and safe in its original product domain. Thus, a technology adapted from a different domain can provide superior technological benefits alongside reduced risk over technologies already introduced to the market or novel technologies. These arguments suggest that:

> HYPOTHESIS 3. The benefits of the innovation over existing products increase as the role of exaptive technology in the origin of the idea increases.

Method

This section explains the historical method, sampling, data collection, measures, and analysis and models.

Historical method

We use the historical method to test the hypotheses. Golder (2000) defines the historical method as scientifically "collecting, verifying, interpreting, and presenting evidence from the past" to throw new light on strategic phenomena that evolved in the past (p. 157). The historical method is relevant when experiments are not possible and surveys of current survivors would lead to distinct biases. For example, using the historical method, Golder and Tellis (1993) showed that most pioneers failed in contrast to studies using surveys that showed that most pioneers survived to become market leaders (Kalyanaram and Urban 1992; Urban et al; 1986, Robinson and Fornell 1985). The discrepancy is due to survival bias. Surveys sample only survivors and do not sample failed pioneers. Market leaders wrongly call themselves pioneers when the real pioneers have failed or have ceased to exist over time.

The historical method involves collecting data from multiple, independent, and reliable sources that describe the events as close to the time of their occurrence. Such sources include— but are not limited to— news reports, patent records, trade magazines, industry reports, and firm archives. The researchers must assess resources considering reliability, independence, and credibility of sources and the consistency of information from multiple sources (Golder 2000). Prior studies have used the historical method when researching phenomena that evolved in the past and relying on current surviving respondents could lead to biases (Bairstow and Young 2012; Chandy and Tellis 2000; Golder 2000; Golder, Shacham, and Mitra 2009; Golder and Tellis 1993; 2004; Sood and Tellis 2005). However, such a historical approach is still scarce in innovation studies (Montoya-Weiss and Calantone 1994; Page and Schirr 2008).

The historical method is suitable for researching the origin of ideas for innovation for the following reasons. First, it can best answer the research question as to what was the temporal order of roles played by customers, inventors, users, and technologies in the origin of real, important market innovations. Second, it provides a valuable longitudinal perspective to ascertain changes in these roles over time, if any (Montoya-Weiss and Calantone 1994; Page and Schirr 2008). Third, it is "rich in detail" providing hitherto unknown valuable details about ideation in innovation that may have lessons for today's innovators (Golder 2000; Hargadon and Douglas 2001). Thus, Hargadon and Douglas (2001) state, "Historical cases can provide the necessary distance to observe how an innovation both emerges from … its institutional environment" (p. 476). Fourth, it is descriptive—how innovations are *actually* developed—rather than prescriptive—how innovations *should* be developed (e.g., Narver, Slater, and MacLachlan 2004). Fifth, by including failures, it fairly addresses the problem of survival bias (Golder and Tellis 1993).

Sampling

Finding a sample of innovations for this study poses four challenges. First, we would like a sampling frame that ensures a cross section of industries. Second, to avoid survival and selection bias (Golder and Tellis 1993), we would like a sampling frame that includes innovations that were both successes and failures and both radical and incremental. Third, we need a sampling frame that covers a long time-period, so we can observe the stability and dynamics of the phenomena. Fourth, each year firms introduce tens of thousands of innovations. We need a manageable sample of the most important of these innovations that will enable a valuable in-depth investigation.

To meet these challenges, we use as our sampling frame various published lists of outstanding innovations—whether important, interesting, radical, disruptive, or gross failures, commercialized in the U.S. during the 20th century. The number of innovations is infinite. Any single list of innovations is arbitrary and limited. Therefore, from an extensive search of the literature and databases, we identified 18 published lists of innovations. Seven of these publications targeted general or industry magazine readers. Four targeted educators. Five targeted general readers, of which two were generated by readers. Two seem to have targeted inventors. Additionally, four of the 18 lists listed failed innovations. The remaining 14 publications listed mostly successful innovations, alongside occasional failures or unfavorable innovations. We then created a master list that included the union of all these separate lists. As a sign of inter-list reliability, the vast majority of the innovations in our final sample were mentioned in more than one published list and 39% of the innovations were mentioned in at least three lists. After we excluded innovations not in accordance with the criteria we stated above, this process yielded a set of 598 innovations. The innovations in the lists came from a wide variety of industries. We classified the innovations into nine general industries based on a United States Patent and Trademark Office (USPTO) classification (Hall, Jaffe, and Trajtenberg 2002). This list spans all decades of the 20th century, and contains failures and success, incremental and radical innovations. Additionally, our final sample overlaps prior research using historical analyses. For example, 23 of the 52 20th century innovations in Chandy and Tellis (2000) are represented or closely represented in our sample (by closely we mean, for example, cassette tape player in Chandy and Tellis (2000) vs. cassette tape in our sample). Our final sample also overlaps 14 of the 25 20th century innovations in Golder, Shacham, and Mitra (2009). Thus, this sampling frame, while not perfect, reasonably addresses the four challenges posed above in a relatively objective (inter-personally certifiable) manner, while covering 1) a wide spectrum of industries, 2) a wide spectrum of periods, and 3) both successes and failures.

To provide a manageable sample of under two hundred innovations for an in-depth, detailed historical analysis, and to adequately represent early and late innovations, we drew a working sample as follows. Because of the nature of distribution, we were concerned that a simple random sample may over represent some industries. To fairly represent industries and decades, we used stratified random sampling by industry and decade. Within each industry, we classified the innovations into decades. From each decade and each industry, we sampled innovations in proportion to the patents issued by the USPTO. For example, if between 1960 and 1969, 20% of the patents in the US were issued for electrical devices and 15% were issued for transportation, then from that decade we randomly sampled 20% electrical devices innovations and 15% transportation innovations. Altogether, we randomly sampled 17-20 innovations per decade, totaling 186 innovations from nine industries that were commercialized in the U.S. between 1900 and 1999. Insufficient historical information regarding six innovations resulted in a final sample of 180 innovations.

This final sample follows a tradition of prior research that examined a focused set of innovations of special interest (e.g., Golder 2000; Golder, Shacham, and Mitra 2009). In addition, this sample compares favorably with samples from innovation studies or from studies using the historical method: First, our sample covers nine industries, compared with prior studies covering one to three industries (e.g., Chandy et al. 2006, Chandy and Tellis 1998, Prabhu et al. 2005, Shankar et al. 1998, Sorescu et al. 2007). Second, it covers radical and incremental innovations, compared with prior studies covering only radical innovations (e.g., Chandy and Tellis 2000; Golder, Shacham, and Mitra 2009). Third, it covers successes and failures compared with prior studies covering only successes (e.g., Agarwal and Bayus 2002, Bass 1969, Chandy and Tellis 2000; Golder, Shacham, and Mitra 2009). Fourth, it covers innovations of high-profile and low-profile firms, compared with prior studies covering only top advertising firms (e.g., Moorman 1995, Moorman and Miner 1997).

In particular, in the biggest prior historical study of innovations, Chandy and Tellis (2000) restricted their sample to only two industries and only those successful innovations that started categories that crossed 1,000,000$ in revenues. Their approach generated 64 innovations. Relative to that sample, our sample is considerably larger, spans nine industries, and includes both successes and failures and both radical and incremental innovations. Moreover, most of the innovations in our sample have not survived over time, thus considerably reducing survival bias.

Data collection

For each of the sampled innovations, we collected information using the historical method (e.g., Golder 2000, Golder, Shacham, and Mitra 2009, Sood and Tellis 2005). Our sources were patent documentations, peer-reviewed articles, books, biographies of inventors, industry and other magazine articles, company websites, and online archives such as Lexis Nexis. Following the historical method, we carefully assessed every source considering aspects such as reliability, credibility, and the recurrence of information in multiple sources. We used information only after establishing the reliability and credibility of the source according to the criteria of the historical method. Additionally, we thoroughly crosschecked all the evidence that was critical for the evaluation of the idea and the innovation (Golder 2000). We enhance the historical method practiced in prior research by a) assigning research assistants who are trained history students for the gathering, cross-checking, and reliability assessment of the information and evidence[1]; and b) assigning a qualified historian to closely supervise the process. We constructed a formal manual for information gathering. The manual included specific instructions of what information the research assistants should gather (e.g., the historical circumstances surrounding the origin of the idea, the motivation for the idea, the innovation itself, the firm and inventor, available substitutes during the idea origination, the technology underlying the idea, other technologies available, success, and customers' reactions). The manual also included a checklist of the information needed, the type of sources the research assistants should access, the order in which they should present the information, and so forth. In addition to their classwork training (at least 2.5 years of training in reliability assessment of sources), all research assistants went through a training period in which they worked closely with the supervising historian to make sure they understood and carefully followed the research manual. The research assistants were unaware of the hypotheses or purpose of the research, thus the descriptions are not biased. After completing information gathering for an innovation, the supervising historian reviewed the description and made sure it was in line with the manual, otherwise returning it to the assistants for further work. Finally, the supervising historian edited descriptions to eliminate variability stemming from style. The supervising historian had experience in the area of the history of technology including the teaching of an advanced course involving the history of technology. In sum, the skill, expertise, intense training, and close supervision of this team compares favorably with prior studies using a similar method.

Overall, our sampling and data collection have several strengths. First, our sample represents both successful and failed innovations. Second, our sample represents innovations that substantially differ from their predecessors in terms of technology and those that do not. Third, our sample relates to innovations that were commercialized, rather than patents or innovations

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[1] We recruited four undergraduate students as research assistants during their final semester. We selected them, among other qualifications, based on their grades and their being prospective graduate students.

that remained ideas. In many cases patents and ideas do not mature into working products and remain passive knowledge that does not translate into further technological evolution (Golder, Shacham, and Mitra 2009; Trajtenberg 1990). Fourth, our sample covers a long period of one hundred years and a broad range of nine industries. Fifth, our sample entails innovations noted by writers, editors, and readers. Sixth, the publications from which we sampled as well as our data sources are all publicly available. Seventh, a team with a solid background of assessing historical texts and sources collected the information.

Measures

This subsection covers the measures of the dependent, the independent, and control variables. Figure 2 shows the constructs and their measures. For some of our measures we follow a method used in major journals such as *Science, Management Science, Journal of Marketing Research,* and *Journal of Marketing*, and use judgments of judges—consisting of knowledgeable judges and raters (e.g., Chandy and Tellis 2000, Coviello and Joseph 2012, Goldenberg, Lehmann, and Mazursky 2001; Goldenberg, Mazursky, and Solomon 1999a; 1999b). The judges read descriptions of innovations formulated by the team of historians. Providing such standard information to judges was used in some of the upper mentioned major journals and studies. We use two independent sets of judges for different measures: judges knowledgeable on innovation and research assistants trained as raters. We elaborate the measures and the natures of the judgments next.

Role of the Agent and Technology. To assess the role of the agents and of technology, we trained three research assistants as raters. The raters were unaware of the hypotheses or purpose of the research. Each rater went through a training session that included a thorough oral explanation of the constructs of agent and technology, followed by a reading of an explanation. These explanations are similar to what we provide in the Theory section. We gave the raters some illustrative examples for each construct. Each rater then completed a training session of rating the constructs for three innovations after reading their historical description. One of the authors then debriefed the rater. We did not include the ratings of the training session in the final sample. Upon a completion of the training, we followed Chandy and Tellis (2000) and gave the raters detailed descriptions of the 180 innovations, ideas, and historical records on each of the characteristics we asked them to rate. All raters viewed all descriptions. For each innovation, the raters used a seven-point scale to assess 1) two unipolar items: to what extent did the idea originate with the customer and to what extent did the idea originate with the inventor; and 2) three unipolar items: to what extent the idea was based on novel, imitative, or exaptive technology. The inter-rater reliabilities for these measures are .83, .75, .82, .81, and .84 respectively. We did not restrict the ratings in any way. For example, the raters were free to rate an idea high on the role of the customer, and also high the role of the inventor. We applied this lack of restriction for the technology ratings as well.

An additional masters student recruited as a research assistant, unaware of the hypotheses of the study, further coded innovations according to historical records for the following organizational and other variables: whether the innovation was for self-use (rather than for profit) coded as user, whether the inventor was a private individual or one working for a firm (Singh and Fleming 2010), whether the inventor was a serial entrepreneur, whether the inventor had a formal degree in the sciences or engineering, or was a layperson with none of the above in his/her record, whether a firm of over 50 employees generated the innovation (coded as large firm), and whether the innovation gave rise to a new firm. One of the authors reviewed these coding against the historical record and found no need for revisions.

Innovation's Superior Benefits. For this measure and for subsequent ones we followed previous studies (Chandy and Tellis 2000, Goldenberg, Lehmann, and Mazursky 2001, see also Franke, Poetz, and Schreier 2014) and had judges with substantial knowledge and experience in innovations, rate the characteristics of the 180 innovations. These were four individuals knowledgeable on innovation, with a number of years of relevant teaching, research, or practical experience.[2] Still, due to the variety of innovations examined and because we wanted to ensure that all knowledgeable raters were exposed to consistent information, we followed Chandy and Tellis (2000) and gave the judges detailed descriptions of the innovations and information on each of the idea characteristics we asked them to rate. All knowledgeable judges viewed all innovation descriptions, unaware of the hypotheses of the study. The judges evaluated innovations' characteristics from the perspective of the market as can be learned from the historical records. The use of knowledgeable judges was important for two main reasons. First,

[2] We recruited four (rather than three) individuals because these individuals enabled a combination of teaching, research, and practical experience.

their knowledge and experience enable them to provide quality ratings that novices cannot provide. Second, it was important that the individuals rating these variables differ from the individuals that rate the roles of agent and technology in the origin of the idea.

For measuring the extent of superior benefits of the innovation compared with other contemporaneous products, we used a combination of four seven-point scale items. Based on theoretical constructs in the literature (Chandy and Tellis 1998, Garcia and Calantone 2002, Moreau, Lehmann, and Markman 2001; Sethi 2000), the items assess the quality of the innovation over existing products; the extent to which it enabled customers to complete a task faster; the extent to which the innovation fits customers currently using substitute products; and the extent to which the innovation differed from contemporaneous products. The latter item was adapted from Moreau, Lehmann, and Markman (2001). The inter-rater reliabilities for these measures are .89, .79, .86, and .80 respectively. We averaged the item ratings for each knowledgeable judge and then across all judges. We report reliability tests in the Results section.

Industry Effects. We use nine dummy variables capturing the nine industries represented in our sample. We use a USPTO classification (Hall, Jaffe, and Trajtenberg 2002).

Time Effects. For time fixed effects we define a set of five time-dummy-variables as: before WWI, during WWI, inter-war period, during WWII, after WWII. We select the World Wars as milestones for the following reasons. First, studies report a connection between innovation and international trade (Chuang and Hsu 2004; Grossman and Helpman 1991) and during WWI and WWII international trade came into halt and recovered only after 1950 (e.g., Findlay and O'Rourke 2001; Glick and Taylor 2005). Second, prior research on innovation refers to WWII as an important milestone for dichotomizing time (Golder and Tellis 1993; 2004). For robustness, we provide an analysis with a continuous time variable reflecting the year the innovation was first introduced to the market, with consistent results.

Success / Failure. As mentioned above, four of the lists' publications were of failed or unfavorable innovations. Other publications explicitly list certain innovations as unsuccessful, dead-ends, or useless.[3] To control for valence of the innovation, we employ a dichotomous variable: success/failure.

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[3] We use the term failure for innovations which were described by authors of lists using words such as failure, loser, poorly executed, bad/worst idea, technological dead-end, shameful, ridiculous, useless, bad and worst.

Additional Control Variables. After reviewing innovation literature, we control for the following innovation characteristics: creativity, newness to the firm/inventor, and disruption (e.g., Barczak, Griffin, and Kahn 2009; Christensen et al. 2004; Garcia and Calantone 2002; Goldenberg, Lehmann, and Mazursky 2001; Moorman and Miner 1997), for the following reasons. First, they are innovation characteristics most prominent in the innovation literature in two specific aspects: the *origin* of the idea and the *aftermath* of the innovation, respectively. The salience of these variables in innovation review studies emphasizes their prominence in the literature (e.g., Barczak, Griffin, and Kahn 2009; Garcia and Calantone 2002; Hauser, Tellis, and Griffin 2006). Second, they enable conciseness, yet they are comprehensive. We use the knowledgeable judges' rated measures, as described above. For **creativity** we use a seven-item creativity scale (Moorman 1995; Moorman and Miner 1997). For the extent to which the innovation was **new to the inventor or firm** (e.g., Sethi, Smith, and Park 2001; Garcia and Calantone 2002) we use a three-item scale capturing the extent to which: the innovation was new to the inventor / firm; the technology was revolutionary to the inventor / firm; the innovation required new marketing skills from the inventor / firm. The inter-rater reliabilities for these measures are .80, .78, and .74 respectively. For the extent to which the innovation **disrupted** practices (Christensen and Bower 1996), we use a three-item scale capturing the extent to which the innovation disrupted work practices, the extent to which the innovation disrupted conventions, and the extent to which the innovation disrupted consumption practices. The inter-rater reliabilities for these measures are .79, .78, and .82 respectively. We had the knowledgeable judges rate all of these items using seven-point scales as described above. We report all reliability and validity tests for these measures in the Results section.

Analysis and models

To test $H1_0$ and $H1_a$ we test the difference in the means of the role of inventors and customers in the origin of ideas. Additionally, we plot over time the mean of the role of customer and inventor in the origin of ideas.

To test $H2_0$, $H2_a$, and H3 we estimate the following regression model:

$$\text{SuperiorBenefits}_i = \alpha_1 + \beta_1\text{Customer}_i + \beta_2\text{Inventor}_i + \beta_3\text{User}_i + \beta_4\text{Private}_i + \beta_5\text{Imitative}_i + \beta_6\text{Novel}_i + \beta_7\text{Exaptive}_i + \sum_{l=8}^{11}\beta_l\text{Time}_i + \sum_{m=12}^{15}\beta_m\text{Time} * \mathit{Customer}_i + \sum_{n=16}^{19}\beta_n\text{Time} * \text{Inventor}_i + \sum_{n=20}^{23}\beta_q\text{controls}_i + \upsilon_i \quad (1)$$

where i is a subscript for innovation, SuperiorBenefits is the innovation's superior benefits to customers, Customer is the role of the customer in the origin of the idea, Inventor is the role of the inventor in the origin of the idea, User is innovation generated for self-use, Private is innovation generated by a private individual (vs. an individual in firm), Imitative is the role of imitative technology, Novel is the role of novel technology, Exaptive is the role of exaptive technology, Time is a five period dummy variable, α_1 and β_1-β_{23} are coefficients to be estimated, and υ_i is an error term initially assumed to follow a normal distribution. We incorporate a set of interactions between the agent and the periods because the literature suggests changes in the role of the agents over time. These interactions may reflect changes in thought and practice (Vargo and Lusch 2004; Wilkie and Moore 2003). For robustness check, we estimate a model based on Equation 1 which includes industry effects and further control variable drawn from the literature as we discuss above.

Results

This section presents the results of the testing of validity, reliability, and the hypotheses and includes some additional analyses.

Discriminant validity, reliability, and validity

The definitions of the two dimensions—agent and technology—clearly discriminate between these two innovation sources: agent refers to the (human) agent generating the origin of the idea and technology refers to the technological basis of the idea. Accordingly, in a confirmatory factor analysis, the measures of inventor and customer did not load higher than .17 on the technology construct, indicating the discriminant validity of these dimensions.

For the control variables in our analysis that capture critical innovation characteristics, we conducted the following reliability and validity testing. For the creativity scale, consistent with

Moorman (1995) and Moorman and Miner (1997), the coefficient alpha is high (.96). These studies have also established the validity of the scale. For the new to the inventor or firm scale, the coefficient alpha is .90, and for the disruption of practices scale the coefficient alpha is .92. To further assess the validity of these control variables we conducted confirmatory factor analysis. All items loaded higher than .85 on one of three factors, consistent with the above characteristics described in the literature. Each of the three factors explained 10%-60% of the variance. The alpha for the dependent variable of superior benefits is .76. These results support the validity of the measures. Table 1 provides descriptive statistics and correlations for all variables rated by trained raters and the knowledgeable judges. Table 2 provides correlations for coded organizational variables such as firm size and inventor's education.

Hypotheses testing

$H1_0$ posits that the role of the customer in the origin of ideas is greater than the role of the inventor, while the rival hypothesis, $H1_a$, posits the opposite. We find that the role of the inventor in the origin of ideas is significantly greater than the role of the customer (5.99 vs. 2.71 respectively, $p < .001$; see also Figure 3). Thus, we can reject $H1_0$ but not $H1_a$.

Table 3 Column a reports results of the estimation of Equation 1 that tests $H2_0$, $H2_a$, and H3. We provide estimates of the model using dummy time variables, with the first period (1900-1913) as the reference point.

$H2_0$ posits that the benefits of an innovation over existing products increase as the role of the customer to the origin of the idea increases and $H2_a$ posits the opposite. Estimates of the model show that the main effect of the customer is negative and significant ($\beta = -.447$, $p = .023$). Estimates of alternative models (Table 3 columns b-e) provide similar results. These results lead us to reject $H2_0$ but not $H2_a$.

H3 predicts that the benefits of the innovation over existing products increase as the role of exaptive technology increases. Estimates of the model (Table 3 Column a) show that exaptive technology is positively and significantly associated with the innovation's superior benefits ($\beta = .195$, $p = .003$). Thus, H3 is not rejected. Robustness checks (Table 3 Columns b-e) yield similar results. We tested the change in R^2 from a model including the agent and technology variables to a model not including them. For the model reported in Table 3 Column a based on Equation 1, when including the agent and technology variables, the increase in R^2 is significant ($F_{(6, 156)}$ = 7.00, $p < .001$). Similarly, for the model reported in Column c when including the agent and technology variables, the increase in R^2 is significant ($F_{(6, 147)}$ = 7.01, $p < .001$). These results indicate the importance of the agent and technology of the idea to the innovation's superior benefits. Note that the high R^2 is due to the relatively large number of fixed effects relative to sample size.

Survival analyses

We conduct survival analyses to estimate the conditional failure rate of the innovations in our sample. We collected data on longevity, in terms of the number of years the innovation survived. We use a Cox proportional hazard model with the probability of an innovation to die as the dependent variable, and the independent variables include the measures of agent, technology, and additional control variables. Table 4 presents the coefficients of a hazard model. We find that the hazard for the death of an innovation significantly decreases as the superior benefits of the innovation increase. We also find that the higher the role of imitative technology in the origin of the idea the higher the hazard for the death of the innovation.

Addressing potential sampling biases

This subsection explores whether the results are affected by potential biases.

First, one may question whether the results suffer from survival bias by omitting failed innovations. Actually, we used our sampling frame precisely to avoid such a bias. In fact, 21% of our sample are failures. Whereas one may still argue this percentage is an under-representation of failures, failures are far better represented in our sample compared with prior research on innovation. For example, Agarwal and Bayus (2002), Bass (1969), Chandy and Tellis (2000), and Golder, Shacham, and Mitra (2009) investigate only successes. Moreover, a review study of Da Rin, Hellmann, and Puri (2011) emphasizes the extremely limited research on failures despite its great importance. Still, we treat the under-representation of failures econometrically, using propensity score matching, where we match successful and failed innovations based on their propensity scores. This method enables econometrically balancing unequal groups, to which the allocation is not random. We use innovation characteristics as predictors and estimate propensity scores using a probit model. We then use the propensity scores as predictors of superior benefits in a regression model (based on Table 3 Column c), with matching successes and failure innovations. We use two matching methods: radius score matching and nearest neighbor matching. Using both these methods, we find a significant 'average treatment effect on the treated' ($t = -8.685$ and $t = -5.093$ respectively, $p < .05$). This finding suggests that controlling for the unequal allocation of innovations to successes and failures, successful innovations are significantly associated with superior benefits.

Second, very few innovations in our sample are user innovations. What would be the effect of a larger portion of user innovations? We use propensity score matching methods to answer this question. Here too, we use innovation characteristics as predictors and estimate propensity scores using a probit model. We then use the propensity scores as predictors of superior benefits in a regression model (based on Table 3 Column c) with matching user and non-user innovations. Using both radius score matching and nearest neighbor matching methods, we find no significant 'average treatment effect on the treated' ($t = .951$ and $t = .692$ respectively, $p > .10$). This finding suggests that our results do not seem to suffer any serious bias from the small sample of user innovations.

Additional Analyses

We conduct some additional analyses. First, we introduced an interaction between customer and inventor to Equation 1 to test whether this interaction leads to superior benefits. However the interaction is insignificant ($\beta = -.350$, $p = .134$). Second, the centrality of the customer in marketing underwent changes over the years. These changes were the result of shifts in marketing though (Vargo and Lusch 2004; Wilkie and Moore 2003). It would therefore be valuable to examine the role of customers in the origin of ideas for innovations over time and see if this role changes over time. Testing for these dynamics, Table 5 Column a reports results of the estimation of the following equation:

$$Customer_i = \alpha_1 + \beta_1 Year_i + \beta_2 Creative_i + \beta_3 New_i + \beta_4 Disrupt_i + \varepsilon_i \quad (2)$$

where Year is the year the inventor/firm first introduced the innovation, α_1 and β_1-β_4 are coefficients to be estimated, and ε_i is an error term initially assumed to follow a normal distribution. The logic behind this model is that it tests the relationship between the role of the customer and time of introduction while controlling for the creativity, newness, and disruption of the innovation. The addition of a time trend significantly increases R^2 ($F_{(1, 175)} = 4.77$, $p = .030$), and the role of the customer is negatively associated with this time trend (β = -.169, $p = .030$). Figure 3 exhibits the mean roles of customers and of inventors in the origin of ideas over time, and demonstrates a decrease in the role of the customer. We find that the correlation between the year of introduction and the role of the customer is negative and significant (r = -.188; $p < .01$). Similarly, the correlation between the decade of introduction and the role of the customer is negative and significant (r = -.188; $p < .01$). We also test the difference between the first and second half of the 20^{th} century, and find that the role of the customer was higher in the first half of the 20^{th} century than in the second half (3.00 vs. 2.42 respectively, $p < .01$).

Third, one could argue that spreading on industries and periods could question generalizability. We tested the robustness of coefficients for the first and second half of the century based on Equation 1. For the first half of the century, the coefficient of the role of the customer is negative and significant (β = -.674, $p = .015$), whereas the coefficient of exaptation is positive but insignificant (β = .182, $p > .10$). For the second half of the century, the coefficient of the role of the customer is negative but insignificant (β = -14.585, $p > .10$) and the coefficient for exaptation is positive and significant (β = .168, $p = .018$). We also tested this model for non-traditional industries only (computers, communications, electrical, drugs & medical). Here too, the coefficient of the role of the customer is negative but insignificant (β = -.237, $p > .10$) and the coefficient for exaptation is positive and significant (β = .242, $p = .027$). These results indicate potential generalizability of the results.

Discussion

All innovations start with an idea. Research suggests that firms generate a large number of ideas from a variety of individuals to produce successful innovations (Terwiesch and Xu 2008). However, research is scarce on how successful and unsuccessful innovations originate (Shane and Ulrich 2004). In particular, the literature lacks a) a comprehensive framework for an analysis of the origin of ideas; and b) evidence of the origin of ideas and its effects. This study develops a framework for the origin of ideas for innovations based on two dimensions: agent and technology. Using the historical method and this framework, this study analyzes 180 innovations, commercialized between 1900 and 1999. This section discusses the contributions, findings, questions, implications, and limitations, of this study.

Contributions

In this study we make the following contributions. First, we apply the historical method to carefully investigate the history of 180 innovations of the 20th century. We construct a unique dataset based on the origin of the idea and consequences of these innovations. Second, our sample represents a large variety of industries spanning over 100 years of radical and incremental, disruptive and sustaining, and successful and failed innovations. As such, our sample is unique. Third, we posit that two dimensions underlie the origin of ideas. The dimension of the agent is composed of customer, inventor, and user; and the dimension of the technology is composed of novel, imitative, and exaptive technology. To the best of our knowledge, this is a first attempt in the literature to analyze the origin of ideas in terms of three alternative agents, and three alternative technologies. This framework provides a theoretical contribution. Moreover, we empirically test hypotheses based on the two dimensions of the origin of ideas in a single framework. Fourth, exaptive technology as the basis for an innovation has been noted before (Dew et al. 2004; Sood and Tellis 2005). Still, thus far notions of this start of innovation are limited and primarily anecdotal (e.g., Johnson 2010). We differentiate exaptive technology from more general notions such as recombination and brokering (e.g., Fleming 2001; Hargadon 2002) and test the consequences of innovations for which exaptive technology played a role in the origin of the idea and provide useful information for new product development managers. Fifth, our study enables some novel findings about the origin of ideas that are relevant to researchers and managers interested in new product development.

Findings

The study yields four key findings, the first two of which run counter to the prevalent thinking in the marketing literature:

- The role of inventors is significantly larger than the role of customers in the origin of ideas underlying innovations.

- Superior benefits of an innovation increase with a decrease in the role of the customer in the origin of the idea.
- Superior benefits of an innovation increase with an increase in the role of exaptive technology in the origin of the idea.
- Not only does the role of the customer in the origin of ideas not increase over time, it decreases over time.

Questions

The results raise the following questions: Why is the role of customers in the origin of ideas smaller than the role of inventors? Why does the role of customers in the origin of ideas decrease over time and what are the consequences?

Why is the role of customers in the origin of ideas smaller than the role of inventors? Our finding that the role of the customer is smaller than that of the inventor is not trivial because marketing thought emphasizes the importance of the customer, especially for innovation and new product development. One could argue that this finding stems from a sampling bias because the innovations in the current sample over-represent the involvement of the inventor, whom people easily remember. However, such bias is unlikely to stem from our sampling scheme for two reasons: First, the vast majority of inventors in our sample are not famous. People may remember Edison and Bell, but they don't remember the inventor of the masking tape, brassiere, or halogen lamp—innovations that impact modern life on a daily basis. Second, it is easier for people to remember innovations which they use daily than inventors, some of whom they may never have heard of. Moreover, our sources do not rely on inventors' accounts more than on other accounts. Because the vast majority of inventors in our sample are not famous, a bias stemming from lack of credit to customers is unlikely.

We offer three possible explanations for the finding that the role of the customer is smaller than the role of the inventor. First, most customers focus on current products and are not aware of emerging technologies, especially those that are going to be radical or disruptive. Thus, they are unable to conceptualize radical or disruptive innovations that offer superior benefits to existing products. Second, marketers have only limited influence on their firm's innovation processes. Prior research emphasizes communication problems between marketers and product development teams within firms (e.g., Song and Parry 1997; Wind and Mahajan 1997), and the critical role this inter-firm communication has in ideation (Lovejoy and Sinha 2010). Other research suggests that the influence of the marketing department on R&D decisions is moderate at best (Verhoef and Leeflang 2009). In firms where marketers do not influence innovation processes, the role of the customer in the origin of ideas remains limited. Third, inventors, many of whom have an engineering or other technical background, do not consider customers a good source for ideas.

Moreover, legendary innovators have expressed opinions consistent with our findings. For example, Akio Morita, the leader of Sony, viewed customers as incapable of understanding technological possibilities (Morita, Reingold, and Shimomura 1986). Steve Jobs, founder and legendary CEO of Apple, acted on the premise that customers do not know what they want in terms of innovations of the future (Gallo 2010; Reinhardt 1998).

Why does the role of customers in the origin of ideas decrease over time and what are the consequences? The modern marketing concept emphasizes the centrality of customers. In particular, the modern marketing concept emphasizes the role of contacting customers for ideation and the further development of new products (e.g., Bennett and Cooper 1979; Slater and Narver 1998). This marketing thought has gradually become an inherent part of the formal marketing discipline and education (Goldman and Grinstein 2010). As a result, education in marketing increasingly emphasized the need to focus on customers' wants and needs, whether explicit or latent, in developing new ideas for innovation.

During the second half of the 20th century, the marketing discipline and marketing thought experienced an era of booming growth with ever-increasing numbers of academic publications, AMA memberships, and degrees in business awarded at the doctoral, masters, and bachelor levels (Wilkie and Moore 2003).[4] Consequently, marketing ideas and concepts increasingly disseminated in the business world. The increasing formalization of business education and the increasing numbers of business graduates over time with training in the

[4] For example, in the mid-1950s 42,813 bachelor's degrees in business were awarded annually, and by 1980 this number increased to 184,867. For master's degrees the numbers are even more profound. 3280 MBA degrees were annually awarded in the mid-1950s, about 54,500 degrees were awarded in 1980, 82,000 in 1992, and 115,000 degrees were awarded in 2000 (Greco 2001; Wilkie and Moore 2003). There is also a steady increase in demand for business graduates (Byrne and Leonhardt 1996; Merritt 2000). Graduates from top schools are the most wanted and in recent decades these schools' programs highlight management theory (Lavelle et al. 2006).

modern marketing concept and contacting the customer during new product ideation, suggest that the role of the customer in the origin of ideas would increase over time. Therefore, our finding, that the role of the customer in the origin of ideas decreases over time is not trivial. This change occurs during the 20th century despite: 1) a growing emphasis on customer orientation; 2) an increasing prevalence of a formal management education that emphasizes the customer; and 3) the diffusion of technologies that support customer contact such as the telephone and at the end of the era – the Internet. One may argue that the decrease in the role of the customer is a result of increasing R&D expenditures, which emphasize the role of the (engineer) inventor. However, no clear evidence exists that expenditure on R&D as a percentage of GDP increase over time.[5] One could argue that the number of inventors increased during the second half of the 20th century.[6] However, while we find a decrease in the role of customers in the origin of ideas, we do not find a corresponding increase in the role of inventors (Figure 3).

A possible explanation is that over the 20th century firms increasingly perceived their customers as a source of complaints (Fornell and Wernerfelt 1987) rather than a source of ideas. An alternative explanation is the decreasing importance of the marketing function in business practice. For example, some studies suggest that in recent decades the importance of the marketing function in firms has declined (Day 1996; Nath and Mahajan 2008; Webster 1988; Webster, Malter, and Ganesan 2005). Another possible explanation is that over time firms learned that asking customers about new products is more productive during late development stages than during ideation stages. In late development stages, the customers better understand the product and can easily translate the innovation to actual purchase situations (Dolan 1993), than during the search for ideas, where the innovation is not even a concept. Because scholars and practitioners associate customer input with sustaining, thus imitative technology (Christensen and Bower 1996; Frosch 1996), a relevant question is whether the over-time decline in the role of the customer is coupled with a decline over time in the role of imitative technology. We plot over time the mean role of imitative, novel and exaptive technology in the origin of ideas (Figure 4). The role of novel technology demonstrates a clear decreasing trend (r = -.153, *p*

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[5] Data on R&D expenditures at a macro-level is only available for a limited and recent period. Still, R&D expenditures in the US between 1996 and 2006, for example, remains quite stable, with fluctuations between 2.55% in 1996, 2.76% in 2001 and 2.61% in 2006 (World Development Indicators of the World Bank).
[6] For example, annually awarded engineering PhD degrees increased from 2500 in the late 1970s to 5421 degrees in 2000 (The US Census Bureau Statistical Abstracts).

= .039) while the role of imitative technology seems to somewhat decrease until 1950s and increase afterwards. Indeed, the correlation between imitative technology and a time trend is insignificant (r = .108, $p > .1$). The time trend is also insignificant in a regression model based on Equation 2 where the dependent variable is the role of imitative technology (Table 5 Column b). However, when comparing imitative technology during the first vs. the second half of the 20th century, the role of imitative technology is significantly higher in the second half of the 20th century compared with the first half (3.37 vs. 2.91 respectively, $p = .031$). This finding is in line with prior notions that firms may rely more and more on their already established knowledge (Zahra, Sapienza, and Davidson 2006), and lose the struggle of repeatedly coming up with novel ideas (Bayus 2013). This finding indicates that the second half of the 20th century has witnessed a decrease in the role of the customer along with an increase in the role of imitative technology in the origin of ideas. These two trends question a connection between customer contact and imitative technology, supporting the discriminant validity of our measures.

Fairly recent innovation theory claims that “the contribution of users is growing steadily larger as a result of continuing advances in computer and communications capabilities” (von Hippel 2005, p. 2). Because scholars attribute these proposed trends to post-internet periods, they do not present a challenge in our study, which samples ideas for earlier innovations. Still, such evidence of using internet and other crowdsourcing technologies for the sourcing of ideas using customers (Bayus 2013) bears hope that the role of the customer will regain some of the esteem it lost during the 20th century despite the widely stated customer focus. Future research can examine if customers become aware of technological trends (von Hippel 2005) more than they used to, and consequently their contribution to superior benefits may increase.

Implications

This research has implications for managers and academics. First, managers can learn which agent and which technology in the origin of the idea contribute to superior benefits of the innovation and allocate their resources accordingly. Second, managers can use novel technology solutions for internal problems to serve external customers. For example, in the 1940s, the AT&T labs developed a telephone with push buttons instead of a dial to expedite and ease operators’ work. This technology was the origin of the idea for the touch-tone telephone marketed to customers in the 1960s. Similarly, in 1973, in an attempt to solve a work efficiency problem, a Xerox lab engineer connected the lab's computers to each other. This technology was the origin of the Ethernet idea, enabling local computer networks.

Third, exaptive technology seems to possess an unfulfilled potential (Figure 4) for firms' managers seeking ideas for innovation. In their quest for ideas for new ideas, managers should actively rethink how their technology can serve customers in domains different than the ones they currently serve. For example, 3M capitalized on idea originating from exaptive technology for Scotch tape: the company adapted the concept of adhesive tape from car painting to food wrapping. Managers should also canvass other product domains and identify plausible technology shifts to their own product domain. Exaptation is attractive for managers because (1) novel technology bears great risks for firms (Katila 2002; Sorescu and Spanjol 2008) whereas exaptive technology is less risky as the technology has already proved functioning in its original domain, and (2) adapting existing technologies is cheaper and less time-consuming than innovating from scratch. Exaptive technology is a promising venue for research as well: It is not studied much in the literature, conceptually or empirically, despite its superiority in reduced risks and superior benefits.

Limitations and Future Research

This paper has several limitations that could benefit from further research. First, we analyze a specific set of notable innovations. Whereas one could easily differentiate between radical and incremental and successful and failed innovations within the innovations sampled, future research can analyze innovations that are not notable to ascertain their origins. Second, while this study sought cross-industry generalizations, future research can focus on a single industry or a single decade and provide deeper industry-level insights. Third, while this study included failed innovations (unlike past research), future research could account for a larger portion of innovations that failed, and include data such as sales or market share. Fourth, public historical records do not document everything. Whereas notable innovations are well recorded in the public domain (Hargadon and Douglas 2001), future research can examine in-depth the origin of ideas from the unpublished internal records of firms.

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Table 1 - Descriptive Statistics and Correlations of rated variables

Variable	M	SD	1	2	3	4	5	6	7	8	9
1. Superior benefits	4.93	1.13	1								
2. Role of Customer	2.72	1.43	.023	1							
3. Role of Inventor	5.98	.93	.063	-.727**	1						
4. Role of Imitative technology	3.13	1.65	-.381**	.128+	-.138+	1					
5. Role of Novel technology	5.04	1.49	.464**	-.079	.129+	-.696**	1				
6. Role of Exaptive technology	1.75	1.31	.068	-.047	.039	-.254**	-.274**	1			
7. Creativity	4.96	1.06	.685**	-.085	.160*	-.525**	.548**	.058	1		
8. Practices disruption	4.35	1.45	.712**	.115	--.053	-.168*	.295**	-.052	.521**	1	
9. New to firm/inventor	3.27	1.12	.479**	.111	-.028	-.365**	.373**	.098	.553**	.273**	1

+p < .1 *p < .05 **p < .01

Table 2 - Correlations of Organizational Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. User	1											
2. Entrepreneur	.173*	1										
3. Scientist	-.093	.076	1									
4. Engineer	.057	.204**	.222**	1								
5. Layperson	.156*	.179*	-.152*	-.243**	1							
6. Solo inventor	.262**	.486**	.240**	.139+	.214**	1						
7. Firm size	-.054	-.231**	.113	-.087	-.144	.000	1					
8. Rise to new firm	.174*	.225**	.000	.066	.026	.280**	-.077	1				
9. Survives today	.097	.053	.067	.019	.184*	.093	-.145	.164*	1			
10. Start year	-.121	-.194**	.041	.031	-.300**	-.229**	.222*	-.231**	-.232**	1		
11. Survival in years	.121	.134+	.038	.002	.303**	.209**	-.229*	.249**	.721**	.786**	1	
12. Time to market in years	-.121	-.194**	.041	.031	-.300**	.229**	.222*	-.231**	-.232**	.999**	-.786**	1

+p < .1 *p < .05 **p < .01

Table 3 - Effects of the Origin of Idea on Innovation's Superior Benefits Standardized coefficients

	Dependent variable	(a)	(b)	(c)	(d)	(e)
Agent:	**Customer**	**-.447***	**-.406***	**-.374***	**-.381***	**-11.070***
	Inventor	-.057	-.013	.058	-.080	-2.708
	User	.137*	.136*	.118*	.121*	.083+
	Private individual or individual in firm	.050	.055	.077	.066	.079
	Inventor is entrepreneur					-.026
	Inventor is scientist					-.014
	Inventor is engineer		.127**	.103*		.078
	Inventor is layperson					.014
Technology:	Imitative technology	-.025	.026	.006	.075	.068
	Novel technology	.272**	.254**	.256**	.219*	.205*
	Exaptive technology	**.195****	**.187****	**.171****	**.195****	**.164****
	1900-13					
Time effects:	1914-17	-1.204	-1.037	-.580	-.413	
	1918-38	-.391	-.408	-.188	-.336	
	1939-45	-.340	-.129	-.102	-.194	
	1946-99	-1.326	-.882	-.929	-1.525	
	Customer*1900-13					
	Customer*1914-17	.206	.174	.147	.020	
	Customer*1918-38	.385	.399+	.345	.333	
	Customer*1939-45	.285+	.206	.223	.209	
	Customer*1946-99	.581*	.476+	.519*	.601*	
	Inventor*1900-13					
	Inventor*1914-17	1.121	.978	.546	.504	
	Inventor*1918-38	.082	.073	-.117	.078	
	Inventor*1939-45	.182	.017	.030	.105	
	Inventor*1946-99	.823	.447	.482	1.027	
	Time trend					-.583
	Time trend*customer					2.835
	Time trend*Inventor					11.031
Organizational & control variables and industry effects:	Large firm (vs. small)	.025	.040	.064	.009	.024
	Innovation gave rise to a new firm	-.011	-.015	-.003	-.033	-.010
	Creativity				.284**	.252**
	Practices disruption	.620**	.628**	.612**	.523**	.528**
	New to firm/inventor	.156*	.148*	.138*	.040	.053
	Electrical devices					
	Transportation			-.047		-.027
	Textile			-.118		-.105*
	Food & agriculture			-.154**		-.096+
	Computation			-.066		-.036
	Communications			-.083		-.097+
	Drugs & medical			-.047		-.013
	Chemical – food			-.132**		-.125**
	Amusement, furniture, house			-.059		-.077
	R^2	.693	.693	.740	.723	.746
	R^2 adjusted	.648	.648	.684	.680	.701
+p < .10 *p < .05 **p < .01		$F_{(23,156)}$ = 15.37**	$F_{(24,155)}$ = 15.61**	$F_{(32,147)}$= 13.11**	$F_{(24,155)}$ = 16.91**	$F_{(27,150)}$ = 16.40**

Table 4 - Hazard Model - probability of an innovation to die - Unstandardized coefficients (SE)

		(a)	(b)
	Superior benefits	-.532(.256)*	-.566(.278)*
Agent:	Customer	.209(.177)	.244(.190)
	Inventor	.644(.321)*	.587(.322)+
	User	-1.057(1.112)	-.973 (1.127)
	Private individual or individual in firm	.395.(.668)	-.130(.710)
	Inventor is entrepreneur	.310(.428)	.494(.454)
	Inventor is scientist	-.423(.665)	-.255(.729)
	Inventor is engineer	.417(.410)	.044(.443)
	Inventor is layperson		
Technology:	Imitative technology	.406(.189)*	.395(.205)+
	Novel technology	.151(.219)	.074(.236)
	Exaptive technology	.230(.166)	.250(182)
Additional control variables and industry effects:	Large firm (vs. small)	.113(.570)	-.213(.615)
	Innovation gave rise to a new firm	-1.599(.785)*	-1.554(.816)+
	Creativity	.607(.245)*	.790(.273)**
	Practices disruption	-.437(.175)*	-.488(.194)*
	New to firm/inventor	-.426(.231)+	-.540(.245)*
	Electrical devices		
	Transportation		.740(.539)
	Textile		-.449(1.129)
	Food & agriculture		.319(.774)
	Computation		1.158(.612)+
	Communications		-.103(.826)
	Drugs & medical		.872(.861)
	Chemical – food		1.230(.931)
	Amusement, furniture, house		-.803(.594)
+p < .10 *p < .05 **p < .01		$Chi^2_{(16)}$ = 44.12**	$Chi^2_{(24)}$ = 59.53**

Table 5 - The Role of Customer and Imitative Technology in the Origin of Ideas as A Function of Time Standardized coefficients

	Dependent variable:	(a) Role of the Customer		(b) Role of Imitative Technology	
	Year		-.169*		-.052
Control variables	Creativity	-.332**	-.341**	-.541**	-.544**
	New to firm/inventor	.234**	.188*	-.105	-.119
	Practices disruption	.224**	.197*	.142+	.134+
	R^2	.080	.105	.299	.301
	R^2 adjusted	.064	.084	.287	.285
+p < .1 *p < .05 **p < .01		$F_{(3,176)} = 5.14$**	$F_{(4,175)} = 5.25$**	$F_{(3,176)} = 25.05$**	$F_{(4,175)} = 18.89$**

Figure 1 - Theoretical model

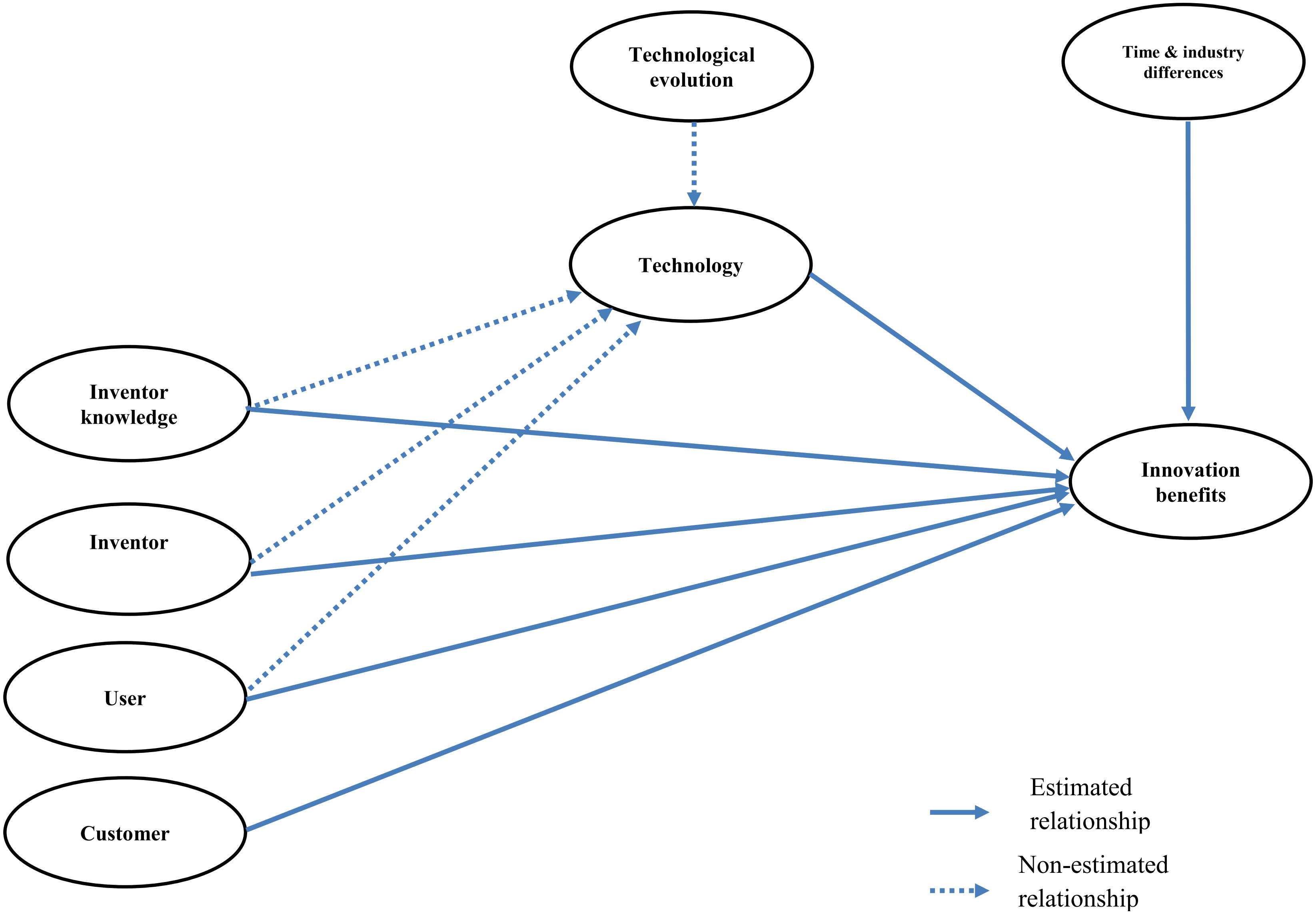

Figure 2 - Theoretical model – constructs and measures

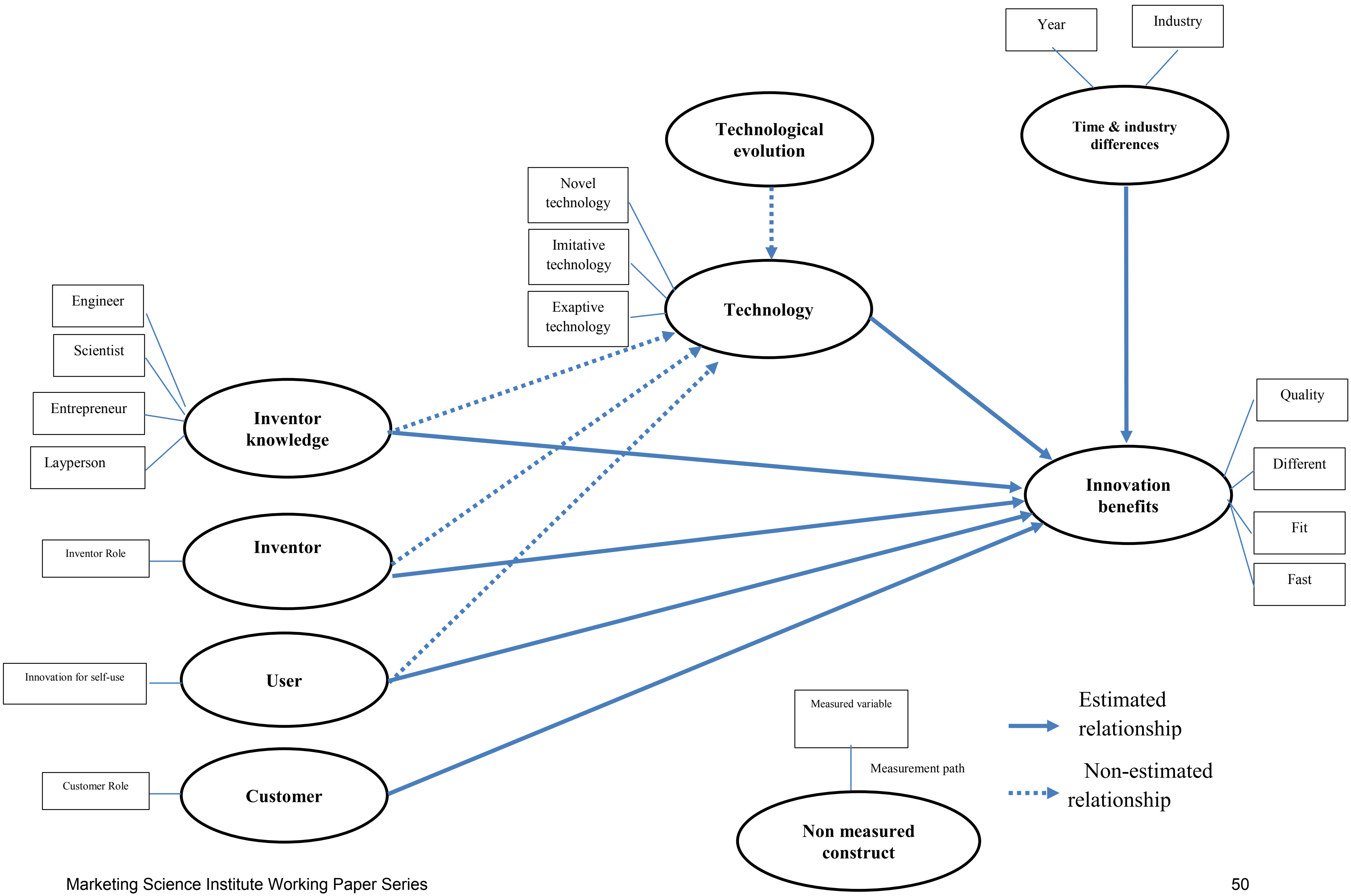

Figure 3 - Mean Role of Customer and Inventor over Time

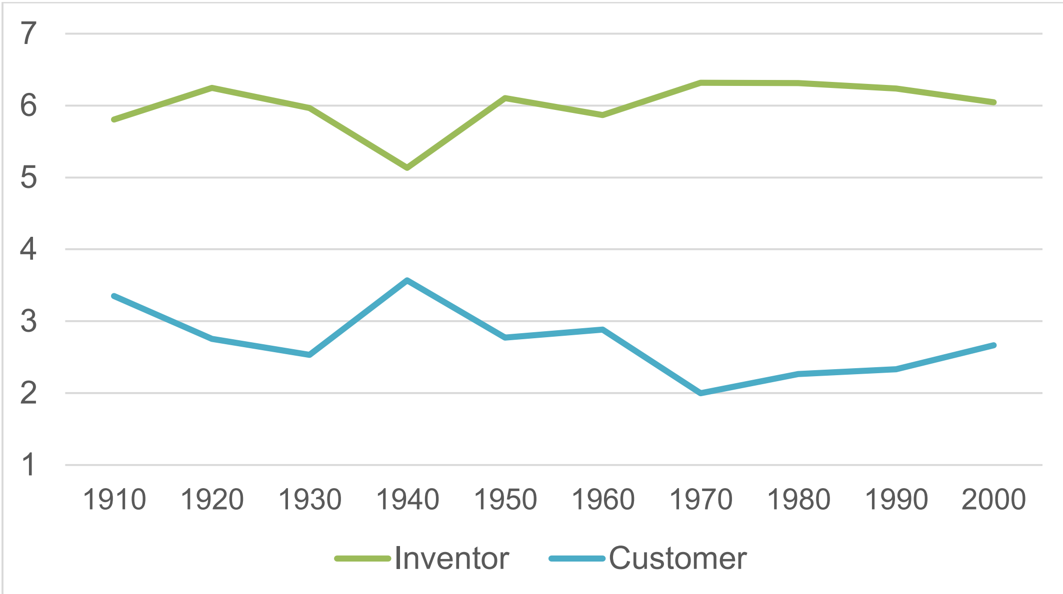

Figure 4 - Mean Role of Technology over Time