Industrial Marketing Management 66 (2017) 1–12

Contents lists available at ScienceDirect

Industrial Marketing Management

journal homepage: www.elsevier.com/locate/indmarman

Non-customers as initiators of radical innovation☆

Stav Rosenzweig

Ben-Gurion University of the Negev, The Department of Management, The Guilford Glazer Faculty of Business and Management, POB 653, Beer Sheva 84105, Israel

ARTICLE INFO

Keywords:
Radical innovation
Non-customers
Suppliers
Learning
Historical approach

ABSTRACT

Customers who initiate innovation is a topic frequently discussed in the marketing literature. However, the literature largely ignores non-customers – individuals or firms not using products in the category – as potential initiators of innovation in general and of radical innovation in particular. We argue that non-customers have high knowledge of their own needs, but their knowledge of technology is insufficient to self-generate an innovation. By approaching a potential supplier with a high knowledge of technology but an insufficient knowledge of the need, a unique dyad is created, characterized by a bilateral knowledge gap that stimulates increased learning and co-creation of a potentially radical innovation. We use an historical approach to examine the technological and social antecedents and consequences of three innovations initiated by non-customers: air-conditioning, the pill, and the jeep. We contend that non-customers can initiate innovations that may potentially change industries, create new markets, and have long-term social and economic effects.

1. Introduction

Customers who initiate innovation is a topic frequently discussed in the marketing literature. However, the literature largely ignores non-customers as potential initiators of innovation in general, and of radical innovation in particular. If non-customers can initiate innovation, then in ignoring them firms might completely miss opportunities to develop important and perhaps radical innovations. Such missed opportunities can have grave consequences, because (1) firms invest billions of dollars every year on R & D and on developing radical innovation in particular (European Commission, 2014; Financial Times, 2014; Wall Street Journal, 2013), and allocating R & D expenditures effectively is critical; and (2) if non-customers can initiate radical innovation but are erroneously ignored by firms, then the entire business network of firms and its management may be critically flawed. The tremendous amounts of money put into market surveys may render the investment in them suboptimal. Firms might miss out on radical innovations that would enable technological leapfrogging, establishing themselves as market leaders and generating new markets for them.

We define non-customers as individuals or firms that constitute the target market of the innovation, but (1) are not using products in the category (that is, if they use substitutes at all, they are ones from other categories), (2) are not previous customers of the firm that generated the innovation for them in that category, and (3) do not possess sufficient technological knowledge to develop the innovation without the help of experts. Accordingly, we define a non-customer-initiated innovation as a specific new product that the non-customer needed, and where this need was conveyed to a potential supplier. Such an initiation may occur when the non-customer and potential supplier interact and the non-customer conveys a need to the supplier, either explicitly asking for help, or implicitly conveying a latent need (for example by conducting a work routine that reveals a need) (Lynn, Morone, & Paulson, 1996). Finally, we define radical innovation as an innovation based on a technology that substantially differs from the technology of existing products, and that provides superior benefits to (future) customers compared with existing products (Chandy & Tellis, 1998).

Radical innovations change existing markets, generate new markets, and change habits and perceptions (Christensen, Anthony, & Roth, 2004; Christensen & Bower, 1996; Garcia & Calantone, 2002). As such, they are likely to have a considerable effect on customers, industries, and even society. The purpose of this study is to answer the following research question: Can non-customers initiate radical innovation? To answer this question, we use an historical approach (see Golder, Shacham, & Mitra, 2009; Hargadon & Douglas, 2001; Rosenzweig, Tellis, & Mazursky, 2015). We examine three historical innovations by studying their detailed history and their technological and social antecedents and consequences. We subsequently estimate how radical they actually were through assessing their longitudinal effects. These three innovations represent industries, end-customers, technologies, and periods that differ from one another. These differences control for idiosyncratic effects, and provide – with necessary caution – a preliminary base for potential generalization to other industries, customers, technologies, and periods (Lynn et al., 1996). For each innovation, we focus on a single dyadic relationship during the relationship

☆ The author thanks Leila Feldman and Noah Schwarz for their research assistance.
E-mail address: stavro@som.bgu.ac.il.

http://dx.doi.org/10.1016/j.indmarman.2017.06.013
Received 29 April 2014; Received in revised form 15 April 2016; Accepted 10 October 2016
Available online 19 July 2017

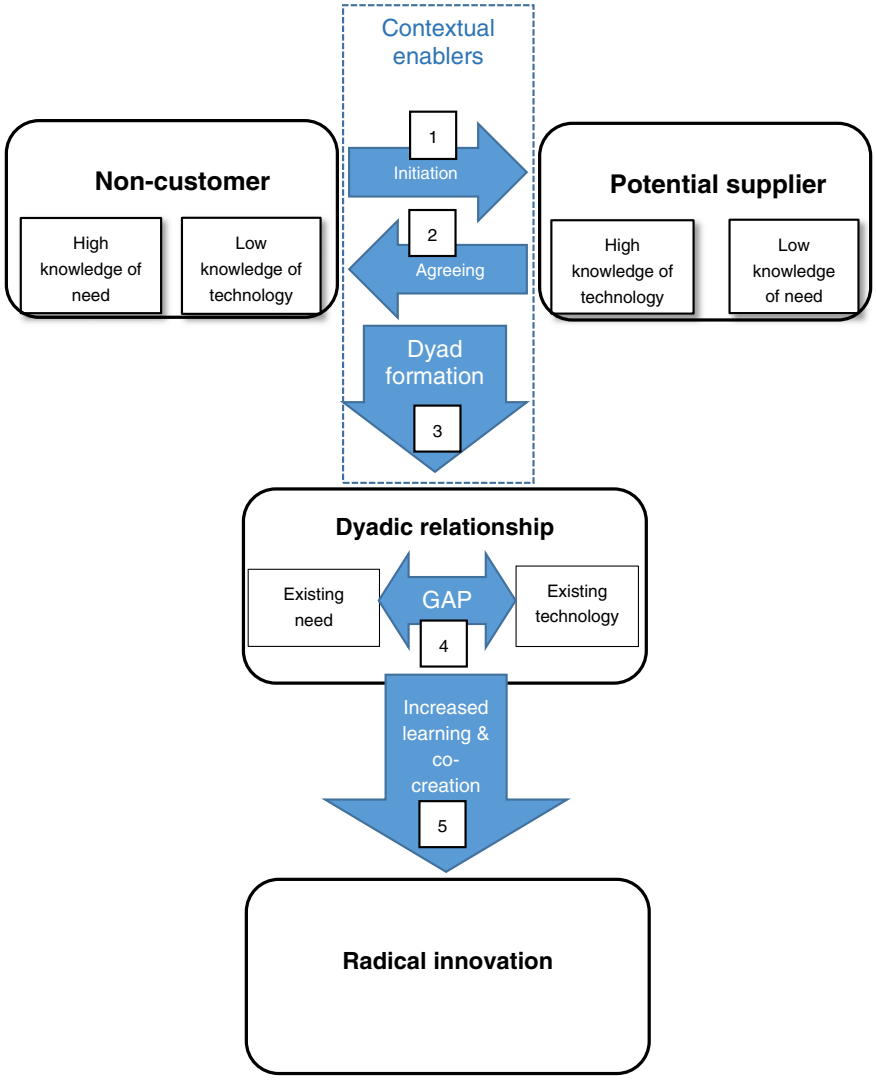

Fig. 1. Non-customers as initiators of radical innovation.

formation, in what eventually became a business network (Håkansson & Ford, 2002; Vargo & Lusch, 2008).

The paper is organized as follows: first, we present the research gap and offer a theoretical framework for explaining how non-customers can initiate the co-creation of radical innovation. We then describe three historical innovations, with the circumstances of their emergence and the consequences of their introduction. Next, we analyze our findings. The final section discusses the contributions, findings, and limitations, and suggests opportunities for future research.

2. Theoretical framework

The marketing literature advocates that to generate innovation, firms should focus on customers (e.g., Narver, Slater, & MacLachlan, 2004; Urban & Hauser, 2004) and co-create the innovations with them (Jalkala & Salminen, 2010; Kohtamäki, Partanen, & Möller, 2013). However, the literature largely neglects opportunities to co-create innovations with non-customers, and radical innovation in particular. Indeed, the studies of Christensen and colleagues (e.g., Christensen, 1997; Christensen & Bower, 1996) suggest that focusing on potential customers can lead to radical or disruptive innovation. However, these studies relate to customers of substitutes in the category (versus non-customers). More importantly, these studies focus on the suppliers as the initiators of the innovation.

But can the non-customers be the initiators of radical innovation? Can co-creating with non-customers produce radical innovation? The literature does not address these questions, and the following theoretical framework intends to bridge this gap in the literature. We offer a theoretical framework for the co-creation of radical innovation by non-customers – as initiators – and their potential suppliers. We present the framework in Fig. 1, and elaborate upon it next.

2.1. The initiation of a dyadic relationship between non-customers and potential suppliers

Consider the case where a firm or an individual realizes a need, and no available product meets this need. If this firm or individual has insufficient technological knowledge to develop a product themselves, they can approach a potential supplier that may possess the required knowledge (Edvardsson, Holmlund, & Strandvik, 2008) (Fig. 1, step 1). The potential supplier has its own customers, and has insufficient knowledge of the need expressed by the non-customer. Once an interaction between the non-customer and potential supplier is established, the potential supplier realizes its insufficient knowledge of the need, but high knowledge of the technology, and considers reciprocating with the non-customer.

Agreement of the potential supplier to develop the needed innovation (Fig. 1, step 2) is contingent upon two critical issues. First, given its low knowledge of the need, the potential supplier must consider the ability of the non-customer to mobilize the required knowledge about

Table 1
Differences between air conditioning, the pill, and the jeep.

Theme		Air conditioning	The pill	The jeep
Initiator	Customer type Usage of substitutes from other categories	B2B The customer (Sackett-Wilhelms Lithographing Company) did not use prior products from the same or different categories.	B2C Some women used a variety of substitutes, whereas others did not. None of the extant substitutes were from a similar product category.	B2B The Army used lightweight vehicles such as motorcycles for reconnaissance and messenger duties, and heavy vehicles such as trucks and armored vehicles. The specific category of lightweight heavy-duty vehicles did not exist in the US, nor did a similar combination vehicle.
	Non-customer request channel	Formal business transaction	Formal request backed up with considerable donations for development.	Formal bid.
	Non-customer involvement in the co-creation of the innovation	After specifying the initial criteria, the involvement of the initiator was primarily through an interaction between the first consultant of Sackett-Wilhelms and Buffalo Forge.	Sanger and McCormick were considerably involved in the entire development process; McCormick moved to be closer to the lab. Other potential users and clinics voluntarily and eagerly participated in the clinical trials.	The Army set the initial criteria but also continuously evaluated progress throughout the development process.
Potential supplier	Willingness to develop the innovation	Despite the difficulty, Buffalo Forge was willing to accept the challenge and develop the required innovation.	Institutions and pharmaceutical firms were reluctant to develop the innovation, primarily because of the hostile social atmosphere.	Car manufacturers were reluctant to develop the innovation. Initially, only one firm was willing to take on the project, and only after military personnel applied pressured.
Other	Social disposition toward the innovation	Indifferent	Strong objections	Indifferent
	Important milestones in development	1902 — non-customer initiation of contact with potential supplier 1906 — patent granted 1906 — commercialization	1953 — non-customer request articulated by Sanger and McCormick 1954 — clinical trials 1957 — commercialization as menstrual disorders treatment 1960 — FDA approval as a contraceptive	1940 — formal bid issuing 1940 — prototype delivered 1941 — mass production by Willys-Overland and Ford

the need, to facilitate joint learning (Batt & Purchase, 2004). Second, the potential supplier must recognize considerable potential benefits that would motivate it to agree to create the partnership. The benefits must be such that they outweigh the monetary and resource allocation costs.

2.2. The bases for dyad formation

The formation of a non-customer–potential supplier dyadic relationship (Fig. 1, step 3) has three minimum characteristics. First, there has to be a balanced knowledge gap; that is, the non-customer has a high knowledge about the need but insufficient knowledge about the technology, and conversely, the potential supplier has a high knowledge of the technology but insufficient knowledge about the need.

Second, both actors must perceive considerable potential benefits. For the non-customer, first and foremost is the benefit of addressing its need, which could have direct financial or technological consequences. However, addressing the need is likely to have additional financial benefits, such as gaining a competitive advantage, reducing costs (e.g., production costs), reducing the costs for its customers, or increasing revenues. These potential benefits motivate the firm to approach the potential supplier despite transactional costs. For the potential supplier, a direct financial benefit is the potential increase in revenues associated with the dyad itself, once the need of the non-customer is met. Other potential benefits are new customers in the non-customer's markets that may be interested in the technological solution. The technological solution may also assist the supplier in serving its existing customers. Mutual benefits may include enjoying the intellectual challenge of meeting the non-customer's need, or increasing the diversification of one's professional network, thereby increasing the likelihood of new opportunities and knowledge spillover (Rosenzweig & Grinstein, 2016; Rosenzweig et al., 2016). Thus, the professional, intellectual, technological, and especially financial benefits of both actors are considerable, creating the primary basis for the dyad.

Third, innovation requires the appropriate social, technological, and organizational settings (Johnson, 2011; Mokyr, 1998; Moss Kanter, 1996). We argue that the initial contact, the suppliers' agreement, and the formation of the dyadic relationship (steps 1–3 in Fig. 1) are contingent upon the suitable contextual enablers, which we discuss next.

2.3. The role of contextual enablers in the dyad formation

We follow prior literature and argue that only with the backdrop of necessary social and technological conditions can dyads of non-customers and potential suppliers emerge and subsequently generate radical innovation. A number of studies have recognized the existence of an appropriate *technological setting* as a necessary condition for the further evolution of technology (e.g., Rosenzweig & Mazursky, 2014). This setting provides the platform of the absorptive capacity necessary for further technological development (Cohen & Levinthal, 1990). To promote technological innovation, an extensive and longitudinal process occurs — not in a single firm, but across multiple firms and even industries (Rosenzweig, 2017; Srinivasan, 2008). For example, a non-customer could have asked for a system to deliver messages over a global network in 1940, however the technology at the time was insufficiently developed to enable any supplier to develop an e-mail-like innovation.

Similarly, the right *social setting* is also essential for the emergence of new technologies and novel scientific discoveries (e.g., Ogburn & Thomas, 1922; Simonton, 1978). A number of scholars argue that the frequent occurrence of simultaneous discoveries and innovations is a strong indicator that social contextual enablers are required for meaningful technological progress to occur (see Liberman & Wolf, 2015; Ogburn & Thomas, 1922; Simonton, 1978, 2003).[1]

[1] We provide examples in Section 4 below.

Table 2
Similarities between air conditioning, the pill, and the jeep.

Theme	Similarities
Solving a problem	Non-customers who were looking for a solution to their problems initiated all three innovations. For air conditioning, Sackett-Wilhelms faced a problem in color printing. For the pill, women were looking for a solution to unwanted pregnancy. For the jeep, the Army faced the problem of transferring people and equipment over hard terrains.
Non-customers' attempts to solve the problem	In all three innovations, non-customers were active and searched for ways to solve their problem. When the first engineer Sackett-Wilhelms' approached was incapable of delivering a suitable solution, the company moved on to an alternate firm — Buffalo Forge Company. For the pill, women searched for ways to solve the problem. Sanger and McCormick initiated contact with Pincus to develop a solution. For the jeep, the Army actively searched for solutions, turning to a large number of car manufacturers and putting Bantam under pressure to accept the contract.
Potential benefits for non-customers	In all three innovations, benefits for the non-customers were far greater than solving a specific problem. For air conditioning, Sackett-Wilhelms could gain advantage over competitors by (1) offering faster delivery (if printing presses did not need to delay operations due to inadequate humidity and temperature) and by (2) offering a higher quality printed matter. Sackett-Wilhelms could also reduce operation costs by reducing the waste of inaccurate printing. For the pill, the medical, economic and social costs of unwanted pregnancy could be avoided and women's control with all associated consequences could be achieved. For the jeep, the Army could match and surpass competitors' armies and gain battlefield superiority, reduce purchase costs, and increase fuel savings.
Potential benefits for potential suppliers	In all three innovations, benefits for the potential suppliers were far greater than increasing revenues by solving the specific problem. For the air-conditioner, Buffalo Forge could supply new customers in new markets and use its innovation to serve current customers in current markets, because it could potentially gain a meaningful technological advantage over its competitors. For the pill, Pincus' laboratory could gain an advantage in developing synthetic hormones, gain the reputation of an innovative experimental lab, and increase the number of customers, donations, etc. For the jeep, Bantam could improve its business position by catering to industrial customers, improving its current car models by introducing jeep elements, and increase its brand equity given its relations with the Army.
Knowledge of technology and need	In all three innovations, the initiators realized they did not have the skill, knowledge, or capability to solve their own problem. The initiators needed someone with more experience and expertise in a specific field to help solve their problem. In all three innovations, non-customers were highly knowledgeable about the need. For the air conditioner, Sackett-Wilhelms knew exactly what they wanted (pre-known level of humidity and temperature to enable quality printing) and how it would help their operation. For the pill, both Sanger and McCormick had considerable experience with Planned Parenthood and thus with women's specific needs and abilities. They could specify the need of an oral contraceptive under women's control. For the jeep, the Army officials specifying the needs were representatives of military forces who were highly knowledgeable of operational needs. They could specify a heavy-duty lightweight vehicle with specified weight, horsepower, etc.
Overlapping knowledge	All three dyadic relationships shared basic overlapping knowledge: for air-conditioning, both parties realized that humidity and temperature affected performance, and could share engineering knowledge. For the pill, given their educational and occupational training, both Sanger and McCormick had paramedical training, which overlapped the knowledge of Pinkus and the development team. For the jeep, both the Army and Bantam shared knowledge regarding basic mechanization and the combination of elements that can produce a functioning mechanical platform.
Success and generating new markets	All three innovations were successful, and subsequently manufacturers and competitors introduced additional improvements. The air conditioner generated a market for industrial, public places, and home and car air conditioners; the pill generated a market for oral contraceptives and a market for lifestyle drugs; the jeep generated a market for lightweight work and leisure vehicles and for SUVs.
Social and economic longitudinal effects	Air conditioning affected industries (e.g., printing, textile), labor management, recreational activity (movies, theaters, and shopping malls), housing prices, and human settlement patterns. The pill affected women's participation in the workforce, and social status, increase in household income, economic changes in the pharmaceutical industry, etc. The jeep affected perceptions of safety (regarding car accidents and crime), facilitated militant perceptions, affected women's own perception and social status, etc.

Accordingly, we argue that technological and social contextual enablers effectively provide the *macro-level determinants* of the radical innovation generated by the dyad. The dyadic relationship and its parties' organizational enablers, in turn, effectively provide the *micro-level determinants*, that is, the specific design of the radical innovation. Therefore, whereas contextual enablers may theoretically provide an opportunity for more than one concurrent innovation, the specific dyad is responsible for the micro-level determinants of the specific radical innovation. This tightrope between macro determinants and micro events of a more accidental nature is a fundamental discussion in historiography (e.g., Carr, 1961). The non-customer is therefore the initiator, and thus an igniter, of a process that could theoretically be ignited by a different entity. The non-customer considerably affects the final product, given its particular need and its choice of a potential supplier as a co-creator. Had a different dyad been formed, the macro-determinants would have been similar but the micro determinants may have been different, fitting the need and capabilities of a different dyad. We discuss the characteristics of the dyadic relationship next.

2.4. A dyadic relationship of increased learning

Why does this specific relationship lead to radical (as opposed to incremental) innovation? An overlapping of basic knowledge is required for the creation of a sustainable dyad. This mutual knowledge provides a platform of communication and facilitates joint learning.[2] However, we contend that a critical characteristic of this relationship is the *gap between the existing need of the non-customer and the existing technology of the potential supplier* (Fig. 1, step 4). This gap stimulates increased learning, which in turn stimulates radical innovation, as we elaborate next.

2.4.1. Knowledge gap and increased learning

Because the supplier has limited knowledge of both the non-customer and its market, the collaboration between the two parties is critical for the learning process. That is, the gap can only be bridged through a relationship where the non-customer and the potential supplier are involved in intensive learning from each other. The potential supplier allocates services, physical resources, and infrastructure, with the aim of meeting (future) customer needs (Grönroos, 2011), but because it faces an entirely new market, it cannot bridge the gap alone. Without the collaboration of its counterpart, the potential supplier cannot achieve the deep understanding of need that is critical for turning the vision of an innovation into a viable technology (Möller, 2010).

In a similar vein, the non-customer cannot remain passive, and must

[2] We provide examples in Section 5: Analysis and results.

actively collaborate with the potential supplier during this learning process (Vargo & Lusch, 2004). Both parties must have access to each other's knowledge sources and joint intellectual capital, coordinate their activities, and make joint decisions (Baraldi, Proença, Proença, & de Castro, 2014; Ford & Håkansson, 2006; Håkansson & Ford, 2002; Vargo & Lusch, 2008). Put differently, the large knowledge gap stimulates *increased* learning, precisely because interaction between parties with entirely different perspectives on a problem can facilitate innovation (Moss Kanter, 1996). Accordingly, prior research suggests that a large gap between existing and desired technology stimulates radical innovation, whereas a small gap does not (Rosenzweig & Mazursky, 2014).

If the initiator is a customer in the category (rather than a non-customer), the knowledge gap between the parties would be considerably smaller because suppliers know customers in the category and are largely aware of their needs. Ideally, suppliers keep adapting their technology to meet customers' needs (see Edvardsson et al., 2008). However, they are unaware of needs of non-customers, and therefore their technology will not fit non-customers' needs. Moreover, because non-customers are unaware of what is typical in the category, they are cognitively free of conventional technologies, and are not entrenched in an existing consideration set. They can thus articulate how they would like the innovation to function — free of prevalent contemporary conventions (Moss Kanter, 1996). This freedom can ignite powerful innovations. Thus, unlike for customers, for non-customers as initiators, the gap between existing need and existing technology is likely to be considerable, and thus stimulate increased learning.

2.4.2. Relational capital and increased learning

Relational capital is the social capital embedded in the specific relationship, and entails trust, openness, and a sense of mutual future circumstances (Kohtamäki et al., 2013). Relational capital in the specific dyad of non-customer and potential supplier has unique characteristics that facilitate learning (Chang & Gotcher, 2007). First, it is characterized by increased trust. Whereas dyads largely have an underlying tension between learning and protecting (Kale, Singh, & Perlmutter, 2000), the non-customer and potential supplier are not active in the same markets. Consequently, stealing ideas from one another has no merit, and neither party takes a considerable risk by subjecting its knowledge to its partner. This lack of risk drives increased trust, which provides grounds for an effective dyad (Kohtamäki et al., 2013; Zaheer, McEvily, & Perrone, 1998), where parties can focus on learning rather than dividing their attention between learning and protecting. Second, the increased trust leads to an increased openness that facilitates greater learning (Kale et al., 2000).

Researchers have connected learning processes with high levels of innovation (e.g., Moorman, 1995; Romijn & Albaladejo, 2002). More specifically, prior research has indicated that high levels of firm learning are positively and significantly associated with the firm's innovativeness (Calantone, Cavusgil, & Zhao, 2002), and that a firm culture that emphasizes learning achieves higher levels of innovativeness (Hurley & Hult, 1998). Therefore, increased learning is likely to lead to radical innovation.

In summary, we argue that two unique characteristics of the dyad drive increased learning (Fig. 1, step 5): (1) the large gap between existing needs and existing technology, which is the primary driver; and (2) the relational capital characterized by increased trust and openness. This increased learning, in turn, drives radical (vs. non-radical) innovation. Importantly, we argue that the gap can induce radical innovation when it is subject to (1) social, technological, or organizational contextual enablers (i.e., the gap is not too large), and (2) an effective dyadic relationship, especially given that more than in other innovation cases, a sizable gap requires a long-term commitment designed to co-create value for both parties (Vargo & Lusch, 2008).

3. Methodology

To answer the research question and establish the theoretical framework that we proposed, we use the historical approach and examine three innovations that were developed in the past (Hargadon & Douglas, 2001; Lynn et al., 1996). Such a retrospective view is valuable if one wishes to examine how radical the innovations have been, by examining their long-term social or economic consequences. We adhere to Golder's (2000) historical approach definition of "collecting, verifying, interpreting, and presenting evidence from the past" (p. 157; see also Woodside, 2010). As Hargadon and Douglas (2001) state, "Historical cases can provide the necessary distance to observe how an innovation both emerges from and reshapes its institutional environment" (p. 476). Prior studies used an historical approach when studying innovation, and in particular radical innovation (e.g., Bairstow & Young, 2012; Chandy & Tellis, 2000; Fullerton, 2011; Golder, 2000; Golder et al., 2009; Rosenzweig, 2015; Rosenzweig & Tellis, 2017; Rosenzweig et al., 2015; Sood & Tellis, 2005).

3.1. Theoretical sampling

This study is exploratory and takes an initial step in developing a comprehensive theory regarding non-customers as initiators of radical innovations. Accordingly, we use theoretical sampling because it enables the illumination of unique examples (Eisenhardt & Graebner, 2007; Woodside, 2010), and we strive to illuminate the existence of non-customer-initiated radical innovations and the unique antecedents and consequences of such innovations. The following criteria guided the sampling process, and evolved with the formulation of the theory (Glaser & Strauss, 1967), with the latter four designed to ground internal validity: (1) innovations that are well documented and whose documentation is public, so that our analyses and findings can be replicated (Stuart, McCutcheon, Handfield, McLachlin, & Samson, 2002); (2) innovations that were commercialized and that are at least 50 years old, to enable a true longitudinal perspective of both antecedents and consequences; (3) innovations "particularly suitable for illuminating and extending relationships and logic among constructs" (Eisenhardt & Graebner, 2007, p. 27); (4) having considerable variance in technology type, market structure, future target market (industrial vs. end consumer), and the time of the innovation; and (5) showing similarities that, combined together, create a holistic picture.

3.2. Sample selection and sources

Prior research suggests that examining single innovations is suitable for longitudinal research (Hargadon & Douglas, 2001; Herstatt & von Hippel, 1992). Still, to facilitate a comprehensive investigation of the phenomenon we observe, and to demonstrate its rigor (see Johnston, Leach, & Liu, 1999; Yin, 2009), we discuss three historical innovations: air conditioning, the birth control pill, and the jeep.

We used a wide range of sources to obtain information about the historical innovations. These sources include primary sources, such as patent applications and contemporary newspapers and magazine articles, as well as secondary sources such as industry magazines, biographical accounts, scholarly books, and peer-reviewed articles. Upon assembling this information, we closely examined each of these sources and carefully assessed their credibility, reliability, and the reoccurrence of information in multiple sources before including the information in our research (Barratt, Choi, & Li, 2011; Golder, 2000). During the course of this study we gathered a large volume of rich information on the studied innovations. Due to space limitations, we are only able to present here a fraction of this rich information. Thus, in accordance with our research question, we focus only on initiation and outline, contextual enablers, and longitudinal consequences.

4. Innovations' descriptions

4.1. Air conditioning

4.1.1. Innovation outline

The Sackett-Wilhelms Lithographing Company of Brooklyn, New York, a printing establishment, was engaged in multicolored printing that required the same page to go through the printer several times. At the debut of the 20th century this process posed a problem: humidity fluctuations made the paper swell or shrink, causing the colors to appear in the wrong place. The outcome was considerable waste or a drastic reduction in manufacturing speed (Simha, 2012). In 1902, with the help of William Timmis, a consulting engineer, Sackett-Wilhelms develop specific requirements to control the fluctuating humidity: a temperature range of 70–80 °F and a constant humidity level of 55%. Sackett-Wilhelms asked the Buffalo Forge Company in New York to build a device that would meet these requirements (Cooper, 1998; Ingels, 1952).

The Buffalo Forge Company was a manufacturer of heating and ventilation equipment for firms producing various goods, such as lumber and coffee (Cooper, 1998; Schellinger, 2008). The Sackett-Wilhelms project was assigned to Willis Carrier, a specialist in fans and ventilation (Ingels, 1952; Nagengast, 2002). Carrier decided to take a different approach than the ice-based cooling systems that had begun to appear in a small number of theaters and concert halls, and instead focused on treating humidity to achieve cooling (Nagengast, 1999). He first tried to dry the air with a chemical solution, and then to create a system that similar to heating, used cold rather than hot liquid running through a coil. However, these attempts proved inefficient (Ingels, 1952).

Carrier's next attempt to comply with the specific requests of Sackett-Wilhelms was by building a new device that cooled or heated water and sprayed the water into a chamber (Simha, 2012). The air treated in the chamber was then released back into the room. This new device was efficient because it controlled not only the temperature and humidity, but also the quality of the air (Cooper, 1998; Nagengast, 1999). Carrier patented this innovation in 1906, as an "apparatus for treating air" (US Patent 808,897).

Buffalo Forge soon realized the potential this device could have for textile mills. Because some textiles, such as cotton, are very sensitive to humidity levels, production relied on a specific level of humidity in the air. In 1906, Buffalo Forge sold an "air conditioner" to a cotton mill, and in 1907 it created a subsidiary company for heating, ventilating, and humidifying, with Carrier as vice president (Cooper, 1998).

4.1.2. Contextual enablers — social and technological background

Numerous technologies and patents for cooling and refrigeration, especially during the 19th century, preceded and enabled the technological leap described above (Nagengast, 1999). The first relatively efficient cooling system, using blocks of ice, is usually considered to be the 1889 Carnegie Hall system developed by Wolff (Cook, 2000; Golder et al., 2009). In 1901, Alfred R. Wolff – an independent heating and ventilation engineer – was tapped to design a heating and ventilation system for the New York Stock Exchange building. This system, similarly using blocks of ice, had a number of critical shortcomings, aside from being cumbersome and expensive (Cook, 2000; Cooper, 1998). Similar ice-based cooling systems were installed in the following years in theaters in New York and Philadelphia (Nagengast, 1999).

Social issues also played a role in both the need and later on in the diffusion of air conditioning systems. The influential work of Frederick Taylor on "scientific management", disseminated in the 1880s and 1890s, suggested the scientific investigation of every manufacturing task and the systematic improvement of the task (Mentzer, 2010). This work brought awareness to manufacturers of potential improvements in production processes. Coinciding with the introduction of air conditioning, several social researchers extolled the benefits of temperature control for improving workers' output, and as a consequence many firms were looking into increasing climate comfort (Ackermann, 2002; Koumparoulis & Solomos, 2012); manufacturers were open to the idea of improving working conditions for both production processes and workers. At the same time, department stores and cinemas were interested in climate control to attract customers, as part of the social trend of a "consumer society", which disseminated ideas of customers' consumption as an indication of their social status (Trigg, 2001).

This set of technological and social circumstances enabled Sackett-Wilhelms to realize that the problem could and should be solved, and Buffalo Forge to reciprocate — thus they co-created air conditioning.

4.1.3. Innovation consequences

The technological leap of Carrier made air conditioning a reality, but Carrier would not have developed it if Sackett-Wilhelms had not initiated the relationship. Carrier's company won the bid to provide air conditioning for the Congress in 1928 (Ackermann, 2002). During the 1920s home air conditioning started to appear, and by the 1950s it became more and more prominent, especially after the Carrier Corporation commercialized a relatively inexpensive and efficient window unit (Arsenault, 1984).

The innovation of air conditioning is one of the landmark inventions of the 20th century. It changed office buildings, homes, and the way of life. It changed architecture, as the porch became less attractive in hot areas compared with an air-conditioned interior. Some scholars even attribute a meaningful drop in fatal car accidents to air-conditioning in cars (Arsenault, 1984; Oi, 1997). Air conditioning has also had an extreme effect on the economy. First, it gradually brought about the end of the large ice-manufacturing industry (Rees, 2005). Second, it increased productivity in factories and drew people into malls and cinemas. Third, it increased home prices and rents in hot and humid areas. Fourth, car air conditioning became a considerable market, with over 90% penetration by 1990. By 2010, air conditioning had become a $63 billion worldwide industry, with Carrier's company still a prominent manufacturer (Arsenault, 1984; Oi, 1997; see also Carrier, 1929, p. 116).

Air conditioning also has had far-reaching social effects. It facilitated population growth in hot areas and changed settlement patterns, as people became more willing to settle in places with adverse weather conditions. In hot areas, where people retreated to their air-conditioned living rooms, social ties with friends and neighbors decreased (Arsenault, 1984). In addition, it has had a considerable positive effect on personal and public health (Ostro, Rauch, Green, Malig, & Basu, 2010), but a negative effect on the ozone layer (Daly, 2006; Farrington & Rugh, 2000).

4.2. The birth control pill

4.2.1. Innovation outline

Margaret Sanger was a nurse who had seen too many women fall to the perils of unwanted pregnancy, such as health risks and poverty. In 1916 Sanger and two associates founded the first Planned Parenthood clinic, in Brooklyn, New York. The aim of the clinic was to promote knowledge about contraception and distribute the contraceptives available at the time, such as female suppositories and condoms. Despite being promptly closed by the police, the clinic quickly reopened, and by 1941 there were 222 Planned Parenthood clinics in the US (Jordan, 2000). Despite the hostile social atmosphere at the time, women sought out the clinics and the information they provided. Sanger estimated that in 1916 she saw 480–500 women over a period of 10 days (Katz, 2002). The Comstock Law against lewd materials from 1873 made disseminating contraceptives or information about them illegal. Women who went to their doctors were turned away or told that abstinence was the only way to prevent pregnancy. Many women did

not even know what to ask for (Chen, 2002). Still, women wanted birth control, and despite the social atmosphere, many explicitly asked for it (Schoen, 2005).[3]

Katherine McCormick, a wealthy heiress and suffragette, had been involved with Planned Parenthood since 1917. Through their involvement with Planned Parenthood, Sanger and McCormick realized the importance of having a foolproof method of contraception that women could control themselves. In 1953 they met with Dr. Gregory Pincus, the head of the Worcester Foundation for Experimental Biology, and asked him to develop an oral birth control. McCormick accompanied her request with large sums of money. Both women were personally involved in the process, and McCormick even relocated to be closer to Pincus's laboratory (Junod & Marks, 2002; Reed, 1978).

The first clinical trials took place in 1954. So many women actively sought to participate that a social worker testified that she had to establish a waiting list. A doctor who ran a later clinical trial in Puerto Rico had particular interest in the pill, because many Puerto Rico women had resorted to sterilization, even if they were looking for a reversible contraception measure. Thus, as in other places, she had no trouble finding volunteers for the trial. When in 1961 the Mexican government put a stop to the trial, women continued to come in, begging for the pill (Marks, 1999; see also Schoen, 2005).

With the conclusion of the clinical trials, the Food and Drug Administration (FDA) authorized the drug for treating menstrual disorders in 1957, and as a contraceptive – branded Enovid – in 1960 (Junod & Marks, 2002). By 1962, the pill had fewer side effects. The price also dropped, and despite the moral controversy, the pill became immensely popular, with the number of American users growing from 408,000 in 1961 to 3.8 million in 1965, and to just under 12.5 million women worldwide by 1967 (Tietze, 1965; Tyrer, 1999). In 2002, 11.6 million women in the US reported being on the pill, with 44.5 million reported having used it at one point or another, and it became the leading method of contraception in the US (Mosher, Martinez, Chandra, Abma, & Willson, 2004). These numbers attest to the women's strong desire for this innovation.

4.2.2. Contextual enablers — social and technological background

A number of social, chemo-medical, and market conditions enabled the innovation of the pill. First, perceptions of birth control as a radical act gradually declined after World War I, and birth control penetrated the middle-class population. As a result, during the 1920s biologists started to take interest in birth control (Borell, 1987). Soon, birth control became a large industry in the US, which was profitable despite the Depression. Women became the primary consumer of contraceptives (suppositories), and despite the market's illegality, this industry sophisticatedly appealed to women's needs (Tone, 1996).[4] Still, the average American woman did not have access to birth control, as the cost of doctors and other medical services almost doubled between 1914 and 1927 and remained out of reach for many (Schoen, 2005; Tomes, 2001).

The medical community of the time was also going through a social transition. The debate about birth control ended in the modification of the Comstock Law to allow for the dissemination of contraceptive information and methods (Goldin & Katz, 2002). Now the interest of the medical community shifted into achieving a dependable and non-hazardous birth control method, an interest that focused primarily on chemical spermicides (Borell, 1987). However, during the late 1930s scientists discovered the impeding effect of progesterone on ovulation (Goldin & Katz, 2002), and during the 1940s advancements were made in the artificial synthesis of hormones (Goldin & Katz, 2002; Lehmann, Bolivar, & Quintero, 1973), setting the stage for the innovation of the pill.

Importantly, whereas the stage for the revolution of the pill was set by evolutionary developments, only the combination of contextual enablers of social consent, women's specific wants, a market atmosphere that favored marketing to women, financial support by philanthropists, and access to chemo-medical knowledge and facilities, could actually bring the initiation of Sanger and McCormick to a practical, usable, and specific innovation.

4.2.3. Innovation consequences

The pill was a contraceptive that women could use regardless of consent or knowledge of men, and its effectiveness was considerably higher than other contemporary methods (Bailey, 2006). It has had far-reaching social consequences, including an immense impact on sexual behavior. It was also the first drug created for healthy people, and started an enormous industry of drugs designed to improve the quality of life and lifestyle drugs (Tyrer, 1999). Most importantly, it influenced women's rights through enabling their participation in the workforce: women with early access to the pill were more likely to delay pregnancy and to join and remain in the paid workforce (Bailey, 2006). For example, during the 1970s, more women applied to medical and law schools, careers that require long-term planning that only the pill could allow (Goldin & Katz, 2002).

4.3. The jeep

4.3.1. Innovation outline

During the 1930s, the US Army realized that there was a need for a lightweight vehicle that could transfer people and heavy equipment over rough terrains and be used for reconnaissance as a complement to- and later on a substitute for the horse cavalry (Nowowiejski, 1994). The possibility of war on the horizon, coupled with evidence of the mechanization lead of the German army, intensified the Army's need for such a lightweight vehicle, as well as for assistance in developing an effective vehicle. A team of representatives from various military forces assembled to specify exactly what the Army's requirements were (Foster, 2004).

In 1940, the Army issued a formal bid for such a vehicle to as many manufacturers as they could find, totaling about 135 requests. The Army specified that the vehicle should weigh a quarter ton and have four-wheel drive, and that 70 vehicles be delivered within 75 days. Manufacturers did not find the request appealing, and they all turned it down. General William Knudsen, head of Army procurement, personally contacted Karl Probst, a consultant at the Bantam Car Company, to take on the project. Probst, who ended up considerably influencing the development of the jeep, initially refused, but General Knudsen convinced him to accept the Army's challenge (Brams, 1996). Bantam was in financial difficulties at the time and saw the contract as a last resort (Foster, 2004; Siuru, 1990).

After 49 days, Bantam delivered a prototype to the Army. The vehicle weighed much more than specified. Still, the vehicle's 60 hp engine and its durability in field tests made it desirable, and the Army approved it (Brams, 1996; Stewart, 1992; jeep.com). Bantam shipped 69 vehicles by the 75th day, and subsequently produced another 2500 vehicles. The Army solicited the Willys-Overland Company and the Ford Company to join the effort, both of which agreed only after learning that the prototype had been successful and that they could use it, as only under those circumstances did the contract seem appealing (Siuru, 1990; Stewart, 1992).

4.3.2. Contextual enablers — organizational and technological background

The 1920s and the 1930s was a period of transition for the US Army on a number of fronts. Whereas light cavalry for fighting and reconnaissance missions were an important part of military doctrine, World War I had introduced tanks and other armored vehicles, thus

[3] For example, a social worker who helped start one of the clinics attested that one of the incidents that motivated her was an encounter with a desperate woman who came to her asking for information on how not to have another baby; the woman later died during her 11th pregnancy (Anderson, 1998).

[4] Advertisements suggested discreet hygiene measures that 'only real women need'.

mandating changes. During the 1930s, a substantial debate developed within the Army on whether reconnaissance forces should use armored vehicles or unarmored ones. Whereas unarmored vehicles meant a greater loss of lives and of vehicles, they would increase mobility and speed, decrease fuel consumption, and thus increase range, as well as the important battlefield aspect of having a smaller silhouette (Cameron, 2010; Nowowiejski, 1994). The organizational changes and debate eventually stabilized, because by 1940 information about the accomplishments of the German army started to emerge.

In Germany, the conceptualization of a lightweight military vehicle started as early as 1934 (Taylor, 2004). German officials found the vehicles of their army insufficient and allocated resources to mechanization. A number of German firms developed truck models for the army, but even the most off-road and lightweight one was relatively heavy and expensive (Milsom, 1975). In 1938, army officials approached Ferdinand Porsche – an automobile industrialist – with capacity, weight, and structural specifications for a new vehicle. The German army used this new Kübelwagen during the invasion of Poland, where it proved to be very efficient (Taylor, 2004).

To summarize, the issuing of the US Army bid in 1940 occurred as a consequence of the Army organizational backdrop. Coupled with the awareness of the technological lead of the German army and the success of its unarmored vehicles in the battlefield, especially after 1939, US Army officials realized the potential contribution of a light-weight vehicle to their warfare.

4.3.3. Innovation consequences

Popular media and US Army generals acknowledged that the jeep was so invaluable that it was one of the tools that won the War. In the battlefield, it became everything from a message carrier to a light attack vehicle. The Army was initially a non-customer: before the jeep, it used horses and motorcycles for reconnaissance — a different category; it was not a customer of Bantam; and it did not possess sufficient knowledge to develop the innovation without the help of experts. Now a customer, the success of the jeep exceeded far beyond the Army's initial projection. Realizing its abilities, coupled with the low price compared with any armored vehicle — and thus its expendability, the Army kept ordering more and more jeeps. Consequently, whereas the Army had a total of 12,000 motor vehicles of all kinds in 1940, by 1945 Bantam, Ford, and Willys alone supplied it with more than 600,000 jeeps (Stewart, 1992).

Ford stopped manufacturing jeeps as soon as the War ended, because the benefits of the jeep did not seem relevant to peaceful household lives, and the post-war American household preferred more stylish and larger vehicles. In contrast, Willys ventured to sell the military-originated vehicle to the public as a work vehicle for farms and factories, capitalizing on its wartime popularity (Popular Science, 1945; Stewart, 1992).

The first civilian version of the jeep, from 1945, is the forbearer of sports utility vehicles (SUVs; Siuru, 1990), meaning that the jeep generated a whole new market of on- and off-road and leisure vehicles. The militaristic social trends of the 1980s, evident in fashion and in popular entertainment (with movies and TV shows such as *Rambo*, *Top Gun*, *The A-Team*, etc.), even made Ford realize the jeep's potential, and it used the jeep to renaissance the SUV with its Ford Explorer. In the 1980s jeeps and SUVs became an emblem of the American spirit (Campbell, 2005). This trend continued well into the 1990s, when SUVs became the fastest-growing segment of the motor vehicle industry (Davis & Truett, 2000). Its militaristic traits broadened the jeep's appeal in light of the rising urban crime and rate of road accidents (Croft, 2006; Time, 2007). Other drivers of its popularity were the generally good economic situation in the US in the 1980s and the perception of its safety (Davis & Truett, 2000). SUVs, the direct decedents of jeeps, significantly changed consumption habits. During the 1980s and 1990s the American car industry sold about 24 million SUVs (Hanson, 2007). By 2000, SUVs were used mostly for general mobility, as opposed to off-road-driving activities. Their size, weight, and physical characteristics elevated fuel consumption to an average 65% more than a large car (Davis & Truett, 2000; Heavenrich, 2005; Rutledge, 2005).

Social changes also occurred. The perception of safety and the elevated driving position made drivers feel in control, and protected from violence and car accidents; this encouraged women to purchase SUVs. The appeal to women brought another interesting social change: soccer moms changed their social status and self-perception by moving up from the minivan (emphasis on mini) to the socially desirable SUV (emphasis on sport utility) (Davis & Truett, 2000). Another social change was the anti-SUV movement, which arose due to the concern about emissions and the US dependence on the oil-rich countries, some of which were clearly involved in terrorism (Davis & Truett, 2000; Rutledge, 2005). Still, SUVs lost little of their public appeal.

New jeeps are still produced today. The Jeep brand has changed hands, and today Chrysler owns it (Siuru, 1990). One could argue that the success of the jeep was a sure thing as soon as the Army posted the bid, however: (1) had its success been obvious, it is likely that more firms would have accepted the challenge. The American auto industry was leaning strongly toward long and heavy cars, and manufacturing a short, light, and unstylish vehicle seemed to car manufacturers very unappealing (Stewart, 1992); and (2) the jeep's success exceeded far beyond its initial military customer, and had far-reaching social and economic consequences.

5. Analysis and results

Our analysis of the differences and similarities of the innovations, stems from the logic that if one reveals similarities in practices and processes between entirely different innovations, the similarities will likely express real phenomena (Lynn et al., 1996). The innovations we discuss here originated during different periods, in different industries, with different end-customers, and in different contexts (see Table 1). Still, some striking similarities between these three innovations exist, primarily in the initiation and development process, and in the extent of the consequences. Table 2 exhibits the similarities between the innovations.

A clear resemblance exists in the process leading to the initial development of the innovations. For each of these innovations non-customers experienced a problem and actively searched for a solution. All three innovations were initiated by the non-customers who realized they did not have sufficient knowledge or skills to develop an appropriate innovation themselves, and turned to potential suppliers for help. The non-customer and the potential supplier shared basic knowledge that enabled them to communicate and establish a sustainable platform for their collaboration. Still, they faced the challenge of bridging the gap between the potential supplier's high knowledge of technology and the non-customer's high knowledge of the need. In all three innovations, the result was, in effect, a technological leap, with little or no resemblance to substitute products that were then available. All three innovations became successful and generated competition and further development.

Most importantly, all three innovations ended up being radical innovations. The air conditioner and the pill differed considerably from any other substitute product or existing technology, and effectively started new product categories. Air conditioning created a market for industrial air conditioners, for recreational activity (movies, theaters, and shopping malls), and home and car air conditioning. It affected ice manufacturing, textile and other industries. It also changed labor conditions in factories, housing prices, and human settlement patterns (Arsenault, 1984; Oi, 1997). The pill generated new markets for lifestyle drugs — from anti-depressants to libido enhancers. It affected women's participation in the workforce, and subsequently their social status. It also increased household income and thus the standard of living (Bailey, 2006; Tyrer, 1999). The jeep considerably differed from military reconnaissance means of horses and motorcycles (Cameron,

2010; Nowowiejski, 1994). In a technological world of sedans, trucks and tanks, the no-door, stiff-springs, small-silhouette, extremely powerful engine, high fire-power, fast, and all-terrain four-wheel drive – and yet light weight – broke numerous technological paradigms. It provided superior benefits to the US army, and later to household consumers, including the perception of safety from violence and car accidents, and the increased social status for women (Davis & Truett, 2000). Thus, air conditioning, the pill and the jeep affected existing markets and generated new ones, and all three innovations had longitudinal social and economic effects.

6. Discussion and conclusions

Academic research widely discusses radical innovation, because scholars and practitioners consider radical innovation to be a strong driver of success and growth (e.g., Baker, Sinkula, Grinstein, & Rosenzweig, 2014). Still, the marketing and innovation literature hardly discusses non-customer-initiated innovations, let alone radical ones. We posit that non-customer-initiated radical innovations justify an in-depth examination and discussion, because they (1) represent a phenomenon that is considerably wider than that expressed in the current literature, and (2) could potentially become more frequent if managers are aware of this phenomenon and its potential contribution to radical innovation.

The present study provides new information in the following ways: (1) classic historiographical works state the assembly of evidence as the backbone of an historical approach (Bloch, 1954; Carr, 1961). Accordingly, the present study assembles and presents evidence in a systematic, orderly, and reasoned manner, thereby generating new information; (2) the present study examines the combination of technological, organizational and social context of each innovation. We thus ask the historian's question "'Why?' about new things or in new contexts" (Bloch, 1954, p. 87); and (3) the present study reveals new, overarching causal connections across the innovations we study, tests the "wider context of adjoining situations and things, studies interrelations, and attempts to establish causal connections and motives", as suggested by the classic historiographical work of Elton (1967, p. 109).

6.1. Conclusions

In identifying the patterns across the innovations we examined, we can suggest the following key findings: (1) non-customers can initiate radical innovation, (2) non-customer-initiated radical innovation may follow an identifiable pattern of emergence, and (3) this innovation can be truly radical, changing existing markets, changing the way customers think and behave, generating new markets, and meaningfully contributing to the evolution of society and economy. Non-customers have high knowledge of their own needs, but their knowledge of technology – if any exists – is not sufficient to self-generate the innovation. By approaching a potential supplier with a high knowledge of technology but an insufficient knowledge of the need, a unique dyad is created. This dyad is characterized by a bilateral knowledge gap that stimulates increased learning. This increased learning, in turn, enables the co-creation of an innovation that has the potential of becoming truly radical.

6.2. Contribution to industrial marketing

The present study makes the following key contributions to industrial marketing. First, we propose a theory for the initiation of radical innovation by non-customers and its co-creation with potential suppliers. We do so by identifying a bilateral gap, where the non-customer has a high knowledge of the need but insufficient knowledge of technology, while the potential supplier has a high knowledge of technology but insufficient knowledge of the need. Second, we posit that this gap is larger than in cases of customers and suppliers, because suppliers have some knowledge of their customers' needs and customers sometimes have some technological knowledge of technologies in their markets. This sizable gap stimulates increased learning and consequently the co-creation of radical innovation. Yet another contribution to industrial marketing is the specification of how a dyadic relationship of a non-customer and a potential supplier can emerge.

Third, we argue that because the non-customer and potential supplier are acting in different markets, they have little to lose in terms of proprietary assets. Thus, contrary to other business-to-business dyads, the non-customer–potential supplier dyad enjoys increased trust and openness that further stimulate learning and the resulting radical innovation. Fourth, we suggest that the above process can only occur if organizational, technological and social contextual enablers are sufficient. In other words, connecting the dots that make a radical innovation is possible only if the dots are already there. These contextual enablers effectively provide the macro determinants of the radical innovation, while the specific dyad shapes the design and functionality of the specific radical innovation. Different natures of other potential dyads would likely have generated different solutions with different innovation specifications.

The contextual enablers we discussed provided a natural platform, not only for the radical innovations we examined, but also for other, unsuccessful innovations that may have emerged from similar needs. Indeed, prior studies have contended the abundance of unsuccessful innovations, many of which are not even recorded, let alone researched (Da Rin, Hellmann, & Puri, 2011; Fridenson, 2004). Considering our theoretical framework, even if the necessary contextual enablers are sufficient for a radical innovation to take place, a number of critical processes must occur simultaneously for a dyad to be created. First, the non-customer must experience a need, and also engage in a relationship with a potential supplier. Second, the supplier must perceive the non-customer as able to mobilize the necessary knowledge for the co-creation of the solution. Third, both the non-customer and the potential supplier must realize benefits that are large enough to outweigh the financial and other transactional costs.

Eventually, even if such a dyad is created, its success in co-creating a viable solution to the problem of the non-customer is not guaranteed. That said, an industrial marketing dyad is more likely to succeed than a business-to-customer relationship, primarily because to establish a dialogue with end-customers, a supplier is likely to use mediators such as marketing research firms. A far more fruitful dialogue can be achieved in industrial arenas, in which non-customers and potential suppliers can directly interact, learn and co-create, free of mediators.

6.3. Theoretical implications

The findings of this study suggest the following theoretical implications. First, this study is a first step in theorizing why non-customers can in fact meaningfully contribute to radical innovation. Prior research focused on serial or professional ideators (e.g., Bayus, 2013; Troy, Szymanski, & Varadarajan, 2001), but these individuals neither constitute the target market nor eventually use the innovation. Other research suggested that lead users can be a source of innovation, however this research specifically refers to users either developing their own products or modifying and improving the products they already use (Baldwin, Hienerth, & von Hippel, 2006; von Hippel, 1976; von Hippel, de Jong, & Flowers, 2012; see also Rosenzweig et al., 2015). Such users are fundamentally different from non-customers, who (1) do not use products in the category and who (2) ask potential suppliers to develop the innovation for them and do not develop it themselves. Accordingly, von Hippel (1986) notes that "the insights of lead users are as constrained to the familiar as those of other users" (p. 696). Accordingly, we argue that the strength of non-customers is that they are not constrained by the technological and marketing paradigms characterizing products in the category. This unfamiliarity frees non-customers from entrenchment, and such cognitive freedom may generate radical innovations that change industries, create new markets,

and have long-term social and economic effects.

Second, realizing that non-customers are indeed capable of initiating radical innovation is an important theoretical step. Whereas research cannot fully explain *why* innovation occurs (Bogers, Afuah, & Bastian, 2010), we add to previous studies (e.g., Rosenzweig & Mazursky, 2014) in suggesting that innovation occurs because of the gap between needs and the existing technology, which is a powerful stimulus for learning and subsequently innovating.

6.4. Managerial implications

Our study provides managerial implications, a number of which may be especially valuable for industrial marketing. First, suppliers should know that the option of deriving radical innovation from non-customers exists. Currently, suppliers might be unaware of this possibility and this may critically hinder their innovation opportunities. Second, managers may cultivate excellent relationships with customers, but may "sit on their laurels" when it comes to identifying new potential markets. Managers should be aware that limited knowledge about new markets has merit, and they should not fear facing it. By knowing that networking with non-customers may lead to radical innovation, managers may become much more active in canvassing the market and in identifying strategically attractive relationships that match – but also extend – the existing capabilities of their firm (see Partanen & Möller, 2012). Most important, however, is that managers will not dismiss ideas for innovations coming from non-customers just because of their low technological knowledge.

6.5. Limitations and future research

In this study, we have made a preliminary attempt to address potential limitations typical in similar research contexts. For example, because examining a single innovation may provide only limited insight, we present three innovations. We also use multiple sources of data and carefully adhere to disciplinary codes such as triangulation and assessing the credibility and reliability of the sources (e.g., Barratt et al., 2011; Golder, 2000). Several limitations remain.

First, we did not sample ideas that did not trigger an observable sequence of events leading to commercialization. Future research may examine ideas that exhibited a clear potential for becoming a radical innovation, but went through an extended incubation time, and determine if and to what extent contextual enablers existed or developed only later. For example, in 1968 AT & T launched Picturephone—a telephone system with a video camera that enabled speakers to see each other. Picturephone was a commercial failure, but Skype, Facetime, and Google Hangouts may be perceived as radical innovations. Second, prior research examined potential radical innovations that failed and were initiated by customers, users, and inventors (Rosenzweig et al., 2015). Future research can examine innovations that were initiated by non-customers but did not end up being radical innovations. Third, the radical innovations we examine have relatively high non-customer involvement. Examining other industries with other levels of involvement may shed light on the micro-level determinants and design of the innovation. Fourth, because historians completely rely on historical records, they must keep in mind that past reports, similar to contemporary ones, are subject to biases and must be interpreted with caution (e.g., Bairstow & Young, 2012). We selected high-profile innovations, as attested to by the multiple studies that cover them. Similarly high-profile innovations are well recorded (Hargadon & Douglas, 2001), which limits potential misidentification or missing records of occasional interactions. Future research can study and record the entire set of interactions between non-customers and potential suppliers during the emergence and development of radical innovation.

References

Ackermann, M. E. (2002). *Cool comfort: America's romance with air conditioning.* Washington, DC and London, UK: Smithsonian Institution Press.

Anderson, M. H. (1998). Private choices vs. public voices: The history of Planned Parenthood in Houston. *A thesis submitted in partial fulfillment of the requirements for a doctor of philosophy*. Houston, Texas: Rice University.

Arsenault, R. (1984). The end of the long hot summer: The air conditioner and the southern culture. *The Journal of Southern History*, *50*(4), 597–628.

Bailey, M. J. (2006). More power to the pill: The impact of contraceptive freedom on women's life cycle labor supply. *The Quarterly Journal of Economics*, *121*(1), 289–320.

Bairstow, N., & Young, L. (2012). How channels evolve: A historical explanation. *Industrial Marketing Management*, *41*, 385–393.

Baker, W. E., Sinkula, J. M., Grinstein, A., & Rosenzweig, S. (2014). The effect of radical innovation in/congruence on new product performance. *Industrial Marketing Management*, *43*(8), 1314–1323.

Baldwin, C., Hienerth, C., & von Hippel, E. (2006). How user innovations become commercial products: A theoretical investigation and case study. *Research Policy*, *35*, 1291–1313.

Baraldi, E., Proença, J. F., Proença, T., & de Castro, L. M. (2014). The supplier's side of outsourcing: Taking over activities and blurring organizational boundaries. *Industrial Marketing Management*, *43*(4), 553–563.

Barratt, M., Choi, T. Y., & Li, M. (2011). Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *Journal of Operations Management*, *29*, 329–342.

Batt, P. J., & Purchase, S. (2004). Managing collaboration within networks and relationships. *Industrial Marketing Management*, *33*(3), 169–174.

Bayus, B. L. (2013). Crowdsourcing new product ideas over time: An analysis of the Dell IdeaStorm community. *Management Science*, *59*(1), 226–244.

Bloch, M. (1954). *The historian's craft*. Manchester, UK: Manchester University Press.

Bogers, M., Afuah, A., & Bastian, B. (2010). Users as innovators: A review, critique, and future research directions. *Journal of Management*, *36*(4), 857–875.

Borell, M. (1987). Biologists and the promotion of birth control research, 1918–1938. *Journal of the History of Biology*, *20*(1), 51–87.

Brams, S. H. (1996). How Jeep came to be. *Ward's Auto World*, *32*(5), 43.

Calantone, R. J., Cavusgil, S. T., & Zhao, Y. (2002). Learning orientation, firm innovation capability, and firm performance. *Industrial Marketing Management*, *31*(6), 515–524.

Cameron, R. S. (2010). *To fight or not to fight? Organizational and doctrinal trends in mounted maneuver reconnaissance from the interwar years to operation Iraqi Freedom*. Fort Leavenworth, KS: Combat Studies Institute Press.

Campbell, D. (2005). The biopolitics of security: Oil, empire, and the sports utility vehicle. *American Quarterly*, *57*(3), 943–972.

Carr, E. H. (1961). *What is history?* Cambridge, UK: Cambridge University Press.

Carrier, W. H. (1929). Air conditioning — Its phenomenal development. *Heating and Ventilating*, *26*(6), ((Reprinted in Nagengast, B. (2002). 100 years of air-conditioning. ASHRAE Journal, 44–46) (1929)).

Chandy, R. K., & Tellis, G. J. (1998). Organizing for radical product innovation: The overlooked role of willingness to cannibalize. *Journal of Marketing Research*, *34*(4), 474–487.

Chandy, R. K., & Tellis, G. J. (2000). The incumbent's curse? Incumbency, size, and radical product innovation. *Journal of Marketing*, *64*(3), 1–17.

Chang, K. H., & Gotcher, D. F. (2007). Safeguarding investments and creation of transaction value in asymmetric international subcontracting relationships: The role of relationship learning and relational capital. *Journal of World Business*, *42*(4), 477–488.

Comstock law. In E. K. Chen (Vol. Ed.), *Civil War, western expansion, and industrialization 1820–1900. . vol. 2. Encyclopedia of women in American history* (pp. 77–). Armonk, NY: Sharpe Reference.

Christensen, C. M. (1997). *The innovator's dilemma: When new technologies cause great firms to fail*. Boston, MA: Harvard Business School Press.

Christensen, C. M., Anthony, S. D., & Roth, E. A. (2004). *Seeing what's next: Using the theories of innovation to predict industry change*. Boston, MA: Harvard Business School Press.

Christensen, C. M., & Bower, J. L. (1996). Customer power, strategic investment, and the failure of leading firms. *Strategic Management Journal*, *17*(3), 197–218.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128–152.

Cook, J. (2000). Evolution of American office architecture to 1950: Pollution vs. passive strategies to design the work environment. In K. Steemers, & S. Yannas (Eds.), *Architecture, city, environment: Proceedings of PLEA 2000 conference*. Oxford, UK: The Alden Press.

Cooper, G. (1998). *Air conditioning America: Engineers and the controlled environment, 1900–1960*. Baltimore, MD: Johns Hopkins University Press.

Croft, R. (2006). Folklore, families and fear: Exploring the influence of the oral tradition on consumer decision-making. *Journal of Marketing Management*, *22*(9/10), 1053–1076.

Da Rin, M., Hellmann, T. F., & Puri, M. (2011). *A survey of venture capital research (No. w17523)*. National Bureau of Economic Research.

Daly, S. (2006). *Automotive air conditioning and climate control systems*. Oxford, UK: Elsevier.

Davis, S. C., & Truett, L. F. (2000). An analysis of the impact of sports utility vehicles in the United States. *Report prepared for the Office of Transportation Technologies*. U.S. Department of Energy.

Edvardsson, B., Holmlund, M., & Strandvik, T. (2008). Initiation of business relationships in service-dominant settings. *Industrial Marketing Management*, *37*(3), 339–350.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32.

Elton, G. R. (1967). *The practice of history*. Sydney, Australia: Sydney University Press.

European Commission (2014). The 2013 EU industrial R & D scoreboard. *Economics of*

industrial research and innovation (Available at: http://iri.jrc.ec.europa.eu/scoreboard14.html).
Farrington, R., & Rugh, J. (2000). *Impact of vehicle air-conditioning on fuel economy, tailpipe emissions, and electric vehicle range*. Colorado: National Renewable Energy Laboratory.
Ford, D., & Håkansson, H. (2006). IMP — Some things achieved: Much more to do. *European Journal of Marketing*, *40*(3/4), 248–258.
Foster, P. R. (2004). *The story of the Jeep*. Iola, WI: Krause Publication.
Fridenson, P. (2004). Business failure and the agenda of business history. *Enterprise and Society*, *5*(4), 562–582.
Fullerton, R. A. (2011). Historical methodology: The perspective of a professionally trained historian turned marketer. *Journal of Historical Research in Marketing*, *3*(4), 436–448.
Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: A literature review. *Journal of Product Innovation Management*, *19*, 110–132.
Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory—Strategies for qualitative research*. Chicago, IL: Aldine Publishing Company.
Golder, P. N. (2000). Historical method in marketing research with new evidence on long-term market share stability. *Journal of Marketing Research*, *37*(2), 156–172.
Golder, P. N., Shacham, R., & Mitra, D. (2009). Innovations' origins: When, by whom, and how are radical innovations developed? *Marketing Science*, *28*(1), 166–179.
Goldin, C., & Katz, L. F. (2002). The power of the pill: Oral contraceptives and women's career and marriage decisions. *Journal of Political Economy*, *110*(4), 730–770.
Grönroos, C. (2011). A service perspective on business relationships: The value creation, interaction and marketing interface. *Industrial Marketing Management*, *40*(2), 240–247.
Håkansson, H., & Ford, D. (2002). How should companies interact in business networks? *Journal of Business Research*, *55*(2), 133–139.
Hanson, R. D. (2007). The gated community on wheels. In E. Cardenas, & E. Gorman (Eds.), *The Hummer myths and consumer culture*. Plymouth, UK: Lexington Books.
Hargadon, A. B., & Douglas, Y. (2001). When innovations meet institutions: Edison and the design of the electric light. *Administrative Science Quarterly*, *46*(3), 476–501.
Heavenrich, R. M. (2005). *Light-duty automotive technology and fuel economy trends: 1975 through 2005*. Advanced Technology Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency.
Herstatt, C., & von Hippel, E. (1992). Developing new product concepts via the lead user method: A case study in a "low-tech" field. *Journal of Product Innovation Management*, *9*, 213–221.
Hurley, R. F., & Hult, G. T. M. (1998). Innovation, market orientation, and organizational learning: An integration and empirical examination. *Journal of Marketing*, *62*(3), 42–54.
Ingels, M. (1952). *Willis Haviland Carrier: Father of air conditioning*. Garden City, NY: Country Life Press.
Jalkala, A., & Salminen, R. T. (2010). Practices and functions of customer reference marketing—Leveraging customer references as marketing assets. *Industrial Marketing Management*, *39*(6), 975–985.
Johnson, S. (2011). *Where good ideas come from: The natural history of innovation*. New York, NY: Riverhead Books.
Johnston, W. J., Leach, M. P., & Liu, A. H. (1999). Theory testing using case studies in business-to-business research. *Industrial Marketing Management*, *28*, 201–213.
Jordan, S. (2000). History of Planned Parenthood. In L. Balter (Vol. Ed.), *Parenthood in America: An encyclopedia. vol. 2*, (pp. 472–475). Santa Barbara, CA: ABC-CLIO.
Junod, S. W., & Marks, L. (2002). Women's trials: The approval of the first oral contraceptive pill in the United States and Great Britain. *Journal of the History of Medicine and Allied Sciences*, *57*(2), 117–160.
Kale, P., Singh, H., & Perlmutter, H. (2000). Learning and protection of proprietary assets in strategic alliances: Building relational capital. *Strategic Management Journal*, *21*, 217–237.
Katz, E. (2002). *The selected papers of Margaret Sanger: Volume I: The woman rebel, 1900–1928*. Chicago, IL: University of Illinois Press.
Kohtamäki, M., Partanen, J., & Möller, K. (2013). Making a profit with R & D services—The critical role of relational capital. *Industrial Marketing Management*, *42*(1), 71–81.
Koumparoulis, D. N., & Solomos, D. K. (2012). Taylor's scientific management. *Review of General Management*, *2*, 149–159.
Lehmann, P. A., Bolivar, A. G., & Quintero, R. R. (1973). Russell E. Marker. Pioneer of the Mexican steroid industry. *Journal of Chemical Education*, *50*(3), 195–199.
Liberman, S., & Wolf, K. B. (2015). Independent simultaneous discoveries visualized through network analysis: The case of linear canonical transforms. *Scientometrics*, *104*, 715–735.
Lynn, G. S., Morone, J. G., & Paulson, A. S. (1996). Marketing and discontinuous innovation: The probe and learn process. *California Management Review*, *38*(3), 8–37.
Marks, L. (1999). Human guinea pigs? The history of the early oral contraceptive clinical trials. *History and Technology*, *15*, 263–288.
Mentzer, M. S. (2010). Scientific management and the American hotel. *Management and Organizational History*, *5*(3–4), 428–446.
Milsom, J. (1975). *German military transport of World War Two*. London, UK: Arms and Armour Press.
Mokyr, J. (1998). The second industrial revolution, 1870–1914. *Storia dell'economia Mondiale* (pp. 219–245). .
Möller, K. (2010). Sense-making and agenda construction in emerging business networks—How to direct radical innovation. *Industrial Marketing Management*, *39*(3), 361–371.
Moorman, C. (1995). Organizational market information processes: Cultural antecedents and new product outcomes. *Journal of Marketing Research*, *32*(3), 318–335.
Mosher, W. D., Martinez, G. M., Chandra, A., Abma, J. C., & Willson, S. J. (2004). Use of contraception and use of family planning services in the United States: 1982–2002. *Advance data from vital and health statistics*. *350*, (pp. 1–46). The US Department of Health and Human Services.
Moss Kanter, R. (1996). When a thousand flowers bloom: Structural, collective, and social conditions for innovation in organizations. In P. S. Myers (Ed.), *Knowledge management and organizational design*. Newton, MA: Butterworth-Heinemann.
Nagengast, B. (1999). A history of comfort cooling using ice. *ASHRAE Journal*, *41*, 49–57.
Nagengast, B. (2002). 100 years of air-conditioning. *ASHRAE Journal*, *44*(6), 44.
Narver, J. C., Slater, S. F., & MacLachlan, D. L. (2004). Responsive and proactive market orientation and new-product success. *Journal of Product Innovation Management*, *21*(5), 20–35.
Nowowiejski, D. A. (1994). *Adaptation to change: US Army cavalry doctrine and mechanization 1938–1945*. Fort Leavenworth, Kansas: School of Advanced Military Studies, United States Army Command and General Staff College.
Ogburn, W. F., & Thomas, D. (1922). Are inventions inevitable? A note on social evolution. *Political Science Quarterly*, *37*(1), 83–98.
Oi, W. Y. (1997). The welfare implication of invention. In T. G. Bresnahan, & R. J. Gordon (Eds.), *The economics of new good* (pp. 109–142). Chicago, IL: University of Chicago Press.
Ostro, B., Rauch, S., Green, R., Malig, B., & Basu, R. (2010). The effects of temperature and use of air conditioning on hospitalizations. *American Journal of Epidemiology*, *172*(9), 1053–1061.
Partanen, J., & Möller, K. (2012). How to build a strategic network: A practitioner-oriented process model for the ICT sector. *Industrial Marketing Management*, *41*(3), 481–494.
Popular Science. (1945) 147(2), 122–124. Available at http://www.popsci.com/archive-viewer?id = GSEDAAAAMBAJ&pg = 122&query = Vol. + 147.
Reed, J. (1978). *From private vice to public virtue*. New York, NY: Basic Book Publishers.
Rees, J. (2005). "I did not know… any danger was attached": Safety consciousness in the early American ice and refrigeration industries. *Technology and Culture*, *46*(3), 541–560.
Romijn, H., & Albaladejo, M. (2002). Determinants of innovation capability in small electronics and software firms in southeast England. *Research Policy*, *31*(7), 1053–1067.
Rosenzweig, S. (2015). Innovation in retrospect: An exploratory study of trends in the levels of innovation. *International Journal of Business and Management*, *10*, 63–73.
Rosenzweig, S. (2017). The effects of diversified technology and country knowledge on the impact of technological innovation. *Journal of Technology Transfer*, *42*(3), 564–584. http://dx.doi.org/10.1007/s10961-016-9492-5.
Rosenzweig, S., & Grinstein, A. (2016). How resource challenges can improve firm innovation performance: Identifying coping strategies. *Creativity and Innovation Management*, *25*(1), 110–128.
Rosenzweig, S., Grinstein, A., & Ofek, E. (2016). Social network utilization and the impact of academic research in marketing. *International Journal of Research in Marketing*, *33*(4), 818–839. http://dx.doi.org/10.1016/j.ijresmar.2016.02.002.
Rosenzweig, S., & Mazursky, D. (2014). Constraints of internally and externally derived knowledge and the innovativeness of technological output: The case of the United States. *Journal of Product Innovation Management*, *31*(2), 231–246.
Rosenzweig, S., & Tellis, G. J. (2017). *How transformative innovation shaped the rise of nations: From ancient Rome to modern America*. London, UK: Anthem Press ISBN 978-1-78308-732-7.
Rosenzweig, S., Tellis, G. J., & Mazursky, D. (2015). Where does innovation start: With customers, users, or inventors? *Marketing Science Institute working papers series, report no. 15-108* (pp. 1–52). .
Rutledge, I. (2005). *Addicted to oil: America's relentless drive for energy security*. London, UK & New York, NY: I. B. Tauris & Co.
Schellinger, P. (2008). Willis Carrier, inventor of air-conditioning. In D. Simonis, E. Ngeow, & E. (Eds.), *Inventors and inventions: Accidents and mistakes* (pp. 259–266). New York, NY: Marshall Cavendish.
Schoen, J. (2005). *Choice and coercion: Birth control, sterilization, and abortion in public health and welfare*. The University of North Carolina Press.
Simha, R. V. (2012). Willis H Carrier. *Resonance*, *17*(2), 117–138.
Simonton, D. K. (1978). Independent discovery in science and technology: A closer look at the Poisson distribution. *Social Studies of Science*, *8*(4), 521–532.
Simonton, D. K. (2003). Scientific creativity as constrained stochastic behavior: The integration of product, person, and process perspectives. *Psychological Bulletin*, *129*(4), 475–494.
Siuru, B. (1990). The Jeep: Fifty years in war and peace. *Mechanical Engineering*, *112*(4), 56–60.
Sood, A., & Tellis, G. J. (2005). Technological evolution and radical innovation. *Journal of Marketing*, *69*, 152–168.
Srinivasan, R. (2008). Sources, characteristics and effects of emerging technologies: Research opportunities in innovation. *Industrial Marketing Management*, *37*(6), 633–640.
Stewart, D. (1992). Hail to the Jeep! Could we have won without it? *Smithsonian*, *23*(8), 60–73.
Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R., & Samson, D. (2002). Effective case research in operations management: A process perspective. *Journal of Operations Management*, *20*(5), 419–433.
Taylor, B. (2004). *Volkswagen military vehicles of the Third Reich: An illustrated history*. Cambridge, MA: Da Capo Press.
Tietze, C. (1965). History of contraceptive methods. *Journal of Sex Research*, *1*(2), 69–85.
Time (2007). *The 50 worst cars of all time*. ((September 7th) http://www.time.com/time/specials/ 2007/article/0,28,804,1,658,545_1658544,00.html?artId = 1,658,545?contType = article?chn = specials).
Financial Times (2014). *Big Auto revs up R & D to record levels*. Henry Foy (January 13.

Available at: http://www.ft.com/intl/cms/s/0/013fa076-7b75-11e3-a2da-00144feabdc0.html#axzz2zgm8o4SJ).
Tomes, N. (2001). Merchants of health: Medicine and consumer culture in the United States, 1900–1940. *Journal of American History*, *88*(2), 519–547.
Tone, A. (1996). Contraceptive consumers: Gender and the political economy of birth control in the 1930s. *Journal of Social History*, 485–506.
Trigg, A. B. (2001). Veblen, Bourdieu, and conspicuous consumption. *Journal of Economic Issues*, 99–115.
Troy, L. C., Szymanski, D. M., & Varadarajan, P. R. (2001). Generating new product ideas: An initial investigation of the role of market information and organizational characteristics. *Journal of the Academy of Marketing Science*, *29*(1), 89–101.
Tyrer, L. (1999). Introduction of the pill and its impact. *Contraception*, *59*(1,1), 11S–16S.
Urban, G. L., & Hauser, J. R. (2004). "Listening in" to find and explore new combinations of customer needs. *Journal of Marketing*, *68*(2), 72–87.
US Patent 808,897, approved in 1906 for Willis H Carrier assignor to Buffalo Forge, NY.
Vargo, S. L., & Lusch, R. F. (2004). Evolving to a new dominant logic for marketing. *Journal of Marketing*, *68*, 1–17 (January).
Vargo, S. L., & Lusch, R. F. (2008). From goods to service(s): Divergences and convergences of logics. *Industrial Marketing Management*, *37*(3), 254–259.
von Hippel, E. (1976). The dominant role of users in the scientific instrument innovation process. *Research Policy*, *5*, 212–239.
von Hippel, E. (1986). Lead users: A source of novel product concepts. *Management Science*, *32*(7), 691–705.
von Hippel, E., de Jong, J. P. J., & Flowers, S. (2012). Comparing business and household sector innovation in consumer products: Findings from a representative study in the United Kingdom. *Management Science*, *58*(9), 1669–1681.
Wall Street Journal (2013). *Global R & D spending growth is expected to slow this year*. Gautam Naik (December 8th).
Woodside, A. G. (2010). Bridging the chasm between survey and case study research: Research methods for achieving generalization, accuracy, and complexity. *Industrial Marketing Management*, *39*, 64–75.
Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage.
Zaheer, A., McEvily, B., & Perrone, V. (1998). Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. *Organization Science*, *9*(2), 141–159.

Dr. Stav Rosenzweig is an assistant professor of marketing at The Department of Management, The Guilford Glazer Faculty of Business and Management, Ben-Gurion University of the Negev, Israel. Her research interests include innovation management at the industry and firm levels, knowledge sources, knowledge creation and knowledge spillover, marketing strategy, and the interrelations of innovation, knowledge, and public policy. Her work was published in a number of journals, including the *Journal of Product Innovation Management*, *Industrial Marketing Management*, and *International Journal of Research in Marketing*.